



Western Washington University
Western CEDAR

Salish Sea Ecosystem Conference

2016 Salish Sea Ecosystem Conference
(Vancouver, BC)

Jan 1st, 12:00 AM - 12:00 AM

Telling Stories: Designing Effective Data Visualization and Climate Change Communication Tools

Ilon E. Logan
Environmental Science Associates, ilogan@esassoc.com

Carol MacIlroy
Carol MacIlroy Consulting, cmacilroy@gmail.com

Follow this and additional works at: <https://cedar.wvu.edu/ssec>



Part of the [Fresh Water Studies Commons](#), [Marine Biology Commons](#), and the [Natural Resources and Conservation Commons](#)

Logan, Ilon E. and MacIlroy, Carol, "Telling Stories: Designing Effective Data Visualization and Climate Change Communication Tools" (2016). *Salish Sea Ecosystem Conference*. 19.
<https://cedar.wvu.edu/ssec/2016ssec/engagement/19>

This Event is brought to you for free and open access by the Conferences and Events at Western CEDAR. It has been accepted for inclusion in Salish Sea Ecosystem Conference by an authorized administrator of Western CEDAR. For more information, please contact westerncedar@wwu.edu.

Telling Stories: Designing Effective Data Visualization and Climate Change Communication Tools

Carol MacIlroy, MacIlroy Consulting, LLC

Ilon Logan, Environmental Science Associates

Salish Sea Conference
Vancouver, British Columbia
April 15, 2016



Presentation Overview

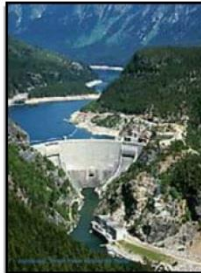
- Skagit River Watershed
- Who is the Skagit Climate Science Consortium?
- Finding and Unpacking Hidden Assumptions
- Need for Storytelling
- Portfolio of Materials
- Visualizing the *Seemingly* Unreal
- Take Aways

SKAGIT RIVER BASIN

~
PUGET SOUND, WASHINGTON



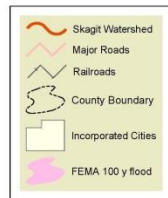
Upper Baker Dam



Ross Dam

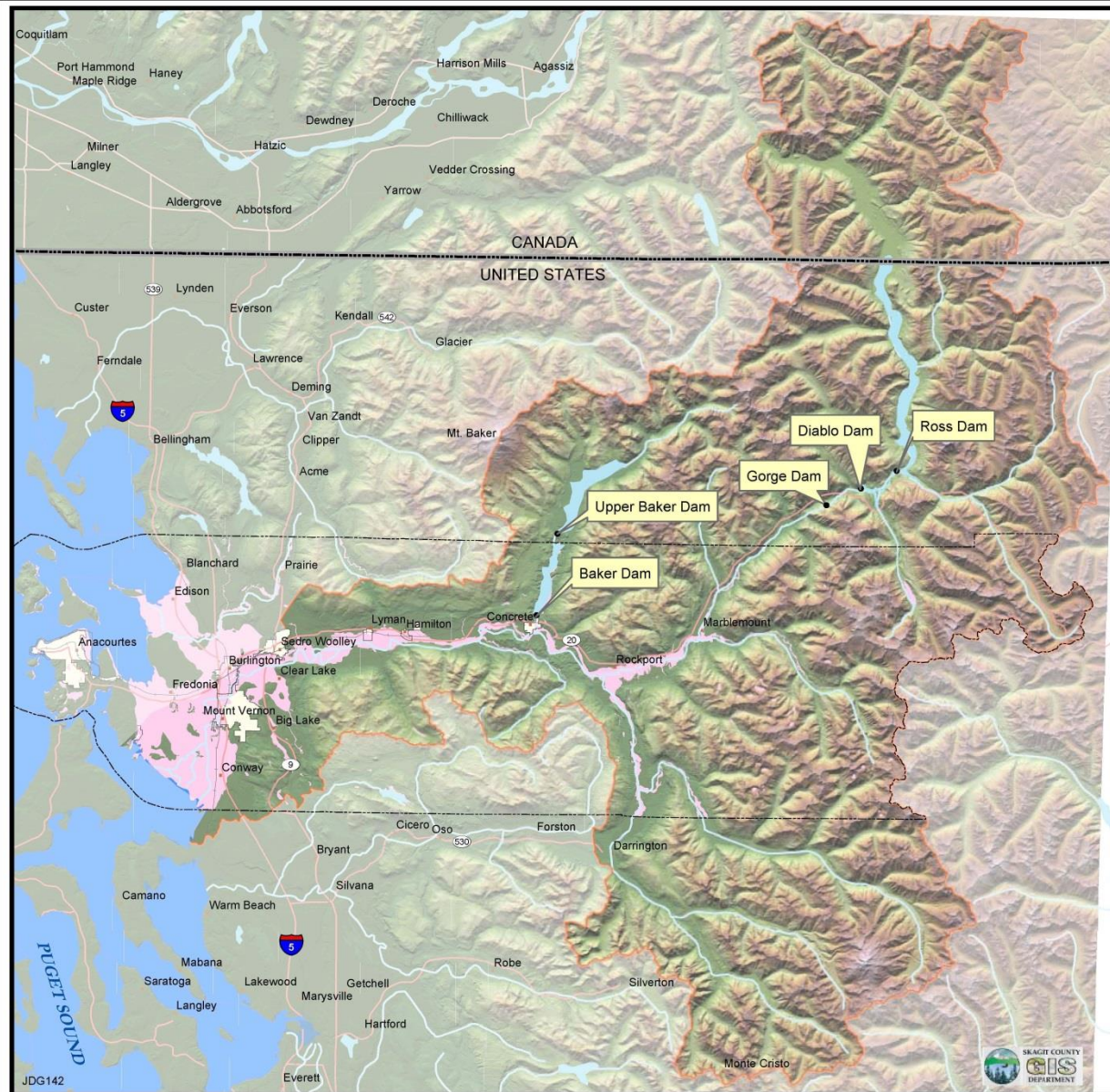


Lower Baker Dam



0 25 50 100 150 200
Miles

Map Printed: June 5, 2003



SC² – Skagit Climate Science Consortium

Members:

- Western Washington University
- University of Washington, Climate Impacts Group
- US Geologic Survey, Forest Service, Park Service
- NOAA, National Marine Fisheries Service
- Seattle City Light
- Pacific Northwest National Labs (Battelle)
- Skagit River System Cooperative
- Swinomish Indian Tribal Community
- University of Notre Dame

SC² – Skagit Climate Science Consortium

Mission

- Foster collaborative Skagit climate research
- Produce relevant climate science and products
- Link local people with local scientists and Skagit-specific information



SC² – Skagit Climate Science Consortium

Activities and Local Workshops

- General climate impact research
- Workshops with flood managers – flood risk
- Workshops with Skagit Watershed Council – salmon recovery
- Collaboration with WDFW – habitat assessment and adaptation

SC² – Skagit Climate Science Consortium

Presentations/Panels

- Transition Fidalgo, Alliance for Jobs and Energy, Skagit Democrats
- Congressional Tours
- Council of Environmental Quality Roundtable
- Skagit Council of Governments, Skagit Farm Forum, Transition Fidalgo
- EPA and Washington Dept. of Ecology Webinars
- Skagit River Festival

News Media

- KSVR, NPR, KCTS
- Skagit Valley Herald

A Scientific and Community Collaboration

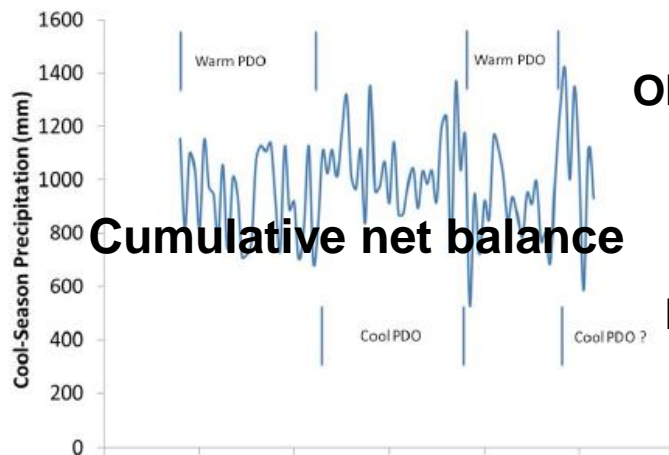


A Scientific and Community Collaboration



Finding and Unpacking Hidden Assumptions

A Story...

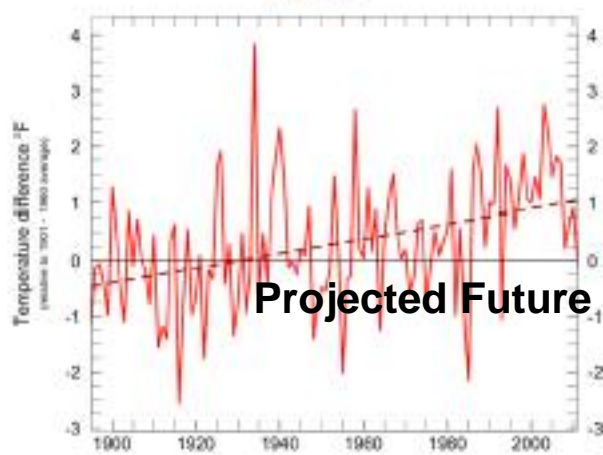


Observed Trend

Peak Average

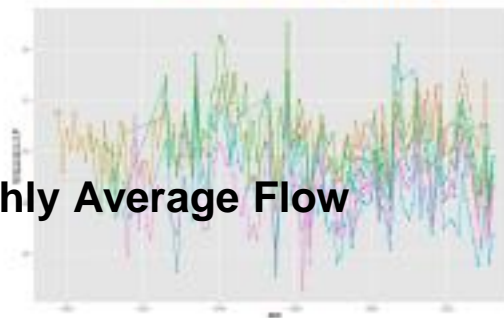
PDO

Figure 2.



Annual Rate of Projected Change

Figure 3. Annual Mean Temperatures for Low Elevation Sites (<1,600 feet)



Trend in glacier volume is strongly negative, but is punctuated by periods of relatively wet, cool weather every ~10 years.

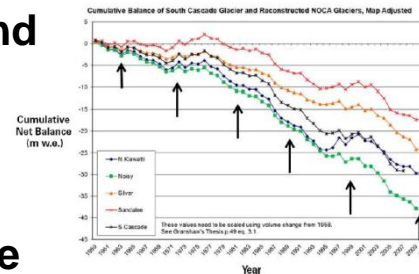
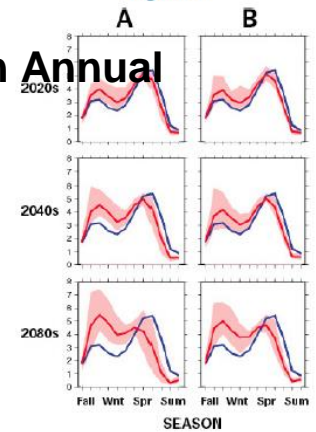
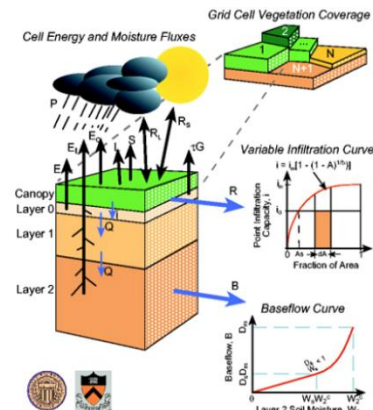


Figure 1.

Mean Annual



Variable Infiltration Capacity (VIC) Macroscale Hydrologic Model



A Story...

By 2040's the current
100-year event will be
a 22-year event!

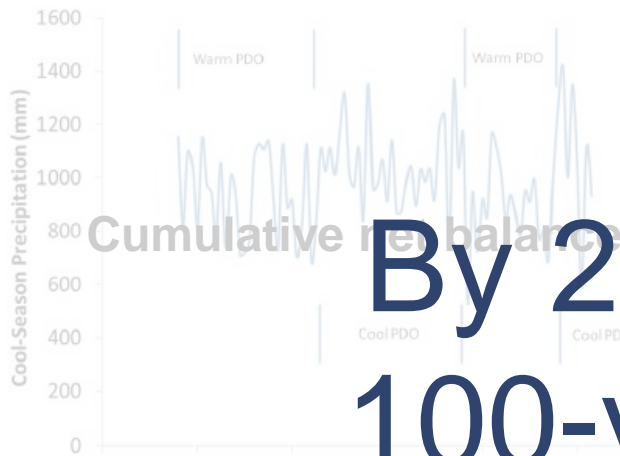
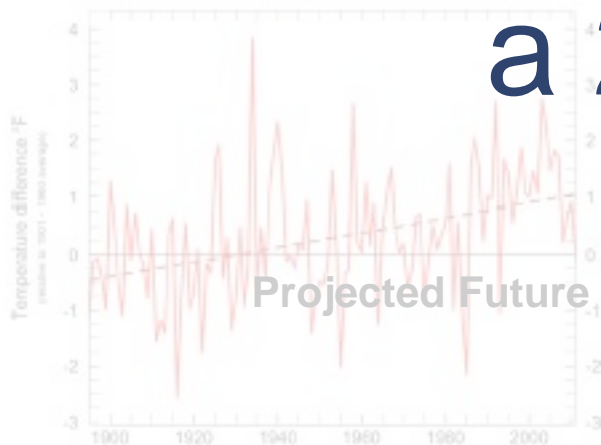


Figure 2.

Projected Future Monthly Average Flow



Observed Trend

Trend in glacier volume is strongly negative, but is punctuated by periods of relatively wet, cool weather every ~10 years.



Mean Annual

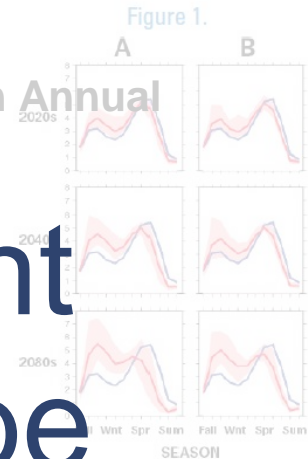
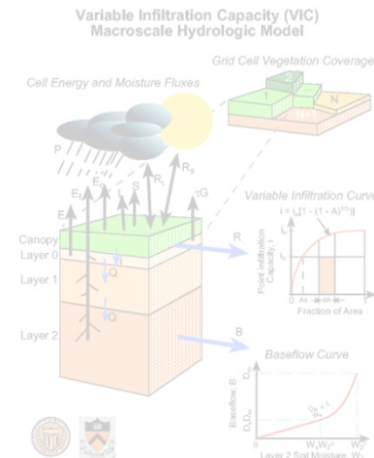
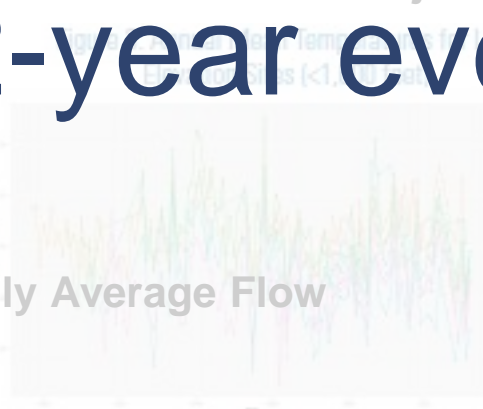


Figure 1.

Annual Rate of Projected Change



Portfolio of New Materials for SC² Storytelling

- Case studies
 - Two page fact-sheets with infographics and photographs
- Infographics
 - Stand alone graphics to illustrate concepts
- Interactive Flood Risk Map
 - Web-based map tool displaying SC2 flood model
- Visual Simulations of Potential Flood Conditions
 - Images of future floods at known locations in watershed



DELTA ECOSYSTEMS



THE CHALLENGE

Delta ecosystems include sand and mud flats, eelgrass and kelp beds, salt marshes, and tidally-influenced shrub and forested wetlands. These ecosystems are critical for numerous birds, mammals, fish, and shellfish, all of which are valued by many. Delta ecosystems are also a significant tribal resource that provides salmon and shellfish for tribal food supply, profitable harvests, and cultural practices. A significant portion of the Skagit delta was altered at the turn of the century when much of it was diked and drained for agricultural and other purposes. Today, the fish and wildlife in the delta face threats and changes from climate related impacts such as high water temperatures, rising sea levels, increasing sediment loads, and increasing frequency and magnitude of floods. Science and restoration practitioners are working to improve their understanding of how much climate change, in conjunction with other actions, will alter delta ecosystems and how best to guide protection and restoration actions and investments to be most effective.

Some key issues for delta ecosystem restoration:



BALANCING INCOMING SEAS AND OUTGOING SEDIMENT

Natural delta habitats are built and maintained over time by a continuous supply of sediment transported down eroding slopes and river channels. Much of the area encompassing the Skagit delta is slowly sinking due to natural and human-induced subsidence and the lack of new sediment, which is mostly cut off by dikes and levees and a channelized river. As sea levels rise and more sediment is transported through the watershed as a result of climate change, how will delta habitats react? Where will sediment be deposited? Will the sediment continue to help habitats build and "keep pace" with a rising sea level? Will sediment fill in too quickly and cover important habitats like eelgrass beds? Will sea levels rise and submerge existing habitat resulting in different landscapes and a set of vegetation or mudflats?



BEAVERS AND VEGETATION CHANGES

Beavers in the Skagit Delta rely on tidal shrub habitats. As "nature's engineers," beaver dams and lodges create deep pools in the tidal channels of the delta and these pools serve as high quality rearing and refuge habitat for juvenile salmon and other small fish. In fact, beaver dams can quadruple the number of low-tide pools, which in turn support three times the amount of juvenile salmon as low-tide shallow waters. One recent study found 117 functional beaver dams in the Skagit delta. Tidal shrub vegetation appears to be more sensitive to sea level rise and changes in salinity than other vegetation types, thus there is concern for the long-term viability of this habitat and its benefits for salmon. Furthermore, due to past alteration, there is very little tidal shrub habitat remaining in the delta magnifying the importance of this habitat.



SALMON SURVIVAL AND REPRODUCTION

All Pacific salmon species swim through river deltas as they move from their freshwater birth place to the Puget Sound saltwater and back. Each species uses delta habitats differently and at different times of year. Salmon are potentially affected by rising sea levels and ocean acidification through changes in quantity and quality of estuary rearing habitat, prey supply, migration timing and success, and loss of previous restoration actions as a result of sedimentation or sea level rise. Changes in upstream hydrology and increases in sediment affect fish survival through egg scour and suffocation, stranding, high water temperatures, and habitat alteration or lack of access at peak or low flows. How can restoration activities in the delta be designed to meet these changing conditions? Where and what type of habitat restoration would best ensure salmon survival and reproduction into the future?

DELTA ECOSYSTEMS (PAGE 2 OF 2)



Skagit Delta

LOOKING FORWARD TO MORE SOLUTIONS, MORE ACTION

SC² scientists have the opportunity to better understand the linkages between salmon survival thresholds and projected changes in temperature, peak and low flows, erosion, and shifts in vegetation as a result of changes in salinity, water levels, and sediment from a changing climate.

We are conducting extensive hydrodynamic modeling of restoration efforts in the Skagit delta, which will inform discussions between farmers, salmon advocates, and flood risk managers. We can use empirical models to further determine how tidal marsh vegetation and habitats will react to changes in sea level rise and changes in upstream flow patterns. Lastly, we are pursuing more information about the role tidal marshes can play in protecting important dike and levee infrastructure from storm surge, waves, and flooding.



The Skagit Climate Science Consortium (SC²)

SC² is a nonprofit 501(c)(3) organization consisting of scientists working with local people to assess, plan, and adapt to climate related impacts. Composed of research scientists from universities and federal, municipal, and tribal governments and agencies working in the Skagit basin, SC² members seek to understand how the landscape, plants, animals and people may be affected by changes in the patterns of rain, snow, temperature, storms and tides.

www.skagitclimatescience.org

Visit our website to learn more about who we are, what we do, and the various resources we can provide.

Or contact Carol MacIntyre:
cmacintyre@gmail.com or 206-293-4741.



DRINKING WATER



THE CHALLENGE

Located in the lowlands of the Skagit watershed, the previous City of Anacortes Water Treatment Plant was aging, inefficient, and at risk for flood-related damages projected to increase in the future in a changing climate.

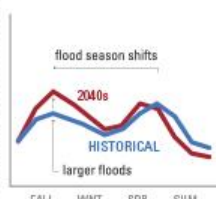
The plant's regional importance is clear—it is the largest single source of potable water in Skagit and Island Counties. It provides 29 million gallons of water each day to approximately 58,000 customers, including the Shell and Tesoro Refineries, the City of Anacortes, the City of Oak Harbor, the Town of La Conner, the Naval Air Station Whidbey, and the Swinomish Indian Tribal Nation. The Anacortes Public Works Department wanted to build a bigger plant for its customers, but they wanted to build a smarter plant too.



A smarter plant would need to tackle current and future issues such as:

FLOOD DAMAGE

Critical pieces of the facility that process the water and make it safe for drinking were at risk of flooding. Flood waters would flow over the ring dike that protected the plant and then needed to be pumped out. To make matters worse, floods in the Skagit watershed are projected to happen more often and during more months of the year, resulting in increased risk of damage to the treatment plant.



Skagit floods are projected to be bigger and occur during different months of the year.

SEDIMENT

Along with cold crisp waters, the Skagit River carries huge amounts of sediment. Every year, treatment plant employees remove more than 20,000 cubic yards of river sediment so water will be safe for drinking. This is a football field covered with 11 feet of dirt! The annual sediment load in the Skagit River is expected to increase significantly as a result of climate change—more than any other watershed in the Puget Sound region.



COVERING AN ENTIRE FOOTBALL FIELD

The amount of sediment removed annually from the old plant.

SALTWATER INTRUSION

When the tide is high, salty water from the bay travels up the Skagit River. In recent decades, tidal influence has moved up the river, closer to the water intake pipe for the treatment plant where salt water would contaminate drinking water. Of concern is a potential change in the saltwater wedge, which is the result of having lower summer flows in the Skagit River and higher sea levels in the bay that pushes the denser seawater farther inland.



SALTWATER INTRUSION

Saltwater is slowly creeping up the Skagit River and climate change will likely worsen this problem.

DRINKING WATER (PAGE 2 OF 2)



New Treatment Plant (2013)

SC² AS A PROVEN RESOURCE

SC² scientists supported City of Anacortes in developing a smarter plant—resilient to climate change.

Scientists from SC², including Eric Grossman, Tarang Khangar, and Alan Hamlet, worked directly with the City Public Works Department for over three years to provide unbiased scientific information the City could use to make smarter investments and weigh the risks of action and inaction. This required new analysis and taking the time for the scientists to understand water treatment operations. Once the scientists understood key thresholds, they designed analyses and studies to answer specific questions City of Anacortes staff had. As a result, the new plant was constructed with design elements to protect it against current and future flood events and the increase in sediment load. In addition, SC² performed preliminary modeling of salinity risks to the water intake pipe and found that it is not likely an immediate concern based on currently modeled rates of sea level rise and the lifespan of the plant.

LOOKING FORWARD TO MORE SOLUTIONS, MORE ACTION

SC² is positioned to support communities and decision-makers with water supply infrastructure. In the future, we plan to:

- Develop a better understanding of the future composition of sediment loads in the river (is it mostly silt, sand, or clay?) critical to Anacortes plant maintenance and functions
- Work with other water right holders, such as farmers, to identify climate change pressures on their water supply
- Work with Anacortes on their wastewater treatment plant to make sure that it is also resilient to climate change and sea level rise in particular
- Advance the integrated model of hydrology, glacier melt, and sediment

"It's really refreshing to see a local community just making practical, common sense, scientifically engineering-driven decisions rather than ideological issues. To me it's an inspiring example of how if you just focus on science and what it means in your machinery, you get things done."

— Governor Jay Inslee
(Skagit Valley Herald June 9, 2014)



The Skagit Climate Science Consortium (SC²)

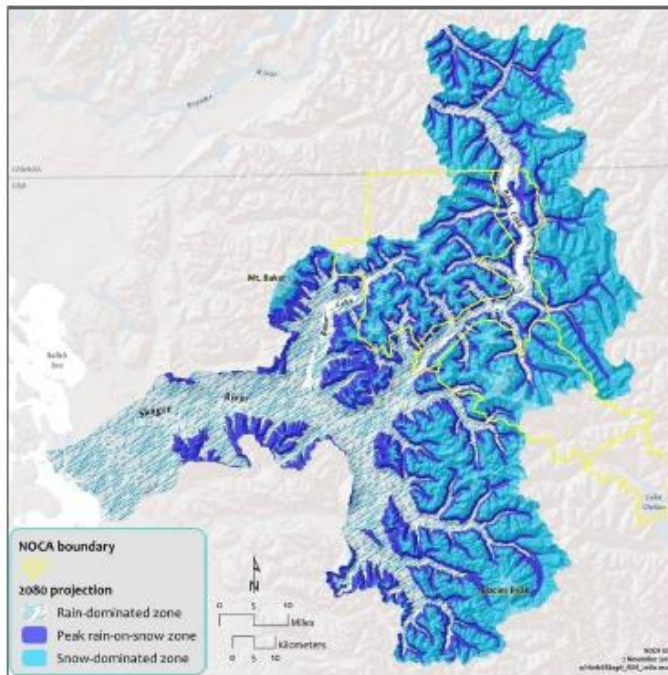
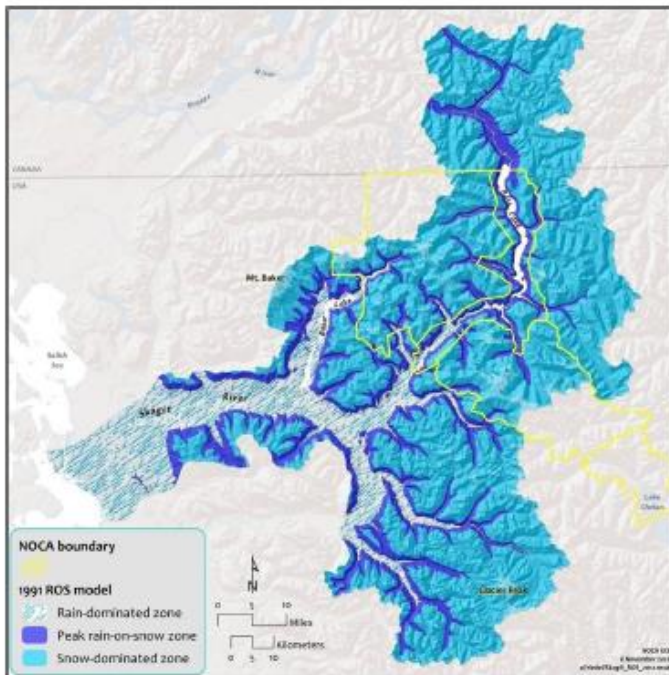
SC² is a nonprofit 501(c)(3) organization consisting of scientists working with local people to assess, plan, and adapt to climate related impacts. Composed of research scientists from universities and federal, municipal, and tribal governments and agencies working in the Skagit basin, SC² members seek to understand how the landscape, plants, animals and people may be affected by changes in the patterns of rain, snow, temperature, storms and tides.

www.skagitclimatescience.org

Visit our website to learn more about who we are, what we do, and the various resources we can provide.

Or contact Carol MacIlroy:
cmacilroy@gmail.com or 206-293-4341.

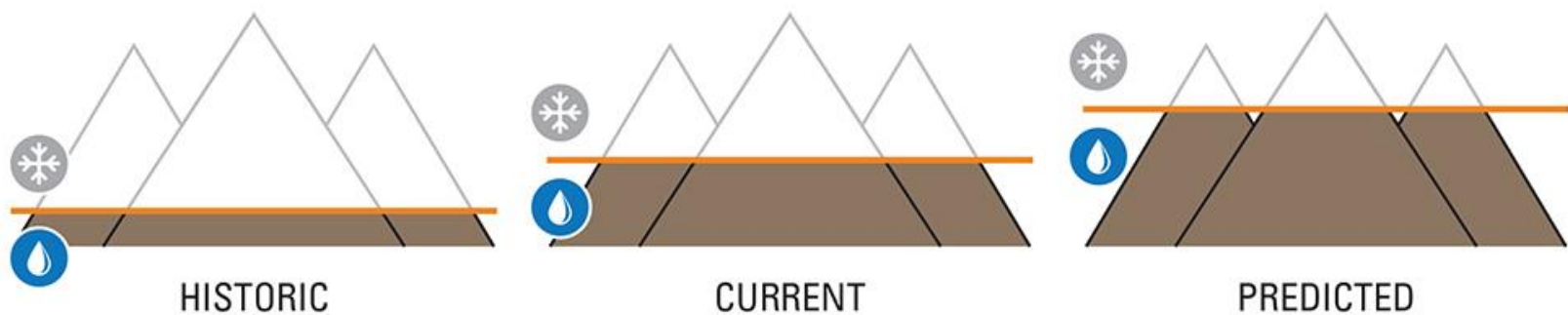
Rain-on-Snow Model Outputs



	% Rain	% ROS	% Snow
1991	17	15	68
2040 (+3.2 °F -+ 900 ft)	27	19	54
2080 (+5.3 °F -+ 1500 ft)	35	22	43

	Acres Rain	Acres ROS	Acres Snow
1991	350,000	309,000	1,411,000
2040	553,000	399,000	1,118,000
2080	716,000	460,000	893,000

Rising Winter Freezing Levels



FREEZING LEVEL



When precipitation falls as snow, it is stored as ice and snow that slowly melts, providing water to the Skagit River throughout the year, including late summer and drought periods.

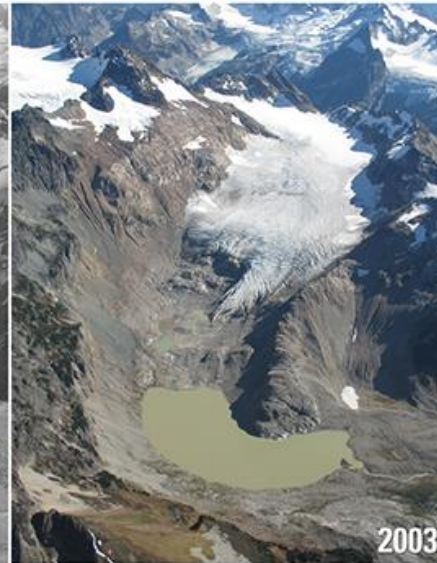
When precipitation falls as rain, water quickly enters the Skagit River during fall and winter, often contributing to flood risk. As freezing levels rise, the area potentially susceptible to flooding increases.

In the Skagit, the average winter freezing elevation has risen consistently since 1948.

Changes in Glaciers

South Cascade Glacier

Lower slopes of Sentinel Mountain, North Cascades; flows into South Fork Cascade River



Forbidden Glacier

North slopes of Forbidden Peak, North Cascades; flows into Thunder Creek and Ross Lake

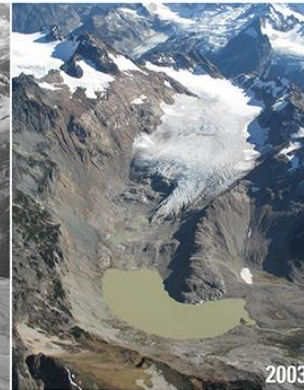


A glacier forms when winter snowfall exceeds summer melting. It shrinks or "retreats" when melting outpaces the accumulation of new snow. Glaciers are extremely sensitive to climate change. The warmer air temperatures have resulted in increased rates of melting and a longer melt season. As freezing elevations have moved higher over the past several decades, portions of some glaciers are not able to rebuild themselves in the winter through accumulated snowfall.

Changes in Glaciers

South Cascade Glacier

Lower slopes of Sentinel Mountain, North Cascades; flows into South Fork Cascade River



A glacier forms when winter snowfall exceeds summer melting. It shrinks or "retreats" when melting outpaces the accumulation of new snow. Glaciers are extremely sensitive to climate change. The warmer air temperatures have resulted in increased rates of melting and a longer melt season. As freezing elevations have moved higher over the past several decades, portions of some glaciers are not able to rebuild themselves in the winter through accumulated snowfall.

Forbidden Glacier

North slopes of Forbidden Peak, North Cascades; flows into Thunder Creek and Ross Lake



Silver Glacier

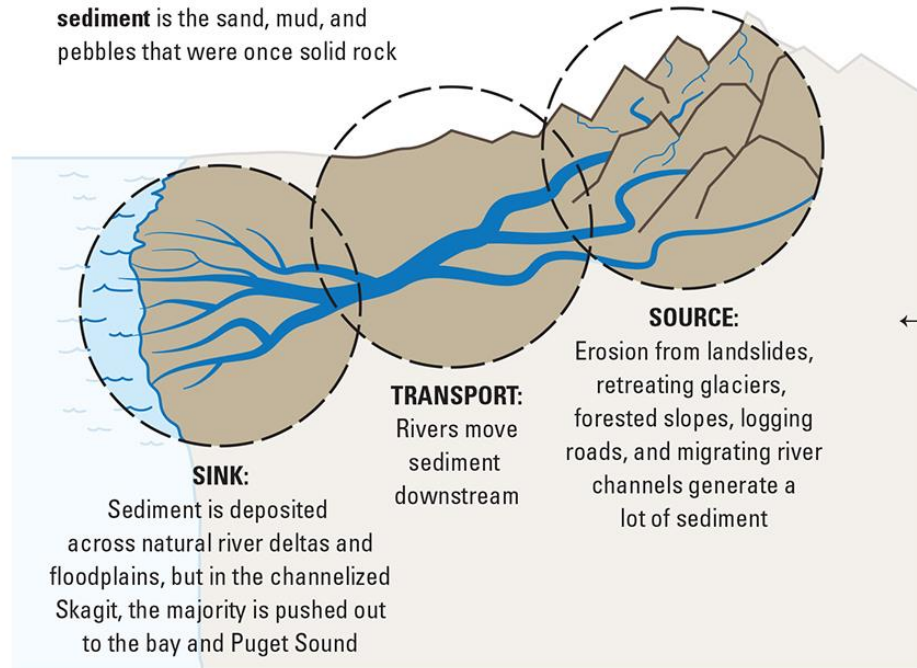
North side of Mt. Spickard, North Cascades; flows into Ross Lake



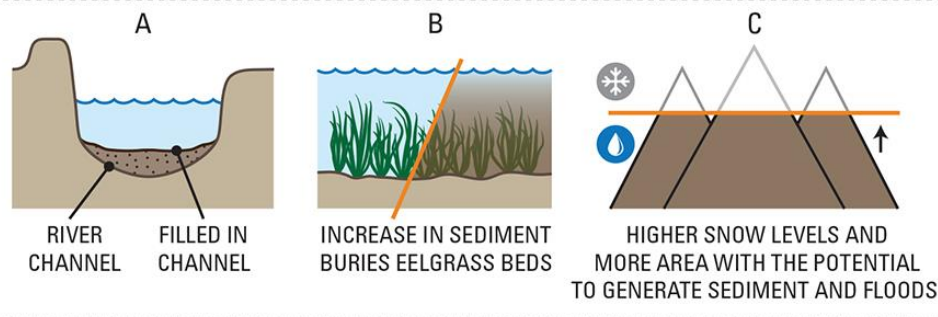
Flow of Sediment

How Climate Change Affects Sediment in the Skagit River

sediment is the sand, mud, and pebbles that were once solid rock



Current flow of sediment from Cascade Mountains to Skagit Bay and Puget Sound



Projected High Tide Model Outputs

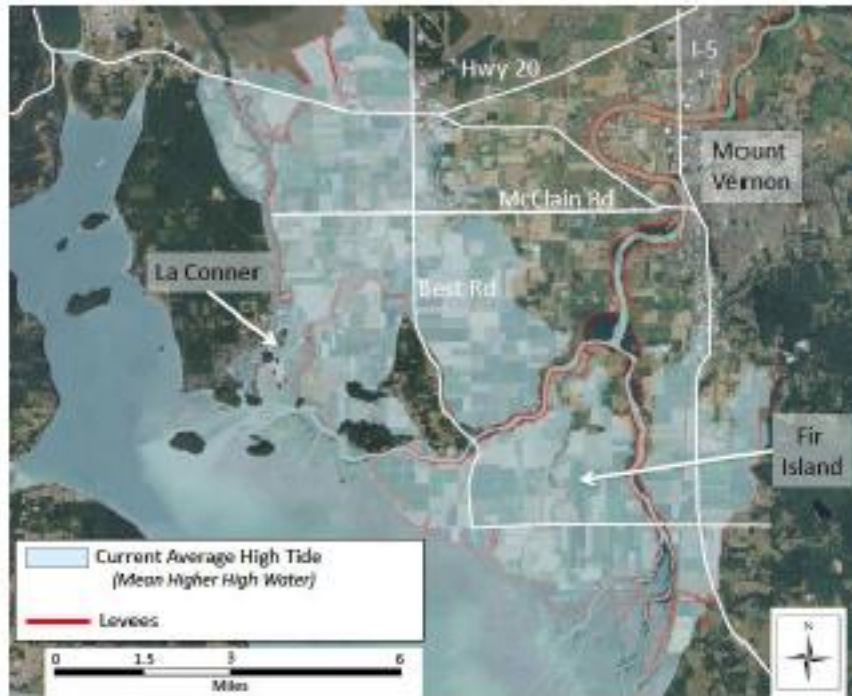


Figure 1. Current extent of high tide if there were no dikes

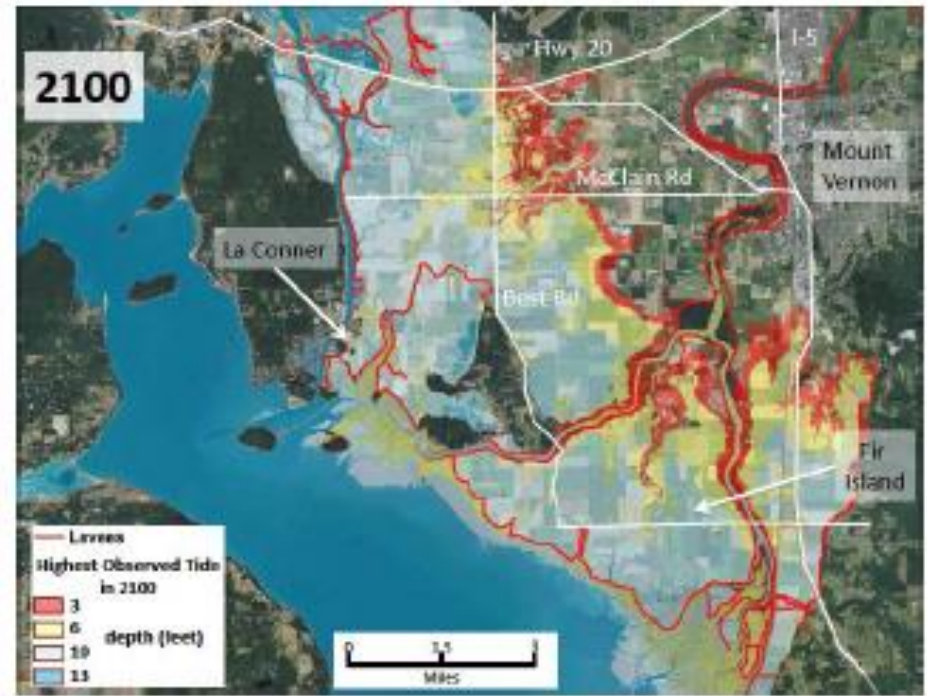
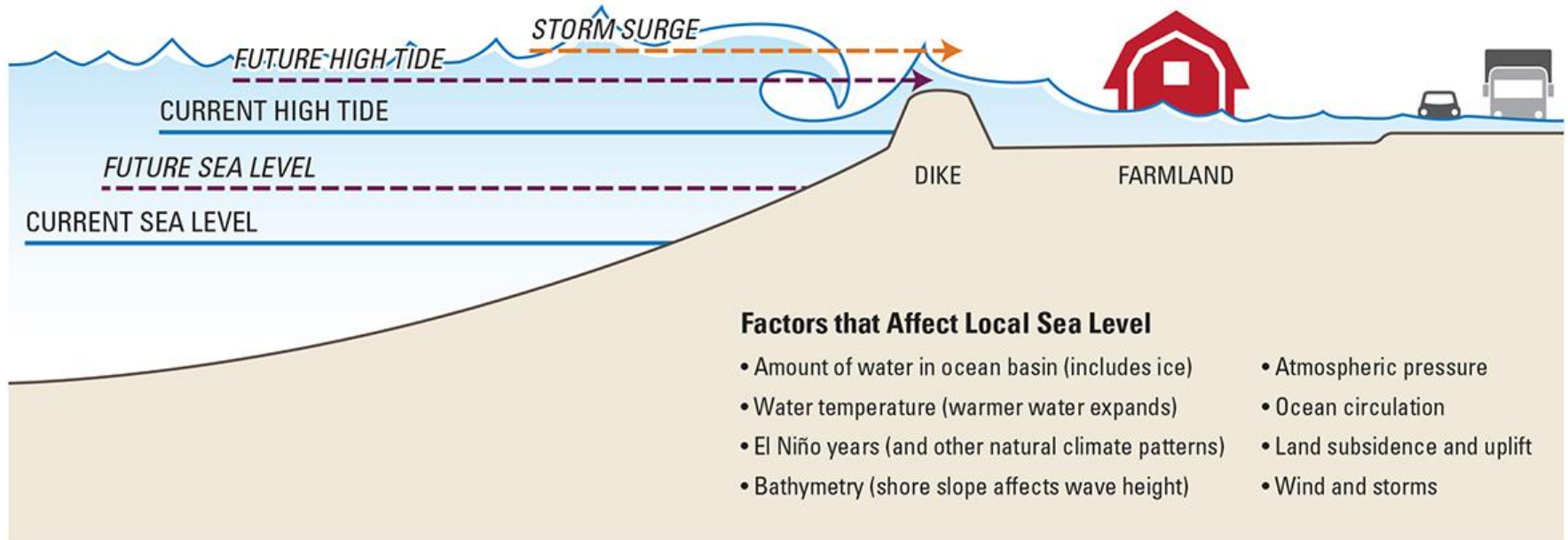


Figure 2. Projected extent and depth of an extreme high tide with the current dike system

Rising Sea Levels & Storm Surge



NOTE: Sea, tide, and storm surge levels are for illustrative purposes only and do not depict actual or projected levels.

Projected Groundwater Model Outputs

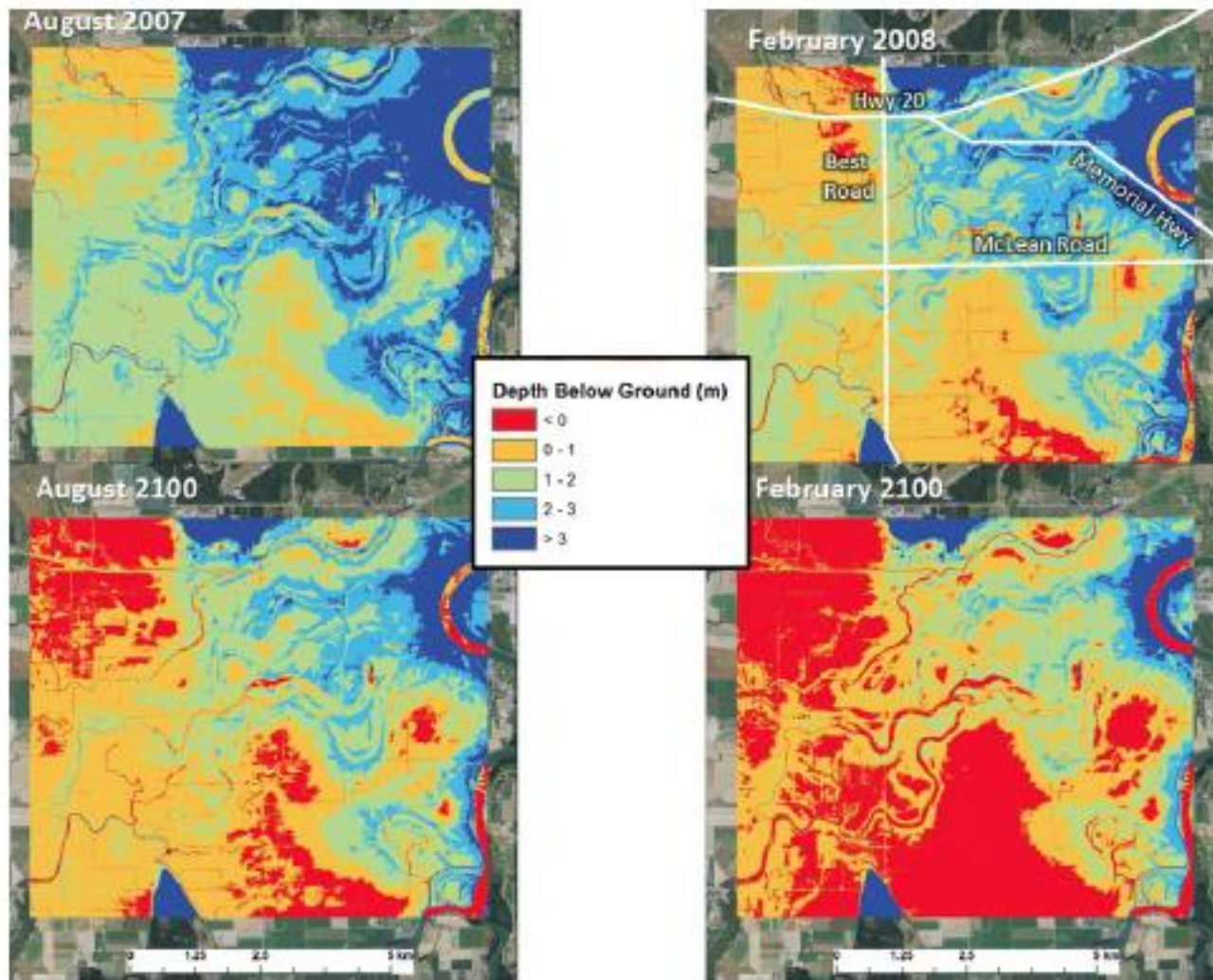
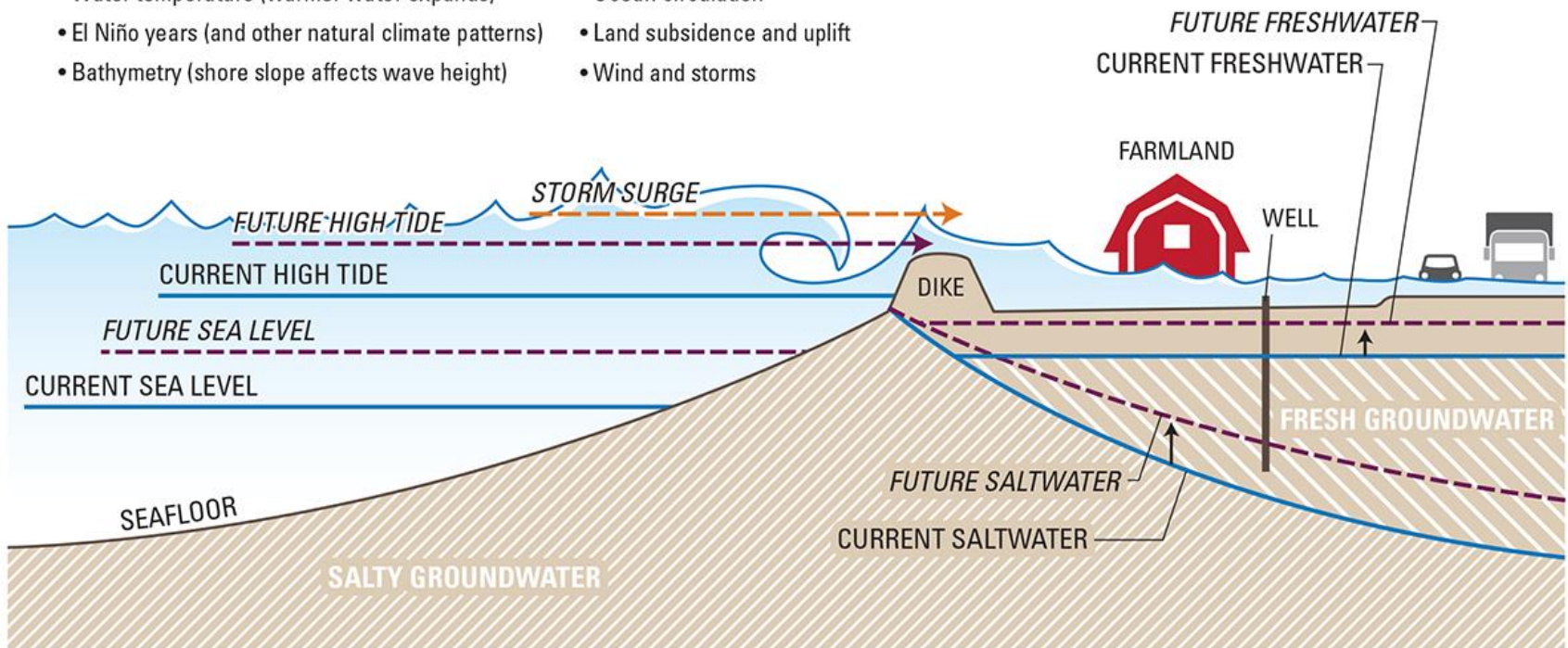


Figure 4. Areas in red depict where fresh groundwater surfaces

Rising Sea Levels, Groundwater & Storm Surge

Factors that Affect Local Sea Level

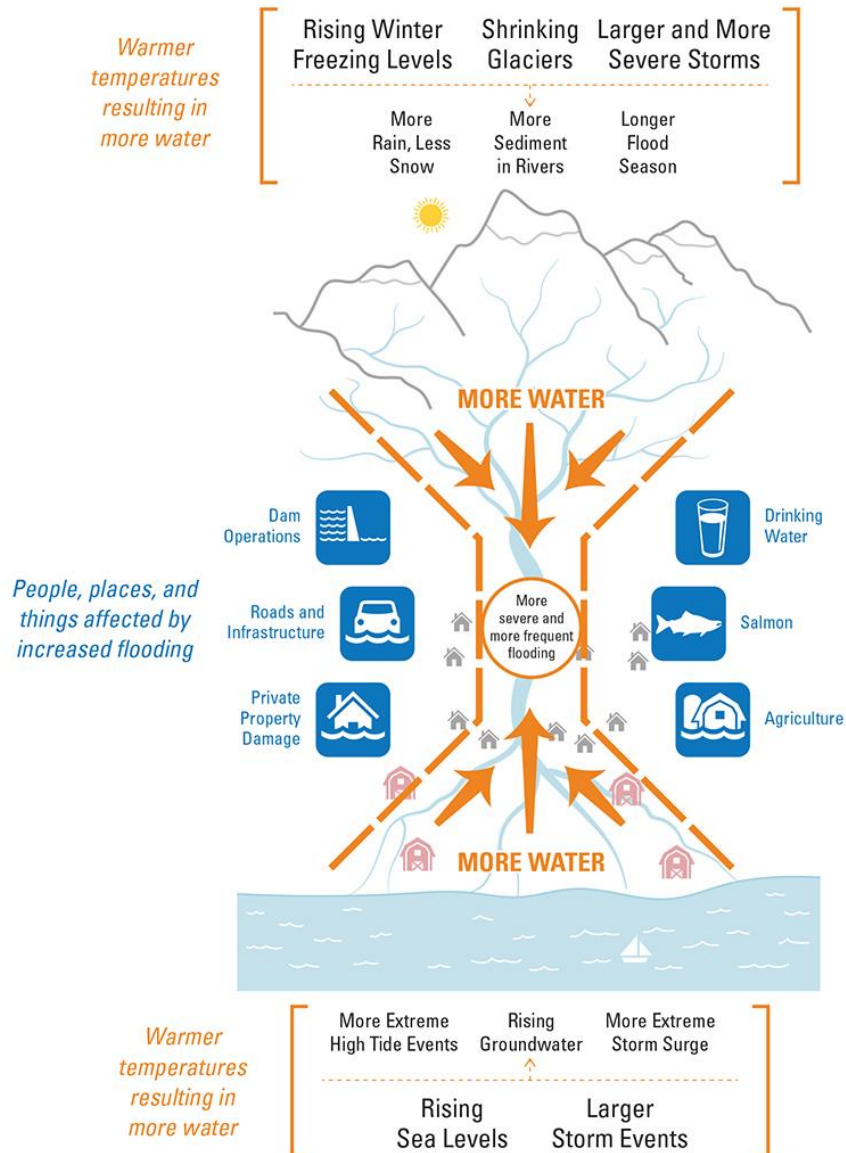
- Amount of water in ocean basin (includes ice)
- Water temperature (warmer water expands)
- El Niño years (and other natural climate patterns)
- Bathymetry (shore slope affects wave height)
- Atmospheric pressure
- Ocean circulation
- Land subsidence and uplift
- Wind and storms



NOTE: Sea, tide, and storm surge levels, depth of groundwater, and location of saltwater lens are for illustrative purposes only and do not depict actual or projected levels.

Climate Change: Combining Forces

Why Skagit Flood Risk is Increasing



Visualizing the *Seemingly* Unreal

Combined Effects of Projected Sea Level Rise, Storm Surge, and Peak River Flows on Water Levels in the Skagit Floodplain

ABSTRACT

Current understanding of the combined effects of sea level rise (SLR), storm surge, and changes in river flooding on near-coastal environments is very limited. This project uses a suite of numerical models to examine the combined effects of projected future climate change on flooding in the Skagit floodplain and estuary. Statistically and dynamically downscaled global climate model scenarios from the ECHAM-5 GCM were used as the climate forcings. Unregulated daily river flows were simulated using the VIC hydrology model, and regulated river flows were simulated using the SkagitSim reservoir operations model. Daily tidal anomalies (TA) were calculated using a regression approach based on ENSO and atmospheric pressure forcing simulated by the WRF regional climate model. A 2-D hydrodynamic model was used to estimate water surface elevations in the Skagit floodplain using resampled hourly hydrographs keyed to regulated daily flood flows produced by the reservoir simulation model, and tide predictions adjusted for SLR and TA. Combining peak annual TA with projected sea level rise, the historical (1970-1999) 100-yr peak high water level is exceeded essentially every year by the 2050s. The combination of projected sea level rise and larger floods by the 2080s yields both **increased flood inundation area (+74%)**, and increased average water depth (+ 25 cm) in the Skagit floodplain during a 100-year flood. Sea level rise combined with the observed FEMA 100-year flood resulted in **a 35% increase in inundation area** by the 2040s, as compared to a **57% increase in inundation** for the combined 2040s scenario.



Explore Potential Flood Impacts in the Lower Skagit Watershed through Modeling Scenarios

Major Flood Scenario

CHOOSE LEVEL SCENARIO

ALL LEVEES
INTACT

LEFT LEVEES
REMOVED

RIGHT LEVEES
REMOVED

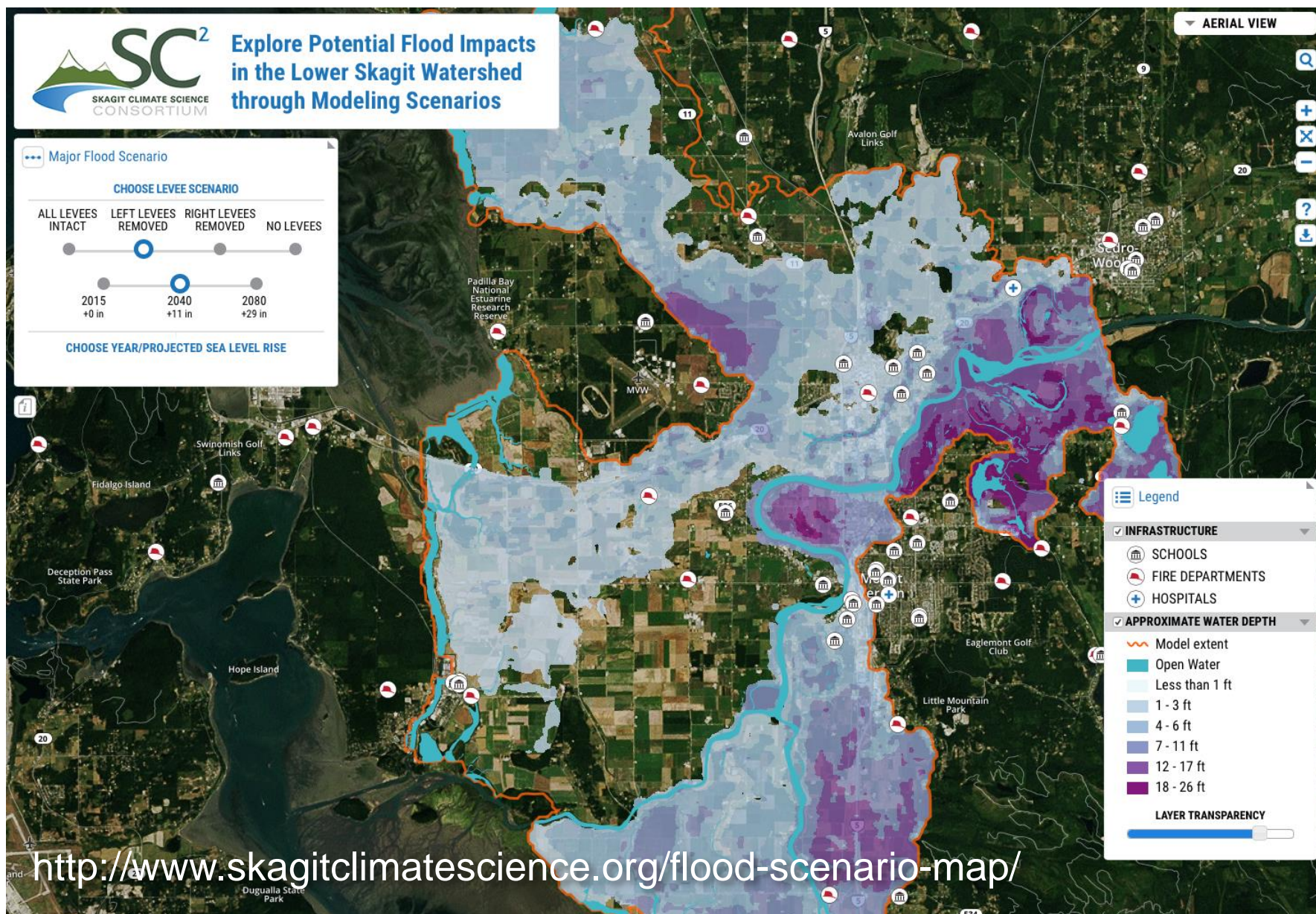
NO LEVEES

2015
+0 in

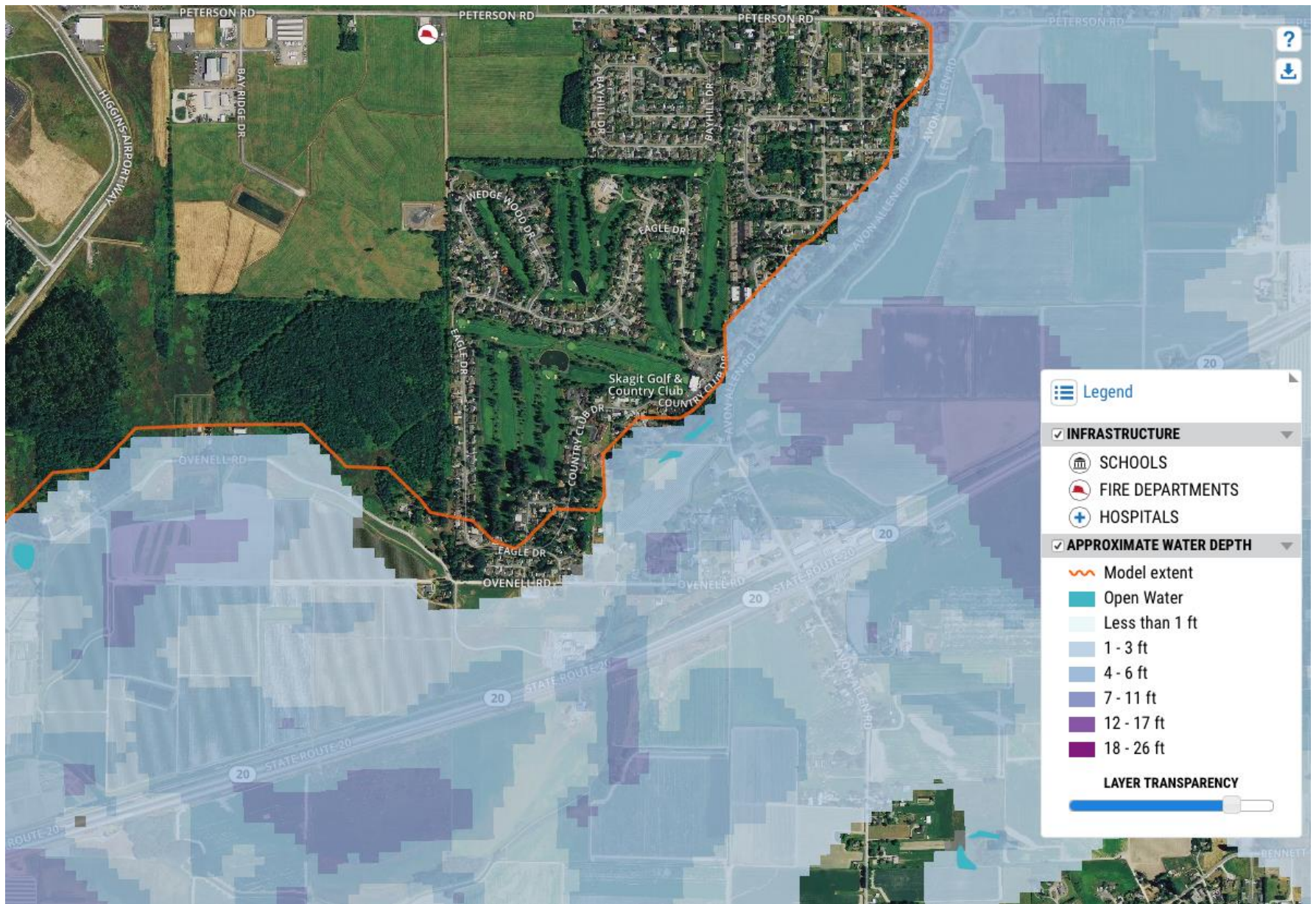
2040
+11 in

2080
+29 in

CHOOSE YEAR/PROJECTED SEA LEVEL RISE



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









Take Aways

Finding and Unpacking Hidden Assumptions

- Listen honestly and respectfully to concerns/questions and do the work to find and unpack assumptions

Visualizing the *Seemingly* Unreal

- Try new ways to show how the future might look

New Partners and Partnerships to Communicate and Learn

- Who doesn't think or view the world like you?
Can they be an ally?

Take Aways

Terminology Matters

- Understand specifically what decision-makers need to understand the challenge or explore solutions that concern them

Audience

- Who are you trying to reach? What can you learn about what they know, want, or how to reach them?



For more information, visit SC² website at

www.skagitclimatescience.org

Carol MacIlroy cmacilroy@gmail.com 206–293-4741

Ilon Logan ilogan@esassoc.com 206-789-9658

