Sea Level Rise Update 2016

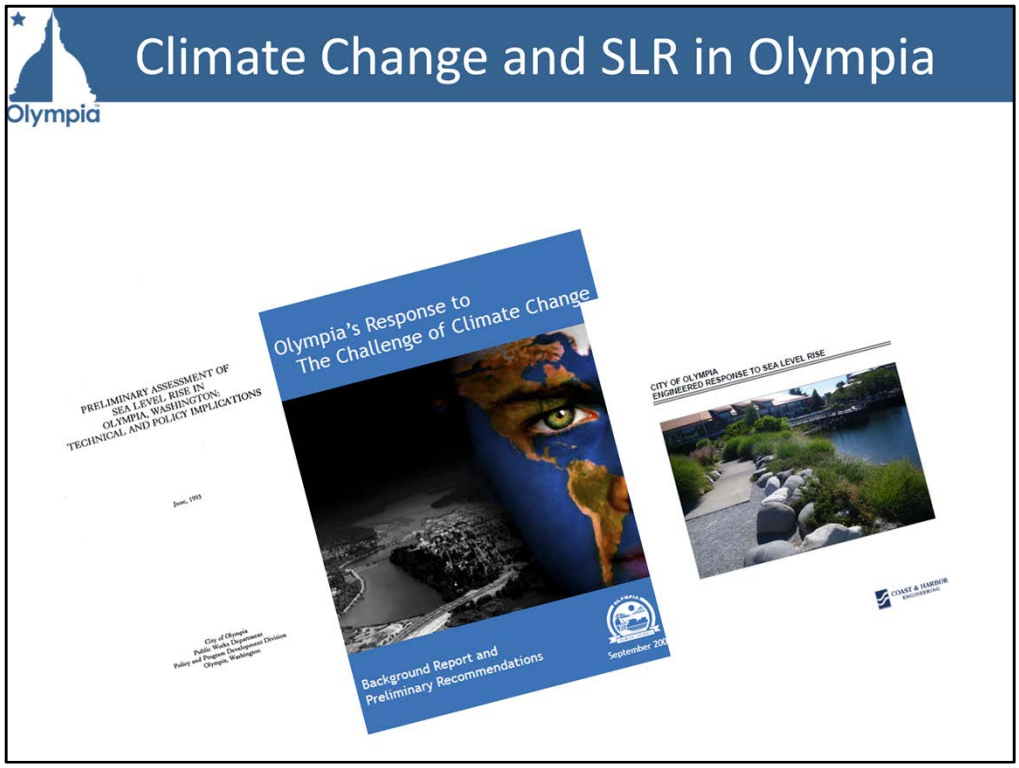
December 17, 2012…17.6 Foot Tide

Now is the time to develop our vision and strategy for adapting to sea level rise

February 9, 2016

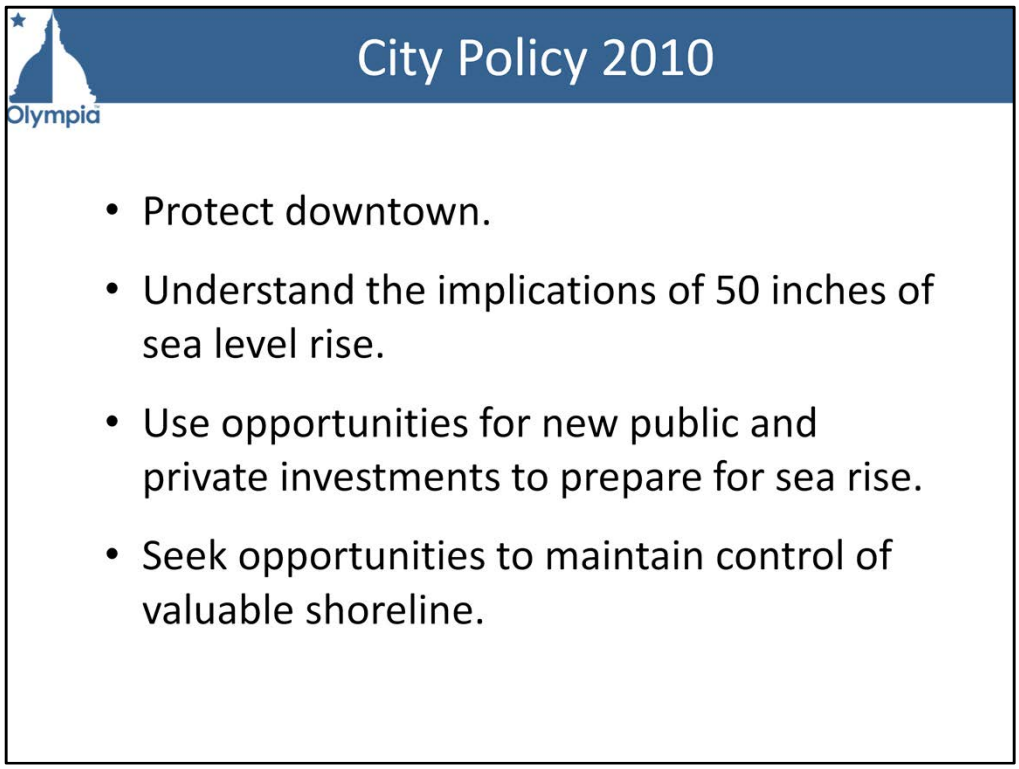
City of Olympia | Capital of Washington State

Planning for sea level rise is challenging. The related science is technical, complex and diverse. I will try to help you understand some of the science, and the implications sea level rise may have for Olympia. I'll also provide you with some potential responses and concepts for adapting to sea level rise. If we are to adapt to SLR and avoid flooding, several decisions and actions will need to take place in the near future.

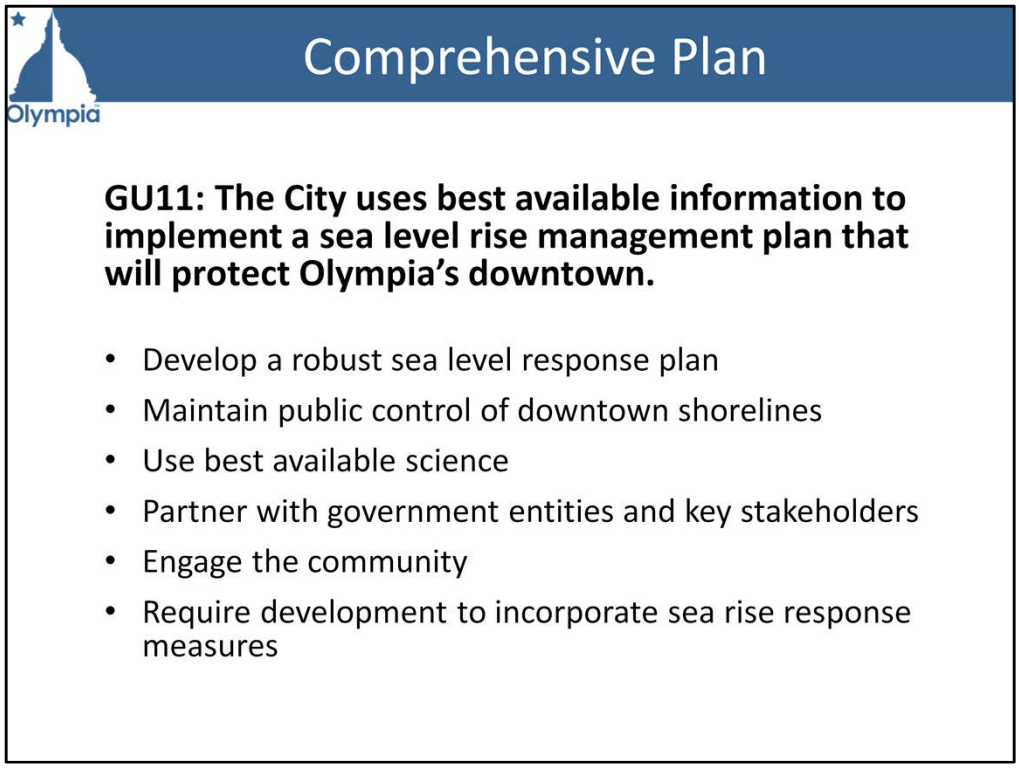


Olympia has been concerned with climate change and sea level rise since 1990. Since then a series of assessment reports have been prepared. Olympia's vulnerability to flooding is well recognized and our understanding of the implications of sea level rise increases incrementally each year.

Since 2008, the Storm and Surface water Utility has provided City Council with an update on sea level rise.

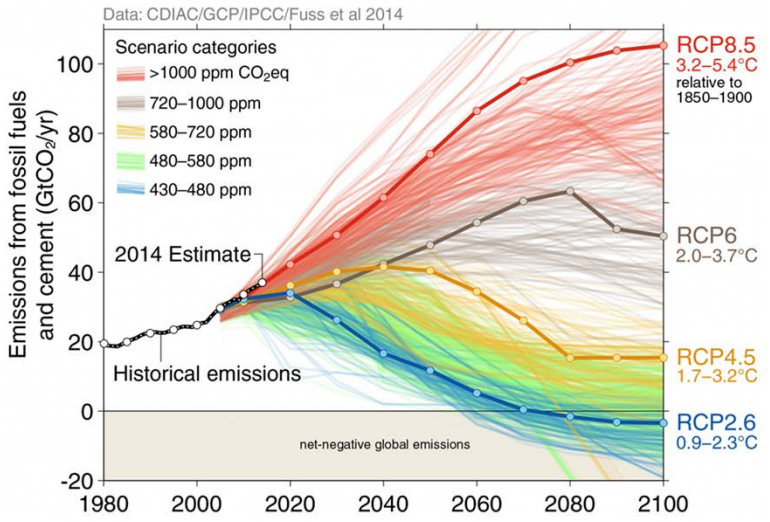


We have been moving forward with the policy established by City Council in 2010. Key points of that policy were to protect downtown and prepare for 50 inches of SLR.



In 2014, the Comprehensive Plan established more detailed policies that provide a foundation for developing a sea level rise program. The comprehensive plan goal and policies for sea level rise were included as an attachment to my staff report.

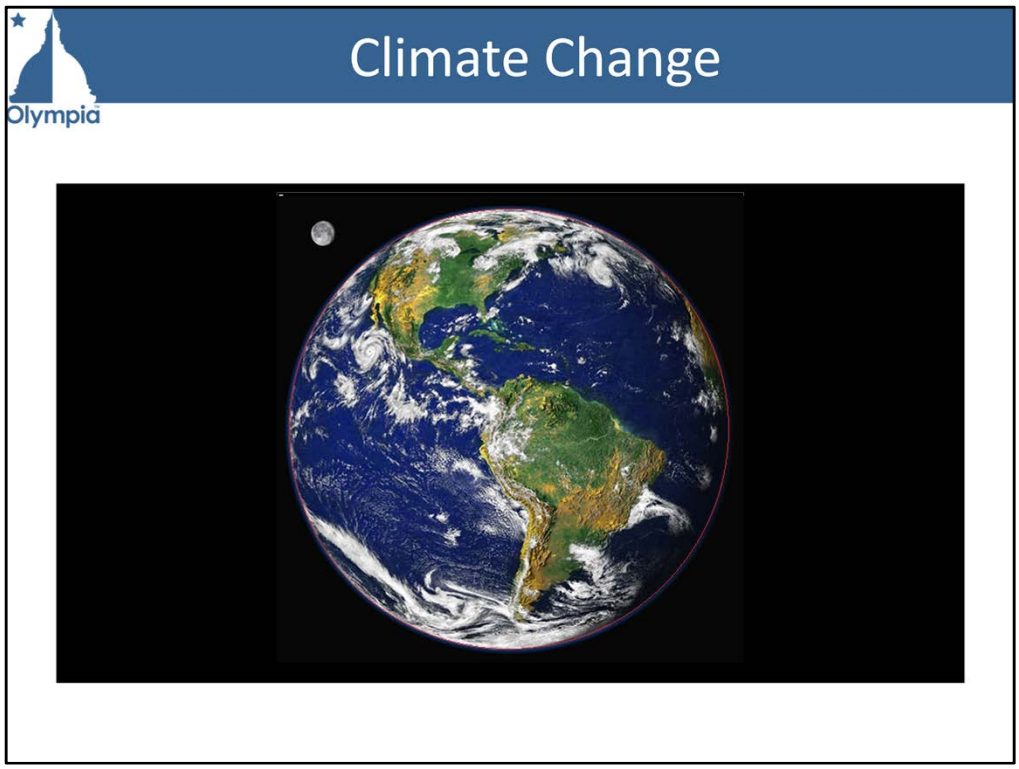
Climate Change



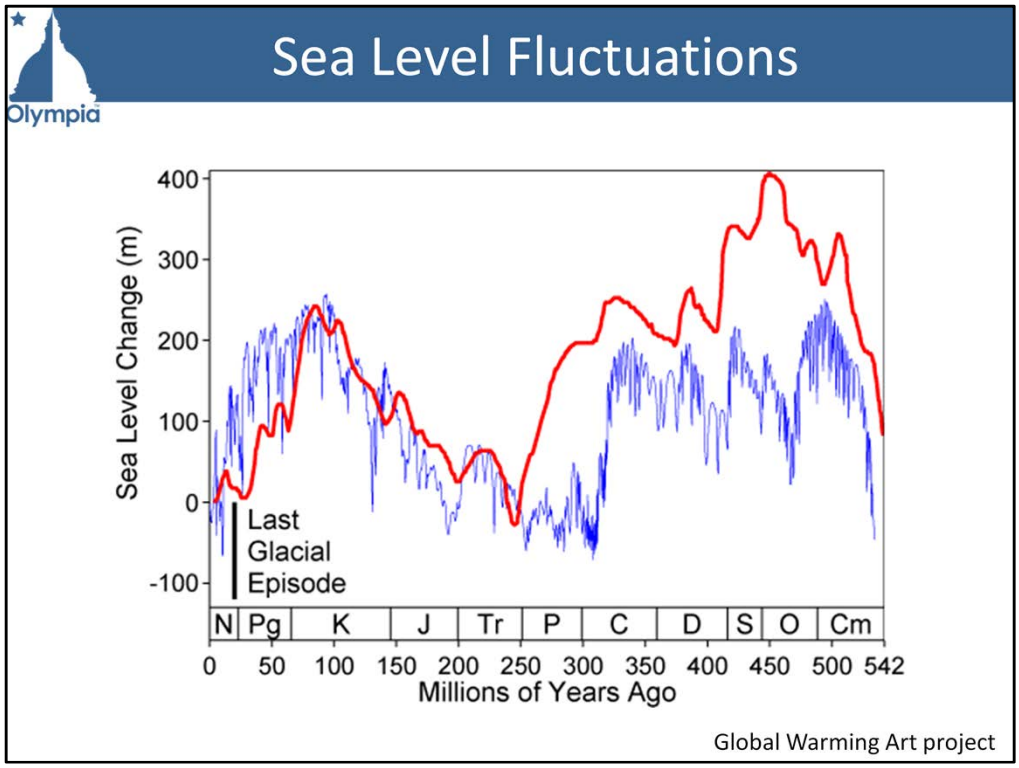
We can't talk about sea level rise without discussing climate change. This slide is a little complicated, but it is important.

In 2007, scientists modeled more than a thousand different greenhouse gas emissions scenarios to determine their implications on climate change and sea level rise. To simplify discussions, 4 of the trajectories were selected to be representative of scenario categories and are known as the representative concentration pathways or RCPs. At the time, these were essentially the pathways we were given to chose from moving forward. The lowest concentration pathway RCP 2.6 depicted as the heavy blue line in this figure assumed immediate action would be taken to reduce greenhouse gas emissions.

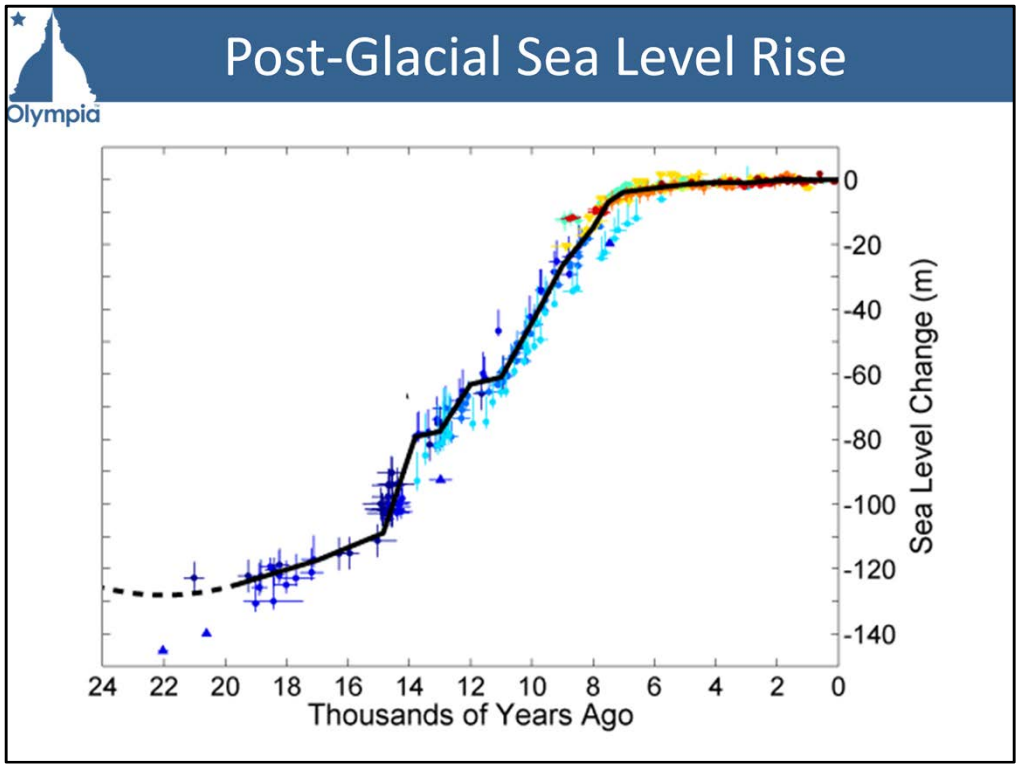
The highest pathway RCP 8.5 depicted as the heavy red line in this figure assumed something close to business as usual and RCPs 4.5 and 6 fell somewhere in between. Since little has been done since 2007, the low concentration pathway RCP2.6 is no longer considered achievable and unfortunately the reality is that low oil prices amongst other things currently place us on a pathway somewhere above RCP 8.5.



Earth's atmosphere is remarkably thin. Relatively, it is thinner than the red circle in this image. Our atmosphere is the oxygen we breath and the carbon dioxide plants need. It helps to sustain life and is shared by every living thing. It shields us from solar radiation. It distributes precipitation and keeps us warm. Burning fossil fuels over the past couple hundred years has released carbon into the atmosphere at a rate almost hundred thousand times faster than the planet originally sequestered it. Despite an enormous amount of research the real risks and consequences of the fossil fuel era are still uncertain, but we know there will be implications.

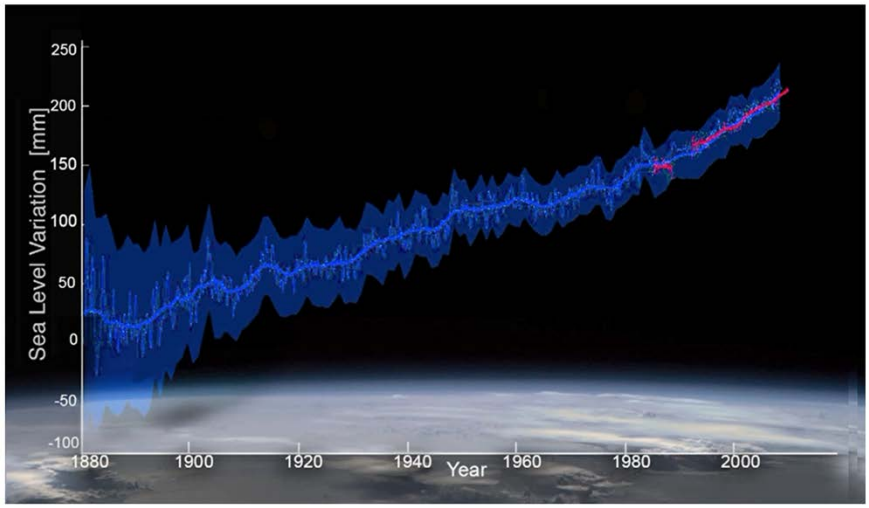


We know that the climate and sea levels have always been changing. At times, sea levels have been both higher and lower than today.

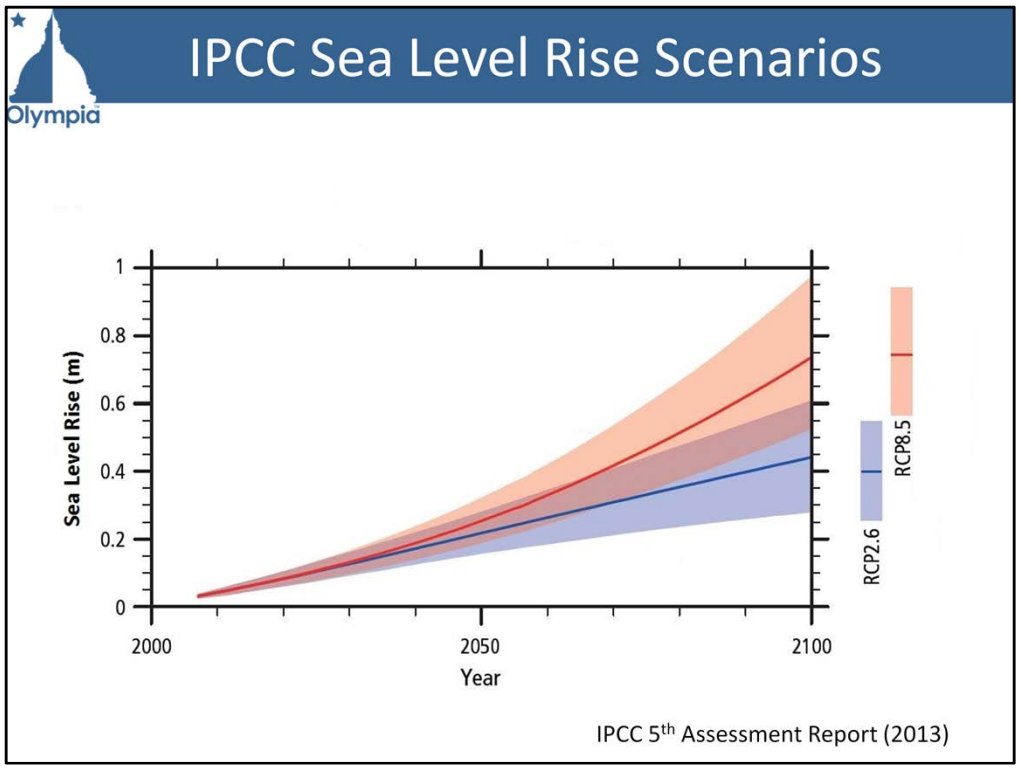


Since the end of the last ice age, sea levels have risen more than 400 feet. As this figure indicates, the process was not slow and steady but, rather, it happened in fits and starts at times increasing at rates of more than a foot per decade. The accelerated rates were most likely a result of collapsing ice-sheets. Over the last 5,000 to 7,000 years, sea levels and coastlines have been relatively stable.

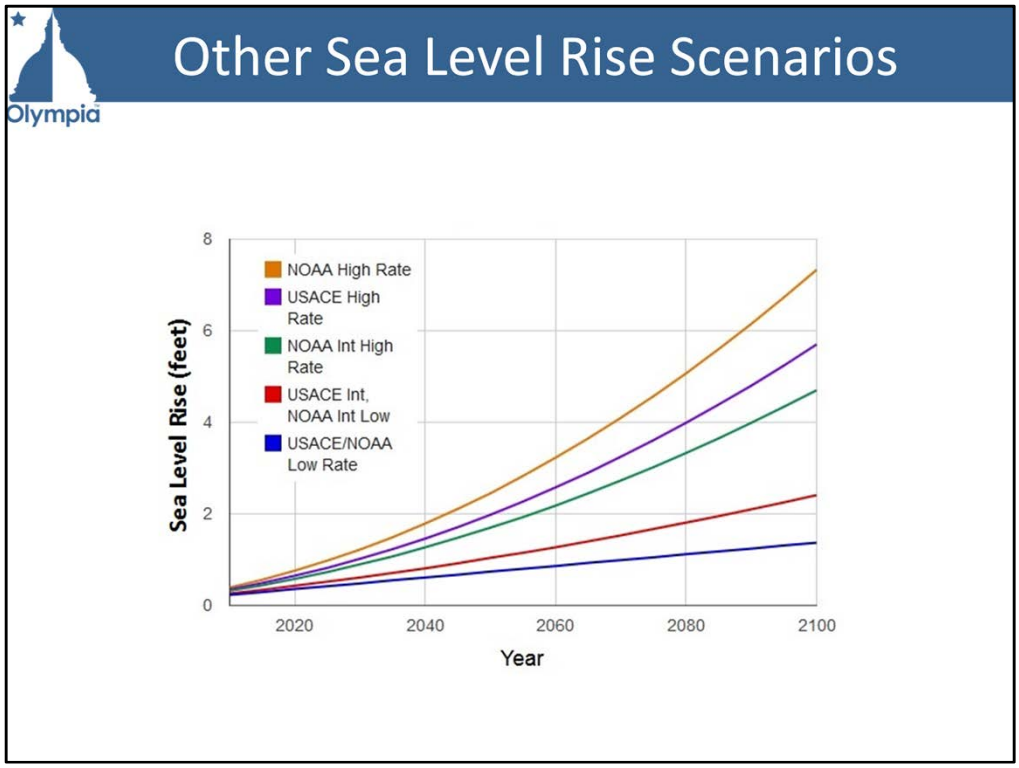
Sea Level Trends



Between 1890 and 1990, tide gauges indicate sea levels rose about 7 inches. But over the last 20 years, satellite data indicates the rate of SLR nearly doubled that of the previous 100 years.

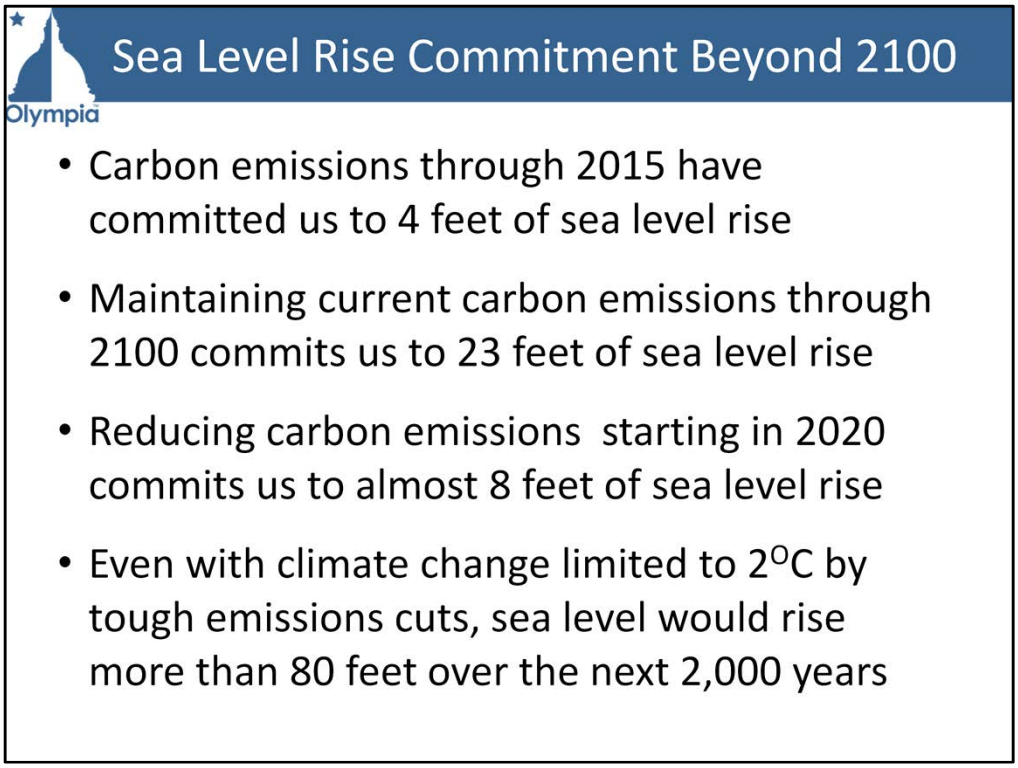


This figure depicts the Intergovernmental Panel on Climate Change or IPCC's projections for sea level rise based on the concentration pathways I discussed in the earlier slide. The projections range from between 11 and 38 inches by the end of the century. These projections are more than 50% percent higher than those put forth in 2007. The key difference is that 2007 projections did not take into account the possibility of rapid ice flow from Greenland and Antarctica. As I mentioned earlier, we are currently on a pathway above RCP8.5 depicted by the red line in this figure. Although many scientists consider them to be too conservative, the IPCC's projections are considered to be the gold standard and the official projections.



New research on sea level rise comes out almost weekly. Since the IPCC's last report, the Army Corps of Engineers has projected that sea levels could rise by as much as five feet by the end of the century; and the National Oceanic and Atmospheric Administration predicts up to six and a half feet of sea level rise. All of these projections may still be too low.

Even more recent research suggests that the two biggest contributors to sea level rise, thermal expansion of ocean water and decline of the greenland and antarctic ice sheets, have been underestimated.
Two groups of researchers—one from NASA's Jet Propulsion Lab and the other from the University of Washington—concluded last year that a segment of the West Antarctic ice sheet has gone into "irreversible decline." The segment, known as the Amundsen Sea sector, contains enough water to raise global sea levels by four feet alone, and its melting could destabilize other parts of the ice sheet, which hold enough ice to raise sea levels ten feet or more.

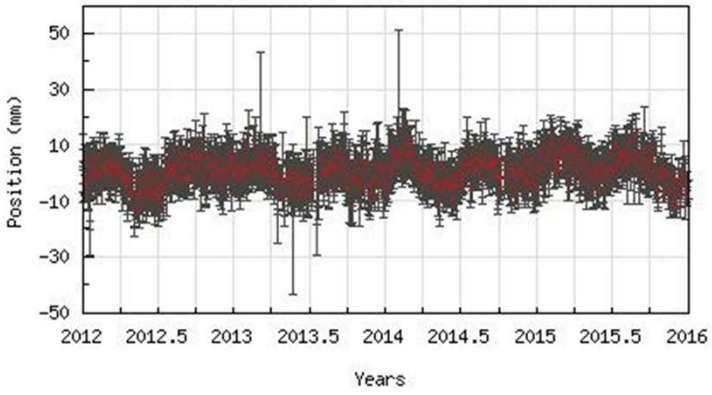


Most SLR projections stop at the end of the century, but sea levels will continue to rise for centuries. A recent study indicates that even if we had stopped carbon emissions today, we are still locked into 4 feet of sea level rise. If we were to continue at a reduced emission scenario like RCP 2.6 through the end of the century, we will be committed to almost 8 feet of sea level rise. And if we continue on our current emissions rate through the end of the century we will be committing to 23 feet of eventual sea level rise. Note that the timeframe for this magnitude of sea level rise may be several centuries, well beyond typical planning horizons. (Princeton Climate Group)

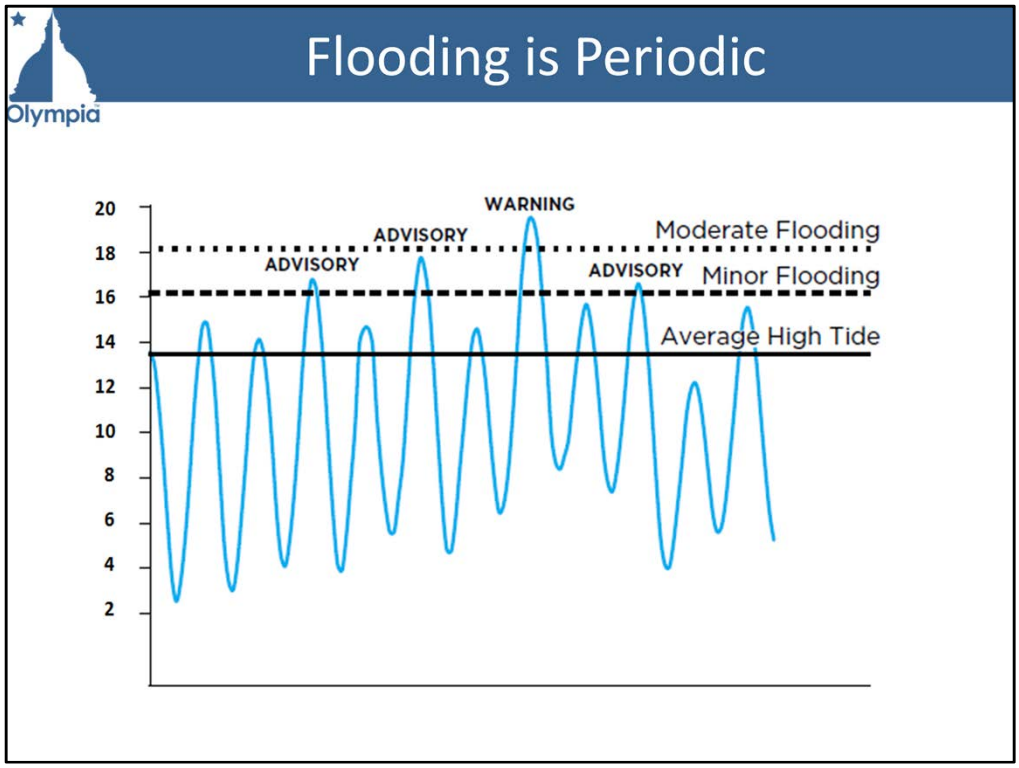
A study published yesterday, indicates that even if we limited temperature increases to 2 degrees celsius, we are committing to 80 feet of sea level rise over the next 2,000 years. (OSU & Bern SUI)

Vertical Land Movement

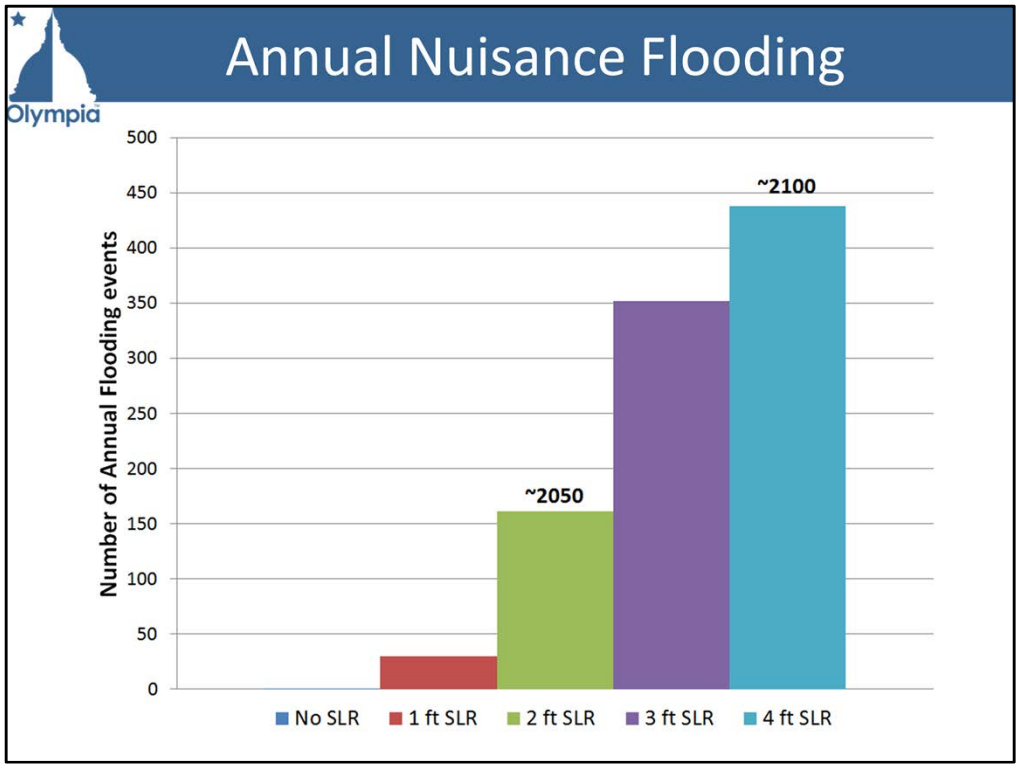
Downtown Olympia appears to be subsiding 0.9 in/decade



On top of rising seas, Olympia appears to be subsiding. The Washington State Reference Network monitors land movement of fixed regional stations throughout the state. Short term results indicate downtown Olympia or at least city hall is subsiding 0.9 inch per decade. This means that over next century SLR could be 11 inches greater in Olympia than elsewhere.
Panga.org



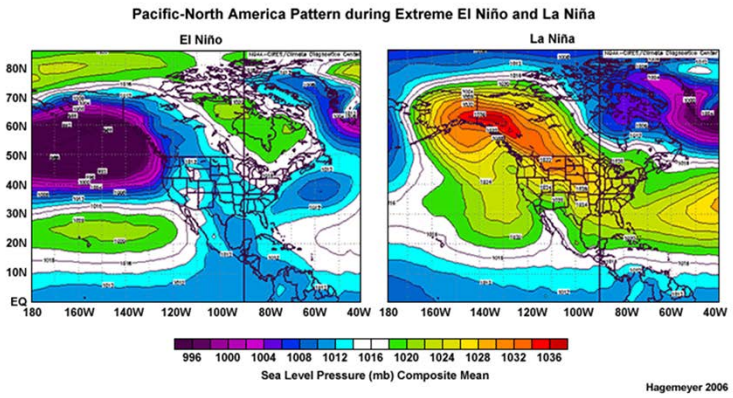
Olympia is most vulnerable to flooding only during relatively short-term, hour- or two-hour long tidal events. Fortunately there are tools in place to help us predict these events. City staff as well as regional emergency management personnel monitor forecasts regularly.



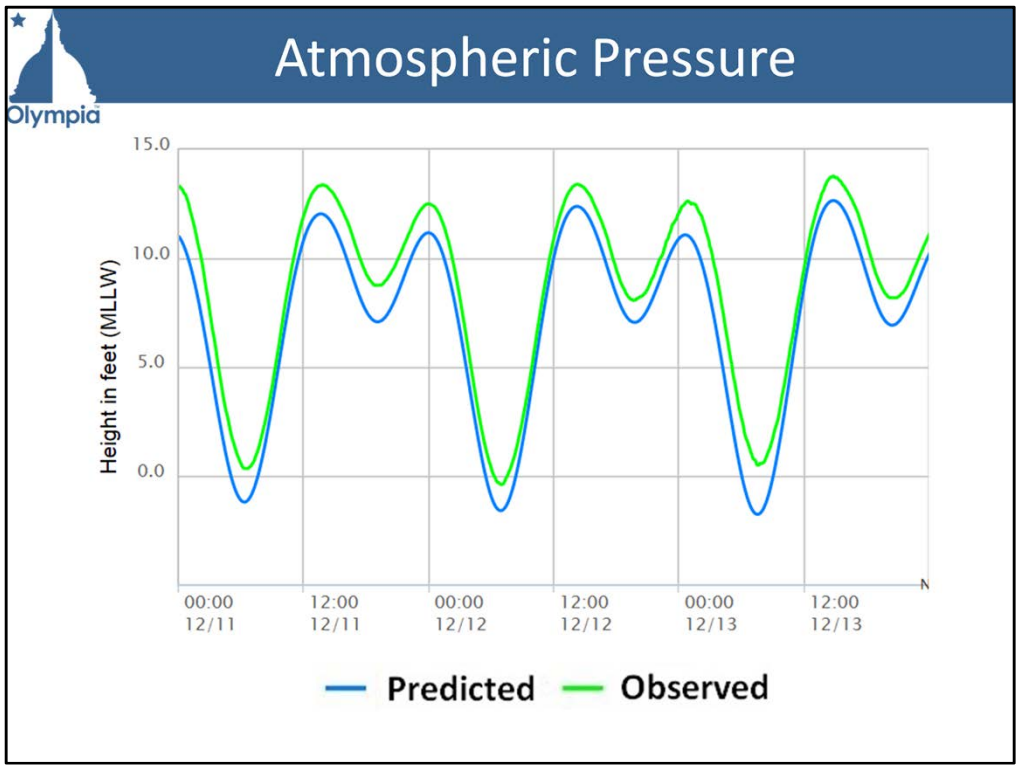
Currently, we only see nuisance flooding once or twice a year. As sea levels rise, so will the frequency of flooding. Unless we do something, with 1 foot of sea level rise we can expect to see flooding 30 times a year. With 2 feet of sea level rise we can expect nuisance flooding 160 times a year and with 4 feet of sea level rise we can expect to see it almost 440 times per year or during more than half of our high tide events.

Nuisance flooding - 17 ft MLLW

Importance of El Nino events



In the near term, El Nino events are a greater hazard than the climate driven sea level rise. During El Nino events, sea levels in the North Pacific can be elevated several inches for several months due to decreased atmospheric pressure. With climate change, it is increasingly likely that El Nino events will become greater in magnitude and increase in frequency.

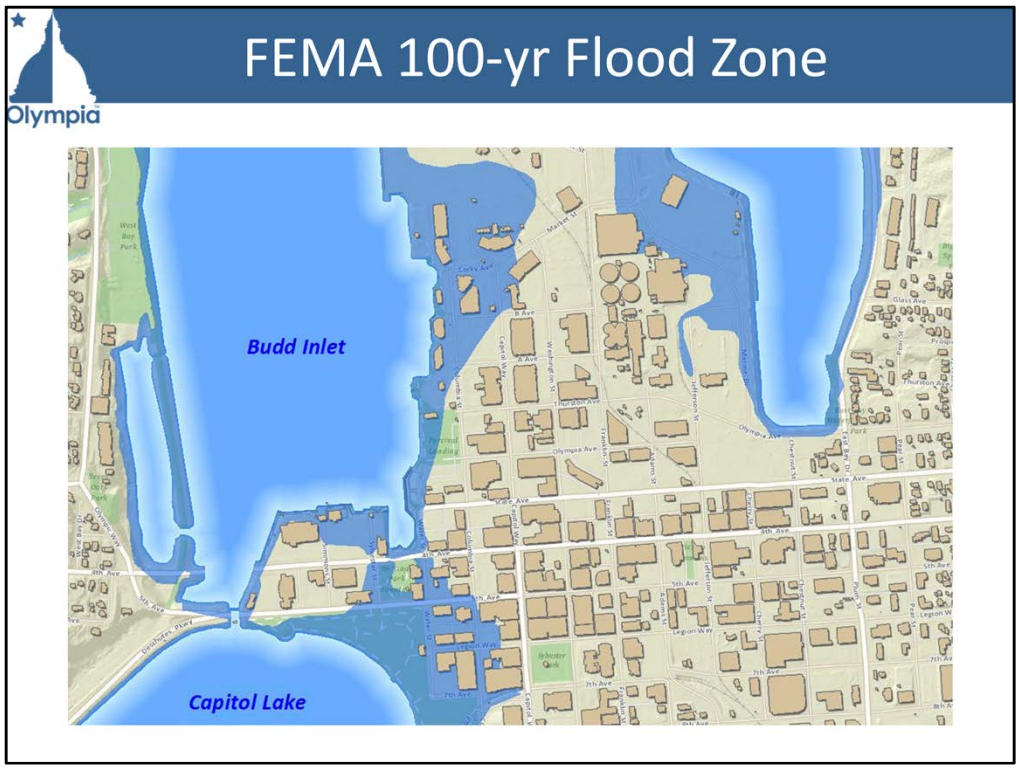


The current El Nino event has had dramatic impacts on our tides. In November and December observed tides averaged almost 6 inches higher than predictions. On December 11th and 13th, tides were 30 inches higher than predicted. If this had occurred during any of 58 tidal events this winter, we would have seen flooding in excess of FEMA's flood elevations.

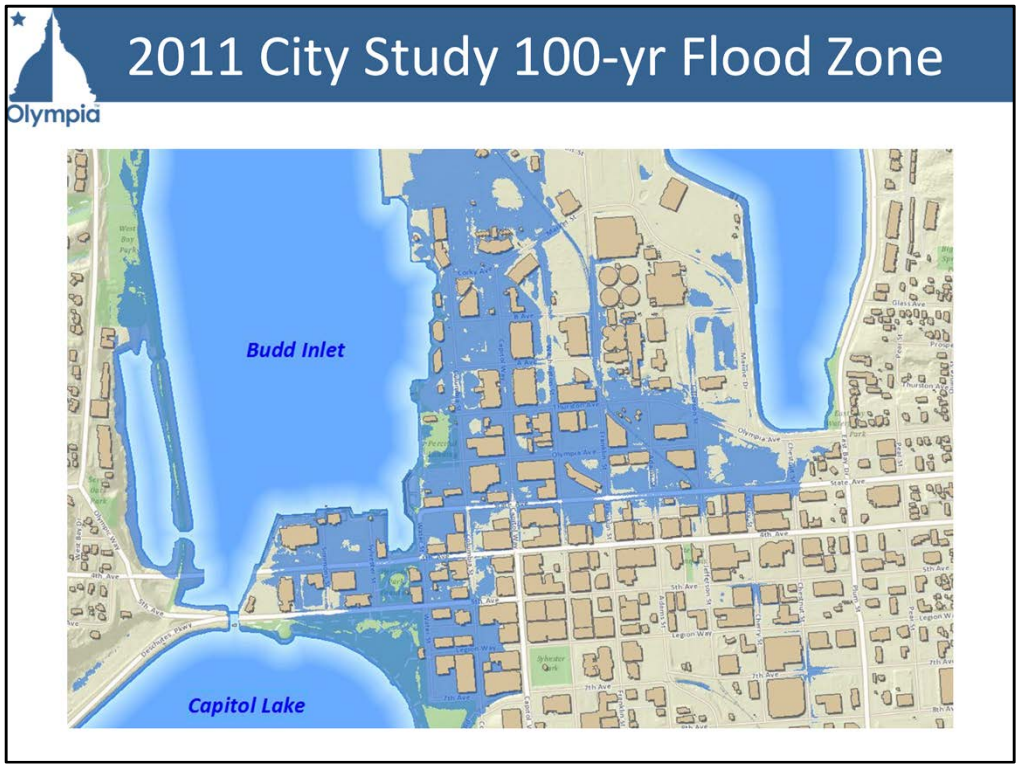
If this had occurred during any of 6 specific tidal events this winter, we would have seen flooding equivalent to a FEMA flood with 1 foot of SLR.

What this means is that in the near term, SLR associated with El Nino events can exceed SLR projections made by the IPCC for 2100.

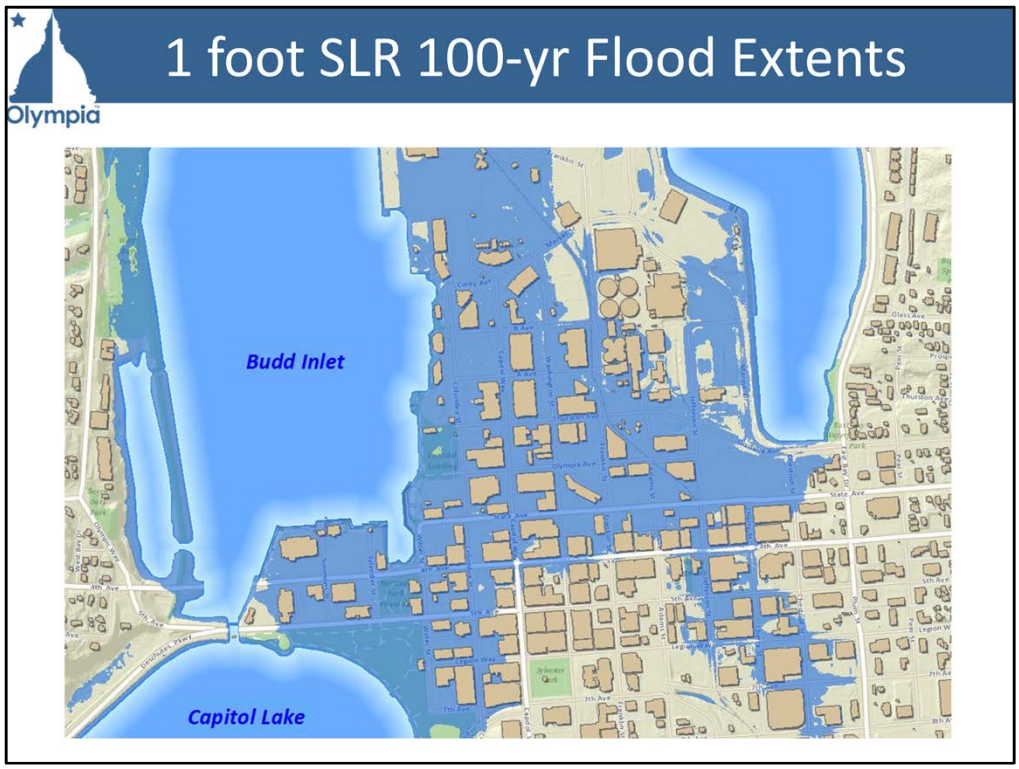
NOAA real time gage



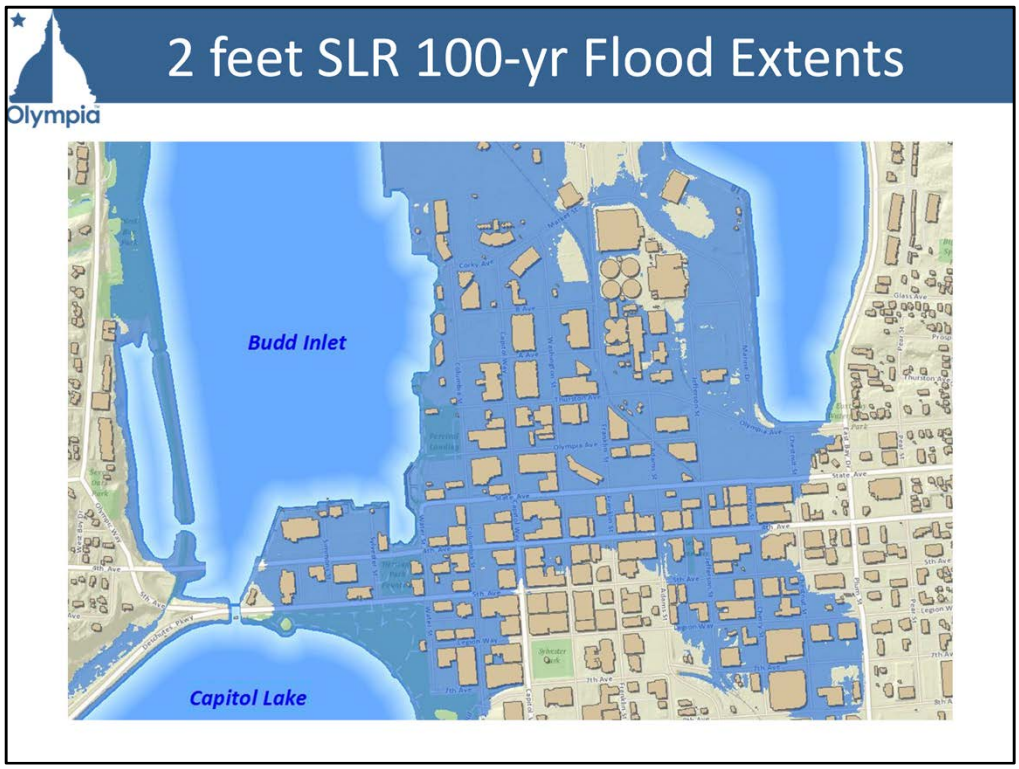
So what are the are the implications of sea level rise for Olympia? This image depicts FEMAs current mapped flood zones in downtown Olympia. Olympia is most vulnerable to flooding from Capitol Lake associated with combined high river flows and high tides.



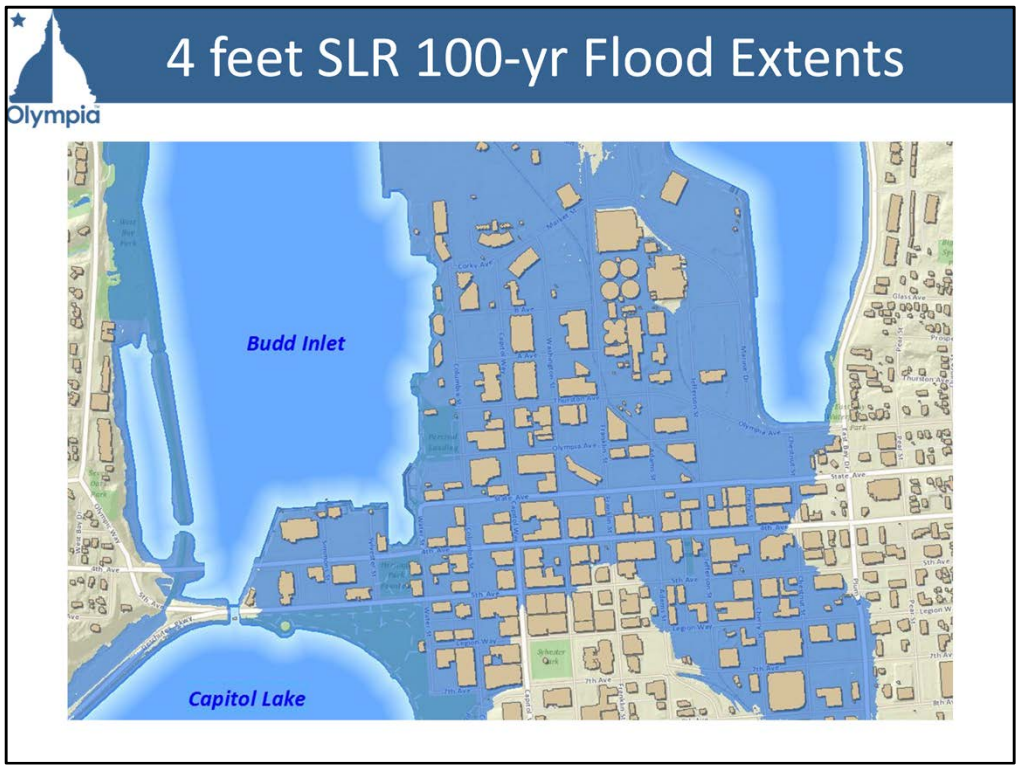
In 2010, the City hired the consultant Coast and Harbor to prepare the 2011 Engineered Response to Sea Level Rise which provided an excellent start for a SLR program. As part of that exercise, Coast and Harbor evaluated the City's current vulnerability to coastal flooding taking into account the most current tidal data, real wind data, storm surge and wave runup. The result was a flood elevation roughly 0.8 feet higher than FEMA estimates. This image depicts the flooding extents anticipated at that flood elevation. If high tides and atmospheric conditions had matched up this winter there is a chance we could have seen this condition during any of 15 tide events this winter.



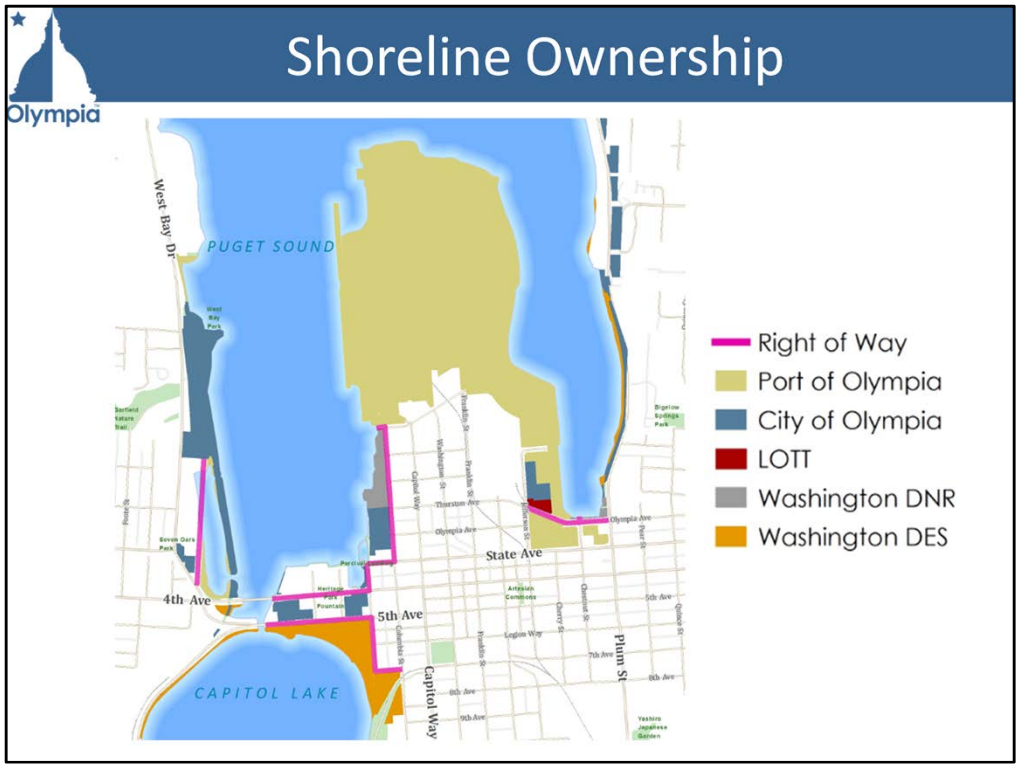
When seas rise one foot flooding will extend south to 4th Avenue and along the Moxlie Creek alignment.



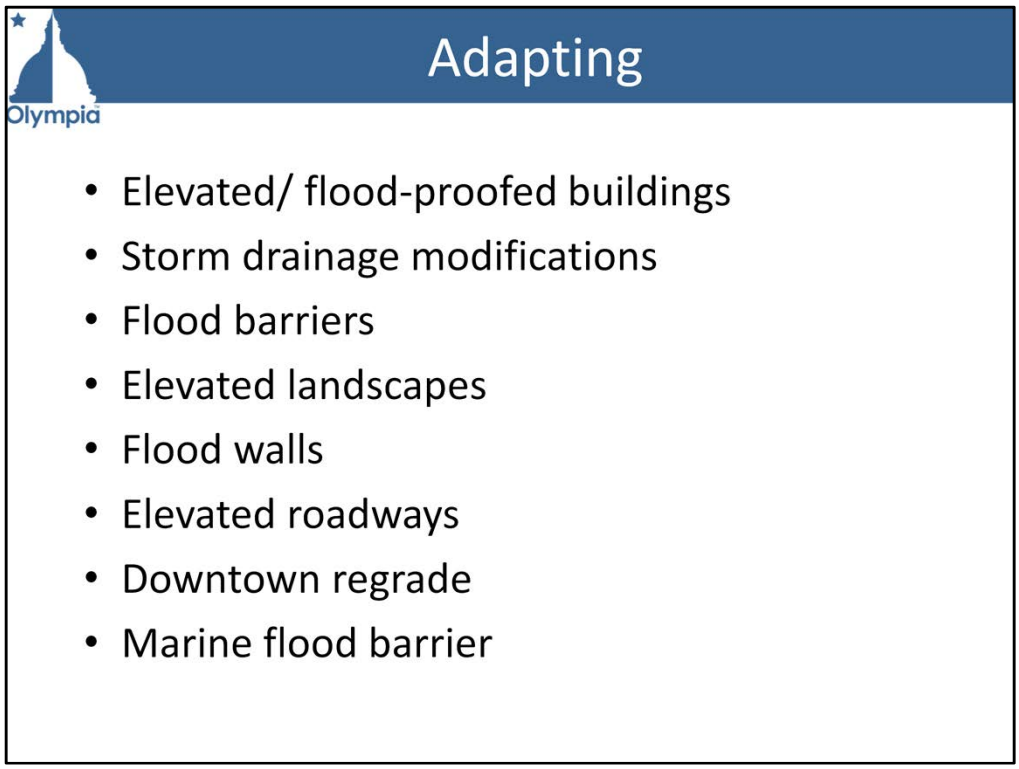
2 feet of sea level rise will extend flooding even further south.



As I mentioned earlier, even if we had stopped carbon emissions last year, we are locked into 4 feet of sea level rise eventually.

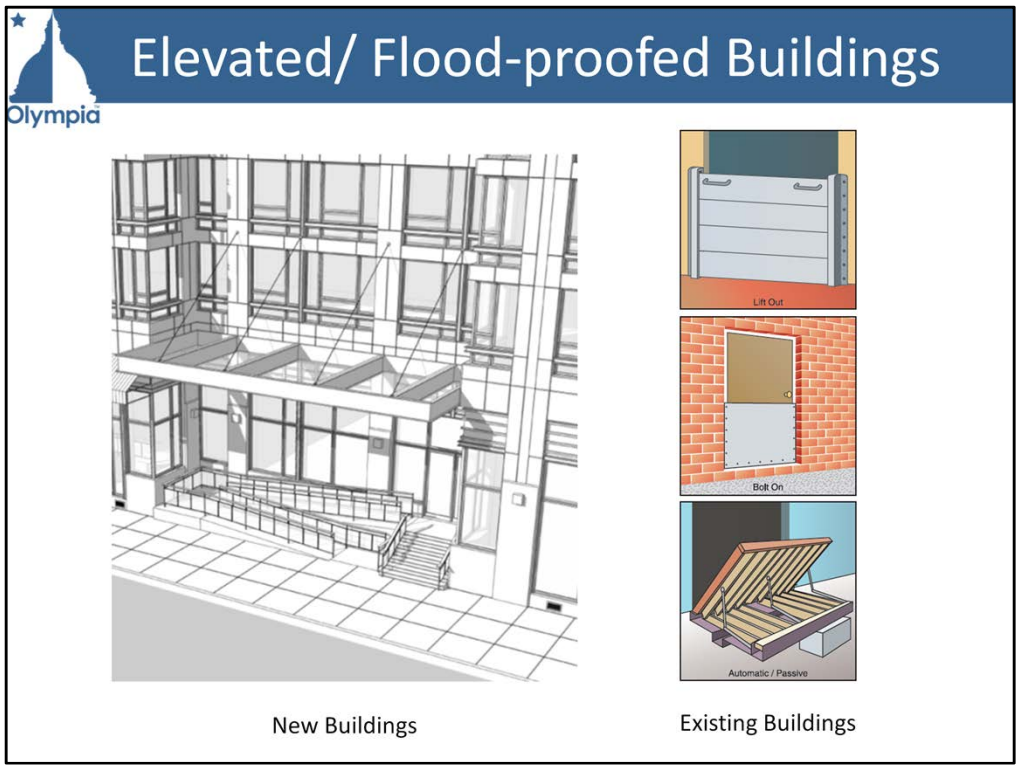


Now that I've discussed the science behind climate change, and the various sea level rise projections. And the previous slides showed us the potential implications for downtown, It should be clear that we will need to adapt to protect downtown from flooding. One fortunate thing we have going for us is that the majority of our vulnerable shoreline is owned or under the control of government agencies. To adapt to SLR, the city will need to partner and coordinate closely with the Port of Olympia and the State of Washington.



Currently we have an opportunity to adapt before we flood. We've been fortunate thus far. Now we need to solidify our vision and strategy to support specific infrastructure improvements and the processes that will be required to prepare for sea level rise. Actions and investments now will reduce future costs and provide immediate community benefits through reduced risks to property, lower flood insurance premiums and lessened interruption of business during and after a flood event.

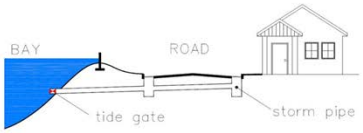
I will now discuss potential measures for adapting downtown to SLR. All of those listed and more will need to be considered. Our adaptation will likely be done incrementally. Initially we will need to prepare for one to two feet of sea level rise. Whatever we do should build the foundation for and not preclude measures to address 4 to 8 feet of sea level rise.

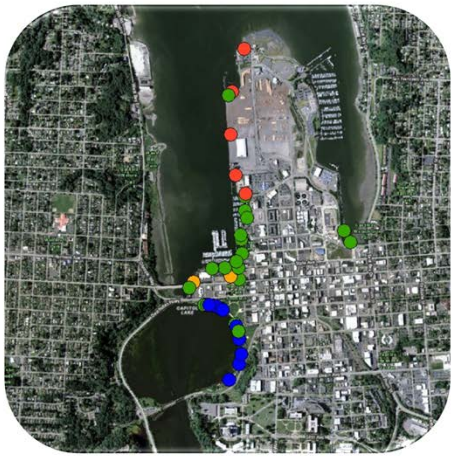


Requiring new structures to be elevated will be a first line of defense that can provide those structures with decades of protection. We should consider revising our flood damage protection municipal code to establish minimum structure elevations in downtown. Seattle has set minimum finished floor elevations 2 feet above FEMA flood elevations. British Columbia is 1 meter above flood elevations.
Existing structures may be able to retrofit and floodproof to avoid significant flood damage.

Storm Drainage System

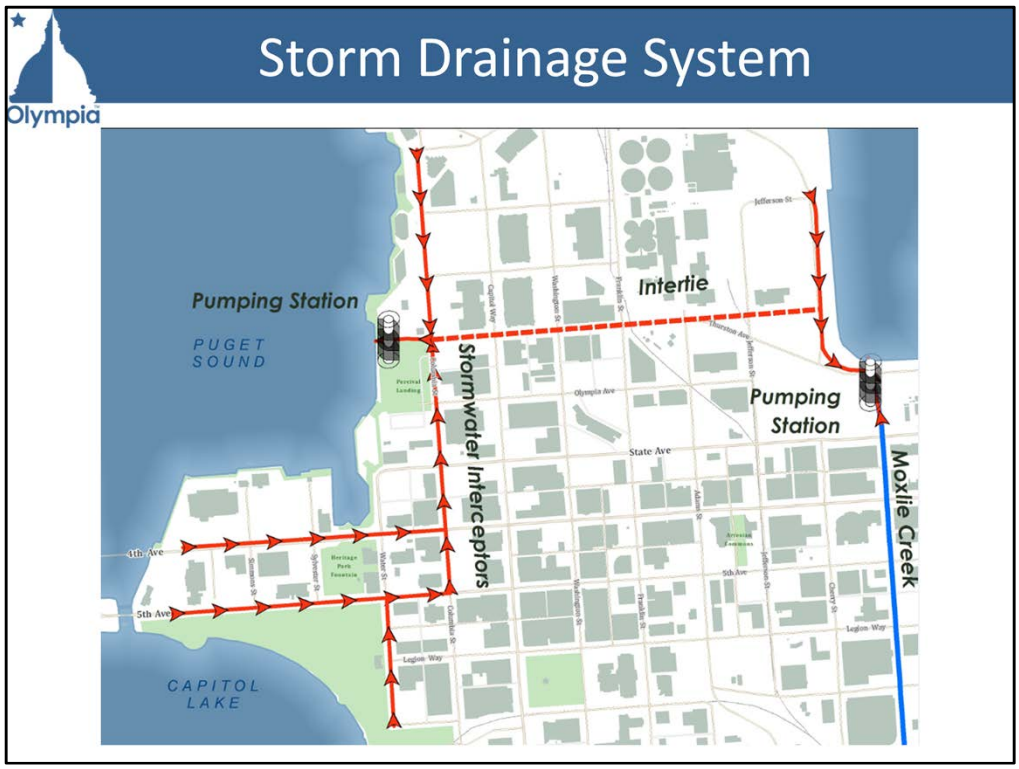
Backflow flooding at Budd Bay Cafe



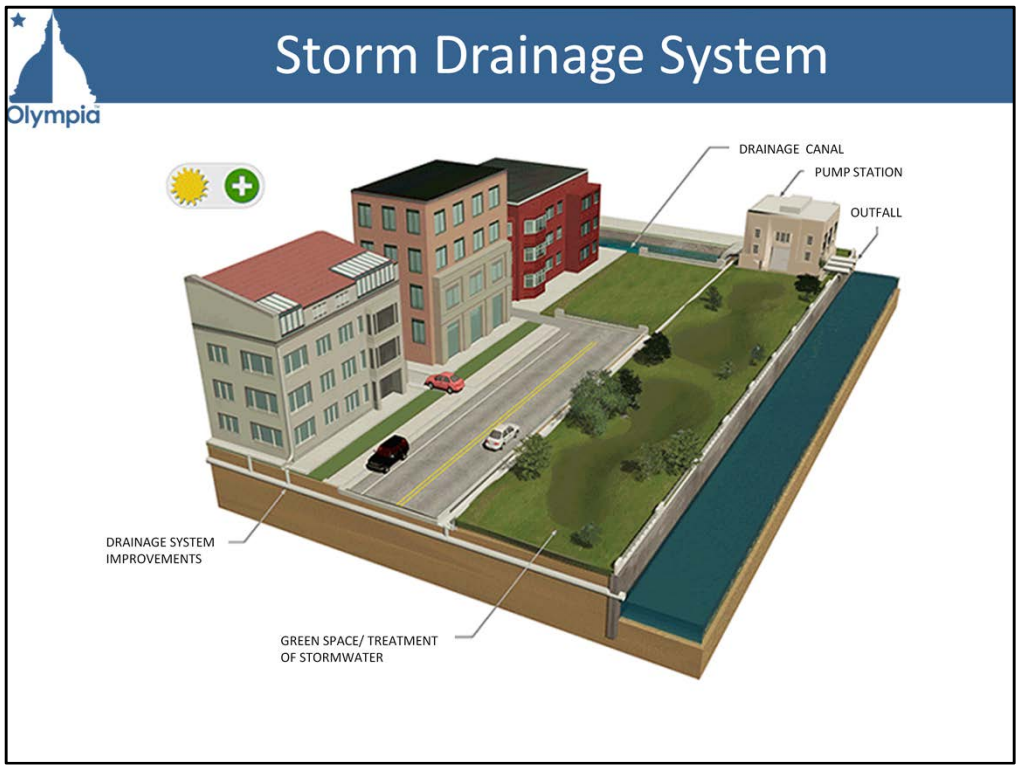


Stormwater Outfalls

To adapt to SLR, the City's storm drainage system will need to be modified. The City has 36 storm outfalls connected to Budd Inlet and Capitol Lake that are susceptible to backflow flooding.
An example of backflow flooding can be observed periodically in front of Budd bay Cafe. Initially we will need to install tide gates on the most vulnerable outfalls.



But eventually, we will need to consolidate drainage systems and install pumping stations to get Moxlie Creek and stormwater runoff out of downtown.



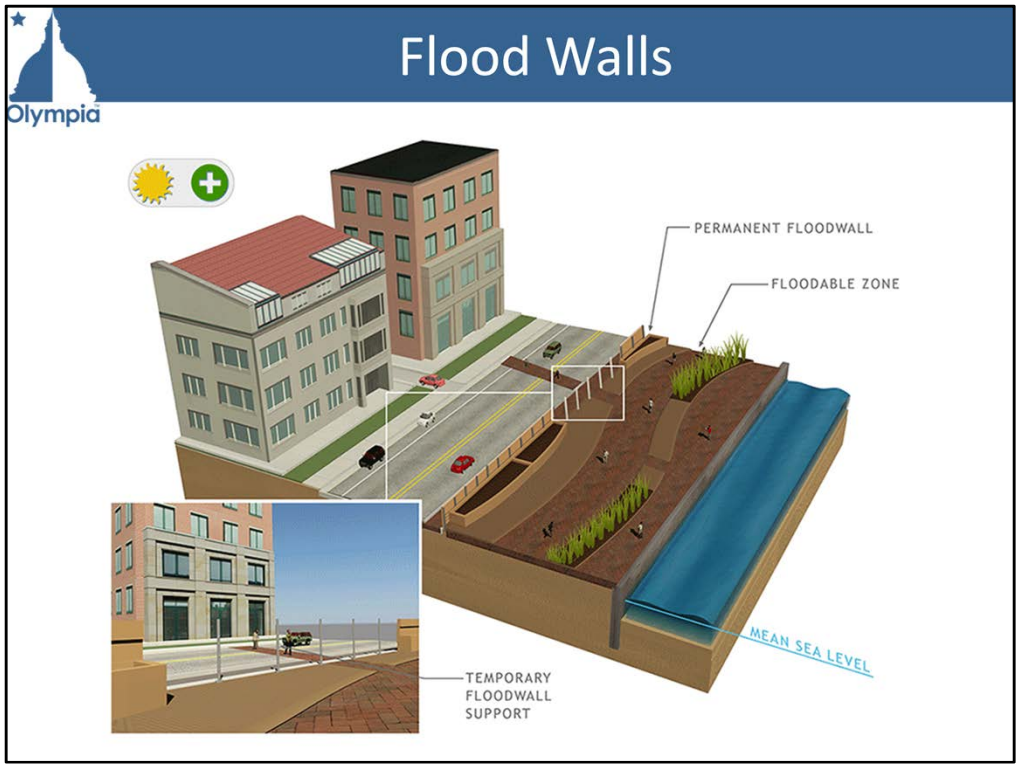
Consolidating drainage systems may allow us to install treatment for the consolidated flows. Separating existing combined sewers may also help protect the LOTT wastewater treatment plant from being overwhelmed during flooding.

Flood Barriers

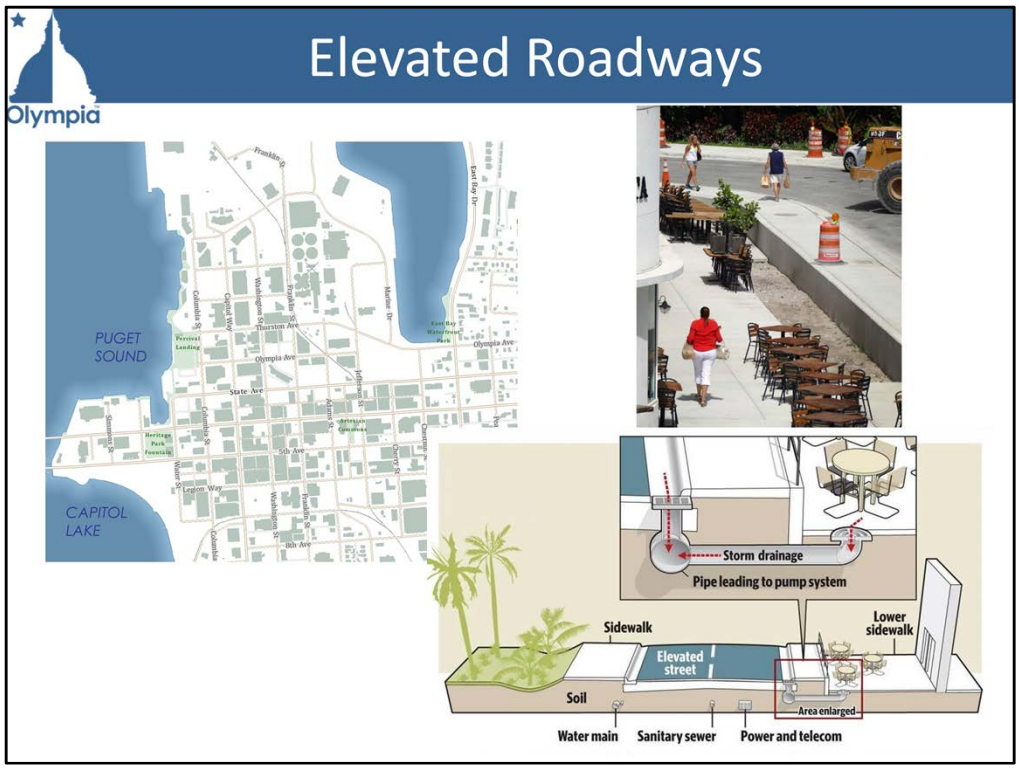
Flood barriers may need to be considered in some locations. Here is an example of a flood wall on the grounds of a medical center in Columbus Ohio. A flood gate across the entrance raises automatically in flood conditions.

As I mentioned before, downtown is most vulnerable to flooding from Capitol Lake. The risk of flooding will only increase with sea level rise. In the not too distant future, one thing that will need to be considered will be elevating the grades of Heritage Park. Similar measures could be taken along the West Bay waterfront west of Columbia Avenue.

Alternatively along the waterfront, we may consider linear planter boxes connected with flood gates to allow access to the shoreline when tides are favorable.



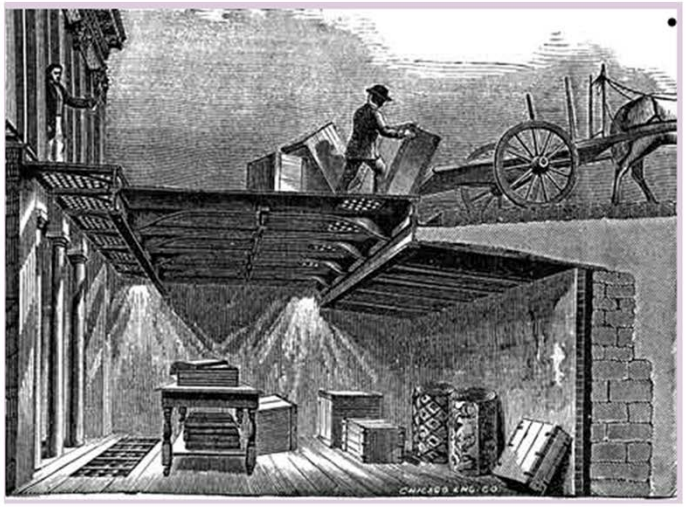
Another option we may consider are floodwalls in some locations. Again whatever we do initially to prepare for 1 to 2 feet of SLR, should build the foundation for future measures to address 4 to 8 feet of SLR.



Emergency access between east and west Olympia and through downtown will need to be maintained. Some roadways may need to be elevated to insure access during flooding. In some locations, the public right-of-way is the property in closest proximity to the shoreline that we have control of. Elevated roadways may be one way to build a flood barrier to protect downtown. This is a strategy Miami Beach has taken for parts of its shoreline. The images in this slide depict recent reconstruction to elevate Purdy Avenue in Miami Beach.

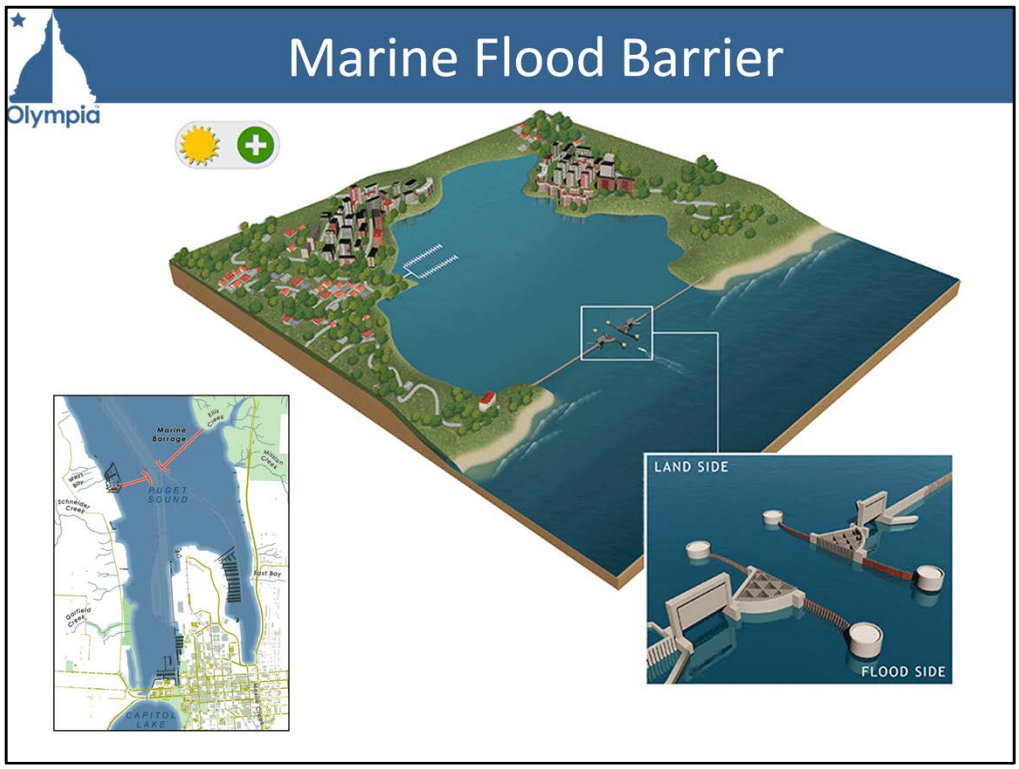
Miami Herald

Downtown Regrade

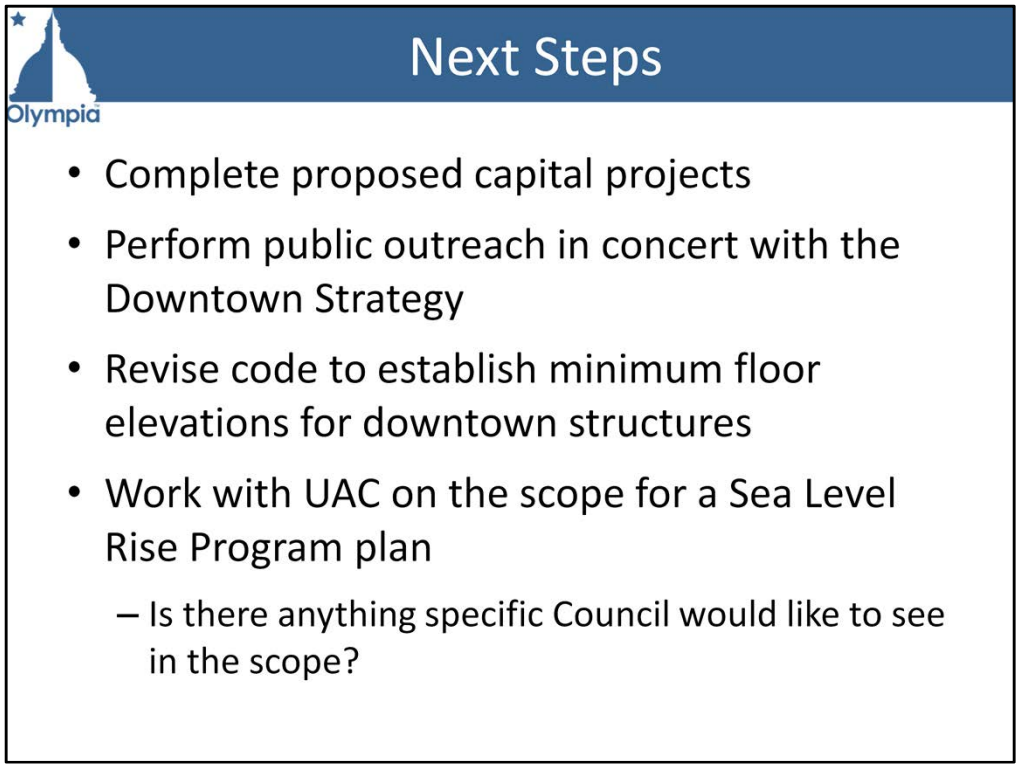


Seattle Pioneer Square Regrade

Risks of flooding are never fully eliminated by barriers. The only sure way to combat SLR will be to rise with it.
A large part of downtown is already built on fill.
To stop flooding, parts of Pioneer Square in Seattle are now up to 12 feet higher than they once were. An even larger undertaking occurred in Chicago in the 1800s.



We are fortunate to live at the end of a narrow and shallow inlet. It would have enormous environmental implications, but in the long term we may need to consider a marine barrier also known as a barrage. Similar measures have been constructed in Venice and Singapore, on the Thames south of London and of course in the Netherlands.



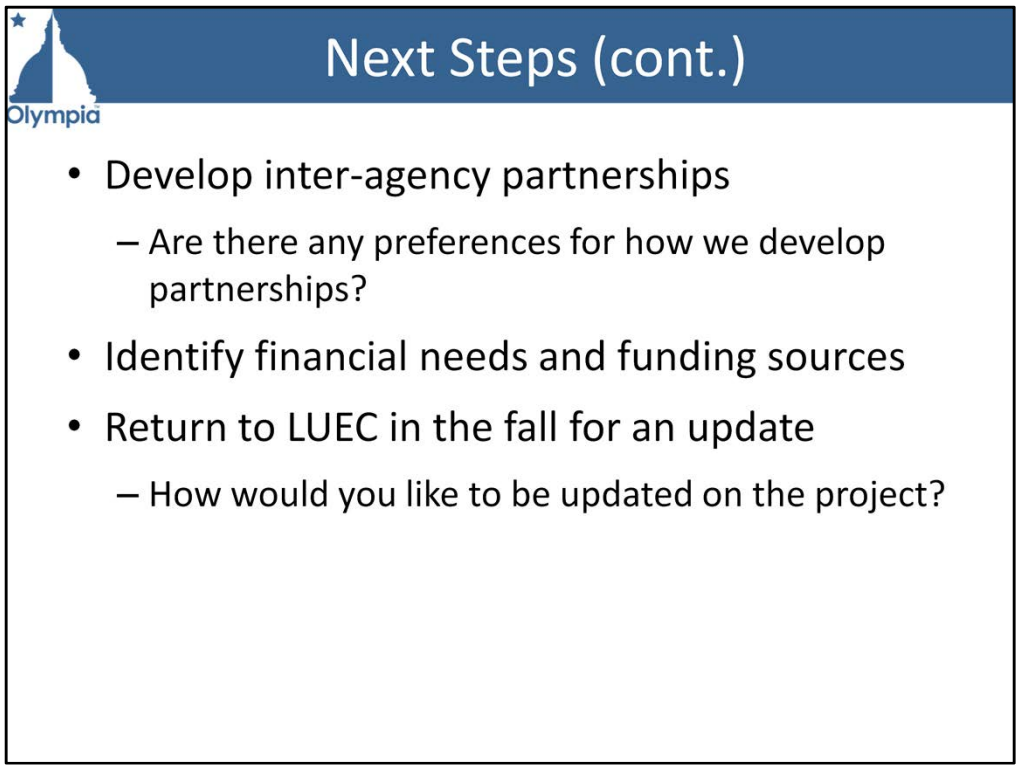
As I mentioned earlier, we may never have an opportunity like we have now. We understand that our current vulnerabilities to flooding are greater than previously anticipated and we know that vulnerability will increase with sea level rise. We should develop a vision and plan to begin adapting to SLR sooner than later. The next steps we propose are to:

Complete ongoing and proposed capital projects. These include modifying drainage in 7th Avenue near Water Street to reduce the need for pumping stormwater when lake levels are high. We will also be maintaining the tide gate near the Fiddlehead Marina. Next year we will design for the installation of new valves near the hands on museum and in Heritage Park.

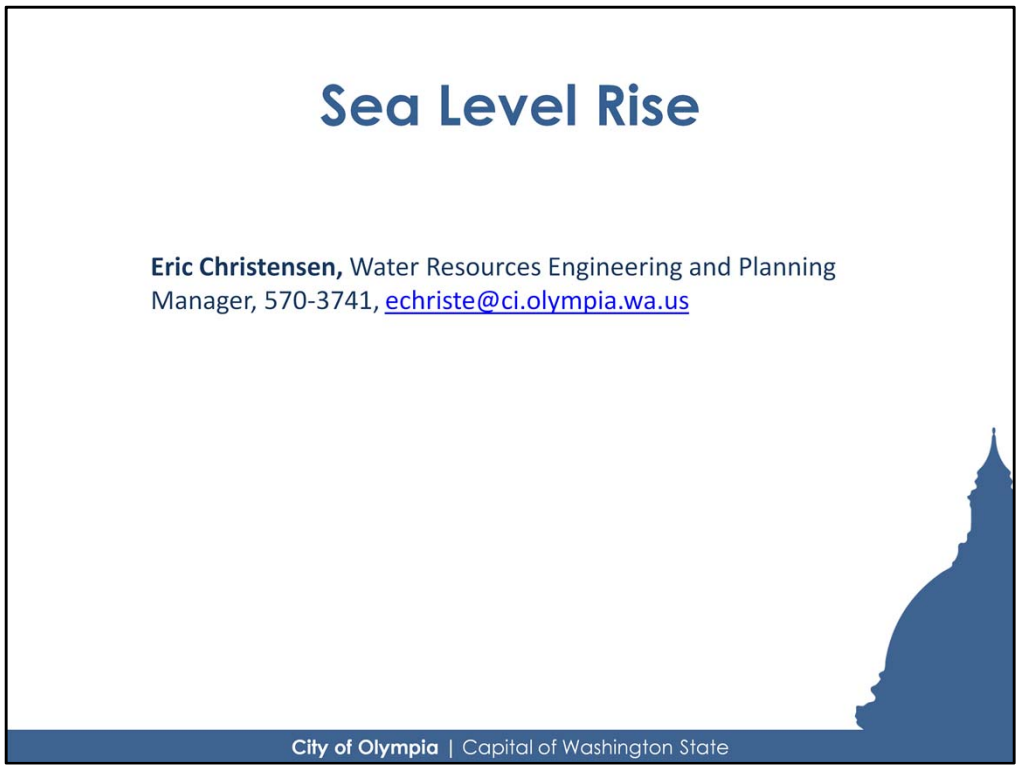
We will need to public's knowledge of sea level rise and its implications and start getting feedback on potential measures for protection from flooding.

We recommend revising the flood damage protection code to establish minimum structure elevations in downtown that are at least 2 feet above current flood elevations. CP&D staff will likely be bringing this forward later this year.

We plan to work with the UAC to develop a scope for a Sea Level Rise Program plan. To protect downtown, we will need to develop a team, likely to include new staff dedicated to sea level rise. We can't let the citizens' confidence, investor confidence, and confidence in our downtown start to erode. We ask Council at this time whether there is anything specific beyond the comprehensive plan policies that you would like to see in the plan scope.



As I indicated earlier, we will need to work with the State Department of Natural Resources and the Department of Enterprise Services, as well as the Port of Olympia and the LOTT Clean water Alliance to develop strategies for combatting sea level rise. We can't go it alone and we will only be as strong as the weakest point in our defenses. Does Council have any preferences or suggestions for developing partnerships with other agencies?
We will need to better understand our financial needs and identify funding sources for a Sea Level Rise Program. Funding will need to be substantial and should be equitable. At this time we estimate the cost of measures to protect downtown from 50" of sea level rise to be in excess of $60 million.
We plan to return to the LUEC for a further update in the fall. Is there another means by which you would like to be updated and is there anything specific that you would like us to address at that time?



The Utility will continue to seek funding to help expand the water quality retrofit program.