FLOOD CONTROL STUDY

MARIN COUNTY FLOOD CONTROL ZONE NO. 3

PREPARED AT THE DIRECTION OF THE

MARIN COUNTY BOARD OF SUPERVISORS

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MARVIN W. BRIGHAM—DIRECTOR OF PUBLIC WORKS

JANUARY, 1957

ENGINEERING OFFICE OF CLYDE C. KENNEDY
604 MISSION STREET, SAN FRANCISCO

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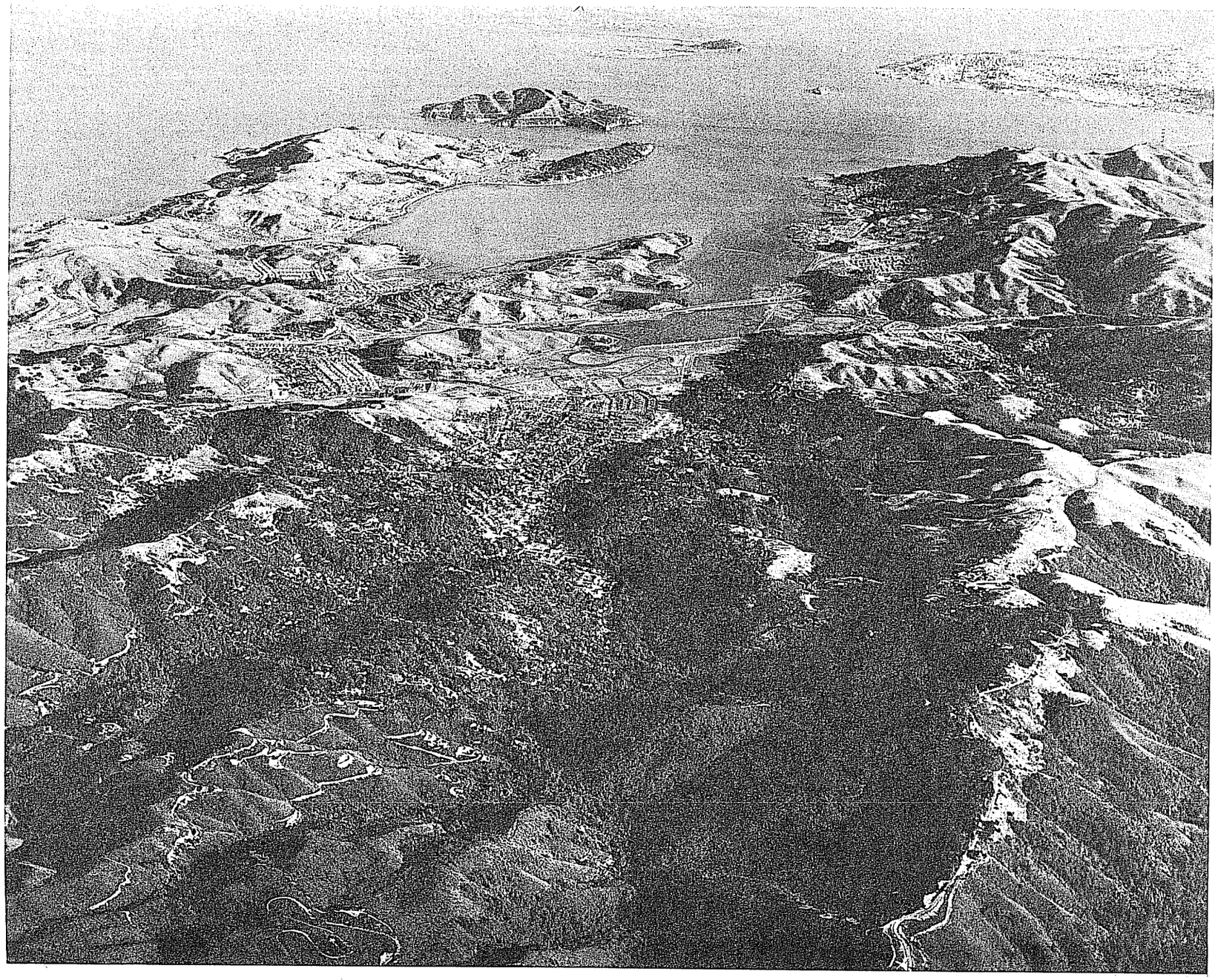


Frontispiece: Marin County Flood Control Zone No. 3

Aero Portraits
SAN RAFAEL, CALIF

INTRODUCTION

The problem of flood control in Marin County has been one of popular interest, especially in recent years. Recognizing the problem as one of importance to the County, the Board of Supervisors formed the Marin County Flood Control and Water Conservation District in 1953. The District, including all of Marin County, has as its purposes:

1. To control and conserve flood and storm waters;

2. To protect watercourses, watersheds, harbors, and public highways;

3. To protect life and property from damage or destruction from flood waters and from tidal action;

4. To remove and by-pass drainage, storm, flood and other waters;

5. To conserve waters for beneficial use; and

6. To engage in recreational activities incidental to and in connection with the purposes of the District.

Severe flood damage in Marin County during the winter of 1955 focused attention upon the need to provide adequate flood protective measures. In the area adjacent to Richardson Bay, notably Tamalpais Valley and the Locust area of Mill Valley, the damage was extreme and covered a large area. It has been estimated that Tamalpais Valley alone suffered about $250,000 in damages.

Recognizing the need for positive action in this area of concentrated damage, the Board of Supervisors formed Flood Control Zone No. 3 in July 1956. The Zone includes Richardson Bay and drainage areas tributary to the Bay, as shown on Plate No. 1.

The County of Marin retained the Engineering Office of Clyde C. Kennedy in September 1956 to make an engineering study and report on flood control works needed in the Zone, including consideration of a tidal barrier and a regulator basin.

Illustration No. 1: Camino Alto and Sycamore, December 1955
Independent Journal Photo

The scope of this study and report includes:

1. An investigation of the adequacy of existing stream channels to contain flood waters;

2. An investigation of the adequacy of existing culverts, bridges, and drainage structures to pass flood waters;

3. Recommended improvements to existing stream channels;

4. Recommended improvements to culverts, bridges and drainage structures;

5. An investigation of the feasibility of construction of a tidal barrier;

6. An estimate of cost of required improvements to stream channels and related drainage structures;

7. An estimate of cost of tidal barrier, if feasible;

8. Determination of alternative methods of financing of required flood control works; and

9. An investigation of Federal and State laws concerning flood control works and the availability of funds from these sources.

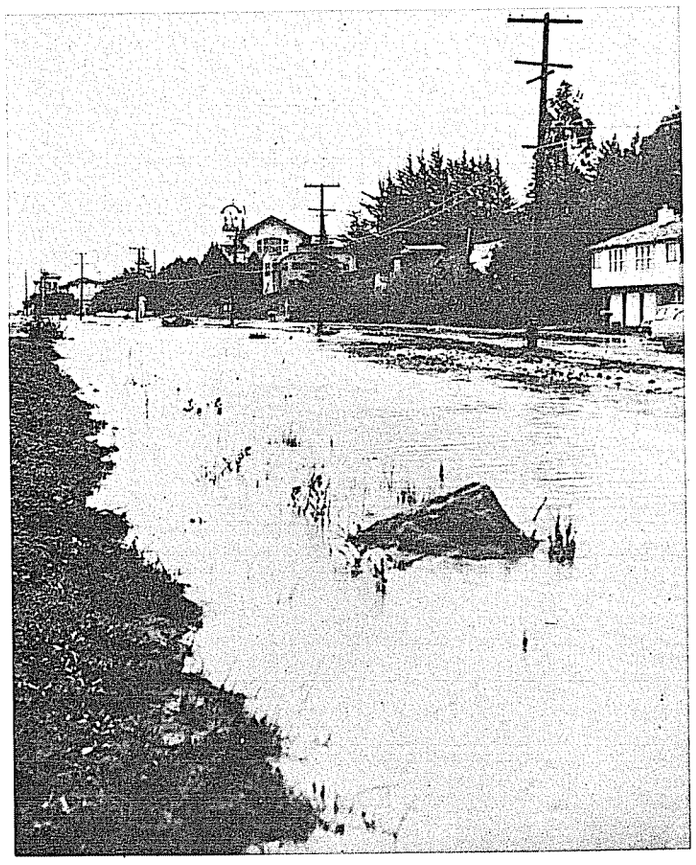


Illustration No. 2: Lower Miller Avenue, December 1955
Independent Journal Photo

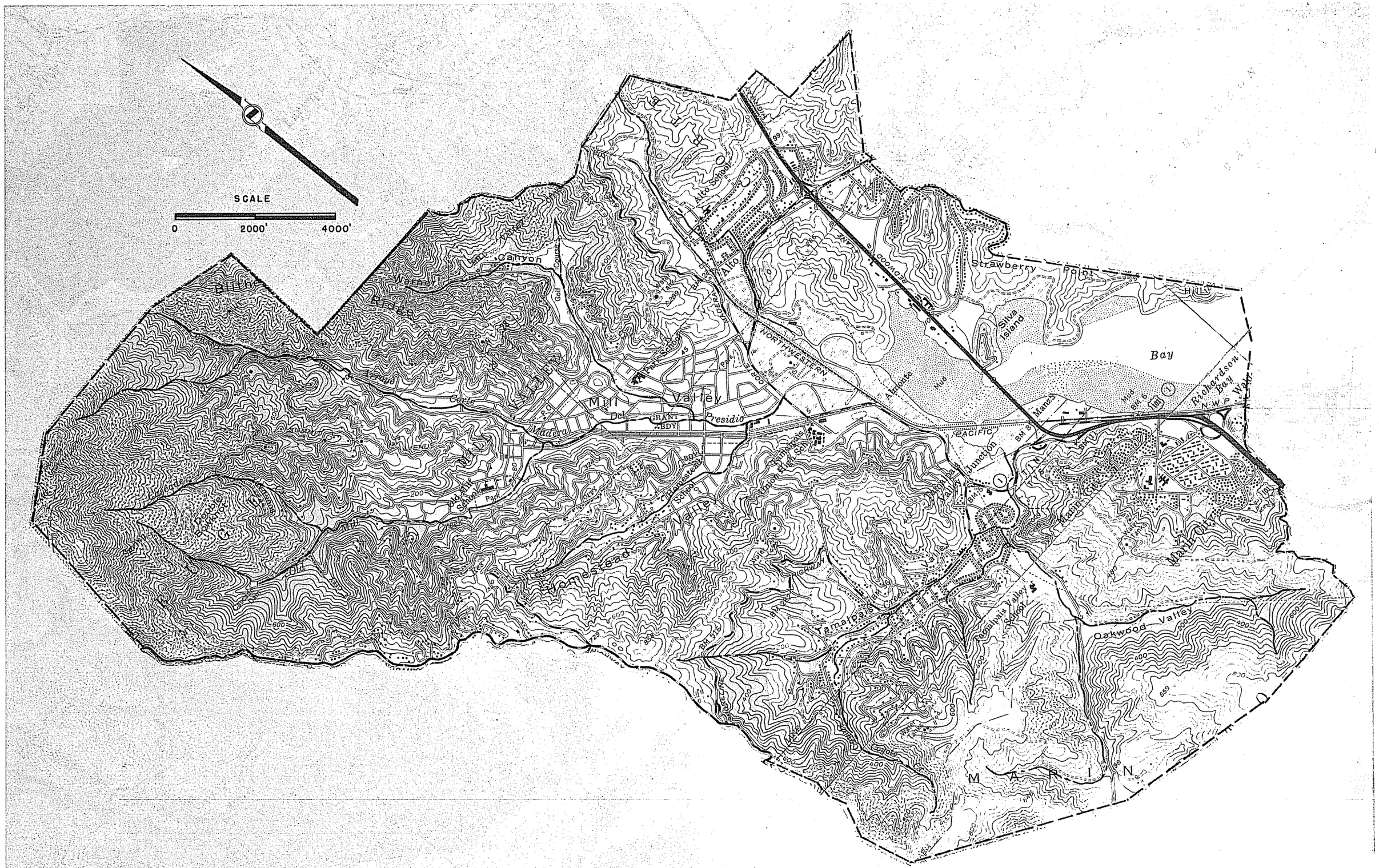
The study and report develops a preliminary plan to define the nature and scope of required works which will serve as a master plan. The plan will meet the present and future needs for a definite program to proceed with corrective measures to the drainage and flood control system of the Zone.

A consideration of local storm drainage problems is beyond the scope of this report.

During the preparation of this report, progress reports have been made to the County Department of Public Works and the Board of Supervisors. Meetings have also been held with representatives of the San Francisco District Corps of Engineers to discuss findings of the Corps of Engineers on recommended flood control measures for Tamalpais Valley. These meetings also afforded an opportunity to correlate and compare basic criteria for design of flood control works.

Reference is made in this report to an Appendix. This Appendix contains technical data and records supplemental to and substantiating the conclusions of this report. It has been made available in only a limited number of copies. A copy is on file in the Director of Public Works Office, County of Marin.

PLATE NO. 1 delineates the boundaries of Flood Control Zone No. 3. The area included in the Zone is approximately 13.5 square miles.



MARIN COUNTY FLOOD CONTROL ZONE NO. 3

FLOOD CONTROL STUDY

JANUARY 1957

ZONE MAP

ENGINEERING OFFICE OF CLYDE C. KENNEDY

SAN FRANCISCO

FINDINGS AND CONCLUSIONS

Existing stream channels in the Zone are not adequate to pass storm flood flow.

A majority of existing culverts, bridges and drainage structures on stream channels in the Zone are not adequate to pass storm flood flow.

The construction of a barrier is Richardson Bay is structurally feasible but is not essential to the flood control works in the Zone.

The construction of flood control works in the Zone, including stream channels, culverts, bridges and drainage structures will furnish adequate flood protection for the Zone. The estimated cost of these flood control works is approximately 2.5 million dollars, not including rights-of-way and legal costs.

The construction of flood control works in the Zone, including barrier, stream channels, culverts, bridges and drainage structures will furnish adequate flood protection for the Zone. The estimated cost of these flood control works is approximately 3.8 million dollars, not including land, rights-of-way and legal costs.

If flood control works are to be constructed in stages, it is recommended that construction should be in the following order:

1. Coyote Creek Group.
2. Arroyo Corte Madera del Presidio Group.
3. Sutton Manor Branch

Local storm drainage facilities should be constructed concurrently with each of the above stages.

A barrier located in Richardson Bay near the Richardson Bay Highway Bridge does not furnish sufficient basin storage capacity for storm flood flow. A barrier located in Richardson Bay from Strawberry Point to Waldo Point furnishes sufficient basin storage capacity for storm flood flow.

A dual-purpose regulator basin that can be fully developed for recreational purposes and also function as an integral part of the flood control works is structurally feasible.

Local storm drainage facilities will be required to alleviate local drainage problems regardless of the flood control project adopted.

The construction of flood control facilities can be financed by general obligation bonds or local improvement proceedings. Some financial aid may be secured from State or United States government sources.

DESCRIPTION AND HYDROLOGY OF ZONE

The Zone consists of an area of approximately 13.5 square miles in Southern Marin County. The streams in the Zone include the Coyote Creek Group and the Arroyo Corte Madera del Presidio Group. The streams discharge into Richardson Bay, which is included in the Zone. Plate No. 1 shows a map of the Zone.

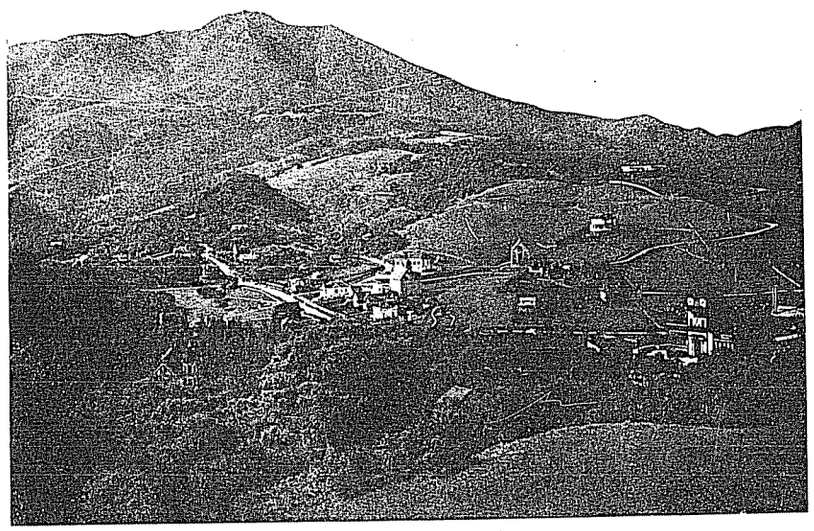


Illustration No. 3: Mill Valley Development circa 1900
City of Mill Valley Photo

The Zone consists of level land adjoining Richardson Bay and steep hills surrounding this area. The hills rise abruptly to a maximum elevation of approximately 2600 feet on the southeast slope of Mount Tamalpais. North slopes and deeper ravines of south slopes are covered with trees and heavy underbrush including oak, eucalyptus, redwood, and madrona. Exposed southern slopes are generally covered with grass or scrub brush.

Rock formations are chiefly of the Franciscan series, fine grained sandstones with some isolated outcrops of igneous rock. Soils are generally loams and clay loams derived from the Franciscan series. The littoral areas contain marine alluvium deposited when the valleys were arms of San Francisco Bay.

The Zone consists of approximately 35 percent residential area and 65 percent undeveloped land. Developed residential areas are primarily in the lower areas of the Zone, but some development extends to considerable elevation. Areas adjacent to Richardson Bay are being developed for residential and commercial use. Some of these areas are on filled land which was formally marshy or tidal land.

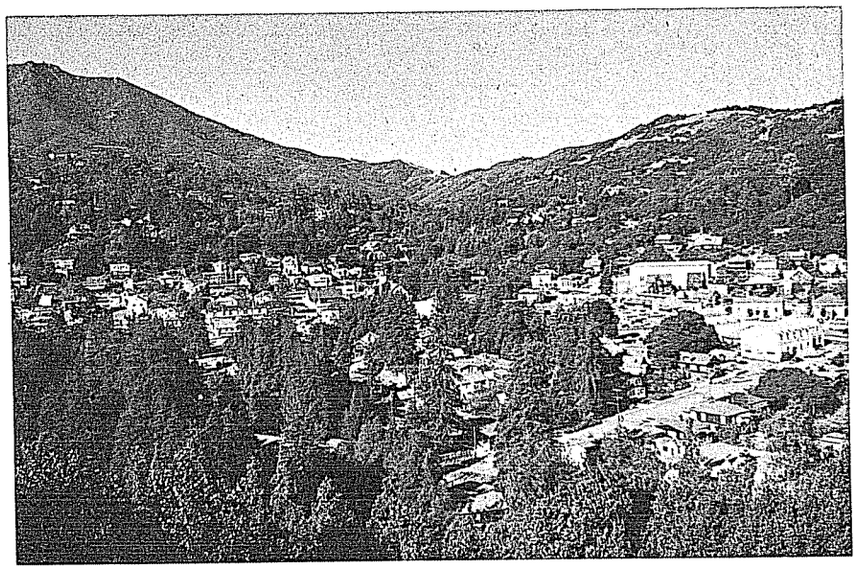


Illustration No. 4: Mill Valley Development
November 19, 1956

Climate in the Zone is mild, and the moderating effect of moist winds and fog causes an equable climate. Prevailing winds are southwesterly or westerly. Wind velocities average about 10 miles per hour and seldom exceed 35 miles per hour.

The rainy season extends from October to May. Summer rainstorms are infrequent. Most of the precipitation occurs from December to March inclusive. Rains are frequently heavy with numerous brief showers intervening between heavy storms. The average annual rainfall of Mill Valley is approximately 39 inches. Plate No. 2 shows the rainfall pattern for a typical heavy rainfall at various locations.

A U.S. Weather Bureau rainfall station is located in the Zone, approximately 1.8 miles northwest of the Mill Valley Post Office at an elevation of 950 feet. The station has been maintained in this location since 1955. A Weather Bureau station has been located on Mount Tamalpais since 1898, at seven different locations varying in elevation from 950 feet to 2600 feet. All locations were on the fringe of the Zone.

Rainfall records have been kept by the Marin Municipal Water District at its Mill Valley office since 1939. The exposure and accuracy of the station are rated "good" by the Weather Bureau. These records were compiled and used for this report as being more applicable to the Zone than U.S. Weather Bureau records. The compiled rainfall records are included in the Appendix to the report.

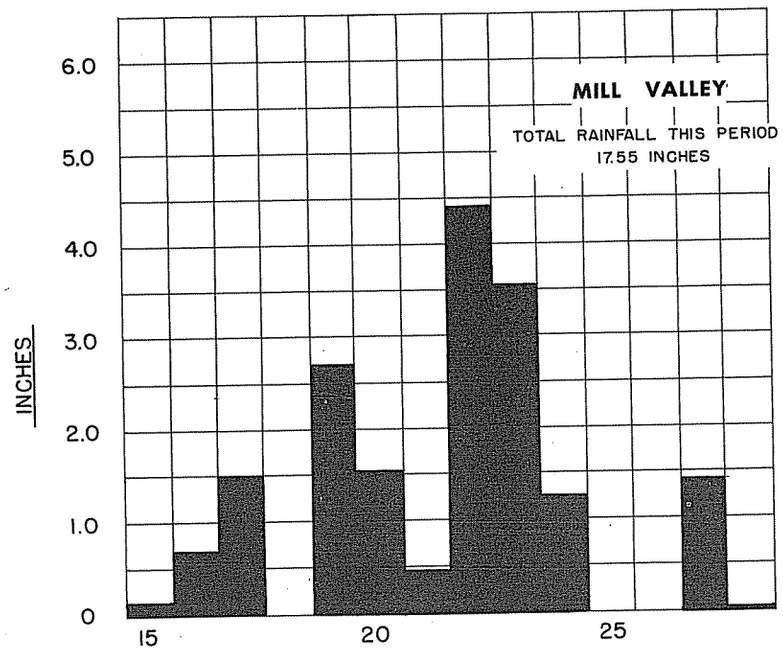
Intensity-duration-frequency curves were developed from the records of rainfall and are shown on Plate No. 3. A discussion of the derivation of the curves is included in the Appendix to the report.

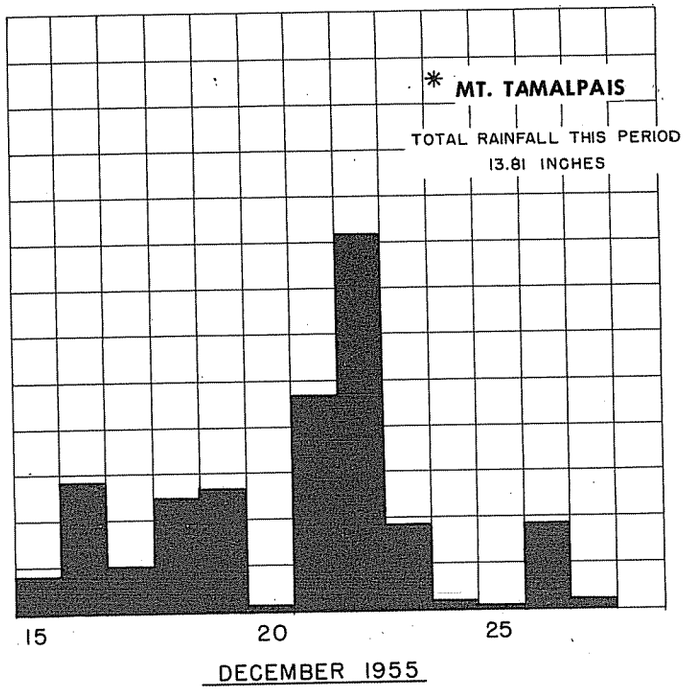
No adequate records of flow in the streams of the Zone are available. The computation of stream runoff in this report is based on the Rational Method modified by routing techniques assuming no stream storage. The method permits the estimate of peak stream flow from rainfall data and from a consideration of the physical characteristics of the drainage area. The method relates the quantity of runoff directly to the coefficient of runoff (percent of runoff), the rainfall intensity and the drainage area. Further discussion of the Rational Method is included in the Appendix to the report. Plate No. 4 shows the major streams and drainage areas in the Zone. Peak runoff amounts, at designated points, are also tabulated.

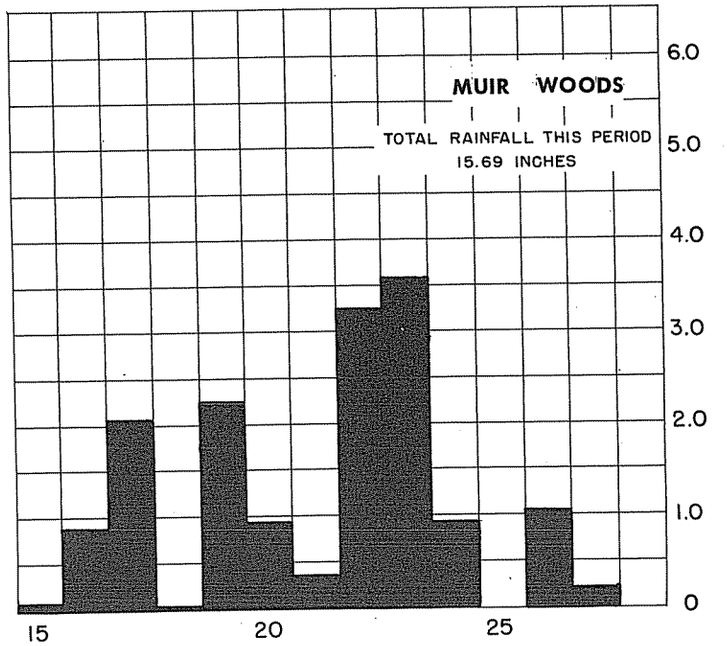
In the consideration of flood control works including a barrier and a regulator basin in Richardson Bay, the determination of total storm runoff is required. The preferred method of determination is by the use of the flood hydrograph. The flood hydrograph is a curve showing the time-discharge relationship for a given stream. The measurement of the total area under the curve of the hydrograph will give the total storm runoff for the stream. Data for the plotting of the actual flood hydrographs for the streams in the Zone were not available.

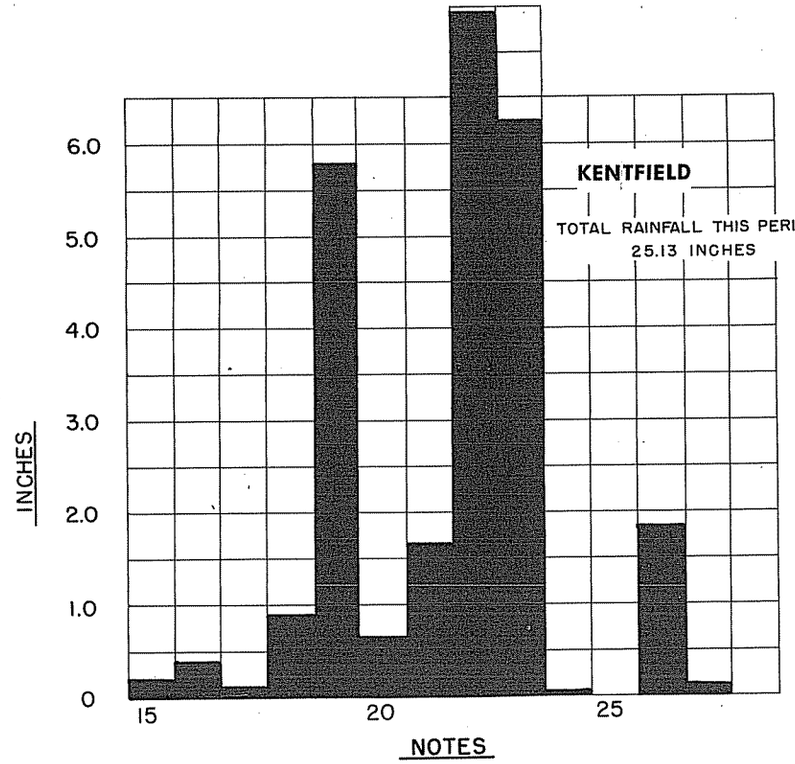
The Basic Hydrograph method was selected as the most feasible means of determining the total storm runoff for the stream. An explanation of the Basic Hydrograph method is included in the Appendix to the report. Plate No. 5 shows a comparison of actual flood hydrographs with basic flood hydrographs for Novato Creek and Corte Madera Creek, where records sufficient to construct actual flood hydrographs were available. Plates Nos. 6, 7, and 8 show flood hydrographs for streams in the Zone. Plate No. 9 shows the basin inflow hydrograph and the mass curve for the basin.

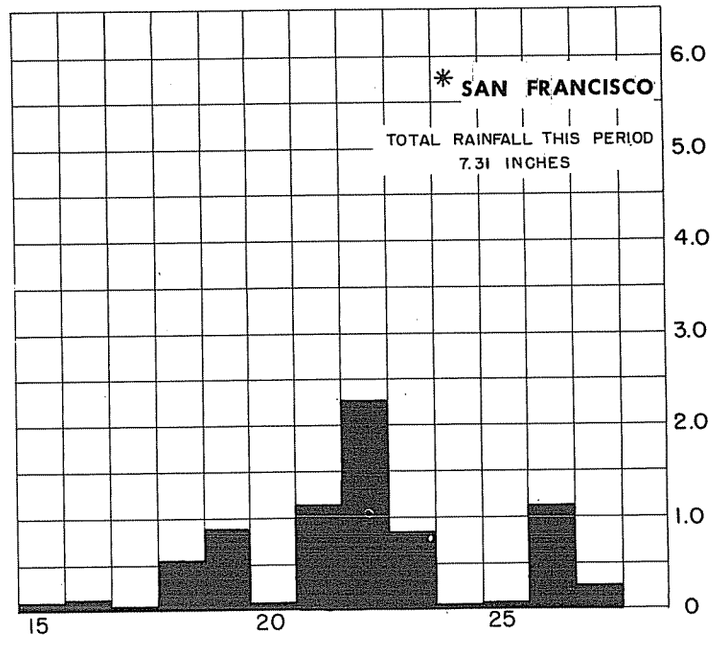
PLATE NO. 2 is a plot of rainfall patterns at selected stations for the storm period December 15-28, 1955. Stations noted as recorder stations show the total rainfall at the station for the day indicated. The Mill Valley, Kentfield, and Muir Woods stations are non-recording and show the total amount of rainfall during the 24-hour period preceding the observation times noted. Storms of December 1955 are notable because of the protracted duration of rainfall. These rainfall patterns are characterized by greater amounts of rain during the middle of the period and are typical of heavy storms in the Zone.











NOTES

1. SOURCE OF DATA: U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
2. * DENOTES RECORDING STATION SERVED BY AUTOMATIC RAINFALL RECORDER.
3. MILL VALLEY OBSERVATIONS ARE RECORDED DAILY AT 8A.M.
4. KENTFIELD OBSERVATIONS ARE RECORDED DAILY AT 6 P.M.
5. MUIR WOODS OBSERVATIONS ARE RECORDED DAILY AT 9 A.M.

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RAINFALL PATTERNS

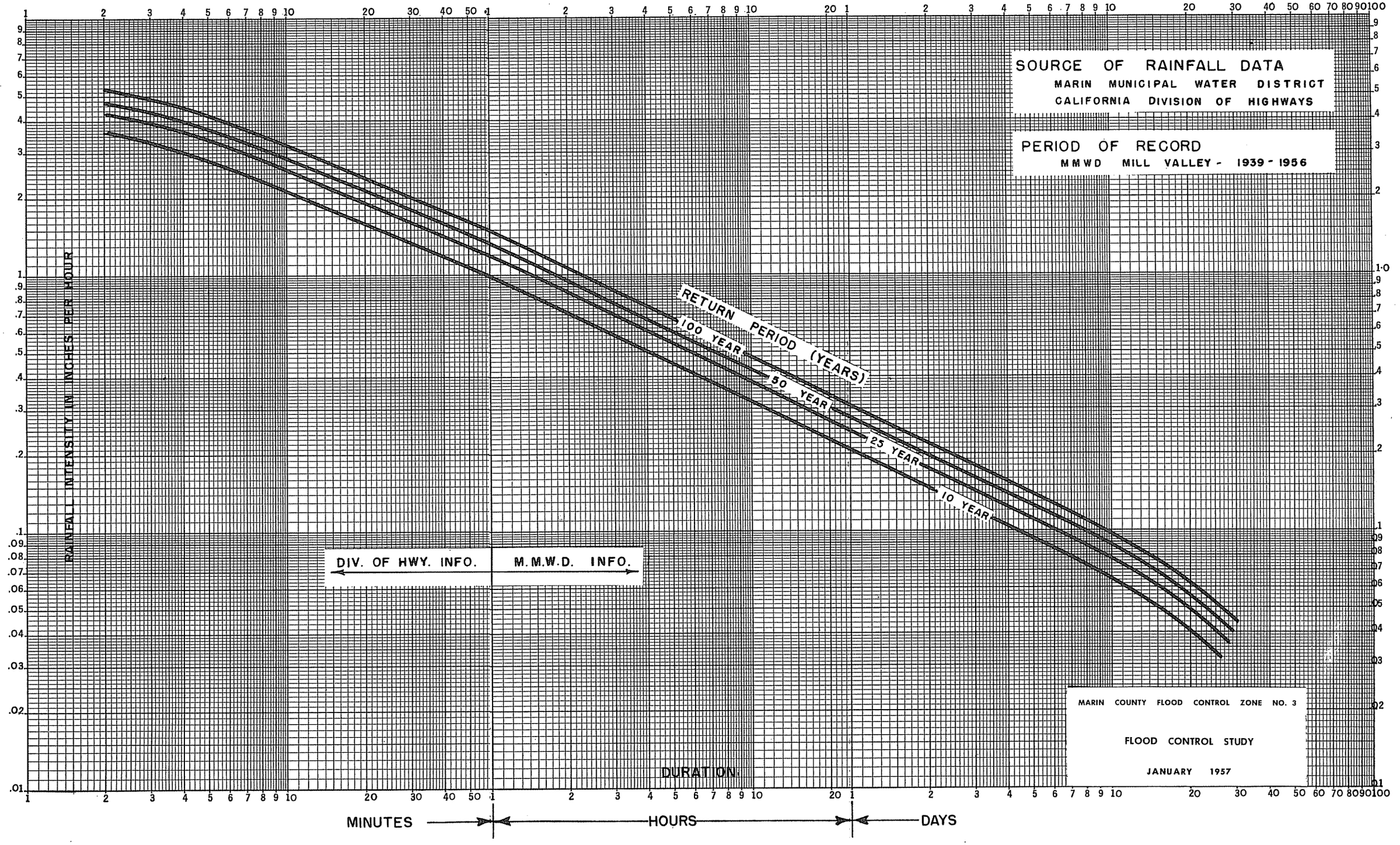
DECEMBER 15 TO 28, 1955

ENGINEERING OFFICE OF CLYDE C. KENNEDY

SAN FRANCISCO

PLATE NO. 2

PLATE NO. 3 shows intensity-duration-frequency curves developed from statistical analysis of basic rainfall data for the Zone. The portions of the frequency curves for rainfall durations of less than one hour are based on information contained in the Joint Departmental Report on the Performance of Culverts and Culvert Practice, California Division of Highways, 1941. For a selected storm frequency and duration, this plate will show average rainfall intensity for the duration selected.



INTENSITY-DURATION-FREQUENCY CURVES

ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

PLATE NO. 3

PLATE NO. 4 shows the major drainage areas of the Zone. The approximate size of each of these areas is as follows:

Mill Valley Drainage Basin	4020 acres
Tamalpais Valley Drainage Basin	2270 acres
Sutton Manor Drainage Basin	785 acres
Areas Tributary to Richardson Bay	950 acres

The table of storm flow quantities shows runoff rates from the area tributary to each point of concentration as the storm flow is routed downstream. The table also shows the summation of flow at each point of concentration at the time of passage of storm flow peak.

LEGEND

- POINTS OF CONCENTRATION
- MILL VALLEY DRAINAGE BASIN
- TAMALPAIS VALLEY DRAINAGE BASIN
- SUTTON MANOR DRAINAGE BASIN
- DRAINAGE AREAS TRIBUTARY DIRECTLY TO BAY
- BOUNDARY OF FLOOD CONTROL ZONE
- DRAINAGE BASIN LIMIT LINES
- STREAMS AND MAJOR TRIBUTARIES

GRAPHIC SCALE
0 2000' 4000'

SUTTON MANOR BRANCH
U.S. HIGHWAY 101
WARNER CANYON CREEK
BLITHEDALE AVE.
CAMINO DEL PRESIDIO ALTO
RICHARDSON BAY
ARROYO CORTE MADERA DEL PRESIDIO
CORTE MADERA AVE
BUENA VISTA AVE.
ARROYO CORTE MADERA
MILLER AVE.
REED CREEK
THROCKMORTON AVE.
OLD MILL CREEK
SHORELINE HWY.
COYOTE CREEK
MARIN BRANCH
TENNESSEE VALLEY BRANCH
CREST

STORM FLOW QUANTITIES
(IN C.F.S.)

POINTS OF CONCENTRATION	FLOW INCREMENT	SUMMATION OF FLOW
1	600	600
2	150	2990
3	110	2840
3A	500	500
4	140	2230
4A	420	420
5	420	1670
6	360	360
7	380	890
8	510	510
9	70	2160
10	80	2090
11	210	1020
12	470	810
12A	340	340
13	180	990
14	400	810
15	410	410

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MAJOR DRAINAGE AREAS

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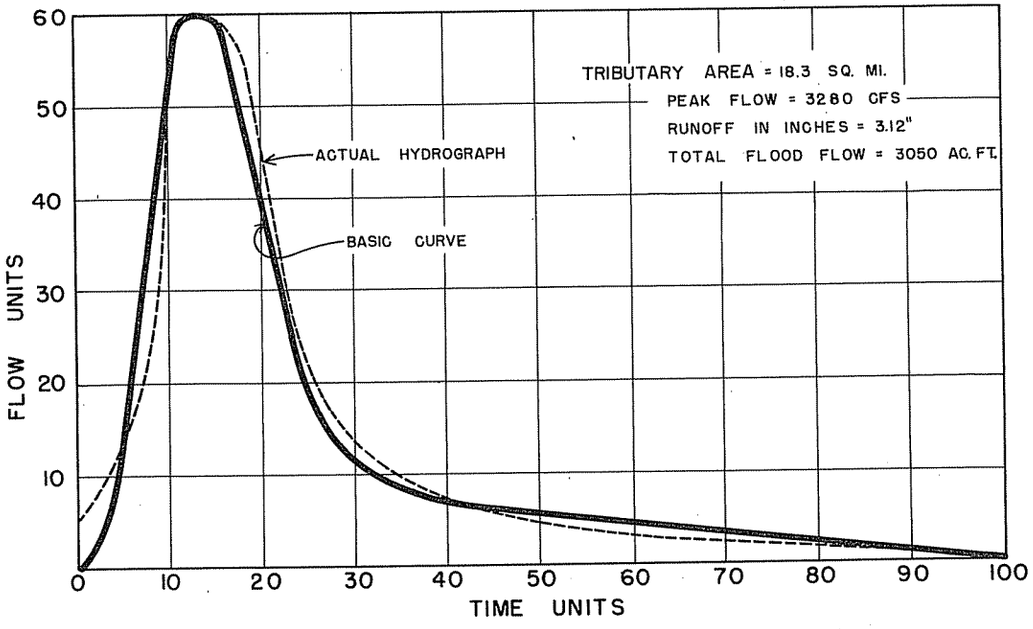
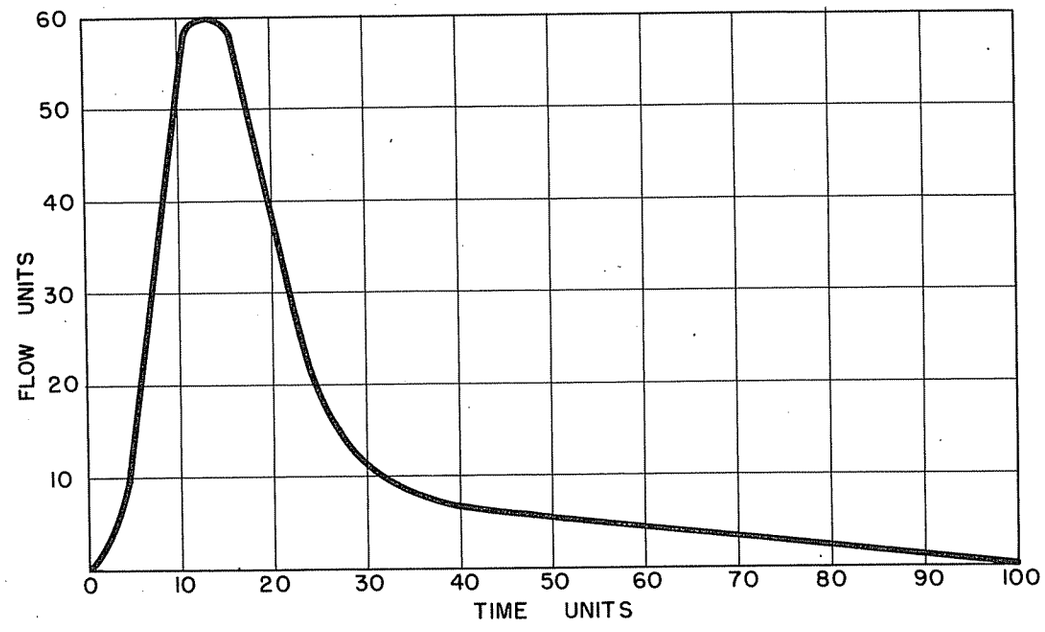
PLATE NO. 4

PLATE NO. 5 shows the Basic Hydrograph used for defining the shape of hydrographs for each stream in the Zone. Basic Hydrographs and actual hydrographs are shown for two streams in Marin County indicating the general correlation of the curves.

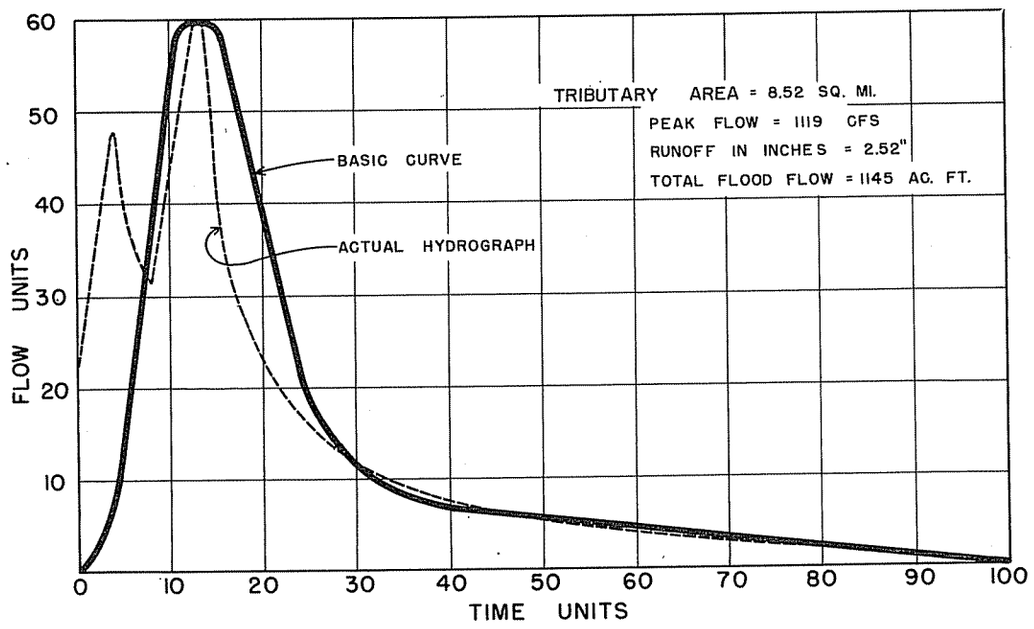


CORTE MADERA CREEK

DECEMBER 1952



BASIC HYDROGRAPH



NOVATO CREEK

DECEMBER 21-22 1955

TOTAL AREA UNDER CURVE 1196.5 "SQUARE UNITS"

PEAK FLOW ÷ 60 = VALUE OF ONE FLOW UNIT

TIME OF PEAK ÷ TIME UNITS TO PEAK = VALUE OF ONE TIME UNIT

VALUE OF ONE SQUARE UNIT = $\frac{(\text{VALUE OF FLOW UNIT})(\text{VALUE OF TIME UNIT})}{12}$

WHERE: VALUE OF SQ. UNIT IS IN ACRE FEET
VALUE OF FLOW UNIT IS IN CFS
VALUE OF TIME UNIT IS IN HOURS

TOTAL FLOOD FLOW = (1196.5)(VALUE OF SQUARE UNIT)

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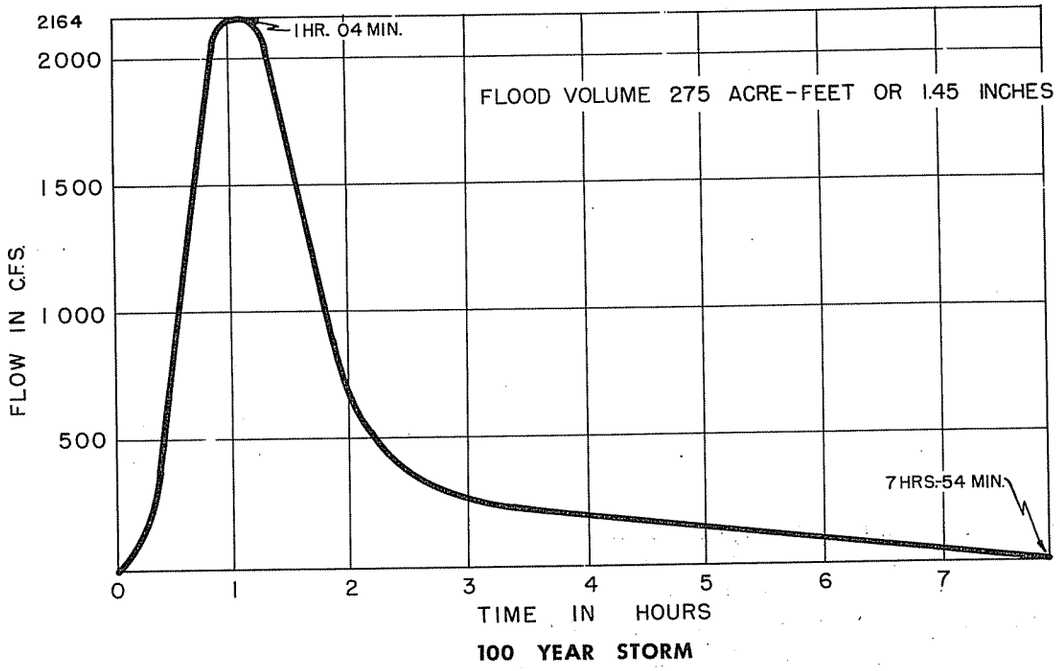
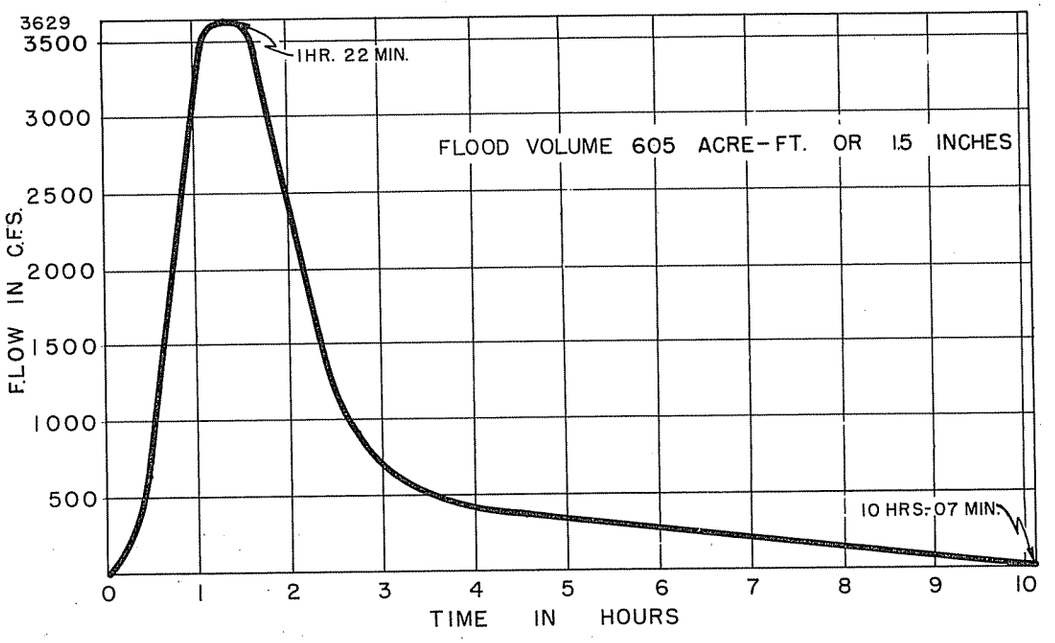
HYDROGRAPHS

ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

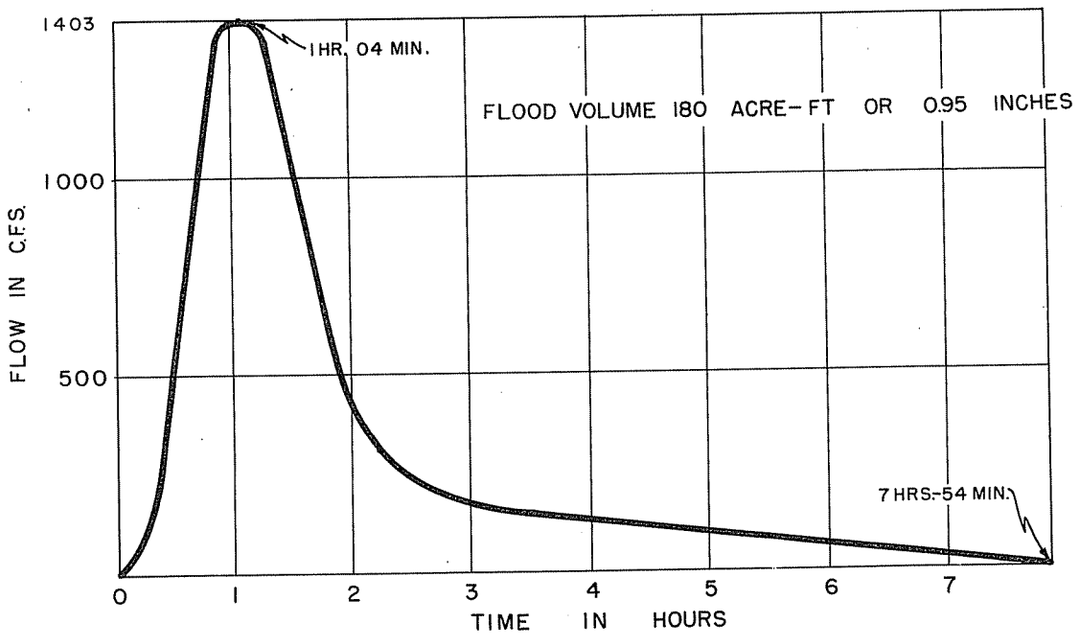
PLATE NO. 6 shows stream hydrographs at the point of discharge into Richardson Bay for each of the major stream groups. Flood Volume or total runoff amount is as shown for each stream. The time of peak for each hydrograph is the time required for the entire tributary area to begin contributing to stream flow.



100 YEAR STORM

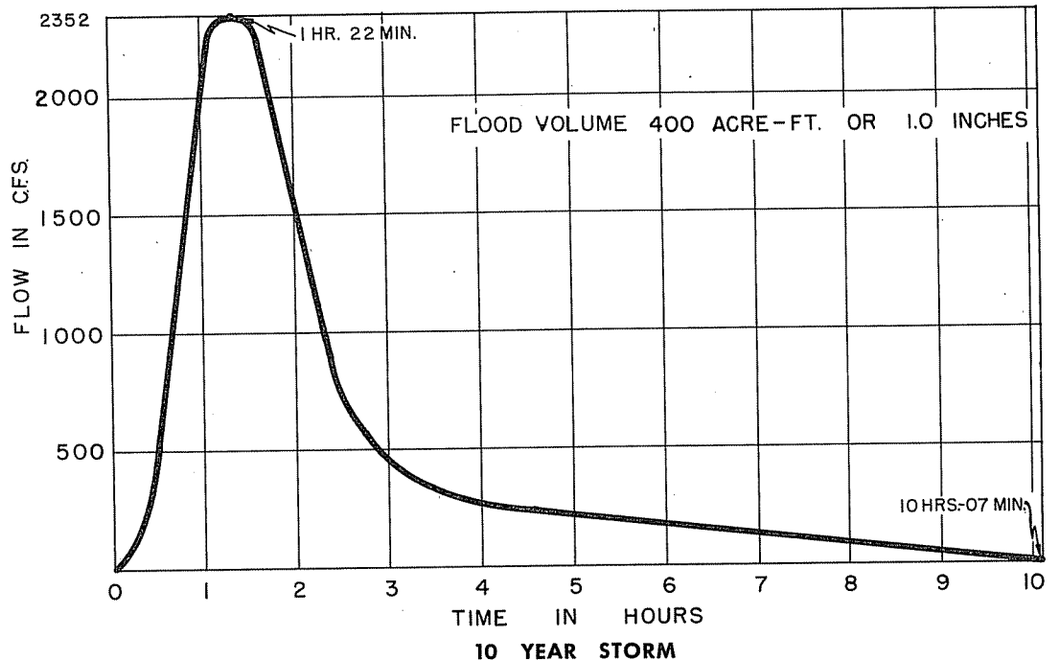


100 YEAR STORM



10 YEAR STORM

COYOTE CREEK GROUP



10 YEAR STORM

ARROYO CORTE MADERA DEL PRESIDIO GROUP

MARIN COUNTY FLOOD CONTROL ZONE NO. 3
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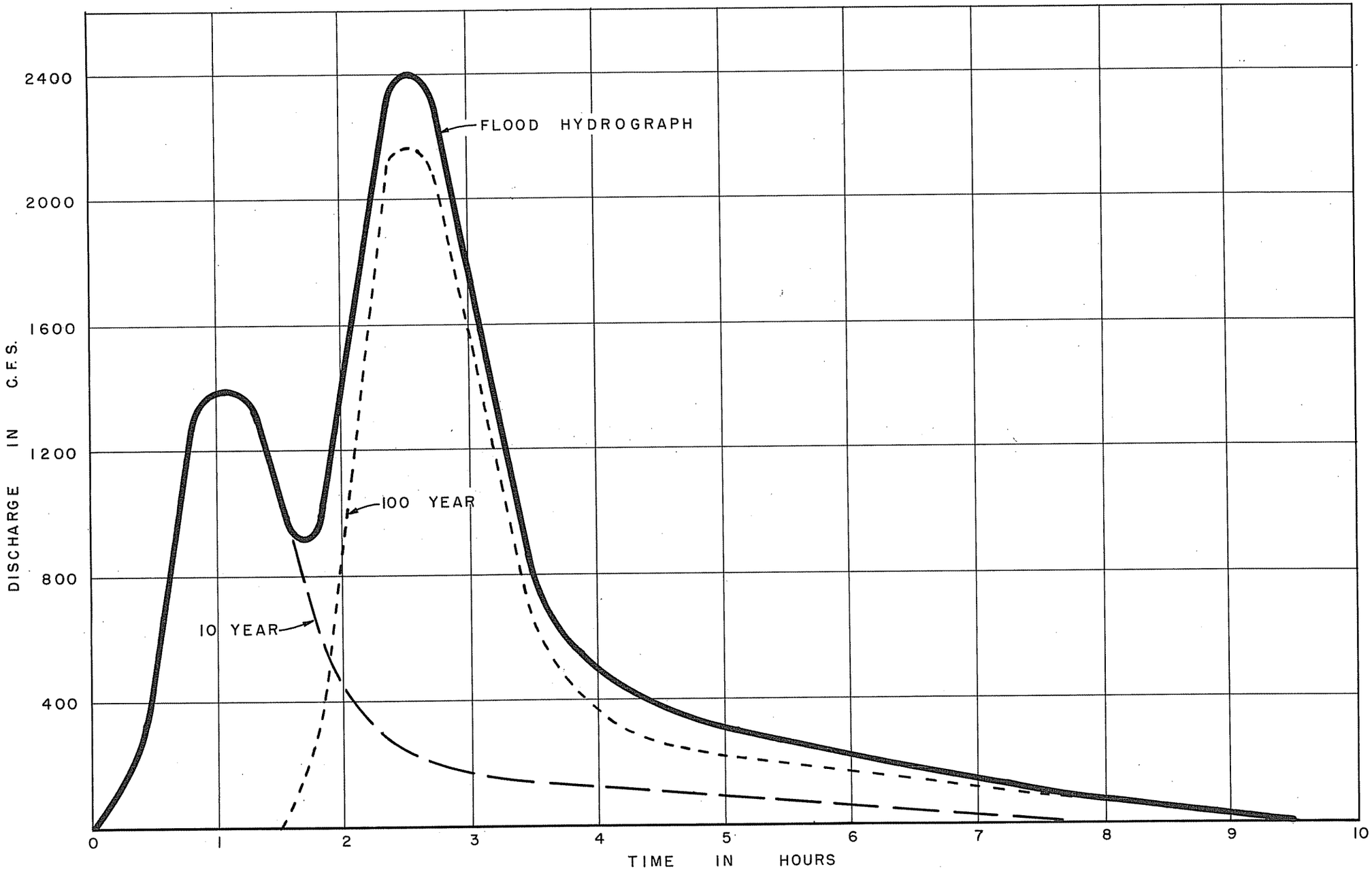
CREEK HYDROGRAPHS

ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

PLATE NO. 7 shows the shape of the hydrograph for Coyote Creek at its discharge into Richardson Bay. The hydrograph shown is for maximum storm flow condition to determine required regulator basin capacity and represents the combining of 10-year and 100-year storm runoffs. Because of Zone rainfall patterns, this combined storm condition is considered rather than that of an isolated storm.



PEAK 10 YEAR DISCHARGE 1403 C.F.S.

PEAK 100 YEAR DISCHARGE 2164 C.F.S.

BASIN DESIGN CONDITION — 10 YEAR DISCHARGE FOLLOWED BY 100 YEAR DISCHARGE

PEAK FLOOD DISCHARGE 2400 C.F.S.

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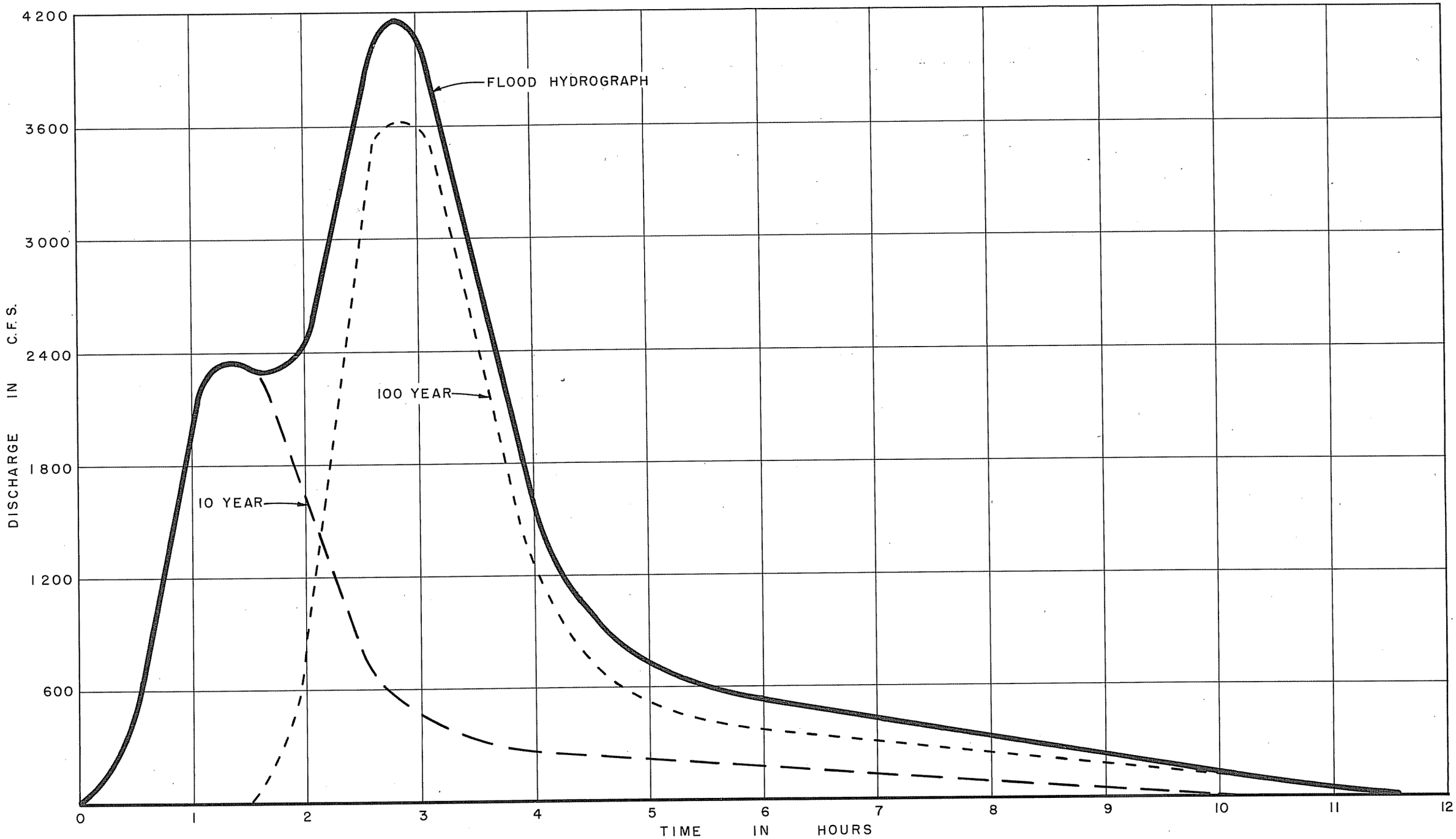
COYOTE CREEK FLOOD HYDROGRAPH

ENGINEERING OFFICE OF CLYDE C. KENNEDY

SAN FRANCISCO

PLATE NO. 7

PLATE NO. 8 shows the shape of the hydrograph for Arroyo Corte Madera del Presidio at its discharge into Richardson Bay. The hydrograph shown is for maximum storm flow condition to determine required regulator basin capacity and represents the combining of 10-year and 100-year storm runoffs. Because of Zone rainfall patterns this combined storm condition is considered rather than that of an isolated storm.



PEAK 10 YEAR DISCHARGE 2352 C.F.S.

PEAK 100 YEAR DISCHARGE 3629 C.F.S.

BASIN DESIGN CONDITION — 10 YEAR DISCHARGE FOLLOWED BY 100 YEAR DISCHARGE

PEAK FLOOD DISCHARGE 4170 C.F.S.

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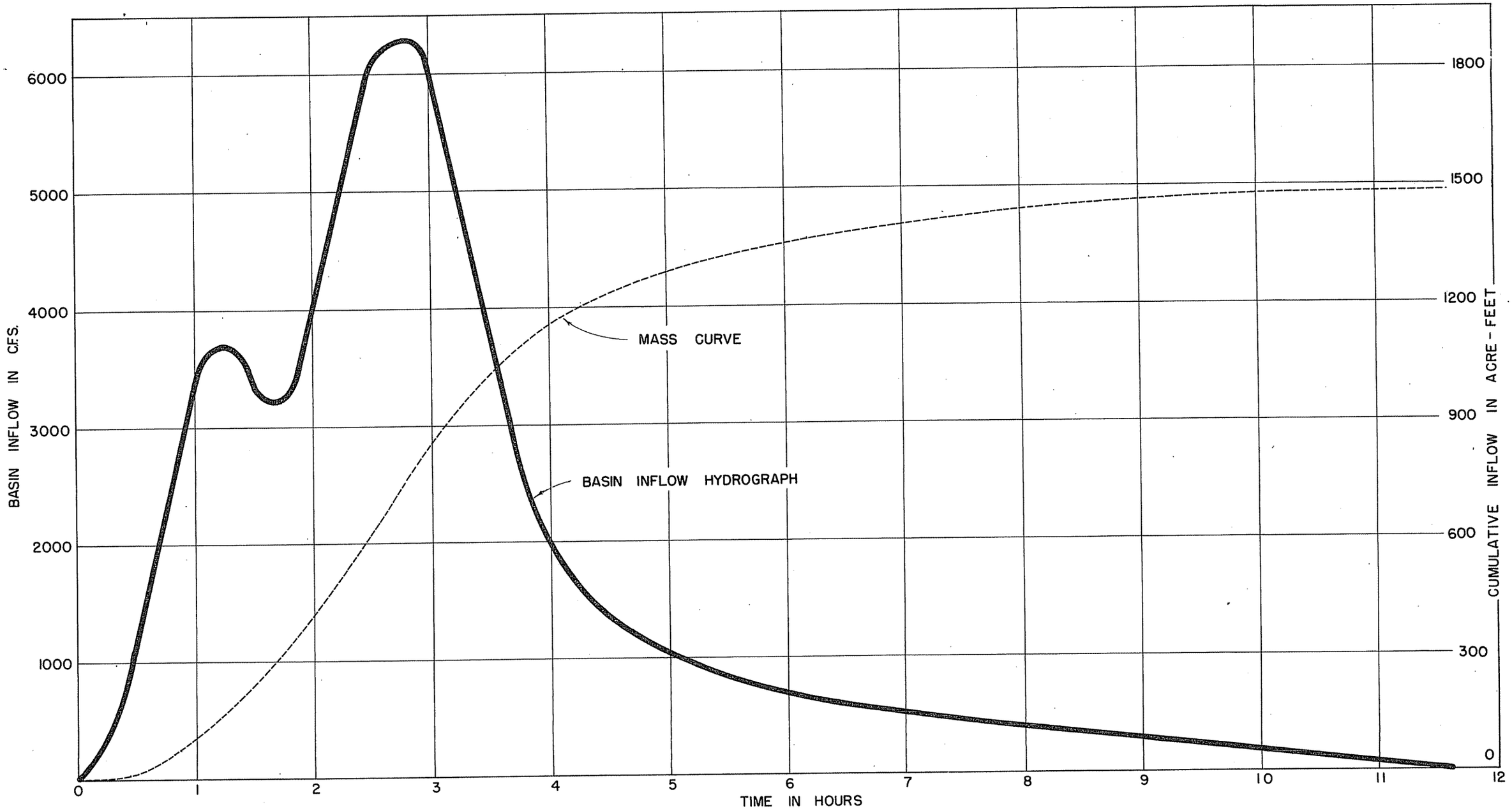
ARROYO CORTE MADERA DEL PRESIDIO FLOOD HYDROGRAPH

ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

PLATE NO. 8

PLATE NO. 9 shows the summation of the two stream hydrographs discharging into Richardson Bay under the maximum storm flow condition. The plotted mass curve shows the total volume of runoff which has entered the regulator basin at any time following the beginning of the 10-year storm.



PEAK BASIN INFLOW = 6300 C.F.S.
TIME TO PEAK = 2 HOURS 50 MINUTES
DESIGN CONDITIONS – 10 YEAR STORM
FOLLOWED BY 100 YEAR STORM
TOTAL BASIN INFLOW = 1490 ACRE-FEET

MARIN COUNTY FLOOD CONTROL ZONE NO. 3
FLOOD CONTROL STUDY
JANUARY 1957

BASIN INFLOW HYDROGRAPH AND MASS CURVE

ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

PLATE NO. 9

HISTORICAL FLOODS

General flood damage in the area of the Zone has occurred at periodic intervals over past years. Storms which caused general flooding occurred in March 1907, January 1909, January 1916, February 1940, December 1952 and December 1955.

The storm of December 1955 is representative of past storms and because of its recent occurance is well recalled by residents of the County. The rainfall pattern for this storm is typical of heavy storms in the area. Preceded by frequent rains of light intensity the storm extended over the period from December 15 - 28 as shown on Plate No. 2. High tide conditions occurred simultaneously with extreme stream runoff and intensified the effects of flooding in the lower areas of the Zone. Strong winds with gusts up to 80 miles per hour increased these high-tide elevations thus further intensifying the effects of flooding.

Illustration No. 5: December 1955 Storm
Independent Journal Photo

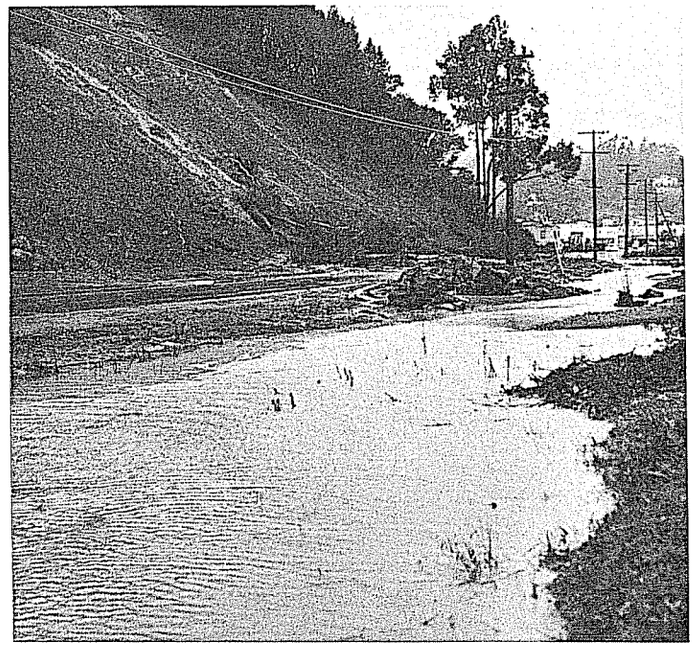


Illustration No. 6: December 1955 Storm
Independent Journal Photo

Arroyo Corte Madera del Presidio and Old Mill Creek overflowed in downtown Mill Valley. Sutton Manor branch overflowed. All low areas of the Zone were flooded, the most serious conditions being in the Tamalpais Valley and Locust areas.

Damage in the Zone was widespread, and estimates range as high as one million dollars. It has been estimated that Tamalpais Valley alone incurred about $250,000 in direct damages from the storm.

The heavy damage of this storm was a result of the combination of several extreme conditions. First, heavy stream runoff from the storm. Second, high tide conditions occurred simultaneously with heavy runoff. Third, wind velocities caused tide levels above predicted high tides.

The severe damage from this storm emphasizes the need for legal means of control of minimum elevations of landfill in new subdivision development in lower areas of the Zone. A zoning ordinance setting minimum fill elevations could provide the means for proper control of this development. From the study and investigations that have been made in connection with this report, it is recommended that an elevation of 13.0 (M. L. L. W.) be considered as a minimum for fill elevations in the Zone.

TIDES

The United States Coast and Geodetic Survey reference station for tide variations in San Francisco Bay is located at the Presidio in San Francisco. A subordinate tide station is located at Sausalito, and data for this station is related to the Presidio station. The tide conditions in the Zone discussed in this report are based upon tide conditions at the Sausalito Station.

Tidal fluctuations in Richardson Bay have a significant effect upon the carrying capacity of streams and drainage structures in the Zone. Photographs included with this study show the backwater effect of tides upon some of the drainage structures on streams in the Zone. These photographs were taken at a time of high tide during a time of no stream flow. It can be seen that capacities of these drainage structures and stream channels to carry storm waters without overflow is severely limited by tidal backwater.

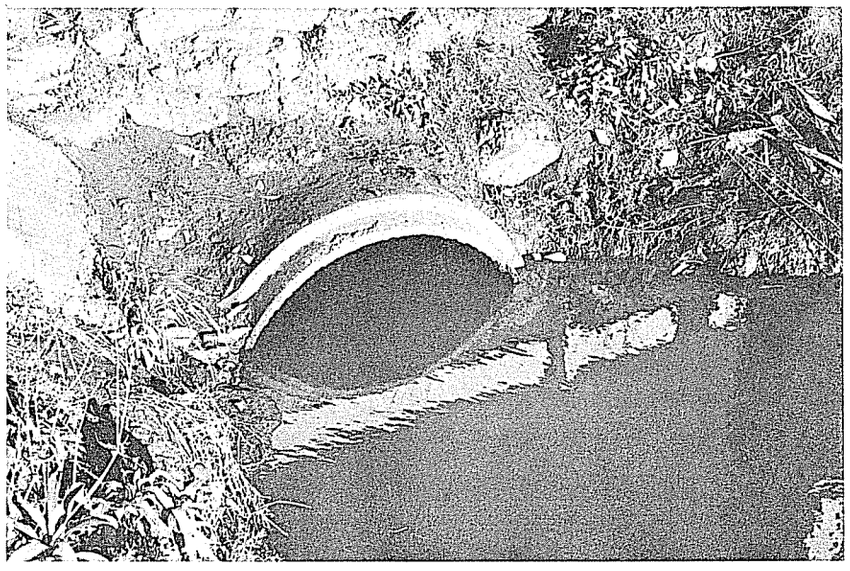


Illustration No. 7: Tidal Effect on Sutton Manor Branch
Camino Alto and Ashford
November 19, 1956

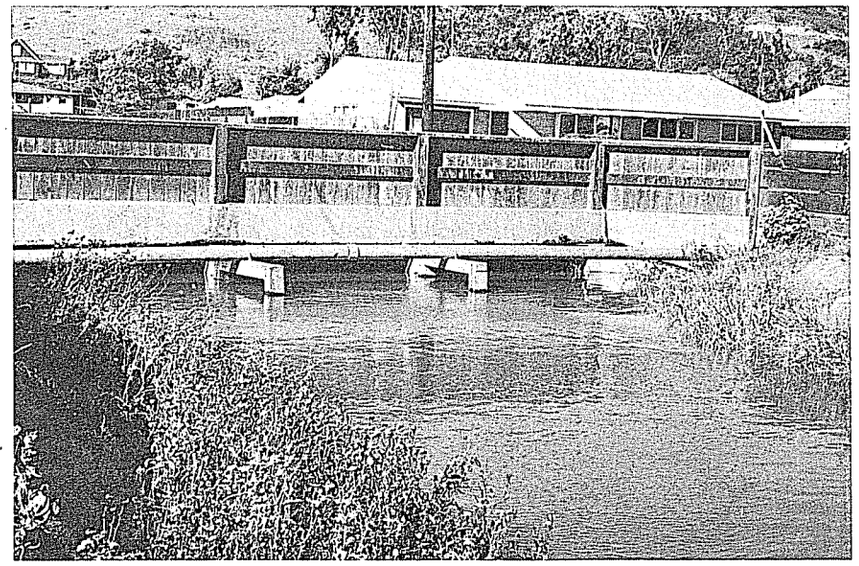


Illustration No. 8: Tidal Effect of Coyote Creek
Flamingo Road, Culvert No. 33

Under storm conditions, velocities of storm flow will tend to displace tide waters and capacity will be somewhat greater than the available capacity indicated in the photographs. However, in the areas where tidal effect is the most pronounced, stream flow velocities are lower and this increase in capacity will be small.

Tide Tables are published by the U.S.C. and G.S. and give predicted tide elevations for various stations in terms of mean lower low water (M. L. L. W.). Actual tide elevations may vary from the predicted elevations. The maximum observed variation between the predicted and actual tide elevation at Sausalito during December 1955 was 2.3 feet. The variation, commonly called "set-up" is caused primarily by wind friction on the water surface and storm water runoff into the Bay.

The selection of minimum effective tide and maximum tide are important in a study of a barrier and regulator basin. The minimum effective tide determines the minimum basin water surface which can be assumed prior to the beginning of a storm. This minimum basin water surface governs the area and capacity of the regulator basin.

The maximum tide will determine the required elevation of the top of the barrier. Maximum tide elevation consists of the highest predicted tide plus the maximum estimated set-up due to wind effect.

The selected tidal elevations for the conditions discussed above are:

1. Maximum tide — Elevation 11.0
2. Minimum effective tide — Elevation 3.0

If a barrier is not to be constructed, tidal fluctuations affect the stream analysis. The selection of a tide level of elevation 9.0 assumes a maximum tide condition increased by the wind-wave set-up for Richardson Bay during the time of selected storm frequency.

Plate No. 10 shows a curve of predicted and actual tide elevations at Sausalito for the month of December 1955.

Design tide conditions for the study and report are shown on Plate No. 11.

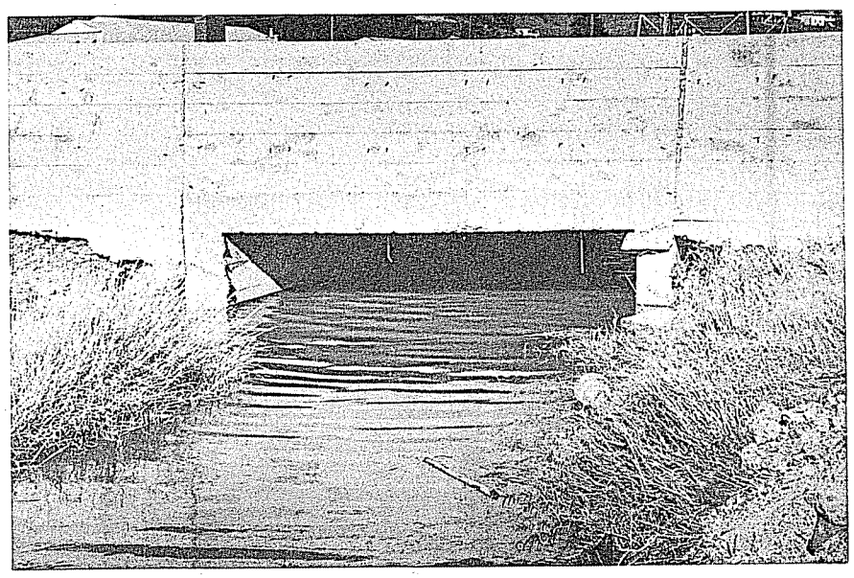


Illustration No. 9: Tidal Effect on Tennessee Valley Branch
Marin Avenue, Culvert No. 35
November 19, 1956

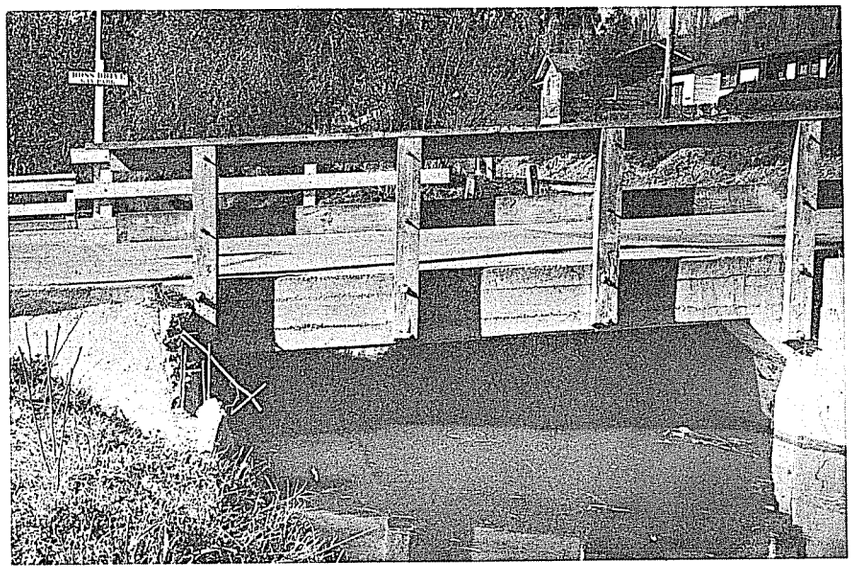
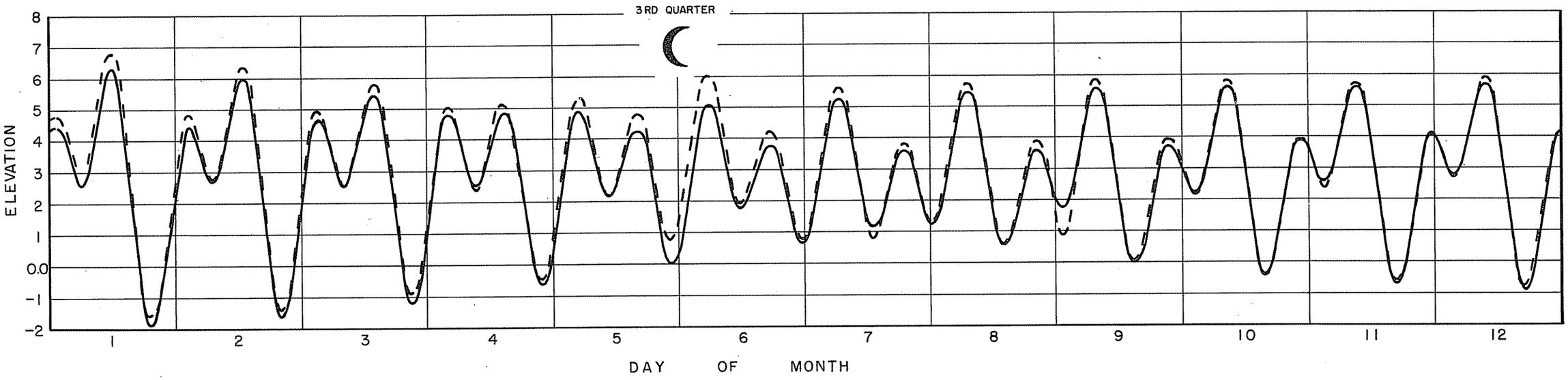
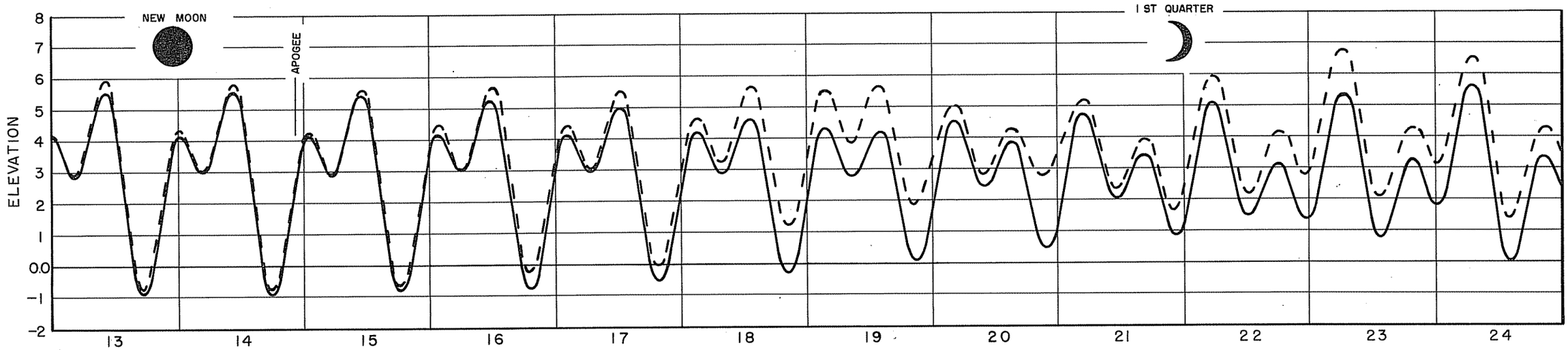
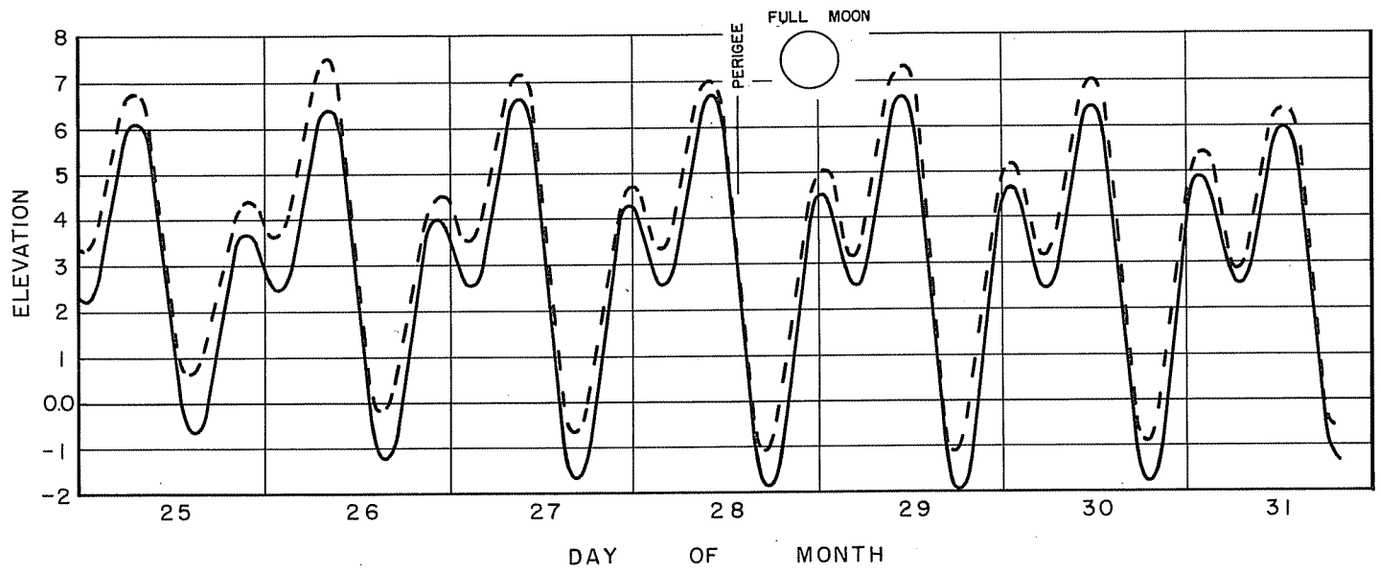


Illustration No. 10: Tidal Effect on Coyote Creek
Ross Drive
November 19, 1956

PLATE NO. 10 shows actual and predicted tides for the month of December 1955. Predicted tides are for the Presidio and have been converted to the Sausalito mean lower low water datum by means of published tidal differences. Actual tides are similarly determined. The highest tide for the month occurred on December 26th. Maximum deviation from the predicted tide occurred on December 20th.







LEGEND

PREDICTED TIDE

ACTUAL TIDE

NOTE

ALL ELEVATIONS BASED ON SAUSALITO M.L.L.W.

MARIN COUNTY FLOOD CONTROL ZONE NO. 3
FLOOD CONTROL STUDY
JANUARY 1957

DECEMBER 1955 TIDES

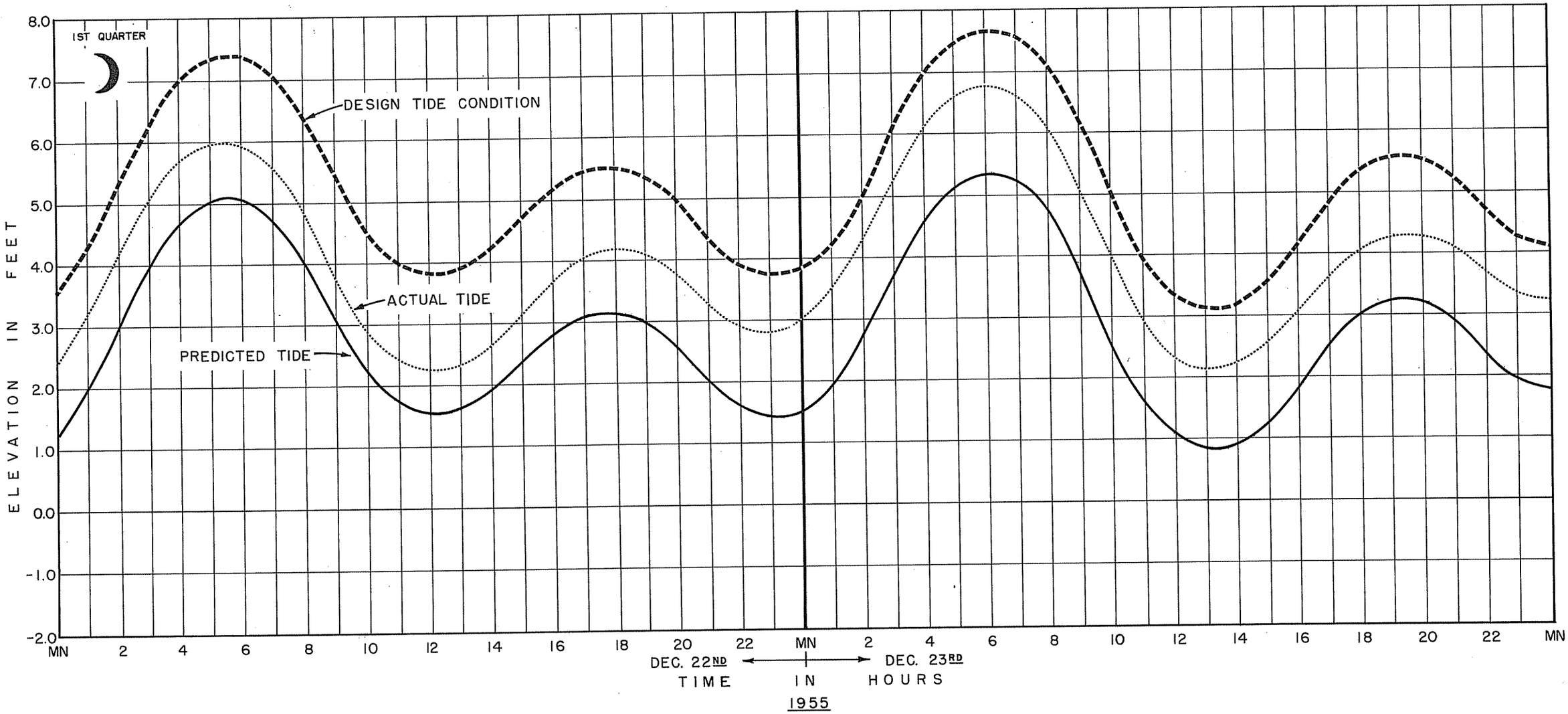
ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

PLATE NO.10

PLATE NO. 11 shows design tides used in determining the required capacity of the regulator basin and the discharge structure. Design tide is based upon a predicted neap tide for the month of December 1955 increased by the maximum observed set-up for the month. It is assumed that this maximum set-up will not actually persist for more than approximately an 8-hour period.

The predicted tide is published by the U. S. C. & G. S. for the Presidio and has been converted to the Sausalito mean lower low water datum by means of published tidal differences

A neap tide is that portion of the tidal cycle characterized by minimum range and occurring on the days following the first and third quarters of the moon.



NOTES:

MAXIMUM OBSERVED SET-UP DURING DECEMBER 1955 — 2.3 FEET.

ALL ELEVATIONS BASED ON SAUSALITO M.L.L.W.

PLOTTING METHOD BASED ON ONE-QUARTER, ONE-TENTH RULE OF U.S.C. & G.S.

MARIN COUNTY FLOOD CONTROL ZONE NO. 3
FLOOD CONTROL STUDY
JANUARY 1957

DESIGN TIDES

ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

PLATE NO. 11

STREAMS

A field investigation of the major streams in the Zone was made to determine existing streambed and drainage structure conditions. Existing culverts, bridges and other drainage structures were measured in order to determine existing capacity. Streams in upper elevations are in firm or rocky material, banks are protected by the natural growth and stream channels are generally adequate. Stream channels in the lower elevations are in poor condition. The disposal of brush and debris into the channels seriously reduces the capacity of the stream. Alignment of some streams is poor. The effect of tide conditions has already been discussed.

Streams in the Zone have been analyzed in accordance with the Manning formula. Channel roughness coefficients used in determining capacity of streams are:

1.	For lined channels	0.015
2.	For existing unlined channels	0.035
3.	For new unlined sections	0.025 to 0.030

The design or peak storm for stream analysis is the greatest storm occurring once each 100 years on the average. Extreme tide conditions have been outlined in the section on Tides. The water surface elevation of a regulator basin at time of peak runoff has been selected as elevation 4.5.

Culverts have been analyzed on the basis of equations developed and used by the U.S. Public Roads Administration. Nomographs for determination of culvert capacities are included in the Appendix to this report.

The principal deficiencies of existing stream channels in the Zone are:

1. Poor alignment.
2. Inadequate channel section.
3. Inadequate culverts and bridges.
4. Improper transition sections at bridges and culverts.
5. Accumulation of debris in channels.

Proper alignment of streams in developed residential areas will be difficult and costly. Adequate channel sections, either concrete lined or unlined, can be constructed where the existing channel section is insufficient. Inadequate culverts and bridges can be replaced with new structures. Transition sections at bridges and culverts can be constructed. The accumulation of debris in channels can be removed. The proposed channel improvements are shown on Plates Nos. 12, 14, 15 and 16. Channel section #18 on Plate No. 12 is tabulated as inadequate. No improvements are planned in this section since the property owner is currently making improvements.

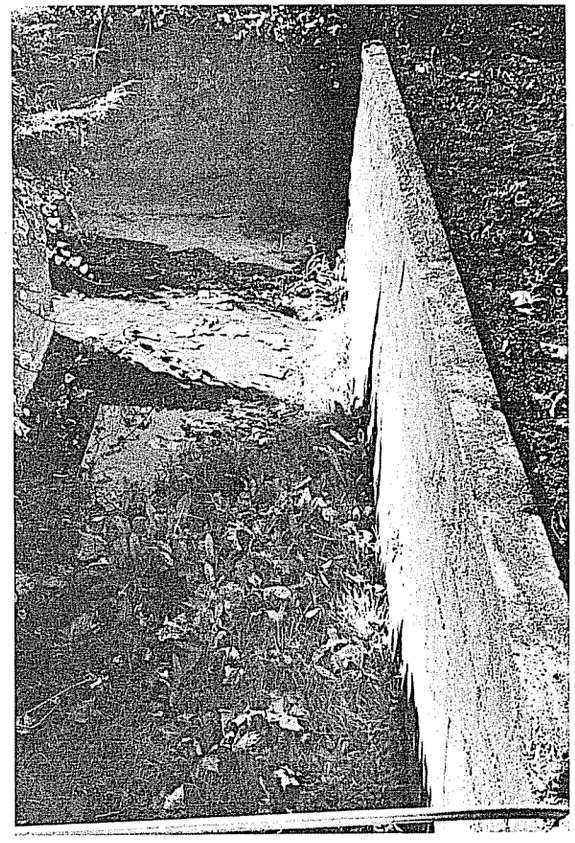


Illustration No. 11: Warner Canyon Creek near Sycamore Avenue. Right Angle Bend
November 19, 1956

Proposed stream channel improvements for the principal streams in the Zone are outlined as follows:

1. COYOTE CREEK GROUP

a. Coyote Creek

From Station	To Station	Proposed Items of Work
0 + 00	10 + 00	Align and enlarge existing channel
10 + 00	15 + 00	Construct enlarged channel
15 + 00	65 + 00	Construct rectangular reinforced concrete channel. Realign in vicinity of Station 65 + 00.

b. Tennessee Valley Branch

0 + 00	30 + 00	Construct enlarged channel

c. Crest-Marin Branch

0 + 00	30 + 00	Construct enlarged channel

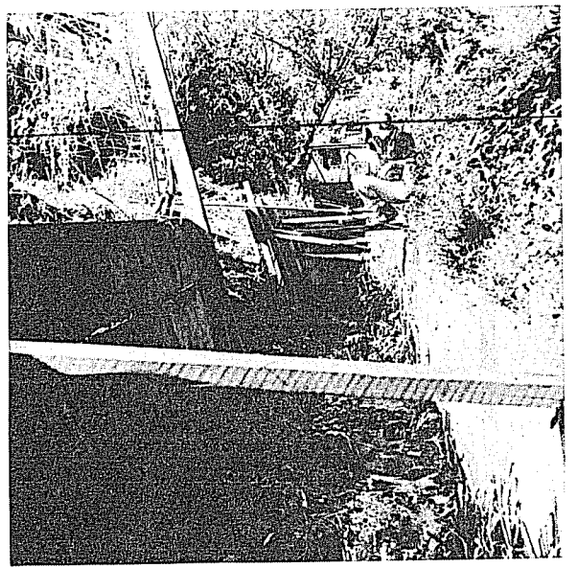


Illustration No. 12: Coyote Creek near Maple Avenue
December 1955 High Water Mark Noted
October 31, 1956

Illustration No. 13: Coyote Creek near Maple Avenue
October 31, 1956

2. ARROYO CORTE MADERA DEL PRESIDIO GROUP

a. Arroyo Corte Madera del Presidio

From Station	To Station	Proposed Items of Work
-10 + 00	0 + 00	Align and enlarge existing channel
0 + 00	33 + 00	Construct enlarged channel
33 + 00	57 + 00	Construct rectangular reinforced concrete channel section
57 + 00	88 + 00	Modify existing concrete-lined channel section
88 + 00	125 + 00	Modify existing channel section

b. Reed Creek

From Station	To Station	Proposed Items of Work
0 + 00	5 + 00	Modify existing rectangular concrete channel section and construct new reinforced concrete section

c. Warner Canyon Creek

0 + 00	22 + 00	Align and modify existing channel

d. Old Mill Creek

0 + 00	3 + 50	Align and modify existing channel

e. Sutton Manor Branch

-20 + 00	-8 + 00	Align and enlarge channel
-8 + 00	9 + 00	Construct enlarged channel
9 + 00	24 + 00	Construct rectangular reinforced concrete channel
24 + 00	32 + 00	Modify existing lined channel and construct new rectangular reinforced concrete channel

Restrictions to flow in stream channels result from culverts or bridges of inadequate capacity. Proposed culvert improvements are outlined below. Culvert locations are shown on Plate No. 13.

Culvert Number	Proposed Items of Work
1	Modify existing bridge to increase capacity.
2	Remove existing culvert. Construct new culvert.
4	Modify existing culvert to increase capacity.
6	Modify existing culvert to increase capacity.
13	Modify existing culvert to increase capacity.
16	Modify existing culvert to increase capacity.
17	Remove existing culvert. Construct new culvert.
18	Remove existing culvert. Construct new culvert.
22	Modify existing culvert to increase capacity.
25	Modify existing culvert to increase capacity.

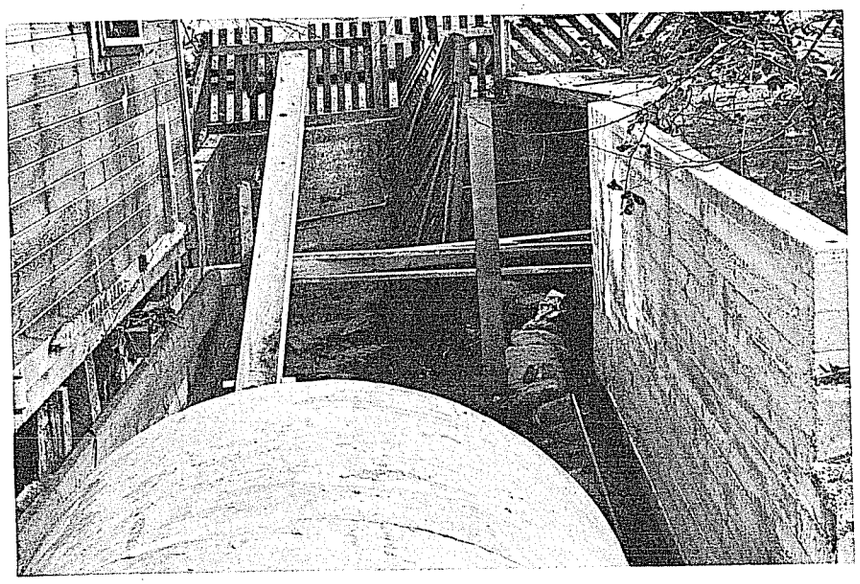


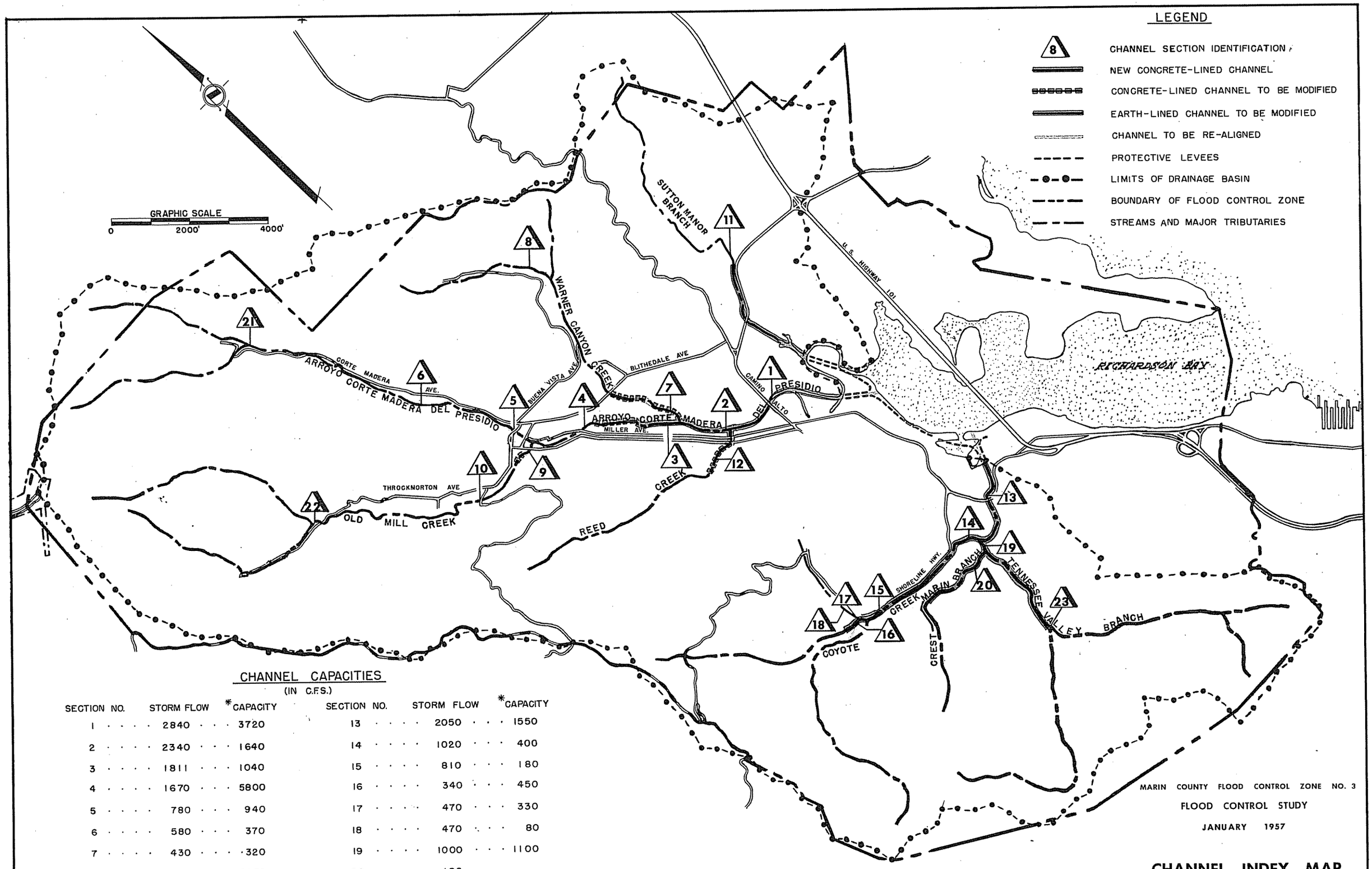
Illustration No. 14: Old Mill Creek at Miller Avenue
Culvert No. 25
November 19, 1956

Culvert Number	Proposed Items of Work
26	Modify existing culvert to increase capacity.
27	Remove existing culvert. Construct new culvert.
28	Remove existing culvert. Construct new culvert.
29	Remove existing culvert. Construct new culvert.
30	Remove existing culvert. Construct new culvert.
31	Modify existing culvert to increase capacity.
32	Modify existing culvert to increase capacity.
33	Remove existing culvert. Construct new culvert.
34	Remove existing culvert. Construct new culvert.
35	Remove existing culvert. Construct new culvert.
36	Remove existing culvert. Construct new culvert.

The United States Corps of Engineers is currently making a study of required flood control works for Coyote Creek basin. The preparation of construction plans and specifications and construction of flood control works may follow if the project is approved by the Chief of Engineers. The limit of government funds for such a project is $400,000 and local participation for the project must include all costs in excess of this amount. Adequate provision for local storm drainage facilities is required but is also a local responsibility.

To satisfy the requirements for local participation in this work, plans for financing costs of the project in excess of $400,000 and the planning for construction of local storm drainage facilities should be given prompt consideration.

PLATE NO. 12 indicates the scope of stream channel improvements required. Existing stream channel capacities at selected points are tabulated and compared to maximum stream flow.



CHANNEL CAPACITIES

(IN C.F.S.)

SECTION NO.	STORM FLOW	*CAPACITY	SECTION NO.	STORM FLOW	*CAPACITY
1	2840	3720	13	2050	1550
2	2340	1640	14	1020	400
3	1811	1040	15	810	180
4	1670	5800	16	340	450
5	780	940	17	470	330
6	580	370	18	470	80
7	430	320	19	1000	1100
8	180	3070	20	180	
9	890	680	21	360	
10	770	8000	22	510	
11	300	660	23	810	
12	500	270			

* NO BACKWATER EFFECT CONSIDERED

MARIN COUNTY FLOOD CONTROL ZONE NO. 3

FLOOD CONTROL STUDY

JANUARY 1957

CHANNEL INDEX MAP

ENGINEERING OFFICE OF CLYDE C. KENNEDY

SAN FRANCISCO

PLATE NO. 12

PLATE NO. 13 compares existing culvert capacity with maximum storm flow and indicates the approximate location of each culvert. The table includes the main culverts in the Zone and serves to indicate the extent of required modifications. Twenty-one of the culverts tabulated are inadequate to pass the design storm.

GRAPHIC SCALE
0 2000' 4000'

SUTTON MANOR BRANCH
WARNER CANYON CREEK
ARROYO CORTE MADERA DEL PRESIDIO
CORTE MADERA AVE.
BUENA VISTA AVE.
BLITHEDALE AVE.
ARROYO CORTE MADERA DEL PRESIDIO
MILLER AVE.
GAMINO ALTO
THROCKMORTON AVE.
OLD MILL CREEK
REED CREEK
U. S. HIGHWAY 101
RICHARDSON BAY
SHORELINE HWY.
COYOTE CREEK
MARIN BRANCH
CREST
TENNESSEE VALLEY BRANCH

CULVERT CAPACITIES
(IN C.F.S.)

CULVERT NUMBER	STORM FLOW	EXISTING CAPACITY
1	2840	5000 *
2	1810	970 *
3	1670	1980
4	780	520
5	780	940
6	700	600
7	640	1320
8	580	620
9	530	950
10	480	540
11	480	480
12	480	480
13	430	280
14	430	630
15	430	630
16	500	360 *
17	430	300 *
18	430	200 *
19	410	420 *
20	410	420 *
21	380	460
22	240	120
23	140	260
24	140	180
25	890	470
26	760	700
27	500	240 *
28	480	280 *
29	420	100 *
30	300	230 *
31	150	30
32	60	50
33	1020	600 *
34	810	120
35	900	280 *
36	180	100 *

* EXISTING CAPACITY OF THESE CULVERTS FURTHER REDUCED BY BACKWATER EFFECT

MARIN COUNTY FLOOD CONTROL ZONE NO. 3

FLOOD CONTROL STUDY

JANUARY 1957

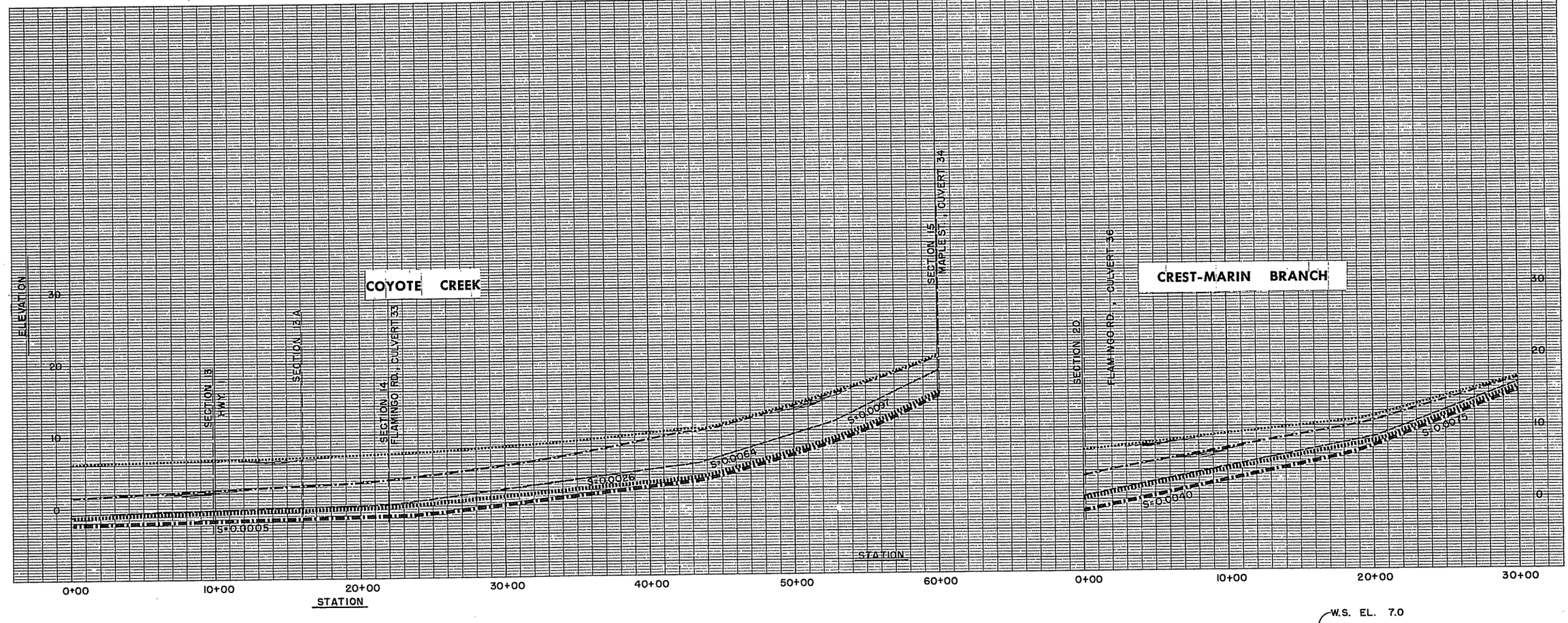
CULVERT INDEX MAP

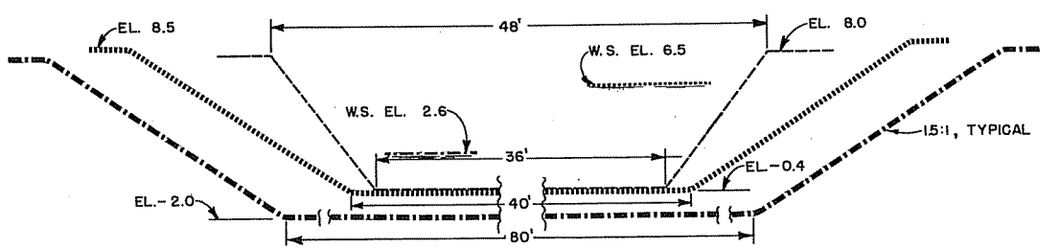
ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

PLATE NO. 13

PLATE NO. 14 shows existing stream profiles and cross sections in the Coyote Creek Group in Tamalpais Valley together with recommended modifications for each of the flood control alternatives considered in this study.

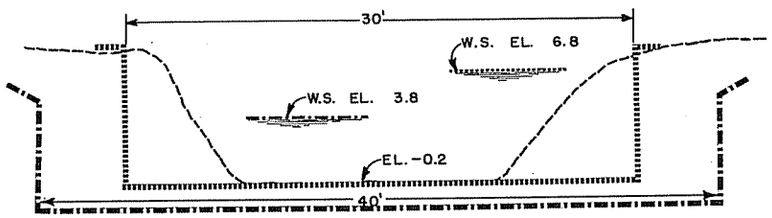
Elevations shown on this plate and Plate No. 15 and 16 are based upon the sea level datum of 1929. To convert elevations shown on these plates to the Sausalito mean lower low water datum, add 2.96 feet to the elevations shown.





SECTION 13

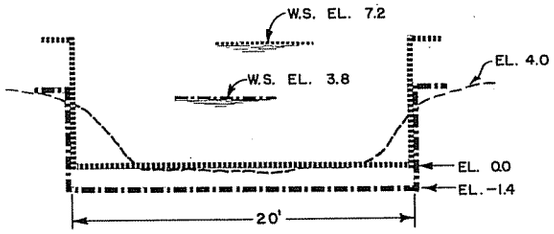
NOTE: ALL ELEVATIONS SHOWN ARE M.S.L.



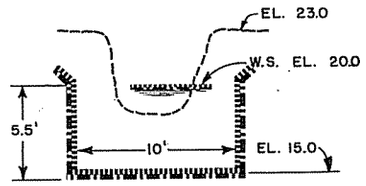
SECTION 13A

GRAPHIC SCALE

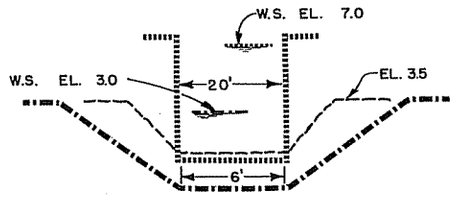
0 1 2 4 6 8 10 12 14
FEET



SECTION 14



SECTION 15



SECTION 20

LEGEND

- EXISTING CHANNEL BOTTOM
- CHANNEL BOTTOM WITHOUT BARRIER
- WATER SURFACE WITHOUT BARRIER
- CHANNEL BOTTOM WITH BARRIER
- WATER SURFACE WITH BARRIER

MARIN COUNTY FLOOD CONTROL ZONE NO. 3
FLOOD CONTROL STUDY
JANUARY 1957

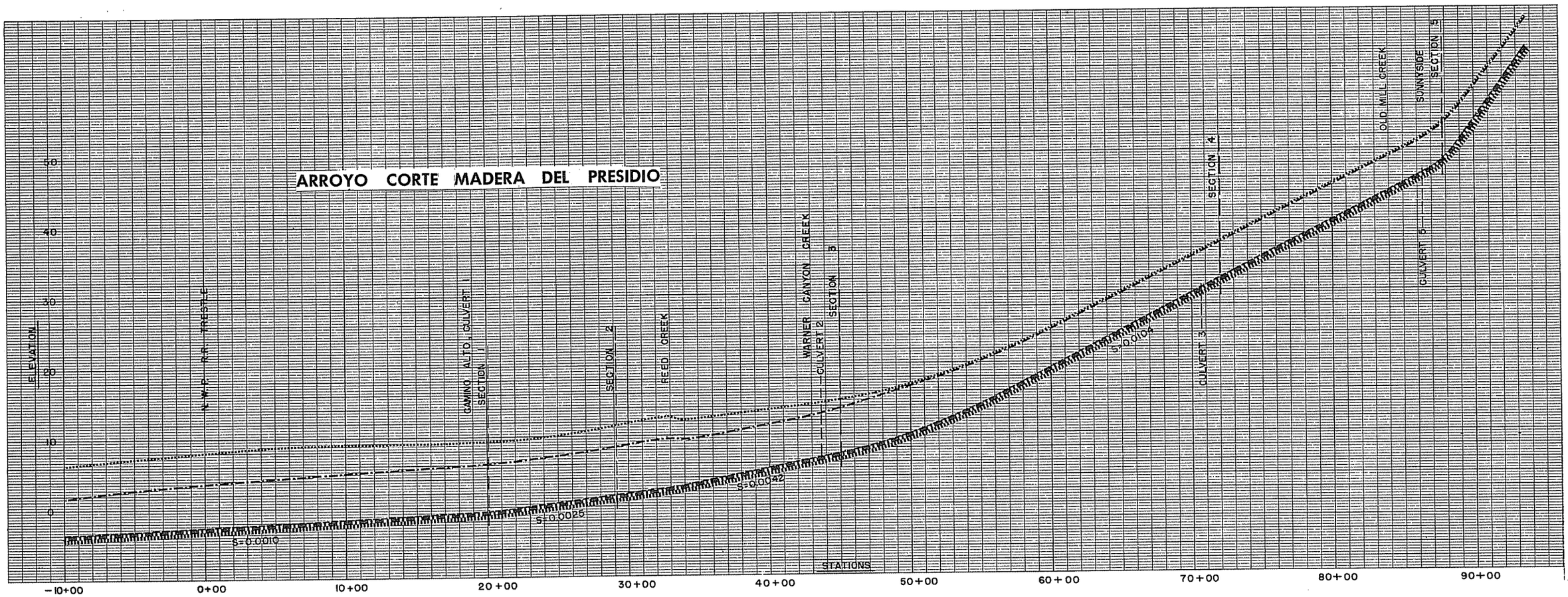
STREAM SECTIONS AND PROFILES

ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

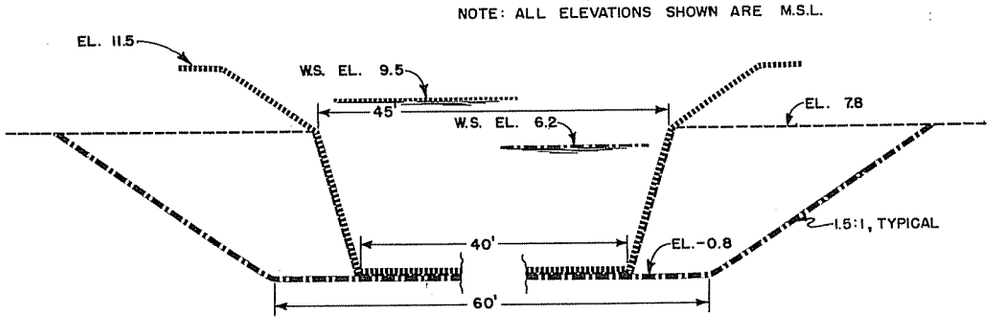
PLATE NO. 14

PLATE NO. 15 shows existing stream profiles and cross sections together with recommended modifications for Arroyo Corte Madera del Presidio. Where no modifications to the section are shown, modifications are not required.

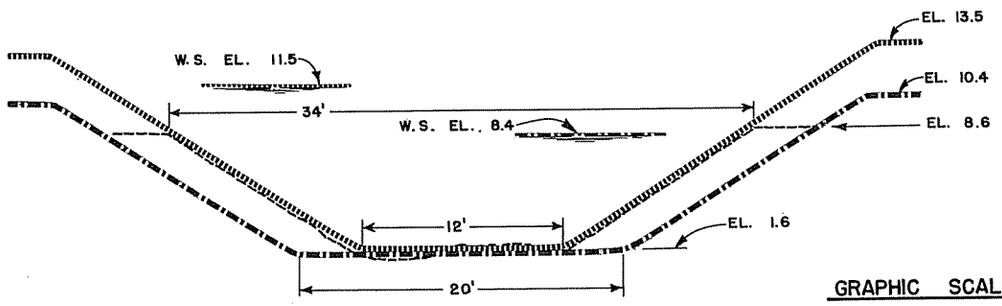
ARROYO CORTE MADERA DEL PRESIDIO



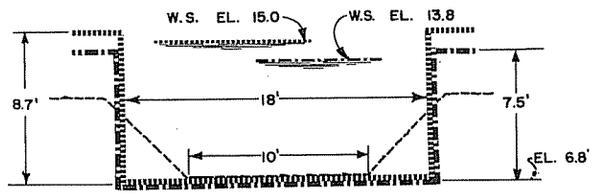
NOTE: ALL ELEVATIONS SHOWN ARE M.S.L.



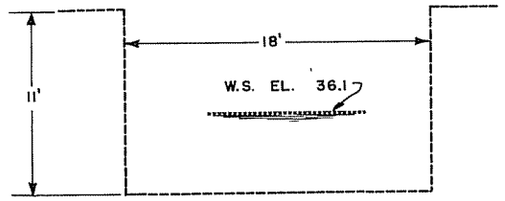
SECTION 1



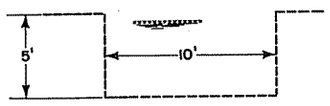
SECTION 2



SECTION 3



SECTION 4

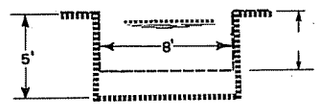


SECTION 5

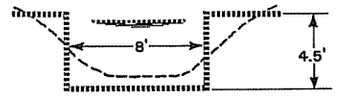
GRAPHIC SCALE

0 1 2 4 6 8 10 12 14
FEET

* SECTIONS NOT SHOWN ON PROFILE



* SECTION 6



* SECTION 21

LEGEND

- EXISTING CHANNEL BOTTOM
- CHANNEL BOTTOM WITHOUT BARRIER
- WATER SURFACE WITHOUT BARRIER
- CHANNEL BOTTOM WITH BARRIER
- WATER SURFACE WITH BARRIER

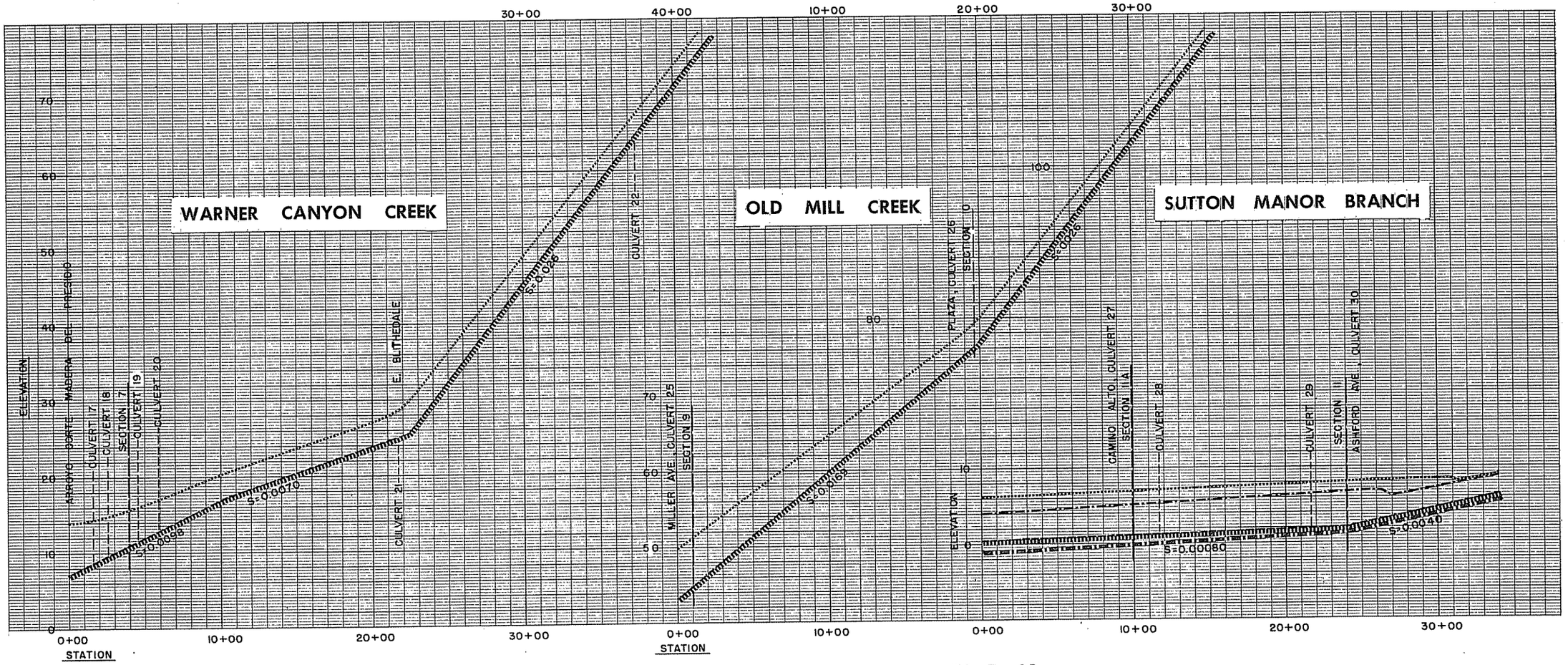
MARIN COUNTY FLOOD CONTROL ZONE NO. 3
FLOOD CONTROL STUDY
JANUARY 1957

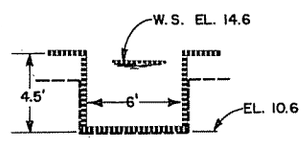
STREAM PROFILES AND SECTIONS MILL VALLEY GROUP

ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

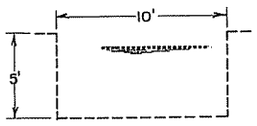
PLATE NO. 15

PLATE NO. 16 shows existing stream profiles and cross sections for main tributaries to Arroyo Corte Madera del Presidio together with recommended modifications for each of the flood control alternatives considered in this study. Where no modifications to the section are shown, modifications are not required.





SECTION 7



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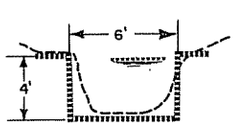

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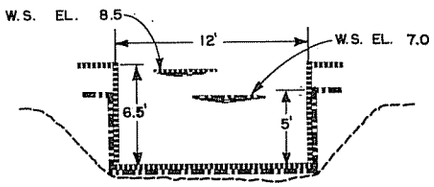
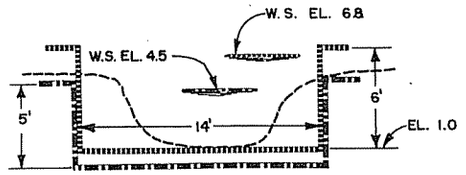
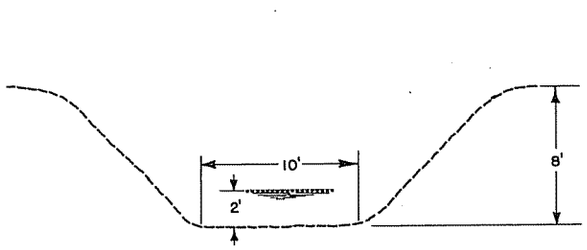


SECTION 11



SECTION 11A



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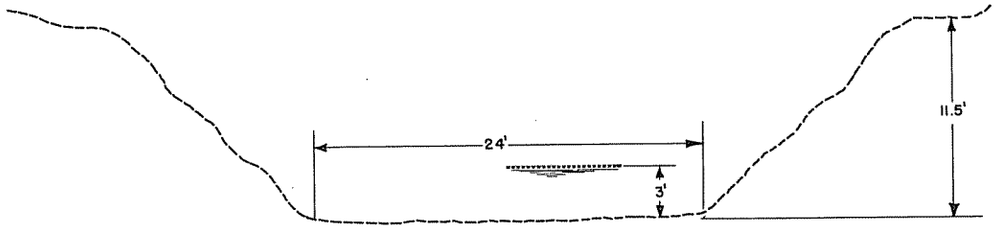

SECTION 10

NOTES

✳ SECTIONS NOT SHOWN ON PROFILE

ALL ELEVATIONS SHOWN ARE M.S.L.

GRAPHIC SCALE

0 1 2 4 6 8 10 12

FEET

LEGEND

- EXISTING CHANNEL BOTTOM
- CHANNEL BOTTOM WITHOUT BARRIER
- WATER SURFACE WITHOUT BARRIER
- CHANNEL BOTTOM WITH BARRIER
- WATER SURFACE WITH BARRIER

MARIN COUNTY FLOOD CONTROL ZONE NO. 3

FLOOD CONTROL STUDY

JANUARY 1957

STREAM PROFILES AND SECTIONS MILL VALLEY GROUP

ENGINEERING OFFICE OF CLYDE C. KENNEDY

SAN FRANCISCO

PLATE NO. 16

BARRIER

Recent popular interest has been expressed for the consideration of a barrier dam as a part of the flood control works for the Zone. A field investigation and study to determine the feasibility of construction of a barrier in Richardson Bay has been made in connection with this report. Subsurface test holes have been drilled and laboratory tests have been conducted on the materials encountered, in order to determine the character of subsurface materials in the area.

The soft compressible mud deposits in the area vary from 30 feet to 110 feet deep. Below this material are stiff sandy clays, dense sands, gravels and sandstone. The soft upper muds have very low strengths at the surface and low to medium strengths at greater depths. The deposits underlying the mud have good strengths and are low in compressibility. The report on subsurface investigation is included in the Appendix to this report.

Construction of a barrier in Richardson Bay would create a regulator basin into which the streams of the Zone would discharge. This basin would be separated from San Francisco Bay by the barrier dam and would not be subject to tidal fluctuations. It would be of sufficient area and volume to retain the storm flood flow from the streams in the Zone. A controlled discharge structure would be an integral part of the barrier and would release storm flood flow during periods of low tide.

Several flood control basins are located in the Bay area and are operating satisfactorily. Included among the existing basins are Seal Slough in San Mateo, the Matadero Basin in Palo Alto and Madera Gardens in Corte Madera.

The advantages of a barrier as a part of flood control works are:

1. The regulator basin behind the barrier would not be subject to tidal fluctuations.

2. Stream flood water flow into the basin would not be impeded by tidal backup in streams. Stream improvements would be somewhat less in cost.

3. Local storm drainage problems would be less severe and the costs of handling local storm drainage would be less.

4. Construction of a barrier would create a basin which could be developed for recreational uses.

The disadvantage of a barrier as a part of flood control works is that the cost of construction of the barrier is in excess of the savings in stream improvements and local storm drainage facilities.

A previous report [1] to the County of Marin delineated a barrier site across the upper end of Richardson Bay immediately below the Richardson Bay Bridge. Plate No. 19 shows this as Barrier Site No. 1. Because of time limitations set on completion of the study an immediate subsurface soils investigation was started at this site at the beginning of this study. Subsequent data compiled on stream flood water discharge and tide conditions indicated that there would be insufficient available volume in the basin with the barrier at this site. The area capacity curve for this basin is shown on Plate No. 17. Additional subsurface soils investigation was authorized and completed on a site extending from Strawberry Point to Waldo Point. Plate No. 19 shows this as Barrier Site No. 2. The available volume in the basin to be formed by the barrier at this site would be adequate to contain the stream flood waters. The area capacity curve for this basin is shown on Plate No. 18.

Barrier construction at Site No. 2 is feasible from an engineering standpoint. The recommended barrier is shown on Plate No. 19. Detailed description of barrier construction is given in the Appendix to this report. A discharge structure is required in the barrier. This structure required for flood control purposes, is titled Tide Gate Details on Plate No. 20 and would be located near Strawberry Point. Twenty-six flap gate openings of five foot square size are needed to discharge stream flood flow.

Other items of construction which need to be considered in conjunction with the barrier construction for flood control purposes are:

1. Road modifications for Bridgeway Boulevard in the vicinity of Waldo Point.

2. Northwestern Pacific Railroad branch line modifications in the vicinity of Waldo Point.

Acquisition of lands in the basin area should also be considered. Title to state owned lands would have to be secured by action of the State Legislature. Tidelands of private ownership would have to be purchased.

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[1] Flood Control for City of Mill Valley and Adjoining Areas by John S. Cotton

Along with the rapid development of Marin County in recent years has come a desire to provide additional recreational facilities for present and future needs.

The Small Craft Harbors Plan prepared by the County of Marin in 1956 proposes four small boat harbors within the basin area. The development of a park in the Richardson Bay area is understood to be of high priority for the County. The State Division of Beaches and Parks will present a report to the State Legislature early in 1957 on the feasibility and desirability of establishing a State Park in Richardson Bay. It is understood that a bill has recently been introduced to the Legislature for the use of General Funds to purchase Richardson Bay for use as a State Park. Construction of a barrier would provide a storage basin that could be developed for recreational purposes. The earth barrier would be of similar construction to that shown for flood control purposes on Plate No. 19 except for a deeper foundation. If the basin is to be fully developed for recreational purposes a dual-purpose lock structure to permit access of boats to the basin from San Francisco Bay as well as discharge of storm flood water is desirable. Lock details for such a structure are shown on Plate No. 20.

Other items of construction which need to be considered in the barrier construction for combined flood control and recreational use are:

1. Dredging of Richardson Bay to sufficient depth to accommodate small boats.

2. Extension of Mill Valley sewage treatment plant outfall discharge sewer or upgrading of treatment.

3. Construction of a fishway at the barrier.

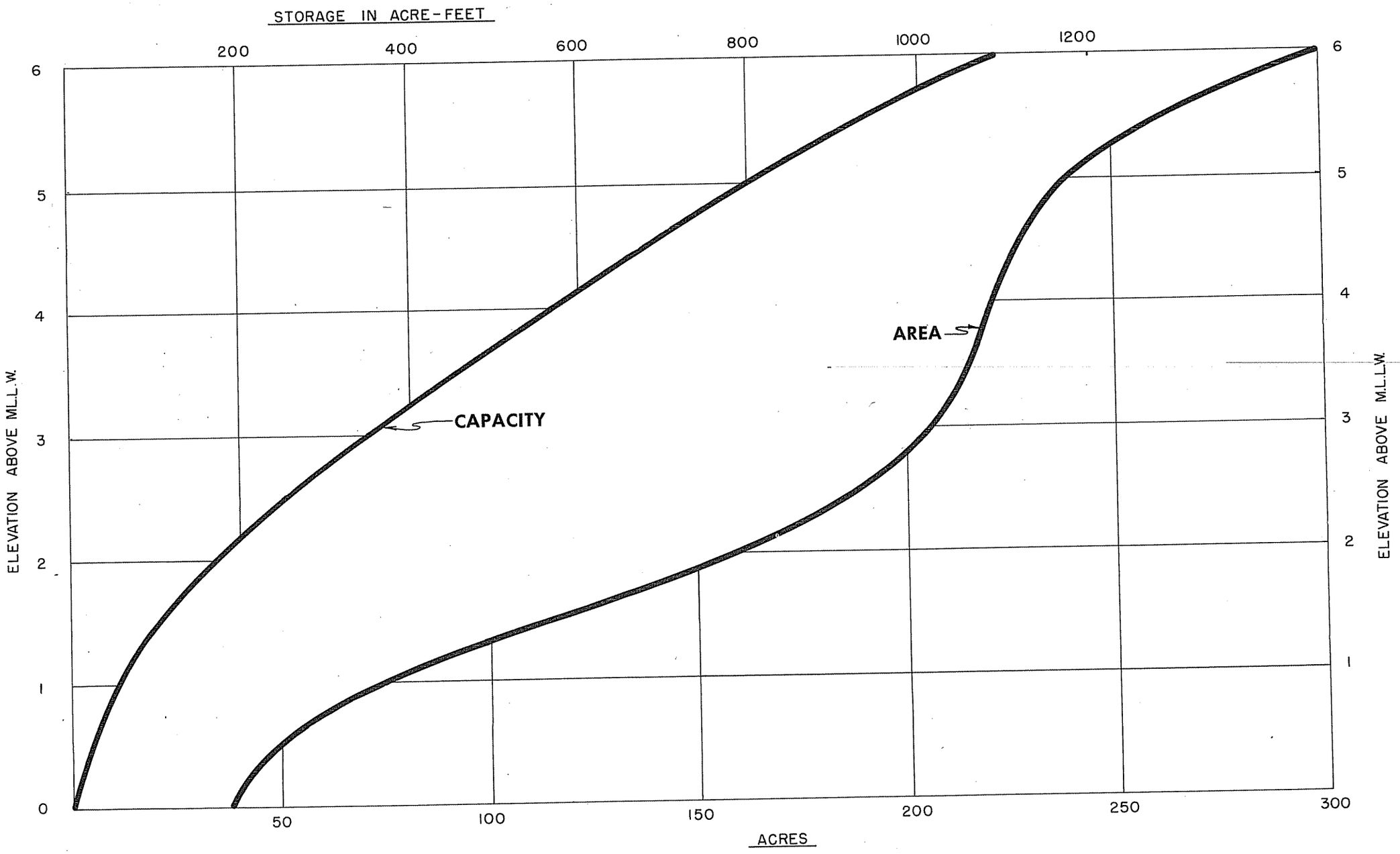
4. Relocation of existing utilities.

Other problems which need to be considered are:

1. Legal implications of a change in land use.

2. Navigational rights.

PLATE NO. 17 is the area-capacity curve for a regulator basin with a barrier at Site No. 1. To contain maximum storm flow, approximately 1500 acre-feet of storage capacity is required between elevation 3.0 and elevation 6.0. A barrier in this location will result in a basin with insufficient capacity.



NOTES

1. CURVES BASED ON A CONDITION OF NO BASIN DREDGING

2. ELEVATIONS BASED ON SAUSALITO M.L.L.W.

MARIN COUNTY FLOOD CONTROL ZONE NO. 3

FLOOD CONTROL STUDY

JANUARY 1957

BASIN AREA-CAPACITY CURVES

BARRIER SITE NO. 1

ENGINEERING OFFICE OF CLYDE C. KENNEDY

SAN FRANCISCO

PLATE NO

PLATE NO. 19 is a map of the regulator basin area and shows both barrier sites. No dredging of the basin area is required to assure sufficient storage capacity for maximum storm flow. No encroachment should be allowed upon the basin boundary shown.

NOTES

1. MAP BASED ON CORPS OF ENGINEERS SURVEY REPORT FOR RICHARDSON BAY DATED 12 MARCH 1947.
2. SOUNDINGS AND ELEVATIONS BASED ON SAUSALITO M.L.L.W.
3. FOR DISCHARGE STRUCTURE DETAILS, SEE PLATE NO. 19.

GRAPHIC SCALES

PLAN 0 200 400 600 800 1000 1200 1400 1600

SECTION 0 10 20 30 40 50 60 70 80

STRAWBERRY

CAMINO ALTO

U. S. HIGHWAY 101

N 43°15'15"W 13,310.29'

STRAW (C. of E.) 2" Iron Pipe S 37°49'18"E 3,041.60'

STRAWBERRY HILL 2 (U.S.C.&G.S.) Stld. Disk

BARRIER SITE NO. 2

STRAWBERRY POINT

BORING #1-2

BORING #2-2

BORING #3-2

BARRIER SITE NO. 1

BORING #4-1

BORING #3-1

BORING #2-1

BORING #1-1

ENCHANTED KNOLLS

SAUSALITO

CANAL

N.W.P. RAILROAD

MILLER AVE.

24" Sanitary

Trestle

Main Traverse is along ℄ of N.W.P. Tracks

DONAHUE ST.

HUMBOLDT ST.

MADISON ST.

ROSEDALE AVE.

BRIDGEWAY BLVD.

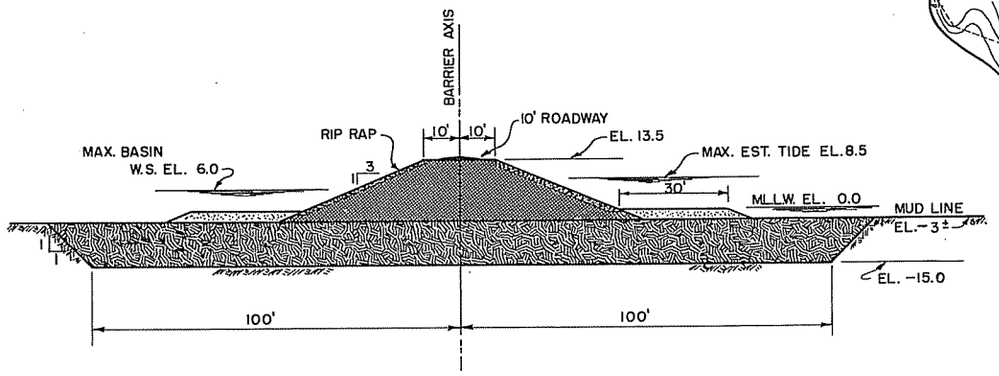
MARIN CITY

CREST

MARIN

STATE HIGHWAY #1

TYPICAL BARRIER SECTION



LEGEND

- ROCK RIPRAP
- IMPERVIOUS IMPORTED FILL
- SAND OR SOIL ROCK PAD
- BAY MUD IMPORT
- EXISTING BAY MUD
- SOIL TEST BORING
- BASIN BOUNDARY

MARIN COUNTY FLOOD CONTROL ZONE NO. 3

FLOOD CONTROL STUDY

JANUARY 1957

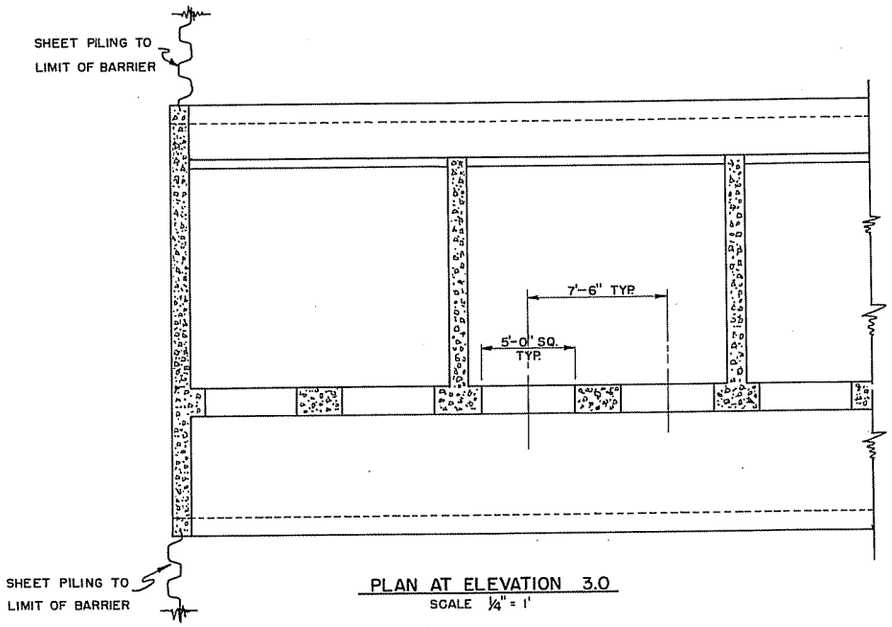
STORAGE BASIN PLAN

ENGINEERING OFFICE OF CLYDE C. KENNEDY

SAN FRANCISCO

PLATE NO. 19

PLATE NO. 20 shows details for the barrier discharge structure for a regulator basin. Tide gates would be used for a basin for flood control purposes only. The lock structure is an alternative discharge structure requiring manual operation should recreational uses of the basin be contemplated.



PLAN AT ELEVATION 3.0
SCALE 1/4" = 1'

NOTES

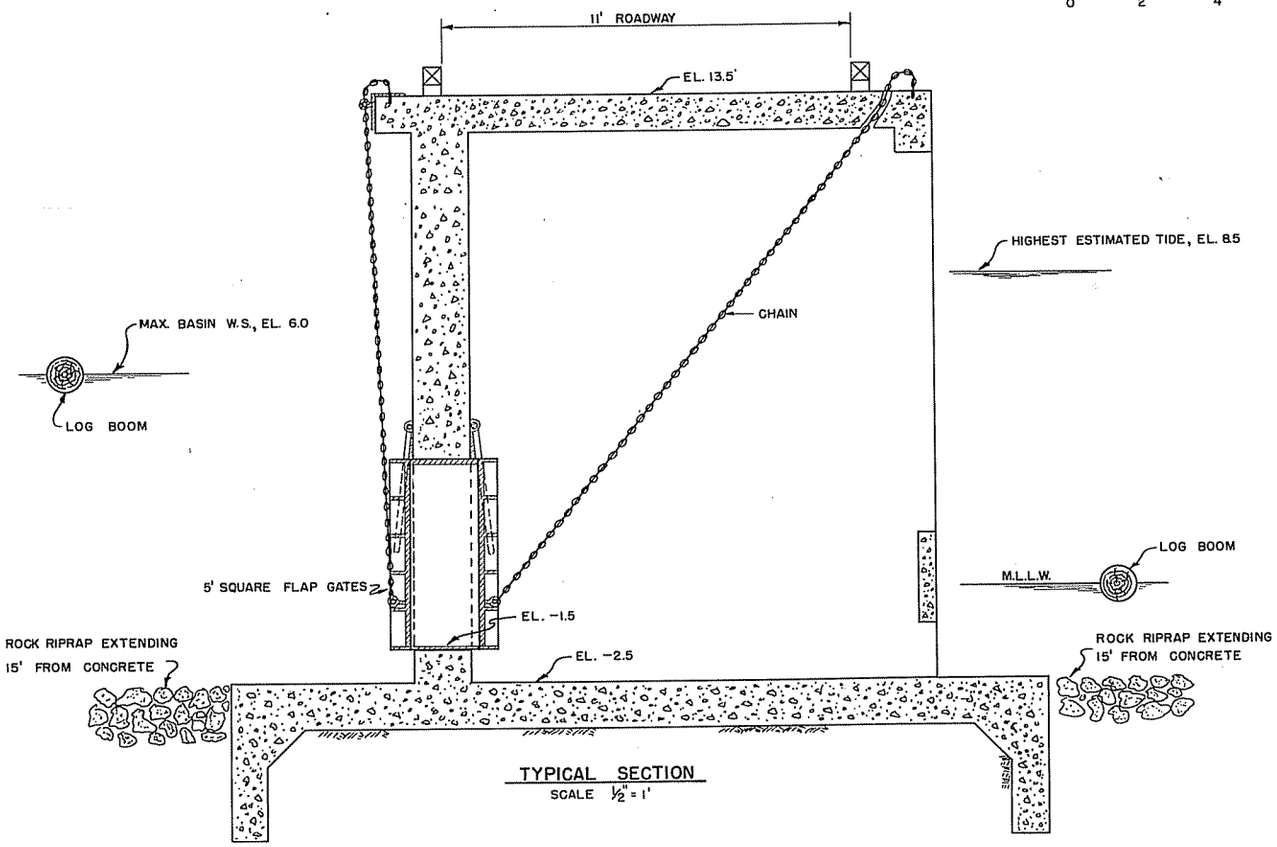
1. ELEVATIONS BASED ON SAUSALITO M.L.L.W.
2. VESSEL LOCKAGE DETAILS NOT SHOWN

GRAPHIC SCALES

1/8" = 1' — 0, 5', 10', 20', 30'

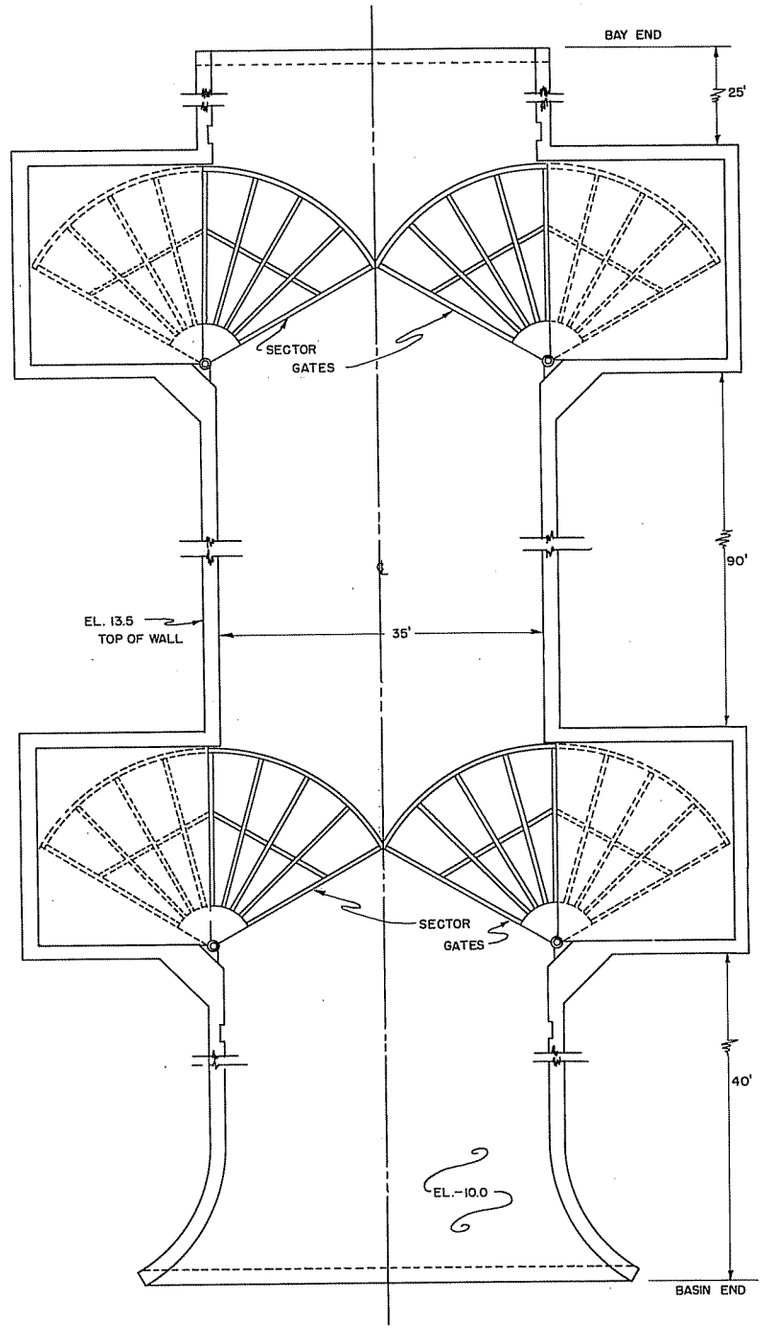
1/4" = 1' — 0, 5', 10', 15'

1/2" = 1' — 0, 2', 4', 6', 8'



TYPICAL SECTION
SCALE 1/2" = 1'

TIDE GATE DETAILS



LOCK DETAILS

SCALE 1/8" = 1'

MARIN COUNTY FLOOD CONTROL ZONE NO. 3
FLOOD CONTROL STUDY
JANUARY 1957

DISCHARGE STRUCTURES

ENGINEERING OFFICE OF CLYDE C. KENNEDY
SAN FRANCISCO

PLATE NO. 20

FINANCING

Two general methods of financing the flood control facilities are available. These are by general obligation bonds or improvement district proceedings.

Advantages of general obligation bonds are:

1. Lower interest rate.
2. Lower overall cost.
3. Yearly adjustment of contribution based on development of area.

Disadvantages of general obligation bonds are:

1. Election required.
2. Two-thirds majority required for passage of bonds.

Advantages of improvement district proceedings are:

1. No election required.
2. Payment in proportion to benefit received.

Disadvantages of improvement district proceedings are:

1. Higher interest rate.
2. Higher overall cost.

Voting of general obligation bonds is the generally accepted method of financing large flood control projects. Although there is no legal limit on the bonding capacity of the Zone to finance flood control works, a practical limit is the salability of the bonds.

Bonds in the Marin County Flood Control and Water Conservation District are subject to a 5 percent maximum annual interest. Bonds must be retired in 40 years. Bond service costs are collected by an ad valorem tax levy.

Two public laws of the State of California provide for State financial aid for flood control projects. The State Water Resources Law of 1945 provides funds limited to the cost of land, easements, rights-of-way, and utility relocation required in connection with construction of facilities. It must be shown that benefits of the project exceed the estimated costs.

The California Watershed Protection and Flood Prevention Law authorizes the State to pay costs of local cooperation required by acts of Congress, but is limited to costs of lands, easements, rights-of way, and utility relocation. It must be shown that benefits of the project exceed estimated costs.

Federal laws provide funds for flood control facilities. Public Law 685 provides funds for flood control projects not specifically authorized by Congress and not within areas intended to be protected by projects so authorized. It provides that not more than $400,000 shall be allocated for flood control purposes to any single locality from the appropriation for any one fiscal year. Local contributions are required for any project authorized under the provisions of this law.

Agencies with funds available for flood control work that have been contacted with respect to possible financial aid include: U.S. Department of Agriculture, U.S. Housing and Home Finance Agency, Bureau of Reclamation, U.S. Corps of Engineers, Federal Civil Defense Agency, State of California Division of Beaches and Parks, and the State Office of Legislative Counsel.

It is desirable that the services of a qualified municipal financing consultant be secured to analyze the financing problems involved and to recommend a method of procedure. Three objectives that can reasonably be expected through the use of a municipal financing consultant are:

1. The required funds will be obtained at the lowest possible cost.
2. Repayment of debt will be in accordance with the needs and resources of the Zone.
3. The financing of the facilities will be expedited.

ESTIMATE OF COST

The estimates of cost of flood control facilities are based upon current construction costs in the San Francisco Bay Area. The estimates do not include allowance for acquisition of stream channel rights-of-way, legal fees, or administrative costs. Regulator basin and barrier costs do not include the estimated cost of real estate or railroad and highway modifications at Waldo Point.

Based on information available on real estate costs in the area, it is estimated that real estate costs for the barrier and regulator basin would be approximately $400,000.

FLOOD CONTROL FACILITIES INCLUDING BARRIER

Item	Cost	
STREAMS:		
Channel Improvements	$1,400,000	
Culvert Improvements	265,000	
Subtotal	$1,665,000	
STORAGE BASIN:		
Barrier	$ 910,000	
Discharge Structure	275,000	
Subtotal	$1,185,000	
CONSTRUCTION COST		$2,850,000
Contingencies		450,000
		$3,300,000
Engineering: Preparation of Plans and Specifications and Supervision of Construction		500,000
PROJECT COST		$3,800,000

FLOOD CONTROL FACILITIES WITHOUT BARRIER

Item	Cost	
STREAMS:		
Channel Improvements	$1,540,000	
Culvert Improvements	260,000	
Subtotal	$1,800,000	
PROTECTIVE LEVEES:	65,000	
CONSTRUCTION COST		$1,865,000
Contingencies		280,000
		$2,145,000
Engineering: Preparation of Plans and Specifications and Supervision of Construction		320,000
PROJECT COST		$2,465,000