- FINAL REPORT -
TOWN-WIDE STORM DRAINAGE AND FLOOD CONTROL STUDY
PHASE 2

For

TOWN OF CORTE MADERA

December 2008

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Civil + Structural Consulting Engineers

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LIST OF REFERENCES

1. Anderson, Nichols & Co., Inc., "Flood Control Study in the Vicinity of Lucky Drive & Highway 101, Marin County, California," July 1984.
2. A-N West, Inc., "Conceptual Design Report to Town of Corte Madera, High Canal Storm Water Pump Station at Lucky Drive," July 1993.
3. A-N West, Inc., "Town of Corte Madera, Study [of] Management of lagoon #1 and Marquart Lagoon," July 20, 2000.
4. EDAW, "Lucky Drive Levee Project, Phase II, Administrative Draft Environmental Impact Report," March 2, 2001.
5. EOA, Inc., "Town of Corte Madera, Lagoon Management Report," July 2000.
6. Harding Lawson Associates, "Geotechnical Investigation, Lucky Drive Drainage and Flood Control Improvements, Corte Madera, California," March 17, 1986; Letter of Supplemental Geotechnical Information, April 8, 1986; Addendum, July 21, 1986.
7. Harding Lawson Associates, "Soil Engineering Recommendations, Boat House on Lucky Drive, Corte Madera, California," June 4, 1987.

8. Kennedy/Jenks Engineers, "Engineering Report, Flood Control Study, Madera Gardens Area, Town of Corte Madera," October 1983.
9. Lee & Praszker, "Flood control Study, Corte Madera, Marin County, California," October 1, 1975.
10. Town of Corte Madera, "Initial Environmental Study and Mitigated Negative Declaration, Lucky Drive Flood control Project," April 1986.
11. Town of Corte Madera, "Resolution No. 3198, Amendment to Town Council's Lagoon and Marsh Management Policies, to be titled *Water Quality Management Policy,*" adopted October 16, 2001.
12. Yoder-Trotter-Orlob, "A Master Storm Drainage Plan for the Town of Corte Madera," December 1970.

1. EXECUTIVE SUMMARY

1.1 Purpose of Study

The purpose of this Study is to update the Town's Storm Drainage Master Plan in a phased approach. This project is Phase 2 of this update and includes Watersheds 1, 2, 3, 4, 8, 9, and 10 (Refer to Exhibit A, Watershed Map).

The Town's objective for this project is to study the flooding potential and assess the flood control facilities within these Watersheds 1, 2, 3, 4, 8, 9, and 10. The study, at a minimum, should provide "realistic and viable solutions for the prevention of tidal flooding, alternative methods for the elimination of curb and street ponding, and a list of future capital improvements necessary for sustained operation of existing facilities, and for the improvement of sub-standard and/or now inadequate drainage systems throughout the watersheds."

1.2 Study Limits

The study limits encompass Watersheds 1, 2, 3, 4, 8, 9, and 10 (Refer to Exhibit A) in the Town of Corte Madera. These watersheds cover all of the Town west of the former Northwestern Pacific Railroad (NWPRR) track and US Highway 101 plus Watershed 8, which is off Paradise Drive at the east Town limit.

Watershed 1 lies generally between Pixley Avenue and Madera Boulevard. Draining to Lagoon No. 1 and Low Canal, its southerly limit is the ridgeline south of Tamalpais Drive. Its north limit is Chickasaw Avenue. It includes a portion of Town Park and a limited amount of commercial development along Tamalpais Drive. The rest of the watershed is residential. The southern portion is quite steep while the northern portion is flat and low-lying. Watershed 1 covers 167 acres.

Watershed 2 lies northeast of Palm Hill and drains to Marquart Lagoon. This low-lying area is entirely residential. Watershed 2 covers 33 acres

Watershed 3 contains the southwest corner of the Town and drains into High Canal. Some of the northwesterly portion of Watershed 3 lies within the City of Larkspur. Land uses are mostly residential, with commercial land use along the main streets. Watershed 3 also includes Town Hall and a portion of Town Park. The southern portion is quite steep while the northern portion is flat and low-lying. Some of the steep hillsides are still in their natural state. Watershed 3 covers 406 acres.

Watershed 4 straddles Highway 101 and drains to Shorebird Marsh. Its south limit is the ridgeline south of Tamalpais Drive. Its east limit follows the route of the abandoned Northwestern Pacific Railroad (NWPRR) line east of and parallel to Highway 101 northward to Rich Street. From Rich Street, the limit turns back toward the southwest along the abandoned NWPRR line that came from Larkspur. It continues southwesterly along Wornum Drive under US-101. Continuing southward, the limit generally follows Tamal Vista Boulevard and Madera Boulevard to south of Tamalpais Drive, extending back up to the ridgeline. Land use is residential and commercial south of Tamalpais Drive, and commercial and marsh area to the north. The commercial area includes Town Center Corte Madera and The Village at Corte Madera. The southern portion is quite steep, while the northern portion is flat and, in places, low-lying. Watershed 4 covers 307 acres.

Watershed 8 is east of Highway 101 and drains to San Francisco Bay. It lies between Westward Drive and the easterly Town limit beyond Robin Drive. It extends northward from the ridgeline to San Francisco Bay. Land use includes Marin Country Day School, an apartment complex, and an industrial/commercial property. The southern portion of the watershed is steep and undeveloped. The most southerly portion lies within the City of Tiburon. Watershed 8 covers 206 acres

Watershed 9 straddles Highway 101 and drains to Lagoon A (Black Kettle Lagoon) and Corte Madera Creek at Lucky Drive. It extends north from Wornum Drive to the north Town Limit at Corte Madera Creek. This low-lying area is predominately commercial use, including the Marin Municipal Water District offices, and some residential use. East of Highway 101, a portion of Watershed 9 lies within the City of Larkspur. Watershed 9 covers 72 acres.

Watershed 10 is on the northeast side of Palm Hill. It drains to the channel north of Birch Avenue, which drains to Redwood Marsh. The upper portion is a steep hillside and the lower portion relatively flat. The only land use is residential. Watershed 10 covers 22 acres.

1.3 Conclusions

Based on this study, the following are our conclusions:

1.3.1. Flood-related Problems

The flood related problems in the study area can generally be described by location as follows:

- Upper watersheds on the hillsides (south of Tamalpais Drive): The flood problems are mainly due to undersized storm drain pipes and poor inlet conditions. There are very few upper watershed flood problems as reported by the Town.
- Lower watersheds on relatively flat terrain (north of Tamalpais Drive): The flood problems are due to settlement, including some differential settlement, undersized storm drainage pipes, and tidal inundation.

1.3.2. Flooding Conditions within Lower Watersheds

There are two types of flooding conditions in the lower watersheds:

- Flooding due to storm water runoff in areas that have an inadequate local storm drainage system (interior drainage problems)
- Flooding due to tidal inundation by waters of San Francisco Bay and Corte Madera Creek

Of the two flooding conditions, tidal inundation has caused the majority of flooding in residential and commercial properties around the Lucky Drive area (yards and some garages). In addition, street ponding due to an inadequate storm drainage system and differential settlement has become very common and continues to be a major concern for the Town and the residents. The solutions to these two flooding problems are basically independent of each other, yet both need to be solved for a total comprehensive solution.

1.3.3. Flooding Solutions

In general, the solution to the inadequate storm drainage system is to:

- Provide continuous curb drainage in areas of curb ponding
- Replace and/or augment the existing storm drainage system with new storm drain pipes, catch basins, and manholes
- Improve existing pump stations so they can adequately discharge storm flows, including storm events coincident with high tides
- Provide new pump stations where the stormdrainage system cannot handle the design runoff by gravity alone..

In general, the solution to the tidal inundation is to:

- Install floodwalls and levees along the portion of the south bank of Corte Madera Creek that lies within the Corte Madera Town Limit.
- Install floodwalls and levees along the portion of the south bank of Corte Madera Creek that lies outside the Corte Madera Town Limit. These would be located on a combination of unincorporated land, the Highway 101 right-of-way (also unincorporated land), and a portion of the City of Larkspur*. Being outside the Corte Madera Town limit, these floodwalls and levees are outside the scope of this study. They are shown schematically on Exhibit K but are not included in the construction cost estimates.*
- Reconstruct and raise the existing levee along the old NWPRR embankment parallel to and east of Highway 101 to protect against high tide events.

Tidal inundation improvements outside the Town Limits are shown schematically on Exhibit K.

1.4. Recommendations

We propose that the solutions to the two flooding conditions within the lower watersheds be phased, with the intent that the solutions to the inadequate storm drainage systems be constructed first. This is because we anticipate that construction of these interior drainage improvements would present significantly fewer and lesser environmental impacts than solutions to the tidal flooding problems.

1.4.1. Storm Drainage Improvements

We recommend the system of storm drainage improvements. (Refer to the separately bound drawings for locations and details):

1. Replacing/improving and maintaining the existing stormwater pump stations
2. Replacing sections of standard curb and gutter with grated drain lines
3. Installation of additional street catch basins
4. Replacement of some sections of storm drain pipe with larger pipes
5. Installation of additional new storm drain pipes and manholes

In areas where there is street ponding or "bird baths" due to differential settlement, the existing curb and gutter will be replaced by segments of grated line drains as shown on the separately bound drawings.

1.4.2. Tidal Inundation Improvements

We recommended the following tidal inundation improvements (Refer to the separately bound drawings for locations and details):

1. Install concrete or masonry floodwalls along Corte Madera Creek with an initial top of wall elevation of 8.5 feet National Geodetic Vertical Datum (NGVD). The walls should be constructed with the footings wide enough to allow the tops of the walls to be raised by up to 3 feet in the future. This would allow for additional protection and could account for future settlement. For comparison, Elevation 7.0 feet NGVD is the minimum allowable floor elevation for new building construction in a flood plain in the Town of Corte Madera, per Town ordinance.

2. Install levees between the sections of floodwall along Corte Madera Creek with an initial top elevation of 9.0 feet NGVD. A 3-foot high floodwall could be added to the top of these levees in the future for additional protection.

3. Reconstruct and raise the existing levee along the old NWPRR embankment parallel to Highway 101 to an initial top elevation of 10.0 feet NGVD. A 2-foot high floodwall could be added at a future date for additional protection.

4. Install floodwall and levee stairway access at various locations, as shown on the drawings.

5. Remove and replace affected existing docks. Details to be determined during final design.

6. Install lined drainage ditches and gravity outlet drainage boxes behind floodwalls and levees. Provide the outlet pipes with "duckbill" type check valves, as shown on the drawings.

The heights of the floodwalls and levees would vary along their lengths, as shown on the profiles on the drawings. In general, most of the sections of floodwall and levee along Corte Madera Creek would be approximately three to five feet above the existing ground at the floodwall location. The depths of fill along the old NWPRR embankment (NWPRR Levee) would generally be from two to three feet. (In both locations, some segments would be lower or higher than these values, as shown on the profiles.)

1.4.3. Basis for Recommended Elevations for Tops of Floodwalls and Levees

The recommended elevations for tops of floodwalls and levees along Corte Madera Creek are based on review of the numerous past reports and tidal studies by various agencies and consultants. They are in line with EDAW's *Design Option No. 2: Modified FEMA Design* for the recommended initial construction; and with EDAW's *Design Option No. 1: FEMA Design* for the recommended ultimate construction. (Reference 4, EDAW, 2001, Page 3-8.)

1.4.4. FEMA (Federal Emergency Management Agency) Requirements

To qualify for FEMA-approved 100-year protection for the study area, improvements would have to be made to provide the minimum freeboards for both coastal and riverine conditions. These minimums are:

- Riverine area levees and floodwalls (along Corte Madera Creek in Watershed 9) must provide a minimum freeboard of 3 vertical feet above the water-surface level

of the base flood. A minimum freeboard of 4 vertical feet is required within 100 feet horizontally either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. A minimum freeboard of 3.5 vertical feet is required at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee. In regards to the levee sections along Corte Madera Creek, FEMA has indicated that "Even though the tide comes into Corte Madera Creek, the flood stage is the governing factor, therefore the levees would have to meet the riverine minimum freeboard standard (44 CFR 65.10b1)..." (EDAW, Page 3-10.)

For the ultimate FEMA 100-year design elevation of 11.0 feet NGVD, the floodwalls would be raised and low floodwalls would be built on top of the sections of levee between the floodwalls.

- Coastal area levees and floodwalls (along the bay in Watersheds 4 and 9) must provide a minimum freeboard of 1-foot above the height of the one percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation at the site. (EDAW, Page 3-10.)

  For the ultimate FEMA 100-year design elevation of 12.0 feet NGVD, a two-foot high floodwall could be added to the NWPRR Levee.

For a FEMA Flood Insurance Rate Map (FIRM) revision, FEMA would require the Town's storm drainage and flood protection system to meet NFIP criteria and provide flood protection from the 100-year flood. Upon completion of construction, the Town would apply to FEMA for a "Letter of Map Revision" (LOMR). This would require an Interior Drainage Study, filling out a Levee/Floodwall System Analysis Form, and a stability and seepage analysis of the levees. FEMA would also require that all stormwater pump stations be provided with permanent "on-site" stand-by generators or other uninterruptible power sources. (Only the High Canal Pump Station has a power supply meeting this requirement.) Upon approval by FEMA, they would issue an A-99 Interim Designation Letter of Map Revision (LOMR).

While FEMA approval would eliminate the legal requirement that flood insurance be purchased as a condition of obtaining a loan from a federally insured or regulated lender, a lending institution may, at their discretion, still require purchase of flood insurance. It must be noted that removal from the FEMA 100-year flood plain does not guarantee protection from all future floods and, therefore, each property owner should consider the level of risk they are willing to accept in their decision regarding flood insurance coverage. However, once an area is removed from the 100-year flood plain, flood insurance rates would probably be substantially reduced.

1.5. Estimated Preliminary Construction Cost Estimates

The following budgetary level construction cost estimates were prepared using escalated unit prices to mid 2009 (Refer to Appendix A).

The construction cost estimates do not include any cost for utility relocations, permanent or temporary construction easements, environmental studies, permitting, or engineering design services.

The recommended Storm Drainage Improvements total construction cost is estimated to be $5,600,000.

The recommended Tidal Inundation Improvements total construction cost is estimated to be $4,800,000.

1.6. Anticipated Functional Life of Storm Drainage Facilities

The following are typical expected economic life expectancies of storm drainage facilities:

Pump Station Electrical and Mechanical Equipment..... 25 Years
Pump Station Structures..... 50 – 100 Years
Storm Drainage pipes..... 50 Years

2. INTRODUCTION

2.1. Purpose of Study

The Town of Corte Madera is seeking to update its Storm Drainage Master Plan in a phased approach. This project is Phase 2 of this update and includes Watersheds 1, 2, 3, 4, 8, 9, and 10. (Refer to Exhibit A). This phase includes all portions of the Town west of the former NWPRR tracks east of US-101 plus Watershed 8, which is on Paradise Drive at the east Town Limit.

The Town's objective for this project is to study and assess the flood control facilities within Watersheds 1, 2, 3, 4, 8, 9, and 10. The study at a minimum should provide "realistic and viable solutions for the prevention of tidal flooding, alternative methods for the elimination of curb and street ponding, and a list of future capital improvements necessary for sustained operation of existing facilities and for the improvement of sub-standard and/or now inadequate drainage systems throughout the watersheds".

2.2. Study Limits

The study limits encompass Watersheds 1, 2, 3, 4, 8, 9, and 10 (Refer to Exhibit A) in the Town of Corte Madera. These watersheds cover all of the Town west of the former NWPRR track east of and parallel to US Highway 101 plus Watershed 8, which is off Paradise Drive at the east Town limit.

Watershed 1 lies generally between Pixley Avenue and Madera Boulevard. Its sub-watersheds drain to:

- Low Canal, which drains to Lagoon 1, or
- Edgewater Lagoon which drains to Lagoon 1, or
- Directly to Lagoon 1

Lagoon 1 drains to High Canal through its pump station and/or the adjacent floodgates, depending on the relative water levels of the lagoon and the canal. High Canal discharges to Corte Madera Creek through the High Canal Pump Station and/or its tide gates. The watershed's southerly limit is the ridgeline south of Tamalpais Drive. Its north limit is Chickasaw Avenue. It includes a portion of Town Park and a limited amount of commercial development along Tamalpais Drive. The rest of the watershed is residential. The southern portion is quite steep while the northern portion is flat and low-lying. Watershed 1 covers 167 acres.

The Lagoon 1 Pump Station has the following characteristics (References 8 and 12):

Nominal Pump Station Discharge Capacity .....40 cfs (18,000 gpm)

Number of Pumps .....4 Each
(2 @ 3,000 gpm & 2 @ 6,000 gpm = 18,000 gpm)

Horsepower of Pumps 2 @ 25 HP & 2 @ 50 HP)

The pumps are electrically powered and are of the "motor above base" type.

Watershed 2 lies northeast of Palm Hill and drains to Marquart Lagoon. Marquart Lagoon drains to High Canal through flood gates and/or the adjacent pump station, depending on the relative water levels in the lagoon and the canal. High Canal discharges to Corte

Madera Creek through the High Canal Pump Station and/or its tide gates. This low-lying area is entirely residential. Watershed 2 covers 33 acres.

The Marquart Lagoon Pump Station has the following characteristics (Reference 12):

Nominal Pump Station Discharge Capacity .....4.5 cfs (2,000 gpm)

Number of Pumps .....1 Each

The pump described above has been replaced by a smaller pump having a discharge capacity of 2.5 cfs (Reference 3). The replacement pump is electrically powered and is of the submersible type.

Watershed 3 contains the southwest corner of the Town and drains into High Canal or into Pixley Lagoon, which drains into High Canal. High Canal discharges to Corte Madera Creek through the High Canal Pump Station and/or its tide gates. Some of the northwesterly portion of Watershed 3 lies within the City of Larkspur. Land uses are mostly residential, with commercial land use along the main streets. Watershed 3 also includes Town Hall and a portion of Town Park. The southern portion is quite steep while the northern portion is flat and low-lying. Some of the steep hillsides are still in their natural state. Watershed 3 covers 406 acres.

The High Canal Pump Station has the following characteristics:

Nominal Pump Station Discharge Capacity .....186 cfs (83,750 gpm)

Number of Pumps .....4 Each
(1 @ 8,750 gpm & 3 @ 25,000 gpm = 83,750 gpm)

Horsepower of Pumps .....1 @ 44 HP & 3 @ 135 HP

The pumps are electrically powered and are of the submersible type.

Watershed 4 comprises two sub-watersheds, 4A and 4B.

Sub-Watershed 4A straddles Highway 101 and drains to Shorebird Marsh, which is drained to San Francisco Bay by the Shorebird Marsh Pump Station. Its south limit is the ridgeline south of Tamalpais Drive. Its east limit follows Meadowsweet Drive and Canow Street to Casa Buena Drive. It extends west 300 feet along the south side of Casa Buena, crosses Casa Buena, and follows the north side of Casa Buena to Highway 101. Crossing 101, it continues east to the route of the abandoned NWPRR line east of, and parallel to, Highway 101. The limit then runs northward along the abandoned NWPRR to Rich Street. From Rich Street, the limit turns back toward the southwest along the abandoned NWPRR line that came from Larkspur. It continues southwesterly along Wornum Drive under US-101. Continuing southward, the limit generally follows Tamal Vista Boulevard and Madera Boulevard to south of Tamalpais Drive, extending back up to the ridgeline. Land use is residential and commercial south of Tamalpais Drive, and commercial and marsh area to the north. The commercial area includes Town Center Corte Madera and The Village at Corte Madera. The southern portion is quite steep, while the northern portion is flat and, in places, low-lying. Sub-Watershed 4A covers 264 acres.

The Shorebird Marsh Pump Station has the following characteristics:

Nominal Pump Station Discharge Capacity .....40 cfs (18,000 gpm)

Number of Pumps .....3 Each
(3 @ 6,000 gpm = 18,000 gpm)

Horsepower of Pumps .....3 @ 25 HP

The pumps are driven by diesel engines through right angle drives.

Sub-Watershed 4B also straddles Highway 101 but drains to the Marina Village Pump Station, which discharges to San Francisco Bay. Its south limit is the ridgeline south of Tamalpais Drive. Its east limit follows the route of the abandoned NWPRR line east of, and parallel to, Highway 101 to the levee around the detention basin at the Marina Village Pump Station. From the pump station levee, the limit runs west across Highway 101 to Casa Buena Drive. It extends west along the north side of Casa Buena to a point 300 feet west of Canow Street, crosses Casa Buena, and returns along the south side of Casa Buena to Canow. It turns south along Canow and follows Meadowsweet Drive to the ridgeline. Sub-Watershed 4B covers 43 acres.

The Marina Village Marsh Pump Station has the following characteristics:

Nominal Pump Station Discharge Capacity .....40 cfs (18,000 gpm)

Number of Pumps .....3 Each
(3 @ 6,000 gpm = 18,000 gpm)

The pumps are electrically powered and are of the submersible type.

Watershed 8 is east of Highway 101 and drains to San Francisco Bay through gravity outfalls. It lies between Westward Drive and the easterly Town limit beyond Robin Drive. It extends northward from the ridgeline to San Francisco Bay. Land use includes Marin Country Day School, an apartment complex, and an industrial/commercial property. The southern portion of the watershed is steep and undeveloped. The most southerly portion lies within the City of Tiburon. Watershed 8 covers 206 acres.

Watershed 9 straddles Highway 101. It extends north from Wornum Drive to the north Town Limit at Corte Madera Creek. Its sub-watersheds drain to:

- Town Corporation Yard Pump Station which discharges into Corte Madera Creek, or
- Black Kettle Lagoon (Lagoon A) which is drained to Corte Madera Creek by the Lucky Drive Pump Station, or
- Directly into High Canal which is drained to Corte Madera Creek by the High Canal Pump Station, or
- Directly into Corte Madera Creek

The portion of Watershed 9 east of Highway 101 lies within the City of Larkspur and drains into Black Kettle Lagoon. This watershed is low-lying and is predominately commercial use, including the Marin Municipal Water District offices, and some residential use. Watershed 9 covers 72 acres.

The Lucky Drive Pump Station, which drains Black Kettle Lagoon, has the following characteristics:

Nominal Pump Station Discharge Capacity .....60 cfs (27,000 gpm)

Number of Pumps .....3 Each
(3 @ 9,000 gpm – 27,000 gpm)

Horsepower of Pumps .....3 @ 60 HP

The pumps are electrically powered and are of the submersible type.

Construction of the replacement Corporation Yard Pump Station is scheduled for Fall 2008. It will have the following characteristics:

Nominal Pump Station Discharge Capacity .....7.2 cfs (3,200 gpm)

Number of Pumps .....2 Each
(2 @ 1,600 gpm = 3,200 gpm)

Horsepower of Pumps .....2 @ 12 HP

The pumps will be electrically powered and will be of the submersible type.

Watershed 10 is on the northeast side of Palm Hill. It is also known as "The Apache Watershed." It drains to a channel leading to Redwood Marsh. The marsh is drained to Corte Madera Creek by the Redwood Marsh Pump Station which is operated by the City of Larkspur. The upper portion is a steep hillside and the lower portion relatively flat. Land use is entirely residential. Watershed 10 covers 22 acres.

2.3. Scope of Services

The following tasks are copied from the agreement for professional services between the Town of Corte Madera and A-N West, Inc. The word "We" refers to A-N West and/or their subconsultants. The phrase "Cost Estimate" in all cases refers to a "Statement of Probable Construction Costs" which is based on the preliminary designs presented in this Phase 2 study. The word "KSR" refers to Kister, Savio, and Rei who are surveying and mapping subconsultants to A-N West.

Task 1 – Review Existing Documents (ANW)

Review existing documents relating to flooding and flood control in watersheds 1, 2, 3, 4, 8, 9 and 10. Documents to be reviewed will include A-N West, Inc. past studies and plans within the watersheds, and existing aerial and topographic maps available from the Town of Corte Madera, including the Storm Drainage Maps dated 1985.

We will use these existing Storm Drainage Maps dated 1985 as a reference for general layout of the existing storm drainage system, its pipe sizes, and its drainage inlet locations.

Task 2 – Review and Assessment of Existing Facilities (ANW)

We will meet with the Town Engineer and Maintenance Staff to review the existing flood control and drainage facilities including existing storm water pump stations, slide and flap gates, areas of known levees and floodwalls, ponds and canals, and areas of known flooding and erosion. After reviewing the existing documents in Task 1 and reviewing the existing facilities with the Town, we will make extensive site visits to observe the existing facilities and observe overland flow patterns and document these on our plans.

Task 3 – Preparation of Aerial Topographic Maps (KSR)

The mapping will include:

- Aerial topographic mapping of Water shed #8 at a scale of 1" = 100' with 2' contours and spot elevations. Scope of work to include flight control survey and digital mapping in AutoCAD2002 format.
- Rectified Digital Color Orthophotos in the form of tiff images.

- Aerial topographic mapping of Watersheds # 1, 2, 3, 4, 9 and 10 at a scale of 1″=60′ with 2′ contours and spot elevations. Scope of work to include flight control survey and digital mapping in AutoCAD2002 format.
- Rectified Digital Orthophotos in the form of tiff images.

We have assumed that no supplemental field survey will be needed. If it is needed it would be a change of scope and fee.

Task 4 – Evaluation and Update of Hydrology, Hydraulics and Tidal Influence (ANW)

We propose to use similar hydrologic and hydraulic design criteria, including tidal influences as was used in the Town's Phase 1 Study.

We propose to update the watershed hydrology by generally using the Rational Method of analysis (Q=CIA).

We will evaluate the hydraulics of storm drain pipes, street gutters, detention pond storage, pump stations, gravity outfalls and a combination of the above.

Task 5 – Preparation of Alternative and Recommended Conceptual/Preliminary Plans (ANW)

We will prepare up to two schematic alternative Preliminary Plans. They will be evaluated and presented in the Study Report (Task 11) with one of them being a recommended solution.

Some possible alternative solutions to the inadequate storm drainage system may include pump stations, upsizing storm drain pipes, replacing rolled curb and gutter with standard curb and gutter, adding grated line drains in the gutter, adding additional catch basins and drainage inlets, and adding additional outfalls with flap or slide gates in structures located in the street.

Some possible alternative solutions to the tidal flooding may include earth levees, flood walls (sheet pile or cantilever walls depending on height), combination levee/floodwall, and different levels of flood protection (i.e. 25 year, 50 year, 100 year etc. with different levee and floodwall heights).

We propose showing alternative solutions to the inadequate storm drainage systems in the upper portions of the watersheds (hillside) schematically on the new 100 scale topographic maps (proposed sheet size 36″ x 48″).

We propose showing the alternative solutions to both the inadequate storm drainage systems and tidal flooding in the lower portions (flat areas) on the new 60 scale topographic maps (proposed sheet size 36″ x 48″).

We will also provide schematic sections and details of the storm drain improvements and preliminary profiles and sections of levees and floodwalls.

Task 6 – Preparation of Preliminary Cost Estimate (ANW)

We will prepare preliminary budgetary construction cost estimates of the alternative and recommended conceptual solutions. These will be provided in the Study Report (Task 11).

Task 7 – Jurisdictional Assessment (ANW)

We will prepare a jurisdictional assessment of the regulatory agencies which may require permits including the Army Corps of Engineers, BCDC, F&G, F&W and the RWQCB. We will document the jurisdictional assessment in the Study Report (Task 11).

Task 8 – Review FEMA Requirements (ANW)

We will review FEMA requirements as they relate to the conceptual preliminary plans. We will document the FEMA requirements in the Study Report (Task 11).

Task 9 – Brief Discussion of Potential Environmental Impacts (ANW)

We will evaluate in general potential environmental impacts that may be associated with the conceptual solutions and briefly describe these impacts in the Study Report (Task 11). The basis of the evaluation will be the information from existing study reports.

Task 10 – Brief Discussion of Existing Property Impacts (ANW)

We will evaluate in general, potential impacts on properties within the watersheds including impacts to access and views that may be associated with the conceptual solutions studied; and briefly describe these impacts in the Study Report (Task 11).

Task 11 – Preparation of Study Report (ANW)

We will prepare and submit a Draft Study Report with the Draft Conceptual/Preliminary Plans, and Draft Preliminary Cost Estimates. After the Town's review of the draft documents, we will incorporate the Town's comments and submit a Final Study Report, Final Conceptual Preliminary Plans and Final Preliminary Cost Estimates.

Task 12 – Prepare and Attend Meetings (ANW)

We will prepare for and attend at least four public meetings for public outreach, presentation of progress reports and presentation of the Final Report to the Flood Control Board and Town Council.

3. STUDY MEANS AND METHODS

3.1. Vertical Datum

Unless noted otherwise, all elevations in this study are referenced to the National Geodetic Vertical Datum (NGVD) of 1929. NGVD is approximately Mean Sea Level. The other commonly used vertical datum is Mean Lower Low Water (MLLW) which is used in Tide Tables. The difference between these two datums varies with locality. To approximately relate NGVD elevations to the MLLW datum in the Corte Madera Creek area, add 2.6 feet to the NGVD elevation to obtain the corresponding approximate MLLW elevation (Refer to Exhibit N). Expressed as a formula:

APPROXIMATE ELEVATION MLLW (Tide Tables) = ELEVATION NGVD + 2.6′ FEET

3.2. Base Mapping

The base mapping for the study area watersheds was new aerial topographic mapping as follows:

- Aerial topographic mapping of Watersheds # 1, 2, 3, 4, 9 and 10 at a scale of 1″ = 60′ with 2′ contours and spot elevations. Scope of work included flight control survey and digital mapping in AutoCAD2002 format.
- Aerial topographic mapping of Water shed #8 at a scale of 1″ = 100′ with 2′ contours and spot elevations. Scope of work included flight control survey and digital mapping in AutoCAD2002 format.
- Rectified Digital Color Orthophotos in the form of tiff images for all watersheds.

The existing drainage systems shown on the new base mapping are based on the Town of Corte Madera's Storm Drainage Maps dated 1985, as updated by the Town. The Town's Maps were used for general layout of the existing storm drainage systems, pipe sizes, and drainage inlet locations. This information was rectified with the new aerial orthophotos. No field survey of existing drainage facilities was performed. (It would have been outside the scope of services for this Study.)

3.3. Hydrologic and Hydraulic Standards Applied to the Study

Hydrology

Hydrologic calculations for this study were based on using the Rational Method of Analysis (Q = CiA) (Refer to Appendix B).

The stormwater runoff peak discharge (Q) was calculated for the 25 year and 100 year return periods. The Town of Corte Madera uses the 25 year return period for design of new storm drainage systems and the 100 year return period event for the design of new pump stations.

The Rainfall Intensity (i) was based on CALTRANS (District 4) Rainfall Intensity-Duration-Frequency Charts.

For the Tributary Area Drainage Maps refer to Exhibits A and E.

Hydraulics

Using the calculated flows for each subwatershed, backwater calculations (assuming "Full Pipe" condition) were prepared to analyze the existing and new improved storm drainage systems; and to evaluate whether the existing and new improved systems can discharge to the existing outfalls or existing pump stations without flooding (Refer to Appendix B). The starting water surface elevations for the backwater calculations were taken from Reference 11, the Town Lagoon and March Management Policies as amended in 2001.

For this study, "without flooding" is defined as:

- For 25 year runoff: Backwater surface elevations no higher than catch basin or drainage inlet grate elevations.
- For 100 year runoff: Backwater surface elevations no higher than the top of the street curb elevations.

3.4. Tides

Numerous past reports have performed extensive studies of tidal effects in and about the Town of Corte Madera. These have documented stillwater tides and design tide elevations, including wave run-up and freeboard for floodwall and levee designs for various tide event frequencies. Table 1 below presents a summary and comparison of some of documented stillwater tide elevation data.

Table 1

Still-Water Tide Elevations

San Francisco Bay Near Corte Madera

Elevations in NGVD

Tide Event Frequency	May 1986 W&K (NGVD)	Oct 1988 PWA (NGVD)	May 1991 URS (NGVD)	June 1991 CDM (NGVD)	May 1992 EMI (NGVD)	May 1996 COE (NGVD)	March 2001 EDAW (NGVD)
10 year	5.7					5.6	
25 year	6.2					-	
50 year	6.6					6.0	
100 year	7.1	6.4	6.5	6.4	6.5	6.1	6.3
500 year						6.4	

W&K Winzler & Kelly Consulting Engineers
PWA Philip Williams & Associates
URS URS Consultants
EDAW EDAW, Inc.
CDM Camp Dresser & McKee Inc.
EMI Earth Metrics Inc.
COE Corps of Engineers

3.5. Water Levels in Corte Madera Creek

As reported in Reference 4 (EDAW, 2001), improvements have been made to the Corte Madera Creek channel upstream of the Bon Air Road bridge. The current channel capacity upstream of the bridge is 3,300 cubic feet per second, which is equivalent to the 20-percent flood event (5-year event). Further improvements are under study (Corte Madera Creek General Re-evaluation Report, 2000) to increase the capacity to approximately 5,400 cfs, the 3.3-percent flood event (30-year event). The Corte Madera Creek channel

downstream of Bon Air Road is capable of containing this increased flow but at a higher water level than for the 5-year event. Backwater calculations found that the water level downstream of Bon Air Road would be 0.1 foot higher during the 3.3-percent event and a mean higher high water tide (3.0 feet NGVD); and 0.3 foot higher during a 100-year tide (6.4 feet NGVD).

4. FLOODING CONDITIONS

4.1. Description of Flooding Problems

The description of flooding in Corte Madera as reported in Reference 12 (Yoder-Trotter-Orlob, 1970) is as applicable today as it was when it was written:

> *'All floods of any consequence in Corte Madera have occurred in the low areas that have been reclaimed from the Bay marsh and tidal lands. Generally speaking, these reclaimed areas encompass everything in and east of the Madera Gardens and the lands north of Paradise Drive. These approximate one-half of the present Town Area:*
>
> *"Flooding can result from either of two phenomenon [sic]. The first is from storm runoff originating within Corte Madera and flooding low lands due to inadequate drainage channels and pipes necessary to transport this water into San Francisco Bay. The second cause is from high water in the Bay that in turn pushes salt water up into the stream channels and inundates all un-leveed lands below the tide level. The elevation of the water surface in the Bay is dependent upon the tide, local runoff, and wind an wave effects.*
>
> *"The extent of flooding has been further complicated by the fact that some of the originally reclaimed tidal lands were not filled high enough. The clay materials in the Bay mud are so unstable that land subsidence takes place over periods of 30 to 50 years. Thus, certain areas in Corte Madera have subsided to elevations that now cannot be drained with the existing storm drainage system.*
>
> *Another flood complication is the gradual filling of the tidal lands that served originally as natural ponding areas. These were once commonplace in the Town. The storm waters that would have drained to these areas must now proceed down the channels in into the Bay, or to other low lands where ponding can occur."*

A number of stormdrainage improvements have been constructed since 1970. However, land subsidence continues to this day in those areas having deeper fill over the Bay mud.

Portions of Watersheds 1, 2, 3, 4, and 9 are lower than 4.6 feet NGVD (7.2 feet MLLW), which is the typical highest annual stillwater tide at Corte Madera Creek (from published tide tables).

- An appreciable number of residences have main floor levels below 4.6 feet NGVD.
- The main floor levels of some residences are as low as 2.0 feet NGVD.
- In a number of locations, street and parking lot elevations are lower than 2.0 feet NGVD, ranging down to as low as 1.2 feet NGVD.
- Ground levels along Corte Madera Creek are as low as 4.5 feet NGVD.
- The top of the abandoned railroad line next to Shorebird Marsh is as low as 4.7 feet NGVD.

Some of the highest observed tide water levels are as follows:

- 7.4 feet ± NGVD (10.0 feet ± MLLW) in December 1997 at Corte Madera Creek (from Town Public Works)
- 6.3 feet ± NGVD (8.87 feet ± MLLW) on 01-27-83 at SF Presidio (from Winsler & Kelly May 1986 Report)
- 5.6 ± NGVD (8.17 feet ± MLLW) on 02-06-78 at Corte Madera Creek (from Winsler & Kelly May 1986 Report)

Historic curb ponding has been documented by the Town and by A-N West (Refer to Exhibit B).

4.2. Types of Flooding

There are two main flooding conditions that need to be addressed and solved in the study area:

- Flooding due to storm water runoff in areas that have an inadequate storm drainage system. These interior drainage problems are due to inadequate storm drainage pipes or stormwater pumping stations. The *Storm Drainage Improvements* described in this study address this condition.
- Flooding due to tidal inundation. This is due to the tops of levees being too low. The *Tidal Inundation Improvements* described in this study address this condition.

4.2.1. Upper Watershed Flooding Problems

Upper watershed area flood problems on the hillsides (portions of Watersheds 1, 2, 3, 4, and 10, and all of Watershed 8) are mainly due to undersized storm drain pipes and poor inlet conditions. There are very few upper watershed flood problems as reported by the Town, and the Town plans to correct these by routine maintenance and replacement of old corrugated metal pipes (CMP's) with new storm drains as needed.

4.2.2. Lower Watershed Flooding Problems

Lower watershed area flood problems on relatively flat terrain (Portions of Watersheds 1, 2, 3, 4, and 10; and all of Watershed 9) are potentially subject to:

- Extensive ponding in streets and parking lots
- Flooding of the ground floor of residences and businesses
- Tidal flooding

These problems are due to combinations of:

- Being at low elevations
- Having inadequate storm drainage pipes
- Having either inadequate stormwater pumping stations or no pumping stations at all
- Lack of adequate levee height
- Long term subsidence
- Differential settlement

The solutions to these problems will be a combination *of Storm Drainage Improvements* and *Tidal Inundation Improvements*.

FEMA mapped the floodplain limits within Corte Madera Creek on its FIRM Map dated March 1977 (Refer to Exhibit C) with a base flood elevation of 6.0 feet NGVD for the mouth of Corte Madera Creek at the Bay. FEMA is currently updating its FIRM mapping covering the Town of Corte Madera. It is expected that flood elevations will be adjusted. The new FIRM mapping will show elevations using the NAVD 1988 datum rather than the previously used NGVD datum.

4.3. History of Lucky Drive Project

The following project history is based primarily on Reference 4 (EDAW, 2001).

Recurrent flooding in the low-lying areas in the vicinity of Lucky Drive and Highway 101 just south of Corte Madera Creek has been a problem for decades. As early as 1970, studies of the area recommended flood control facilities to alleviate the periodic flooding. Over time, land development and various temporary and permanent flood control facilities were constructed that changed the hydrologic characteristics of the watershed.

In October 1985, A-N West, Inc. was hired to design the Lucky Drive Flood Control Project. The project included two pump stations, various collection system elements, levees, and floodwalls. The goal of the project was to develop an area-wide, comprehensive stormwater management and flood protection system. In April 1986, an Initial Environmental Study and Mitigated Negative Declaration for the Lucky Drive Flood Control Project were published by the Town of Corte Madera (Reference 10). The reports found that the project was not likely to result in significant unavoidable adverse impacts to the environment under the requirements of the California Environmental Quality Act (CEQA).

Additionally, pursuant to the National Environmental Policy Act (NEPA) guidelines (Section 1508.9), the report recommended a Finding of No Significant Impact (Section 1508.13), contingent on the implementation of mitigation measures related to water quality, vegetation and wildlife, views, pedestrian access, and noise. On June 10, 1986, the Corte Madera Planning Commission unanimously approved the Negative Declaration for the Lucky Drive Flood Control Project, contingent upon several minor design changes. The Negative Declaration was appealed by local residents, who requested preparation of an Environmental Impact Report (EIR).

In September 1986, the design of the levees and floodwalls was stopped due to a court judgement, and the project was divided into two phases. Phase I included critical facilities that could be constructed without possible delays from additional environmental review or right-of-way procurement. Phase I of the Lucky Drive Project included the following:

- Stormwater pump stations at Lucky Drive in Black Kettle Lagoon and in the northeast corner of the project area (immediately east of the northbound Sir Francis Drake off-ramp south abutment of Highway 101).
- Stormwater collection system facilities in the vicinity of Lucky Drive, northeast of the pump station at the corner of Larkspur, and in Redwood Highway east of Highway 101 at Industrial Way.
- Relocation of the vertical slide gate in the existing outfall structure of the 36-inch gravity bypass line that is located on the west side of Highway 101 at Corte Madera Creek.

Lucky Drive Phase I improvements were installed in 1987, except for the collection system facilities in Redwood Highway east of Highway 101 at Industrial Way. Because of the court ruling, Phase II was rescheduled for a future date.

Reference 4 (EDAW, 2001) was the Administrative Draft Environmental Impact Report for the Lucky Drive Phase II Project. This Administrative Draft has not yet been certified or approved by the Town council. Phase II consists of a system of earth levees, masonry floodwalls, associated stormwater modifications, and levee/floodwall access ramps, stairs, and floodgates. More specifically, it consisted of:

- A system of earth levees and masonry floodwalls along the southern edge of Corte Madera Creek. A section of levee would be constructed where space for the base of the levee was available. A floodwall where be built where space was not available or where wetlands or other sensitive areas would merit protection.
- Earth levee along the abandoned railroad tracks next to Shorebird Marsh

5. IMPROVEMENTS

5.1. Introduction

We have studied solutions to address the two main conditions in the study area:

- Flooding due to storm water runoff in areas that have inadequate storm drainage pipes and/or pump stations (*interior drainage problems*).
- Flooding due to levees not being high enough (tidal inundation)

Of the two flooding conditions, tidal inundation has caused the majority of flooding in commercial and residential properties (parking lots, yards, and some garages). However, but street ponding due to an inadequate storm drainage system and differential settlement has become very common and continues to be a major concern for the Town and the residents.

The solutions to these two flooding problems are basically independent of each other, yet both need to be solved for a total comprehensive solution.

We propose that the solutions to these two flooding conditions be phased, with the intent that the solutions to the inadequate storm drainage systems be constructed first. This is because we anticipate that construction of these interior drainage improvements would present significantly fewer and lesser environmental impacts than solutions to the tidal flooding problems. Thus construction of the interior drainage improvements could begin much earlier than tidal inundation improvements.

5.2. Recommended Storm Drainage Improvements

The overall goal of the storm drainage improvements is to bring the hydraulic capacity of the entire storm drainage system up to the 25-year level of design. In general, the recommended measures include providing continuous curb drainage in areas of curb ponding: and replacing and/or augmenting the existing storm drainage system with new storm drain pipes, catch basins, manholes and pump stations to discharge storm flows including storm events coincident with high tides.

The locations and types of recommended storm drainage improvements are shown on Exhibit G. These improvements are described in general terms by watershed as follows:

Watershed 1: Replace undersized existing storm drainage pipes with larger pipes. An option in some locations would be to install a new parallel pipe sized so that the combined capacities of the new and old pipes would satisfy the criteria. In areas where there is street ponding or “bird baths” due to differential settlement, the existing curb and gutter will be replaced by segments of Grated Line Drains. For typical Grated Line Drains details and photos refer to Exhibit J.

Watershed 2: Replace undersized existing storm drainage pipes with larger pipes. An option in some locations would be to install a new parallel pipe sized so that the combined capacities of the new and old pipes would satisfy the criteria. In areas where there is street ponding or “bird baths” due to differential settlement, the existing curb and gutter will be replaced by segments of Grated Line Drains. For typical Grated Line Drains details and photos refer to Exhibit J.

Replace the existing Marquart Lagoon Pump Station and slip-line the existing lagoon outfall pipe, which also serves as the pump station's intake and discharge.

Watershed 3: Replace undersized existing storm drainage pipes with larger pipes. An option in some locations would be to install a new parallel pipe sized so that the combined capacities of the new and old pipes would satisfy the criteria. In areas where there is street ponding or "bird baths" due to differential settlement, the existing curb and gutter will be replaced by segments of Grated Line Drains. For typical Grated Line Drains details and photos refer to Exhibit J.

- Improve operation of High Canal Pump Station by adding an automatic power-operated trash rack cleaner, as recommended by Town Maintenance Staff. This item is not included in the construction cost estimate, pending decision by Town Public Works.

Watershed 4 (Sub-watersheds 4A and 4B):

We recommend the following stormdrainage improvements:

- Replace undersized existing storm drainage pipes with larger pipes. An option in some locations would be to install a new parallel pipe sized so that the combined capacities of the new and old pipes would satisfy the criteria.
- In areas where there is street ponding or "bird baths" due to differential settlement, the existing curb and gutter will be replaced by segments of Grated Line Drains. For typical Grated Line Drains details and photos refer to Exhibit J.

Watershed 8: Replace undersized existing storm drainage pipes with larger pipes. An option in some locations would be to install a new parallel pipe sized so that the combined capacities of the new and old pipes would satisfy the criteria.

Watershed 9:

We recommend the following stormdrainage improvements:

- In areas where there is street ponding or "bird baths" due to differential settlement, the existing curb and gutter will be replaced by segments of Grated Line Drains. For typical Grated Line Drains details and photos refer to Exhibit J.
- Construction of a replacement Corporation Yard Pump Station is currently scheduled for completion before the start of the 2008-2009 rainy season.

Watershed 10: Replace undersized existing storm drainage pipes with larger pipes. An option in some locations would be to install a new parallel pipe sized so that the combined capacities of the new and old pipes would satisfy the criteria. In areas where there is street ponding or "bird baths" due to differential settlement, the existing curb and gutter will be replaced by segments of Grated Line Drains. For typical Grated Line Drains details and photos refer to Exhibit J.

5.2.1. Pump Station for Watershed 2

This pump station will be relatively small and could be of the underground type shown on Exhibit I. It could consist of two small submersible pumps installed in a wet well. The wet well would be on the order of 6 feet in diameter.

Each of these pump stations will be provided with a gravity by-pass pipe in case of pump station failure. The existing gravity pipes near the pump stations will be used for the by-pass pipes. Just upstream of the gravity by-pass pipe a Gravity By-Pass Manhole will be installed with a "Duck-Bill" check valve. (Refer to Exhibit Q.) The manhole invert will be one and one-half foot lower than the check valve invert to provide room for sediment without obstructing the "Duck-Bill" check valve.

5.3. Recommended Tidal Inundation Improvements

In general, the solution to the tidal inundation is to install a combination of floodwalls and levees along the south bank of Corte Madera Creek; and to reconstruct and raise the existing levee along the old NWPRR embankment east of Highway 101 to protect against high tide events. Upon reviewing the past reports and tidal studies, we recommend using the following preliminary design elevations for this study:

South Bank of Corte Madera Creek:

- Recommended initial construction:

  Tops of floodwalls - Elevation 8.5 feet NGVD
  Tops of levees between floodwalls - Elevation 9.0 feet NGVD

- 100-Year Ultimate Design – Elevation 11.0 feet NGVD for tops of both floodwalls and levees (per EDAW)

NWPRR Levee:

- Recommended initial construction - Elevation 10.0 feet NGVD
- 100-Year Ultimate Design - Elevation 12.0 feet NGVD (per EDAW)

The subsoils upon which the floodwalls and levees would be placed are relatively weak and subject to both short and long term settlement. Based on the geotechnical data available, it is anticipated that the new floodwalls would settle approximately 0.5 foot over 30 years and the new levees would settle approximately 1.0 foot over the same period.

The recommended tidal inundation improvements are as follows:

Watershed 4: Raise and reconstruct the existing levee along the old NWPRR embankment to an initial Elevation 10.0 feet NGVD (Refer to Exhibits K, L and N). The amount of initial raising would be on the order of two to three feet, with a maximum of five feet. The northern end of the levee work would be at the Town Limit line at Industrial Way.

For the ultimate 100-year design, a two-foot high floodwall could be added to the NWPRR Levee to bring its crest elevation up to the FEMA 100-year design elevation of 12.0 feet NGVD.

Watershed 9: We recommended the following tidal inundation improvements for initial construction (Refer to Exhibits K, L, M, N, and O):

1. Install concrete or masonry floodwalls along Corte Madera Creek with an initial top of wall elevation of 8.5 feet NGVD. The walls should be constructed with the footings wide enough to allow the tops of the walls to be raised by up to 3 feet in the future. This would allow for additional protection and could account for future settlement. (For comparison, Elevation 7.0 feet NGVD is the minimum allowable floor elevation for new

building construction in a flood plain in the Town of Corte Madera, per Town ordinance.)

2. Install levees between the sections of floodwall along Corte Madera Creek with an initial top elevation of 9.0 feet NGVD (Refer to Exhibit N). A 3-foot high floodwall could be added to the tops of these levees in the future.

3. Install floodwall timber or concrete stairway access at various locations (Exhibit O).

4. Remove and replace affected existing docks. Details to be determined during final design.

5. Install lined drainage ditches and gravity outlet drainage boxes behind the floodwalls and levees, and provide the outlet pipes with "duckbill" type check valves (Exhibit O).

The heights of the floodwalls and levees would vary along their lengths, as shown on the profiles on the drawings (Exhibit L). In general, most of the length of the floodwall varies in height from approximately three to five feet above the existing ground at the floodwall location. (Some segments of floodwall are lower or higher in height than this range, as shown on the profiles.)

Final design would include developing site-specific variations for each segment of floodwall and/or levee, with each variant best fitting its location's site-sensitive marsh habitats, residential needs and landscaping, and other adjacent uses. Through the planning and public participation process the project design will be refined to reflect the desires and needs of the community. Design options for the floodwalls could include changes in surface treatment. Options for the levees could include variations in side slope.

For the ultimate FEMA 100-year design elevation of 11.0 feet NGVD, the floodwalls would be raised and low floodwalls would be built on top of the sections of levee between the floodwalls.

5.3.1. Additional Improvements Required Outside the Town Limits

To provide a complete system of protection from tidal inundation for Watershed 9, similar improvements would have to be constructed outside the Town Limits. They would be built in a combination of the City of Larkspur, the Highway 101 right-of-way, and an unincorporated portion of Marin County. They would be required for both the recommended initial construction and the ultimate 100-year design. These improvements are shown schematically on Exhibit K and consist of:

- Floodwalls and levees extending northeasterly along Corte Madera Creek to Highway 101
- Floodwall/levee connections to Highway 101 bridge abutments
- Floodwalls and levees extending east of the highway and then south to industrial Way

These improvements are outside the scope of this study because they would lie outside the Town Limit. Therefore, they are only shown schematically (Exhibit K) and no construction cost estimates were prepared.

5.3.2. Alternative Tidal Inundation Improvements

The alternative tidal inundation improvements that were considered were as follows:

1. Alternative "A" – Provide higher initial top of floodwall elevations:

- Watershed 4 top-of-levee Elevation 12.0 feet NGVD.
- Watershed 9 top of floodwall Elevation 11.5 feet NGVD and top of levee Elevation 12.0 feet NGVD

This would provide the Corps of Engineers 100-year design protection, including settlement allowances of 0.5 foot the floodwalls and 1.0 foot for levees. Refer to Exhibit N. Advantages of initial construction at these higher elevations would include:

- Immediate provision of the Corps of Engineers 100-year design protection.
- Avoiding future raising of floodwalls and levees, or adding low floodwalls to levees, and the associated construction impact on property owners. However, should future land subsidence be greater than 0.5 foot for floodwalls and/or 1.0 foot for levees, then further floodwall and/or levee raising could be required.

Disadvantages of initial construction at these higher elevations would include:

- The property owners along the Corte Madera Creek in Watershed 9 would have a significant visual and access impact due to the additional 3 feet of floodwall/levee height.
- This alternative does not eliminate the potential for future floodwall and/or levee raising caused by future land subsidence.

2. Alternative "B" – Raise existing house foundation walls and construct new floodwalls between houses. This alternative was studied by the Corps of Engineers in their 1996 San Clemente Creek report. Conditions there were similar to conditions along Corte Madera Creek. The Corps alternative "consisted of raising homes along San Francisco Bay and San Clemente Creek. House foundations would be modified and raised along the bayfront and San Clemente Creek. The raised foundations would be connected together by floodwalls between adjacent houses, providing a continuous floodwall with a 100-year level of protection for all property inboard of the foundations."

This alternative was ruled out by the Corps at the early stage of their study because of the significant effects on the homeowners. These effects included temporary displacement of all waterfront residents during construction and significant changes to appearance and character of the neighborhoods. These changes would be due to the increased height of the house ridgelines above street level that would create a visual "looming effect" along the waterfront. In addition, the waterfront homeowners would lose their backyards to periodic flooding. For the above reasons, we have also ruled out this alternative.

3. In addition to the two alternatives above, the other flood barriers that were considered but ruled out were:

- Using only levees along Corte Madera Creek – ruled out because of the very large permanent encroachment on each property.
- Floodwalls constructed of steel or vinyl sheetpiling – ruled out because of construction difficulties in working in tight spaces in back yards and between fences.

6. IMPACTS

6.1. Potential Environmental Impacts

6.1.1. Storm Drainage Improvements

The recommended storm drainage improvements will have very localized disturbance to existing wetlands at the locations of proposed stormwater pump stations discharge pipes and discharge structures. Because of this localized disturbance, the storm drainage improvements may only require a JARPA permitting process.

6.1.2. Tidal Inundation Improvements

During the review of the permit application process, and pursuant to Section 7 of the Endangered Species Act, a determination will be required as to whether or not the construction activities related to the improvements "will have adverse impacts on the continued existence of threatened or endangered species, or on critical habitats for these species." The placement of floodwalls, levees, rock riprap, temporary rock construction pads and discharge pipes and structures in wetlands are considered "fill". Based on past reports, "there are two endangered species documented as being present in or near the project area, the salt march harvest mouse and the California clapper rail." A mitigation plan would probably be required for replacement of any lost habitat an/or wetlands.

Watershed 4. The discussions in Reference 4, EDAW, 2001 are generally applicable to the tidal inundation improvements recommended by this study for Watershed 4. These improvements will potentially disturb existing wetlands at various locations along the proposed NWPRR Levee. This will require a CEQA review. It is anticipated that a full Environmental Impact Report (EIR) will be required.

Watershed 9. Reference 4 specifically addressed environmental impacts of tidal inundation improvements that had been planned for the south bank of Corte Madera Creek. Reference 4's findings are applicable to the Watershed 9 tidal inundation improvements proposed in this study. These improvements will potentially disturb existing wetlands along the full length of the proposed construction. This will require a CEQA review. It is anticipated that a full Environmental Impact Report (EIR) will be required.

6.2. Existing Property Impacts

Watersheds 1, 2, 3, 8, and 10. The impacts to the existing properties due to the recommended storm drainage improvements would include property disturbance due to installation of storm water pump station discharge pipes between some of the houses and installation of storm water discharge structures behind the rear yards of some of the houses. There would also be the impacts of temporarily blocking off or portions of streets for installation of new storm drainage pipes and structures.

Watershed 4. The proposed NWPRR levee reconstruction and raising will take place within the lands of the Golden Gate Highway and Transit District. Encroachment permits will probably be required for both construction and for operation and maintenance of the completed project.

Watershed 9 .The impacts to the existing properties due to the recommended tidal inundation improvements along Corte Madera Creek would include visual and view impacts

to the houses directly along the creek due to the installation of the floodwalls and levees. The floodwalls and levees would impair property owners' access to the water and to their boat docks. In addition, these properties would be disturbed during construction of the floodwalls, stairs over the floodwalls, drainage swales, and drainage facilities constructed behind the floodwalls. One or more easements will probably be needed from each property owner for:

- Temporary Construction Access
- Construction
- Maintenance

6.3. Jurisdictional Assessment

All of the recommended tidal inundation improvements and some of the recommended storm drainage improvements will be within the jurisdictions of the following agencies.

1. U.S. Army Corps of Engineers (Corps)
2. U.S. Fish and Wildlife Service (USFWS)
3. National Marine Fisheries (NMFS)
4. California Department of Fish and Game (CDFG)
5. California Regional Water Quality Control Board (RWQCB)
6. San Francisco Bay Conservation and Development Commission (BCDC)
7. California Department of Transportation, District 4
8. Golden Gate Highway and Transit District
9. Town of Corte Madera
10. County of Marin
11. City of Larkspur

Depending on the scope and location of the recommended improvements, permits will be required from some or all of the above Jurisdictions. While any improvements outside the Town Limit of the Town of Corte Madera are beyond the scope of this study, the County of Marin and the City of Larkspur are included in case some portion of an improvement must physically extend into their jurisdictions.

We anticipate that the following permits will be required:

1. U. S. Army Corps of Engineers Section 404 with Permit 401 Water Quality Certification and/or Section 10 Permit for placing fill into the waters and/or wetlands of the United States. The Corps will consult with United States Fish and Wildlife Service and National Marine Fisheries Service as part of their permit process.

2. National Pollution Discharge NPDES Permit. Required for construction of the floodwall sumps with tide gates and stormwater pump station discharge pipes and structures. NPDES permits regulate the discharge of pollutants from a point source into navigable waters.

3. California Department of Fish and Game Streambed Alteration Agreement is likely to be required.

4. San Francisco Bay Regional Water Quality Control Board Letter of Determination. RWQCB will also need a copy of the BCDC Permit as a part of their review process.

5. Bay Conservation and Development Commission Administrative Permit

6. Caltrans District 4 encroachment permits for any construction and/or operation and maintenance of facilities within their right-of-way

7. Sonoma Marin Area Rail Transit District (SMART) and Golden Gate Highway and Transit District encroachment permits for construction and for operation and maintenance within their rights-of-way

8. Town of Corte Madera encroachment permits for construction; and grading, building, and erosion control permits

9. County of Marin encroachment permits for construction; and grading, building, and erosion control permits

10. City of Larkspur encroachment permits for construction; and grading, building, and erosion control permits

6.4. FEMA (Federal Emergency Management Agency) Requirements

For a FEMA Flood Insurance Rate Map (FIRM) revision, FEMA would require the Town's storm drainage and flood protection system to meet NFIP criteria and provide flood protection from the 100-year flood. Studies and other documentation would have to demonstrate that 100-year protection is provided that meets FEMA requirements for protection from:

- Riverine Flooding
- Coastal Flooding
- Interior Drainage Flooding

Upon completion of construction, the town would apply to FEMA for a "Letter of Map Revision" (LOMR). This would require an Interior Drainage Study, filling out a Levee/ Floodwall System Analysis Form, and a stability and seepage analysis of the levees. FEMA would also require that all stormwater pump stations be provided with permanent "on-site" stand-by generators or other uninterruptible power sources. (Only the High Canal Pump Station has a power supply meeting this requirement.) Upon approval by FEMA, they would issue an A-99 Interim Designation Letter of Map Revision (LOMR).

While FEMA approval would eliminate the legal requirement that flood insurance be purchased as a condition of obtaining a loan from a federally insured or regulated lender, a lending institution may, at their discretion, still require purchase of flood insurance. It must be noted that removal from the FEMA 100-year flood plain does not guarantee protection from all future floods and, therefore, each property owner should consider the level of risk they are willing to accept in their decision regarding flood insurance coverage. However, once an area is removed from the 100-year flood plain, flood insurance rates would probably be substantially reduced.

The FEMA requirements to be met listed below for the three types of flooding are based on Reference 4 (EDAW, 2001).

6.4.1. FEMA Riverine Requirements

Watershed 9 would be subject to FEMA's riverine area requirements for floodwalls and levees. The basic requirement is a minimum freeboard of 3 vertical feet above the water surface of the base flood. A minimum of 4 vertical feet is required within 100 feet

horizontally either side of structures (such as bridges) riverward of the levee, or wherever the flow is constricted. A minimum freeboard of 3.5 feet is required at the upstream end of the levee, tapering to not less that the minimum at the downstream end of the levee. Reference 4 established Elevation 11.0 feet NGVD for the tops of both floodwalls and levees along Corte Madera Creek.

6.4.2. FEMA Coastal Requirements

The FEMA coastal requirements are applicable to the NWPRR Levee proposed for Watershed 4. For a project to provide 100-year protection, FEMA would require a minimum freeboard of 1-foot above the height of the one percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation. Reference 4 indicates Elevation 12 feet NGVD to be the required elevation for the tops of both floodwalls and levees for the NWPRR Levee.

A stability and seepage analysis of the existing embankment system would need to be performed to FEMA standards.

6.4.3. FEMA Interior Drainage Requirements

The interior drainage study would have to demonstrate that all buildings would be a minimum of one foot above the 100-year water surface elevation. The study would have to consider:

- Hydraulic capacities of stormwater pipelines
- Hydraulic capacities of pump stations
- Operation of the lagoons and pump stations during the 100-year event
- Effects of water levels in the canals on operation of pump stations and flap gated gravity outfalls
- Effects of water levels in Corte Madera Creek and the Bay on operation of pump stations and flap gated gravity outfalls

It should be noted that FEMA requires that, for 100-Year protection, all storm water pump stations be provided with permanent "on-site" non-interruptible power source, such as stand-by generators. Only the High Canal Pump Station has this capability.

7. SUMMARY OF COST ESTIMATES

7.1. Introduction

The following budgetary level construction cost estimates were prepared using escalated unit prices to mid-2009. The construction cost estimates do not include any costs for utility relocations, permanent or temporary construction easements, rights-of-way, environmental studies, permitting, or engineering design services. Detailed construction cost estimates appear in Appendix A.

7.2. Recommended Storm Drainage Improvements

The recommended storm drainage improvements have an estimated total construction cost of $5,600,000. The breakdown by Watershed Number is shown in Table 2 below:

Table 2

Recommended Storm Drainage Improvements

Engineer's Cost Estimate

2009 Price Levels

Item No.	Item Description	Construction Cost
1	Watershed 1	$1,670,000
2	Watershed 2	$963,000
3	Watershed 3	$773,000
4	Sub-Watershed 4A	$792,000
5	Sub-Watershed 4B	$715,000
6	Watershed 8	$8,000
7	Watershed 9	$391,000
8	Watershed 10	$252,000
	Total	$5,564,000
	Rounded Total	$5,600,000

7.3. Recommended Tidal Inundation Improvements

The recommended tidal inundation improvements have an estimated total construction cost of $4,800,000.

7.4. Potential Funding Sources

The following are potential funding sources:

- Town's General Fund
- Assessment District(s)
- User Fees
- Bonds
- Storm Drainage Fees for Development and Redevelopment Projects
- Federal Grants

Of the sources listed, assessment districts, user fees, and bonds require elections that are subject to the California Constitutional Amendment added by Proposition 218, which was passed in 1996. This amendment requires a two-thirds majority for approval. While benefit assessments only require a majority vote, the votes are weighted in proportion to property assessments.

"Storm Drainage Fees for Development and Redevelopment Projects" can be imposed without an election, but this option is limited because most of the study area has already been developed with no plans for redevelopment.

7.5. Anticipated Functional Life of Storm Drainage Facilities

The following are typical expected economic life expectancies of storm drainage facilities:

Pump Station Electrical and Mechanical Equipment..... 25 Years
Pump Station Structures..... 50 – 100 Years
Storm Drainage pipes..... 50 Years

PROPOSED CAPITAL IMPROVEMENT PROJECTS

Proposed Capital Improvement Projects
(From Town-Wide Storm Drainage and Flood control Study Phase 2)

ITEM NO.	PROJECT	DESCRIPTION	COST	PRIORITY
1	Watershed #2 Pump Station	Pump Station Replacement	$348,000	High
2	Watershed #1 Piping Improvements	12" - 30" Storm Drain Pipes, Catch Basins and Misc.	$834,000	Medium
3	Watershed #1 Curb Drain Improvements	Grated Line Drains, Concrete Curb & Gutter, Reconstruct Existing Sidewalk and AC Pavement	$836,000	Medium
4	Watershed #2 Piping Improvements	12" - 18" Storm Drain Pipes, Catch Basins and Misc.	$166,000	Medium
5	Watershed #2 Curb Drain Improvements	Grated Line Drains, Concrete Curb & Gutter, Reconstruct Existing Sidewalk and AC Pavement	$449,000	Medium
6	Sub-Watershed #4A Piping Improvements	12" - 42" Storm Drain Pipes, Catch Basins and Misc.	$524,000	Medium
7	Sub-Watershed #4A Curb Drain Improvements	Grated Line Drains, Concrete Curb & Gutter, Reconstruct Existing Sidewalk and AC Pavement	$268,000	Medium
8	Sub-Watershed #4B Piping Improvements	12" - 54" Storm Drain Pipes, Catch Basins and Misc.	$687,000	Medium
9	Sub-Watershed #4B Curb Drain Improvements	Grated Line Drains, Concrete Curb & Gutter, Reconstruct Existing Sidewalk and AC Pavement	$29,000	Medium
10	Watershed #3 Piping Improvements	12" - 48" Storm Drain Pipes, Catch Basins and Misc.	$600,000	Low
11	Watershed #3 Curb Drain Improvements	Grated Line Drains, Concrete Curb & Gutter, Reconstruct Existing Sidewalk and AC Pavement	$172,000	Low
12	Watershed #8 Piping Improvements	12" - 18" Storm Drain Pipes, Catch Basins and Misc.	$8,000	Low
13	Watershed #9 Piping Improvements	12" - 30" Storm Drain Pipes, Catch Basins and Misc.	$162,000	Low
14	Watershed #9 Curb Drain Improvements	Grated Line Drains, Concrete Curb & Gutter, Reconstruct Existing Sidewalk and AC Pavement	$229,000	Low
15	Watershed #10 Piping Improvements	12" - 24" Storm Drain Pipes, Catch Basins and Misc.	$38,000	Low
16	Watershed #10 Curb Drain Improvements	Grated Line Drains, Concrete Curb & Gutter, Reconstruct Existing Sidewalk and AC Pavement	$215,000	Low
RECOMMENDED STORM DRAINAGE IMPROVEMENTS - PHASE 2 ROUNDED TOTAL			**$5,600,000**	
17	Watershed #4 & #9 Levees & Floodwalls	Levees and Floodwalls (Tidal Improvements)	$4,800,000	High
RECOMMENDED STORM DRAINAGE & TIDAL IMPROVEMENTS – PHASE 2 GRAND TOTAL			**$10,400,000**	

Notes:
1. The construction cost estimates do not include any costs for utility relocations, permanent or temporary construction easements, rights-of-way, environmental studies, permitting, or engineering design services
2. Pump Stations should be constructed prior to or at the same time as Piping Improvements for each Sub-Watershed or Watershed.
3. Tidal Inundation Improvements (i.e. Levees and Floodwalls) should be constructed as one project for Phase 1 and as one project for Phase 2.
4. For location of Storm Drainage Improvements by Sub-Watershed or Watershed, refer to Exhibit "G" Plans.

Basis for Selection of Priority Factors

The following is the basis for selection of Priority Factors (High, Medium or Low) for the proposed CIP Storm Drainage Improvement Projects:

HIGH (SEE NOTE BELOW)

1. High potential for significant ponding / flooding from hydraulic backwater effects.
2. Subwatershed / watershed size is medium to large.
3. Subwatershed / watershed topography average elevations are low to medium.
4. Subwatershed / watershed is subject to tidal flooding.
5. The need for a new pump station is high.

MEDIUM:

1. Medium potential for significant ponding / flooding from hydraulic backwater effects.
2. Subwatershed / watershed size is medium to large.
3. Subwatershed / watershed topography average elevations are medium to high.
4. The need for a new pump station is medium or storm drain piping connects to an existing pump station.

LOW:

1. Low potential for significant ponding / flooding from hydraulic backwater effects.
2. Subwatershed / watershed size is small to medium.
3. Subwatershed / watershed topography average elevations are medium to high.
4. The need for a new pump station is low or storm drain piping connects to an existing pump station.

NOTE:

In addition, we consider all the Tidal Inundation Improvements (i.e. Levees and Floodwalls) to be a HIGH Priority and recommend that they be constructed as one project for Phase 1 and as one project for Phase 2.