ESA

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

www.esassoc.com

memorandum

date	December 18, 2017
to	Bonny O'Connor, AICP
cc	Tina Wehrmeister; Bob Battalio, PE
from	James Jackson, PE
subject	Future Conditions Scenarios for Pacifica LCP Update

In this memorandum we summarize the guidance from the State of California on sea-level rise (SLR) including the draft guidance update released in November 2017, propose SLR scenarios to be used in the Pacifica Local Coastal Plan (LCP) Update and describe the various data sources to be used for the vulnerability assessment.

State Guidance on Sea-Level Rise

The California Ocean Protection Council first released a statewide guidance document in 2010 following Governor Schwarzenegger's executive order S-13-08. This interim guidance document informed and assisted state agencies to develop approaches for incorporating SLR into planning decisions. The document was updated in 2013 (OPC 2013) after the National Research Council (NRC) released its final report *Sea Level Rise for the Coasts of California, Oregon, and Washington* (NRC 2012), which provided new projections of future SLR.

The California Coastal Commission (CCC) adopted SLR policy guidance in 2015 (CCC 2015). The document describes climate change scenarios that should be considered at various planning horizons for vulnerability and adaptation planning, and provides a step-by-step process for addressing SLR and adaptation planning in updated Local Coastal Programs and is summarized below (CCC 2015, p 18):

1. Determine a range of SLR projections relevant to LCP planning area/segment using best-available science, which is currently the 2012 National Resource Council (NRC) Report.

2. Identify potential physical SLR impacts in the LCP planning area/segment, including inundation, storm flooding, wave impacts, erosion, and/or saltwater intrusion into freshwater resources.

3. Assess potential risks from SLR to coastal resources and development in the LCP planning area/segment, including those resources addressed in Chapter 3 of the Coastal Act.

4. Identify adaptation measures and LCP policy options to include in the new or updated LCP, including both general policies and ordinances that apply to all development exposed to SLR, and more targeted policies and land use changes to address specific risks in particular portions of the planning area.

5. Draft updated or new LCP for certification with California Coastal Commission, including the Land Use Plan and Implementing Ordinances.

6. Implement the LCP and monitor and re-evaluate strategies as needed to address new circumstances relevant to the area.

Note that item 1. refers to “best available science” which at the time of the CCC (2015) report was NRC (2012) as included in State Policy by OPC (2013). Since then, California has commissioned an update (Griggs et al, 2017) and is planning an update to Policy in early 2018. Consequently, a key question is how to select the “best available science” and anticipate the State Policy update. Additional information is provided in the following sections of this document.

Current Guidance on Climate Change and Sea-Level Rise Scenarios

The accumulation of greenhouse gases in the Earth’s atmosphere is causing and will continue to cause global warming and resultant climate change. For the coastal setting, the primary exposure will be an increase in mean SLR due to thermal expansion of the ocean’s waters and melting of ice sheets.

State planning guidance for coastal flood vulnerability assessments call for considering a range of scenarios (OPC 2013; CCC 2015). These scenarios bracket the likely ranges of future greenhouse gas emissions and ice sheet loss, two key determinants of climate whose future values cannot be precisely predicted. Scenario-based analysis promotes the understanding of impacts from a range of scenarios and identifies the amounts of climate change that would cause impacts.

The state guidance recommends using scenarios that represent low, medium, and high rates of climate change. Recent studies of current greenhouse gas emissions and projections of future loss of ice sheet indicate that the low scenario probably underrepresents future SLR (Rahmstorf et al. 2012; Horton et al. 2014). Also, note that even if SLR does not increase as fast as projected for the High scenario, SLR is projected to continue beyond 2100 under all scenarios. The assumptions that form the basis for the NRC (2012) scenarios are as follows:

Low Scenario – The medium scenario assumes population growth that peaks mid-century, high economic growth, and assumes a global economic shift to less energy-intensive industries, significant reduction in fossil fuel use, and development of clean technologies.

Medium Scenario – The medium scenario assumes population growth that peaks mid-century, high economic growth, and development of more efficient technologies, but also assumes that energy would be derived from a balance of sources, thereby reducing greenhouse gas emissions.

High Scenario – The high scenario assumes population growth that peaks mid-century, high economic growth, and development of more efficient technologies. The associated energy demands would be met primarily with fossil-fuel intensive sources.

Table 1 presents SLR projections for current state guidance. These NRC values for relative SLR at 2030, 2050 and 2100 for San Francisco are relative to 2000 and includes regional projections of both mean SLR and vertical land subsidence of 1.5 millimeters per year for the San Andreas region south of Cape Mendocino.

Table 1
State guidance: mean sea-level rise projections for San Francisco (NRC 2012)

Year	Low Range	Mid Curve	High Range
2030	2 in (0.2) ft	6 in (0.5 ft)	12 in (1 ft)
2050	5 in (0.4 ft)	11 in (0.9 ft)	24 in (2 ft)
2100	17 in (1.4 ft)	36 in (3 ft)	66 in (5.5 ft)

Given that coastal hazards increase with the rate and amount of SLR, it seems prudent to emphasize the higher scenarios for planning and engineering. We therefore do not recommend analysis of the Low SLR scenario.

2018 SLR Guidance Update (November 2017 Draft)

The California Natural Resource Agency and Ocean Protection Council just released a draft (CalNRA & OPC 2017) of the upcoming 2018 guidance update to the 2013 State of California guidance document (OPC 2013). The guidance update provides a synthesis of the best available science on SLR in CA, a step-by-step approach for state agencies and local governments to evaluate SLR projections, and preferred coastal adaptation strategies. The key scientific basis for this update was developed by the working group of the California Ocean Protection Council Science Advisory Team (OPC-SAT) titled *Rising Seas in California: An Update on Sea-Level Rise Science* (Griggs et al. 2017). The above mentioned studies and guidance documents are shown in Figure 1 to illustrate the relationship between these documents. Note that the OPC 2018 report is not yet finalized.

Figure 1
California sea-level rise guidance documents and scientific basis for each

The guidance update includes the following key changes and additions to the OPC 2013 guidance:

- **For years before 2050, SLR projections are provided only for the high emissions scenario (RCP 8.5).** The world is currently on the RCP 8.5 trajectory, and differences in SLR projections under different scenarios are minor before 2050.

- **Includes new "extreme" SLR projections associated with rapid melting of the West Antarctic ice sheet.**

- **Shifts from scenario-based (deterministic) projections to probabilistic projections of SLR.** The guidance update recommends a range of probabilistic projections for decision makers to select given their acceptable level of risk aversion for a given project.

- **Provides estimated probabilities of when a particular SLR amount will occur.** In addition to SLR projections that are tied to risk acceptability, updated guidance provides information on the likelihood that sea-level rise will meet or exceed a specific height (1 foot increments from 1 to 10 feet) over various timescales.

The guidance update includes significant advances in the scientific understanding of SLR. Compared to the ***scenario-based*** SLR projections in the 2013 version of state guidance, the updated guidance incorporates ***probabilistic*** sea-level rise projections, which associate a likelihood of occurrence (or probability) with various sea-level rise heights and rates into the future and are directly tied to a range of emissions scenarios (described below). Using probabilistic sea-level rise projections is currently the most appropriate scientific approach for policy setting in California, providing decision makers with increased understanding of potential sea-level rise impacts and consequences. The guidance update also includes an extreme SLR scenario that is based on rapid melting of the West Antarctic ice sheet.

The guidance update now provides a range of probabilistic projections of SLR that are based on two Intergovernmental Panel on Climate Change (IPCC) emissions scenarios called representative concentration pathways (RCPs[1]), as well as a non-probabilistic projection associated with rapid West Antarctic ice sheet mass loss. These three climate scenarios are explained below:

RCP 2.6 *Scenario* – This scenario corresponds closely to the aspirational goals of the 2015 Paris Agreement, which calls for limiting mean global warming to 2 degrees Celsius and achieving net-zero greenhouse gas emissions in the second half of the century. This scenario is considered very challenging to achieve, and is analogous to the Low scenario in NRC (2012).

RCP 8.5 *Scenario* – This scenario is consistent with a future where there are no significant global efforts to limit or reduce emissions. This emission scenario is consistent with that used to develop the High SLR scenario in NRC (2012) but the 50th percentile is closer to the Mid SLR rate and amount in NRC (2012).

H++ Scenario – This extreme scenario was proposed by the Ocean Protection Council Science Advisory Team in response to recent scientific studies that have projected higher rates of SLR due to the possibility of more rapid melting of ice sheets.

[1] Named for the associated radiative forcing (heat trapping capacity of the atmosphere) level in 2100 relative to pre-industrial levels.

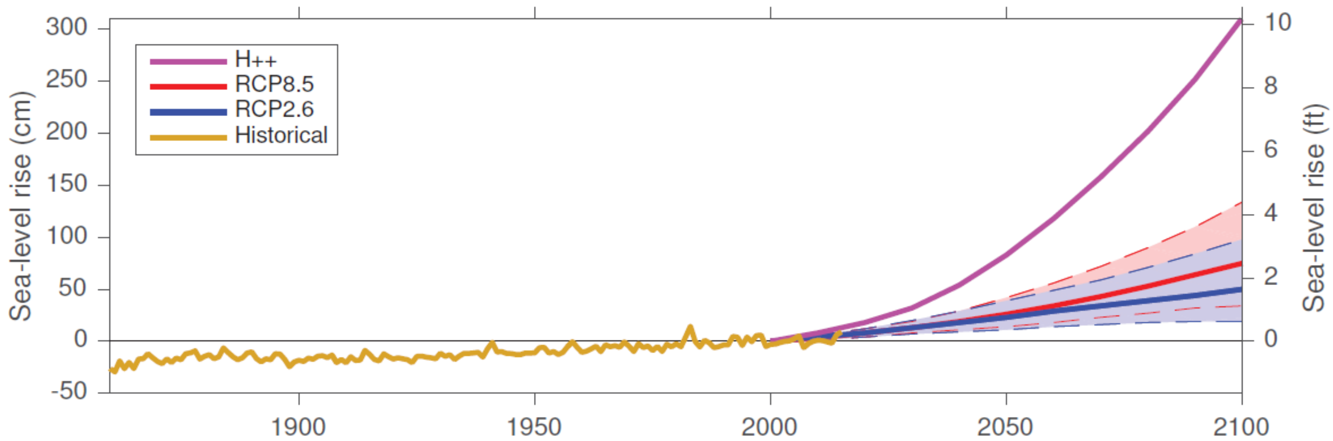


Figure 2
Relative sea level in San Francisco (from Griggs et al. 2017)

The solid RCP lines in Figure are the 50th percentiles (50% chance of occurrence/exceedance). The shaded areas bound by dashed lines 2 represent the 5th percentile (90% chance, slower SLR) and 95th percentile (5% chance, faster SLR) for the RCPs. Table 2 presents the probabilistic projections of SLR from Figure 2 with additional probabilities for the RCPs and the non-probabilistic H++ scenario (depicted in blue on the right-hand side). High emissions represents RCP 8.5; low emissions represents RCP 2.6. Because differences in SLR projections under the various emissions scenarios are minor before 2050, the update only provides RCP 8.5 projections of SLR up to 2050. **State-recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined by red boxes in Table 2.**

For longer lasting projects with less adaptive capacity and medium to high consequences should sea-level rise be underestimated, the State suggests that decision makers take the more precautionary, more risk-averse approach of using the medium-high sea-level rise projections across the range of emissions scenarios. The State further recommends incorporating the H++ scenario in planning and adaptation strategies for projects that could result in threats to public health and safety, natural resources and critical infrastructure such as large power plants, wastewater treatment, and toxic storage sites.

Table 2
Projected sea-level rise for San Francisco in Feet (CalNRA & OPC 2017)

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					
		Median *50% probability sea-level rise meets or exceeds…*	Likely range *67% probability sea-level rise is between…*		1-in-20 chance *5% probability sea-level rise meets or exceeds…*	1-in-200 chance *0.5% probability sea-level rise meets or exceeds…*	H++ scenario (Sweet et al. 2017) *Single scenario
				Low-risk Aversion		Medium - High risk Aversion	Extreme-risk Aversion
High emissions	2030	0.4	0.3 -	0.5	0.6	0.8	1.0
	2040	0.6	0.5 -	0.8	1.0	1.3	1.8
	2050	0.9	0.6 -	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6 -	1.3	1.6	2.4	
High emissions	2060	1.1	0.8 -	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8 -	1.5	1.9	3.1	
High emissions	2070	1.4	1.0 -	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9 -	1.8	2.3	3.9	
High emissions	2080	1.7	1.2 -	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0 -	2.1	2.8	4.7	
High emissions	2090	2.1	1.4 -	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0 -	2.4	3.2	5.7	
High emissions	2100	2.5	1.6 -	3.4	4.4	6.9	10.2
Low emissions	2110	1.7	1.2 -	2.5	3.4	6.3	
High emissions	2110	2.6	1.9 -	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2 -	2.8	3.9	7.4	
High emissions	2120	3	2.2 -	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3 -	3.1	4.4	8.5	
High emissions	2130	3.3	2.4 -	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3 -	3.4	4.9	9.7	
High emissions	2140	3.7	2.6 -	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3 -	3.8	5.5	11.0	
High emissions	2150	4.1	2.8 -	5.8	7.7	13.0	21.9

The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009.

Pacifica LCP Study

Considering the updated guidance discussed above, public webinars on the guidance update process[2], the latest science on SLR and the need to use existing SLR hazard data for Pacifica, the following planning horizons and future projections of SLR are proposed for the Pacifica LCP study.

Planning Horizons

The timeframe identified for a project is an important consideration for SLR projections. Until 2050, there is strong agreement among the various climate models for the amount of SLR that is likely to occur (OPC 2013). Therefore, it is important to consider a range of SLR scenarios for future planning and projects with timeframes and to look beyond 2050. The planning horizons proposed for this project are 2050 and 2100, selected to be consistent with SLR policy guidance documents. The updated guidance introduced planning horizons beyond 2100 but further horizons are outside of the project scope. The 2050 and 2100 planning horizons are recommended so that decisions about land use can be matched to the timeframe for project lifespans and to facilitate the identification of triggers for adaptation measures. By using the planning horizons of 2050 and 2100, we can assess a range of SLR that could occur at Pacifica in the mid and long-term whether or not the amounts of SLR are realized at, before or after these years. These planning horizons (years) will determine the amounts of SLR that are used to assess vulnerability to coastal flooding hazards and the timeframes over which coastal erosion hazards and consequent impacts are evaluated. Past studies of SLR impacts on Pacifica (discussed below) have also used the planning horizons of 2050 and 2100, so we may readily apply the results of those studies.

Future Projections for Sea-level Rise

Now that the draft guidance update is public, we propose that this study focus on the probabilistic projections of SLR as well as the H++ scenario. Given the timeframe for this project and assets at risk, ESA proposes to utilize the probabilistic projections from each risk aversion level and select SLR amounts that fall within the range of low and high emissions scenarios beyond 2050.A total of six SLR cases are proposed, including existing conditions (2018: no SLR), to perform the vulnerability assessment and subsequent adaptation plan. Table 4 below presents the proposed future SLR amounts based on the State-recommended projections. The SLR amounts are selected for the Low risk aversion (17% chance), Medium-High risk aversion (0.5% chance) and Extreme risk aversion (H++ scenario, probability n/a). Values for 2100 were selected within the range of low and high emissions. The probabilities associated with each projection may or may not be applied in the subsequent economics analyses.

Table 4
Proposed future SLR amounts for various levels of risk aversion with associated probability of occurrence (CalNRA & OPC 2017)

Year	Low risk (17% chance)	Med-High risk (0.5 % chance)	Extreme risk (n/a)
2050	1 ft	2 ft	-
2100	3 ft	6 ft	10* ft

*We will analyze SLR of 6 ft at 2075 in place of 10 ft at 2100 to assess flooding impacts under the extreme scenario (H++). This is required because of the lack of erosion and flooding data for 10 ft of SLR.

[2] More information can be found here: http://www.opc.ca.gov/climate-change/updating-californias-sea-level-rise-guidance/

Hazard Data for Pacifica SLR Vulnerability Assessment

There are a number of studies that have mapped coastal hazards for the Pacifica shoreline. ESA reviewed the following data sources for suitability in this analysis given modeling approach geographic coverage of hazard zones and calculation methods:

- Our Coast Our Future (OCOF)
- Pacific Institute
- Regional Sediment Management Plan, San Francisco Littoral Cell (RSM)
- Sea Change (SMC)
- FEMA maps
- Recent storm events and associated reports and data

There are differences and redundancies in the above data sources. For example, accelerated coastal erosion in response to SLR is only available in the Pacific Institute (1st generation circa 2008) and the RSM (2nd generation 2012), while the SMC Sea Change provides one example of a hybrid use of the available information. Only the RSM provides projected future beach widths. Background information and explanations of each of the above listed sources are detailed in the following sections.

ESA proposes to use OCOF flooding and Pacific Institute erosion layers (consistent with the San Mateo County-wide vulnerability assessment) in combination with erosion layers produced for the RSM plan. Utilizing the combination of these layers enables the analysis of alternative adaptation options in the next task of this project. Because this study is limited to the application of existing hazard data sources, SLR amounts assumed in these data sources do not exactly match the State-recommended SLR amounts, but are reasonably close given the uncertainty of SLR modeling and emissions scenarios. Table 5 presents the SLR amounts assumed for each hazard data source for comparison against the State-recommended values in the updated guidance document. Ranges shown for the data sources correspond to low and high SLR scenarios considered (PI and OCOF).

Table 5
SLR amounts from guidance update compared to SLR amounts for input data sources

Year	State-recommended SLR amount	PI erosion SLR amount	RSM erosion SLR amount	OCOF flood hazard SLR amount
2050	1 and 2 ft	1.4 and 1.5 ft	1.6 ft	0.8 and 1.6 ft
2100	3, 6 and 10* ft	3.3 and 4.6 ft	5 ft	3.3 and 5.7 ft

*We will analyze SLR of 6 ft at 2075 in place of 10 ft at 2100 to assess flooding impacts associated with this extreme SLR scenario (H++). This is required because of the lack of erosion and flooding data for 10 ft of SLR.

The “PI erosion SLR amount” corresponds to SLR amounts considered in the Pacific Institute study (PWA 2009). The “OCOF flood hazard SLR amount” in the fourth column corresponds to the amount of SLR to be used to evaluate flooding impacts using OCOF data. Because the OCOF hazard data was developed for SLR increments of 25 cm, it is necessary to consider these slightly different SLR amounts in order to assess flooding impacts. In order to assess flooding impacts associated with the extreme SLR scenario of 10 ft at 2100, we will apply the 6 ft OCOF flood hazards at 2075, which is when this SLR is met on the H++ curve in Figure 2. This approach was used to evaluate an extreme SLR scenario for the County of Los Angeles (ESA 2016c). The “RSM erosion surrogate SLR amount” corresponds to the SLR amounts associated with the erosion hazard data that will be used to assess vulnerability and adaptation alternatives. The differences between the SLR amount from the state guidance update and corresponding hazard data sources are small compared to the level of uncertainty associated with the SLR projections themselves.

Our Coast Our Future (OCOF)

Our Coast Our Future (Ballard et al. 2016) is a collaborative project that provides online maps and tools to help users understand, visualize and anticipate vulnerabilities to SLR and storms. The project maps 40 different SLR and storm scenarios using the USGS Coastal Storm Modeling System (CoSMoS) in an interactive web environment that includes layers for flooding extent, depth, duration, wave heights, current velocity, as well as various infrastructure and ecology layers. More OCOF information can be found at: http://data.pointblue.org/apps/ocof/cms/

The USGS developed scenarios that cover a wide range of SLR amounts (0 to 2 meters in 0.25 increments, 5 meters) and coastal storms (average conditions, 1-year, 20-year and 100-year return period) based on an ensemble of Global Climate Models (GCMs) developed for the 5th Assessment Report of the Intergovernmental Panel on Climate Change[3].

Pacific Institute

In 2009, Philip William and Associates, Ltd. (PWA, now ESA) was funded by the Ocean Protection Council to provide the technical hazards analysis supporting the Pacific Institute report on the “Impacts of Sea Level Rise to the California Coast” (PWA 2009; Pacific Institute 2009). In the course of this work, PWA projected future coastal flooding hazards for the entire state based on a review of existing FEMA hazard maps. In addition, PWA projected future coastal erosion hazard areas for the northern and central California coastline, ending at Santa Barbara. These hazard areas were used in the Pacific Institute study, which evaluated potential socio-economic impacts of SLR. The maps completed as part of the Pacific Institute study specifically stated that the results were not to be used for local planning purposes, given the use of “best statewide available data sets”; however, the modeling methods were developed to be readily re-applied as improved regional and local data became available.

Coastal Regional Sediment Management Plan, San Francisco Littoral Cell

A Coastal Regional Sediment Management Plan (CRSMP) is a guidance and policy document that discusses how Regional Sediment Management (RSM) can be applied in a rapid, cost-effective, and resource-protective manner. ESA (2016a) completed a Draft CRSMP for a segment of the San Francisco Littoral Cell along the San Francisco and San Mateo Counties Pacific coastline for the Coastal Sediment Management Workgroup (CSMW). The CSMW was a taskforce, co-chaired by the U.S. Army Corps of Engineers and the California Natural Resources Agency, and focused on the adverse impacts of coastal erosion on coastal habitats. Along with other federal, state and local/regional entities, the CSMW worked to implement RSM to augment or restore natural processes. The RSM is a source of information for Pacifica’s LCP Update, specifically the vulnerability and adaptation components, and the existing data base of assets and hazards. Coastal erosion hazards were developed for the CRSMP for a range of potential adaptation alternatives including allow erosion (do nothing), beach nourishment, beach nourishment with reef, armor, and hybrid approaches.

[3] Information can be found here: https://cmip.llnl.gov/cmip5/index.html

Sea Change San Mateo County

This study established and executed a risk-informed methodology to assess SLR vulnerability and flood risk in San Mateo County (SMC 2017). The assessment used data from all three sources mentioned above for evaluating the vulnerability of the County and its assets to coastal hazards. Specifically, SMC used a baseline scenario of today's 1% annual chance flood. The mid-level scenario is the 1% annual chance flood plus 1 meter of SLR; and, the high-end scenario used is the 1% flood plus 2 meters of SLR. As this may suggest, the study did not attribute these SLR scenarios with a time frame. This is more consistent with the CoSMoS and thus OCOF approach (discussed above), the data of which will be used in this study. Though the Pacifica study seeks to be consistent with the San Mateo County work, it is necessary for the economics analysis (to be discussed in future memos) that we assign a time and planning horizon to the differing levels of SLR.

The SMC assessment identified and evaluated vulnerability of built and natural assets, and communities to present and future coastal hazards. The effort resulted in a county-wide inventory of vulnerable assets and corresponding maps, again classified by consequences severity. The study provided profiles on a diverse group of these assets, including transportation assets, critical facilities, schools, ports, and waste water for example, to provide stakeholders a sense of scale and types of potential consequences. Each profile and the overall report offered a first glance into potential adaptation strategies that could be used to reduce flooding and erosion risk in the future.

FEMA maps

FEMA flood hazard maps, which are used for the National Flood Insurance Program, present coastal and fluvial flood hazards. FEMA recently released updated coastal flood hazard maps for San Mateo County (effective 8/2/2017) according to the 2005 Pacific Coast Guidelines (FEMA 2005a). These maps will only assess existing hazards and will not consider future erosion or projected SLR. Furthermore, FEMA maps will not present potential flood exposure to events that have a lower probability, but are larger in magnitude, than the 1% annual chance. The latest FEMA National Flood Hazard Layer is hosted online via an ArcGIS webmap[4].

Observed events, associated reports and data

Observations of coastal flooding and erosion events provide real world examples of the impacts that can be sustained by Pacifica, both in terms of the severity of a particular rain storm or wave event and the actual damages to infrastructure, property and other assets. One way to characterize the vulnerabilities that Pacifica faces with projected SLR is to estimate the return period[5] of observed events of flooding or erosion and predict how the frequency of these events (and damages) may increase in the future given climate change and SLR. For example, this is accomplished by choosing a flood event that is representative of impacts, estimating the return period for the event, and predicting future return periods at given times considering SLR. This approach was used in the vulnerability assessment prepared for the City of Del Mar (ESA 2016b). The following events may be analyzed for this study:

- 1983 winter – large swell and precipitation
- 1997-1998 El Nino – large swell

[4] http://fema.maps.arcgis.com/home/webmap/viewer.html?webmap=cbe088e7c8704464aa0fc34eb99e7f30
[5] Return Period is an estimate of the time between individual events (e.g. precipitation or wave event) of a given severity.

- January 11, 2001 – wave event and overtopping at Sharp Park seawall and erosion damages to Beach Blvd seawall (photographs shown in Figure 3)
- 2009-2010 winter – large swell and resulting bluff erosion at Manor
- January 21, 2016 – large swell (photographs in Figure 4)
- Others identified and documented by City staff (for example see account for January 2, 2006 in Figure 5)

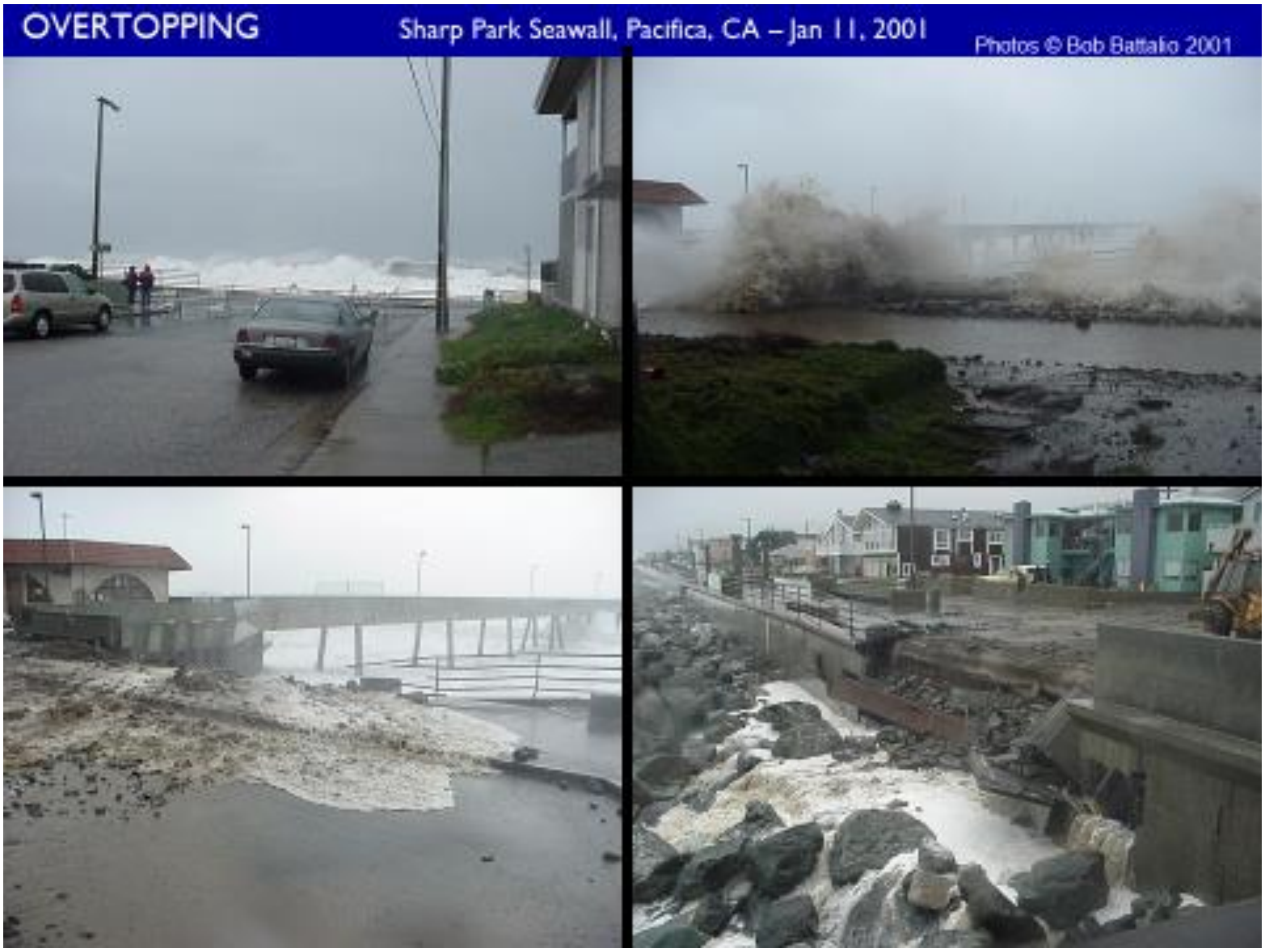
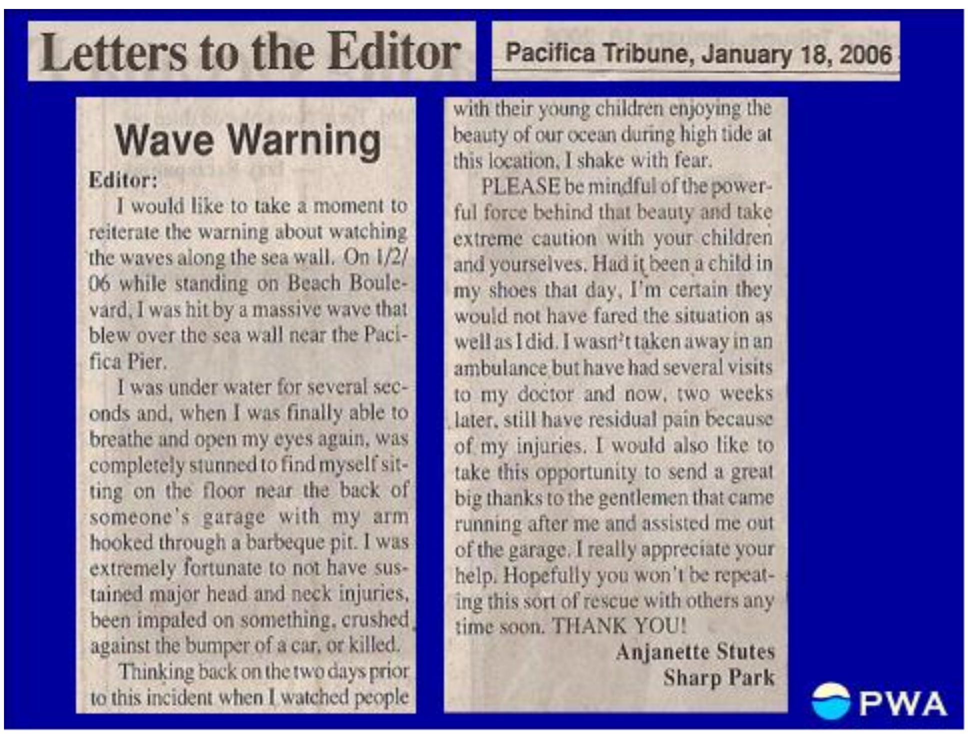


Figure 3
Observed flooding and erosion events at Pacifica on January 11, 2001

Figure 4
Observed flooding and erosion events at Pacifica on January 22, 2016



Letters to the Editor

Pacifica Tribune, January 18, 2006

Wave Warning

Editor:

I would like to take a moment to reiterate the warning about watching the waves along the sea wall. On 1/2/06 while standing on Beach Boulevard, I was hit by a massive wave that blew over the sea wall near the Pacifica Pier.

I was under water for several seconds and, when I was finally able to breathe and open my eyes again, was completely stunned to find myself sitting on the floor near the back of someone's garage with my arm hooked through a barbeque pit. I was extremely fortunate to not have sustained major head and neck injuries, been impaled on something, crushed against the bumper of a car, or killed.

Thinking back on the two days prior to this incident when I watched people with their young children enjoying the beauty of our ocean during high tide at this location, I shake with fear.

PLEASE be mindful of the powerful force behind that beauty and take extreme caution with your children and yourselves. Had it been a child in my shoes that day, I'm certain they would not have fared the situation as well as I did. I wasn't taken away in an ambulance but have had several visits to my doctor and now, two weeks later, still have residual pain because of my injuries. I would also like to take this opportunity to send a great big thanks to the gentlemen that came running after me and assisted me out of the garage. I really appreciate your help. Hopefully you won't be repeating this sort of rescue with others any time soon. THANK YOU!

Anjanette Stutes
Sharp Park

PWA

Figure 5
Reported wave overtopping event at Pacifica on January 2, 2006

References

Ballard, G., Barnard, P.L., Erikson, L., Fitzgibbon, M., Moody, D., Higgason, K., Psaros, M., Veloz, S., Wood, J. 2016. Our Coast Our Future (OCOF). [web application]. Petaluma, California. www.ourcoastourfuture.org.

Barnard, P.L., M. van Ormondt, L. H. Erikson, J. Eshleman, C. Hapke, P. Ruggiero, P. N. Adams, A. C. Foxgrover, 2014. Development of the Coastal Storm Modeling System (CoSMoS) for predicting the impact of storms on high-energy, active-margin coasts. Natural Hazards 74(2): 1095-1125. doi:10.1007/s11069-014-1236-y

California Coastal Commission, 2015. California Coastal Commission Sea-level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea-level Rise in Local Coastal Programs and Coastal Development Permits. Adopted on August 12, 2015. accessed online: http://www.coastal.ca.gov/climate/slrguidance.html.

California Natural Resources Agency (CalNRA) and California Ocean Protection Council (OPC), 2017. Draft State of California Sea-Level Rise Guidance: 2018 Update. Released November 2017.

Environmental Science Associates (ESA), 2016a, San Francisco Littoral Cell Coastal Regional Sediment Management Plan, Draft, Prepared for the US Army Corps of Engineers and the Coastal Sediment Management Workgroup.

Environmental Science Associates (ESA), 2016b, City of Del Mar Sea-Level Rise Adaptation Plan Administrative Draft. Prepared for the City of Del Mar, August 2016 updated September 2016.

Environmental Science Associates (ESA), 2016c, Los Angeles County Coastal Hazard Modeling and Vulnerability Assessment Technical Methods Report. Prepared for the City of Santa Monica, December 2016.

FEMA, 2005. Final Draft Guidelines for Coastal Flood Hazard Mapping for the Pacific Coast of the United States. Accessible:http://www.fema.gov/media-library-data/1389126436477-5bd6d5959718cf3f5a4b6e919f0c3b42/Guidelines%20for%20Coastal%20Flood%20Hazard%20Analysis%20and%20Mapping%20for%20the%20Pacific%20Coast%20of%20the%20United%20States%20%28Jan%202005%29.pdf

Griggs, G, Árvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA (California Ocean Protection Council Science Advisory Team Working Group), 2017. Rising Seas in California: An Update on Sea-Level Rise Science. California Ocean Science Trust, April 2017.

Horton, B.P., Rahmstorf, S., Engelhart, S.E., and Kemp, A.C., 2014. Expert assessment of sea-level rise by AD 2100 and AD 2300, *Quaternary Science Review*, 84: 1-6, doi: 10.1016/j.quascirev.2013.11.002.

National Resource Council (NRC), 2012. "Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future." Prepublication. National Academy Press: Washington, D. C.

Ocean Protection Council (OPC), 2013. State of California Sea-Level Rise Guidance Document, Developed by the Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT), with science support provided by the Ocean Protection Council's Science Advisory Team and the California Ocean Science Trust, March 2013 update: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf

Pacific Institute, 2009. “The Impacts of Sea-Level Rise on the California Coast.” A paper from the California Climate Change Center, May 2009.

Philip Williams and Associates (PWA), 2009. "California Coastal Erosion Response to Sea-level Rise - Analysis and Mapping." Prepared for the Pacific Institute.

Rahmstorf, S., Foster, G., and Cazenave, A., 2012, Comparing climate projections to observations up to 2011, *Environmental Research Letters*, 7: 044035, doi:10.1088/1748-9326/7/4/044035.

San Mateo County, 2017. County of San Mateo Sea-level Rise Vulnerability Assessment Draft Report. Accessed online: http://seachangesmc.com/wp-content/uploads/2015/08/Final-ALL-Compiled-Public-Draft-4-3-17-V2.pdf