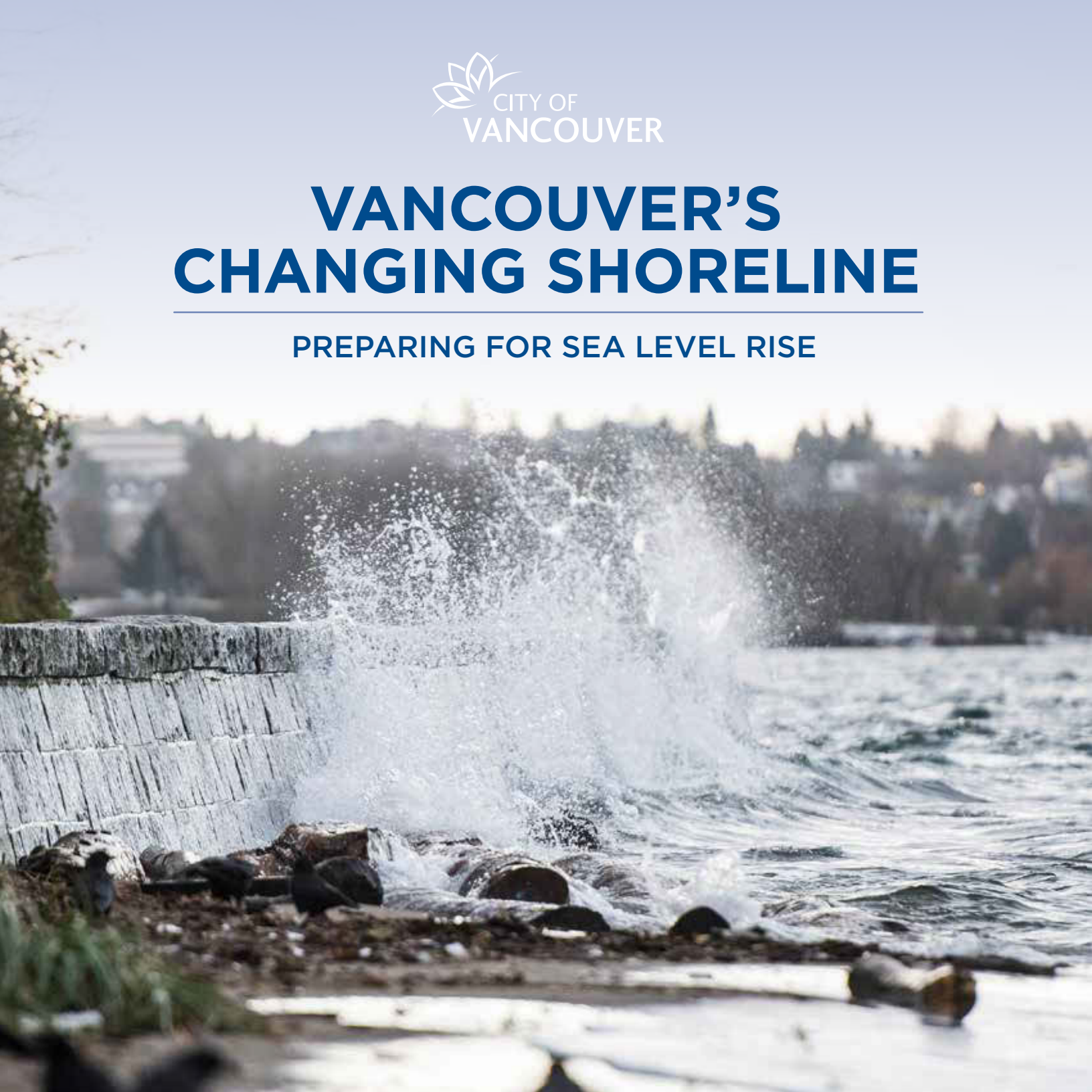
CITY OF VANCOUVER

VANCOUVER'S CHANGING SHORELINE

PREPARING FOR SEA LEVEL RISE











VANCOUVER'S CHANGING SHORELINE

Preparing for Sea Level Rise

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As a west coast city located on the shore of the Salish Sea, Vancouver's past and future are strongly tied to both the ocean and the Fraser River.

A CITY BY THE SEA

Flanked to the north by Burrard Inlet, to the west by the Salish Sea, and to the south by the north arm of the Fraser River, Vancouver has always been a coastal community defined by its proximity to the ocean, river and mountains. Thousands of years before European settlement, xʷməθkʷəyə̓ m (Musqueam), Sḵwxwú7mesh (Squamish) and səl̓ilwətaʔɬ (Tsleil-Waututh) villages and settlements dotted the shorelines, with trade and travelers using the waterways as highways to travel great distances. Each Nation had, and continues to have, its own relationship to the area, including place names and uses for the lands and resources.

Vancouver's early growth as a fishing, forestry and marine shipping hub in the late 19th and early 20th centuries was also tied to the sea and the city's location at the mouth of the Fraser River. Today, our city remains a bustling west coast seaport and Indigenous peoples retain their strong connections to the water. Vancouver's waterways play a central role in our economy, and they also contribute to health and well-being by connecting us to nature, culture, and places for sports and recreation.

▲ *The west coast has been home to Indigenous communities for time immemorial.*

OUR SALISH SEA

This area has long been viewed by Coast Salish people as one body of water. In 2009, the Strait of Georgia and Juan de Fuca, along with Puget Sound were officially given the name of the Salish Sea.

▲ *The Salish Sea area, indicated by the green shading, is one of the world's most biologically rich inland seas, home to 37 species of mammals, 172 species of birds, 247 species of fish, and over 3,000 species of invertebrates. It is also home to eight million people.*

SEA LEVEL RISE IN VANCOUVER

The shorelines where we work, live and play are already experiencing modest sea level rise and episodes of coastal flooding. To date, observed sea level change in Vancouver over the past century (1910 – 2017) has been 3.7 cm (Environmental Reporting BC).

The foot of Cambie Bridge with possible future sea levels painted in shades of blue as part of a public art project.

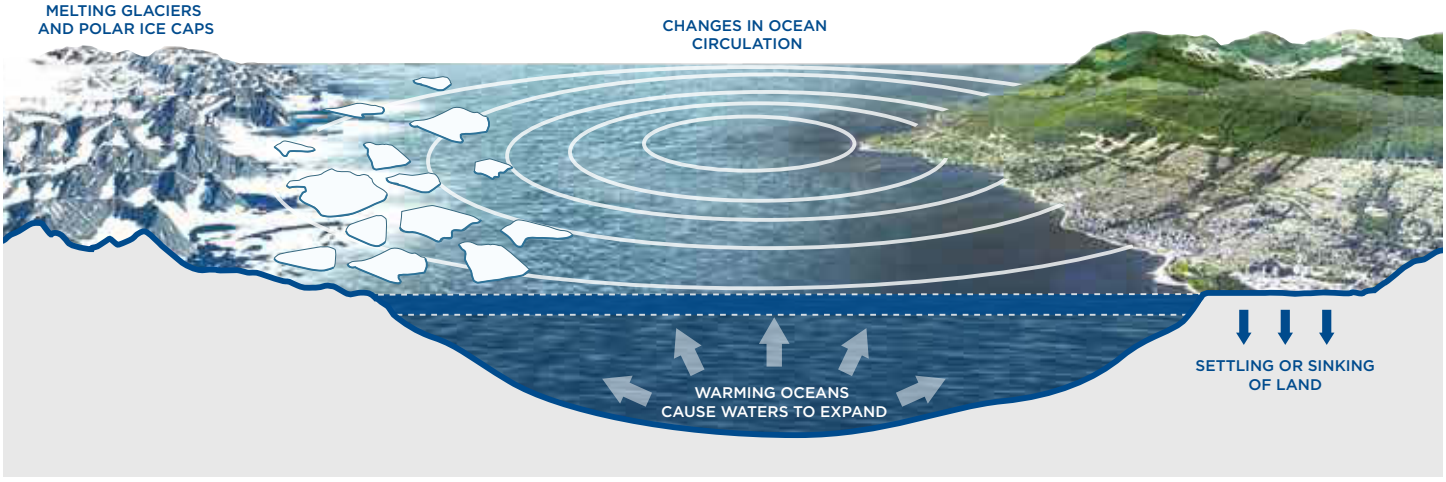
Coastal flooding at Locarno Beach, 2012

CLIMATE CHANGE AND SEA LEVEL RISE

As our global climate continues to warm, the ocean and the waterways and rivers that connect to it are changing. Increasing temperatures are melting glaciers and polar ice caps, feeding more fresh water into the ocean. Climate change is also driving up the average temperature of ocean waters, causing them to physically expand in volume. The combined effects of these events is causing sea level rise. Based on sea level rise observations and computer modelling, the Province advised municipalities in 2011 to plan for 1 metre (3 feet) of sea level rise by 2100, and 2 metres (6 feet) by 2200.

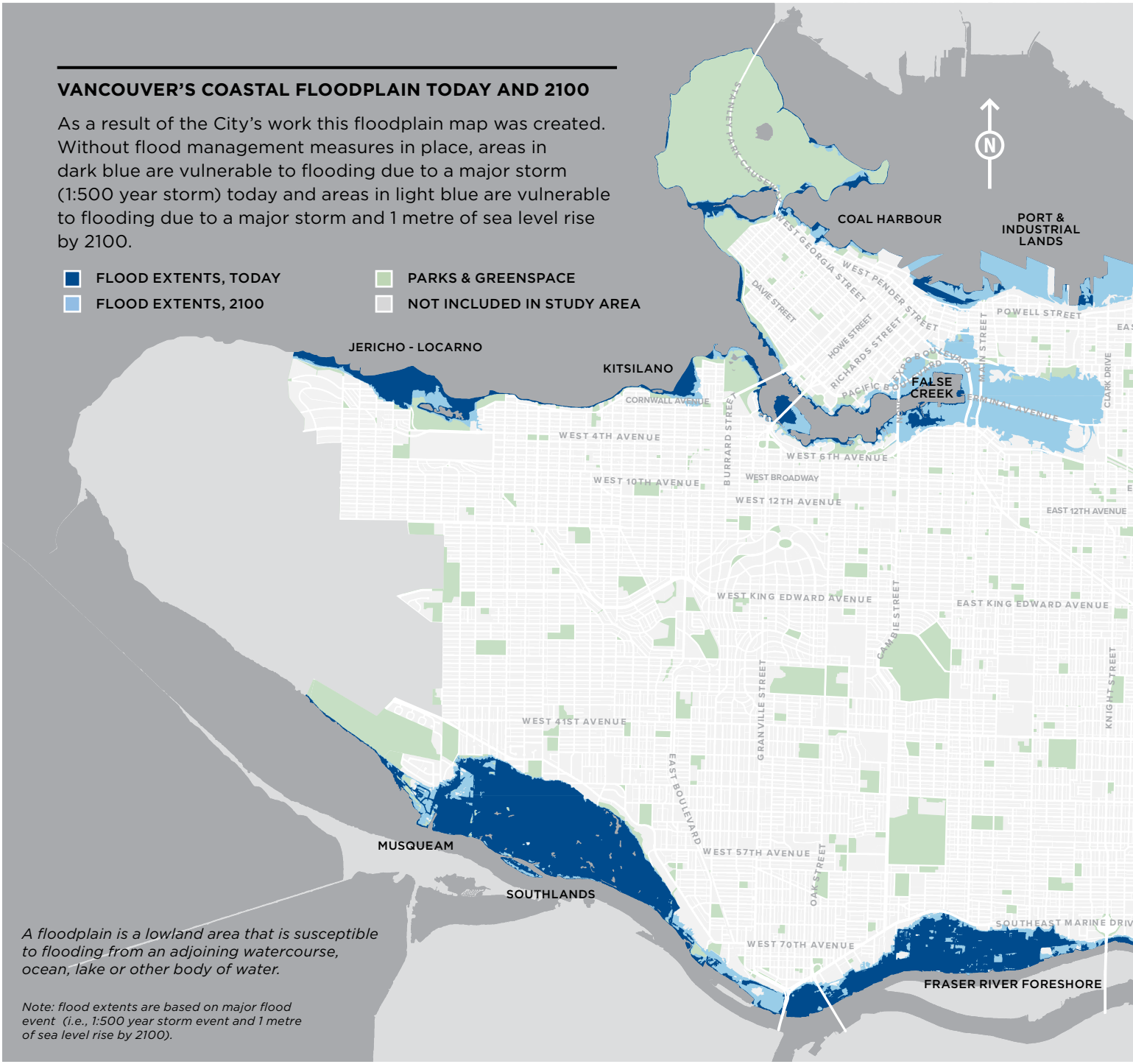
Historic sea level rise cannot be used to predict future increases given the accelerating pace of climate change. It is clear that higher sea levels in the future will erode beaches, damage or destroy buildings and infrastructure in low-lying coastal areas, and permanently inundate some locations. Beaches and critical coastal ecosystems will be lost due to coastal squeeze. In 2012, the City of Vancouver initiated technical work to understand the impacts of sea level rise along the city's coastline.

SOME CAUSES OF SEA LEVEL RISE



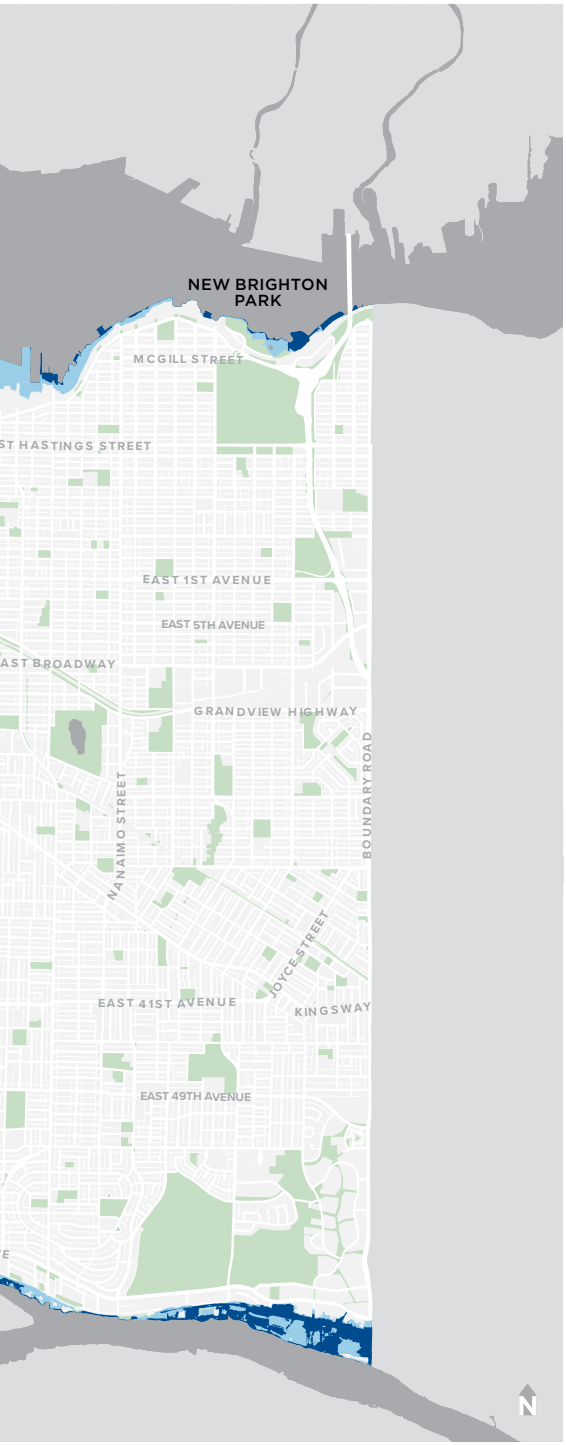
VANCOUVER'S COASTAL FLOODPLAIN TODAY AND 2100

As a result of the City's work this floodplain map was created. Without flood management measures in place, areas in dark blue are vulnerable to flooding due to a major storm (1:500 year storm) today and areas in light blue are vulnerable to flooding due to a major storm and 1 metre of sea level rise by 2100.



A floodplain is a lowland area that is susceptible to flooding from an adjoining watercourse, ocean, lake or other body of water.

Note: flood extents are based on major flood event (i.e., 1:500 year storm event and 1 metre of sea level rise by 2100).



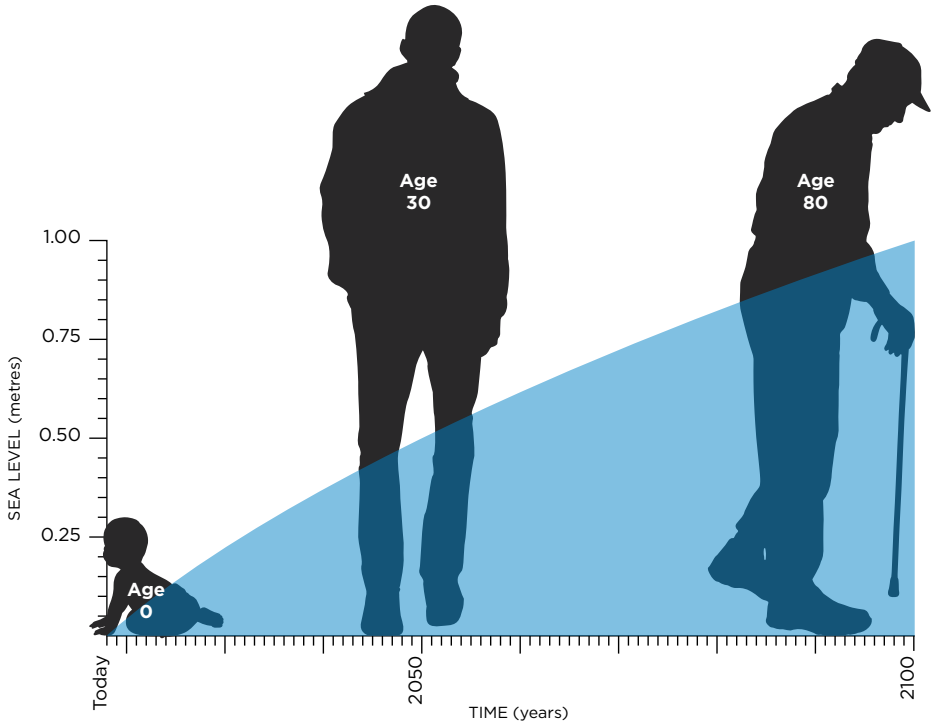
CHANGES WE CAN'T AVOID

The greenhouse gases (GHGs) that we have already emitted into our atmosphere will continue to heat our planet for thousands of years, regardless of how effective we are at reducing global carbon emissions. Why? Once emitted into the atmosphere, GHGs have a long lifespan. Over their lifespan they interact with global atmospheric and oceanic systems in ways that disrupt our climate patterns. Globally, we are "locked-in" to a certain level of continued warming and sea level rise for the foreseeable future.

How long will sea level rise take? That's harder to say. The last major assessment report completed by the United Nations' International Panel on Climate Change in 2014 indicated that it is happening more quickly than they expected in their 2007 assessment report. The pace of sea level rise is uncertain. We are making plans that are flexible and that can accommodate sea level rise of 50 cm by 2050, 1 metre by 2100, and an additional 1 metre thereafter.

A LIFETIME OF SEA LEVEL RISE

Someone born today will experience a metre of sea level rise by the time they are 80 years old.



High tide and storm surge at Jericho Pier, 2012

STORM SURGES AND KING TIDES

From December to February, Vancouver regularly experiences winter storms whose winds can push water levels up anywhere from 50 cm to 100 cm above normal levels. These events are called storm surges and can generate problems when they coincide with high seasonal tides, called king tides. King tides occur three or four times a year during the winter months and are 50 cm to 100 cm higher than regular high tides.

King tides offer us a chance to see what normal sea levels may look like in the future as they rise due to climate change. By 2050, when sea levels are expected to be 50 cm higher than today, our regular sea levels could look like some of today's king tides.

Current conditions, no storm surge

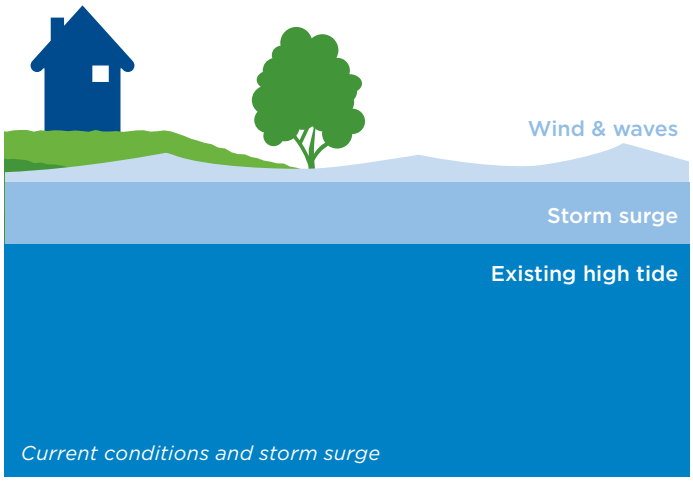
STORM CLOUDS AHEAD

With the changing climate, a consensus of scientists and climate experts have told us to expect more extreme weather conditions. Vancouver is expected to experience more frequent and severe winter storms with heavy precipitation.

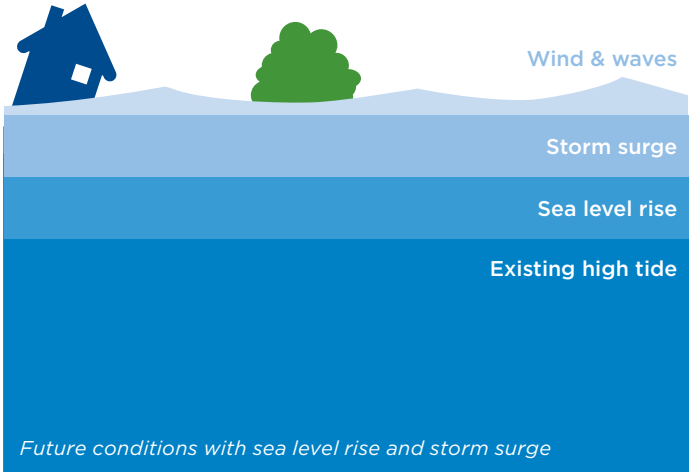
These winter storms will create powerful storm surges, driving more water up onto our shorelines and flooding low-lying areas. Unexpectedly large storm surges have already damaged some of Vancouver's most treasured places, including the seawall in Stanley Park, which was closed for repairs after storm surges during the winters of 2012 and 2015.

Winter storms will also bring rain. Vancouver's new *Rain City Strategy* will guide how we can better manage future heavy precipitation and use rainwater in Vancouver. The strategy's goal is to capture and treat 90% of the rainwater that falls in Vancouver using a combination of green infrastructure and conventional pipe systems, which will help minimize overland flooding.

Stanley Park seawall damage, 2012



Current conditions and storm surge



Future conditions with sea level rise and storm surge

WHAT'S AT RISK FOR VANCOUVER?

According to the United Nations, about 40% of the world's population lives within 100 kilometres of the coast today. As a result, coastal cities and communities all over the world are increasingly vulnerable to flooding, shoreline erosion, and hazards from storms.

In addition, recent research from the US National Oceanic and Atmospheric Association indicates that in 2016, global sea level was 82 mm higher above the historical average recorded in 1993. This means that many communities are already experiencing coastal flooding from sea level rise. Given that ocean conditions are different around the world, sea levels have increased much more in some areas than they have in Vancouver.

In Vancouver, we are keenly aware of the many places, people and habitats at risk. We know that if we do not take action to manage the impacts of sea level rise, there will be properties damaged, communities displaced, human health put at risk, and critical shoreline ecosystems lost.

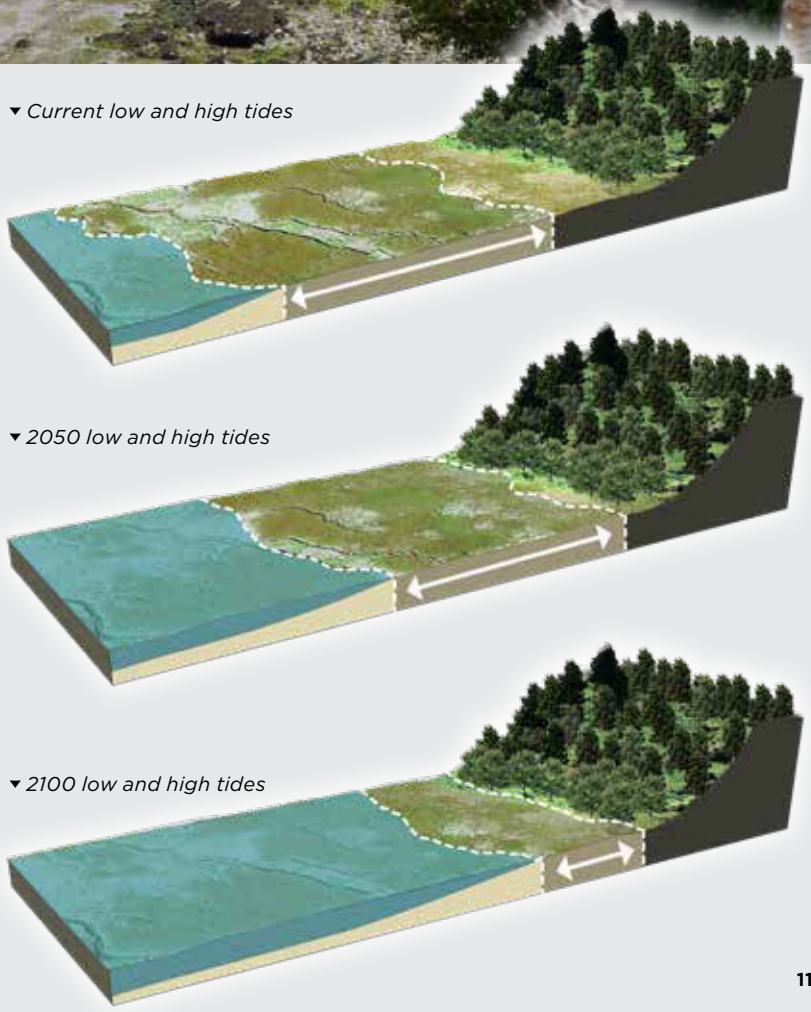
Kitsilano Pool during a king tide and storm surge event, 2012

▲ *Vancouver's few remaining areas of natural shoreline, like this stretch between Kitsilano Beach and Jericho Beach, are at risk of being permanently lost due to sea level rise.*

COASTAL SQUEEZE

From heavily industrial waterfronts along Burrard Inlet, to relatively natural ocean shorelines between Kitsilano Beach, and Jericho Beach, and along the Fraser River estuary from Boundary Road to the marsh flats near Musqueam, our city's coastline is as varied and dynamic as the city it surrounds.

It is Vancouver's more natural coastlines, and the important intertidal areas they are home to, that are particularly at risk from climate change. These intertidal ecosystems will be impacted, reduced, and squeezed over time as they face permanent inundation due to rising sea levels and increased development pressure on land.



WHAT IS CLIMATE CHANGE ADAPTATION?

Adaptation refers to actions taken to respond to the impacts of climate change, including sea level rise and coastal flooding. Adaptation takes advantage of available opportunities to avoid, reduce and prepare for impacts. This is different from mitigation, which refers to our efforts to limit climate change by reducing the greenhouse gases responsible for climate change.

The creation of a salt marsh in New Brighton Park is an example of habitat restoration and adaptation. The new marsh creates space for plants and sea life. It also provides space for high ocean waters and a buffer against waves during storm surge events.

Local crews work to remove sand on streets that were impacted by the storm surge of Hurricane Sandy in Rockaway, N.Y., November 2012.

Photo: Jocelyn Augustino/FEMA

Vancouver is taking action now to prevent and minimize potentially devastating impacts to local communities, our economy, and our natural environment, and to avoid even higher costs down the road. Regionally and around the world, sea level rise and flood-related events are already causing costly and sometimes permanent damage.

PLANNING FOR CHANGE

Vancouver has long recognized the need to plan for future sea level rise and to help vulnerable neighbourhoods, communities and businesses along our shoreline become more resilient to the coastal flooding challenges ahead. In 2012, City Council approved a Climate Change Adaptation Strategy, which recommends several priority actions for the City. As one of the priority actions, the Coastal Flood Risk Assessment program, was launched shortly afterwards to prepare for sea level rise and its impacts on the city of Vancouver.

The sea level rise program, a first program of its kind in Canada, is a multi-phase undertaking to determine the risk, consequences and vulnerability of Vancouver to future sea level rise and storm surge scenarios. The first phases of work identified flood hazard "zones" in Vancouver, each one distinct in terms of its community features, facilities, environmental features, topography, and exposure to tides and weather (wind and waves).

2012 - 2014 — **VULNERABILITY ASSESSMENT**
- *Flood hazard areas identified*

2014 - 2016 — **PRELIMINARY ADAPTATION OPTIONS**
- *Adaptation options identified for each flood hazard area*

2014 — **FLOOD CONSTRUCTION LEVEL**
- *A new flood construction level is adopted for the floodplain area*

2017 - 2019 — **ENGAGEMENT & EARLY ACTIONS**
- *Beginning with areas most at risk, collaborate with the community on design options and first steps*

2020 - beyond — **DESIGN CONVERSATIONS**
- *Technical analysis and feasibility*
- *Community input*
- *Implementation*

FRASER RIVER SHORELINE AND FLOODPLAIN

Today, the Fraser river floodplain is the area most vulnerable to flooding in the City of Vancouver.

Trying to anticipate the hazards of future flooding is a complex and technically challenging undertaking. Our sea level rise program first modelled different sea level rise scenarios with a corresponding range of potential storm surge events (i.e., different intensities of storms) for different periods in the future. This work helped us to better understand our flood risks and identify which flood hazard zones are most vulnerable to these risks.

The Fraser River shoreline, which runs from Boundary Road in the east to Musqueam in the west, was identified as one of the most vulnerable areas. Other low lying areas around Jericho and Locarno beaches followed, along with some areas in the Port of Vancouver, which are under the jurisdiction of Port Metro Vancouver.

In the next phase of our sea level rise work, a variety of potential solutions, or adaptation options, were investigated at a high level for each of the flood hazard zones.

Future project phases will start rolling out in 2018/2019, and will refine emerging options with the public and local communities, experts and staff. This work will be undertaken systematically, beginning with the most vulnerable areas along Vancouver's Fraser River shoreline. There will be multiple opportunities for the public to shape this work.

CLIMATE MITIGATION – PLAYING OUR PART

In addition to our ongoing climate adaptation work, Vancouver is also deeply committed to reducing greenhouse gas (GHG) emissions that are driving climate change. The *Greenest City Action Plan* and *Renewable City Action Plan* are two examples of initiatives working to reduce the city's contribution to global climate change. These initiatives will change how we build, heat, and power buildings, as well as change how we get around. These actions will reduce our GHGs. The *Renewable City Action Plan* targets a transition to 100% renewable energy and an 80% reduction in carbon pollution by 2050.

RISK = LIKELIHOOD x CONSEQUENCE

Risk is the combination of the likelihood of an event occurring and its consequences. For flood planning, this means understanding the likelihood of a high intensity storm taking place, in addition to sea level rise, and the flood damage the event could cause.

The chance that a particular sea level rise and coastal flooding scenario will occur.

The impacts to local shoreline areas and communities if flooding were to occur. This includes identifying the areas where the water will go (i.e., hazard areas) and identifying the specific vulnerabilities in the hazard areas (e.g., homes, businesses, community facilities, infrastructure and services, habitats, recreation areas).

EXPLORING OUR OPTIONS

As part of the second phase of our sea level rise program, a number of preliminary adaptation options were identified for each of the 11 flood hazard zones. The pros and cons, estimated costs, and likely trade-offs for each option were evaluated as part of the study. This information provides us with a starting point for conversations with residents, businesses and experts about flood management options in each of the areas, as well as how each option or combination of options supports local community values (e.g., aesthetics, access to recreation).

The adaptation options that were assessed can be organized into four general approaches:

1. RESIST: Build structures to keep floodwater out and protect areas and community assets. Common approaches here include shoreline and inland dikes or offshore features to help reduce wind and wave action (which can help push more water ashore during storm surges).

2. ACCOMMODATE: Rather than keeping floodwater out, these flood management options aim to keep community assets dry when flooding occurs. Examples include raising buildings and infrastructure or designing them so that they can accommodate temporary flooding and stay dry when flooding occurs (e.g., "wet-proofing," "dry-proofing").

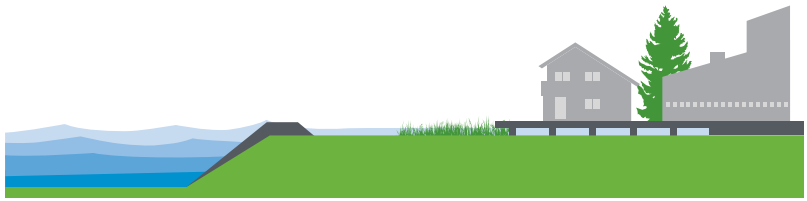
3. MOVE: Plan for the eventual relocation of people and/or facilities and buildings in high exposure, high risk areas of the city. This approach often includes returning portions of land to pre-development conditions (i.e., "naturalizing").

4. COMBINATION: Use of a combination of approaches in a flood hazard area (i.e., protect, accommodate, retreat) to achieve a range of community values, like habitat conservation, recreation, and livability. This will likely be one of the most common approaches we take along Vancouver's shoreline.

RESIST

ACCOMMODATE

MOVE



COMBINATION

CHOOSING OUR PATH FORWARD

As has been the case in other jurisdictions in the Pacific Northwest and around the world, it is likely that Vancouver's flood hazard areas will use a combination of approaches phased in over time as sea level continues to rise. Vancouver has approached other complex, long-term challenges, like climate change mitigation (the reduction of greenhouse gas emissions), using a similar phased, multi-pronged approach.

As we plan for the future and for work with communities to identify values and appropriate flood management options for flood hazard zones, it is important to remember that while only a small number of zones may experience flooding today, the majority of zones will experience flooding between 2040 and 2100.

Although the City needs to make immediate development and capital decisions for some areas in the short term, for other areas, we need to take the required steps to keep the door open for implementing future options over the longer term. In the years ahead, we will no doubt need to make many tough decisions.

These decisions will require us to consider multiple values like habitat preservation, aesthetics, the local economy, and the like, along with potentially difficult trade-offs.

Although the timelines might appear long, Vancouver is taking action now on a number of fronts through community planning, capital planning, and City operations and maintenance work. This includes:

- Incorporating flood-resilient design standards into the Vancouver Building By-law for flood hazard areas (see Flood Construction Levels text box);
- Regulating sub-division and development in at-risk areas to avoid increasing coastal flooding vulnerability;
- Minimizing the construction of City-owned critical infrastructure in at-risk areas;
- Raising the physical height of City utilities (e.g., roads, water, sewer) during regularly planned infrastructure renewal projects;
- Developing and implementing a flood monitoring and warning system.

BUILDING UP FOR THE FUTURE: FLOOD CONSTRUCTION LEVELS

The buildings we construct today will last at least 75 to 100 years. Over that same time period sea levels will rise 50 cm to 100 cm or more, putting the very same buildings, communities, and businesses that exist in flood hazard areas at risk from flooding. To reduce this risk to homes and the local economy, the City adopted a one metre increase to Flood Construction Levels (FCL) in its Building By-law to protect against sea level rise. Adopted in 2014, this standard means that new buildings constructed in flood hazard areas will be raised by an additional metre at minimum or more, depending on local soil conditions.

New homes under construction near the Fraser River

WHAT IS RESILIENCY?

The ability to recover from a disturbance, such as a flooding event, or withstand the ongoing pressures of sea level rise. The more resilient our city is the more it has the ability to maintain its normal patterns and functions.

ADAPTATION AND RESILIENCE

Looking to the future, the impacts of climate change will continue, exacerbating shocks and stresses Vancouver residents may experience as the city grows and develops over the next century. Stresses are day-to-day or cyclical issues like lack of affordable housing, crime, and social inequity. Shocks are events like fires, floods, and earthquakes. Day-to-day stresses can harm cities just as dramatically as one-off events.

Recognizing the challenges ahead, Vancouver is also working on developing a Resilience Strategy to increase community and operational capacity to:

- Proactively address our vulnerabilities
- Learn from experiences
- Adapt to change

Planning for sea level rise presents an opportunity to help build our city's overall resilience and will be linked to the development of the Resilience Strategy. Some of this work includes building residents' understanding and awareness around sea level rise and coastal flooding, the options available for the City to pursue and the community's role in them, and improving neighbourhood emergency management so we are ready to respond to any future coastal flood or climate emergency that may arise.

GREENSHORES™

▲ *Jericho Beach*

Adapting to sea level rise provides an opportunity to take a new made-in-Vancouver approach to managing flood risk. Softer options, like GreenShores™ dikes and other flood management approaches represent new strategies that can help protect waterfront properties while also protecting and restoring habitats and creating new recreation opportunities. We can apply Greenest City values in our adaptation work.

CONCERNS, VALUES AND ASPIRATIONS

In 2017 the City of Vancouver hosted climate change and sea level rise conversations and education events across the city. During that time, over 15,000 Vancouver residents were engaged on the topic and many shared their concerns, values and aspirations for a future with sea level rise in it.

94% of residents surveyed agreed that it is important for Vancouver to prepare for future flooding due to sea level rise. 81% of those surveyed said that they think about climate change in their day-to- day life.

CLIMATE MITIGATION: EVERYONE HAS A ROLE TO PLAY

Vancouverites have always been at the forefront of taking climate action. Now, more than ever, we need to reduce our greenhouse gas emissions.

How do you do that?

- Discover a new bus route and plan to take transit for one new trip next week.
- Choose one way to reduce energy use at home.
- Compost all food scraps.
- Plant a tree, a garden or your favourite vegetables.
- Plan a Meatless Monday meal with your family and friends.

Taking these simple steps to reduce our GHG emissions will also help support Vancouver's ongoing adaption work.

Adapting to sea level rise and associated coastal flooding will involve everyone, including our Indigenous partners whose cultural and spiritual connections to the Salish Sea stretches back thousands of years.

Photo: Gathering of Canoes 2017, by Jeremy Board, CC-by-nc, flickr.com

Adapting to sea level rise and associated coastal flooding will be an ongoing process. By starting our work together now, we will have time to listen, learn and make thoughtful decisions.

NEXT STEPS

The first phases of our sea level rise work helped us understand where and how we are vulnerable and what options might be considered to manage coastal flooding in identified hazard areas. Over the next several years, we will continue to explore, implement and plan for short, medium, and long-term adaptation options based on the unique neighbourhoods in Vancouver.

Over the coming months and years, we will be continuing to expand and enrich our efforts to engage people in this critical work. As a resident or business owner, your input will be vital. Your voice can help shape our collective response to climate change and sea level rise as it continues to impact our city by the Salish Sea.

We want to hear from you. Have an idea or a question? Let us know.

STAY CONNECTED:

Keep up to date about all the ways you can help Vancouver minimize the effects of climate change and make Vancouver a greener place to live, work and play. Sign up for our newsletter or follow us on social media.

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- vancouver.ca/greennews
- #vansealevelrise

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