REGULAR MEETING
CITIZENS’ FLOOD ZONE COMMITTEE
WEDNESDAY, SEPTEMBER 12, 2018 6:30 P.M.
CITY HALL COUNCIL CHAMBERS
450 SAN RAFAEL AVENUE
BELVEDERE, CALIFORNIA

AGENDA

OPEN FORUM

This is an opportunity for any citizen to briefly address the Committee on any matter that does not appear on this agenda. Upon being recognized by the Chair, please state your name, address, and limit your oral statement to no more than three minutes. Matters that appear to warrant a more lengthy presentation or Committee consideration will be agendized for further discussion at a later meeting.

SCHEDULED ITEMS

1. Approve minutes of the February 27, 2018, meeting of the Citizens' Flood Zone Committee

2. Update on the Department of Water Resource grant and discussion on progress of the Belvedere Lagoon Coastal Levee System Evaluation project including review of San Francisco Bay water inflow findings and design configurations needed to reduce this occurrence.
   Staff recommendation: Consider the Bay water inflow findings and provide feedback on a preferred design alternative.

ADJOURN

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The following accommodations will be provided, upon request, to persons with a disability: agendas and/or agenda packet materials in alternate formats and special assistance needed to attend or participate in this meeting. Please make your request at the Office of the City Clerk or by calling 415/435-8913. Whenever possible, please make your request four working days in advance.
CALL TO ORDER OF REGULAR MEETING

The meeting was called to order at 6:03 PM.

OPEN FORUM

No one wished to speak.

SCHEDULED ITEMS

1. Approve minutes of the October 11, 2017, meeting of the Citizens' Flood Zone Committee

The minutes were approved as presented.

2. Update on the Department of Water Resource grant and discussion on the Phase 1 Alternatives Analysis for the Belvedere Lagoon Coastal Levee System Evaluation project.

Stetson Engineer James Reilly provided a presentation to the Committee on the progress of the DWR grant. Mr. Reilly reviewed the hydrologic studies conducted for the Lagoon showing the effects of a 100-year Rain Storm event and a 100-year Coastal Storm event and stated that flood protection improvements should be designed for a 100-year Coastal
Storm event through a raised barrier. Mr. Reilly reviewed CLE Engineering’s assessment of the existing conditions at the San Rafael Avenue and Beach Road seawalls. Mr. Reilly then reviewed the next steps taken, including a meeting with the San Francisco Bay Conservation and Development Commission (BCDC) where revised sea level rise projections were provided. The Committee discussed which probability projection/risk aversion should be used to set the target for the initial levee raise and how frequently sea level rise projects from BCDC may change.

Mr. Reilly reviewed the other off shore flood protection alternatives that were considered in his review, as well as the evaluation matrix which determined that raising the levees was the best option. Mr. Reilly then showed how the proposed raised levee heights were determined and photograph mock-ups of the raised levee. The Committee discussed the impact that adding another pump to the Lagoon would have on the necessary heights of the raised levees and the process by which the Belvedere Lagoon Property Owners Association (BLPOA) would install another pump. The Committee also discussed Tiburon’s flood preparation activities and the possible location of a wall to keep overflow from Tiburon out of the Lagoon.

CLE Engineer Adrian Cormier discussed the engineering of the Beach Road seawall. The Committee discussed the cost of the various options presented and generally felt it fiscally prudent to select a design which could be added to in the future should sea level rise projections continue to rise. The Committee discussed the recommendation from staff, the history of flooding in the Lagoon, and the importance of the final product being aesthetically pleasing. Committee Member Ken Johnson made a motion, seconded by Committee Member Andrew Allen, to recommend the City Council approve staff’s recommendation to fix the immediate issues at Beach Road in such a manner that work will not need to be done twice during the next phase of the seawall project and to collect as much engineering and cost data as possible. The motion was approved unanimously.

The Committee briefly discussed the breakwater at the San Francisco Yacht Club.

Adjourn

The meeting was adjourned at 7:11 PM.

THE FOREGOING MINUTES were approved at a regular meeting of the Citizens’ Flood Zone Committee on __________________, by the following vote:

AYES: __________________________
NOES: _________________________
ABSENT: _______________________
ABSTAIN: ______________________

APPROVED: _______________________
Thomas Cromwell, Chair

ATTEST: _________________________
Craig Middleton, City Manager
TO: Citizens’ Flood Zone Committee
FROM: Craig Middleton, City Manager
Robert Zadnik, Public Works Manager
James Reilly, Stetson Engineers

SUBJECT: Progress Report on Phase 2 Alternatives Analysis for Beach Road Lagoon Coastal Levee System Evaluation.

Recommended Motion/Item Description

Consider the progress report and provide staff with comments or recommendations as to the preferred alternative(s) and further discussions with the City of Tiburon

Background

At the February 2018 Citizens’ Flood Zone Committee (CFZC) meeting, City staff and James Reilly (Stetson Engineers) presented an update on the Phase 1 Alternatives Analysis of potentially feasible types of flood protection methods for the Belvedere Lagoon area. Types of flood protection methods were described and divided into traditional and non-traditional methods located on-shore and off-shore. All methods considered had the capability of reducing the water level during the 1% annual chance coastal flood by either reducing the stillwater or wave runnup, or both. They were evaluated, and screened. The preferred type was recommended based on relevant selection criteria.

Levee raise through construction of a barrier along the levee top was identified as the preferred type of flood reduction method. Levee raise/barrier is effective; is the least costly of all types considered; could be permitted by BCDC; and could be designed in a way that adds a minimal amount of weight to underlying soils, thereby avoiding inducement of further levee settlement. Importantly, levee raise could be designed in a way that is adaptable to future sea level rise.

The purpose of this follow-up report is to present an update of the Phase 2 Alternatives Analysis, which focusses on selecting the best configuration for the levee raise/barrier. Alternative configurations varying in terms of location, size/height and arrangement were evaluated. The preferred configuration will be selected for subsequent development of landscape renderings, feasibility-level design and cost estimating, environmental review and regulatory permitting.
The San Rafael Avenue and Beach Road levee tops slightly undulate and range in elevation from a low of about 8.0 ft NAVD to over 10.0 ft NAVD. Previous hydraulic analysis, as documented in the City’s 2014 FEMA CTP Grant Study, indicated that raising the height-deficient stretches of the San Rafael Avenue and Beach Road levee uniformly by installing barriers to elevation 10.0 ft NAVD and 10.7 ft NAVD, respectively, would reduce overtopping during the present-day 1% annual chance coastal flood sufficient to prevent the lagoon from rising to flood levels. Additional height would need to be added to the barriers to account for future sea level rise and further settlement. Measures to prevent coastal floodwaters from entering the lagoon through overtopping along the Tiburon waterfront will also likely be needed in order to minimize the height required for the Beach Road levee barrier.

Installing a barrier along the top of the San Rafael Avenue levee is considered appropriate because there are no buildings on the outboard side of the levee that would be effected by the barrier. On the other hand, there are several structures on the outboard side of the Beach Road levee that may be affected, particularly with regard to building access. For this reason, additional hydraulic analysis was performed to explore non-uniform barrier heights for the purpose of reducing the required barrier height along specific reaches occupied on the outboard side by buildings. The analysis found that the barrier heights along building-occupied reaches could only be lowered a few inches, offering little benefit in terms of easier access. Therefore, only uniform barrier height was considered in the Phase 2 analysis.

Highlights of the Phase 2 analysis are described below and will be presented at the Citizens’ Flood Zone Committee on Wednesday September 12th.

**Design Approach for the Levee Barriers**

Conceptual-level designs and layouts/alignments were prepared for alternative configurations of levee barriers for San Rafael Avenue and Beach Road. The designs would reduce, but would not completely eliminate, levee overtopping. Overtopping and flow into the lagoon would be reduced sufficiently to prevent the lagoon from rising high enough to flood shoreline homes. Designs were prepared according to the following guidelines:

- Prevent coastal flooding during the 1%-annual-chance coastal flood
  - from either the southeast (over Beach Road and Tiburon shoreline) or northwest (over San Rafael Avenue), but not from both directions simultaneously, and
  - under present-day conditions and future sea-level rise conditions in year 2050;
- Be capable of being readily modified to prevent flooding under future sea-level rise conditions in year 2100;
- Keep construction
  - within public right of way and
  - within BCDC’s “shoreline band” by avoiding or minimizing construction seaward of the mean tide line;
- Provide added structural stability to Beach Road to reduce levee deformation during a strong seismic event so that access to Belvedere Island can be maintained, and provide an option for structural stability to San Rafael Avenue; and
- Avoid impacts on public access or enhance access.
Design Elevations for the Levee Barriers

Design elevations for the levee barriers were determined through hydraulic analysis of tidal and wave conditions during the 1%-annual-chance coastal flood. The analysis accounted for future sea level rise (“SLR”) and used projections recommended in the “State of California Sea-Level Rise Guidance, 2018 Update” (“State SLR Guidance”). The State SLR Guidance provides a range of future SLR projections for various probabilities and assumed projections of CO2 emissions. The higher-end SLR projection for the “Likely Range 67% Probability” under conditions of “High CO2 Emissions” was used in determining the design elevation of the barrier. This projection reflects moderate SLR relative to the other projections and was considered reasonable in light of the limited present-day efforts to combat global climate change worldwide. The design elevations used for both levee barriers was 11.6 feet NAVD88 based on the following:

- FEMA’s determined present-day 1%-annual-chance stillwater elevation 9.7 feet
- Future SLR (year 2050, most likely, high emissions) 1.1 feet
- Wave runup during 1% annual-chance flood 0.3 feet
- Future settlement (year 2050) 0.5 feet

**Design Elevation** 11.6 feet

Descriptions of Alternatives

San Rafael Avenue (Main) Barrier

This levee barrier prevents coastal flooding during storms that come from the northwest. The alignment of the barrier follows the existing pedestrian path along San Rafael Ave and the length of the barrier would be approximately 1,800 feet. Based on the existing elevation of the path, the height of the barrier would range from about 2 to 3.5 feet above the grade of the path. Three alternatives were developed for the main San Rafael Avenue Barrier. The first two involve raising the height of the existing pathway and the third involves constructing a concrete floodwall on the bayside of the existing path. All three alternatives include retaining the pedestrian path.

- **Alternative 1A:** Raise the path using concrete block retaining walls filled between with compacted fill. A small landscaping wall would be constructed at the curb of the existing roadway and compacted fill would be placed at a 2:1 slope from the landscaping wall up to the new path elevation of 11.6 feet.
- **Alternative 1B:** Raise the existing path with compacted fill and rip-rap only. Imported fill would be placed at a 2:1 slope from the existing roadway curb up to the new path elevation of 11.6 feet. New imported rip-rap would be placed on the bayside and on-top of the existing rip-rap for slope protection.
- **Alternative 2:** Construct a concrete floodwall and concrete footing on the bayside of the existing pathway. The elevation of the existing path would remain as it currently is.
San Rafael Avenue/West Shore Road Barrier
This levee barrier prevents coastal flooding that could potentially reach the lagoon by crossing the southwest flank of the San Rafael (main) barrier during storms that come from the northwest. The design elevation for the San Rafael Ave/West Shore Barrier is 10.8 feet, since this area is on natural ground and, as such, there is no anticipated wave runup or future settlement in this area. Three alternative barriers were developed for the San Rafael Ave/West Shore intersection:

- **Alternative 1:** Construct a concrete floodwall along San Rafael Avenue where it turns in an easterly direction with a retractable barrier across the intersection with West Shore Road. The retractable “FloodBreak” barrier would allow for continued vehicular and pedestrian access at the intersection and would only be deployed during a severe flood event. This alternative would require rehabilitation of the Belvedere Way connector for emergency use for West Shore residents to evacuate during a flood event when the “FloodBreak” barrier was deployed.

- **Alternative 2:** Raise the street elevation and sidewalks in the vicinity of the San Rafael Avenue/West Shore Road. The street elevation would be raised approximately 3.5 feet from the existing grade. Two existing driveways to private residences would be re-done and installed at an increased slope.

- **Alternative 3:** Construct a concrete floodwall from the main San Rafael Avenue barrier along an approximate 600 foot segment of West Shore Road (west side). Eight (8) retractable flood gates would be installed across existing driveways and walkways to provide the needed flood barrier when closed and access when open.

Beach Road Barrier
This levee barrier prevents coastal flooding during storms that come from the southeast. The length of the barrier would be approximately 1,400 feet. Three alternatives, all involving a concrete floodwall with a sheetpile foundation, were developed for the Beach Road Barrier. The alignment for the first alternative is along the seawall and Beach Road sidewalk. The alignments for the other two alternatives are primarily along the Beach Road median.

- **Alternative 1:** Construct a concrete floodwall with an alignment following the existing seawall at the edge of the Beach Road sidewalk. The length of the floodwall would be approximately 1,400 feet and height would be approximately 2.5 feet. Twenty-two (22) retractable floodgates would be installed in the floodwall to provide a flood barrier when closed and pedestrian access when open to existing buildings on the bayside of the barrier including the SF Yacht Club. The sheetpile foundation would be structurally tied into the existing seawall.

- **Alternative 2A:** Construct a concrete floodwall along the median of Beach Road and a portion along the existing seawall. The total length of the floodwall would be approximately 1,450 feet and its height would range from approximately 1.5 to 3.5 feet above existing grade. Three retractable “FloodBreak” barriers would be installed for this alternative. Additionally, three floodgates would be installed to provide flood barrier and pedestrian access to buildings located on the bayside of the barrier.

- **Alternative 2B:** Construct a concrete floodwall along the median of Beach Road. The total length of the floodwall would be approximately 1,450 feet and its height would range from approximately 1.5 to 3.5 feet. Four retractable “FloodBreak” barriers would be installed for this alternative.
Tiburon Barrier
This levee barrier prevents coastal flooding during storms that come from the southeast causing
overtopping of the downtown Tiburon shoreline and waterfront. Under present-day coastal flood
conditions the lagoon, in combination with lagoon pumps, has sufficient capacity to attenuate the
overtopping flood volume entering the lagoon. But under future SLR conditions the lagoon
capacity and pumps are insufficient to prevent lagoon shoreline flooding. A barrier to Tiburon
overtopping is needed. Three alternatives were developed for the Tiburon Barrier.

- **Alternative 1**: Purchase a temporary flood barrier (e.g., a commercially available water
  filled bladder) that would be deployed along Main Street prior to a forecasted flood
event. The temporary barrier would need to be approximately 500 feet long and 2 feet
  high.
- **Alternative 2**: Construct a permanent concrete floodwall within the City of Tiburon.
The length of the barrier would be approximately 800 feet and the height would range
  from about 2-4 feet. Four retractable “FloodBreak” barriers would be installed for this
  alternative.
- **Alternative 2B**: Construct a permanent concrete floodwall within the City of Belvedere.
The length of the barrier would be approximately 1,800 feet and the height would range
  from about 2-7 feet. Two retractable “FloodBreak” barriers would be installed for this
  alternative.

### Summary of Preliminary Conceptual-Level Capital Cost Estimates

#### Belvedere Levee Barrier Alternatives Analysis

<table>
<thead>
<tr>
<th>Concept-Level Capital Cost Estimates</th>
<th>Length of Levee Raise (ft)</th>
<th>Cost ($ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>San Rafael Ave Main Levee</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1 - Raise Existing Path</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1A - Concrete Block Walls with Imported Fill</td>
<td>1,800</td>
<td>1.7 - 3.1</td>
</tr>
<tr>
<td>1B - Imported Fill and Rip-Rap</td>
<td>1,800</td>
<td>3.1 - 3.9</td>
</tr>
<tr>
<td>Alternative 2 - Concrete Floodwall on Bayside of Existing Path</td>
<td>1,800</td>
<td>1.6 - 2.1</td>
</tr>
<tr>
<td>Option - Sheetpile San Rafael Ave for Seismic Protection</td>
<td>1,800</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>San Rafael Ave / West Shore Rd</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1 - Retractable Barrier (FloodBreak) across Intersection</td>
<td>400</td>
<td>1.7 - 2.2</td>
</tr>
<tr>
<td>Alternative 2 - Raise the Street Elevation at Intersection</td>
<td>400</td>
<td>1.1 - 1.4</td>
</tr>
<tr>
<td>Alternative 3 - Floodwall along West Shore Rd</td>
<td>600</td>
<td>1.4 - 1.8</td>
</tr>
<tr>
<td><strong>Beach Road Levee</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1 - Floodwall along Seawall with Sheetpiling*</td>
<td>1,400</td>
<td>9.1 - 11.2</td>
</tr>
<tr>
<td>Alternative 2A - Floodwall along Beach Rd Median &amp; Seawall with Sheetpiling*</td>
<td>1,450</td>
<td>8.5 - 10.5</td>
</tr>
<tr>
<td>Alternative 2B - Floodwall along Beach Rd Median with Sheetpiling*</td>
<td>1,450</td>
<td>8.8 - 10.8</td>
</tr>
</tbody>
</table>
*Sheetpiling accounts for approximately $4.5 million

| **Tiburon Barrier**                  |                           |                 |
| Alternative 1 - Temporary Barrier Along Main St | 500 | 60k - 100k |
| Alternative 2 - Flood Wall in Tiburon | 800 | 2.9 - 3.7 |
| Alternative 3 - Flood Wall in Belvedere | 1,800 | 3.4 - 4.3 |

**TOTAL PROJECT COST**  
11.3 - 27.1
Recommendation

Consider the progress report and provide staff with comments or recommendations.

Attachments

Graphics and other materials to be presented at the September 12th CFZ Committee meeting.
TABLE 1: Projected Sea-Level Rise (in feet) for San Francisco

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. 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. High emissions represents RCP 8.5; low emissions represents RCP 2.6. Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.

*Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.

<table>
<thead>
<tr>
<th>Probabilistic Projections (in feet) (based on Kopp et al. 2014)</th>
<th>H++ scenario (Sweet et al. 2017) *Single scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MEDIAN</strong></td>
<td><strong>LIKELY RANGE</strong></td>
</tr>
<tr>
<td>50% probability sea-level rise meets or exceeds...</td>
<td>66% probability sea-level rise is between...</td>
</tr>
<tr>
<td>High emissions 2030</td>
<td>0.4</td>
</tr>
<tr>
<td>2040</td>
<td>0.6</td>
</tr>
<tr>
<td>2050</td>
<td>0.9</td>
</tr>
<tr>
<td>Low emissions 2040</td>
<td>1.0</td>
</tr>
<tr>
<td>2060</td>
<td>1.1</td>
</tr>
<tr>
<td>High emissions 2060</td>
<td>1.4</td>
</tr>
<tr>
<td>2070</td>
<td>1.4</td>
</tr>
<tr>
<td>Low emissions 2070</td>
<td>1.3</td>
</tr>
<tr>
<td>High emissions 2080</td>
<td>1.7</td>
</tr>
<tr>
<td>2090</td>
<td>1.4</td>
</tr>
<tr>
<td>High emissions 2090</td>
<td>2.1</td>
</tr>
<tr>
<td>Low emissions 2100</td>
<td>1.6</td>
</tr>
<tr>
<td>High emissions 2100</td>
<td>2.5</td>
</tr>
<tr>
<td>2110*</td>
<td>1.7</td>
</tr>
<tr>
<td>High emissions 2110*</td>
<td>2.6</td>
</tr>
<tr>
<td>Low emissions 2120</td>
<td>1.9</td>
</tr>
<tr>
<td>High emissions 2120</td>
<td>3</td>
</tr>
<tr>
<td>Low emissions 2130</td>
<td>2.1</td>
</tr>
<tr>
<td>High emissions 2130</td>
<td>3.3</td>
</tr>
<tr>
<td>2140</td>
<td>2.2</td>
</tr>
<tr>
<td>High emissions 2140</td>
<td>3.7</td>
</tr>
<tr>
<td>Low emissions 2150</td>
<td>2.4</td>
</tr>
<tr>
<td>High emissions 2150</td>
<td>4.1</td>
</tr>
</tbody>
</table>

*Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.
Belvedere Levee Raise - Design Elevations

<table>
<thead>
<tr>
<th>Description</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEMA 1% Annual Chance Stillwater Elevation</td>
<td>9.7 feet NAVD 88</td>
</tr>
<tr>
<td>Future sea-level raise (2050 &quot;most likely&quot;, high emissions)</td>
<td>1.1 feet NAVD 88</td>
</tr>
<tr>
<td>Future 2050 Stillwater Elevation</td>
<td>10.8 feet NAVD 88</td>
</tr>
<tr>
<td>Wave Runup for Allowable Overtopping - San Rafael Ave</td>
<td>0.1 - 0.3 feet NAVD 88</td>
</tr>
<tr>
<td>Wave Runup for Allowable Overtopping - Beach Rd</td>
<td>0.2 - 0.3 feet NAVD 88</td>
</tr>
<tr>
<td>Future levee settlement (by 2050)</td>
<td>0.5 feet NAVD 88</td>
</tr>
<tr>
<td>Levee Raise Design Height - San Rafael Ave</td>
<td>11.4 - 11.6 feet NAVD 88</td>
</tr>
<tr>
<td>Levee Raise Design Height - Beach Road</td>
<td>11.5 - 11.6 feet NAVD 88</td>
</tr>
</tbody>
</table>
Belvedere Levee Barrier – List of Alternative Configurations
9/12/2018

San Rafael Ave Main Levee

• Alternative 1 – Raise the Existing Pathway
  o 1A – Concrete Block Walls with Imported Fill
  o 1B – Imported Fill and Rip-Rap

• Alternative 2 – Construct Concrete Floodwall on the Bayside of the Existing Path

San Rafael Ave / West Shore Rd

• Alternative 1 – Concrete Flood Wall with Retractable “FloodBreak” Across Intersection
• Alternative 2 – Raise the Street Elevation at Intersection
• Alternative 3 – Concrete Flood Wall with Flood Gates along portion of West Shore Rd

Beach Road Levee

• Alternative 1 – Flood Wall along the Bayside of Beach Road with Flood Gates

• Alternative 2 – Flood Wall along Beach Road Median with Retractable “FloodBreak” Across Intersections
  o Alignment 2A
  o Alignment 2B
San Rafael Ave. Elevation Profile Along Non-Permeable Top of Embankment

RAISED ELEVATION = 11.4 FT
TRANSECT 60
RAISED ELEVATION = 11.5 FT
RAISED ELEVATION = 11.6 FT
RAISED ELEVATION = 10.8 FT
GROUND SURFACE ELEVATION (2018 SURVEY DATA)
GROUND SURFACE ELEVATION (2010 LIDAR DATA)
NORTH OF LAGOON RD HAS REDUCED BAY MUD THICKNESS. MAY NOT HAVE FUTURE SETTLEMENT

LEGEND:
- LEVEE BARRIER ALIGNMENT (SEE FIG 2 & 3 FOR ALTERNATIVES)
- CONCRETE FOOD WALL (SEE FIG 4 ALT 1 & FIG 6 ALT 3)
- ALTERNATIVE 1 & 3: FLOOD BREAK (SEE FIG 4 ALT 1 & FIG 6 ALT 3)
- ALTERNATIVE 2: RAISE STREET ELEVATION (SEE FIG 5 ALT 2)

SOURCES:
1. GROUND SURFACE ELEVATION: FEMA LIDAR DATA 2010.
2. AERIAL PHOTO: MARIN COUNTY 2014.

DATE: SEPTEMBER 6, 2018
JN: 2364
STETSON ENGINEERS INC.

SAN RAFAEL AVE LEVEE BARRIER OVERVIEW PLAN VIEW AND PROFILE

F:\DATA\2364\AutoCAD\ConceptualDesign\SanRafaelConceptualDesignOptions.dwg
ALTERNATIVE 1A - RAISE PATHWAY WITH CONCRETE BLOCK WALLS

ALTERNATIVE 1B - RAISE PATHWAY WITH ADDITIONAL FILL

* CAN VARY 2:1 VEGETATED SLOPE TO 1.5:1, IF NECESSARY
ALTERNATIVE 2 - CONSTRUCT CONCRETE BLOCK FLOOD WALL
FIGURE 4

LEGEND:
- CONTOUR LINES (LIDAR DATA)
- WALKING PATH TO BE RAISED
- CONCRETE FLOOD WALL
- FLOOD BREAK (RETRACTABLE BARRIER)
- FLOOD GATE

SCALE (Feet)

0 30 60

SOURCES:
1. GROUND SURFACE ELEVATION: FEMA LIDAR DATA 2010.
2. AERIAL PHOTO: MARIN COUNTY 2014.

STETSON ENGINEERS INC.

INTERSECTION OF SAN RAFAEL AND WEST SHORE RD
ALTERNATIVE 1
Belvedere Way Connector
FIGURE 5

SOURCES:
1. GROUND SURFACE ELEVATION: FEMA LIDAR DATA 2010.
2. AERIAL PHOTO: MARIN COUNTY 2014.

INTERSECTIO OF SAN RAFAEL AND WEST SHORE RD
ALTERNATIVE 2

LEGEND:
- CONTOUR LINES (LIDAR DATA)
- WALKING PATH TO BE RAISED
- CONCRETE RETAINING WALL
- CONCRETE FLOOD WALL

SCALE (Feet)
0 30 60
FIGURE 6

LEGEND:
- CONTOUR LINES (LIDAR DATA)
- WALKING PATH TO BE RAISED
- CONCRETE FLOOD WALL
- FLOOD BREAK (RETRACTABLE BARRIER)
- FLOOD GATE

SOURCES:
1. GROUND SURFACE ELEVATION: FEMA LIDAR DATA 2010.
2. AERIAL PHOTO: MARIN COUNTY 2014.
Beach Rd, Elevation Profile Along the Concrete Seawall and Sidewalk

**SOURCES:**
1. GROUND SURFACE ELEVATION: FEMA LIDAR DATA 2010.
2. AERIAL PHOTO: MARIN COUNTY 2014.

**LEGEND:**
- ALIGNMENT OF CONTINUOUS CONCRETE FLOOD WALL WITH FLOOD GATES
- PEDESTRIAN FLOOD GATE (22 TOTAL)
- SECTION WITH EXISTING SEAWALL
- SECTION WITH EXISTING SEAWALL AND OPEN RAILING
- SECTION WITH EXISTING BUILDING AT SIDEWALK

**SCALE (Feet):**
0 125 250

**DATE:** SEPTEMBER 6, 2018
**JN:** J354-15

**BEACH RD LEVEE RAISE**
**ALIGNMENT ALTERNATIVE 1**
Elevation Profile Along the Road Centerline and Concrete Seawall

RAISED ELEVATION = 11.5 FT

GROUND SURFACE ELEVATION

SOURCES:
1. GROUND SURFACE ELEVATION: FEMA LIDAR DATA 2010.
2. AERIAL PHOTO: MARIN COUNTY 2014.

LEGEND:
- CONCRETE FLOOD WALL
- FLOOD BREAK (RETRACTABLE BARRIER)

SCALE (Feet)

DATE: SEPTEMBER 6, 2018
S.S. NELSON STUD PLACED ON 1' x 1' GRID.
MIN. 3" EPOXY EMBEDMENT (TYP.)

5,000PSI CEMENT CONCRETE,
\( \frac{3}{4} " \) AGGREGATE, W/FLY ASH

CORROSION RESISTANT THREADED ROD,
MIN. 6" EPOXY EMBEDMENT
1 @ 3" EITHER SIDE OF SHEET INTERLOCK

A□-28-700 SHEET PILE
20' LONG - TOP 10' EPOXY COATED

EX. CONC. SEAWALL

EX. RAILING

EX. SIDEWALK
(VARIES)

EX. GRADE

GRAPHIC SCALE

1 INCH = 2 FEET

CITY OF BELVEDERE

PROPOSED SHEET PILE TOE PROTECTION

BEACH ROAD

LOCATION

BELVEDERE, CA

CLIENT

CITY OF BELVEDERE
S.S. NELSON STUD PLACED ON 1'×1' GRID. MIN. 3" EPOXY EMBEDMENT (TYP.)

5,000PSI CEMENT CONCRETE OVERLAY W/RECURVE SECTION, 3/4" AGGREGATE, W/FLY ASH

EX. A-28-700 SHEET PILE AND TOE PROTECTION

EX. SIDEWALK (VARIES)

EX. GRADE

GRAPHIC SCALE

(IN FEET)
1 INCH = 2 FEET

CITY OF BELVEDERE

PROPOSED SEAWALL OVERLAY
BEACH ROAD

10 Commercial Blvd | Ste 100 | Novato, CA 94949

t: 415.884.8011 | www.cleengineering.com
Flood Gate Examples
## Belvedere Levee Barrier Alternatives Analysis

### Concept-Level Capital Cost Estimates

<table>
<thead>
<tr>
<th>Location</th>
<th>Alternative</th>
<th>Length of Levee Raise (ft)</th>
<th>Cost ($ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>San Rafael Ave Main Levee</strong></td>
<td>Alternative 1 - Raise Existing Path</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1A - Concrete Block Walls with Imported Fill</td>
<td>1,800</td>
<td>1.7 - 3.1</td>
</tr>
<tr>
<td></td>
<td>1B - Imported Fill and Rip-Rap</td>
<td>1,800</td>
<td>3.1 - 3.9</td>
</tr>
<tr>
<td></td>
<td>Alternative 2 - Concrete Floodwall on Bayside of Existing Path</td>
<td>1,800</td>
<td>1.6 - 2.1</td>
</tr>
<tr>
<td></td>
<td><em>Option - Sheetpile San Rafael Ave for Seismic Protection</em></td>
<td>1,800</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>San Rafael Ave / West Shore Rd</strong></td>
<td>Alternative 1 - Retractable Barrier (FloodBreak) across Intersection</td>
<td>400</td>
<td>1.7 - 2.2</td>
</tr>
<tr>
<td></td>
<td>Alternative 2 - Raise the Street Elevation at Intersection</td>
<td>400</td>
<td>1.1 - 1.4</td>
</tr>
<tr>
<td></td>
<td>Alternative 3 - Floodwall along West Shore Rd</td>
<td>600</td>
<td>1.4 - 1.8</td>
</tr>
<tr>
<td><strong>Beach Road Levee</strong></td>
<td>Alternative 1 - Floodwall along Seawall with Sheetpiling*</td>
<td>1,400</td>
<td>9.1 - 11.2</td>
</tr>
<tr>
<td></td>
<td>Alternative 2A - Floodwall along Beach Rd Median &amp; Seawall with Sheetpiling*</td>
<td>1,450</td>
<td>8.5 - 10.5</td>
</tr>
<tr>
<td></td>
<td>Alternative 2B - Floodwall along Beach Rd Median with Sheetpiling*</td>
<td>1,450</td>
<td>8.8 - 10.8</td>
</tr>
<tr>
<td></td>
<td><em>Sheetpiling accounts for approximately $4.5 million</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tiburon Barrier</strong></td>
<td>Alternative 1 - Temporary Barrier Along Main St</td>
<td>500</td>
<td>60k - 100k</td>
</tr>
<tr>
<td></td>
<td>Alternative 2 - Flood Wall in Tiburon</td>
<td>800</td>
<td>2.9 - 3.7</td>
</tr>
<tr>
<td></td>
<td>Alternative 3 - Flood Wall in Belvedere</td>
<td>1,800</td>
<td>3.4 - 4.3</td>
</tr>
</tbody>
</table>

**TOTAL PROJECT COST**  
11.3 - 27.1
## DWR LLAP Grant Implementation Plan

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Task</th>
<th>Outcome</th>
<th>DWR’s Cost Share (55%)</th>
<th>City’s $ Cost Share (45%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>End</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 months</td>
<td>FEMA CLOMR</td>
<td>FEMA issues CLOMR</td>
<td>33,000</td>
<td>28,000</td>
</tr>
<tr>
<td>5 months</td>
<td>Stop?</td>
<td>off-ramp</td>
<td>Feasibility Study and Phase 2 Geotechnical and Coastal Structural Evaluation of Modified Levees</td>
<td>Prepare feasibility-level design and estimate cost for preferred alternative w/sea level rise adaptability</td>
</tr>
<tr>
<td>12 months</td>
<td>Stop?</td>
<td>off-ramp</td>
<td>Environmental Review and Permitting</td>
<td>Prepare CEQA/NEPA documentation; prepare environmental permit applications</td>
</tr>
<tr>
<td>5 months</td>
<td>Stop?</td>
<td>off-ramp</td>
<td>Alternatives Analysis</td>
<td>Develop alternatives for 100-year flood protection, estimate costs; identify preferred alternative</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Phase 1 Geotechnical and Coastal Structural Evaluation of Existing Levees</td>
<td>Identify deficiencies, describe remedial measures, estimate costs</td>
</tr>
</tbody>
</table>

* Does not include City’s in-kind contribution (staff time) of approximately $25,000.