Adaptation Evaluation to Confront Compound Flood Risk at a Coastal Water Sanitation Facility

SAMUEL MCWILLIAMS[1], DAVID REVELL[1], KISHEN PRATHIVADI[2]; [1]INTEGRAL CONSULTING INC., [2]SEWER AUTHORITY MID-COASTSIDE

integral

The Problem

The SAM Facility is at risk of compound flooding from two creek systems and a retreating dune field.

The Sewer Authority Mid-Coastside (SAM) wastewater treatment plant serves ~27,000 residents across six San Mateo County communities. The facility sits in the Pilarcitos Creek floodplain, ~800 ft from the Pacific, at the confluence of Pilarcitos Creek and the Kehoe Watercourse, but is not included in the FEMA flood insurance rate maps

As sea levels rise, dune erosion will migrate the Pilarcitos Creek outlet toward the facility, introducing wave interaction with fluvial discharge and putting critical infrastructure at risk. The protective berm surrounding the facility may be at risk of overtopping due to discharge through the river systems.

Integral Consulting was retained by SAM to quantify this compound flood risk and evaluate adaptation strategies.

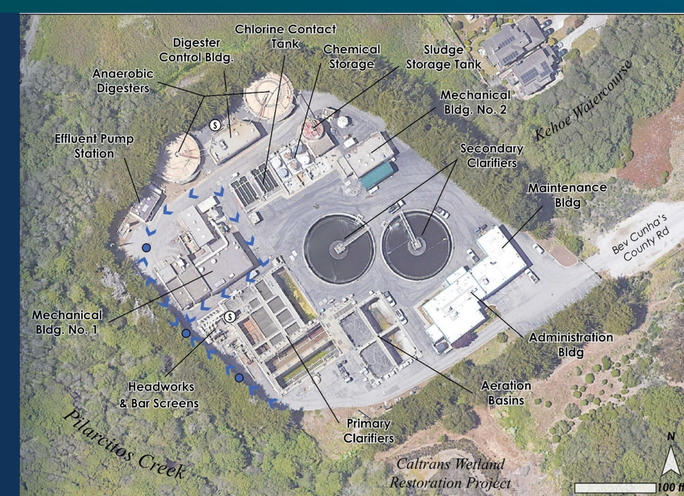

Figure 1. *SAM Plant building and features considered during the vulnerability study*

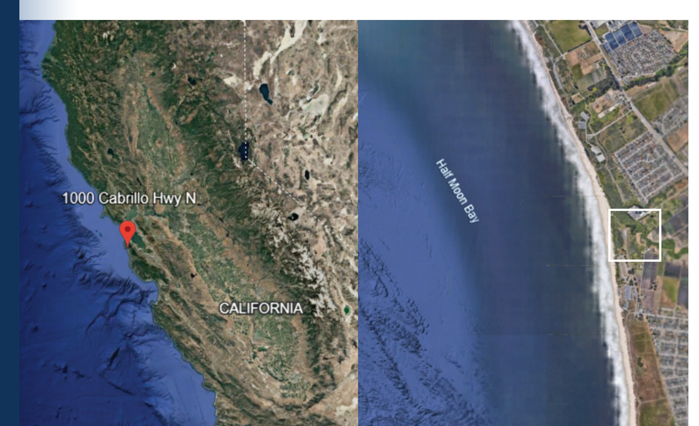

Figure 2. *Site location in Half Moon Bay, CA*

Figure 3. *Conceptual site model showing the physical processes evaluated in this study*

Modeling Approach

Three models simulate the processes contributing to flood risk.

Hydrodynamic Model:

A DFlow-FM model was used to simulate fluvial and compound flooding. The grid ranges from 50 m offshore to less than 1.5 m within the facility. Manning's *n* values from 0.025 to 0.14 represent surface roughness based on land use.

Boundary Conditions

- Pilarcitos Creek discharge from USGS gage
- Kehoe Watercourse discharge scaled by watershed area
- Ocean water levels include tide, wave setup, and sea level rise increments from 0 to 7 ft.

Dune Erosion:

Four cross-shore transects, empirical approach, dune position projected at 1-ft sea level rise (SLR) increments. Eroded geometries incorporated into updated DEMs fed back into DFlow-FM.

Wave Runup:

Boundary conditions calibrated to January 5, 2023 drift log evidence (~27 ft NAVD88), projected under each SLR increment.

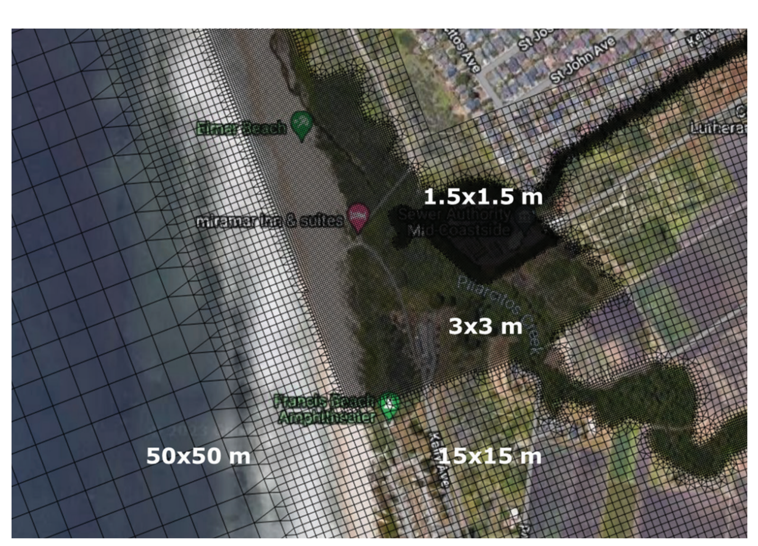

Figure 4. *Model grid resolution from the offshore domain (50x50m) to the facility and Kehoe Watercourse (1.5x1.5m)*

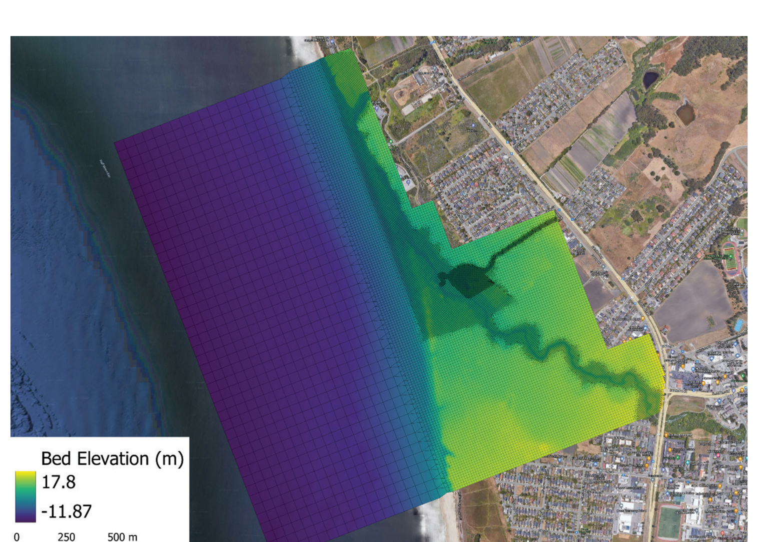

Figure 5. *Model bathymetry for present day DEM*

The Calibration Event

A December 31, 2022, atmospheric river event flooded the facility during the study period and provided the primary model calibration data set.

Peak discharge of 2,190 cubic feet per second (cfs) overtopped the berm at ~21 ft NAVD88, impacting the Mechanical Building No. 1, the electrical room, pipe gallery, and effluent building.

Integral documented flood depths on January 6, 2023, using GPS-located overbank deposits and field measurements. Extreme value analysis of USGS gage records (Station 11162630, 1987–2023) identified the event as a 37-year return period storm and yielded 100-year (2,519 cfs) and 500-year (3,212 cfs) design discharges.

A concurrent January 5, 2023, wave event deposited drift logs at ~27 ft NAVD88, providing independent coastal model calibration data.

Figure 6. *Flooding at Mechanical Building No. 1 (left); Low-lying location south of berm overtopping (right)*

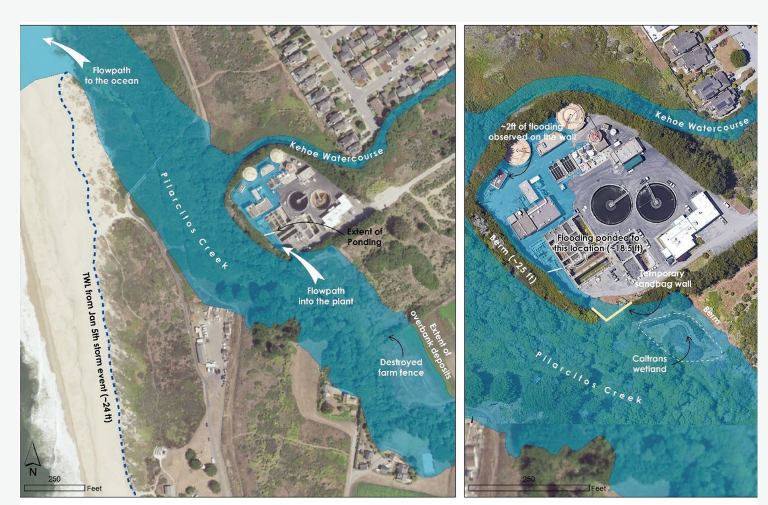

Figure 7. *Representation of fooding extents during December 31 storm derived from deposits, photos, and observations of high water*

Figure 8. *DFlow-FM model results for the December 31 storm. The model reproduced observed flood depths to within a few inches at key facility locations*

Sea Level Induced Shoreline Change

The potential for dune retreat may impact key infrastructure and alter the location of the creek mouth. A coastal hazard model considered wave conditions and sea level rise to evaluate shoreline evolution.

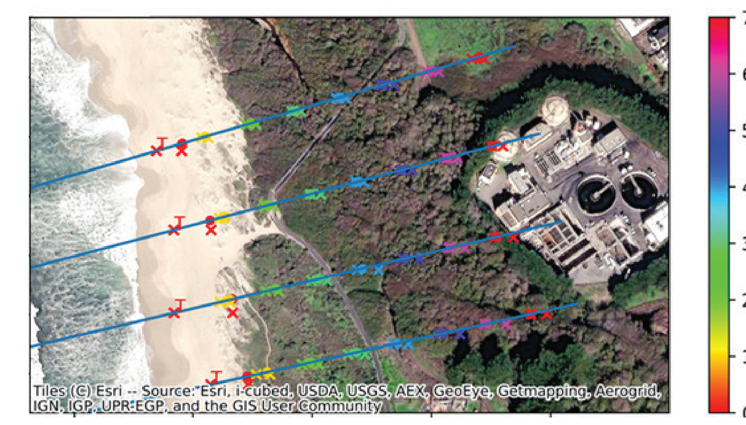

Figure 9. *The four transects considered for erosion modeling and corresponding predictions of dune toe (x points), crest (o points), and back toe (x points) locations given sea level rise projections*

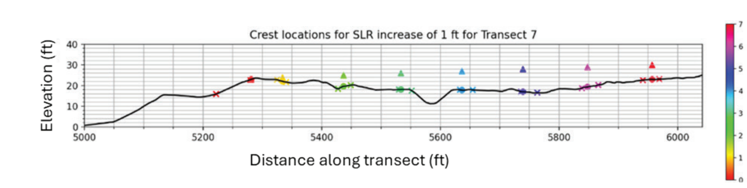

Figure 10. *Cross-sectional view of the predictions of dune crest (o) and toe (x) locations*

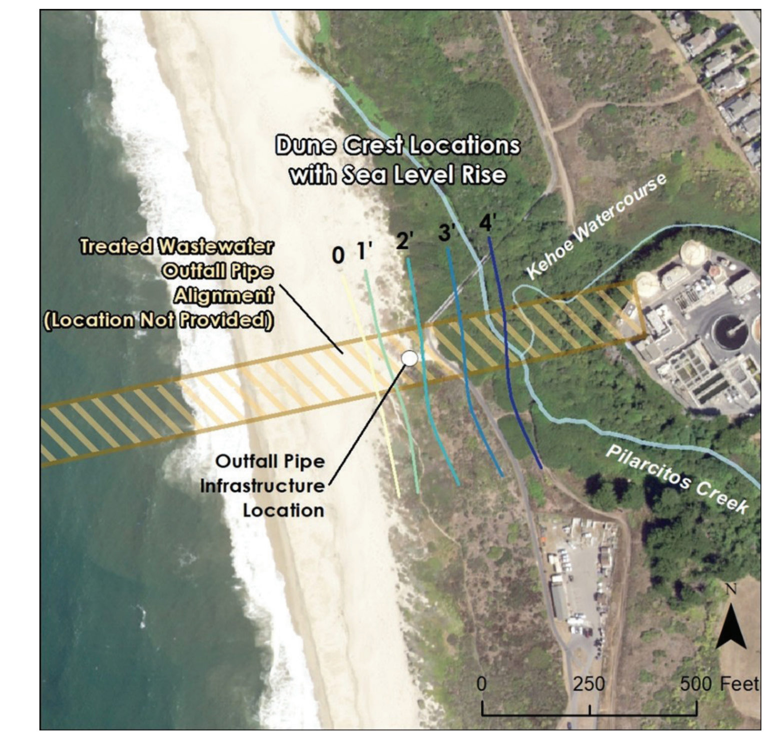

Figure 11. *Treated wastewater outfall pipe alignment with dune erosion from SLR*

Facility Flooding Adaptations

The model can be used to evaluate site response due to proposed adaptations. Modification of elevations, inclusion of structures, and changes in vegetation influence were evaluated.

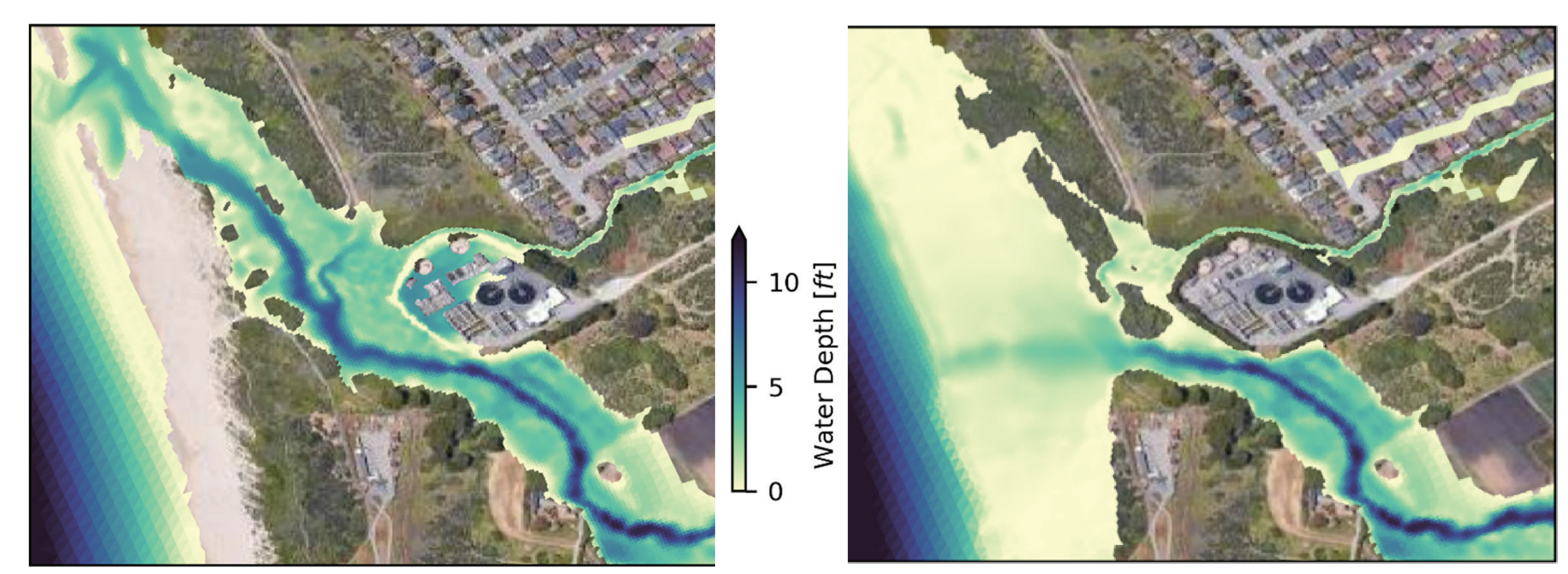

Figure 12. *Modeled flood events, 500-year discharge event with wave runup (left), 500-year fluvial flood with 4 ft SLR and berm elevation of 27 ft (right)*

Results

Compound flood risk escalates in three phases; the first critical threshold occurs before 2 ft SLR.

Controlled fluvial	Outfall Exposure	Dune breach	500-yr + 4ft SLR
Present	< 2 ft SLR (2050–2070)	4 ft SLR (2080–2100)	Design Condition
Post-2022 berm repairs protect against 100-yr discharge at current ocean levels. No protection against 500-yr event or compound coastal interaction.	Dune erosion threatens the treated wastewater ocean outfall and Elmar Beach vent structure. Outfall realignment or protection warranted.	Pilarcitos Creek outlet migrates toward the facility. Coastal wave processes begin compounding fluvial discharge, increasing flood depths and areal extent.	Flood volumes and extents substantially exceed berm capacity at the ~21 ft NAVD88 low point. Governs adaptation evaluation per OPC 2018.

Adaptation Evaluation

A berm raise to at least 27 ft (NAVD) is the only evaluated strategy providing full protection under the governing design condition.

Berm raising:

A minimum crest of 27 ft (NAVD), a 6-ft increase at the southern low point, eliminates overtopping under 500-yr + 4 ft SLR.

Berm crest (ft NAVD88)	500-yr + 4 ft SLR
~21 (existing)	Overtopped
~24.6	Partially overtopped
26.2	Marginally protective
27.0	**No overtopping**

Accommodation:

Critical components (electrical, blowers, generator, effluent pumps) require a minimum 6-ft elevation above existing grade for current flood hazard protection, increasing with SLR. Integral identified relocation sites within the existing footprint.

Nature-Based:

Vegetation management and 1-acre wetland expansion showed negligible flood risk reduction. Not recommended as standalone measures.

Conclusion

A calibrated model defines compound flood risk and a viable protection strategy.

A calibrated compound flood model quantified risk absent from FEMA mapping, produced defensible adaptation thresholds, and delivered results directly into postdisaster recovery funding applications.

Next steps: groundwater intrusion assessment via berm-perimeter monitoring wells; cost–benefit analysis across adaptation pathways; trigger-based monitoring program for phased adaptation implementation.

Contact

Sam McWilliams

Senior Consultant, Practice Director

Integral Consulting Inc.

415-787-6307

smcwilliams@integral-corp.com