REPORT
on
WATER CONSERVATION AND FLOOD CONTROL
of the
SANTA MARIA RIVER
in
SANTA BARBARA AND
SAN LUIS OBISPO COUNTIES

March 1931

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The estimated waste into the sea during this 12 year period amounted to 81 percent of the total supply. This figure applied to the average annual water crop of 124,398 acre feet indicates an average waste of about 100,000 acre feet per year. While the figures given above are estimates and approximate only, the quantities used in estimating the disposition of the runoff could be substantially changed without materially affecting the conclusion.

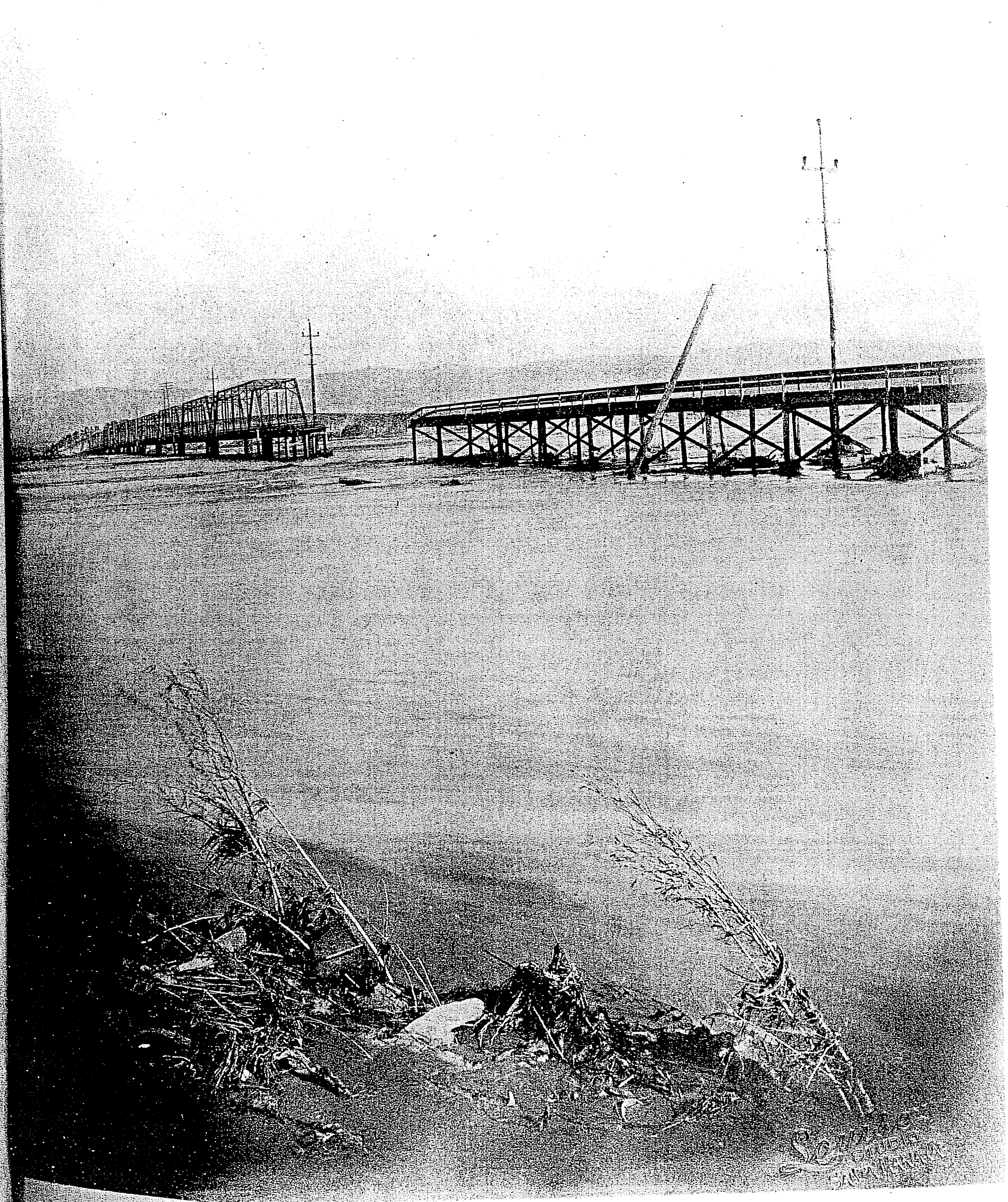
F L O O D S:

The Santa Maria River and other streams draining the coastal section of Southern California have flow characteristics entirely different from the rivers tributary to the Sacramento and San Joaquin Valleys. The streams draining these great valleys have their sources in the high Sierra Nevada Mountains, where the winter precipitation usually occurs in the form of snow. In the early summer following warm rains which melt the snow, the streams slowly rise to flood proportions and gradually subside through a period of from 60 to 90 days. The flood flows are quite regular and certain in occurrence. The great bulk of the runoff occurs during the period of the year when it is most needed for irrigation purposes.

On the coastal streams, however, the runoff is "flashy". The mountainous portions of the watersheds are steep and precipitous, usually having scant forest cover. Practically all of the precipitation occurs in the form of rain from October to April. The rain falling on basins of this character rapidly runs off. Following storms of heavy intensity, the streams rapidly rise to violent and destructive floods. They reach their peak in a few hours and recede with similar rapidity. During the summer months they are practically dry. To be of beneficial use, these winter

View of the Santa Maria River after flood peak of February 1914 had passed, showing destruction of the approach to the County Highway Bridge.

Photo by courtesy of
R. E. Easton.



flood waters must be held in storage either in artificial reservoirs created by the building of dams in the stream channels, or in underground basins. From a drainage basin as large as that of the Santa Maria River, the major floods are large and of destructive violence. In the mountainous portion of the drainage basin the streams flow in channels having relatively steep gradients. In such channels they flow with high velocity and carry large quantities of debris eroded from the mountains. In the lower reaches of the streams where their gradients are flatter, broad alluvial plains have been built up through the depostiion of detrital material. This fill has accumulated through the meanderings of the stream through channels which are very unstable. Through the continual deposition of alluvium the river tends to build its channel above the surrounding country, and unless confined by artificial means, break from their banks and make new channels. The alluvial fill, because of its high fertility, is occupied and cultivated. As the plain develops and property values rise, the flood menace increases until it becomes necessary to construct artificial works for their control and protection of the improved property. Such has been the history of most of the coastal streams of Southern California.

It has been estimated that in the great flood of January 1916, in Los Angeles, Orange and San Diego Counties, the total direct damage caused by this flood amounted to $10,000,000.00. Twenty-eight lives were lost, directly attributed to the flood. In the years that have passed since 1916, the menaced area in these counties has greatly developed. In Los Angeles County the coastal plain has become densely populated. If a flood were to occur to-day, equal in volume to that of 1916, and no flood protection works had been built, the property loss would be many times greater than it was in 1916. Since that time, Los Angeles County has spent millions of dollars on flood control works, including retarding reservoirs in the mountains and channel protection in the valleys. Within the last two years a flood control district has been organized including all of Orange County. This district is now proposing a bond issue in the neighborhood of $16,000,000.00 for flood control works, consisting principally of retarding reservoirs for reducing the flood peaks and increasing the percolation to the ground water underlying the coastal plain.

It is exceedingly difficult for the layman to appreciate the violence and volume of a flood of 100,000 second feet. This is especially true of a newcomer or recent residents of Southern California, who have never seen a river such as the Santa Maria in flood. Accompanying this report are a number of photographs showing the Santa Maria River during past floods. None of them were taken at the time of the peak flow. A study of these pictures should convince the most skeptical of the great destruction that would result if one of these violent major floods should break from its present channel, and flow across the present cultivated areas of the valley. A careful study of the present channel of the river indicates that such a possibility is not only possible, but will probably occur unless some system of flood control is promptly adopted.

In the Santa Maria Valley, 25 percent of the fertile bottom lands are now occupied by the waste flood channel of the Santa Maria River. Prior to the flood years, which began in 1907, this channel was much smaller than it is today. During the large flood of 1909, it was estimated that 1,000 acres of improved farming land was destroyed in a few hours. Each recurring flood has resulted in an increasing loss of land. Following the flood of 1909, a reclamation district was organized under state laws in the Santa Maria Valley for the purpose of constructing and maintaining flood protection works on the Santa Maria River. This district is known as Reclamation District No. 798. An engineer was employed, plans and specifications were prepared, and protection works constructed. The system of protection adopted consisted in driving rows of timber piles or jetties along the banks of the stream on the Santa Barbara County side, to deflect the flood flows from the improved property. Wire and cable were fastened to the wooden piles. The engineer in his report to the District recommended that cottonwood trees be planted between the piling. In carrying out the work, however, little planting was done. A bond issue was voted and with the money derived therefrom, a considerable number of such jetties were built. Since that time the work has been extended with moneys raised by assessment. To date it is estimated that in the neighborhood of $400,000.00 has been spent for this work and bond interest. Steps have recently been taken to have this District dissolved. During the years that have passed since the last great flood, a large portion of this work, because of its temporary nature, has depreciated to such an extent that little protection exists at the present time.

In preparing plans for flood control and protection works, a knowledge of the frequency and magnitude of past flood flows on the streams is of first importance. As no measurements have ever been made of the discharge of the Santa Maria in the vicinity of the menaced area, it has been necessary to compile data from other sources, such as rainfall records, flood flows on neighboring streams and from personal observations of long time residents of the valley. A number of people have been interviewed, who by length of residence, contact with the river, and other qualifications, should be competent to give more or less authentic information. Their testimony relative to the years of greatest flood varies greatly. Most of them agree, however, that the seasons of greatest discharge in the past fifty years included 1883-84, 1889-90, 1908-09, 1910-11 and 1913-14.

While maximum floods do not always occur during seasons of greatest rainfall, a study of such records indicates the seasons during which large floods most likely occurred. For this reason, a compilation was made of the seasons of maximum rainfall at places in the vicinity of the Santa Maria River. This data is shown in Table No. 25. The seasons of heavy rainfall are listed below in the order of magnitude, and the relative amount is indicated by the percentage of the long-time seasonal average.

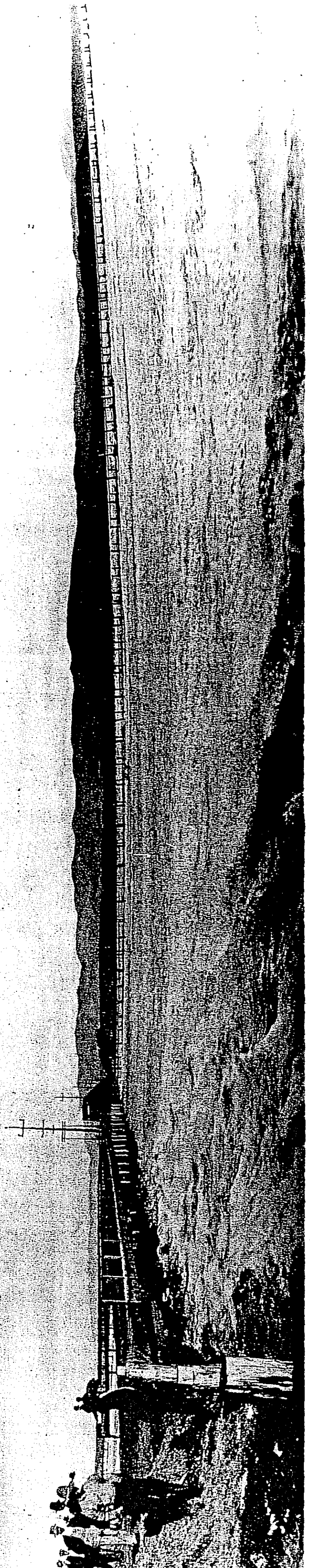
Season	Rainfall in Percent of 61 year mean
1889-90	198%
1883-84	187%
1910-11	174%
1908-09	170%
1913-14	161%
1877-78	153%
1904-05	143%
1906-07	143%
1892-93	139%
1875-76	134%
1885-86	134%
1879-80	132%
1914-15	131%
1905-06	124%
1915-16	120%

In this tabulation it will be noted that the total rainfall during the seasons 1914-15 and 1915-16 are near the end of the list, although the records of neighboring streams indicate peak discharge during these two seasons, much greater than others, when the total seasonal rainfall was much greater. For example, the season 1904-05 is seventh on the list, while none of the streams measured during this season indicate a large flood.

Upper View. Santa Maria River during the flood of February 9, 1915, looking north at County Highway crossing.

Lower View. Santa Maria River channel after subsidence of the flood of 1915 showing destruction of valuable farming lands.

Photos by courtesy of
Mr. Scott.



Of more importance than the total seasonal rain is the daily amount and the hourly rate. Table No. 26 has been compiled from the records of the U. S. Weather Bureau at San Luis Obispo, and shows the maximum rates of rainfall recorded at that place.

Table No. 27 has been compiled to show the time during the seasons when floods are most liable to occur. This data taken from the monthly record of rainfall at San Luis Obispo, indicates floods may occur from November to April inclusive, January being the most favorable for large flows.

The flood of January 1916, was one of exceptional violence in the area from Los Angeles County to the Mexican line. It was particularly severe in San Diego County. The U. S. Geological Survey has published Water Supply Paper No. 426, containing much information regarding that flood, and comparing it with records of previous floods in that vicinity. While somewhat removed from the Santa Maria Basin, we have found that during times of unusual and extreme flood discharge, the storms were general over the whole of Southern California. The following statement, taken from that paper, shows information relative to flood flows in Southern California, compiled from many sources:

"To determine whether the flood of 1916 was more or less severe than previous floods in Southern California, a search was made of the early records, and many old residents of the country were interviewed. The results of this work are summarized in the following pages. Of particular interest is the record of wet and dry years, compiled by Mr. A. Campbell, who has lived in San Diego County since 1869. Information as to conditions in most of the years prior to 1840 was taken from records of the Mission Fathers."

1770	Drouth
1786	Copious Rainfall
1787	Rainfall insufficient; crops short
1791	Extremely dry no rain for whole year
1794	Rainfall insufficient; crops short
1795	Very dry
1811	Flood Year
1815	Flood year
1819	Short in rain and crops
1825	Great flood - changed course of Santa Ana River
1826(	
1827(	Dry years (Gen. Vallejos)
1828(	
1832	Short in rain and crops
1840-41	Driest year ever known
1841-42	Wettest year ever known
1842-43	Very open and dry
1843-44	Very dry; no grain grown in Sacramento Valley
1845	Drouth
1845-46	Wet in north; dry in Southern California; cattle starved
1846-47	Considerable rain; crops good
1848-49	Most snowy winter known; rainfall moderate
1849-50	One of the wettest and most flood winters
1850-51	Open; rainfall moderate
1853	Big floods and snow
1850-56	Flood and good years
1856-57	Driest in 20 years
1857-62	Medium rainfalls
1862-63	Dry years
1863-69	All good wet years
1869	A very exceptional year. In October the thermometer registered 110 dgg., and a rainfall in December is estimated at 12 inches in 24 hours.
1869-70	Dry season
1870-71	Dry season
1872-74	Fairly wet seasons
1875-76	Good rainfall
1876-77	Dry season
1877-82	Good seasons
1882-83	Dry seasons
1883-84	Wettest winter known
1885-93	Series of good years
1893-94	Short rainfall
1895-6-7	Three good wet years
1897-1900	Three dry years
1901-1910	Fairly good wet years
1910-1913	Dry years at end of season
1912-1913	Dry year

The following additional information was obtained from 'A history of California Floods and Droughts' by J. M. Guinn:

1822. A flood covered the lowlands and rose to a greater height than ever before known.

1851-52. A severe flood year in Southern California. At old Fort Miller on headwaters of San Joaquin River, Dr. W.T. Edgar, surgeon of the post, observed a rainfall of 46 inches during January and February 1852.

1863. Santa Ana River at Anaheim ran 4 feet deep and spread in an unbroken sheet to Coyote Hills, 3 miles beyond. It rained 30 days in succession, beginning December 24, 1861."

Since 1916, only minor floods have occurred on the Santa Maria during the seasons 1917-18 and 1921-22.

A study of all data available indicates that during the period from 1906-07 to 1917-18 inclusive, flood discharge was of most frequent occurrence of any time in the past 60 years. During this period of 12 seasons, large floods occurred in 7 of them, i.e.,

1906-07	1914-15
1908-09	1915-16
1910-11	1917-18
1913-14	

During this period, records of daily discharge were kept on the Santa Ynez River near Lompoc from 1910 to 1918 inclusive. The total drainage area above this point is 795 square miles, and the estimated average seasonal runoff is 164,000 acre feet, as compared with a total drainage area of the Santa Maria River above Fugler's Point of 1656 square miles, and an estimated average seasonal runoff of 116,600 acre feet. The following tabulation shows the maximum daily discharge of the Santa Ynez River near Lompoc during the floods measured:

1910-11	20,400	sec.feet
1913-14	30,800	"
1914-15	32,500	"
1915-16	15,000	"
1917-18	14,400	"

The greatest instantaneous flow recorded during these years occurred January 25, 1914, when it amounted to 41,800 second feet or 52.5 second feet per square mile.

Many formulas for estimating the maximum flood flow of rivers and streams have been developed by various engineers. Maximum flood discharge is dependent upon many factors, including the area and shape of the drainage basin, its topography, geological formation, character and extent of forest cover, the intensity and duration of rainfall during heavy storms and the gradients and character of the stream channel itself. In view of these many variable factors, all the formulae are of necessity emperical, and involve the use of coefficients largely determined from personal judgment guided by measured records on neighboring watersheds having characteristics similar to those of the stream to be estimated.

The most comprehensive analysis of flood flow made in recent years is contained in a paper presented to the American Society of Civil Engineers in 1926 by C. S. Jarvis, Mem. Amer. Soc. C.E. In his paper Mr. Jarvis analyzed the various formulas which had been previously developed and presented a tabulation containing over one thousand records of measured maximum flood discharge on streams throughout the world. In most of the formulas which have been presented in the past, the maximum flood discharge has been shown to vary with the area of the drainage basin. Mr. Jarvis demonstrated this fact in his analysis and suggested the following formula:

$$Q = \frac{C}{0.01\sqrt{A}}$$ in which

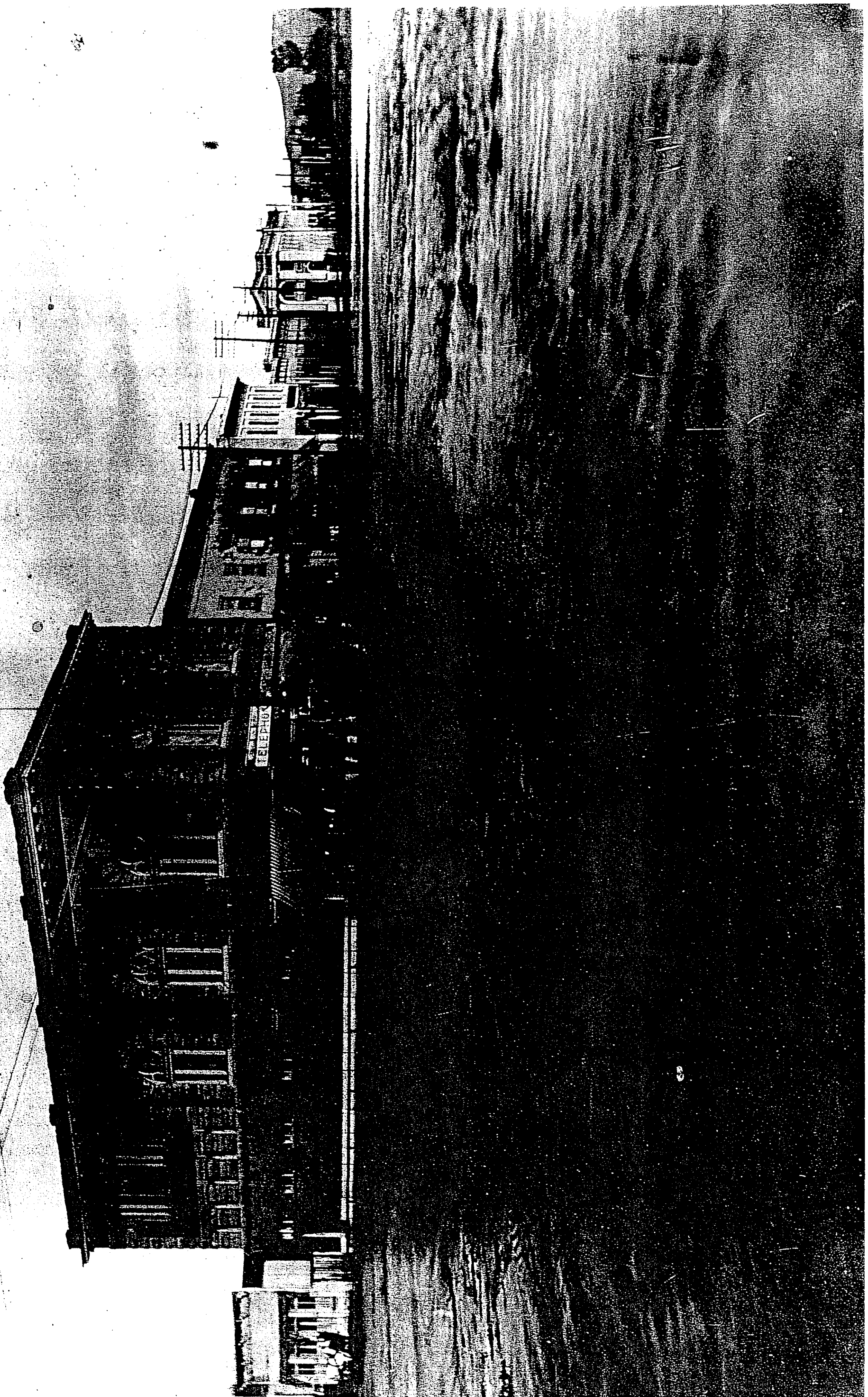
"Q" = the peak discharge in second feet per square mile

"A" = the area of the drainage basin in square miles

"C" = a coefficient determined from measured flood records on neighboring and similar drainage areas. This formula has been used in estimating peak discharge of the Santa Maria River and its tributaries. In determining a value of the coefficient "C" to use in the above formula, an analysis has been made of all of the maximum recorded flood discharge

View showing flood conditions at the intersection of Broadway and Church Streets in Santa Maria during flood of 1915.

Photo by courtesy of
J. L. Nicholson.



available in Southern California.

Systematic measurements of Southern California streams were initiated by the U. S. Geological Survey about 1893, the most complete record available being on the San Gabriel River near Azusa. A daily record of flow on that stream is available for the past 40 years. A careful study of all available records shows that during this period the seasons of greatest flood discharge were 1913-14 and 1915-16. The flood of January 1916 was the greatest on all streams south and east of and including the San Gabriel River. On the drainage basins north and west of the San Gabriel River to and including the Santa Maria River, the flood of February 1914 was the greatest during the 40 year period. Table No. 28 is a record compiled from all available sources of maximum measured flood discharge during these two storms. From these figures the value of "C" in the Jarvis formula has been computed. The average value of "C" for the flood of January 1916 on the southern streams was 23.07 and on the northern streams during February 1914 flood it averaged 14.36 This analysis indicates that the flood of January 1916, on the southern basins was much more violent than any flood that had occurred on the northern streams during the past 40 years.

From the records assembled on this table, values of the coefficient "C" have been assumed for the drainage basin of the Santa Maria River and the estimated maximum peak discharge during the past 40 years has been computed. These figures indicate a maximum flow of 95,717 second feet in the Santa Maria River at Fugler's Point. This figure has been app roximately checked by a determination of the maximum flow at the Southern Pacific Railroad bridge near Guadalupe. We have obtained from the Railroad Company a cross section of the river at this point and the maximum elevation of the water surface since the bridge was built in 1893. From this cross section and the slope of the channel at this point the discharge has been computed to have been 102,050 cubic feet per second. During the long interim that has passed since large floods occurred in the Santa Maria River, practically all high water marks have been destroyed. The cross section of the channel has also changed to such an extent that no other determinations of maximum flow can be computed by this method with any degree of accuracy.

Forty years is far too short a period to determine the maximum flood flow that may be expected from any drainage area. For example, measurements were made on the Miami River at Dayton, Ohio, for forty years prior to the great flood of 1913. The flood of 1913 on this stream, however, was two and one half times greater than any recorded flood during the previous forty years. The channels of the streams themselves also show evidence of floods much greater than any that have occurred during recent historical time. The most generally accepted method of estimating maximum flood flow is by constructing a diagram of probable frequency of flood flows on some stream where records are available for a considerable period of time such as the San Gabriel River at Azusa. This method has been adopted by the State of California in their studies of the water resources of the State. Diagram No. 6 attached hereto has been taken from Bulletin 14 of the State Engineer, entitled "The Control of Floods by Reservoirs". This diagram shows the probable frequency of flood discharge on typical California Streams of various amounts for the period of record. By extending these curves it is possible to estimate the maximum flow that would probably occur during longer periods. The maximum 24 hour average flow of the San Gabriel River during the 40 years of record occurred in January 1916 and amounted to 22,300 second feet. From the prabability curve above referred to we find that the maximum flood flow on this stream would amount to the following percentages of the 1916 discharge for various periods of time:

Once in a year	12.5%	of 40 year maximum
Once in 10 years	64 %	" " " "
Once in 25 years	86 %	" " " "
Once in 50 years	103 %	" " " "
Once in 100 years	119 %	" " " "
Once in 1000 years	170 %	" " " "

Applying this percentage to the maximum estimated flow of the Santa Maria River during the past forty years we find that a flood in excess of 160,000 second feet might occur on the Santa Maria River once in a thousand years. This does not mean that it will probably be a thousand years before such a flood will occur, as it is as likely to occur next year as any other year in the thousand year period. The following tabulation shows the estimated maximum flood discharge of the Santa Maria River and its tributaries during the past forty years and the estimated probable discharge that might occur once in a thousand years:

STREAM	Drainage Area Sq. Mi.	Estimated 40 year Maximum Sec.ft.	Estimated 1000 year Maximum Sec. ft.
Santa Maria River at Fugler's Point	1656	95,700	162,700
Cuyama River at Vaquerro Flat Reservoir Site	1146	76,100	130,000
Sisquoc River at Round Corral Reservoir Site	284	42,100	71,600
Santa Maria River above Fugler's Point excluding Cuyama River above Vaquerro Flat Reservoir Site and Sisquoc River above Round Corral Reservoir Site	226	33,800	57,400

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THE SANTA MARIA CHANNEL - ITS PRESENT CONDITION:

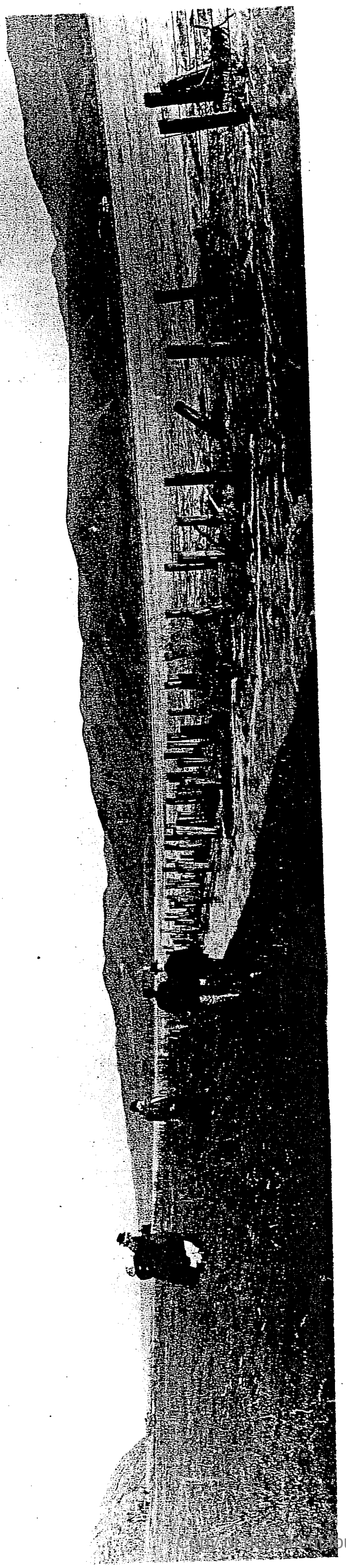
The Santa Maria Valley has been built up by the accumulation of detrital material deposited by the river in its meanderings between the ancient alluvium composing the Nipomo Mesa on the north and the south mesa. Unless confined by artificial means the streams passing over such a plain, flow in channels which are very unstable. A study of the topography of the valley and of the aerial maps indicates the location of former channels at numerous places. The aerial map is of particular interest in that evidence of the flow of water over the valley floor is disclosed, which is not apparent as one travels over the valley. The present channel of the river generally follows the northerly edge of the valley floor. It is quite probable that the river at some previous time discharged into the sea in the vicinity of Osa Flaco Lake. A study of the topography also shows an ancient channel along the southerly side of the valley from Fugler's Point to the sea near the present outlet. This channel is evidenced by the depression known as the Canada Verde. Most of the land in this depression is now cultivated and occupied.

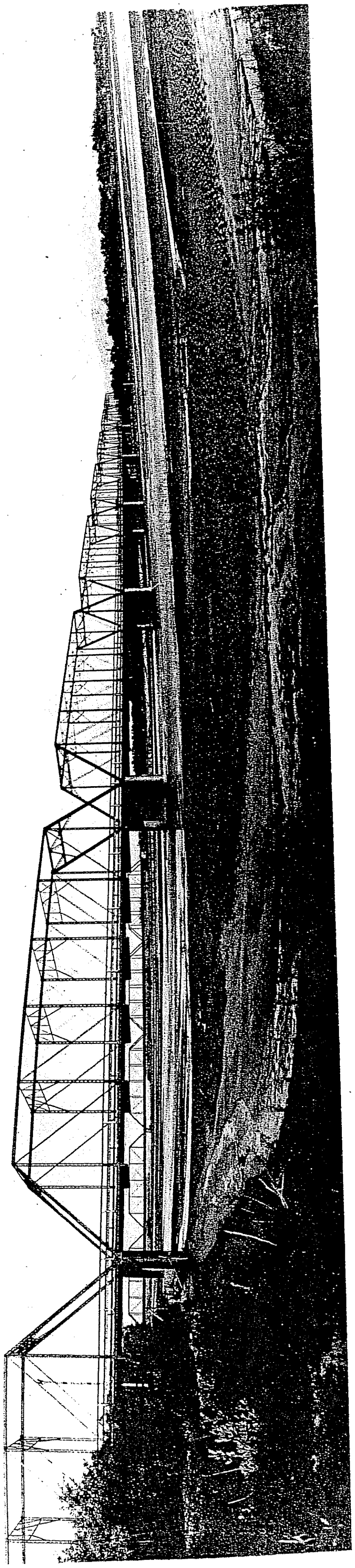
The present channel has changed materially during recent times. The large and violent floods that occurred during the period from 1906 to 1918 destroyed large areas of valuable farming lands resulting in the broad sterile flood channel we find today. It is estimated that during the flood of 1909 over 1000 acres of valuable cultivated lands were destroyed. The waste lands in the channel now occupy about 25 percent of the entire valley floor. In many places it is over a mile in width. During the past ten or fifteen years there has been a substantial raising in elevation of the channel bed, particularly in its easterly end, where it has been built up to such an extent that in many places its lowest point is but four or five feet

Upper View. Santa Maria River near Fugler's Point during flood of 1915.

Lower View. County Highway Bridge across the Santa Maria River near Guadalupe, following the flood of February 1914. Prior to the clearing recently done this entire channel was choked with a heavy growth of willows except for a narrow channel of about half a span length.

Photos by courtesy of
R.E. Easton and Mr. Scott.





below the elevation of the adjoining cultivated areas.

From the junction of the Cuyama and Sisquoc rivers at Fugler's Point, the Santa Maria River now flows in a northwesterly direction following the toe of the Nipomo Mesa on the northerly side of the valley to a point about 2 miles west of the State Highway bridge north of Santa Maria, a distance of approximately 11 miles. In this section the northerly bank consists of the high and precipitous bluff of the Nipomo Mesa. On its southerly side the channel has poorly defined banks, the bed of the stream being no more than 4 or 5 feet below the valley floor. The channel itself consists of a broad sandy wash ranging from a half mile to over a mile in width. At the lower end of this section the river turns and flows in a westerly direction leaving the Nipomo Mesa and crossing the valley floor through a broad sandy channel over a mile in width between ill defined banks. Beginning at a point about three miles east of the town of Guadalupe the channel narrows and has cut more deeply below the surrounding valley floor. From this point to the sea the banks are well defined, varying from 5 to 30 feet in height. The material forming these banks, however, is soft and easily eroded and when subject to attack by violent floods rapidly cuts back.

Long time residents state that prior to the last ten or fifteen years there was very little growth in the channel of the stream throughout its length. During recent years, however, a dense growth of willows has sprung up in the lower portion of the channel. At the time this investigation was initiated this growth had become sufficiently dense to practically clog the channel. If a large flood occurred with the channel in this condition the growth would probably have been sufficient barrier to cause the stream to break from its banks at points above, resulting in severe damage.

One of the first steps taken in connection with this work was the clearing of a channel through the section where this growth existed. A right of way 600 feet in width was obtained without cost from the property owners effected and with funds provided by the counties of Santa Barbara and San Luis Obispo, the State of California and the Southern Pacific Railroad, all growth was removed for a width of approximately 400 feet. This work was done as a temporary relief until such times as permanent works are built. It is important that the channel should be maintained free of all brush at all times.

Field surveys have been made of the existing channel from which its carrying capacity has been computed. A traverse with levels was run up the bed of the channel to determine its gradient. At numerous locations cross sections were taken from which the carrying capacity was computed for various depths of water. Map No. 9 attached hereto shows the results of this survey. The total length of the channel between Fugler's Point and the sea is approximately 23.5 miles and the total fall is approximately 370 feet. From the ocean to a point about one mile west of Guadalupe it has a gradient of about 2 feet in a thousand, from this point for a distance of about 2.5 miles easterly the gradient is approximately 2-3/4 feet in a thousand, from which point it steepens to a uniform slope of 3 feet per thousand to Fugler's Point. The capacity of the channel as determined at the various cross sections indicates many locations where a flood of 50,000 second feet could not be carried without overflowing the existing banks. At a number of points, particularly in the vicintty of the Suey Bridge, the capacity is not more than 25,000 second feet. A particularly bad condition exists near the point where the channel leaves the Nipomo Mesa and flows to the west. The most natural location for the channel below this point would be to follow along the foot of the mesa. If during a flood the river were to break its banks at this point, great damage would be done to the valuable and fertile farming lands of the Oso Flaco district in San Luis Obispo County. Levels across the valley floor show it to be practically level on lines at right angles to the center of the channel. It has been previously pointed out that during the past 40 years floods have occurred up to at least 100,000 cubic feet per second and the studies indicate the possibility of a flood of 160,000 second feet occurring once in a thousand years. If a flood of 100,000 second feet were to occur with the channel in its present condition, no one could foretell just where a new channel might be cut. It is as liable to go through the city of Santa Maria as any other location. A real flood menace exists which to be permanently relieved will require extensive and expensive works. This danger is iminent and calls for prompt and immediate relief. The value of the property effected and the future development of the valley justify the expenditures herein estimated to be required, not only for flood protection, but to insure the adequacy of the water supply for the 50,000 acres of irrigable valley lands.

METHODS OF FLOOD CONTROL:

Flood control is usually accomplished by channel improvements in the menaced area or by check dams and retarding reservoirs in the mountainous portions of the watershed, or by a combination of the two. Channel improvements usually consist of the building of levees or jetties to confine the flow in a relatively narrow channel to prevent overflow of adjacent improved lands. To be effective the improved channel should be relatively straight and of such width and depth that the velocity of flow during times of flood shall be sufficient to prevent the deposition of material carried in suspension and at the same time should not be so great as to erode or destroy the training works. The works may be temporary or permanent. Temporary improvements usually consist in the driving of single or double rows of timber piling with wire or heavy netting fastened to the piles, brush being placed behind. The life of such structures is not over 10 or 15 years due to the decay of the piling or the wire fabric. This type of construction has been used in many instances on Southern California streams similar to the Santa Maria River.

Experience has shown that the more permanent type of construction is not only much more effective, but is more economical over a period of years when interest, depreciation and maintenance are considered. The Los Angeles County Flood Control District has improved over 200 miles of channel in that county. Many different methods of bank protection have been employed. They have found the most effective system consists in the construction of substantial levees or dykes having their inner slope paved or protected to prevent erosion from the high velocities obtaining during flood flows.

One method of paving used on streams where large rocks or boulders exist in the channel, is to build up a mat of hand laid rock and boulders enclosed in wire mesh, well tied together. This is not only placed on the inner face of the levee but is also extended beyond the inner toe of the fill to form an apron. The advantage of this type of construction lies in its flexibility which permits its settlement at points where scour occurs. This work is not permanent as its usefulness is lost when the enclosing wire fabrics corrodes. Its cost is also high. In Los Angeles County it varies from 20 cents per square foot for a 5 inch mat to 30 cents for one 8 inches in thickness. The Los Angeles District has also protected a number of miles of levee with a reinforced concrete slab. On the lower portion of the levee and for some distance out from the toe a flexible slab or apron made of reinforced concrete or "gunite" has been built. The effectiveness of this type of construction during heavy floods has not yet been demonstrated. The most effective and proven method of protection and the one adopted by the Los Angeles District on the broad channels carrying large volumes of water across the flat Coastal Plain consists in placing a heavy blanket of large derrick size rock on the inner slope of the levee and for some distance out from the toe. Such rock must be sound and of sufficient weight to prevent its being carried out by high velocities in the channel. A standard gage railroad is built on top of the levee and permanently maintained for the rapid transportation of additional rock in an emergency. This method is also used on the lower Colorado River. The cost of such works is naturally great.

Check dams have been extensively used in Europe on small and precipitous watersheds. They consist of a series of relatively low dams constructed at frequent intervals in the bed of the channel as it descends through the mountains. The general theory of flood control and regulation by such structures is that the storage capacity back of the dams will soon fill with debris resulting in a flattening of the grade, causing a reduction in velocity and consequent retardation of flood flows and reduction in erosion. The Los Angeles County Flood Control District has built several thousand such structures on the smaller watersheds of the county. The first ones built consisted of hand laid rock walls not adequately tied to the rock forming the canyon walls and bed. Almost without exception they failed and were washed out during the first large flood subsequent to their construction. It has been demonstrated that to be of permanent value they must be well built of masonry or wire bound mats adequately bound together and tied to the native bedrock. Experience has also shown that their value for flood reduction or protection has been very much overrated. Their principal benefit has been in reducing erosion during floods. When properly built their cost is prohibitive for watersheds containing more than four or five square miles. On the larger drainage basins it will usually be found that flood regulation can be better and more economically obtained by creating retarding reservoirs by the construction of one or more substantial dams.

The use of retarding or regulating reservoirs for flood control has been adopted many times in the past. Such reservoirs are created in a drainage basin above the menaced area by the construction of a dam or dams having a permanent outlet at the stream bed of predetermined capacity. Under actual operation during time of floods, all flows less than the capacity of the outlet pass through the reservoir unretarded. When the flows exceed the capacity of the outlet, the excess water accumulates in storage in the reservoir basin until such time as the natural flow has again declined below the capacity of the outlet when the water level in the reservoir will then steadily lower until empty. Under such a system the violent flood peaks are removed and the flow of the river is sustained over a longer period of time at a greatly reduced rate. On our Southern California streams where floods are very flashy, reaching their peak in a matter of a few hours, and declining as rapidly, the storage capacity required for such regulation is not great. On many of our streams where the flood flows have been measured it has been found that the momentary peak discharge may be two or three times as great as the average flow for the 24 hours in the day when the peak occurred. The outlet from the reservoir may be permanently open or may be controlled by the installation of gates. Due to the human element entering into the operation of such gates, the outlets should be constructed without control apparatus. In some cases retarding reservoirs have been combined with holdover storage, the lower portions of the reservoir basin being equipped with controlled outlets and the storage capacity at the higher levels being used for flood regulation. In some cases such regulating reservoirs have been combined with holdover storage for power purposes.

Retarding reservoirs are of particular value on Southern California streams where water is obtained from wells in the ground water basins over which the natural channel passes. By reducing the flood peaks and prolonging the flow over a greater length of time, the amount of water naturally percolating into these ground water basins can be very substantially increased. The holding of these flood flows in storage even for a short time has a desilting effect which also tends to increase the natural percolation. Where flood control is obtained by levied channels the natural percolation to the ground water is decreased. As previously stated, the amount of percolation depends upon the volume of the flow and the area submerged by the stream. Where the river is confined between levied banks the velocity is increased in percolation. Flood control by channel improvements consequently increases the waste into the sea rather than reducing it. It has been shown that on the Santa Maria River holdover storage in artificially constructed reservoirs is not economical and the most effective storage can be obtained in the alluvial fill underlying the Santa Maria Valley. Regulating or retarding reservoirs on this stream would therefore accomplish the dual purpose of flood control and water conservation. Numerous examples of the use of retarding reservoirs exist in this country. The most notable example of their construction during recent years was by the Miami Conservancy District in the vicinity of Dayton, Ohio. In March 1913 a flood of unprecedented volume occurred in the Miami Valley. It has been estimated that the total loss amounted to $150,000,000. Following that flood the Miami Conservancy District was organized and a plan of flood control was prepared after a most thorough investigation and analysis. The plan consisted of a combination of retarding reservoirs and channel improvements. The total cost of the entire project was about $30,000,000. Five large retarding reservoirs were built. All of the dams were constructed of earth, having permanently open ports at stream level. The effectiveness of the retarding reservoirs for flood control has been thoroughly demonstrated during the floods that have occurred in the Miami Valley since the completion of the project. In discussing the Miami project it should be pointed out that these reservoirs were built for flood regulating purposes only, water conservation not being an important feature.

In Los Angeles County twelve retarding reservoirs have been constructed in the mountainous portions of that county. Several more are either now under construction or contemplated to be built in the immediate future. They have all been built with the idea of conserving the regulated outflow by spreading on the more porous portions of the channel overlying the Coastal Plain from which the greater portion of the developed water supply is obtained. The cost of storage in the reservoirs which have been built to date varies from $70.00 to over $500.00 per acre foot. Their effectiveness has been demonstrated in the operation of those reservoirs which have been subjected to flood flows since their completion. The City of Stockton has recently completed a large retarding reservoir for flood regulation purposes on the Calaveras River at a cost of approximately $1,000,000.00.

PROPOSED PLAN FOR SANTA MARIA VALLEY:

A plan of flood control and water conservation for the Santa Maria River with preliminary estimates of cost has been prepared and presented herewith. The proposed program involves the construction of two retarding reservoirs to be built on the Cuyama and Sisquoc Rivers. Under this plan it is believed the maximum benefits will be obtained at the minimum cost. The outflow from these two reservoirs during floods such as might occur once in forty years will be reduced to such a rate that most of the runoff from the tributary watersheds can be placed underground by spreading in the present channel, the limiting factor being the capacity of the ground water basin to receive such replenishment. The cost of constructing flood regulation works on all the minor tributaries of the Santa Maria River will be prohibitive at this time and as the funds available for this investigation were inadequate for the complete development of such a comprehensive plan the studies and plans were limited to the principal tributaries, i.e. the Cuyama and Sisquoc rivers. Under the plan proposed almost complete regulation will be obtained on these two streams abofe the reservoirs. The present channel of the river has adequate capacity after the recommended works are completed to safely carry the ordinary flood discharge from the unregulated portions of the drainage basin. It is probable, however, that at some future time it will be found desirable to extend the works over the smaller streams entering below the proposed reservoirs. Nothing proposed herein will prohibit or interfere with such a program.

A reconnoissance was made of the entire drainage basin of the Cuyama and Sisquoc Rivers to determine the location of all possible reservoir sites. The State Engineer in connection with a study of the water resources of the State of California made an investigation in 1923 of possible reservoir sites in the drainage basin of the Santa Maria River. This investigation included rough and preliminary surveys of the damsites. Only one of the reservoirs was surveyed, that being on the Cuyama River near the Permasse Ranch. The capacity of other reservoirs was determined very approximately from the topographic sheets of the U. S. Geological Survey. The following tabulation taken from the records of the State Engineer gives data relative to the sites investigated by him:

RESERVOIR SITES
IN
SANTA MARIA DRAINAGE BASIN
FROM
INVESTIGATION BY THE STATE OF CALIFORNIA, 1922

Reservoir Name	Stream	Sec.Twp.Range	Capacity Ac.ft.	Height ft.	Crest Length	Cost of Dam Proper	Cost per Ac.ft.	Geology
la Huasna	Huasna River	NW14 11N 33W	309,400	207	1200 ft.	$3,000,000	$10.00	Schist foundation for earth filled dam
Cuyama Narrows	Cuyama "	SE35 11N 33W	379,700	220	1720 "	3,082,400	9.00	Shale
Bee Rock	Sisquoc "	SW24 9N 31W	37,700	165	850 "	1,099,200	30.00	Shale foundation for earth filled dam
LaBrea	LaBrea Creek	NW3 9N 31W	39,700	165	900 "	1,712,000	46.00	Shale foundation for earth filled dam

In 1925 a Board of Engineers were employed by the Santa Maria Chamber of Commerce to report on a plan of water conservation on the Santa Maria River. In their report additional information is given relative to possible reservoir sites on the stream. After a thorough investigation of all this available data and an intensive field examination, three sites were selected for further study. One called Vaquerro Flat Reservoir is located on the Cuyama River about 7 miles above its junction with the Sisquoc. The other two sites were on the Sisquoc River. One called the Round Corral site, is located about 2 miles above the point where the Sisquoc River emerges from the mountains, the other located a short distance above is known as the Bee Rock Reservoir site. The location of these reservoirs is shown on Map No. 1. Detailed topographic surveys were made of these reservoir sites to determine their capacity for various heights of dam. Surverys were also made of the dam sites in order to make preliminary estimates of cost of the dams required. The suitability of the Vaquerro Flat damsite from a geological standpoint was investigated by Prof. J. P. Buwalda, head of the Department of Geology of the California Institute of Technology. Bed rock conditions at this site were also investigated by diamond core drilling and the sinking of test pits. No exploration work to determine the depth to bed rock at either the Round Corral or Bee Rock sites has been done. The cost estimates presented for these sites are based on an assumed depth to bed rock and while these estimates are believed to provide a liberal allowance for the cost of the cutoff wall, they should be regarded as tentative only until such time as the actual depth to bed rock has been determined. The capacity of the reservoirs created by various heights of dams is shown by the following tabulation:

RESERVOIR CAPACITY IN ACRE FEET

Depth of Water at Damsite	Vaquerro Flat Reservoir on the Cuyama River	Round Corral Reservoir on the Sisquoc River	Bee Rock Reservoir on the Sisquoc River
0	0	0	0
10	436	150	300
20	1,928	461	790
30	5,018	1,050	1,480
40	9,866	1,937	2,335
50	15,929	3,050	3,350
60	22,944	4,545	4,524
70	30,874	6,200	5,900
80	39,819	8,149	7,582
90	50,196	10,300	9,600
100	62,568	12,737	11,885
110	77,568	15,500	14,400
120	95,152	18,711	17,667
130	115,421	22,300	21,200
140	138,363	26,240	25,251
150		30,600	29,700
160		35,257	34,762

The large capacity obtainable at the Vaquerro Flat site is indicated by a comparison with those on the Sisquoc River, a dam 100 feet in height at this point giving more than five times as much storage as one of the same height on the Sisquoc. From the standpoint of capacity the Vaquerro Flat site is one of the most favorable in Southern California. A topographic map of the Vaquerro Flat site is attached hereto as Map No. 10 and one of the Round Corral site is included and designated Map No. 11.

These reservoirs are not only more economical to construct per acre foot of capacity than any other possibilities on the two streams, but have the great advantage of commanding the major portion of the mountainous watershed above the Santa Maria Valley. Out of a total drainage area above Fugler's Point, of 1656 square miles, 1426 square miles or 86 percent are tributary to these two reservoirs, 1146 square miles of the Cuyama drainage being above the Vaquerro Flat site and 280 square miles of the Sisquoc drainage lying above the Round Corral site. The total estimated average seasonal water crop of the entire Santa Maria basin amounts to 124,398 acre feet as shown in Table No. 22. Of this amount it is estimated that 102,058 acre feet or 82 percent is tributary to these two reservoirs.

Elaborate studies have been made to determine the reservoir capacity required to regulate all flood flows during the 37 year period covered by this study, to given rates of discharge. To make these studies it was necessary to estimate the daily flow at the two reservoir sites for each season. This was done from the measured records of daily discharge of similar streams in Southern California by multiplying the daily discharge of the measured stream by the ratio of the total estimated seasonal runoff of the Cuyama or Sisquoc rivers to the total season runoff of the measured stream. Table No. 29 shows the total estimated seasonal discharge of the Cuyama River at the Vaquerro Flat site and the measured discharge of other Southern California streams from which the daily hydrograph was prepared. Table No. 30 gives similar data for the Sisquoc River. From the daily flow computed as described above a computation was made to determine the reservoir capacity required at each site to regulate the natural inflow to mean rates of outflow of 1000, 2000, and 3000 second feet. Table No. 31 shows the results of this study at the Vaquerro Flat site for the 37 year period and Table No. 32 shows similar figures for the Sisquoc River. For the Cuyama River it was found that the maximum storage required to regulate to a uniform flow of 1000 second feet was 127,506 acre feet, for 2000 second feet, 54,325 acre feet and for 3000 second feet 40,100 acre feet. On the Sisquoc River it was found that a maximum capacity of 112,417 acre feet was required for a uniform outflow of 1000 second feet, 26,964 acre feet for an outflow of 2000 second fee t and 20,595 acre feet for 3000 second feet.

ENGINEERING OFFICES—J. B. LIPPINCOTT—LOS ANGELES, CAL.

Dams for flood regulating reservoirs are usually built by leaving a permanent opening through the dam at stream bed elevation. At the reservoir proposed herein it is planned to construct the outlet conduit as a tunnel through the abutments of the dams. During most of the time the reservoir is empty, all natural inflow of an amount less than the capacity of the opening passing through the reservoir unretarded. When the flow increases to a point beyond the capacity of the opening the excess water starts accumulating in the reservoir. As the depth of water increases in the reservoir the discharge through the outlet becomes greater due to the increasing head or pressure on the upper end.

The capacity of various size tunnels for various depths of water in the reservoir has been computed. From this data an estimate has been made of the average rate of discharge from the time flow starts until the water level has reached a given elevation by giving consideration to the storage capacity of the reservoir at the various levels. For an exact determination, however, it would be necessary to study each individual flood hour by hour. The date upon which the estimated flood runoff is based do not justify such a detailed computation.

From the results obtained from the studies outlined above, diagrams have been prepared by which the afficiencies of reservoirs of various capacities having different size outlets can be quickly studied. Diagram No. 7 relates to the Vaquerro Flat Reservoir. The vertical scale on this graph shows the reservoir capacity in acre feet and the elevation of the water surface to obtain such capacity. The horizontal scale shows the average rate of discharge through the outlet conduits. The solid curved lines drawn on the diagram show the reservoir capacity required for various rates of discharge for all floods from 1893 to date and are plotted from figures given in Table No. 30. For example during the flood of 1910-11 a reservoir capacity of 45,800 acre feet would have been required to regulate to a uniform outflow of 2500 second feet. The curved dotted lines drawn on the diagram show approximately the average rates of discharges for various size tunnels during the period required to accumulate different amounts of water in the reservoir. For example from the diagram we find that with a ten foot tunnel the average rate of discharge from reservoir empty to 50,000 acre feet in storage would be 2920 second feet. The intersection of the dotted curved lines with the solid curve lines shows operating conditions during the various floods. For example, let us determine the maximum amount that would have been in storage in the reservoir during the flood of 1910-11 and the average rate of discharge thhough a ten foot tunnel. From the intersection of the curved line designated 1910-11 with the dotted curved line marked 10 ft. conduit, we find a maximum accumulation in storage of 42,500 acre feet and an average rate of outflow through the tunnel of 2770 second feet. By similar methods the effectiveness of reservoirs of various capacity having various sized outlet tunnels can be quickly determined. Diagram No. 8 shows the same data for the Sisquoc Reservoir.

Where a reservoir is built for holdover storage for a gravity water supply its safe yield can be accurately determined. From the value of the water obtained the resulting benefits can be computed. By balancing the value of such benefits with the cost of various sized reservoirs the most economic amount of storage to be provided can be determined. When a reservoir is to be built for flood control purposes its economic capacity cannot be determined with any such degree of accuracy. If we knew the amount of damages that would result from floods of various magnitudes an approximate estimate might be made. Unfortunately we do not know and cannot know the amount of such damages. Where water conservation is one of the benefits obtained by the construction of such a reservoir as is the case in this plan the problem becomes still further complicated. The ability of the community to finance any such plan must also be given consideration. If a plan were proposed for immediate construction which would provide for the complete regulation of all floods that might occur once in a thousand years or even once in five hundred years, its initial cost would be prohibitive for the valley in its present state of development even though the cost could be justified from the value of the benefits received. It is therefore necessary to prepare a plan that can be immediately financed and the maximum benefits secured at such cost. The plan should also be prepared in such manner that the works may be enlarged or expanded in the future without loss.

Preliminary plans and estimates have been prepared from which the cost of constructing the necessary dams, acquiring reservoir lands and rights of way can be compared for reservoirs of various capacities at the two sites under consideration, i. e. the Vaquerro Flat site on the Cuyama River and the Round Corral site on the Sisquoc River. Complete cost estimates have been prepared for three dams at each site. The following tabulation is a summary of these estimates and data relative to the effectiveness of each as flood control reservoirs:

SUMMARY OF RETARDING RESERVOIR STUDIES ON SANTA MARIA RIVER

Reservoir Capacity to Spillway Acre feet	Elevation Spillway Crest	Total Estimated Cost	Cost per Acre foot Storage	Diameter of Outlet Tunnel	Maximum Capacity of Outlet to Spillway Crest Second Feet	Flow over Spillway Once in Following Years
CUYAMA RESERVOIR @ VAQUERRO FLAT SITE						
30,874	550	$1,407,269.00	$45.50	10'	3,310	18.5
		1,414,535.00	45.80	11	4,090	20
		1,423,301.00	46.10	12	4,960	30
		1,432,160.00	46.40	13	5,890	42
		1,440,785.00	46.65	14	6,860	50
35,192	555	1,517,178.00	43.15	10	3,450	20
		1,524,444.00	43.30	11	4,260	32
		1,533,210.00	43.60	12	5,170	42
		1,542,069.00	43.85	13	6,150	60
		1,550,694.00	44.10	14	7,170	90
39,819	560	1,610,533.00	40.45	10	3,560	32
		1,617,799.00	40.60	11	4,430	44
		1,626,565.00	40.80	12	5,355	60
		1,635,424.00	41.08	13	6,390	100
		1,644,049.00	41.25	14	7,460	190
SISQUOC RESERVOIR @ ROUND CORRAL SITE						
17,100	815	1,177,946.00	68.85	10	4,580	50
		1,185,212.00	69.40	11	5,740	100
		1,193,978.00	69.80	12	7,050	250
20,420	825	1,262,489.00	61.80	10	4,790	100
		1,269,755.00	62.00	11	5,980	200
		1,278,521.00	62.50	12	7,320	500
24,200	835	1,426,404.00	58.90	10	4,980	200
		1,433,670.00	59.25	11	6,220	500
		1,442,436.00	59.60	12	7,600	1000

After careful consideration of the data summarized in this tabulation the following plan is recommended:-

1. That a dam be constructed on the Cuyama River at the Vaquerro Flat site to create a reservoir having a capacity of 35,192 acre feet to the spillway crest at elevation 555, and that a permanently open tunnel of horse-shoe section be constructed at stream bed elevation to have a maximum diameter of 14 feet. Such a reservoir would regulate all floods that might occur once in 90 years. By this plan it is estimated that a maximum flood of approximately 85,000 second feet at this point under existing conditions might be regulated to maximum rate of outflow from the reservoir of 7,170 second feet. The total estimated cost of the necessary lands, rights of way and dam with appurtenant structures is $1,550,694.

11. That a dam be constructed on the Sisquoc River at the Round Corral site to create a reservoir having a capacity of 17,100 acre feet to the spillway crest and that a permanently open tunnel of horse-shoe section be constructed at stream bed elevation to have a maximum diameter of 11 feet. It is estimated that such a structure would regulate all floods that might occur at frequencies of less than once in 100 years. By this plan a natural flow at this point of approximately 50,000 cubic feet per second might be reduced to a maximum rate of outflow 5740 second feet. The total estimated cost of acquiring the necessary lands and constructing the dam and appurtenant works is $1,185,212.

TYPE OF DAM PROPOSED:

In selecting the type of dam proposed, consideration has been given to many factors including the total cost; suitability of the damsite from the standpoint of topography, geological formation and strength of abutments; safety during earthquake; availability and cost of construction materials; ease and rapidity of construction; and suitability for future enlargement. It has been fouhd from preliminary studies that an earth fill dam at each of these sites would not only be more economical to construct but would also meet the requirements enumerated above more satisfactorily than any other of the various types in general use. An earthfill dam when properly built according to conservative plans is one of the safest and lasting of structures. In planning and building such a dam, however, certain requisites are necessary for its stability. It should have conservative slopes and an adequate top width. The materials used in its construction and the method of placing the same should be such as to insure an impervious structure. An adequate tie or cutoff should be made to the underlying bed rock to prevent the flow of water under the dam. The upstream face of the dam should be paved or protected to prevent cutting or erosion from waves on the reservoir surface. Most of the failures of earth dams recorded in the past have been caused by overtopping of the dam due to lack of spillway capacity. In the plans proposed herein particular attention has been given to the design of an adequate spillway. The capacity provided has been based on the flood that might occur once in a thousand years. Even under such a flood there would still be ample freeboard between the maximum water level in the reservoir and the top of the main fill. As a further precaution and to prevent overtopping from high waves that might occur with a full reservoir, a substantial reinforced concrete parapet wall has been provided on top of the fill. Provision has been made to prevent erosion at the downstream toes of the dam during large flows over the spillway. Under present state laws the plans of all dams built in the state must be approved by the state engineer who also has supervisial authority during construction. It is believed that no difficulty will be had in obtaining such approval of the plans as submitted herewith. Before final plans are prepared and construction actually started, furhher exploration of bed rock conditions will be necessary.

Preliminary plans of the dams proposed are shown on Maps No. 12 and 13. The estimates are based on the present cost of labor and materials and recent contracts awarded for similar structures. The unit prices used are field costs or the estimated amount a responsible contractor might bid for the individual items. To the field cost has been added an allowance of 25 percent for overhead and unforeseen contingencies. The detailed estimate of the Vaquerro Flat Dam is attached hereto as Table No. 33 and for the Round Corral Dam as Table No. 34. The estimated cost per acre foot of storage capacity at the Vaquerro Flat site on the Cuyama River is $44.10 and $69.40 at the Round Corral site on the Sisquoc River. The following tabulation gives comparable figures showing the cost per acre foot of storage at reservoirs built by the Los Angeles County Flood Control District:

Big Dalton	600.00
Big Santa Anita	789.54
Devils Gate	70.02
Live Oak	620.07
Pacoima	260.64
San Dimas	310.34
Sawpit	1006.31
Sierra Madre	1330.80
Thompson Creek	276.57

RELATION OF COSTS AND BENEFITS:

The total estimated cost of the two proposed reservoirs is $2,735,906. To justify such an expenditure it is necessary to estimate the value of the resulting benefits. Under the plan proposed herein the benefits are two-fold, namely, water conservation and flood control. It has been shown that out of a total irrigable area of 50,000 acres in the Santa Maria Valley, 27,000 acres, or 54 percent of the total are now under irrigation. The studies indicate that even under the present rate of draft the ground water sources from which the water supply is derived are now over-drawn. With the irrigated area increasing at the rapid rate maintained during the past few years, it is imperative that an additiona supply be obtained. It has been shown that the cost of securing such additional water by gravity from artificially constructed surface reservoirs wherein the stream flow during wet periods is held in storage for later use during periods of drought is prohibitive at the present time. The most feasible and economic method of obtaining an additional supply is by increasing the natural replenishment to the underground basin, conserving the large volume of flood water which under natural conditions wastes to the sea during flood years. It is estimated that the total annual net draft on the underground basin at the present time is approximately 40,500 acre feet, and for the entire 50,000 acres of irrigable land it will amount to 75,000 acre feet. Studies which have been made indicate that if the works proposed herein are constructed and operated as recommended, the natural replenishment to the ground water basin will be increased to such an extent that a supply of water can be obtained adequate for the entire irrigable area of 50,000 acres.

An analysis has been made of the annual cost of the proposed project per irrigable acre, assuming the entire cost is borne by the irrigated area. In making this analysis no allowance has been made for the value of the benefits derived from flood protection. This feature will be discussed later. It is quite probable that substantial financial aid can be secured from outside sources such as the state and county. Numerous examples can be cited where the state has contributed large sums of money to other communities faced with a similar problem. These contributions have been made on the basis of flood control. Assuming the funds required are derived from the sale of bonds bearing interest at 6 percent to be retired at the end of 40 years from the accumulation in a 4 percent sinking fund, the annual cost will be 7.05 percent of the total investment or $192,881.00, which is equivalent to $3.86 per irrigable acre per annum. The State Engineer in cooperation with the U. S. Department of Agriculture, has recently made an analysis of the cost of water in various sections of California. Included in this study are estimates showing the cost of water per acre foot when obtained from individual electrically driven farm pumping plants such as those used in the Santa Maria Valley, with wells from 300 to 350 feet in depth yielding approximately 900 gallons per minute and with an average pumping lift of 100 feet and a duty of water of 3 acre feet per acre, the annual costs per acre amount to approximately $10.00. This figure includes all fixed charges such as interest, depreciation and repairs, and operating expenses such as power, labor and maintenance. If the total cost per acre for a 100 foot lift at the present time is $10.00, the additional cost caused by the construction of the proposed works of $3.87 per acre would therefore be equivalent to lifting the water something like 40 feet more. If the proposed works are not constructed and the irrigated area expands in the future as it has in the past, the ground water levels will continue to decline at a rapidly increasing rate and it will not be many years before the pumping lift will be increased this 40 feet. If after the works are constructed the pumping lift can be maintained at or near the present average of 100 feet, the cost of water per irrigated acre in the Santa Maria Valley will be approximately $14.00. Considering the character of the crops grown and their value, such a figure is not a high cost when compared with other communities of Southern California where similar crops are grown, particularly where the water supply is all pumped. In considering this figure it should be borne in mind that the ultimate cost given above is a maximum as no credit has been given for value of flood protection nor has any deduction been made for possible contributions from outside sources.

It is impossible to estimate accurately the value of flood protection in any community. This is particularly true where the value of the improvements in the menaced area are increasing as rapidly as in the Santa Maria Valley. If we knew the damages that might be caused by floods of various magnitude together with the frequency of their occurence, it might be possible to estimate the value of flood protection in the same manner as one estimates the value of insurance. If a flood of 100,000 second feet were to occur with the channel in its present condition, no one could foretell at just what point the river might break from its banks nor the course it might take in passing to the sea. It is as liable to go through the City of Santa Maria as any other portion of the area. It is not difficult to conceive that the damages from such a flood might easily amount to more than $1,000,000. The damages are made up not only of the destruction of valuable farming lands, but also include the damgges to utilities such as telephone, telegraph lines, railroads, highways and bridges. It has been estimated that the direct damages done byy the 1916 flood in Los Angeles County alone amounted to approximately $10,000,000.

The above figures demonstrate that the benefits that would result from the carrying out of the program herein amply justify the proposed estimated investment. It may be argued that the carrying out of this plan could be delayed some four or five years without material effect. From the standpoint of water supply this may be true, as the water now held in storage below the present pumping level should probably sustain the use for such a period. A serious flood menace exists, however, which calls for immediate relief. Based on past records we are now approaching the end of a long group of dry years. The next group of years should be above average with accompanying floods. A repetition of the flood of 1909, 1911, 1914 or 1915 would cause damage much greater than the saving that might be effected from a few years delay. If it is considered impossible to carry out the entire program at the present time we recommend the construction of the Vaquerro Flat dam and reservoir on the Cuyama, to be followed as soon as possible by the construction of the reservoir on the Sisquoc River.