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WATERSHED
WORK PLAN

Approved by Congress
July 30, 1958

# CENTRAL SONOMA WATERSHED

SONOMA COUNTY, CALIFORNIA

APRIL 1958

# WATERSHED WORK PLAN

## CENTRAL SONOMA WATERSHED

Sonoma County, California

Prepared under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended by the Act of August 7, 1956 (Public Law 1018, 84th Congress; 70 Stat. 1088)

Prepared by

Santa Rosa Soil Conservation District

Sonoma County Flood Control and
Water Conservation District

With assistance by

U. S. Department of Agriculture
Soil Conservation Service

April 1958

RESOLUTION NO. 5482

RESOLUTION IN SUPPORT OF THE WATERSHED WORK PLAN FOR THE SANTA ROSA CREEK SUBWATERSHED OF THE CENTRAL SONOMA WATERSHED PROJECT.

WHEREAS, application has heretofore been made to the Secretary of Agriculture for assistance in preparing a plan for works of improvement under the Watershed Protection and Flood Prevention Act (Public Law 566) as amended by the Act of August 7, 1956 (Public Law 1018), and

WHEREAS, the City of Santa Rosa was a Sponsoring Local Organization of said application; and

WHEREAS, there has been developed through the cooperative efforts of the Sponsoring Local Organizations and the Soil Conservation Service, a watershed work plan for the Santa Rosa Creek Subwatershed of the Central Sonoma Watershed project;

NOW, THEREFORE, BE IT RESOLVED that the City of Santa Rosa is in agreement with the provisions of said watershed work plan and concurs in the Sponsoring Local Organizations' support of the plan.

IN COUNCIL DULY PASSED this 17th day of December, 1957.

AYES: (5) Mayor Mitchell, Councilmen Jensen, Rafanelli, Toohey, Stolting

NOES: (0) None

ABSENT: (0) None

APPROVED: KENNETH R. MITCHELL
Mayor

ATTEST: JOHN HAWKES
City Clerk

I hereby certify that the foregoing is a true and correct copy of a resolution duly and regularly passed by the City Council of the City of Santa Rosa at a regular meeting thereof held 12-17-57

John Hawkes
City Clerk of the City of Santa Rosa, Calif.

WATERSHED WORK PLAN AGREEMENT

between the

SANTA ROSA SOIL CONSERVATION DISTRICT

Local Organization

SONOMA COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT*

Local Organization

(Located in the State of California and hereinafter collectively referred to as the Sponsoring Local Organizations)

and the

SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organizations for assistance in preparing a plan for works of improvement for the Central Sonoma Watershed Project, State of California, under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended by the Act of August 7, 1956 (Public Law 1018, 84th Congress; 70 Stat. 1088); and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organizations and the Service a mutually satisfactory plan for works of improvement for the Central Sonoma Watershed Project, State of California, hereinafter referred to as the watershed work plan, which is annexed to and made a part of this agreement:

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organizations and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvements

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* The governing board of the Sonoma County Flood Control and Water Conservation District is also the Sonoma County Board of Supervisors.

as set forth in said plan will be installed, within 6 years, and operated and maintained substantially in accordance with the terms, conditions and stipulations provided for therein.

It is mutually agreed that in installing and operating and maintaining the works of improvement described in the watershed work plan:

1. The Sonoma County Flood Control and Water Conservation District will acquire without cost to the Federal Government such land, easements, or rights-of-way (including relocation or replacement of utilities) as will be needed in connection with the works of improvement. (Estimated cost $1,889,000.)
2. The Sonoma County Flood Control and Water Conservation District will acquire, or provide assurance that landowners or water users have acquired, such water rights pursuant to State law as may be needed in the installation and operation of the works of improvement.
3. The Service will bear the entire construction cost of structural measures for flood prevention. (Estimated cost $7,829,400.)
4. The Service will bear the cost of all installation services applicable to works of improvement for flood prevention. (Estimated cost $2,029,500.)
5. The Sonoma County Flood Control and Water Conservation District will bear the cost of administering contracts. The functions to be performed are limited to such items as advertising jobs; inviting, receiving and opening bids; awarding contracts; handling and accounting for funds; and related activities. (Estimated cost $78,500.)
6. The Santa Rosa Soil Conservation District will obtain agreements from the owners of not less than 50% of the land above each floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.
7. The Santa Rosa Soil Conservation District will encourage landowners and operators to operate and maintain land treatment measures for the protection and improvement of the watershed.

8. The Sonoma County Flood Control and Water Conservation District will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

9. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred will be used.

10. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose. In like manner, financial and other assistance to be furnished by the Sponsoring Local Organizations is contingent on the appropriation of funds for this purpose. Where there is a Federal contribution to the construction cost of works of improvement, a separate agreement in connection with each construction contract will be entered into between the Service and the Sponsoring Local Organization prior to issuance of invitations to bid. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

11. The watershed work plan may be amended or revised, and this agreement may be modified or terminated by mutual agreement of the parties hereto.

12. No member of, or delegate to, Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

APPROVED AS TO FORM:
RICHARD M. RAMSEY

SONOMA COUNTY COUNSEL

SANTA ROSA SOIL CONSERVATION DISTRICT

By Stanley D. Custer

Title President

Date April 23, 1958

The signing of this agreement was authorized by a resolution of the governing body of the Santa Rosa Soil Conservation District adopted at a meeting held on April 3, 1958.

Kenton N. Smith
(Secretary, Santa Rosa Soil Conservation District.)

Date: April 23, 1958

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

By Everett Sampson

Title Chairman

Date: 4/21/58

The signing of this agreement was authorized by a resolution of the governing body of the Sonoma County Flood Control and Water Conservation District adopted at a meeting held on April 21, 1958.

Eugene D. Williams
(Clerk of the Board)

Date: 4-23-58

SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

By Hudson Young
(Administrator)

Date: 9/17/58

Date 12-3-57

RESOLUTION IN SUPPORT OF THE WATERSHED WORK PLAN FOR THE CENTRAL SONOMA WATERSHED PROJECT

WHEREAS, application has heretofore been made to the Secretary of Agriculture for assistance in preparing a plan for works of improvement under the Watershed Protection and Flood Prevention Act (Public Law 566) as amended by the Act of August 7, 1956 (Public Law 1018); and

WHEREAS, the Bellevue-Wilfred Drainage District was a Sponsoring Local Organization to said application; and

WHEREAS, there has been developed through the cooperative efforts of the Sponsoring Local Organizations and the Soil Conservation Service, a watershed work plan for the Santa Rosa Creek Subwatershed of the Central Sonoma Watershed Project;

NOW, THEREFORE, BE IT RESOLVED that this organization is in agreement with the provisions of said watershed work plan and concurs in the Sponsoring Local Organizations' support of the plan.

BELLEVUE-WILFRED DRAINAGE DISTRICT

By: F. R. Stoff

Title: Chairman

Date: 12-3-57

The signing of this resolution was authorized by action of the governing board of the BELLEVUE-WILFRED DRAINAGE DISTRICT at a meeting held on December 3, 1957.

Leota Shea

Secretary

Date: December 3, 1957

Date Dec. 16, 1957

RESOLUTION IN SUPPORT OF THE WATERSHED WORK PLAN FOR THE SANTA ROSA CREEK SUBWATERSHED OF THE CENTRAL SONOMA WATERSHED PROJECT

WHEREAS, application has heretofore been made to the Secretary of Agriculture for assistance in preparing a plan for works of improvement under the Watershed Protection and Flood Prevention Act (Public Law 566) as amended by the Act of August 7, 1956 (Public Law 1018); and

WHEREAS, the Laguna Storm Water District was a Sponsoring Local Organization of said application; and

WHEREAS, there has been developed through the cooperative efforts of the Sponsoring Local Organizations and the Soil Conservation Service, a watershed work plan for the Santa Rosa Creek Subwatershed of the Central Sonoma Watershed Project;

NOW, THEREFORE, BE IT RESOLVED that this organization is in agreement with the provisions of said watershed work plan and concurs in the Sponsoring Local Organizations' support of the plan.

LAGUNA STORM WATER DISTRICT

By: Carl Kimes

Title: Chairman, Board of Trustees

Date: Dec. 16, 1957

The signing of this resolution was authorized by action of the governing board of the LAGUNA STORM WATER DISTRICT at a meeting held on Dec. 16, 1957 1957.

Russell Dennis Secretary
Laguna Storm Water Dist

Date: Dec. 16, 1957

Date December 19, 1957

RESOLUTION IN SUPPORT OF THE WATERSHED WORK PLAN FOR THE CENTRAL SONOMA WATERSHED PROJECT

WHEREAS, application has heretofore been made to the Secretary of Agriculture for assistance in preparing a plan for works of improvement under the Watershed Protection and Flood Prevention Act (Public Law 566) as amended by the Act of August 7, 1956 (Public Law 1018); and

WHEREAS, the Goldridge Soil Conservation District was a Sponsoring Local Organization to said application; and

WHEREAS, there has developed through the cooperative efforts of the Sponsoring Local Organizations and the Soil Conservation Service a watershed work plan for the Santa Rosa Creek Subwatershed of the Central Sonoma Watershed Project;

NOW, THEREFORE, BE IT RESOLVED that this organization is in agreement with the provisions of said watershed work plan and concurs in the Sponsoring Local Organizations' support of the plan.

GOLDRIDGE SOIL CONSERVATION DISTRICT

By E Briggs

Title President

Date 12-19-57

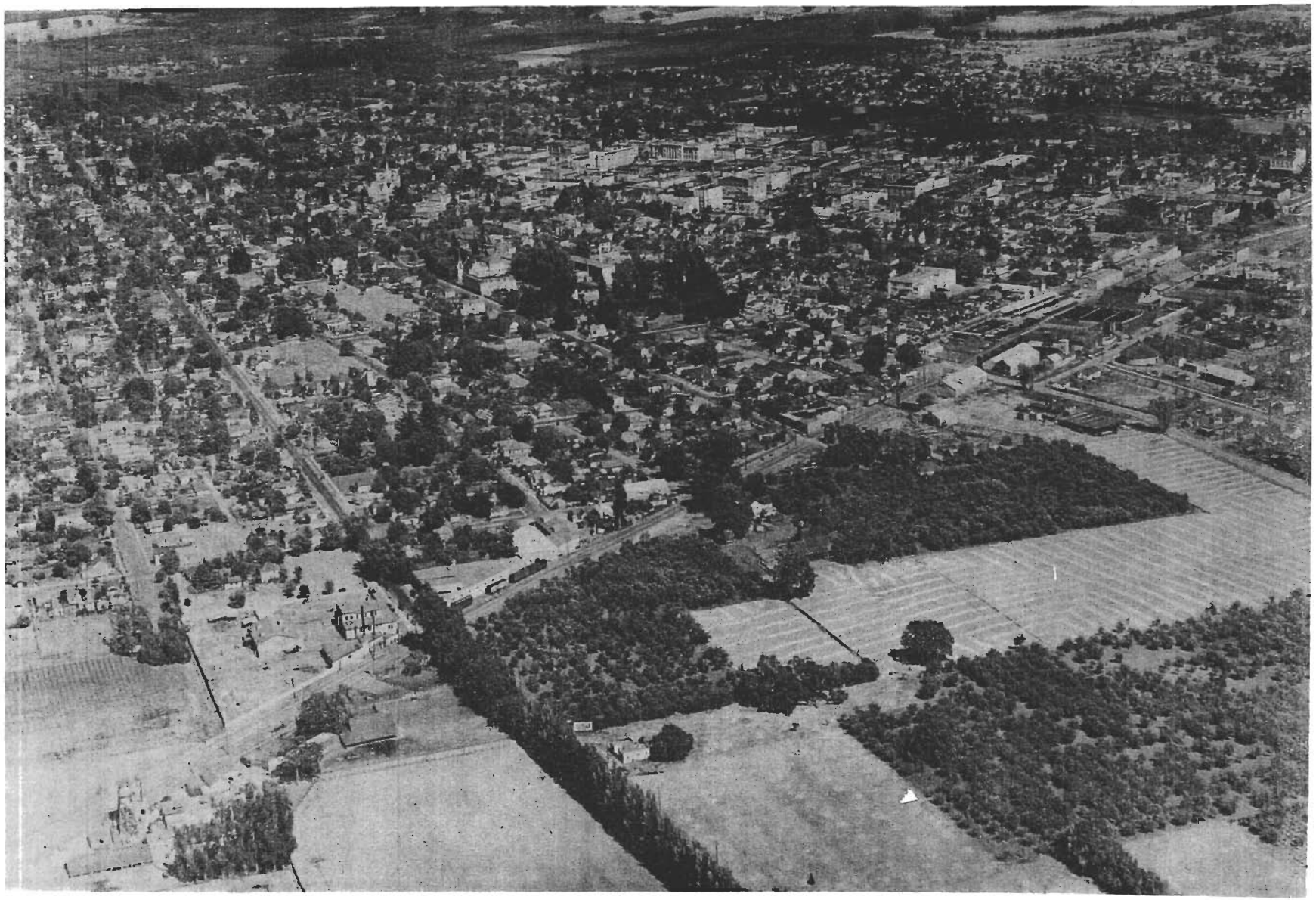
The signing of this resolution was authorized by action of the governing board of the GOLDRIDGE SOIL CONSERVATION DISTRICT at a meeting held on 12-19, 1957.

Clarence D. Younger
Secretary

Date 12-19-57

POPULATION 11,800





SANTA ROSA in 1936

SAN FRANCISCO EXAMINER PHOTO

POPULATION 29,050



SAN FRANCISCO EXAMINER PHOTO

SANTA ROSA in 1957

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SECTION I

# THE WATERSHED WORK PLAN

# CENTRAL SONOMA WATERSHED

Sonoma County, California

April 1958

## SUMMARY OF PLAN

The Watershed Work Plan was prepared under the guidance of a steering committee composed of representatives of the agencies signing the application for assistance under Public Law 566, namely, the Santa Rosa Soil Conservation District, Gold Ridge Soil Conservation District, City of Santa Rosa, Laguna Storm Water District and the Bellevue-Wilfred Drainage District. Participants in the technical work were the Sonoma County Flood Control and Water Conservation District and the Santa Rosa Soil Conservation District, assisted by the U. S. Soil Conservation Service.

The total watershed area for which assistance was requested includes 163,000 acres. The current work plan is confined to the 50,000 acre (78 square-mile) Santa Rosa Creek subwatershed. A new application for assistance on the remaining acreage is in process. All references to the Central Sonoma Watershed appearing in this report are limited to the Santa Rosa Creek subwatershed.

In this watershed some 5% of the land is in row and field crops, 14% in orchard and vineyard, 56% in pasture and range, 12% in woodland and brush, and 13% in miscellaneous uses, mainly urban and suburban developments.

This work plan describes a 6-year project for flood prevention at an estimated total installation cost of $11,826,400. The non-Federal share of this will be $1,967,500. In addition, local interests will bear the cost of operation and maintenance with a capitalized value of $3,692,800. Of the total project cost of $15,519,200, the non-Federal share will be $5,660,300 and the Federal share $9,858,900.

The average annual cost of the project is estimated at $547,300, of which $347,600 will be borne by the Federal Government and $199,700 will be from non-Federal sources.

## MEASURES TO BE INSTALLED

### LAND TREATMENT MEASURES

Land treatment measures have been installed under the regular Soil Conservation District programs to the extent that the watershed is well stabilized under its present use and treatment. The installation of additional needed land treatment measures will not produce significant and

measurable effects in reducing floodwater and sediment damages because of the small areas in isolated locations on which they are needed.

The Santa Rosa Soil Conservation District will give major emphasis to maintenance and improvement of the existing measures and to the planning and application of additional measures where needed.

## STRUCTURAL MEASURES

Structural measures included in the plan are: six floodwater retarding structures having a combined capacity of 5,960 acre feet; 31.2 miles of channel improvement involving straightening, shaping, riprapping and vegetating; 0.6 mile of channel control by rail and wire revetment; 1.8 miles of channel improvement by installation of concrete lining; and 2,000 linear feet of stream bank stabilization structures for controlling critical sediment source areas. All of these measures are planned for construction within six years.

Of the $15,519,200 total cost of structural measures, the local share of $5,660,300 will be used for the following obligations: land, easements, rights-of-way and utility relocation, 34%; operation and maintenance (capitalized at 2½% over 50 years), 65%; and administration of contracts, 1%.

## DAMAGES AND BENEFITS

The estimated average annual damage without the project from all storms up to the 1% frequency of occurrence * is $708,500.

The estimated average annual damage with the project (on the same basis) is $3,000.

The average annual primary benefit accruing to structural measures is $705,500. Of the average annual primary benefit, $602,700 is due to reduction of direct damage and $102,800 indirect.

The ratio of the average annual benefit to the average annual cost is 1.3 to 1.

## PROVISIONS FOR ACCOMPLISHING AND FINANCING CONSTRUCTION

The Sonoma County Flood Control and Water Conservation District has been organized in accordance with the laws of the State of California and is a legal subdivision of the State with powers of taxation and eminent domain. It can accept contributions, levy assessments, issue warrants, hold elections for the issuance of bonds and make levies to retire bonds. This agency will prepare final plans with the assistance of the Soil Conservation Service and will contract for the construction of all structural measures included in the work plan.

* A 1% frequency of occurrence event is one of such magnitude that it will be equalled or exceeded in 1% of the years in a long period.

## OPERATION AND MAINTENANCE

All structural measures included in the plan will be operated and maintained by the Sonoma County Flood Control and Water Conservation District.

## DESCRIPTION OF THE WATERSHED

### LOCATION AND SIZE

The Central Sonoma Watershed lies fifty airline miles north of San Francisco and surrounds the City of Santa Rosa. It covers an area of 50,000 acres and is tributary to the Russian River via the Laguna de Santa Rosa and the lowest segment of Mark West Creek. It includes all of Santa Rosa Creek and its tributaries.

### PHYSICAL DATA

Santa Rosa Creek and its major tributaries head in precipitous country with a maximum elevation of 2,730 feet. In general, the mountainous areas are well wooded or have an adequate grass cover, except for a few massive outcroppings of hard rock. Mountain slopes steeper than 50% are common and the minimum channel gradient is about 2%.

After leaving the mountains, the creeks flow through a belt of rolling land, generally in grass, pasture or cover-cropped orchard, and out onto the flat floors of tributary valleys before they reach the Santa Rosa Plain. Through the tributary valleys, the channels are incised some 10 to 30 feet into alluvium and the gradients are in the range of 0.25 to 0.50%.

Santa Rosa and Matanzas Creeks are entrenched through the City of Santa Rosa and are partly protected by native vegetation and intermittent revetments. As it leaves Santa Rosa, the combined channel gets smaller until it becomes entirely inadequate to contain the flows that occur in most years. At the lower end of the watershed the gradient flattens to about 0.1% before the stream enters the Laguna.

Soils of the mountainous areas are generally medium-textured. In the open grass-oak range areas they are moderately shallow, averaging two feet deep, but where there is forest cover the soils are somewhat deeper and have good moisture-holding capacity. In the rolling land some profile development is common and run-off rates would be excessive if the land were left without cover. The tributary valleys are characterized by medium-textured recent alluvial soils. On the Santa Rosa Plain west of the city to the Laguna de Santa Rosa, the common soil condition is a medium to heavy surface soil underlain at one or two feet by a claypan.

With few exceptions, notably several small areas in the headwaters of Matanzas Creek, the cover on the entire watershed is good. Cover crops are used almost universally in the orchards and vineyards and depletion of range cover happens only in years when rainfall is unusually short. Only a small proportion of the farmed land is irrigated.

Land use by land capability classes is as follows:

| LAND USE | LAND CAPABILITY CLASS | | | | | | | | Total Area | % of Total Area |
|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | VI | VII | VIII | Misc. | | |
| Row and Field crops | 530 | 880 | 850 | 270 | 120 | | | | 2650 | 5 |
| Orchard and vineyard | 690 | 2830 | 2950 | 290 | 200 | | | | 6960 | 14 |
| Pasture and range | | 540 | 3940 | 3440 | 10630 | 9550 | | | 28100 | 56 |
| Woodland and brush | | | | | 880 | 2440 | 2550 | | 5870 | 12 |
| Miscellaneous | | | | | | | | 6420 | 6420 | 13 |
| TOTAL | 1220 | 4250 | 7740 | 4000 | 11830 | 11990 | 2550 | 6420 | 50000 | 100 |

Precipitation in the watershed ranges from about 22 inches annually at the driest point, on the Santa Rosa Plain, to some 38 inches in the upper reaches. At Santa Rosa the average annual precipitation is 29.5 inches. The rainy season normally begins in October and ends in May with practically no effective precipitation in the rest of the year. A little snow falls in the mountains but almost none on the valley floor. At Santa Rosa the average temperature is 57 degrees, the highest temperature on record is 112 and the lowest is 15 degrees. The frost-free season, as shown by Weather Bureau records, is 213 days.

## ECONOMIC DATA

There are no significant areas of publicly-owned land in the watershed. While a few range-land holdings are still in units of more than 500 acres, the trend elsewhere has been toward reduction in size and there are few non-range holdings larger than 80 acres.

Until World War II, the economy was largely agricultural with some support from industry associated with the timber resource of nearby areas. Production, harvesting, processing and marketing of tree fruits, grapes, hops, livestock and dairy products constituted the major sources of income.

Of recent years this economy has been undergoing a major change involving a tremendous increase in population, as indicated by the following data.

POPULATION

| Year | City of Santa Rosa | Sonoma County |
|---|---|---|
| 1940 | 12,605 | 69,052 |
| 1950 | 17,902 | 103,405 |
| 1957 | 29,050* | 140,800** |

* Estimated by City of Santa Rosa Planning Commission and includes annexation of new developments necessitated largely by population influx.

** Estimated by California Department of Finance.

Sonoma County's rate of growth has been higher than that of the State as a whole since 1940, according to a 1957 report by Industrial Planning Associates of San Francisco and Washington, D.C.

Forecasts by the Sonoma County Planning Commission in 1947 and by Stanford University's Professor William A. Spurr in 1949 set 112,000 as the population the county would reach by 1960. For the same target date the State Office of Planning and Research, in 1948, predicted 125,000. All of these forecasts were exceeded by about 1955, when only two-thirds of the prediction period had elapsed.

The most recent available authoritative forecasts are those made by Mr. V. B. Stanbery, in 1956 studies for the Bay Area Rapid Transit Commission. He made a "high" prediction, assuming continued national prosperity and the development of water resources and highways as now planned, and also a "low" prediction representing a less prosperous condition and a slowing down of physical developments. His estimates are as follows:

ESTIMATED FUTURE POPULATION
OF SONOMA COUNTY

| Year | High | Low |
|---|---|---|
| 1960 | 152,000 | 137,000 |
| 1970 | 213,000 | 164,000 |
| 1980 | 283,000 | 197,000 |

It may be noted that the low prediction for 1960 had already been exceeded at the close of 1957.

The population increase has resulted from a number of factors:

(1) The location with reference to San Francisco makes Santa Rosa an attractive headquarters for people who sell products and services originating in the San Francisco Bay Area to markets in the north coastal part of the State.

(2) The same factors have encouraged the advent of people who are connected with the distribution of the products of the north coast area through the San Francisco markets.

(3) Climatic conditions and the pleasant aspect of the region bring in many retired people, as well as business and professional people, who enjoy living within reasonable distance of San Francisco without the urban congestion. The large proportion of older people living in the area is attested by the fact that the average age of people in Sonoma County is 1.8 years greater than the State average.

(4) Recent increases in industrial development indicate that further expansion along this line will take place within the watershed and nearby. The number of people engaged in manufacturing in Santa Rosa increased by 2,000, or 66%, from 1950 to 1956. Transportation facilities, a new and adequate water supply, and a favorable labor market are expected to favor the trend.

(5) Influx of the people in the above categories creates a local demand for building trades, services, professions and marketing facilities. (Over 2,400 building permits were issued in Santa Rosa from 1952 to 1956, inclusive.)

These types of development will be encouraged by the introduction of a new water supply from Coyote Dam, now under construction on the Russian River, and by the recent completion of a new freeway to San Francisco. The new Richmond-San Rafael bridge now makes the Oakland-Richmond area more accessible. With new population arriving in the State at the rate of 1000 per day, it seems reasonable to expect a continued influx into the watershed.

Agricultural production will continue but will be diminished by encroachment of residential, commercial and industrial developments. Increase in the market value of land suitable for subdivision is forcing such land out of agriculture. It is not unusual for tracts of favorable land to bring more than $3,000 per acre.

Current and expected changes in the population and economy of the watershed are particularly important in relation to the watershed project in that projections of the trend are used as a basis for much of the project evaluation. The city and county planning agencies predict that intensification of the land use pattern is inevitable; therefore, the project proponents believe strongly that joint action toward flood prevention should be taken now, before new installations are flooded and before serious encroachment onto the flood plain interferes with accomplishment of the necessary works of improvement.

## WATERSHED PROBLEMS

### FLOODWATER PROBLEMS AND DAMAGES

Flooding in the watershed occurs in most years and sometimes three or four times in a single winter. Within the past 20 years, twelve winters have had damaging floods. Of these, the most severe occurred in 1955-56, the next greatest in 1937-38 and the third in 1939-40.

Historical data on the damages from past floods lose much of their significance in the light of the current and expected developments in the watershed. However, they have served, along with hydrologic information and authoritative projections of the development pattern, as a basis for the following computations of flooded areas and flood damage values:

### PROJECTED FLOOD DAMAGE

| Area | 1% Frequency* | | 4% Frequency* | | 10% Frequency* | |
|---|---|---|---|---|---|---|
| | Area flooded (acres) | Damage ($)** | Area flooded (acres) | Damage ($)** | Area flooded (acres) | Damage ($)** |
| Santa Rosa Creek | 1,806 | 6,464,200 | 1,215 | 2,839,900 | 935 | 632,800 |
| Brush Creek (Rincon Valley) | 321 | 678,600 | 234 | 317,400 | 193 | 198,900 |
| Piner Creek | 865 | 698,500 | 550 | 342,300 | 324 | 136,900 |
| Matanzas Creek | 272 | 988,900 | 0 | 0 | 0 | 0 |
| Spring Creek | 113 | 122,100 | 58 | 64,100 | 31 | 34,800 |
| TOTAL | 3,377 | 8,952,300 | 2,057 | 3,563,700 | 1,483 | 953,400 |

* Frequency of occurrence is the percentage of the years in a long period in which a flood of a given magnitude will be equalled or exceeded.

** Direct damage only.

#### SANTA ROSA CREEK

Above the junction with Brush Creek (Rincon Creek), the main Santa Rosa Creek channel is so deep and wide that overtopping by flood flows is rare. While some channel erosion takes place, the average annual flood damage is too small to justify the cost of channel improvement measures.

From Brush Creek through the City of Santa Rosa to a point about a mile west of the City, the channel is deeply entrenched. Intermittent revetments and partial vegetative cover now afford only a minor degree of protection against bank erosion. The channel is large enough to carry the stream flow most years but, when unusually large floods (about 4% frequency or larger) occur, water will flow into business and residential areas near the center of the city. After the flood of 1955-56, which did not overtop the banks, more than $60,000 was spent for repairing and rehabilitating streamside buildings, utilities, bridges and protective works. Land loss through this reach has been computed at 0.37 acre per year.

In the lowest reach of the Santa Rosa Creek channel, peak flows from all tributaries pour in concurrently when there are major storms. With a low channel gradient, inadequate cross-section and slow egress through the Laguna de Santa Rosa, the creek channel is incapable of transporting the accumulated flow, and widespread inundation results. Fields and pastures are flooded by silt-laden water and debris lodges against obstructions. Road culverts and tributary channels frequently are plugged, increasing the spread of water. Pastures and other crops are severely damaged and fences are broken down. Existing dikes, levees and revetments are damaged or destroyed and gravel bars and debris are deposited in stream and drain channels. Restoration of the flood-damaged farm land to productive use requires costly removal of debris, sand and gravel, and shaping or releveling for farming operations. Where a flood of 1% frequency of occurrence would now inundate mainly pasture and farm crops, the development pattern indicates that such a flow 15 years hence would damage about 3,900 homes and the associated improvements.

The problem of discharging water at the outlet of Santa Rosa Creek is complicated by the fact that backwater frequently fills the Laguna de Santa Rosa when the Russian River is in flood.

BRUSH CREEK

Through most of Rincon Valley the Brush Creek channel is incised and has good capacity. In the last mile above Highway 12 it diminishes to an inadequate size and is choked with brush and trees. Several major tributaries enter the main channel in this restricted reach. The largest flow in the past 20 years inundated an area here about three-fourths of a mile along the creek and a half mile wide. Several flows in recent years have resulted in only slightly less flooding.

Under the present level of development, damage to about 44 homes in the Brush Creek subwatershed would result from a flood of 1% frequency of occurrence. Under the anticipated level of development 15 years hence, the number will increase to about 530. As the level builds up, the damageable values of roads, streets, and utilities may be expected to increase. Problems related to overflow of septic tanks probably will be eliminated by construction of a sanitary sewer system within the next few years.

PINER CREEK

With the exception of an area of hilly headwater land, the Piner Creek subwatershed is relatively flat and has a network of channels, some distinct and some obscure. Channel gradients are low and the flood water velocities are slow. Under these conditions any run-off results in ponding, which expands into damaging inundation in prolonged or high-intensity storms. Under the present level of development a 1% frequency of occurrence flow can be expected to damage about 182 houses. Within the next 15 years, however, the number is expected to increase to about 890.

In addition to residential damage, orchards, pastures, roads and utilities are adversely affected by standing water. An unhealthy condition is induced, especially where septic tanks and water supply are affected.

MATANZAS CREEK

In the upper watershed, there are several raw slide areas along the channel and a number of small gullies in the grassland. These represent sources of sediment that would lodge in the Matanzas flood detention reservoir (to be installed as a part of this project) and reduce its effective life.

Through Bennett Valley, the Matanzas Creek channel is large and becoming larger. With grade recession and bank erosion progressing rapidly, the major problem is erosion rather than overflow. Land loss is computed at 0.33 acre per year.

Within the City of Santa Rosa the channel is large but flow is moderately restricted by trees and brush and a part of the channel has vegetative protection.

The existing intermittent structural and vegetative protection has not completely solved the problem of bank erosion.

When a flood occurs that is of about 2% frequency of occurrence, or larger, Santa Rosa Creek will already be out of its banks near the confluence with Matanzas. Matanzas Creek will then overflow, adding to the flood damage in downtown Santa Rosa.

SPRING CREEK

Spring Creek is tributary to Matanzas Creek and drains a large portion of the valley land lying between Matanzas and Santa Rosa Creeks, as well as a large area of steep mountainous land. The channel across the valley generally is shallow and, in some places, indistinct, particularly where it is overgrown with brush and trees. Overtopping and ponding occur during about half the years. Residential development is rapidly encroaching, even onto certain lands that have often been ponded. In one such case a reach of channel was cleaned by the subdivider, providing temporary protection for the homes just completed, however, measures of a more permanent nature are needed. Under the present level of development a flood of 1% frequency of occurrence could be expected to affect 144 residences. Under the level of development expected

15 years hence, the number would be about 529. Annadel Dam, a 500 acre-foot water conservation structure in the hills with a watershed of 1,090 acres, provides some protection against small floods and might be operated to provide a higher degree of protection.

## EROSION PROBLEMS

While erosion has been a major problem in parts of the watershed, the efforts of the Soil Conservation District and other agencies have resulted in its reduction to a minor status. Only occasionally is a cultivated field now caught without protective cover during the rains. Widespread conversion to pasture and other permanent or seasonal cover has removed most of the previously eroding land from consideration. Progress is still being made toward further range improvement and control of the remaining upland gullies. Other sources of sediment are slips and bank cutting in the main channels.

## WATER SUPPLY PROBLEMS

Over past years the ground water resource has been somewhat overdrawn. Current construction of Coyote Dam on the Russian River by the U. S. Corps of Engineers will permit introduction of a new and adequate water supply. Current studies of water conservation sites have shown that the cost of building or enlarging reservoirs within the watershed to conserve the native supply is greater than the cost of importing an equal amount of water.

## PUBLIC HEALTH PROBLEMS

In several parts of the watershed, septic tanks and domestic wells may both be affected by the same bodies of flood water to the detriment of the water supply and the sanitation of the area. While no excessive mosquito infestations are known, it is probable that ponding and imperfect sanitation encourage the breeding of undesirable insects.

Effluent from the City of Santa Rosa sewage treatment plant near Santa Rosa Creek is mingled with flood water when the stream overflows in this vicinity. While the treated effluent is not unsantitary, it is unpleasant to the recipients, and the detergents contained in it may have undesirable effects that are not now known.

# EXISTING OR PROPOSED WORKS OF IMPROVEMENT

## STRUCTURAL MEASURES

The State Water Plan, prepared by the State Department of Water Resources, notes the possibility of a water conservation dam on Mark West Creek below the Laguna de Santa Rosa. While the measures to be installed under the work plan will slightly reduce the peak flood flows at this site, they will not affect the design or function of the dam materially.

Concurrently with the channel improvements to be accomplished under this work plan, or as the economic development creates the need, the Flood Control District, the Soil Conservation District, and other agencies will build numerous lateral channels to bring excess local water into the main channel system provided under this plan. Without the plan, such laterals could not operate for lack of outlets. This endeavor will be entirely separate from the present plan and the costs related thereto have not been included as project costs. It is estimated that some 50 miles of lateral channels will be built at a cost of about $1,500,000. Currently, some $70,000 is being spent annually within the City of Santa Rosa for storm drain construction. Total storm drain construction within the Santa Rosa Creek watershed is estimated at $150,000 annually.

## PROGRESS IN ESTABLISHMENT OF SOIL CONSERVATION PRACTICES

Since the Santa Rosa Soil Conservation District was organized in 1946, farmers owning approximately 60 percent of the agricultural land within this watershed have entered into cooperative agreements with the District. Records show that, during this period, 3,624 acres of cultivated cropland were converted to permanent pasture. This land conversion is predominantly in the upper portion of the watershed area and is a factor in the reduction of run-off and sediment. A total of 5,152 acres of pasture and range were seeded. Improvement of channels amounted to 25,600 linear feet with 1,450 feet of revetments installed. Other practices include: 13 sediment dams, 2 miles of diversion ditches, 26 stock ponds, 13 springs developed, 2,660 rods of fencing, proper grazing use of 21,808 acres, 18 irrigation dams impounding 1,600 acre feet of water, 19½ miles of open drain ditches benefiting 1,626 acres, sprinkler irrigation on 1,840 acres, land leveling on 446 acres, and cover cropping on 876 acres.

The cost for the installation of existing measures that reduce run-off and sediment is over $152,000. Other conservation practices that have no direct run-off and sediment retarding value for the project are not included in the cost estimate or in the list above. A detailed tabulation is shown in Table 1A.

Lands in the drainage areas above floodwater retarding structures are under active Soil Conservation District basic farm plan cooperative agreements to the extent shown in the following tabulation:

| Structure | Percentage of drainage areas under SCD co-operative agreement | Percentage of drainage areas with basic conservation farm plans |
|---|---|---|
| Santa Rosa Creek Reservoir | 81 | 81 |
| Brush Creek - Middle Fork Reservoir | 76 | 76 |
| Brush Creek - West Fork Reservoir | 100 | 80 |
| Piner Creek Reservoir | 52 | 52 |
| Matanzas Creek Reservoir | 77 | 72 |
| Spring Creek Reservoir | 100 | 100 |

## MEASURES FOR FISHERY IMPROVEMENT

Certain dam sites would accommodate larger reservoirs than are planned for floodwater detention. Additional capacity would be of value in relation to the fishery resource; however, no firm source of funds is immediately available for defraying the cost of enlarging the structures and altering the outlets. Should such funds become available before detailed planning is underway, the plans may be changed to include economically justified facilities for fishery improvement at non-Federal cost. Any change in reservoir design to provide conservation storage will be made in accordance with applicable State and Federal law.

## WORKS OF IMPROVEMENT TO BE INSTALLED

### LAND TREATMENT MEASURES FOR WATERSHED PROTECTION

On-farm land treatment measures have already been accomplished to a high degree during the 12 years the Santa Rosa Soil Conservation District has been in existence. (See Table 1A) While additional land treatment measures are desirable and will be accomplished under the regular program of the Soil Conservation District, their effects upon floodwater and sediment production are not measurable and they are, therefore, not included in the work plan.

The Soil Conservation District will assure the continuance of the protection afforded by the existing land treatment measures by giving major emphasis to their maintenance. The District will also urge the establishment of additional land treatment measures where needed.

## LAND TREATMENT MEASURES FOR FLOOD PREVENTION

Protection from fire in the watershed is the responsibility of the State Division of Forestry and cooperating local fire control agencies. Inasmuch as the present level of protection, as indicated by recent fire history, is in line with Statewide standards of the Division, further fire protection measures are not included in the watershed work plan.

## STRUCTURAL MEASURES

The watershed plan involves the construction of earth-fill floodwater retarding structures and channel improvements. Six floodwater retarding structures are included, one or more on each major tributary, and improvements are to be installed on 33.6 miles of channel. The locations of the structural measures are shown on Map No. 3 and the structural features are presented in drawings in Section 2 of this report and in Tables 3 and 3A.

The floodwater retarding structures and channel improvements in combination are designed to afford protection against floods of 1% frequency of occurrence. This system will also provide outlets for local flood water, which will be conducted to the channels as a local project apart from the measures included in the work plan.

All floodwater retarding structures will have ungated low-level outlets and will have emergency spillways designed to come into use when the 1% frequency flood is exceeded.

Improved channels will be shaped to confine low flows to aid fish migration. Channels will be provided with bank protection in all improved reaches. In channels having design flows in excess of 1,000 cubic feet per second, or having a combination of high velocity and flow depths in excess of five feet, rock riprap will be installed to a minimum of one-third of the design flow depth. Vegetation will be established above the riprap for added protection during infrequent high stage flows. In small channels where flow conditions are less severe, the main protective feature will be vegetation. Rock riprap to the full channel depth will be installed at locations especially susceptible to bank erosion, and concrete grade stabilization structures will be used where danger of grade recession exists. Concrete-lined channels will have 1-1/2:1 side slopes except for a short section at the junction of Santa Rosa Creek and Matanzas Creek where vertical walls will be used to negotiate two sharp bends, two bridges and the junction itself. Banks above the concrete lining will be sloped and vegetated. To prevent the erosion of banks by side drainage into the channels, all improved channels will be constructed so that side drainage is admitted only at structures built for the purpose.

Vegetation on the bank slopes of most of the channels will be a sod-forming grass with high erosion-resisting ability.

SANTA ROSA CREEK

A floodwater retarding structure will be built at the Santa Rosa Creek site where the topography affords an opportunity for relatively inexpensive off-stream storage. A reinforced concrete structure on Santa Rosa Creek will divert flows above 1,100 cubic feet per second through a vegetated earth channel to the reservoir. The channel will have a capacity of 5,000 cubic feet per second and the capacity of the reservoir will be 3,500 acre feet. An ungated low-level outlet through the dam will regulate outflow at maximum water level to 400 cubic feet per second and discharge it back to Santa Rosa Creek. Where this flow enters the creek, a barrier will be installed to prevent fish from entering the outlet channel. Automatic control of inflow by spilling from the diversion dam and channel will protect the dam against floods exceeding the 1% frequency event.

Improvement of the main channel will include concrete lining through the downtown part of the City of Santa Rosa, some 1.4 miles, where the channel width is limited by the encroachment of urban development and where the depth of the channel and steepness of the banks result in severe bank erosion. A small baffled channel in the bottom of the main channel is provided as an aid to fish migration.

Upstream from the concrete lined section to Farmer's Lane, about 0.7 miles below the junction with Brush Creek, the channel will be shaped and will be provided with rock riprap to about 40 percent of the design water depth. This reach, 1.6 miles long, will have concrete grade stabilizers. At grade stabilizers and at transitions, junctions and critical bends, the banks will be riprapped to full channel depth.

The remaining 0.7 miles to the Brush Creek junction is wide and relatively shallow, with a shifting gravel bottom causing considerable bank erosion. This reach will be shaped and the main flow will be confined by rail and wire fences, each backed by two rows of willow or black locust trees and by vegetated banks.

From the west end of the concrete-lined section to Piner Creek, a distance of 3 miles, the channel will be shaped, enlarged where necessary, and straightened, and will be provided with rock riprap to 40 percent of the design water depth. At bends and junctions the banks will be riprapped to full channel depth.

From Piner Creek to the Laguna de Santa Rosa basin a vegetated, leveed channel will be constructed. Upstream from Willowside Road the banks will be riprapped to about 40 percent of design water depth. Below Willowside Road the channel will take the form of a broad, leveed floodway containing a relatively small low-flow channel. The leveed channel will confine the design flood as far as Willowside Road under all conditions, and the floodway is designed to carry it to the Laguna under normal backwater conditions. The total length of the reach is 3.7 miles.

Four small waterways tributary to Santa Rosa Creek in the lower reach also will be shaped and vegetated, and three of these, identified as Channels 3, 4 and 5, will be leveed to prevent flooding by backwater from Santa Rosa Creek. The fourth, Channel 10, drains a low lying area and will be let into Santa Rosa Creek by flap-gated pipes through the levee.

BRUSH CREEK

Two floodwater retarding structures are to be built on tributaries to Brush Creek, with a combined capacity of 230 acre feet. From the dams to the junction with Santa Rosa Creek, the channels will be enlarged and straightened and will be provided with grade stabilization structures where needed. Two other tributaries will be given similar treatment. Banks will be riprapped at junctions and sharp bends and the main channels will have continuous rock riprap to a minimum of one-third of the design flow depth. Improved channels will aggregate about 7.4 miles.

PINER CREEK

Flood peaks will be reduced by a 230 acre foot capacity floodwater retarding structure to be built near the County Hospital on Paulin Creek, a major tributary to Piner Creek. The two main channels draining the valley portion of this watershed will be enlarged and straightened to provide capacity for the hill run-off, which they collect, and to furnish an outlet for numerous small drainage channels whose tributary area is mostly in the valley. Two smaller tributaries contributing to the flooding of the northwestern section of the City of Santa Rosa also will be enlarged upstream as far as Mendocino Avenue. From the Northwestern Pacific Railroad tracks to the junction with Santa Rosa Creek, these channels will have rock riprap to a minimum of one-third of the design water depth. Banks will be riprapped to their full height at junctions and critical bends. Realignment of the lower end of Piner Creek will bring it into Santa Rosa Creek 0.4 mile upstream from the present junction, eliminating 0.4 mile of inadequate channel.

MATANZAS CREEK

A retarding structure with a capacity of 1,500 acre feet will be built on Matanzas Creek near the point where it emerges from the steep land. Critical slide areas contributing sediment to the stream above the floodwater detention structure will be stabilized by adjustments in the alignment of the channel and the installation of about 2,000 feet of pipe and wire revetment.

For a distance of about 0.4 mile above the junction with Santa Rosa Creek the channel will be concrete lined. Upstream from the lined section for a distance of 1.5 miles the channel will be shaped and will be provided with rock riprap to a minimum of one-third of the design flow depth.

At junctions and critical bends the banks will be riprapped to full channel depth. Considerable bank protection work has been done in the upper portion of this channel reach which will be left intact wherever it is in good condition.

SPRING CREEK

One floodwater retarding structure with a capacity of 467 acre feet will be built near the point where the stream emerges from the hills. Below this structure 1.3 miles of the main channel and 0.7 mile of a tributary, Channel 7-D, will be enlarged, straightened and vegetated. The banks of the lower reach of the main channel will be protected with riprap to a minimum of one-third of the design water depth. Channel 7-D will be realigned to enter the main channel 1,300 feet above the present junction. Since flooding of the lower reach of Spring Creek, below the junction with Channel 7-D, will be reduced to minor amounts and infrequent occurrence by the retarding structure, the project will not include improvement of this reach.

COSTS

The total installation cost of the six floodwater retarding structures is estimated at $3,300,300. In addition to construction costs, this includes such costs as rights-of-way and utility relocation as well as engineering and other installation services, but does not include the expense of operating and maintaining the dams. A comparable figure pertaining to the 33.6 miles of channel improvement is $8,526,100 and the sum of the two is $11,826,400. The channel improvement cost includes replacement of bridges to their present widths. Some of these bridges are to be widened at an additional non-Federal cost (see Table D) but the widening is not included as a project cost because it is not performed in the interest of flood prevention. A break-down of project costs is presented in Table 1.

The annual cost of all structural measures, computed over a 50-year period, is $547,300. Federal and local costs have been amortized at 2.5% and annual charges for operation and maintenance have been included.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COSTS

Central Sonoma Watershed Project, California

| Installation Cost Item | Unit | No. to be Applied (Non-Fed. land) | Estimated Cost (Dollars)* | | |
|---|---|---|---|---|---|
| | | | Federal (P.L.566 funds) | Non-Federal | Total |
| STRUCTURAL MEASURES | | | | | |
| Floodwater Retarding Structures | | | | | |
| Santa Rosa Creek Reservoir & Diversion | No. | 1 | 777,500 | | 777,500 |
| Matanzas Creek Reservoir & Sediment Stabilization Structure | No. | 1 | 639,300 | | 639,300 |
| Piner Creek Reservoir | No. | 1 | 99,100 | | 99,100 |
| Brush Creek Middle Fork Reservoir | No. | 1 | 141,900 | | 141,900 |
| Brush Creek West Fork Reservoir | No. | 1 | 102,000 | | 102,000 |
| Spring Creek Reservoir | No. | 1 | 298,900 | | 298,900 |
| Total Floodwater Retarding Structures | No. | 6 | 2,058,700 | | 2,058,700 |
| Stream Channel Improvements | | | | | |
| Santa Rosa Creek (City) | Mi. | 3.88 | 1,827,000 | | 1,827,000 |
| Santa Rosa Creek (Lower) | Mi. | 11.42 | 1,999,700 | | 1,999,700 |
| Matanzas Creek | Mi. | 1.87 | 374,200 | | 374,200 |
| Piner Creek | Mi. | 7.11 | 721,700 | | 721,700 |
| Brush Creek | Mi. | 7.44 | 784,300 | | 784,300 |
| Spring Creek | Mi. | 1.92 | 63,800 | | 63,800 |
| Total Channel Improvements | Mi. | 33.64 | 5,770,700 | | 5,770,700 |
| Subtotal - Construction | | | 7,829,400 | | 7,829,400 |
| INSTALLATION SERVICES | | | | | |
| Engineering Services | | | 1,174,500 | | 1,174,500 |
| Federal Administration | | | 783,000 | | 783,000 |
| Hydraulic Model Studies | | | 45,000 | | 45,000 |
| Foundation Exploration | | | 27,000 | | 27,000 |
| Subtotal - Installation Services | | | 2,029,500 | | 2,029,500 |
| OTHER COSTS | | | | | |
| Land, Easements and Rights-of-Way | | | - | 1,863,400 | 1,863,400 |
| Fencing | | | - | 4,700 | 4,700 |
| Administration of Contracts | | | - | 78,500 | 78,500 |
| State Dam Filing Fees | | | - | 20,900 | 20,900 |
| Subtotal - Other Costs | | | | 1,967,500 | 1,967,500 |
| TOTAL STRUCTURAL MEASURES | | | 9,858,900 | 1,967,500 | 11,826,400 |
| TOTAL PROJECT | | | 9,858,900 | 1,967,500 | 11,826,400 |
| TOTAL SCS | | | 9,858,900 | 1,967,500 | 11,826,400 |

* Price base, 1957

April 1958

## BENEFITS FROM WORKS OF IMPROVEMENT

### EVALUATED BENEFITS

Only primary flood prevention benefits have been evaluated. These consist of the reduction in floodwater and sediment damages to existing and anticipated improvements by virtual elimination of channel overflow from storms up to 1% frequency of occurrence. The average annual values of benefits by subwatersheds are as follows:

| | |
|---|---|
| Santa Rosa Creek | $420,200 |
| Brush Creek | 100,800 |
| Piner Creek | 83,700 |
| Matanzas Creek | 72,600 |
| Spring Creek | 28,200 |
| Total | $705,500 |

The project will reduce damages to the present development in the watershed in the amount of $300,900. This is 43.6 percent of the total evaluated benefits of the project. The remaining benefits are based upon urban development which is expected to occur in the next fifteen years.

The damages upon which these benefits are based include direct and indirect primary damage for storms up to 1% frequency of occurrence. The types and amounts of damages are as follows:

| Type of Damage | Average Annual Damages | |
|---|---|---|
| | Dollars | Per Cent |
| Floodwater - | | |
| Agricultural | 3,900 | 0.5 |
| Urban | 590,300 | 83.3 |
| Road | 4,600 | 0.6 |
| Sediment - | | |
| Deposition | 3,200 | 0.5 |
| Erosion - | | |
| Land Loss | 3,300 | 0.5 |
| Indirect | 103,200 | 14.6 |
| TOTAL | 708,500 | 100 |

### UNEVALUATED BENEFITS

Preservation of human life and public health are not susceptible to precise monetary evaluation. However, it is certain that benefits will accrue through reduction of overflow and ponding in the areas where sewage and water supplies become intermingled during flood periods. Insect infestations and

unhealthy dampness will be greatly reduced. All of these benefits related to public health are of national interest.

Likewise, unevaluated secondary benefits are of interest outside the watershed. These are the benefits resulting from an increased demand for services and products stemming from the enhanced activity and general well-being in the improved watershed.

The estimates of future development have been based on the most authoritative data available. Nevertheless, experience over the past several years indicates that estimates from similar sources have been conservative as the influx of people accelerates more rapidly than anticipated.

The level of projected development used in the evaluation of project benefits considered the buildup that is expected to take place in the next 15 years as actually occuring during the 15 years after project installation or, 21 years into the future. The project benefits that will accrue to the additional development that will take place from the 16th year to the 50th year have not been taken into consideration, though they will undoubtedly be substantial. Likewise, benefits from reduction of damage to streets, utilities, and automobiles in the areas of projected development were not evaluated.

All of these factors lead to the conclusion that the project will be a better investment than is indicated by the benefit-cost ratios.

## COMPARISON OF BENEFITS AND COSTS

Works of improvement in each subwatershed will yield benefits in excess of costs as shown below:

| Subwatershed | Annual Cost Dollars | Annual Benefit* Dollars | Benefit-Cost Ratio |
|---|---|---|---|
| Santa Rosa Creek | 320,500 | 420,200 | 1.3 |
| Matanzas Creek | 59,800 | 72,600 | 1.2 |
| Piner Creek | 66,900 | 83,700 | 1.3 |
| Brush Creek | 77,500 | 100,800 | 1.3 |
| Spring Creek | 22,600 | 28,200 | 1.2 |

*Benefits from reduction of damages on lower channel reaches have been allotted to structural measures in tributary subwatersheds in proportion to their effect on reduction of overbank flow.

For the project as a whole, the annual cost is $547,300, the annual benefit is $705,500 and the benefit-cost ratio is 1.3:1.

## ACCOMPLISHING THE PLAN

The Sonoma County Flood Control and Water Conservation District, hereinafter referred to as the Flood Control District, will be the action agency in installing, operating and maintaining the works of improvement. As a legal subdivision of the State of California, established under the provisions of the Sonoma County Flood Control and Water Conservation District Act (Stats. 1949, Chap. 994, pg. 1,793, as amended), the Flood Control District has the authorities required of local cooperating organizations under Public Law 566. It has powers of taxation and eminent domain and is authorized to accept contributions, levy assessments, issue warrants, hold elections for issuance of bonds and make levies to retire bonds. It maintains a permanent technical staff which will be augmented as necessary for the discharge of responsibilities assumed under this plan. All the powers and facilities of the Flood Control District will be used to whatever extent is required toward completion of the project.

During the 6-year project period the construction units will be accomplished approximately in accordance with the following schedule:

First year:

Santa Rosa Creek Reservoir and Diversion

Piner Creek Reservoir

Second year:

Brush Creek Middle Fork Reservoir

Brush Creek West Fork Reservoir

Brush Creek Channel Improvement

Spring Creek Reservoir

Spring Creek Channel Improvement

Third year:

Matanzas Creek Reservoir and Sediment Stabilization Structures

Matanzas Creek Channel Improvement

Fourth year:

Lower Santa Rosa Creek Channel Improvement

Fifth year:

Piner Creek Channel Improvement

Sixth year:

Santa Rosa Creek Channel Improvement (City reach)

Installation costs of the above measures are estimated by years as follows:

| Fiscal Year | Federal | Non-Federal | Total |
|---|---|---|---|
| 1958-59 | $ 1,131,800 | $ 451,300 | $ 1,583,100 |
| 1959-60 | 1,749,700 | 457,400 | 2,207,100 |
| 1960-61 | 1,276,900 | 169,100 | 1,446,000 |
| 1961-62 | 2,499,600 | 517,200 | 3,016,800 |
| 1962-63 | 902,100 | 250,400 | 1,152,500 |
| 1963-64 | 2,298,800 | 122,100 | 2,420,900 |
| TOTAL | $ 9,858,900 | $ 1,967,500 | $11,826,400 |

Adjustments in the above schedule may be made to provide that detailed planning will precede construction by a year or more.

Detailed plans and specifications will be prepared by the Flood Control District in accordance with technical and administrative standards of the Soil Conservation Service. This work will be done by the District staff if qualified people are available; otherwise, a consulting firm will be employed for the purpose. In either case, the Federal Government will be asked for reimbursement within the limits of Public Law 1018.

Construction will be done under contracts let by the Flood Control District in accordance with procedures satisfactory to the Soil Conservation Service. The necessary land, easements and rights-of-way will be secured by the Flood Control District.

Activity is under way toward organization of a Flood Control District zone encompassing the total drainage area of the Central Sonoma Watershed Project. It is planned that this will be consummated shortly after the current work plan is completed and the plan data are made available for incorporation in the Zone Plan. This zone will have power to raise funds by taxation and to use them for project maintenance and for the construction and maintenance of necessary lateral drains and channels.

Funds required by the Flood Control District for project expenditures, before regular tax revenues are at hand, will be obtainable by other means. Legislation now exists under which the State of California may reimburse qualified local agencies for their expenditures under Federally approved projects for land, easements and rights-of-way, including relocation of utilities.

Federal assistance for carrying out the works of improvement as described in this work plan will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666, as amended by Public Law 1018, 84th Congress; 70 Stat. 1088).

The Santa Rosa Soil Conservation District, in cooperation with other appropriate agencies, will conduct an informational program to assure that all those affected by the project will be acquainted with the character and location of the measures to be installed, as well as the costs to be incurred and the benefits to be gained.

## PROVISIONS FOR OPERATION AND MAINTENANCE

Maintenance of the existing land treatment measures for watershed protection is the responsibility of the individual land owners. The Santa Rosa Soil Conservation District will emphasize and encourage this activity and will give technical assistance through its regular soil conservation program.

The Flood Control District will assume full responsibility for operating and maintaining all structural works of improvement installed under this plan in such a manner that they will serve the purpose for which they were installed, to the degree for which they were designed. Details of the operation and maintenance obligation for each construction unit or group of construction units will be set forth in agreements to be entered into by the Flood Control District and the Soil Conservation Service before issuance of invitations to bid on construction contracts.

Inspections of all completed works of improvement will be conducted twice annually and after each major flood. Interim and Spring inspections will be made to ascertain what maintenance activities are required as a result of flood flows. The Fall inspection will be to assure that the structural measures are in satisfactory condition to function through the coming rainy season. The inspection group will consist of representatives of the Soil Conservation District, the Flood Control District and the Soil Conservation Service and may include representatives of other interested agencies.

Operation and maintenance of structural works of improvement are estimated at a cost of $130,200 per year. Normally the Flood Control District will do the work with its own personnel and equipment; however, contract procedures may be employed for maintenance work where advantageous. By the time maintenance is required on the measures installed under the project, tax revenues will be available to the Flood Control District.

## COST SHARING

Project costs, estimated at a total of $15,519,200 will be shared as follows:

| | |
|---|---|
| Non-Federal | $5,660,300 |
| Federal | $9,858,900 |

The non-Federal share includes acquisition of land, easements and rights-of-way ($928,600); relocation of bridges, roads and utilities ($939,500); administration of contracts ($78,500); State dam filing fees ($20,900); and the value of annual operation and maintenance capitalized over a 50-year period at 2½% interest ($3,692,800).

As the project is to be built entirely in the interest of flood prevention, the Federal Government will assume the entire construction cost ($7,829,400), and installation services ($2,029,500).

## CONFORMANCE OF PLAN TO FEDERAL LAWS AND REGULATIONS

The principles on which the project is formulated are in harmony with those of comprehensive river basin development. The plan represents an amplification of the measures proposed in the United States Department of Agriculture "Report of Survey, Russian River Watershed" dated July, 1950 and revised in June, 1953 (unpublished).

The provisions of Section 211 of Public Law 540, 84th Congress, are not applicable to the watershed, as new land will not be brought under cultivation by virtue of the works of improvement.

The floodwater retarding reservoirs will be operated in conformance with the regulations prescribed by the Secretary of the Army, under the authority of Section 7 of the 1944 Flood Control Act.

WATERSHED WORK PLAN

CENTRAL SONOMA WATERSHED PROJECT

SECTION 2

INVESTIGATIONS AND ANALYSES

SUPPORTING TABLES

MAPS

## INVESTIGATIONS AND ANALYSES

### PROJECT FORMULATION

#### PRINCIPLES

Formulation of the project has been based on the principle of accomplishing the sponsoring groups' flood prevention objectives in such a manner as to achieve the maximum net project benefits. Numerous alternatives have been compared, involving kinds of measures, locations of structures, types of materials and degrees of protection. Within the limits of sound engineering practices, the selections have been made that gave the maximum net benefits without regard to relative Federal and non-Federal costs.

#### ALTERNATE KINDS OF MEASURES

Other things being equal, floodwater retarding structures have been favored over channel improvements. A preliminary reconnaissance revealed 48 possible retarding sites. Further study of physical and economic factors narrowed the list to the six that are incorporated in the work plan. In no case did the retarding sites have enough capacity and the strategic locations that would be needed to afford the required degree of flood protection without channel improvement. On some important tributary streams, retardation did not prove feasible. The result is a plan providing floodwater retardation balanced with channel improvement.

#### ALTERNATE STRUCTURE LOCATIONS

Alternate floodwater retarding sites are discussed above. In the case of channel locations, essentially the existing locations were accepted. Their present alignment is reasonably direct and the greater part of the main channel is so deep that any substantial change would make excavation costs excessive. In the more populous parts of the watershed, relocation would also involve tremendous expenditures for rights-of-way and utility relocation. Minor realignment is planned to the extent of straightening out irregularities. The lower reach of Piner Creek is shortened by realignment to a junction with Santa Rosa Creek upstream from the existing junction and a tributary of Spring Creek is shortened similarly.

#### ALTERNATE TYPES OF MATERIALS

Configuration of the floodwater retarding sites left little possibility of any alternative to earth-fill dam construction.

Types of channel improvement that were included in comparisons were vegetated earth sections, soil cement, rock riprap, sacked concrete riprap, asphalt lining, gunite lining, concrete lining, pipe and wire revetment and rail and wire revetment. Vegetated channels with structural protection at critical points proved most economical for most of the project. In downtown Santa Rosa, the need for bank protection, the limited available width and the large number of bridges dictated the use of concrete lining. At the upstream

end of the improved portion of Santa Rosa Creek a section of rail and wire revetment was decided upon where importation of fill material would be required to construct a vegetated channel of satisfactory dimensions.

## ALTERNATE DEGREES OF PROTECTION

Benefits were compared with costs at the levels of the 4%, 2% and 1% frequencies of occurrence. This analysis indicated that the maximum net benefits accrued within the range investigated. It also showed that costs increased slightly more than benefits when the level of protection was raised from 2% to 1%. The decision to provide protection against the 1% frequency of occurrence event was based on the following: (1) the difference in cost is small for the additional protection afforded; (2) numerous benefits will accrue that were not evaluated in this report; and (3) the hazard to life on the highly developed flood plain warrants the additional protection.

# HYDROLOGIC INVESTIGATION

Hydrologic procedures were developed for the solution of three problems:

1. The determination of flood peaks for various frequencies of occurrence at a number of points in the watershed for use in design of channels and the evaluation of damages.

2. The determination of flood hydrographs for various frequencies of occurrence to estimate the cost of dams at different levels of protection.

3. The determination of flood hydrographs for design of emergency spillways.

## GENERAL ASPECTS OF FLOODS

Cyclonic storms form over the Pacific Ocean, move easterly, traverse the coastal areas of Sonoma County, and produce the floods of this region. Floods resulting from snow-melt are non-existent, and convective storms are neither frequent nor sufficiently large to influence flooding appreciably. In general, floods are due to intense precipitation or even moderate precipitation on saturated ground.

## REGIONAL STREAM STUDIES

A given flood-producing storm in the California coastal region normally is consistent in duration and pattern throughout the major part of the area it covers. Consequently, regional flood studies are a valuable aid in the estimation of peak flows and the construction of synthetic hydrographs for ungaged streams. Pertinent statistics from such a study are tabulated on page 29. Records from fourteen gaging stations on streams in, and adjacent to, the North Coastal region of California were analyzed; the values of median, or 50% frequency of occurrence, peak flow and of median peak one-day volume were plotted against drainage area and curves were drawn, with mean annual precipitation over the drainage basin as an additional parameter. These

curves, in the range of drainage areas applicable to the project, are shown by Figures 1 and 2. Figure 3 is a plot of peak flows against frequency of occurrence for the various streams analyzed.

## PEAK FLOW - FREQUENCY DETERMINATION

With the values derived from the regional stream study serving as a check, synthetic flood hydrographs were developed for points of concentration, near the points where the streams emerge from the hills onto the flood plain, and were routed downstream. The hydrographs for the various tributaries were combined by addition at their junctions.

The synthetic hydrographs were developed using the unit-hydrograph approach with component hydrographs developed from watershed and rainfall characteristics. Factors taken into account were watershed loss rate and time of concentration, rainfall intensities and the areal and time distribution of rainfall. Figure 8 shows the time distribution used. The intensity of the rainfall for various frequencies was developed from Technical Paper No. 24 of the U. S. Weather Bureau and plotted as shown in Figures 6 and 7. Differences in flood peaks for individual watersheds were attributed to differences in soils and cover conditions, variations in time of concentration of the basins and differences in drainage area.

The flood-routing method described by Walter T. Wilson* was used. One-third to two-thirds storage weighting factors were applied in the manner suggested in his paper.

Since subsurface flow has little effect in raising flood peaks on small watersheds, no modification was made to incorporate subsurface flow independently into the hydrograph; the effect was included in the surface-flow phenomenon and peaks were raised accordingly.

A typical curve of peak flow vs. frequency of occurrence derived from the synthetic hydrographs is plotted in Figure 3 for comparison with the curves from the regional stream study. Figure 4 shows curves of peak flow vs. drainage area, based on the average of points from the synthetic hydrographs. Similar curves plotted by least squares from the regional stream study data are shown for comparison.

The peak flow-frequency data developed are summarized in Table A.

## FLOOD HYDROGRAPH DEVELOPMENT

For the floodwater retarding sites, hydrographs were developed synthetically for a typical 72-hour storm, based on rainfall amounts of 1% frequency of occurrence. The relationship of flood volume to peak flow was checked against the regional stream study results, and the general hydrograph shape was checked by comparison with recorded flood hydrographs of Santa Rosa

* Wilson, W.T., Trans. A. G. U., V. 21, pt. 3, pp. 893-898, 1941

Creek. Flood routing through the floodwater retarding reservoirs demonstrated that the 72-hour storm was of sufficient duration for the design of the structures. Three representative hydrographs, covering the range from the smallest to the largest watershed, are shown in semi-dimensionless form in Figure 5.

## EMERGENCY SPILLWAY DESIGN FLOWS

Synthetic flood hydrographs for design of the emergency spillways for the floodwater retarding structures were developed by the unit-hydrograph method. A rainfall of 9 inches was assumed to occur over the drainage area in a period of six hours.

The hydrographs were constructed in accordance with Soil Conservation Service standards for emergency spillway design as established by Engineering Memorandum Number 3 and the National Engineering Handbook, Section 4, Supplement A.

The resulting peak flows are shown in Table B.

REGIONAL STREAM STUDY
TABULATION OF STATISTICS

| Gaging Station | Period of Record | Drainage Area (sq.mi.) | Mean Seasonal Precip. for Period of Record (inches) | Median Seasonal Peak Flow (cfs) | Median Seasonal Maximum 1-day Flow (cfs days) | Median Seasonal Maximum 2-day Flow (cfs days) | Median Seasonal Maximum 3-day Flow (cfs days) | Median Seasonal Runoff (Acre Feet) |
|---|---|---|---|---|---|---|---|---|
| A. Russian River at Guerneville | 1940-56 | 1,346 | 45 | 46,500 | 42,000 | 77,000 | 100,000 | 1,350,000 |
| B. Russian River nr. Healdsburg | 1940-56 | 793 | 44 | 33,300 | 27,000 | 46,500 | 60,000 | 820,000 |
| C. Russian River nr. Hopland | 1940-56 | 362 | 44 | 18,200 | 12,200 | 19,200 | 24,800 | 340,000 |
| D. East Fork of Russian River nr. Calpella | 1942-56 | 93.9 | 43 | 6,420 | 3,100 | 4,800 | 5,900 | 79,000 |
| E. North Fork Cache Creek nr. Lower Lake | 1931-56 | 198 | 31 | 7,000 | 3,900 | 6,400 | 8,200 | 105,000 |
| F. Kelsey Cr. nr. Kelseyville | 1947-56 | 37.4 | 43 | 3,500 | 1,350 | 2,050 | 2,550 | 39,000 |
| G. Dry Creek nr. Cloverdale | 1942-56 | 88.3 | 50 | 7.800 | 4,000 | 6,200 | 7,800 | 99,000 |
| H. Stony Creek near Fruto | 1901-11 | 601 | 33 | 19,400 | 16,000 | 24,000 | 34,000 | 570,000 |
| I. Conn Cr. nr. St. Helena | 1930-44 | 52.3 | 32 | 2,890 | 1,200 | 1,600 | 2,150 | 18,750 |
| J. Napa River nr. St. Helena | 1930-32 & 1940-56 | 81.3 | 43 | 5,880 | 3,100 | 4,500 | 5,700 | 54,000 |
| K. Putah Creek nr. Guenoc | 1931-56 | 112 | 54 | 12,000 | 6,300 | 9,700 | 12,200 | 125,000 |
| L. Putah Creek at Winters | 1906-31 | 654 | 38 | 22,500 | 18,000 | 26,000 | 33,500 | 300,000 |
| M. Putah Creek nr. Winters | 1931-56 | 577 | 42 | 27,100 | 12,500 | 20,000 | 26,000 | 260,000 |
| N. Petaluma Creek nr. Petaluma | 1949-56 | 29.6 | 25 | 1,130 | 740 | 1,100 | 1,330 | 11,500 |

TABLE A - PEAK FLOWS

| Pt. of Concentration * | Drainage Area Square Miles | Units | Peak Flows Frequency of Occurrence 1% | 2% | 4% | 10% | 50% |
|---|---|---|---|---|---|---|---|
| Santa Rosa Creek | | | | | | | |
| 1. | 77.97 | cfs | 16,800 | 15,000 | 13,100 | 10,500 | 5,330 |
| | | csm | 215 | 192 | 168 | 135 | 68 |
| 2. | 76.75 | cfs | 17,600 | 15,600 | 13,700 | 10,900 | 5,540 |
| | | csm | 229 | 203 | 179 | 142 | 72.2 |
| 3. | 72.92 | cfs | 17,170 | 15,260 | 13,350 | 10,680 | 5,430 |
| | | csm | 235 | 209 | 183 | 146 | 75 |
| 4. | 72.92 | cfs | 17,300 | 15,300 | 13,400 | 10,700 | 5,460 |
| | | csm | 237 | 210 | 184 | 147 | 75 |
| 5. | 59.32 | cfs | 15,550 | 13,800 | 12,100 | 9,680 | 4,930 |
| | | csm | 262 | 232 | 204 | 162 | 83 |
| 6. | 56.94 | cfs | 15,500 | 13,800 | 12,100 | 9,660 | 4,920 |
| | | csm | 272 | 242 | 212 | 170 | 86.4 |
| 7. | 34.43 | cfs | 8,780 | 8,020 | 7,070 | 5,690 | 2,820 |
| | | csm | 255 | 233 | 205 | 165 | 81.9 |
| 8. | 33.47 | cfs | 9,430 | 8,430 | 7,410 | 5,890 | 2,930 |
| | | csm | 282 | 252 | 222 | 176 | 87.5 |
| 9. | 22.96 | cfs | 5,880 | 5,170 | 4,520 | 3,560 | 1,780 |
| | | csm | 256 | 225 | 197 | 155 | 77.5 |
| 10. | 20.83 | cfs | 6,120 | 5,360 | 4,670 | 3,660 | 1,780 |
| | | csm | 294 | 257 | 224 | 176 | 85 |
| 11. | 12.55 | cfs | 3,650 | 3,190 | 2,760 | 2,160 | 1,030 |
| | | csm | 291 | 254 | 220 | 172 | 82 |
| 12. | 8.28 | cfs | 3,130 | 2,740 | 2,410 | 1,890 | 946 |
| | | csm | 378 | 332 | 291 | 229 | 115 |
| 13. | 6.61 | cfs | 2,830 | 2,590 | 2,280 | 1,830 | 909 |
| | | csm | 428 | 392 | 345 | 277 | 138 |
| Piner Creek | | | | | | | |
| 14. | 9.55 | cfs | 3,250 | 2,840 | 2,440 | 1,893 | 840 |
| | | csm | 340 | 298 | 256 | 198 | 88 |
| 15. | 4.04 | cfs | 1,250 | 1,090 | 938 | 712 | 321 |
| | | csm | 310 | 270 | 232 | 176 | 79.5 |
| 16. | 5.51 | cfs | 2,050 | 1,800 | 1,540 | 1,210 | 532 |
| | | csm | 372 | 327 | 280 | 220 | 96.6 |
| 17. | 2.45 | cfs | 1,000 | 875 | 750 | 570 | 257 |
| | | | 408 | 357 | 306 | 232 | 105 |
| 18. | 0.41 | cfs | 225 | 197 | 169 | 128 | 58 |
| | | csm | 549 | 481 | 412 | 312 | 141 |
| Piner Creek Dam | 2.21 | cfs | 900 | 792 | 675 | 513 | 234 |
| | | csm | 409 | 358 | 306 | 232 | 106 |

* Refer to Map No. 2 and Map No. 3

TABLE A - Continued

| Pt. of Concentration * | Drainage Area Square Miles | Units | Peak Flows Frequency of Occurrence 1% | 2% | 4% | 10% | 50% |
|---|---|---|---|---|---|---|---|
| **Brush Creek** | | | | | | | |
| 19. | 10.51 | cfs | 4,200 | 3,840 | 3,390 | 2,720 | 1,350 |
| | | csm | 400 | 365 | 322 | 259 | 128 |
| 20. | 9.92 | cfs | 4,270 | 3,910 | 3,440 | 2,770 | 1,370 |
| | | csm | 431 | 394 | 347 | 279 | 138 |
| 21. | 2.60 | cfs | 1,300 | 1,160 | 1,030 | 837 | 444 |
| | | csm | 500 | 446 | 396 | 322 | 171 |
| 22. | 1.56 | cfs | 650 | 562 | 474 | 362 | 151 |
| | | csm | 417 | 360 | 304 | 232 | 97 |
| 23. | 5.76 | cfs | 2,370 | 2,080 | 1,820 | 1,440 | 718 |
| | | csm | 412 | 361 | 316 | 250 | 124 |
| Brush Creek Middle Fort Dam | 1.55 | cfs | 930 | 836 | 744 | 595 | 297 |
| | | csm | 600 | 540 | 480 | 384 | 193 |
| Brush Creek West Fork Dam | 0.81 | cfs | 607 | 547 | 486 | 389 | 194 |
| | | csm | 750 | 676 | 600 | 480 | 240 |
| **Minor Tributaries** | | | | | | | |
| 24. | 1.05 | cfs | 450 | 393 | 339 | 264 | 120 |
| | | csm | 429 | 374 | 323 | 252 | 114 |
| 25. | 2.78 | cfs | 1,020 | 934 | 822 | 661 | 328 |
| | | csm | 367 | 336 | 295 | 238 | 188 |
| 26. | 1.27 | cfs | 470 | 430 | 379 | 305 | 151 |
| | | csm | 370 | 339 | 298 | 240 | 119 |
| **Matanzas Creek** | | | | | | | |
| 27. | 22.51 | cfs | 7,270 | 6,490 | 5,750 | 4,680 | 2,480 |
| | | csm | 323 | 288 | 256 | 208 | 110 |
| 28. | 21.70 | cfs | 7,260 | 6,460 | 5,660 | 4,530 | 2,290 |
| | | csm | 335 | 298 | 261 | 209 | 1,055 |
| 29. | 15.95 | cfs | 5,590 | 4,970 | 4,360 | 3,480 | 1,770 |
| | | csm | 351 | 312 | 274 | 218 | 111 |
| Matanzas Creek Dam | 11.65 | cfs | 5,000 | 4,450 | 3,940 | 3,200 | 1,700 |
| | | csm | 429 | 382 | 338 | 275 | 146 |
| 30. | 8.44 | cfs | 4,450 | 4,020 | 3,580 | 2,970 | 1,760 |
| | | csm | 527 | 477 | 424 | 352 | 208 |
| **Spring Creek** | | | | | | | |
| 31. | 5.75 | cfs | 1,850 | 1,640 | 1,440 | 1,150 | 586 |
| | | csm | 322 | 285 | 250 | 200 | 102 |
| Spring Creek Dam | 2.31 | cfs | 1,015 | 904 | 792 | 630 | 325 |
| | | csm | 440 | 392 | 343 | 273 | 141 |
| 32. | 1.70 | cfs | 530 | | | | |
| | | csm | 312 | | | | |

* Refer to Map No. 2 and Map No. 3

TABLE B

EMERGENCY SPILLWAY DESIGN PEAK FLOWS

| Dam Site | Drainage Area | Peak Inflow | |
|---|---|---|---|
| | sq. mi. | cfs | csm |
| Santa Rosa Creek Dam | 20.83 | 25,000 | 1,190 |
| Matanzas Creek Dam | 11.64 | 19,710 | 1,693 |
| Piner Creek Dam | 2.20 | 4,000 | 1,820 |
| Brush Creek Middle Fork Dam | 1.55 | 3,310 | 2,140 |
| Brush Creek West Fork Dam | 0.81 | 2,125 | 2,630 |
| Spring Creek Dam | 2.31 | 3,820 | 1,650 |

The locations of these dam sites are shown on Map No. 3.

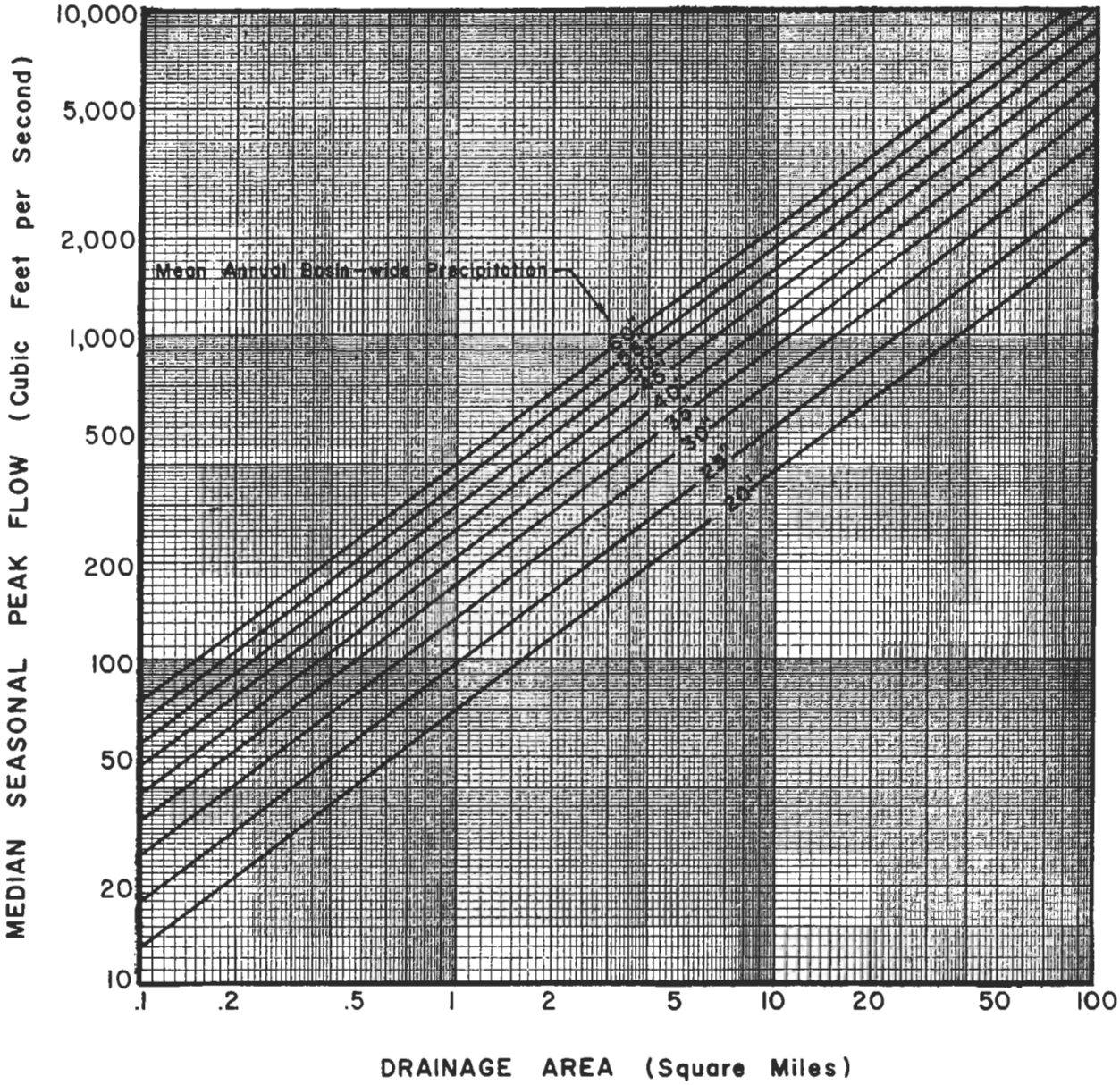



FIG. 1 : Regional Stream Study. AREA – PEAK FLOW CURVES

Central Sonoma Watershed

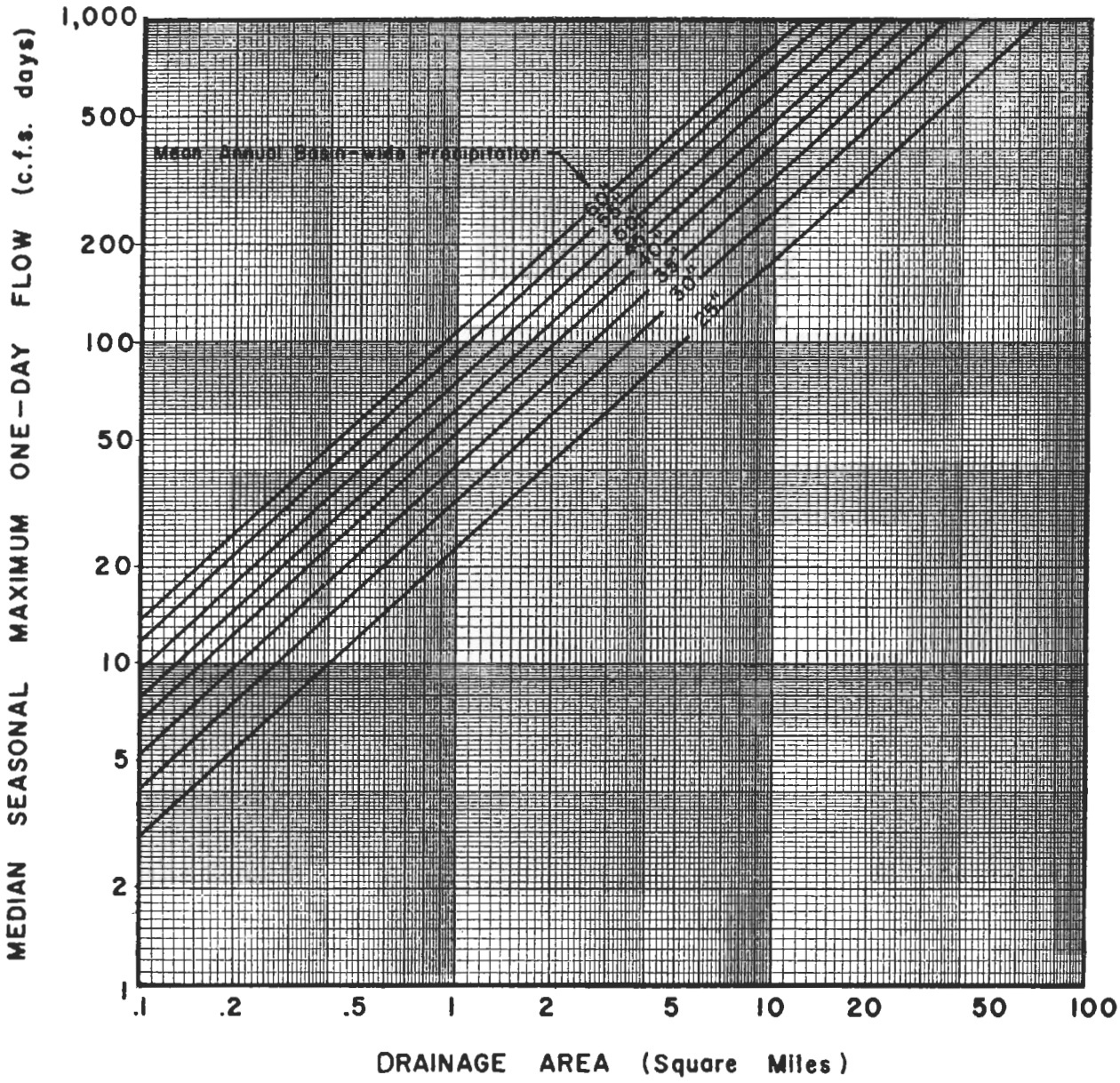
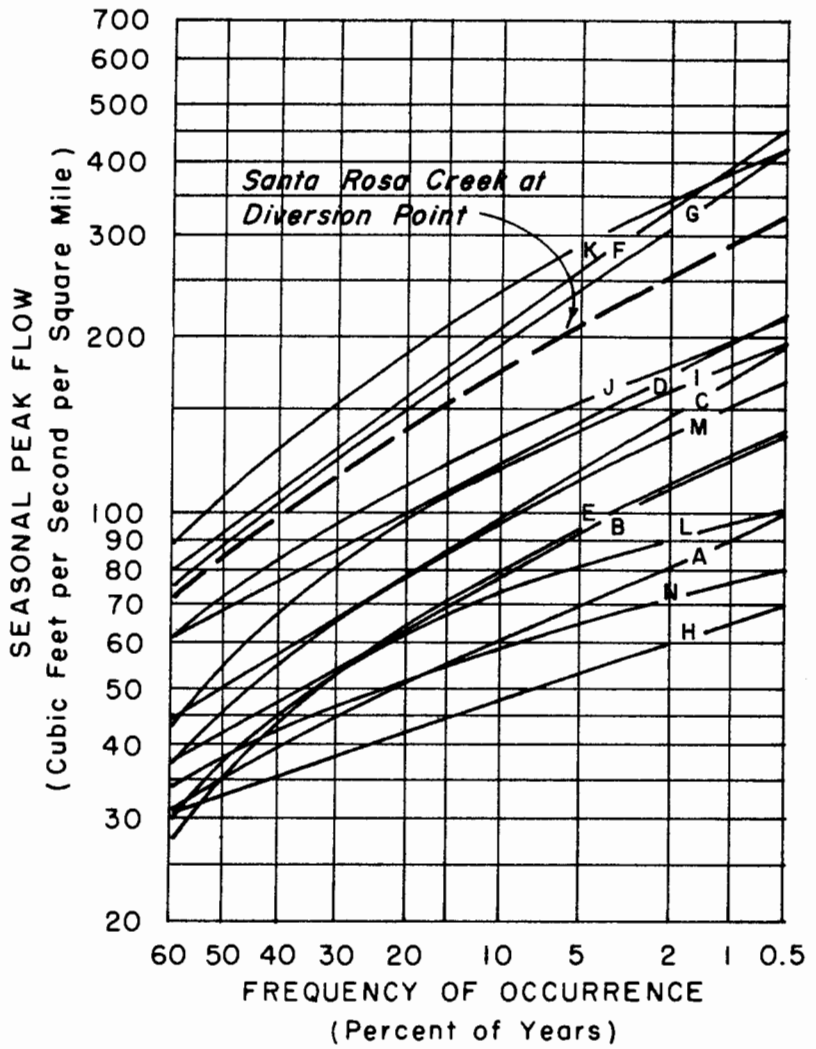



FIG. 2 : Regional Stream Study. AREA-PEAK VOLUME CURVES
Central Sonoma Watershed




A Russian River at Guerneville , 1,346 square miles
B Russian River near Healdsburg , 793 square miles
C Russian River near Hopland , 362 square miles
D East Fork of Russian River near Calpella , 93.9 square miles
E North Fork of Cache Creek near Lower Lake , 198 square miles
F Kelsey Creek near Kelseyville , 37.4 square miles
G Dry Creek near Cloverdale , 88.3 square miles
H Stony Creek near Fruto , 601 square miles
I Conn Creek near St. Helena , 52.3 square miles
J Napa River near St. Helena , 81.3 square miles
K Putah Creek near Guenoc , 112 square miles
L Putah Creek at Winters , 654 square miles
M Putah Creek near Winters , 577 square miles
N Petaluma Creek near Petaluma , 29.6 square miles

FIG. 3 : Peak Flow Frequency Relationship. Central Sonoma Watershed

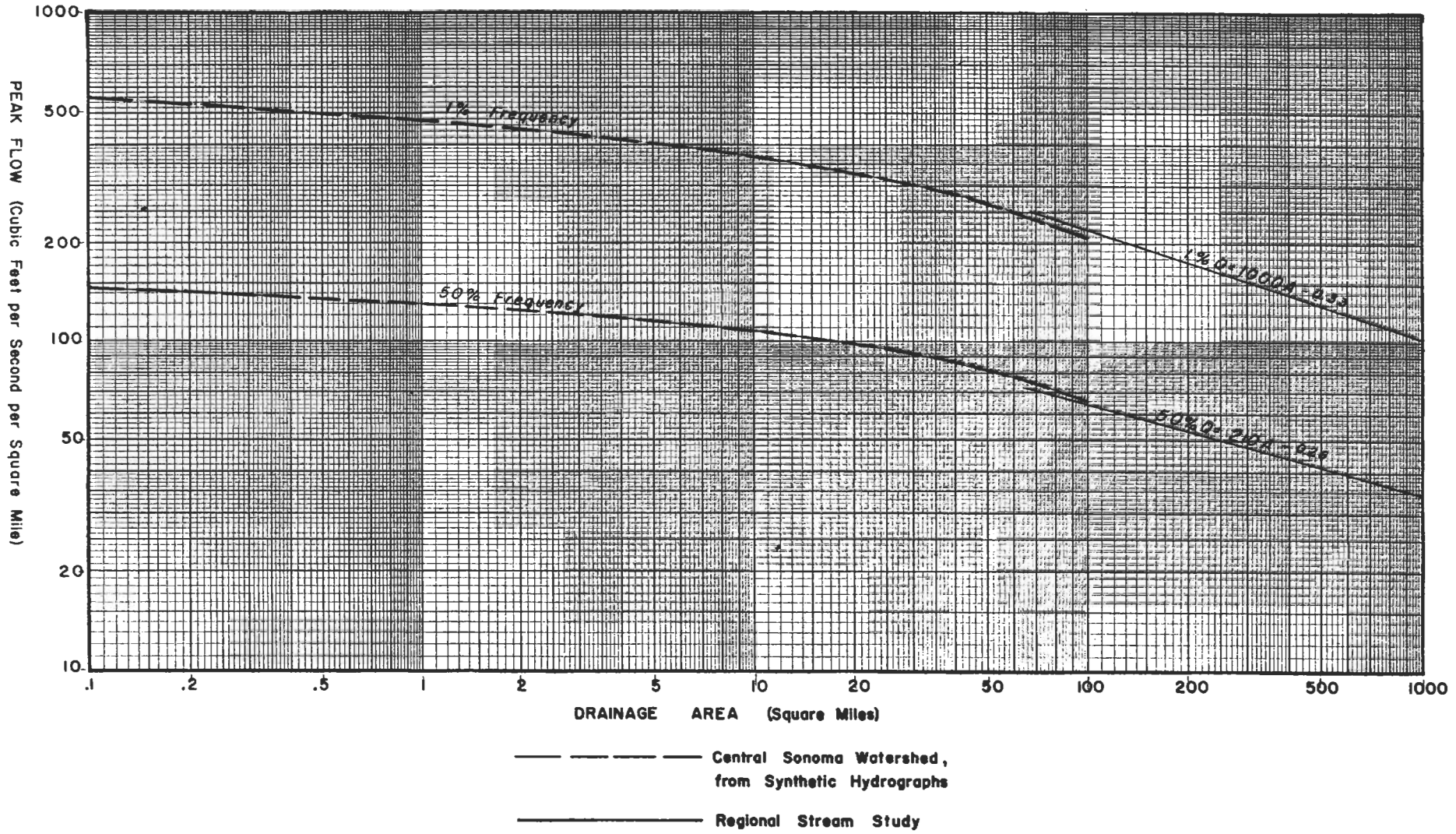



FIG. 4: PEAK FLOW — DRAINAGE AREA RELATIONSHIP. Central Sonoma Watershed

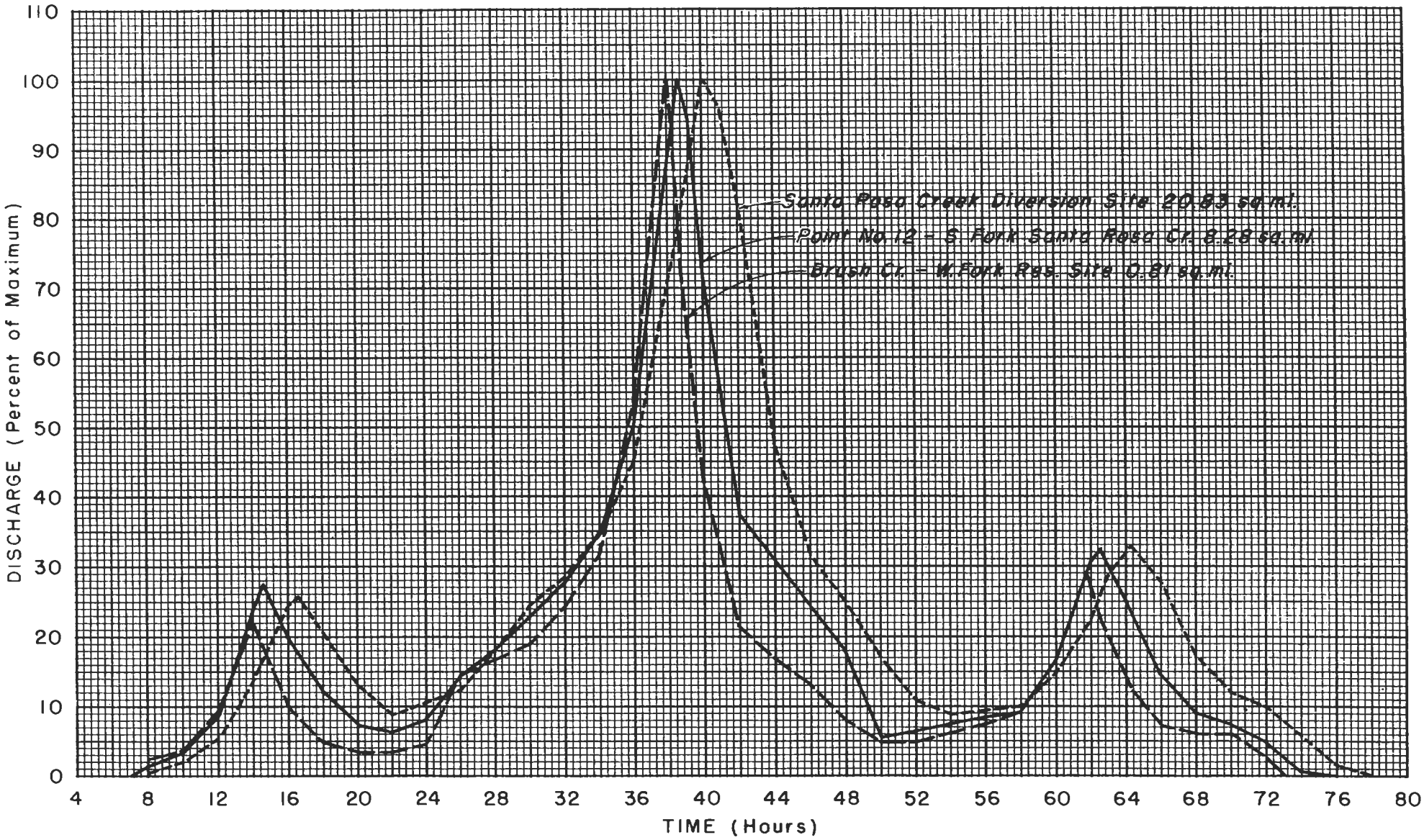



FIG. 5 : 72-Hour Storm Hydrographs, Central Sonoma Watershed.

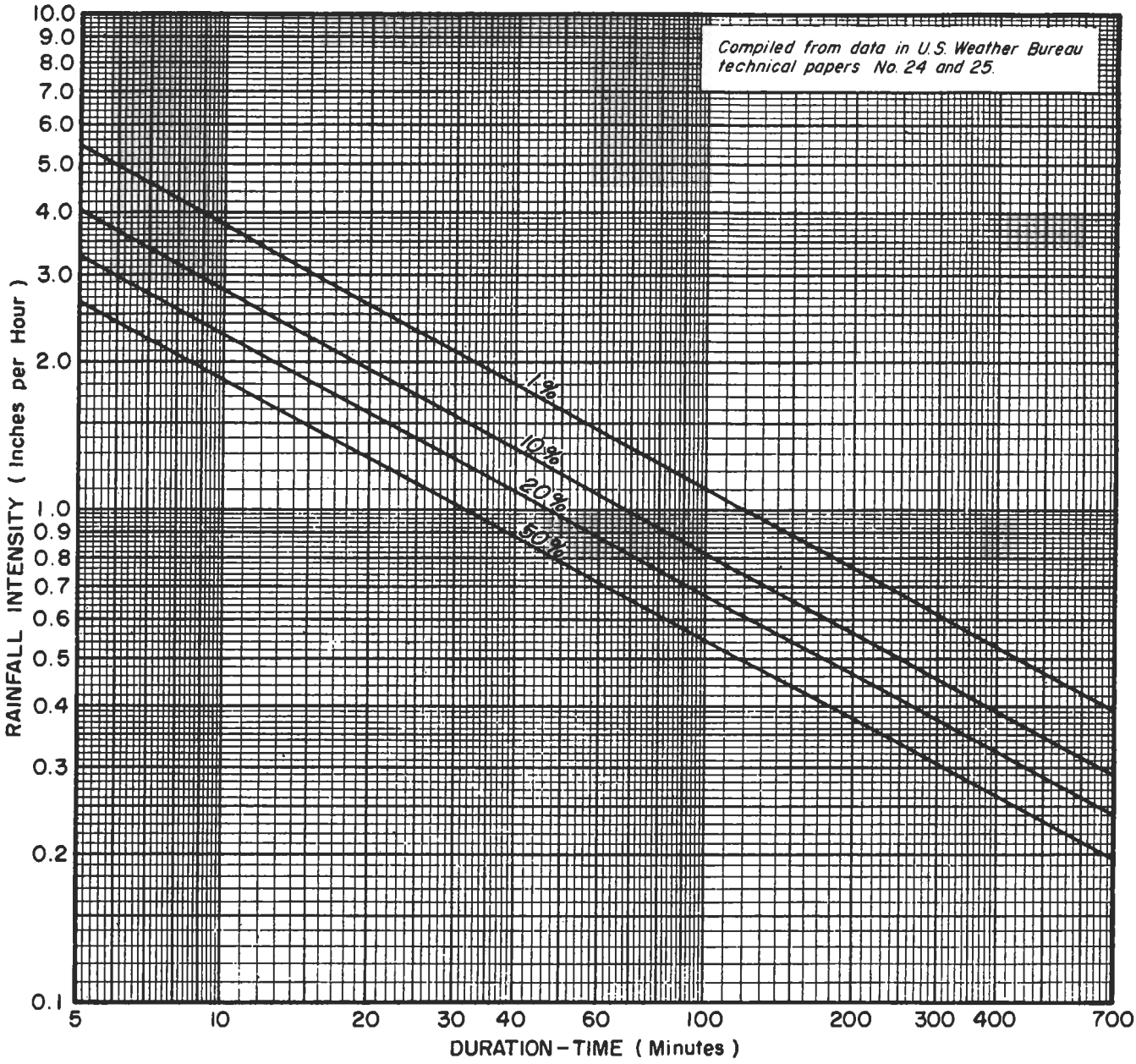



FIG. 6 : Rainfall Intensity – Duration Curves. Central Sonoma Watershed.



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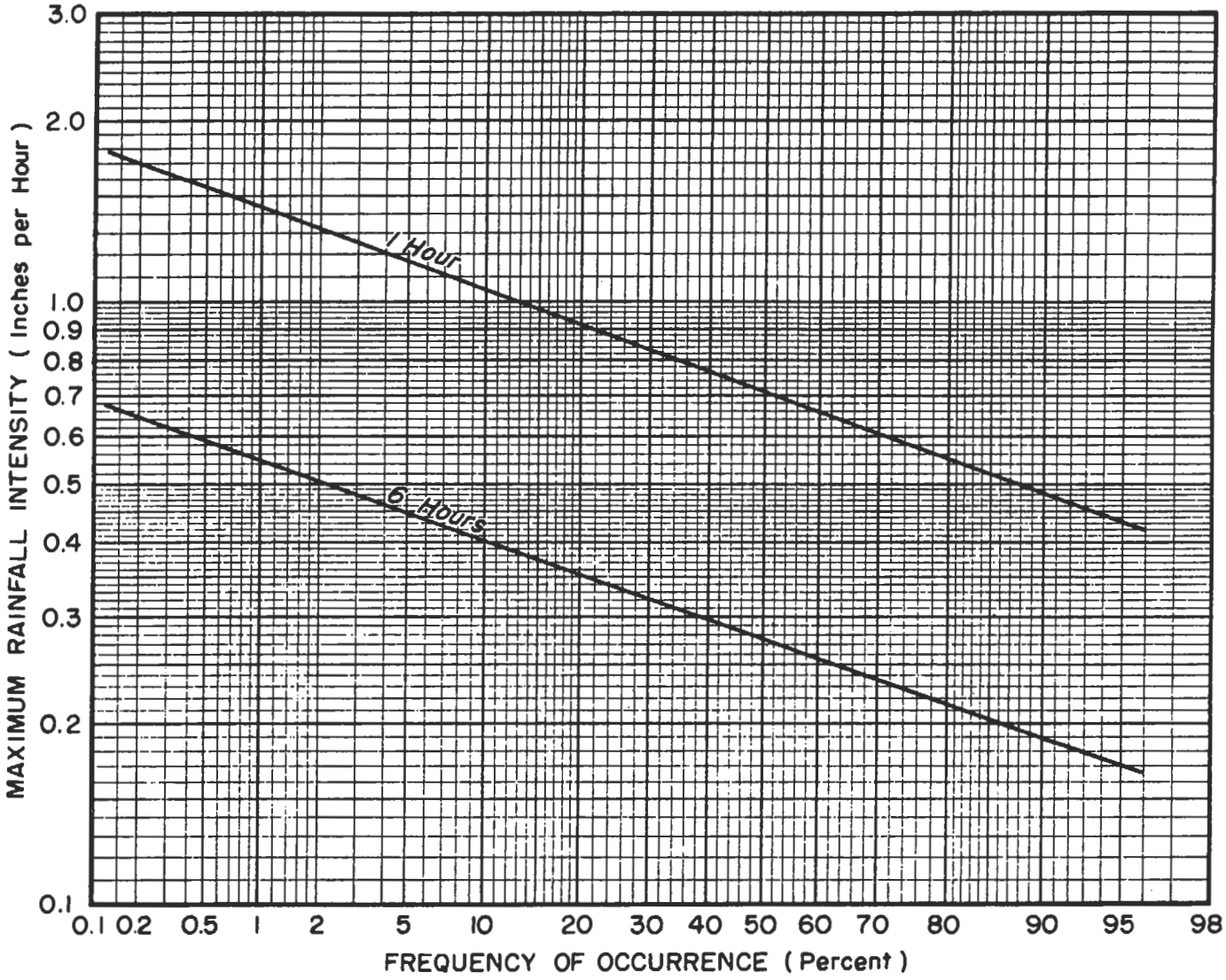


FIG. 7 : Rainfall Intensity-Frequency Curves Central Sonoma Watershed.

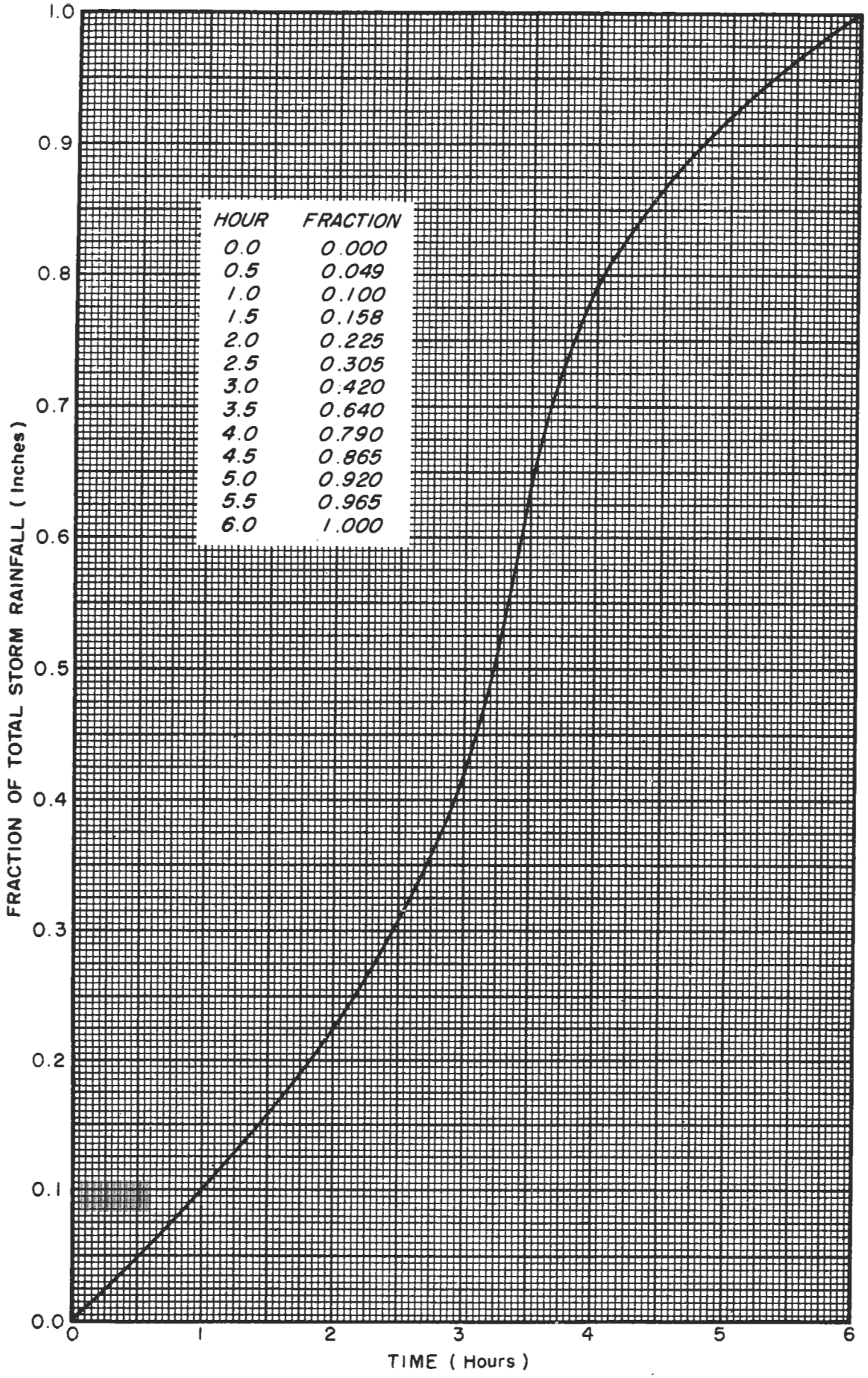


FIG. 8 : Time Distribution of Storm Rainfall. Central Sonoma Watershed.



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## SEDIMENTATION INVESTIGATION

Investigation of sediment problems included measurement of land loss; establishment of sediment production indices above planned reservoirs; location and evaluation of specific sediment sources and determination of the effect of remedial measures; and estimation of sediment storage requirements for the reservoirs in the watershed plan.

### METHOD OF INVESTIGATION

Land loss along Santa Rosa and Matanzas Creeks was measured between 1942 and 1956 by use of comparative aerial photography. Information obtained from flood damage schedules during the flood control survey of the Russian River in 1949-50 and a survey in 1956 also was used. These sources of information gave comparable results when data from the same reaches were available.

Existing data from the Walnut Creek Watershed were used in developing sediment production indices for the Central Sonoma Watershed. There was no such information available from this watershed nor were there reservoirs or ponds suitable for sedimentation surveys. Considerable data were available, however, from the Walnut Creek Watershed about 50 miles to the southeast. The two watersheds are similar in climate, geology, soils, topography and land use. Use of the Walnut Creek data, therefore, appeared justified.

### RATES OF SEDIMENT PRODUCTION

Examination of the watershed showed that cover conditions were fair to good from the standpoint of erosion control except for gullies, associated with slides in the Matanzas Creek Watershed. An annual sediment production rate of 0.18 acre-foot per square mile was indicated for lands in fair to good cover condition in the Walnut Creek Watershed. This rate was used in the watershed under consideration except for the gullied areas. The latter are almost free of vegetation, are steep and subject to sliding directly into the narrow valley bottom. In addition, some overfalls in unconsolidated materials are receding up the drainageways. Soil loss measurements under similar conditions have indicated that an annual rate of about 30 to 40 tons per acre is reasonable. This rate was extended over the acreage affected by this type of erosion, which was measured to be 18 acres on 1956 aerial photographs.

Further adjustments in sediment production indices were necessary in the watershed above the proposed Matanzas Creek Reservoir. Slides on exposed, near-vertical slopes about 100 feet in height and erosion of banks at the floodplain level are substantial contributors of sediment. Estimates of contribution from these sources were made by comparison of the 1942 and 1956 aerial photography. These contributions to total sediment load are calculated to be about 45% from slides along high banks, 30% from lower floodplain banks and 5% from upland gullies. The remaining 20% is estimated to come from the greater proportion of the watershed which is in grass and brush. A rate of sediment of about 0.8 acre-foot per square mile is indicated from these several sources.

## EVALUATION OF MEASURES FOR SEDIMENT REDUCTION

The present density of grass and brush growth over most of the upland tributary watersheds indicates that further improvement in cover density would cause only a minor reduction in sediment. Since this rate is already small, no cover improvement measures are included in the project.

Matanzas Creek Watershed is the only area tributary to a planned reservoir in which a substantial reduction in sediment production may be achieved. The control measures planned at the base of high slides are designed to eliminate these slides as a sediment source. This control will reduce sediment production by 45%.

## SEDIMENT STORAGE IN PROPOSED RESERVOIRS

Sediment production for a 50-year period was computed for each of the watershed areas above planned reservoirs with stabilization measures installed. Rates of sedimentation were then adjusted for trap efficiency in accordance with methods prescribed for use by the Soil Conservation Service. An additional 10 percent adjustment in sediment production was made to account for sediment losses through ungated outlets.

The Santa Rosa Creek off-channel reservoir is a special situation. With flows below 650 c.f.s. and portions of higher flows continuing down the creek channel, it is estimated that only about 50% of the sediment load will be diverted into the off-channel reservoir. An additional adjustment is made for losses through the ungated outlet. The trap efficiency of the reservoir is considered very high.

Sediment storage requirements for the 50-year period for the six proposed floodwater retarding reservoirs are given below:

| Reservoir | Sediment storage requirements |
|---|---|
| Santa Rosa Creek Reservoir | 85 acre feet |
| Matanzas Creek Reservoir | 200 acre feet |
| Piner Creek Reservoir | 15 acre feet |
| Brush Creek Middle Fork Reservoir | 10 acre feet |
| Brush Creek West Fork Reservoir | 5 acre feet |
| Spring Creek Reservoir | 17 acre feet |

## ECONOMIC EVALUATION

### FLOOD DAMAGE EVALUATION

A previous analysis was made of the floodwater and sediment damages for this watershed in the development of the USDA Report of Survey, Russian River Watershed, California, dated July, 1950 (unpublished). This analysis was reviewed at the beginning of the investigation of this project. It was found that urban development had progressed so rapidly that much of the data used in that report was no longer valid. Because of this, new data were collected and a new analysis was made. The damage items that still appeared valid were retained and used in this investigation.

The damage area was divided into evaluation units, each constituting a geographical area assumed to be subject to individual planning and analysis, as follows:

A. Lower Santa Rosa Creek, extending from Willowside Road to the west edge of the City of Santa Rosa, and including the lower reach of Piner Creek where flood waters of Santa Rosa and Piner Creeks co-mingle.

B. Santa Rosa Creek, City and Upper reaches, upstream from the west edge of the City of Santa Rosa.

C. Matanzas Creek (tributary to Santa Rosa Creek) exclusive of Spring Creek.

D. Piner Creek (tributary to Santa Rosa Creek).

E. Brush Creek (tributary to Santa Rosa Creek).

F. Spring Creek (tributary to Matanzas Creek).

The investigation of damages was made in each evaluation unit independently. It was concluded later that Units A and B actually were interdependent and they were combined for evaluation as Unit AB.

Damages were computed at 1956 prices and then converted to the long term projected price level by using the following conversion factors:

| | |
|---|---|
| Crop damage | 1.00 |
| Other agricultural damage | .95 |
| Land damage | .95 |
| Urban development | .97 |

In the computation of average annual damages the maximum flood used was that of 1% frequency of occurrence. Rare floods of greater magnitude, if included, would have produced a small increase in the average annual damage.

Indirect damage was estimated as a percent of direct damage for each class of property. The experience of residents and leaders of business, industry and local governments in this and other flooded areas was used to

establish the rates. Twenty-five percent was used for commercial property to cover the loss of trade during and after floods until the establishments can be cleaned up and new goods obtained, the extra cost of buying and transporting new stock under emergency conditions, and the extra cost of financing business operations after heavy losses. Twenty-two percent was used for industrial property to cover damage of manufacturing materials and losses due to work stoppage caused by floodwater damaging plant and interrupting power and transportation facilities. Fifteen percent was used for all other damage to compensate for loss of productive time in replacing or renovating damaged property, extra travel and expense to secure goods and services, and delay and inconvenience in securing financial assistance in repairing damage. Other types of damage used to establish indirect damage ratio were the cost of re-routing traffic, evacuation of flooded areas, and providing relief to flood-stricken residents.

Because of the tremendous residential and commercial development the area is undergoing, described under ECONOMIC DATA in Section I of this report, it was obvious that the project must be formulated to protect future developments as well as those existing now. Accordingly, the economic analysis was based partly upon future development patterns.

The Sonoma County Planning Commission, as the most authoritative source, furnished information on the ultimate density of future residential development and the rates of development expected during the next 15 years. This information was based on the assumption that adequate flood prevention measures would not be installed. The watershed planning staff estimated the percentages of commercial and industrial occupancy by comparison with neighboring areas. The maximum ultimate density of development used was four homes per acre in the most favorable areas and two homes per acre in the less favorable areas.

The projections used in damage computations are those recorded below:

| Evaluation Unit | Percentage of full development predicted in 15 years | Type of Development | | |
|---|---|---|---|---|
| | | Residential | Commercial | Industrial |
| Lower Santa Rosa Cr.,Unit A | 80% | 100% | | |
| Piner Creek, Unit D | 50% | 90% | 5% | 5% |
| Brush Creek, Unit E | 80% | 95% | 5% | |
| Spring Creek, Unit F | 100% | 100% | | |

The city reaches of Santa Rosa and Matanzas Creeks have already reached practically full development so no projection of future conditions was needed. Future development was not evaluated for the upper reaches of Santa Rosa and Matanzas Creeks although build-up of these areas can be expected to take place at about the same rate as in the areas tabulated above. A tentative examination of damages showed that, because flooding is not a factor

in these areas, future development will make little difference in the amount of damage.

In making the projections quoted, the Planning Commission was guided by data contained in the following reports:

1. "Regional Planning Needs of the San Francisco Bay Area", prepared by Vanbueren Stanbery and published in February, 1954, by the Bay Area Council.

2. "The Bay Area Rapid Transit Study", prepared by Parsons, Brinckerhoff, Hall and McDonald in 1956.

3. "Population Projections for the San Francisco Bay Area", prepared by Vanbueren Stanbery in 1956.

These studies were used by the City of Santa Rosa and the Sonoma County Flood Control and Water Conservation District in developing plans for sewer and water transmission facilities having an ultimate cost in excess of $20,000,000. Construction is currently underway on approximately $11,000,000 of this total.

Other forecasts, made in the late 1940's and considered authoritative at the time, are already so far exceeded as to be of no value except to emphasize the acceleration that has occurred.

Publications were checked against file material relative to subdivisions accomplished or planned and against population projections made in connection with freeway development and expansion of the Santa Rosa sewer and water systems. Records and estimates by public utilities also were considered as substantiating data.

It is noteworthy that the projections of the Planning Commission extend only 15 years into the future. To the extent that their projection farther into the future would yield additional project benefits, their use is conservative.

The projection estimates of future urban development made by the Planning Commission were used in damage computation as occurring during the 15 years after project installation. Allowance was made in the derived values for lag in development and for depreciation.

Agricultural Damage:

Agricultural damages, largely confined to Lower Santa Rosa Creek, were estimated by use of data collected for the USDA Report of Survey, Russian River Watershed, supplemented by damage information collected on the four floods that have occurred since 1949. Adequate damage data were available for 15 flood events occurring in 19 years, 1937-55. Hydrologic studies showed that the magnitudes and frequencies of floods occurring during this period approximate the magnitudes and frequencies of floods likely to occur in any representative 19-year period. Therefore, the value of the historical damage, computed at 1955 prices, was divided by 19 to give the estimate of the average

annual damage. Since the projected urban development in this watershed would replace about 80% of the agricultural area subject to damage, agricultural damages were reduced.

Urban Damage:

The major item of urban floodwater damage was found to be the damage to existing and projected residential, commercial and industrial property caused by overbank flow. Two other items included in this category were damage to municipal and private property adjacent to the creeks by floods contained in the channels and damage to channel banks as reflected in the cost to property owners of building and maintaining protective works to prevent land loss and flooding.

Floods with below-bank flow through the City of Santa Rosa have caused damage in the past to sewer lines, streets, bridges, channel banks and private property. The 1955 and 1952 floods caused this type of damage. The amount was estimated by interviews with the City Engineer and private property owners, and the average annual damage was computed by the historical method.

The average annual cost of maintaining bank protection and flood prevention works along Santa Rosa and Matanzas Creeks was estimated by a survey of the structures in the creeks and interviews with the owners.

Damage to property as a result of over-bank flow was estimated by projecting floods into the flood plain, determining the values involved and applying depth-damage curves.

Peak flows for several frequencies of occurrence, as presented in Table A, were routed through the flood plain to establish the areas flooded and depths of flooding at each frequency. The resulting flood patterns were checked against maps and photographic records of the 1937, 1945, 1949 and 1955 floods.

An inventory of existing homes was made to establish the average height of floor levels above ground levels. Fifty-six percent were found to average 18 inches above ground, 30% to average 12 inches and the remaining 14% only 5 inches. Industrial and commercial establishments were found to have an average floor elevation 9 inches above ground.

The value of homes to be constructed was assumed to be the same as the value of those now being built in the same areas. Such homes have an average value of $10,000 to $12,000 in the Lower Santa Rosa and Piner Creek areas and $14,000 in the Brush and Spring Creek units. For industrial and commercial properties a value of $200,000 per acre was estimated by comparison with similar developments. These values were reduced to 50% in the Piner Creek unit and 80% in the Lower Santa Rosa and Brush Creek units to compensate for the incompleteness of the development anticipated for the next 15 years. These reduced values for residential, industrial and commercial properties were applied to the flooded areas in proportion to the projected developmental composition by subwatersheds.

In the business section of Santa Rosa the commercial and industrial establishments subject to flooding were inventoried as to type, value (including contents), and elevation of first floor. The values were computed by adjusting values assessed for taxing purposes to 1956 prices. Establishments with basements were inventoried separately and the value of the contents estimated with the assistance of the owners or tenants. Damage to basements and contents was estimated on the assumption that flooding over basement openings would admit a $3\frac{1}{2}$-foot depth of water.

The property values and flooding depths were converted to flood damage values by the application of depth-damage curves developed from records of damaging floods that have occurred in California. These consist of a family of curves representing the three types of establishments and relating water depth over floors to the value of direct damage expressed as a percentage of the property value.

Direct flood damages determined in this manner were plotted against frequency of occurrence for each damage unit, and damage-frequency curves were derived. Indirect damages, estimated as percentages of direct damage, were added.

Damages in the Spring Creek and Piner Creek units were adjusted upward by 25% to include additional damage due to ponding. This condition occurs both inside and outside the area of over-bank flooding and is of considerably greater duration than the more general type of inundation.

Sediment Damage:

Sediment damage in this report refers to deposition of sediment on agricultural land and the road system. It was not possible to segregate sediment deposition damage from floodwater damage in urban areas. Data were collected and converted to average annual damage by the methods used for agricultural damage.

Erosion Damage:

The rate of land loss by streambank erosion was estimated by a combination of field measurements and comparison of aerial photographs taken 14 years apart. Damage was computed at present land values adjusted to long term price level.

Damage Summary:

A table summarizing the average annual damages by evaluation units for floods up to 1% frequency of occurrence follows:

## AVERAGE ANNUAL FLOOD DAMAGE

| Evaluation Unit and Kind of Damage | Direct Damage $ | Indirect Damage $ | Total Damage $ |
|---|---|---|---|
| Lower Santa Rosa Creek - Unit A | | | |
| Floodwater | | | |
| Agricultural - Crops & Property | 3,644 | 547 | 4,191 |
| Urban - Residential | 235,710 | 35,356 | 271,066 |
| Road | 1,074 | 161 | 1,235 |
| Sediment - Deposition | 1,097 | 164 | 1,261 |
| Sub-total, Unit A | 241,525 | 36,228 | 277,753 |
| Santa Rosa Creek, City & Upper Reaches - Unit B | | | |
| Floodwater | | | |
| Urban - Sub-total | 190,472 | 36,102 | 226,574 |
| Residential, Comm. & Ind. | 167,776 | 32,698 | 200,474 |
| Municipal & Private Property | 5,403 | 810 | 6,213 |
| Channel Damage | 17,293 | 2,594 | 19,887 |
| Erosion - Streambank | 1,558 | 234 | 1,792 |
| Sub-total - Unit B | 192,030 | 36,336 | 228,366 |
| Matanzas Creek - Unit C | | | |
| Floodwater | | | |
| Agricultural - Crops | 155 | 23 | 178 |
| Urban - Sub-total | 29,927 | 5,185 | 35,112 |
| Residential, Comm. & Ind. | 24,100 | 4,311 | 28,411 |
| Channel Damage | 5,827 | 824 | 6,701 |
| Erosion - Streambank | 1,230 | 184 | 1,414 |
| Sub-total Damage - Unit C | 31,312 | 5,392 | 36,704 |

## AVERAGE ANNUAL FLOOD DAMAGE, CONTINUED

| Evaluation Unit and Kind of Damage | Direct Damage $ | Indirect Damage $ | Total Damage $ |
|---|---|---|---|
| Piner Creek - Unit D | | | |
| Floodwater | | | |
| Urban - Res., Comm., & Ind. | 61,644 | 11,712 | 73,356 |
| Road | 2,711 | 406 | 3,117 |
| Sediment - Deposition | 1,650 | 248 | 1,898 |
| Sub-total - Unit D | 66,005 | 12,366 | 78,371 |
| Brush Creek - Unit E | | | |
| Floodwater | | | |
| Agricultural - Crops | 78 | 12 | 90 |
| Urban - Sub-total | 59,461 | 10,601 | 70,062 |
| Res. & Comm. | 56,066 | 10,092 | 66,158 |
| Channel Damage | 3,395 | 509 | 3,904 |
| Road | 454 | 68 | 522 |
| Sediment - Deposition | 262 | 39 | 301 |
| Erosion - Streambank | 490 | 73 | 563 |
| Sub-total - Unit E | 60,745 | 10,793 | 71,538 |
| Spring Creek - Unit F | | | |
| Floodwater | | | |
| Urban - Residential | 13,143 | 1,971 | 15,114 |
| Road | 372 | 56 | 428 |
| Sediment - Deposition | 215 | 32 | 247 |
| Sub-total - Unit F | 13,730 | 2,059 | 15,789 |
| Total of All Damages | 605,347 | 103,174 | 708,521 |

DETERMINATION OF BENEFITS:

With the project formulated to give over-all protection against floods of 1% frequency of occurrence, only a minor portion of the $708,500 average annual damage will remain after project installation. In the Matanzas Creek subwatershed, damage in the amount of about $1,600 will consist primarily of land loss along the creek banks. Certain low-lying lands in the Spring Creek subwatershed will still suffer infrequent flood damage amounting to an average of about $1,300 annually, and existing developments within the upper Santa Rosa Creek channel will have damage valued at $100 per year. These residual damages, deducted from the total damage, leave an average annual project benefit of $705,500. (See Table 7.)

The floodwater retarding structures and channel improvements within each evaluation unit are considered interdependent, since the combined effect of the two types of measures is required to provide the benefits calculated for the unit. Benefits, therefore, were assigned to the structures within the units in proportion to the cost of the structures.

The floodwater retarding structures will produce benefits in units downstream from them. The benefit attributed to reduction of overbank flooding in each downstream unit, therefore, was divided among the measures responsible, in proportion to their individual contributions to the reduction of overbank flow; and the benefits thus credited to the floodwater retarding structures were assigned to the units in which the structures will be located. The estimated peak flows and peak reductions at 1% frequency of occurrence were used for this purpose.

A portion of the project benefits will accrue to existing improvements and part to anticipated development. Those related to existing improvements are tabulated below:

| Type | Average Annual Benefits | | |
|---|---|---|---|
| | Direct | Indirect | Total |
| Floodwater | | | |
| Agricultural | $ 10,600 | $ 1,600 | $ 12,200 |
| Non-Agricultural | 238,800 | 44,000 | 282,800 |
| Sediment | 3,200 | 500 | 3,700 |
| Erosion | 1,900 | 300 | 2,200 |
| Total | $254,500 | $46,400 | $300,900 |

The $300,900 benefit to existing development represents 43.6% of the average annual benefit ($705,500) resulting from the project. The remaining 56.4% or $404,600, will accrue to the development expected to take place in the coming 15 years.

Unevaluated Benefits:

In accord with the concept that it is not in the public interest to pursue benefits in excess of those that yield a favorable benefit-cost ratio, certain real and substantial benefits have not been evaluated. Such unevaluated benefits include:

1. Reduction of flood damage to improvements that will be built after the 15-year period used in the County Planning Commission's predictions.

2. Preservation of life and health. This is particularly significant in areas where overflow now causes intermingling of sewage and water supplies by inundation of wells and septic tanks. The effect of insect infestations and unhealthy dampness during these events has not been studied.

3. Reduction of flood damage to streets, utilities and automobiles in areas of projected development.

4. An increased demand for services and products from outside the watershed that will result from the enhanced activity and general well-being within the improved watershed.

PREVENTION OF DAMAGE TO FISH HABITAT

Certain works of improvement that are planned for installation would have an adverse effect on the fishery resource through presenting impediments to steelhead migration. A fish barrier is provided at the outlet from the Santa Rosa Creek floodwater retarding structure, and a baffled center channel will be built into the concrete lining of the Santa Rosa Creek channel to prevent project-induced adverse effects. Study by the U.S. Fish and Wildlife Service and the State Department of Fish and Game shows the expenditure to be justified by the value of this tributary to the Russian River as a spawning site.

## SURVEYS

### FLOODWATER RETARDING STRUCTURES

Topography of the reservoir sites was mapped by Kelsh plotter from 1:9600-scale aerial photography, to a scale of approximately 170 feet to the inch, with a contour interval of 5 feet. Additional details at the dam sites were mapped by transit-stadia.

### CREEK CHANNELS

The creek channels were surveyed by a combination of field measurements and aerial photography. Stationing of the channels was established by measurement of aerial photographs at a nominal scale of 8 inches per mile. The stationing proceeds upstream from the watershed outlet at the Russian River. Representative cross-sections spaced 500 to 1,000 feet apart on all major tributaries were selected in the field and located on the photographs. These were measured in the field and levels were run tying them to the USGS 1929 datum. Some of the larger cross-sections on open reaches of Santa Rosa Creek were developed by Kelsh plotter from 1:6000-scale aerial photography, using field control points established as the level lines were run. Hydraulic calculations and quantity estimates were made from profiles and cross-sections plotted from these data.

## FOUNDATION INVESTIGATION

### FLOODWATER RETARDING STRUCTURES

Geologic exploration was made in sufficient detail to indicate the general feasibility of construction of earth-fill dams at the sites chosen. More detailed investigation will be needed for design of the structures. The formations at the planned locations are described below and are shown in the longitudinal sections of the dams on Drawings 7-E-19192-N through 7-E-19197-N.

Santa Rosa Creek Reservoir:

Three separate embankments are required to confine the reservoir at this site. In the foundation for the main dam and the south auxiliary dam, one to six feet of plastic clay overlies a few feet of stiffer gravelly clay which is underlain by a moderately compact clayey silt. No significantly permeable or compressible strata were found. Construction of the dams will require stripping of the surface clay to depths of two to six feet. The west auxiliary dam site has three to four feet of stiff, red, rocky clay over a compact, gravelly, clayey silt. Here, about four feet of the surface material will have to be stripped from the foundation.

Exploration in the diversion channel showed three feet of rocky clay underlain by moderately compact silty clay near the entrance to the concrete chute on the right abutment. On the valley floor, shallow borings along the course of the diversion channel showed, in general, silty clays overlying rocky clays.

Matanzas Creek Dam:

The foundation at the Matanzas Creek site consists mainly of firm tuff and tuff breccia overlain on the abutments by one to five feet of rocky brown clay and in the bottom of the creek by 4 to 18 feet of stream gravel. A succession of interbedded soft sandstones and shales occurs in the upper part of the right abutment and an outcrop of hard volcanic rock shows at the toe of the right abutment. Moderately hard tuff lies under about one foot of rocky clay in the spillway saddle.

Geologic features make more detailed investigation necessary to establish the feasibility of this dam site.

The proposed protection can be provided by this structure as a part of the inter-related system of improvements, or by increased channel capacity at substantially the same cost.

Piner Creek Dam:

The Piner Creek site is underlain by a wide variety of formations of the Sonoma Volcanic series trending obliquely across the dam axis. The right abutment consists mainly of compact, clayey silt. The left abutment is of partly decomposed volcanic rock of varying hardness overlain by red, rocky, plastic clay. Firm clay, some of it rocky, occupies the downstream portion of the planned spillway cut. Toward the upstream end, decomposed volcanic rock and tuff are present. Some hard rock will be encountered in the deeper part of the cut.

Stripping about four feet deep will be required in the bottom of the canyon and on the left abutment, and one to two feet of clay will have to be removed from the right abutment.

Brush Creek Middle Fork Dam:

The formations at this site are old valley fill materials consisting of compact sands, gravels, silts, and clays with some stratification but little continuity of strata. The entire deposit is tight and of low permeability because of the admixture of clay, except one lens of fairly clean gravel six to nine feet below the surface in the vicinity of the stream channel. Exploration along the spillway alignment showed formations similar to those in the valley bottom.

Only light stripping, sufficient to remove the organic material from the surface, will be necessary.

Brush Creek West Fork Dam:

Relatively tight and impervious gravelly clays, grading down through sandy clay to a nearly black plastic clay 20 feet below the surface, underlie the entire foundation at this site. On the abutments these are covered by ten to thirteen feet of partially cemented sandy gravel which either crops out at the surface or lies under a thin clay soil mantle.

Three to four feet of clay will have to be stripped from the foundation in the valley bottom, and one to two feet of surface soil will have to be removed from the abutments.

Spring Creek Dam:

The entire foundation at the Spring Creek site is underlain by lava flows, some thin-bedded, some massive, all dipping gently toward the left abutment. A heavy clay topsoil and a dense, rocky clay hardpan cover the bedrock on the right abutment. On the left abutment basalt is either exposed or covered by a very thin soil mantle, and in the stream bottom it is largely covered by stream gravels up to five feet in thickness. Surface exposures and bedrock uncovered in test pits exhibit extensive jointing and fracturing to varying depths.

The foundation should be stripped to firm bedrock or to the hardpan where it is present.

## INVESTIGATION OF MATERIALS

### FLOODWATER RETARDING STRUCTURES

Prospective borrow areas for the earth-fill dams were examined and sampled to determine the type and location of suitable fill material as a basis for cost estimation. Preliminary laboratory tests were made to classify the materials, and compaction tests were run on those occurring in the largest quantities. Further exploration and tests will be needed for final design of the structures.

Santa Rosa Creek Reservoir:

Exploration of borrow areas in the reservoir basin indicates that one to six feet of plastic, somewhat organic clay will need to be stripped and that beneath this surface soil, five to eleven feet of usable material will be available, consisting mainly of silty clays and some sandy and gravelly silty clays. Two general areas were explored, one adjacent to the main dam, covering about 25 acres and estimated to contain 260,000 cubic yards of available material, and a 20-acre area near the south auxiliary dam, containing some 250,000 cubic yards. Additional material with similar properties will be available from the excavation of the diversion channel.

Matanzas Creek Dam:

Both slopes of the reservoir basin are mantled by two to six feet of dark brown rocky clay overlying one to eight feet of light brown gravelly clay over bedrock. The greater thicknesses of these materials were found on the right side of the basin in an area between 500 and 1400 feet upstream from the dam site, where a volume of 32,000 cubic yards is estimated to be present below the planned high water line. Approximately 84,000 cubic yards of sandy silty clay is available within an excavation depth of 20 feet on the knoll on the right bank of the reservoir, 1400 to 1700 feet upstream from the dam. Materials from these sources will be suitable for the impervious core section of the fill. The brown rocky clay also blankets the spillway

site, and a considerable portion of the 140,000 cubic yards excavated for the spillway will be usable.

Within 1800 feet of the dam about 70,000 cubic yards of gravel, usable in the outer pervious zones, is present in the stream channel and in benches adjacent to the channel. An additional 30,000 cubic yards is available along the channel slightly farther upstream. Large quantities of partially decomposed volcanic bedrock, fractured into small blocks generally less than three inches in diameter, underlie the surface clay over a large part of the reservoir area. This material, also, is satisfactory for use in the outer zones. Some 26,000 cubic yards is estimated in the area from 800 to 1400 feet upstream from the dam.

Piner Creek Dam:

Materials which will be usable in the auxiliary dykes, consisting of sandy to gravelly clays, were found around the periphery of the pond area. The spillway excavation will provide some 10,000 cubic yards of silt and silty clay and 20,000 cubic yards of decomposed rock and tuff, from which selection can be made for the main dam embankment. Additional material is available in the right bank of the canyon. This is mostly a silty clay. The maximum haul distance will be about 400 feet.

Brush Creek Middle Fork Dam:

Borings made at the dam site and exposures on the stream banks indicate that the general run of material in the basin, to a depth of 30 feet, consisting of clayey sands, gravels and silts, will be suitable fill material with very little selection required. In the emergency spillway site the material consists predominantly of silty clay and some clayey gravel. Excavation of the spillway channel will provide most of the required fill material.

Brush Creek West Fork Dam:

Borings and stream bank exposures in the reservoir basin, plus data from the boring in the valley bottom at the dam site, indicate clay and sandy, gravelly clay to depths of six to fifteen feet extending over a large portion of the basin. It is estimated that about 90,000 cubic yards, or twice the amount needed, is available within the reservoir area.

Spring Creek Dam:

Exploration of an area of about 20 acres in the upper potion of the Santa Rosa Creek reservoir basin indicated that some of the material there could be used in Spring Creek Dam. Beneath a layer of black, plastic clay one to three feet thick, the soil consists principally of clays and clayey silts having satisfactory properties for the center section of the dam. Net borrow depths of five to eleven feet will be practical in the area which thus could yield some 250,000 cubic yards. Some 50,000 cubic yards from this source will be needed for the south auxiliary dam at the Santa Rosa Creek site. The haul distance to the Spring Creek Dam site is about one mile.

In the Spring Creek reservoir area, two test pits were dug, one above the right bank of the creek near the upper end of the reservoir, and another on the right slope near the proposed high water contour. Black to brown plastic clays containing some rock were found, extending to depths of five to seven feet and underlain by three feet of hard claypan over bedrock. These clays could be used in the core of the dam, but it probably will prove more economical to use the imported material from the Santa Rosa Creek reservoir basin because of better workability and easier borrow excavation. Samples of tuff breccia taken by borings at the base of the road cuts at distances of 200, 800 and 1800 feet upstream from the dam site indicate that 78,000 cubic yards of materials suitable for the outer zones of the fill will be available in these areas. Most of the rock from the 20,000 cubic yard spillway cut also is expected to be usable in the outer zones.

## CHANNEL IMPROVEMENTS

Investigation of channel materials consisted of observation of exposures on the cut banks of the channels and measurement of existing bank slopes. In general, bank slopes in the range of 2:1 to $2\frac{1}{2}$:1 were found to be stable and in good condition, while most slopes steeper than this showed signs of washing or instability. Tests of the bank materials and stability analyses will be used in the design stage for a final choice of the bank slopes.

# HYDRAULIC ANALYSIS

## FLOODWATER RETARDING STRUCTURES

Performance of the floodwater retarding structures was determined on the basis of 72-hour storm hydrographs developed as described on page 28. Figure 5 illustrates the shape of the hydrographs. The maximum, or peak, rates of flow used at the various sites, for storms of various frequencies of occurrence, are shown in Table A.

In the case of the Santa Rosa Creek structure, the flow represented by the design hydrograph was divided between the diversion channel and the diversion dam bypass according to their relative capacities. The method of doing this and the resulting divided hydrograph for the design flood are shown in Figure 10. Figure 10 also shows a hydrograph of the outflow from the reservoir and the combined total flow in the creek below the structures. The outflow hydrograph was computed by routing through the reservoir the diverted portion of the original inflow hydrograph. The principal spillway is designed to empty the flood retarding pool in six days following a 1% frequency flood.

The other five reservoirs were designed in the conventional manner for structures of this type. The design flood was routed through the reservoir graphically, and the size of the outlet conduit and elevation of the emergency spillway were chosen so that the peak stage in the reservoir would just reach the crest of the emergency spillway, thus making use of the full capacity of the reservoir but allowing no flow over the emergency spillway. The flood routing calculation for Matanzas Creek Reservoir, shown in Figure 9, illustrates the method used.

Flood hydrographs for design of the emergency spillways were developed as described on page 28, and the resulting peak inflow rates are given in Table B. The spillways were designed to meet the criteria specified by Soil Conservation Service Engineering Memorandum Number 3 for "high hazard" structures. The peak outflow through the spillway was determined by routing through the reservoir assuming the detention pool to be full at the beginning of the flood. In this computation the flow in the principal spillway was assumed to be zero to allow for the possibility of its becoming clogged. Figure 11 shows the flood routing computation for Matanzas Creek Reservoir.

At the Santa Rosa Creek site, the maximum water level in the reservoir is limited by flow through the diversion channel. Stage discharge computations for the creek and adjacent valley show that a freeboard of at least 2.5 feet will be maintained on the storage dam during the "emergency spillway design flood" with the vegetated wasteway shown on Drawing 7-E-19192-N serving as a spillway to limit discharge from the diversion channel into the damsite. While the diversion dam will be inundated in a flood of this magnitude, and the valley for some distance on either side of the creek will be under water, the combination of spill over the diversion dam and flow into the diversion channel is designed to prevent higher floodwater levels than the same flood would produce under present channel conditions.

Provision is made for hydraulic model tests of the diversion works for Santa Rosa Creek Reservoir should such tests prove desirable in the final design of the structures.

Hydraulic and structural data pertaining to the floodwater retarding structures are summarized in Table 3.

## CREEK CHANNELS

The channels were designed by Manning's formula using a value of the roughness coefficient "n" of .035 for vegetated and riprapped channels and .015 for concrete lined channels. In the unlined channels where the velocity at design flow computed in this way would be greater than 9 feet per second, concrete grade stabilization structures will be used. These structures will be placed as needed to reduce the channel gradient to the value that gives a computed velocity of 9 feet per second. A drop of not more than 18 inches is allowed at each stabilizer. A summary of the hydraulic properties of the channels is given in Table 3A.

In general, the alignment of the improved channels will be such that the superelevation of the water surface at the outside of curves will be limited to a maximum of one foot. This limit will be exceeded in Santa Rosa Creek just above its junction with Matanzas Creek, however, where existing buildings and bridges force the creek to follow two sharp bends. Here a rectangular concrete lined channel will be used, with a five-foot freeboard above the average water surface to provide for superelevation and waves. The design here is considered to be conservative. Model tests may be made to aid in the final design of this section of channel, including the junction of Santa Rosa and Matanzas Creeks, and of part of the concrete lined channel below the Santa Rosa-Matanzas Creek junction.

The computed flood peaks without floodwater detention are given for various locations throughout the watershed in Table A. The peak flows were computed by channel flood routing. The effect of each floodwater retarding structure in reducing these flood peaks was computed by the formula:

$$R = \frac{A^{.85} - (A - A_D)^{.85}}{A_D^{.85}} R_D$$

Where R is the reduction in the flood peak in the channel reach under consideration,

$R_D$ is the reduction in the flood peak at the reservoir outlet, computed by flood routing through the reservoir,

A is the total drainage area tributary to the channel reach,

$A_D$ is the drainage area tributary to the reservoir.

The exponent .85 was chosen from the general slope of the curves of peak flow vs. drainage area, Figure 2. From the curves,

Peak flow per square mile, $q = KA^{-.15}$, approximately, and

Peak flow, $Q = qA = KA^{.85}$

where A is the drainage area and K is a constant.

Design peak flows for the channels, determined in this way, are shown in Table 3A, along with the corresponding 1% frequency flows without flood detention.

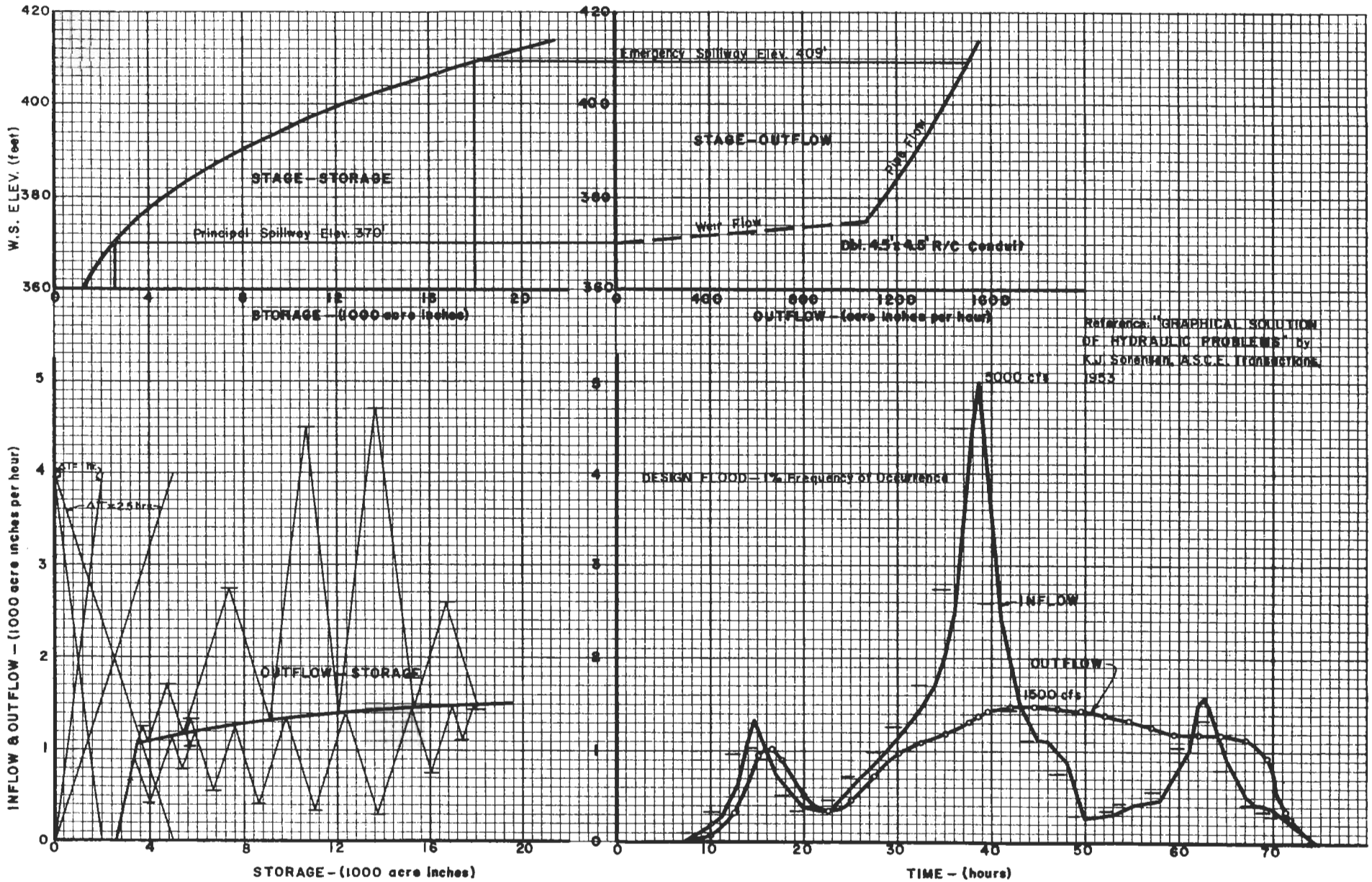



FIG. 9: Flood Routing: MATANZAS CREEK RESERVOIR — Design Flood

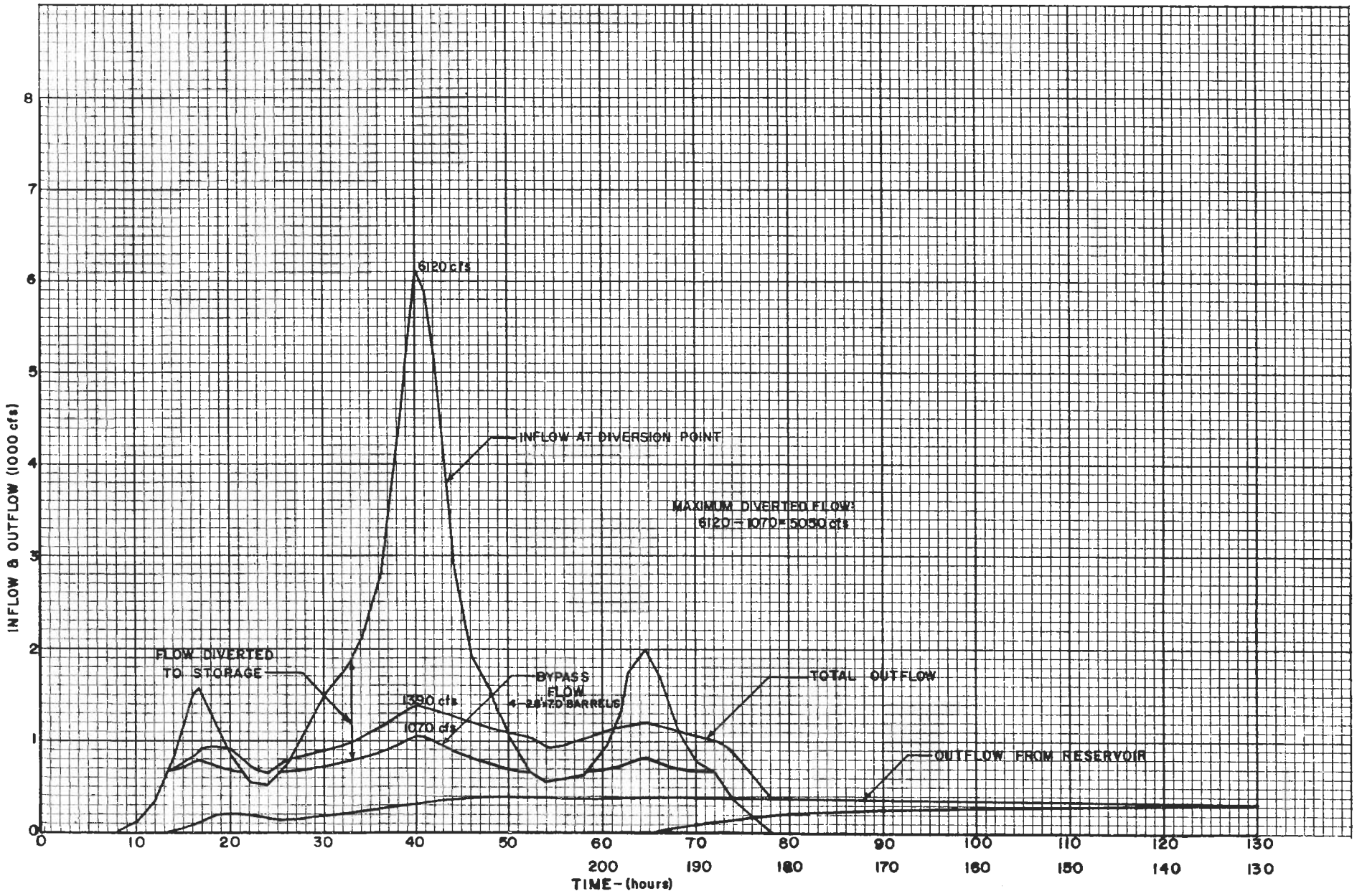



FIG. 10: Flood Routing: SANTA ROSA CREEK RESERVOIR — Design Flood

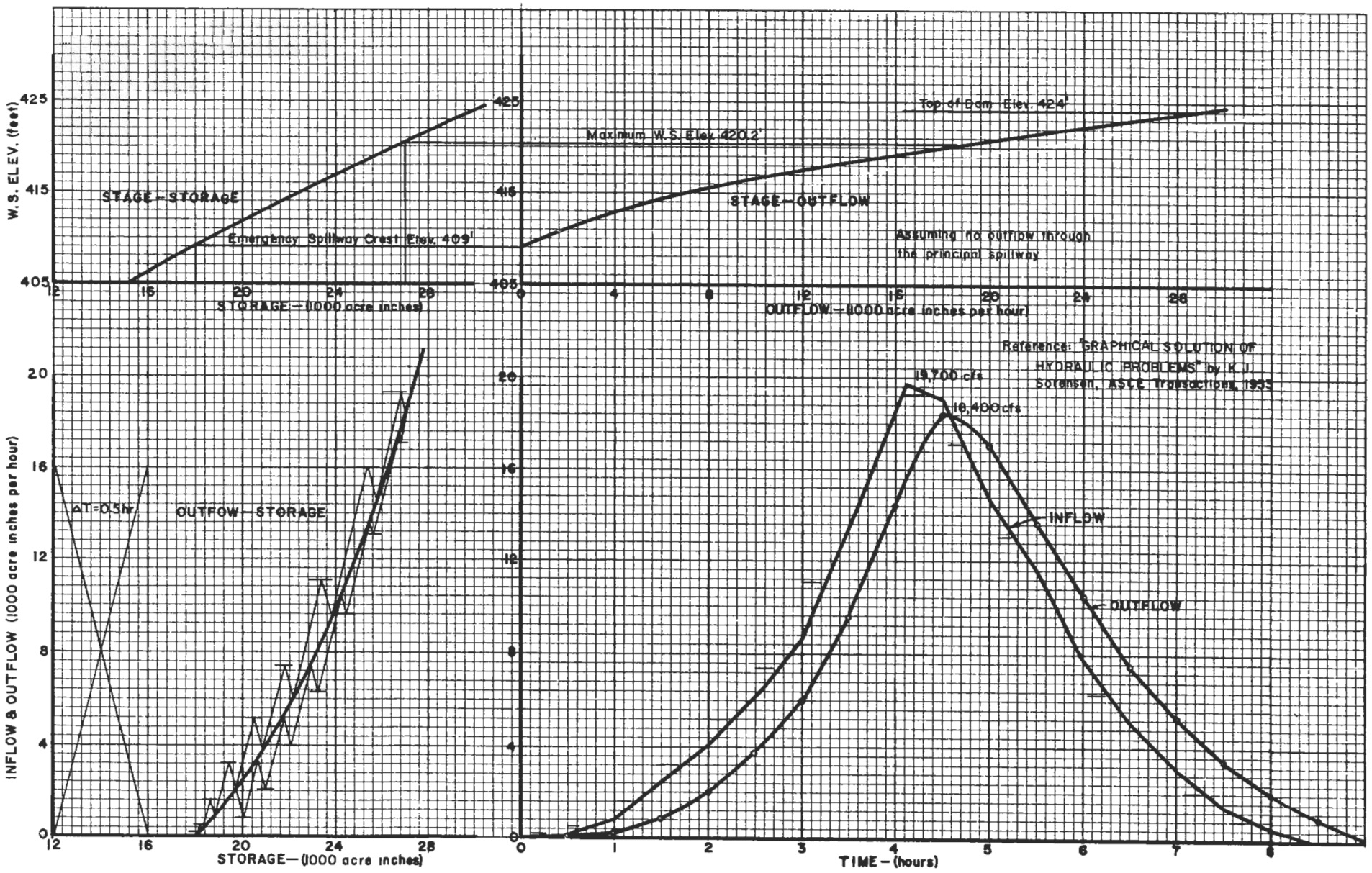



FIG. 11: Flood Routing : MATANZAS CREEK RESERVOIR – Emergency Spillway

## STRUCTURAL DETAILS

### FLOODWATER RETARDING STRUCTURES

The earth-fill dams forming the six retarding reservoirs are of conventional design. The earth embankment will be zoned as needed to make the best use of readily available material. For purposes of the Work Plan the fill slopes are 3:1 on the upstream face and 2:1 or $2\frac{1}{2}$:1 on the downstream face, the steeper slope being used only for dams less than 40 feet high. Final design of the embankment will be based on more detailed foundation exploration and tests of the fill material. Rock riprap will be provided on the upstream slopes of the Spring Creek, Matanzas Creek and Santa Rosa Creek dams, where the reservoir will be large enough to make wave action an important factor.

The reinforced concrete principal spillways will have anti-vortex covers and trash racks to insure their functioning at design capacity. Model studies are currently underway at the University of California to develop designs capable of insuring clog-free structures. Emergency spillways will be concrete-lined with cut-off walls of adequate depth to prevent undercutting, except at Spring Creek Dam where the spillway will be in hard volcanic rock.

The diversion structure for the Santa Rosa Creek reservoir is designed as a reinforced concrete buttress dam with the upstream face on a 1:1 slope. Orifices are provided at the bottom and a trapezoidal notch spillway over the top. A concrete slab serves as a footing for the buttresses and as an apron to protect the channel from the spillway overpour and the discharge of the orifices. Cutoff walls extend into the channel bottom and banks at the upstream and downstream edges of the slab. The channel is protected by rock riprap upstream and downstream from the structure. A graded gravel filter is used below the downstream riprap as an additional precaution against piping.

Control of the flow into the diversion channel is provided by a reinforced concrete drop structure having a drop of 3 feet. Warped structural concrete sidewalls form a 40 foot long transition from the rectangular cross-section of the drop structure to the trapezoidal cross-section of the channel.

### CHANNEL IMPROVEMENT

Bank slopes for the riprapped channels and the vegetated earth channels were set at $2\frac{1}{2}$:1 on Santa Rosa Creek and 2:1 on the other creeks. The choice of slopes was largely the result of an examination of the condition of the existing banks. A slope of $1\frac{1}{2}$:1 was used for the trapezoidal concrete-lined channels. Final design will be based on tests and stability analyses of the bank materials. Riprap planned for the channels consists principally of large rock, one to three feet in diameter for the large channels. Riprap will contain sufficient spalls and fines to prohibit passage of the native bank soils or will be provided with a filter blanket.

Except in the concrete-lined reaches, all channels having design flows greater than 1,000 cubic feet per second, and all smaller channels

having water depths greater than 5 feet combined with velocities of more than 7 feet per second at design flow, will have rock riprap to a minimum of one-third of the design flow depth. This type of protection was determined to be more economical, on an average annual cost basis, than the other possibilities investigated, recognizing that the cost of maintenance would be higher than for some other types. The riprap is designed to prevent bank undercutting by sustained low flows in the larger channels, while a sod cover above the riprap will provide protection against infrequent high flows of relatively short duration. At bends and other points where high velocity flows adjacent to the banks may be expected at high stages, the riprap will be extended to the full channel depth, including freeboard.

The water surface at design flow will be below natural ground except in the lower reaches of Piner and Santa Rosa Creeks. Here levees will be provided, extending upstream to Station 534 on Santa Rosa Creek and to Station 574 on Piner Creek. Water against the levees will reach a maximum depth of about 2 feet through the majority of the protected area. From a half mile above Willowside Road to the Laguna, this will increase to a maximum of 4 feet. The levees are designed for a minimum freeboard of 3 feet, except in the reach below Willowside Road where Laguna backwater will inundate them at times of high flow in the Russian River. Levees below Willowside Road will assure that Santa Rosa Creek floodwaters will be channelized to the Laguna under normal backwater conditions. Since construction of these levees is planned for the fourth year of the project development, their design will be coordinated with the plans currently being developed for flood control on the Laguna.

Grade stabilization structures will consist essentially of slabs of plain concrete across the channel bottom, with cut-off walls at the upstream and downstream edges. They are designed for a maximum drop of 18 inches at each structure. Protection of the banks for increased velocity at the structures will be provided by rock riprap extending downstream ten times the design water depth. The slabs will be faced with cobbles to provide roughness comparable to the remainder of the channel.

The concrete lining planned for trapezoidal channels is non-structural but is provided with steel reinforcing for shrinkage and temperature changes. The rectangular concrete channels are designed to resist earth and water loads on the sidewalls. A 9-inch thick gravel underdrain is provided for all concrete linings.

## COST ESTIMATION

Cost estimates were made on the basis of quantities and estimated unit costs of the individual items involved. The estimates for the structural measures included in the Work Plan are presented in detail in Table C. Some of the factors involved are discussed below.

### CONSTRUCTION COSTS

The unit costs used for construction items were based on recent costs of similar work in the vicinity of Santa Rosa and elsewhere. For the earth-fill dams the unit costs of excavation and embankment vary, with the type of

material and the expected difficulty of construction, from $0.50 to $3.00 for excavation and from $0.60 to $1.00 for compacted embankment. The $0.50 per cubic yard used for most of the channel excavation includes an allowance for wasting the spoil immediately adjacent to the channel. In those cases where the haul distances exceed 10 stations or where difficult digging conditions are expected, costs were increased. Reinforced concrete was estimated at $40 per cubic yard for trapezoidal channel lining, $80 for rectangular lining and $100 for structures, all including steel, and $20 per cubic yard was used for plain concrete. Riprap, estimated at $8.00 per cubic yard, is loose quarry rock with controlled grading, placed by dumping and bulldozing.

The figure of $1,500 per acre used for most of the vegetation is expected to cover all the work needed to establish a good stand, including importing topsoil, fertilizing, hand planting, and at least one irrigation. For drill seeding and fertilizing on relatively level ground $50 per acre was used, and for drill or broadcast seeding and fertilizing on channel banks $300 per acre was used. The $0.10 per lineal foot for maintenance roads is for grading only.

The estimated contract cost based on quantities was increased 15 percent for contingencies.

## INSTALLATION SERVICES

Installation services include foundation exploration, model tests, engineering and Federal administrative services. On the basis of past experience the combined cost of the last two of these items was estimated at 25 percent of the total construction cost. Engineering includes design of the structures, preparation of plans and specifications and supervision of construction.

## RIGHT-OF-WAY COSTS

Right-of-way areas for the channels include channel width plus 13 feet for each maintenance road plus 4 feet clearance on each side. In leveed sections the maintenance roads are on the levees and the right-of-way extends 4 feet beyond the outside toes of the levees. For the reservoirs the right-of-way line approximately follows the contour at the elevation of the top of the dam.

Except for the acquisition of flooding easements on some land subject to infrequent flooding by the emergency spillways, and easements for the sediment stabilization work on upper Matanzas Creek, all right-of-way costs have been computed for fee-title acquisition of the property. Land prices have been estimated with the aid of local real estate agents, using recent property sales as an additional guide.

## BRIDGE REPLACEMENT

The estimated costs of replacing bridges are shown in detail in Table D. For simplicity all inadequate bridges and culverts, with a few minor exceptions, were assumed to be replaced with bridges. A more detailed analysis

in the design stage is expected to show that a cost saving can be made by the substitution of culverts in some cases. Replacement of highway bridges was figured at $15 or $20 per square foot of deck, depending on the type of existing bridge, and two figures, $10 and $15 per square foot, were used for private bridges, the higher figure being applied where the improved channel will require a bridge more than 50 feet long. The width of the water surface in the channel at design flow was used as the required length of bridge in each case, the unit costs being chosen to cover approaches and miscellaneous costs.

The current standard width for two-lane highway bridges, used by the County Road Department, is 28 feet. Where the existing bridge is narrower than this, two costs are given in Table D, one being the cost of replacing the existing structure with another of the same width, and the second, the cost of a bridge 28 feet wide. The former cost is used in the Work Plan, since widening of the bridges provides an additional benefit not related to the objectives of the watershed project. The unit cost used for all replacements with 28-foot bridges is $20 per square foot.

## RELOCATION OF UTILITIES

The costs of moving or replacing utilities were estimated with assistance from the utility companies. The Northwestern Pacific Railroad Company furnished unit costs for railroad trestles.

## OPERATION AND MAINTENANCE

The estimates for operation and maintenance represent the average annual cost of operation, maintenance and replacement, if any, within a period of 50 years. They were computed as a percentage of construction cost, based on experience in similar projects. The percentage varies with the type of structure, from 0.5% for floodwater retarding structures to 6% for vegetated earth channels. For channels having continuous riprap protection on the bottom third of the bank slopes plus full-height riprap at bends and junctions, the amount allowed for maintenance was 4% of the cost of channel enlarging and shaping, plus 2% of the cost of the riprap, plus 4% of the cost of the vegetation for the bank slopes above the riprap.

## TABLE C - ESTIMATED COSTS

### FLOODWATER DETENTION STRUCTURES

### Santa Rosa Creek Reservoir & Diversion

**Federal Costs**

| | | |
|---|---|---|
| **Storage Reservoir** | | |
| Stripping 70,000 c.y. @ $.50 | $ 35,000 | |
| Cut-off Excavation 11,300 c.y. @ $.75 | 8,500 | |
| Compacted Embankment 385,000 c.y. @ $.60 | 231,000 | |
| Gravel Blanket & Drain, 36,000 c.y. @ $3. | 108,000 | |
| R/C Principal Spillway 230 c.y. @ $100. | 23,000 | |
| Rock Facing 6,500 c.y. @ $8. | 52,000 | |
| Filter Blanket for Rock Facing 4,500 c.y. @ $3. | 13,500 | |
| Outlet Channel Excavation 7,000 c.y. @ $.50 | 3,500 | |
| Sub-total | | $ 474,500 |
| **Concrete Diversion Dam** | | |
| Clearing & Grubbing, Lump Sum | $ 1,000 | |
| Structural Excavation, 1,700 c.y. @ $2. | 3,400 | |
| Structural Concrete 290 c.y. @ $100 | 29,000 | |
| Concrete Bank Paving 25 c.y. @ $75. | 1,900 | |
| Compacted Backfill 1,100 c.y. @ $4. | 4,400 | |
| Rock Riprap 330 c.y. @ $8. | 2,600 | |
| Gravel Filter 130 c.y. @ $3. | 400 | |
| Channel Clearing & Shaping Upstream 200 l.f. @ $4. | 800 | |
| Sub-total | | 43,500 |
| **Diversion Channel & Intake Structure** | | |
| Clearing 9 acres @ $200. | $ 1,800 | |
| Excavation & Haul 148,000 c.y. @ $.75 | 111,000 | |
| Wasteway Levees 2,700 c.y. @ $.50 | 1,400 | |
| Vegetation (Banks & Bottom) 11 acres @ $300. | 3,300 | |
| Concrete Outlet Chute 310 c.y. @ $75. | 23,300 | |
| Diversion intake structure 133 c.y. @ $100. | 13,300 | |
| 49 c.y. @ $ 75. | 3,700 | |
| Rock Riprap 24 c.y. @ $8. | 200 | |
| Gravel Filter 35 c.y. @ $3. | 100 | |
| Sub-total | | 158,100 |
| Total Contract Cost | | 676,100 |
| Contingencies @ 15% | | 101,400 |
| Total Construction Cost | | 777,500 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 194,400 |
| Foundation Exploration | | 8,000 |
| Hydraulic Model Tests | | 25,000 |
| Total Federal Cost | | $1,004,900 |

TABLE C - CONTINUED

Santa Rosa Creek Reservoir & Diversion (Cont.)

Non-Federal Costs

| | | |
|---|---|---|
| Rights-of-Way | | |
| 166 acres @ $400. | $ 66,400 | |
| 4 acres @ $1,500 | 6,000 | |
| 16 acres @ $2,200 | 35,200 | |
| 3 Houses | 20,000 | |
| Sub-total | | $ 127,600 |
| R/W Acquisition @ 15% | | 19,100 |
| Bridges & Culverts | | 149,300 |
| Replacement & Protection of 24" Water Pipe | | 19,000 |
| Relocation of Utilities | | 5,000 |
| Fish Barrier | | 1,000 |
| Fencing, 200 l.f. @ $1.85 plus 15% contingencies | | 400 |
| Administration of Contracts @ 1% | | 7,800 |
| State Dam Filing Fees | | 6,500 |
| Total Non-Federal Cost | | $ 335,700 |
| Total Installation Cost | | $1,340,600 |

| | | |
|---|---|---|
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 47,300 | |
| Annual O & M Cost | 3,600 | |
| Total Annual Cost | $ 50,900 | |

TABLE C - CONTINUED

Matanzas Creek Reservoir & Sediment Stabilization Structures

| | | |
|---|---|---|
| **Federal Costs** | | |
| Reservoir | | |
| Clearing 50 acres @ $300. | $ 15,000 | |
| Foundation Excavation 22,000 c.y. @ $.50 | 11,000 | |
| Cut-off Excavation 5,900 c.y. @ $2. | 11,800 | |
| Spillway Excavation 140,000 c.y. @ $.50 | 70,000 | |
| Compacted Embankment 215,000 c.y. @ $.75 | 161,300 | |
| Gravel Blanket & Filter 3,300 c.y. @ $3. | 9,900 | |
| R/C Principal Spillway 1,300 c.y. @ $100. | 130,000 | |
| Rock Facing, 2,800 c.y. @ $8. | 22,400 | |
| Filter Blanket for Rock Facing, 2,000 c.y. @ $3. | 6,000 | |
| R/C Emergency Spillway 388 c.y. @ $75. | 29,100 | |
| 1,750 c.y. @ $40. | 70,000 | |
| Sub-total | | $ 536,500 |
| Sediment Stabilization Structures | | |
| Excavation 25,000 c.y. @ $.40 | $ 10,000 | |
| Revetment 2,000 l.f. @ $3.50 | 7,000 | |
| Locust Trees 1.2 acres @ $500. | 600 | |
| Grass 1.2 acres @ $1,500. | 1,800 | |
| Sub-total | | $ 19,400 |
| Total Contract Cost | | 555,900 |
| Contingencies @ 15% | | 83,400 |
| Total Construction Cost | | 639,300 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 159,800 |
| Foundation Exploration | | 5,000 |
| **Total Federal Cost** | | $ 804,100 |
| **Non-Federal Cost** | | |
| Rights-of-Way 95 acres @ $400. | $ 38,000 | |
| 7 acres @ $300. | 2,100 | |
| Building, Road, Powerline & Well | 40,000 | |
| Sub-total | | $ 80,100 |
| R/W Acquisition @ 15% | | 12,000 |
| Administration of Contracts @ 1% | | 6,400 |
| State Dam Filing Fees | | 6,000 |
| **Total Non-Federal Cost** | | $ 104,500 |
| **Total Installation Cost** | | $ 908,600 |
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 32,000 | |
| Annual O & M Cost | 3,800 | |
| Total Annual Cost | $ 35,800 | |

TABLE C - CONTINUED

Piner Creek Reservoir

| | | |
|---|---|---|
| **Federal Costs** | | |
| Clearing & Grubbing 2 acres @ $300. | $ 600 | |
| 0.8 acre @ $500. | 400 | |
| Stripping 1,500 c.y. @ $.50 | 800 | |
| Cut-off Excavation 1,300 c.y. @ $.75 | 1,000 | |
| Spillway Excavation 31,800 c.y. @ $.50 | 15,900 | |
| Compacted Embankment 24,200 c.y. @ $.75 | 18,200 | |
| Gravel Blanket & Drain 1,500 c.y. @ $3. | 4,500 | |
| R/C Principal Spillway 144 c.y. @ $100. | 14,400 | |
| Spillway Riprap 300 c.y. @ $8. | 2,400 | |
| R/C Emergency Spillway 133 c.y. @ $75. | 10,000 | |
| 450 c.y. @ $40. | 18,000 | |
| Total Contract Cost | | $ 86,200 |
| Contingencies @ 15% | | 12,900 |
| Total Construction Cost | | 99,100 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 24,800 |
| Foundation Exploration | | 3,000 |
| **Total Federal Cost** | | $ 126,900 |
| **Non-Federal Costs** | | |
| Rights-of-Way 42 acres @ $400. | $ 16,800 | |
| Levee to Protect Hospital Boiler Plant, 10,000 c.y. @ $.75 | 7,500 | |
| Relocation of Buildings | 20,000 | |
| Drain & Sump Pump for Hospital Boiler Plant | 1,300 | |
| Sub-total | | $ 45,600 |
| R/W Acquisition @ 15% | | 6,800 |
| Remove and Replace Bridge | | 18,000 |
| Remove and Replace Sewer Line | | 42,300 |
| Administration of Contracts @ 1% | | 1,300 |
| State Dam Filing Fees | | 1,600 |
| **Total Non-Federal Cost** | | $ 115,600 |
| **Total Installation Cost** | | $ 242,500 |
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 8,600 | |
| Annual O & M Cost | 500 | |
| Total Annual Cost | $ 9,100 | |

TABLE C - CONTINUED

Brush Creek - Middle Fork Reservoir

Federal Costs

| | | |
|---|---|---|
| Clearing & Grubbing 3 acres @ $300. | $ 900 | |
| Foundation Excavation 1,900 c.y. @ $.50 | 1,000 | |
| Cut-off Excavation 8,700 c.y. @ $.75 | 6,500 | |
| Spillway Excavation 47,600 c.y. @ $.50 | 23,800 | |
| Compacted Embankment 46,600 c.y. @ $.50 | 23,300 | |
| Gravel Blanket 3,000 c.y. @ $3. | 9,000 | |
| R/C Principal Spillway 150 c.y. @ $100. | 15,000 | |
| Spillway Riprap 140 c.y. @ $8. | 1,100 | |
| R/C Emergency Spillway 160 c.y. @ $75. | 12,000 | |
| 770 c.y. @ $40. | 30,800 | |
| Total Contract Cost | | $ 123,400 |
| Contingencies @ 15% | | 18,500 |
| Total Construction Cost | | 141,900 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 35,500 |
| Foundation Exploration | | 3,000 |
| Total Federal Cost | | $ 180,400 |

Non-Federal Costs

| | | |
|---|---|---|
| Rights-of-Way 31 acres @ $1,500 | $ 46,500 | |
| Farm Buildings | 3,000 | |
| Sub-total | | $ 49,500 |
| R/W Acquisition @ 15% | | 7,400 |
| Administration of Contracts @ 1% | | 1,400 |
| State Dam Filing Fees | | 1,900 |
| Total Non-Federal Cost | | $ 60,200 |
| Total Installation Cost | | $ 240,600 |

| | | |
|---|---|---|
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 8,500 | |
| Annual O & M Cost | 600 | |
| Total Annual Cost | $ 9,100 | |

TABLE C - CONTINUED

Brush Creek - West Fork Reservoir

Federal Costs

| | | |
|---|---|---|
| Clearing 1 acre @ $300. | $ 300 | |
| Foundation Excavation 3,000 c.y. @ $.50 | 1,500 | |
| Cut-off Excavation 9,600 c.y. @ $.50 | 4,800 | |
| Spillway Excavation 6,000 c.y. @ $.50 | 3,000 | |
| Compacted Embankment 45,800 c.y. @ $.60 | 27,500 | |
| Gravel Blanket 1,300 c.y. @ $3. | 3,900 | |
| R/C Principal Spillway 144 c.y. @ $100. | 14,400 | |
| R/C Emergency Spillway 140 c.y. @ $75. | 10,500 | |
| 570 c.y. @ $40. | 22,800 | |
| Total Contract Cost | | $ 88,700 |
| Contingencies @ 15% | | 13,300 |
| Total Construction Cost | | 102,000 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 25,500 |
| Foundation Exploration | | 3,000 |
| Total Federal Cost | | $ 130,500 |

Non-Federal Costs

| | |
|---|---|
| Rights-of-Way 21 acres @ $400. | $ 8,400 |
| R/W Acquisition @ 15% | 1,300 |
| Road Relocation .1 mile @ $40,000 | 4,000 |
| Bridge | 20,000 |
| Administration of Contracts @ 1% | 1,000 |
| State Dam Filing Fees | 1,600 |
| Total Non-Federal Cost | $ 36,300 |

Total Installation Cost $ 166,800

| | | |
|---|---|---|
| Annual Cost (50-yr. amort. @ 2½% interest) | $ | 5,900 |
| Annual O & M Cost | | 500 |
| Total Annual Cost | $ | 6,400 |

TABLE C - CONTINUED

Spring Creek Reservoir

Federal Costs

| | | |
|---|---|---|
| Clearing 12 acres @ $500. | $ 6,000 | |
| Foundation Excavation 11,100 c.y. @ $.75 | 8,300 | |
| Cut-off Excavation 3,300 c.y. @ $2. | 6,600 | |
| Spillway Excavation 20,000 c.y. @ $3. | 60,000 | |
| Compacted Embankment 130,000 c.y. @ $1. | 130,000 | |
| Gravel Blanket & Filter 2,000 c.y. @ $3. | 6,000 | |
| R/C Principal Spillway 280 c.y. @ $100. | 28,000 | |
| Rock Facing on Dam 1,500 c.y. @ $8. | 12,000 | |
| Filter Blanket for Rock Facing 1,000 c.y. @ $3. | 3,000 | |
| Total Contract Cost | | $ 259,900 |
| Contingencies @ 15% | | 39,000 |
| Total Construction Cost | | 298,900 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 74,700 |
| Foundation Exploration | | 5,000 |
| Total Federal Cost | | $ 378,600 |

Non-Federal Costs

| | | |
|---|---|---|
| Rights-of-Way 20 acres @ $400. | $ 8,000 | |
| Flood Easement 8.6 acres @ $250. | 2,200 | |
| Barn | 500 | |
| Sub-total | | $ 10,700 |
| R/W Acquisition @ 15% | | 1,600 |
| Relocation of Graded Road 0.75 mile @ $4,000. | | 3,000 |
| Concrete Box Culvert | | 1,000 |
| Administration of Contracts @ 1% | | 3,000 |
| State Dam Filing Fees | | 3,300 |
| Total Non-Federal Cost | | $ 22,600 |
| Total Installation Cost | | $ 401,200 |

| | |
|---|---|
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 14,100 |
| Annual O & M Cost | 1,500 |
| Total Annual Cost | $ 15,600 |

TABLE C - CONTINUED

CHANNEL IMPROVEMENTS

Santa Rosa Creek Channel Improvement - Lower Reach

| | | |
|---|---|---|
| **Federal Costs** | | |
| Clearing 60,800 l.f. @ $1. | $ 60,800 | |
| Excavation 969,000 c.y. @ $.50 | 484,500 | |
| Excavation 122,250 c.y. @ $.40 | 48,900 | |
| Compacted Embankment 96,700 c.y. @ $.50 | 48,400 | |
| Levee Compaction 94,500 c.y. @ $.20 | 18,900 | |
| Toe Riprap 85,580 c.y. @ $8. | 684,600 | |
| Bank Riprap 14,640 c.y. @ $8. | 117,100 | |
| Filter Blanket for Riprap 33,400 c.y. @ $3. | 100,200 | |
| Vegetation 69.92 acres @ $1,500. | 104,900 | |
| 96 acres @ $50. | 4,800 | |
| Side Drainage Inlets 125 @ Varying Costs | 53,500 | |
| Maintenance Road 109,100 l.f. @ $.10 | 10,900 | |
| Grade Stabilization Structure 70 c.y. @ $20. | 1,400 | |
| Total Contract Cost | | $1,738,900 |
| Contingencies @ 15% | | 260,800 |
| Total Construction Cost | | 1,999,700 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 499,900 |
| **Total Federal Cost** | | $2,499,600 |
| **Non-Federal Costs** | | |
| Rights-of-Way 62.2 acres @ $1,100 | $ 68,400 | |
| 109 acres @ $550. | 60,000 | |
| 41.2 acres @ $750. | 30,900 | |
| 37.3 acres @ $1,500. | 56,000 | |
| Sub-total | | $ 215,300 |
| R/W Acquisition @ 15% | | 32,300 |
| Bridges | | 249,600 |
| Administration of Contract @ 1% | | 20,000 |
| **Total Non-Federal Cost** | | $ 517,200 |
| **Total Installation Cost** | | $3,016,800 |
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 106,400 | |
| Annual O & M Cost | 53,200 | |
| Total Annual Cost | $ 159,600 | |

TABLE C - CONTINUED

Santa Rosa Creek Channel Improvement - City Reach

| | | |
|---|---|---|
| **Federal Costs** | | |
| Clearing 16,100 l.f. @ $1. | $ 16,100 | |
| Shaping 3,910 l.f. @ $1. | 3,900 | |
| Shaping Concrete Subgrade 63,000 s.y. @ $.35 | 22,100 | |
| Excavation 128,600 c.y. @ $.60 | 77,200 | |
| Compacted Embankment 139,500 c.y. @ $.50 | 69,800 | |
| Toe Riprap 23,960 c.y. @ $8. | 191,700 | |
| Bank Riprap 13,600 c.y. @ $8. | 108,800 | |
| Filter Blanket for Riprap 12,500 c. y. @ $3. | 37,500 | |
| Vegetation-Grass 34.7 acres @ $1,500 | 52,100 | |
| Rail & Wire Revetment 6,600 l.f. @ $17. | 112,200 | |
| Vegetation-Trees 3,300 l.f. @ $.20 | 700 | |
| Side Drainage Inlets 32 @ Varying Costs | 12,100 | |
| Maintenance Road 38,800 l.f. @ $.10 | 3,900 | |
| Grade Stabilization Structures 428 c.y. @ $20. | 8,600 | |
| Rectangular Concrete Lining 688 c.y. @ $80. | 55,000 | |
| Trapezoidal Concrete Lining 13,237 c.y. @ $40. | 529,500 | |
| Concrete Fish Channel 1,393 c.y. @ $100. | 139,300 | |
| Fish Channel Baffles | 6,700 | |
| Gravel Drain 12,774 c.y. @ $3.25 | 41,500 | |
| Replace Railroad Bridge | 100,000 | |
| Total Contract Cost | | $1,588,700 |
| Contingencies @ 15% | | 238,300 |
| Total Construction Cost | | 1,827,000 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 456,800 |
| Hydraulic Model Test | | 15,000 |
| **Total Federal Cost** | | $2,298,800 |
| **Non-Federal Costs** | | |
| Rights-of-Way 21.4 acres @ $500. | $ 10,700 | |
| 9.4 acres @ $1,000. | 9,400 | |
| 32.5 acres @ $1,500. | 48,800 | |
| Sub-total | | $ 68,900 |
| R/W Acquisition @ 15% | | 10,300 |
| Relocation of Utilities | | 21,800 |
| Chain Link Fence 1,300 l.f. @ $1.85 plus 15% contingencies | | 2,800 |
| Administration of Contract @ 1% | | 18,300 |
| **Total Non-Federal Cost** | | $ 122,100 |
| **Total Installation Cost** | | $2,420,900 |
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 85,400 | |
| Annual O & M Cost | 24,600 | |
| Total Annual Cost | $ 110,000 | |

TABLE C - CONTINUED

Matanzas Creek Channel Improvement

| | | |
|---|---|---|
| **Federal Costs** | | |
| Clearing 9,900 l.f. @ $1. | $ 9,900 | |
| Shaping 11,400 s.y. @ $.35 | 4,000 | |
| Excavation 18,900 c.y. @ $.60 | 11,300 | |
| Compacted Fill 17,600 c.y. @ $.50 | 8,800 | |
| Toe Riprap 11,730 c.y. @ $8. | 93,800 | |
| Bank Riprap 4,340 c.y. @ $8. | 34,700 | |
| Filter Blanket for Riprap 5,400 c.y. @ $3. | 16,200 | |
| Vegetation 7.6 acres @ $1,500. | 11,400 | |
| Side Drainage Inlets 20 @ Varying Costs | 1,300 | |
| Maintenance Road 14,000 l.f. @ $.10 | 1,400 | |
| Gravel Drain 1,050 c.y. @ $3.25 | 3,400 | |
| Trapezoidal Concrete Lining 2,240 c.y. @ $40. | 89,600 | |
| Rectangular Concrete Lining 495 c.y. @ $80. | 39,600 | |
| Total Contract Cost | | $ 325,400 |
| Contingencies @ 15% | | 48,800 |
| Total Construction Cost | | 374,200 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 93,600 |
| Hydraulic Model Studies | | 5,000 |
| **Total Federal Cost** | | $ 472,800 |
| **Non-Federal Costs** | | |
| Rights-of-Way 28.8 acres @ $1,650. | | $ 47,500 |
| R/W Acquisition @ 15% | | 7,100 |
| Relocation of Utilities | | 4,800 |
| Chain Link Fence 720 l.f. @ $1,85 plus 15% contingencies | | 1,500 |
| Administration of Contract @ 1% | | 3,700 |
| **Total Non-Federal Cost** | | $ 64,600 |
| **Total Installation Cost** | | $ 537,400 |

| | | |
|---|---|---|
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 18,900 | |
| Annual O & M Cost | 5,100 | |
| Total Annual Cost | $ 24,000 | |

TABLE C - CONTINUED

Piner Creek Channel Improvement

Federal Cost

| | | |
|---|---|---|
| Clearing 36,920 l.f. @ $1. | $ 36,900 | |
| Excavation 279,000 c.y. @ $.60 | 167,400 | |
| Compacted Fill 17,600 c.y. @ $.50 | 8,800 | |
| Railroad Trestle Replacement 78 l.f. @ $200. | 15,600 | |
| Bank Riprap 4,510 c.y. @ $8. | 36,100 | |
| Toe Riprap 31,760 c.y. @ $8. | 254,100 | |
| Filter Blanket for Rock Riprap 12,100 c.y. @ $3. | 36,300 | |
| Vegetation 27.4 acres @ $1,500. | 41,100 | |
| Side Drainage Inlets 75 @ Varying Costs | 25,000 | |
| Maintenance Road 51,300 l.f. @ $.10 | 5,100 | |
| Grade Stabilization Structures 60 c.y. @ $20. | 1,200 | |
| Total Contract Cost | | $ 627,600 |
| Contingencies @ 15% | | 94,100 |
| Total Construction Cost | | 721,700 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 180,400 |
| Total Federal Cost | | $ 902,100 |

Non-Federal Costs

| | |
|---|---|
| Rights-of-Way 70.8 acres @ $600. | 42,500 |
| R/W Acquisition @ 15% | 6,400 |
| Bridges | 177,400 |
| Relocation of Utilities | 16,900 |
| Administration of Contract @ 1% | 7,200 |
| Total Non-Federal Cost | $ 250,400 |

Total Installation Cost $1,152,500

| | |
|---|---|
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 40,600 |
| Annual O & M Cost | 17,200 |
| Total Annual Cost | $ 57,800 |

TABLE C - CONTINUED

Brush Creek Channel Improvement

Federal Costs

| | | |
|---|---|---|
| Clearing 39,250 l.f. @ $1. | $ 39,300 | |
| Excavation 298,250 c.y. @ $.60 | 179,000 | |
| Compacted Fill 33,000 c.y. @ $.50 | 16,500 | |
| Bank Riprap 7,260 c.y. @ $8. | 58,100 | |
| Toe Riprap 34,220 c.y. @ $8. | 273,800 | |
| Filter Blanket for Rock Riprap 13,800 c.y. @ $3. | 41,400 | |
| Vegetation 24.8 acres @ $1,500. | 37,200 | |
| Side Drainage Inlets 79 @ Varying Costs | 25,800 | |
| Grade Stabilization Structures 304 c.y. @ $20. | 6,100 | |
| Maintenance Road 48,100 l.f. @ $.10 | 4,800 | |
| Total Contract Cost | | $ 682,000 |
| Contingencies @ 15% | | 102,300 |
| Total Construction Cost | | 784,300 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 196,100 |
| Total Federal Cost | | $ 980,400 |

Non-Federal Costs

| | |
|---|---|
| Rights-of-Way 71.1 acres @ $1,200. | $ 85,300 |
| R/W Acquisition @ 15% | 12,800 |
| Relocation of Utilities | 8,300 |
| Bridges | 154,900 |
| Administration of Contract @ 1% | 7,800 |
| Total Non-Federal Cost | $ 269,100 |
| Total Installation Cost | $1,249,500 |

| | |
|---|---|
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 44,100 |
| Annual O & M Cost | 17,900 |
| Total Annual Cost | $ 62,000 |

TABLE C - CONTINUED

Spring Creek Channel Improvement

Federal Cost

| | | |
|---|---|---|
| Clearing 10,160 l.f. @ $1. | $ 10,200 | |
| Excavation 23,500 c.y. @ $.65 | 15,300 | |
| Bank Riprap 315 c.y. @ $8. | 2,500 | |
| Toe Riprap 1,620 c.y. @ $8. | 13,000 | |
| Filter Blanket for Riprap 600 c.y. @ $3. | 1,800 | |
| Vegetation 6.1 acres @ $1,500. | 9,200 | |
| Side Inlets 20 @ Varying Costs | 2,500 | |
| Maintenance Road 10,200 l.f. @ $.10 | 1,000 | |
| Total Contract Cost | | $ 55,500 |
| Contingencies @ 15% | | 8,300 |
| Total Construction Cost | | 63,800 |
| Installation Services | | |
| Engineering, Administration & Misc. @ 25% | | 16,000 |
| Total Federal Cost | | $ 79,800 |

Non-Federal Cost

| | | |
|---|---|---|
| Rights-of-Way 9.7 acres @ $1,650. | $ 16,000 | |
| 4.5 acres @ $1,350. | 6,100 | |
| Sub-total | | $ 22,100 |
| R/W Acquisition @ 15% | | 3,300 |
| Bridges | | 43,200 |
| Administration of Contract @ 1% | | 600 |
| Total Non-Federal Cost | | $ 69,200 |
| Total Installation Cost | | $ 149,000 |

| | |
|---|---|
| Annual Cost (50-yr. amort. @ 2½% interest) | $ 5,300 |
| Annual O & M Cost | 1,700 |
| Total Annual Cost | $ 7,000 |

TABLE D - BRIDGE REPLACEMENT DATA *

| Channel | Station | Road | Present Structure | Replacement with Equivalent Bridge: Deck Length (ft.) | Deck Width (ft.) | Cost/ sq.ft. ($) | Cost ($) | Bridge 28' wide** Cost ($) |
|---|---|---|---|---|---|---|---|---|
| **Santa Rosa Creek Channel Improvement - Lower Reach** | | | | | | | | |
| Santa Rosa Creek | 384+10 | Private | Wood (Removable) | 102 | 8 | 15 | 12,200 | |
| | 434+10 | Willowside | Wood Truss | 154 | 28 | 20 | 86,300 | |
| | 463+40 | Private | Wood Deck | 154 | 10 | 15 | 23,100 | |
| | 527+40 | Private | Wood (Removable) | 154 | 10 | 15 | 23,100 | |
| | 569+65 | Fulton | Concr. Br. | 48*** | 28 | 20 | 26,900 | |
| Channel #3 | 461+20 | Private | Concr. Br. | 54 | 8 | 15 | 6,500 | |
| | 466+00 | Private | Concr. Br. | 54 | 10 | 15 | 8,100 | |
| | 471+00 | Private | Wood Deck | 54 | 10 | 10 | 5,400 | |
| | 485+30 | Guerneville | Concr. Br. | 54 | 20 | 20 | 21,600 | 30,200 |
| Channel #4 | 523+60 | Guerneville | Concr. Br. | 32 | 20 | 20 | 12,800 | 17,900 |
| | 523+50 | Private | Wood Deck | 27 | 8 | 10 | 2,200 | |
| Channel #5 | 535+50 | Private | Wood Deck | 27 | 8 | 10 | 2,200 | |
| Channel #6 (Piner Cr.) | 562+40 | Fulton | Wood Deck | 60 | 16 | 20 | 19,200 | 33,600 |
| | | | | Subtotal | | | 249,600 | 277,700 |
| **Santa Rosa Creek Reservoir & Diversion** | | | | | | | | |
| Diversion Channel | | Private | None | 100 | 15 | 15 | 22,500 | |
| | | Montgomery | None | 170 | 20 | 20 | 68,000 | 95,000 |
| | | Montgomery | None | 125 | 20 | 20 | 50,000 | 70,000 |
| | | Montgomery | Concr. Culv. | (dbl. 4'x6'x50' RCB) | | | 6,300 | |
| | | Private | Concr. Pipe | (dbl. 4'x6'x20' RCB) | | | 2,500 | |
| | | | | Subtotal | | | 149,300 | 196,300 |
| **Piner Creek Channel Improvement** | | | | | | | | |
| Channel #6 | 574+00 | Private-Velma Ave. | Wood Truss | 60 | 8 | 15 | 7,200 | |
| | 579+40 | Private | Wood Deck | 60 | 8 | 15 | 7,200 | |
| | 595+30 | Guerneville | Concr. Br. | 60 | 28 | 20 | 33,600 | |
| | 639+20 | Marlow | Wood Deck | 45 | 16 | 20 | 14,400 | 25,200 |
| | 647+90 | Private | Wood Deck | 46 | 8 | 10 | 3,700 | |
| | 659+80 | Private | Wood Deck | 42 | 8 | 10 | 3,400 | |
| | 672+00 | Coffey Ln. | Concr. Box | 43 | 16 | 20 | 13,800 | 24,100 |
| | 717+30 | Private | Wood Deck | 36 | 10 | 10 | 3,600 | |
| Channel #6-C | 630+50 | Marlow | Concr. Br. | 42 | 16 | 20 | 13,400 | 23,500 |
| | 647+30 | Steele Ln. | Concr. Box | 40 | 16 | 20 | 12,800 | 22,400 |
| | 650+30 | Private | Wood Deck | 39 | 8 | 10 | 3,100 | |

* Railroad bridges not included.
** Last column represents the cost of rebuilding the bridges to current standards for 2 lane bridges.
*** Two 24' long approach spans to existing 60' span.

TABLE D - Continued

| Channel | Station | Road | Present Structure | Replacement with Equivalent Bridge: Deck Length (ft.) | Deck Width (ft.) | Cost/ sq.ft. ($) | Cost ($) | Bridge 28' Wide** Cost ($) |
|---|---|---|---|---|---|---|---|---|
| Piner Creek Channel Improvement (cont'd.) | | | | | | | | |
| | 655+70 | Private | Wood Deck | 39 | 10 | 10 | 4,000 | |
| | 662+60 | Private | Wood Deck | 40 | 8 | 10 | 3,200 | |
| | 715+50 | US 101 | Concr. Box | (dbl. 6'x8'x120' RCB) | | | 34,000 | |
| Channel #6-F | 736+00 | US 101 | CMP | (dbl. 3'x5'x120' RCB) | | | 20,000 | |
| | | | | Subtotal | | | 177,400 | 218,200 |
| Piner Creek Reservoir | | | | | | | | |
| Channel #6-C-3 | | Co. Farm | Concr.Br. | (triple 4'x8'x84'RCB) | | | 18,000 | |
| | | | | Subtotal | | | 18,000 | 18,000 |
| Brush Creek Channel Improvement | | | | | | | | |
| Channel #40 | 919+00 | Hwy #12 | Concr. Br. | 67 | 48 | 20 | 64,300 | |
| | 984+00 | Private | Wood Deck | 45 | 10 | 15 | 6,800 | |
| | 984+80 | Private | Wood Deck | 40 | 10 | 15 | 6,000 | |
| | 1033+60 | Private | Wood Deck | 39 | 10 | 10 | 3,900 | |
| | 1046+80 | Private | Wood Deck | 39 | 10 | 10 | 3,900 | |
| | 1065+00 | Private | Wood Deck | 39 | 10 | 10 | 3,900 | |
| | 1070+40 | Private | Wood Deck | 33 | 10 | 10 | 3,300 | |
| | 1106+60 | Private | Wood Deck | 28 | 10 | 10 | 2,800 | |
| | 1107+60 | Private | Wood Deck | 28 | 10 | 10 | 2,800 | |
| Channel #43 | 971+00 | Private | Wood Deck | 37 | 10 | 10 | 3,700 | |
| | 974+30 | Acacia Ln. | Wood Deck | 37 | 12 | 10 | 4,400 | 20,700 |
| | 995+40 | Mid.Rincon. | Concr. Box | 36 | 28 | 20 | 20,200 | |
| | 1016+70 | Private | Wood Deck | 32 | 10 | 10 | 3,200 | |
| | 1023+80 | Boas Dr. | CMP | 32 | 31 | 20 | 19,900 | |
| Channel #42 | 965+50 | Private | Wood Deck | 29 | 10 | 10 | 2,900 | |
| | 967+00 | Private | Wood Deck | 29 | 10 | 10 | 2,900 | |
| | | | | Subtotal | | | 154,900 | 171,200 |
| Brush Creek West Fork Reservoir | | | | | | | | |
| Spillway | | Riebli | None | 50 | 20 | 20 | 20,000 | 28,000 |
| | | | | Subtotal | | | 20,000 | 28,000 |

** Last column represents the cost of rebuilding the bridges to current standards for 2 lane bridges.

TABLE D - continued

| Channel | Station | Road | Present Structure | Replacement with Equivalent Bridge: Deck Length (ft.) | Deck Width (ft.) | Cost/ sq.ft. ($) | Cost ($) | Bridge 28' Wide** Cost ($) |
|---|---|---|---|---|---|---|---|---|
| Spring Creek Channel Improvement | | | | | | | | |
| Spring Cr. (#7) | 877+40 | Yulupa | Wood Deck | 40 | 20 | 20 | 16,000 | 22,400 |
| | 911+00 | Private | Wood Deck | 28 | 10 | 10 | 2,800 | |
| | 912+60 | Summerfield | Wood Deck | 28 | 12 | 15 | 5,000 | 15,680 |
| | 920+40 | Private | Wood Deck | 27 | 15 | 15 | 6,100 | |
| | 931+10 | Private | Wood Deck | 27 | 8 | 10 | 2,200 | |
| | 932+20 | Private | Wood Deck | 27 | 10 | 10 | 2,700 | |
| Channel #7-D | 891+40 | Mayette | Wood Deck | 29 | 10 | 15 | 4,400 | 16,200 |
| | 900+60 | Hoen | Wood Deck | 27 | 10 | 15 | 4,000 | 15,100 |
| | | | | Subtotal | | | 43,200 | 83,100 |
| Spring Creek Reservoir | | | | | | | | |
| Spring Cr. | | Private | Wood Deck | (4'x6'x12'RCB) | | | 1,000 | |
| | | | | Subtotal | | | 1,000 | 1,000 |
| Total Cost of Bridge Replacement | | | | | | | 813,400 | 993,500 |

** Last column represents the cost of rebuilding the bridges to current standards for 2 lane bridges.

# SUPPORTING TABLES

## TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of work plan preparation)

Central Sonoma Watershed Project - California

| Measures | Unit | Applied to date | Total Cost* |
|---|---|---|---|
| LAND TREATMENT ** | | | |
| Conversion - Cropland to grassland *** | acres | 3,624 | - |
| Pasture and range seeding | acres | 5,152 | 47,000 |
| Fertilizing (pasture & range) | " | 1,522 | 11,400 |
| Channel improvement | Lin. ft. | 25,600 | 25,600 |
| Revetments | " " | 1,450 | 7,300 |
| Sediment Dams | No. | 13 | 2,000 |
| Diversion ditches | Miles | 2 | 1,500 |
| Stock ponds | No. | 26 | 7,800 |
| Spring Development | No. | 13 | 1,300 |
| Fencing | Rods | 2,660 | 3,300 |
| Subsoiling | Acres | 300 | 1,100 |
| Irrigation Dams (No. 18) | Ac. ft. | 1,600 | 20,800 |
| Cover Cropping | Acres | 876 | 3,300 |
| Irrigation facilities | Acres | 390 | 20,500 |
| Fire prevention measures | " | (unevaluated) | 20,500 |
| Subtotal | | | 152,900 |
| STRUCTURAL MEASURES | | | |
| Channel improvement revetment, riprap, levees and similar works installed by public and private agencies but excluding on-farm measures. | | | 300,900 |
| Subtotal | | | 300,900 |
| TOTAL | | | 453,800 |

* Price base, 1957.

** Only those Santa Rosa Soil Conservation District land treatment measures are tabulated that have values in reducing floodwater and sediment damage. Figures for comparable non-district farm measures are not available but are estimated to be in excess of 50,000 dollars in the last 10 years. Where measures are multi-purpose, the total costs have been reduced by estimation to show only floodwater and sediment prevention values: e.g., the total farmer cost of irrigation facilities is estimated at $136,5000, of which $20,480, or 15% is charged as a contribution to flood prevention, a similar charge of 10% was estimated for irrigation reservoirs and 50% for cover cropping, fertilizing, pasture seeding and similar practices.

*** Costs are included in pasture seeding and fertilizing.

February, 1958

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Central Sonoma Watershed Project, California

(Dollars) *

| Structure Identification | Public Law 566 Installation Cost | | | | | Other Installation Cost | | | Estimated Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | Construction | | Installation Services | | Total Federal | | | Total Non-Federal | |
| | Engineer's Estimate | Contingencies | Engineering ** | Other | | Admins. of Contracts | Easements & R/W *** | | |
| UNIT AB - SANTA ROSA CREEK | | | | | | | | | |
| Floodwater Retarding Reservoir & Diversion | 676,100 | 101,400 | 149,600 | 77,800 | 1,004,900 | 7,800 | 327,900 | 335,700 | 1,340,600 |
| Channel Improvement, Lower Reach | 1,738,900 | 260,800 | 299,900 | 200,000 | 2,499,600 | 20,000 | 497,200 | 517,200 | 3,016,800 |
| Channel Improvement, City | 1,588,700 | 238,300 | 289,100 | 182,700 | 2,298,800 | 18,300 | 103,800 | 122,100 | 2,420,900 |
| Sub-total | 4,003,700 | 600,500 | 738,600 | 460,500 | 5,803,300 | 46,100 | 928,900 | 975,000 | 6,778,300 |
| UNIT C - MATANZAS CREEK | | | | | | | | | |
| Floodwater Retarding Reservoir & Sediment Stabilization Structure | 555,900 | 83,400 | 100,900 | 63,900 | 804,100 | 6,400 | 98,100 | 104,500 | 908,600 |
| Channel Improvement | 325,400 | 48,800 | 61,200 | 37,400 | 472,800 | 3,700 | 60,900 | 64,600 | 537,400 |
| Sub-total | 881,300 | 132,200 | 162,100 | 101,300 | 1,276,900 | 10,100 | 159,000 | 169,100 | 1,446,000 |
| UNIT D - PINER CREEK | | | | | | | | | |
| Floodwater Retarding Reservoir | 86,200 | 12,900 | 17,900 | 9,900 | 126,900 | 1,300 | 114,300 | 115,600 | 242,500 |
| Channel Improvement | 627,600 | 94,100 | 108,200 | 72,200 | 902,100 | 7,200 | 243,200 | 250,400 | 1,152,500 |
| Sub-total | 713,800 | 107,000 | 126,100 | 82,100 | 1,029,000 | 8,500 | 357,500 | 366,000 | 1,395,000 |
| UNIT E - BRUSH CREEK | | | | | | | | | |
| Middle Fork Floodwater Retarding Reservoir | 123,400 | 18,500 | 24,300 | 14,200 | 180,400 | 1,400 | 58,800 | 60,200 | 240,600 |
| West Fork Floodwater Retarding Reservoir | 88,700 | 13,300 | 18,300 | 10,200 | 130,500 | 1,000 | 35,300 | 36,300 | 166,800 |
| Channel Improvement | 682,000 | 102,300 | 117,700 | 78,400 | 980,400 | 7,800 | 261,300 | 269,100 | 1,249,500 |
| Sub-total | 894,100 | 134,100 | 160,300 | 102,800 | 1,291,300 | 10,200 | 355,400 | 365,600 | 1,656,900 |
| UNIT F - SPRING CREEK | | | | | | | | | |
| Floodwater Retarding Reservoir | 259,900 | 39,000 | 49,800 | 29,900 | 378,600 | 3,000 | 19,600 | 22,600 | 401,200 |
| Channel Improvement | 55,500 | 8,300 | 9,600 | 6,400 | 79,800 | 600 | 68,600 | 69,200 | 149,000 |
| Sub-total | 315,400 | 47,300 | 59,400 | 36,300 | 458,400 | 3,600 | 88,200 | 91,800 | 550,200 |
| TOTAL | 6,808,300 | 1,021,100 | 1,246,500 | 783,000 | 9,858,900 | 78,500 | 1,889,000 | 1,967,500 | 11,826,400 |

* Price base, 1957

** Including hydraulic model studies and geologic investigations.

*** Including relocation of utilities, construction of safety fence, and State Dam Filing Fees.

## TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Central Sonoma Watershed Project, California

| ITEM | UNIT | STRUCTURE | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | | Santa Rosa Creek Reservoir | Matanzas Creek Reservoir | Piner Creek Reservoir | Brush Creek Middle Fork Revervoir | Brush Creek West Fork Reservoir | Spring Creek Reservoir | |
| Drainage Area | sq.mi. | 20.8 | 11.6 | 2.2 | 1.6 | 0.8 | 2.3 | 39.3 |
| Storage Capacity | | | | | | | | |
| Sediment | ac.ft. | 85 | 200 | 15 | 10 | 5 | 17 | 332 |
| Floodwater Detention | ac.ft. | 3415 | 1300 | 215 | 120 | 125 | 450 | 5625 |
| Total | ac.ft. | 3500 | 1500 | 230 | 130 | 130 | 467 | 5957 |
| Surface Area | | | | | | | | |
| Sediment Pool | ac. | 25 | 12 | 4 | 2 | 1.2 | 2.5 | 46.7 |
| Flood Det. Pool | ac. | 148 | 58 | 26 | 17 | 13 | 16 | 278 |
| Maximum Height of Dam | ft. | 45 | 90 | 40 | 33 | 39 | 80 | - |
| Volume of Fill | cu.yds. | 355000 | 215000 | 24200 | 46600 | 45800 | 130000 | 816600 |
| Emergency Spillway | | | | | | | | |
| Type | - | * | Channel | Channel | Channel | Channel | Channel | - |
| Frequency of use | Years | 100 | 100 | 100 | 100 | 100 | 100 | - |
| Design storm rainfall | | | | | | | | |
| Duration | Hours | 6 | 6 | 6 | 6 | 6 | 6 | - |
| Total | Inches | 9 | 9 | 9 | 9 | 9 | 9 | - |
| Bottom Width | ft. | - | 162 | 60 | 80 | 48 | 50 | - |
| Design depth | ft. | - | 11.2 | 7.0 | 5.3 | 5.3 | 7.5 | - |
| Design capacity | c.f.s | 25000 | 18400 | 3300 | 2900 | 1800 | 3500 | - |
| Total freeboard | ft. | 2.5 | 3.8 | 3.0 | 1.7 | 1.7 | 2.5 | - |
| Total capacity | c.f.s | 39000 plus | 28700 | 5500 | 4500 | 2700 | 5500 | - |
| Principal Spillway | | | | | | | | |
| Capacity | c.f.s | 400 | 1500 | 300 | 475 | 217 | 185 | - |
| Capacity Equivalents | | | | | | | | |
| Sediment volume | Inches | .08 | .32 | .13 | .12 | .12 | .14 | - |
| Detention volume | Inches | 3.1 | 2.1 | 1.8 | 1.5 | 2.9 | 3.7 | - |
| Spillway storage | Inches | 1.1 | 1.6 | 2.8 | 1.9 | 2.3 | 1.3 | - |
| Class of Structure ** | - | c | c | c | c | c | c | - |
| Flood Peak Reduction | | | | | | | | |
| Peak inflow (1% frequency) | c.f.s | 6120 | 5000 | 900 | 930 | 607 | 1015 | - |
| Peak outflow (design flood) | c.f.s | 1390*** | 1500 | 300 | 475 | 217 | 185 | - |

* Emergency spill is passed over crest of diversion dam and over bank of diversion channel.

** As defined in SCS Engineering Memorandum No. 3.

*** Includes bypassed flow at diversion dam, (See Fig. 10)

February 1958

## TABLE 3A - STRUCTURE DATA - CHANNELS

Central Sonoma Watershed Project, California

| Area & Channel | Station Numbering for Reach | Watershed Area (Sq. Mil.) | 1%-Frequency Peak Flow w/o Retarding Structures (cfs) | Design Flow w/Retarding Structures (cfs) | Type of Channel | Waterway Area (Sq. Ft.) | Velocity (Ft./Sec.) | Channel Gradient (Ft./Ft.) | Bottom Width (Ft.) | Water Depth (Ft.) |
|---|---|---|---|---|---|---|---|---|---|---|
| SANTA ROSA CREEK | | | | | | | | | | |
| Santa Rosa Creek | 344+30 to 434+10 | 76.75 | 17600 | 11020 | Sod | Varies | Varies* | 0.0015 | 70 | 5.4 to 13.0 |
| | 434+10 to 538+00 | 76.75 | 17600 | 11020 | Sod & Riprap | 1460 | 7.6 | 0.0015 | 80 | 13.0 |
| | 538+00 to 693+00 | 59.47 | 15620 | 8710 | Sod & Riprap | 970 | 9.0 | 0.0025 | 42 | 13.0 |
| | 693+00 to 695+00 | Transition | | | Riprap | | | | | |
| | 695+00 to 757+00 | 59.32 | 15550 | 8710 | Concrete Lined | 418 | 20.8 | 0.0036 | 33 | 9.0 |
| | 757+00 to 760+00 | Transition | | | Concrete | | | | | |
| | 760+00 to 764+50 | 33.47 | 9430 | 5140 | Concrete | 245 | 21.0 | 0.0046 | 24.5 | 10.0 |
| | 764+50 to 765+50 | Transition | | | Concrete | | | | | |
| | 765+50 to 770+00 | | | 5140 | Concrete Lined | 270 | 19.0 | 0.0038 | 16.5 | 9.0 |
| | 770+00 to 771+00 | Transition | | | Concrete Lined | | | | | |
| | 771+00 to 856+00 | | | 5140 | Sod & Riprap | 570 | 9.0 | 0.0039 | 20 | 12.5 |
| | 856+00 to 862+00 | Transition | | | Riprap | | | | | |
| | 862+00 to 905+00 | | | 5140 | Rail & Wire Revetment | 624 | 8.2 | 0.0022 | 78 | 8.0 |
| Channel #3 | 445+00 to 505+00 | 2.78 | 1020 | 1020 | Sod | 252 | 4.0 | 0.0013 | 30 | 6.0 |
| Channel #4 | 517+00 to 555+00 | 1.27 | 470 | 470 | Sod | 103 | 4.6 | 0.0028 | 16 | 4.2 |
| Channel #5 | 521+00 to 555+00 | 0.57 | 332 | 332 | Sod | 77 | 4.3 | 0.0028 | 10 | 4.2 |
| Channel #10 | 435+00 to 465+00 | 1.05 | 450 | 450 | Sod | 79 | 5.4 | 0.0040 | 14 | 3.7 |
| | 465+00 to 530+10 | | | 300 | Sod | 54 | 5.6 | 0.0040 | 12 | 3.0 |
| MATANZAS CREEK | | | | | | | | | | |
| Matanzas Creek | 760+00 to 763+00 | 22.51 | 7270 | 3900 | Concrete | 185 | 21.0 | 0.0054 | 18.5 | 10.0 |
| | 763+00 to 764+00 | Transition | | | Concrete | | | | | |
| | 764+00 to 779+00 | | | 3900 | Concrete Lined | 226 | 17.5 | 0.0035 | 10.0 | 9.4 |
| | 779+00 to 780+00 | Transition | | | Concrete Lined | | | | | |
| | 780+00 to 800+00 | | | 3900 | Sod & Riprap | 488 | 8.0 | 0.0027 | 20 | 11.4 |
| | 800+00 to 860+00 | 15.95 | 5590 | 2560 | Sod & Riprap | 342 | 7.5 | 0.0050 | 20 | 9.0 |

* Velocity in Santa Rosa Creek, Sta. 344+30 to 434+10: Main Channel 4.6 to 7.9 fps.
Overflow Area 1.6 to 4.2 fps.

TABLE 3A - CONTINUED

| Area & Channel | Station Numbering for Reach | Watershed Area (Sq. Mi.) | 1%-Frequency Peak Flow w/o Retarding Structures (cfs) | Design Flow w/Retarding Structures (cfs) | Type of Channel | Waterway Area (Sq.Ft.) | Velocity (Ft./Sec.) | Channel Gradient (Ft./Ft.) | Bottom Width (Ft.) | Water Depth (Ft.) |
|---|---|---|---|---|---|---|---|---|---|---|
| PINER CREEK | | | | | | | | | | |
| Channel #6 | 538+00 to 562+40 | 13.45 | 4390 | 3990 | Sod & Riprap | 546 | 7.3 | 0.0021 | 16 | 13 |
| | 562+40 to 615+40 | 10.95 | 3622 | 3212 | Sod & Riprap | 468 | 6.9 | 0.0020 | 16 | 11.8 |
| | 615+40 to 647+90 | 4.34 | 1728 | 1728 | Sod & Riprap | 251 | 6.9 | 0.0031 | 12 | 8.6 |
| | 647+90 to 672+00 | 3.59 | 1435 | 1435 | Sod & Riprap | 198 | 7.3 | 0.0040 | 12 | 7.4 |
| | 672+00 to 676+00 | | | 1240 | Sod | 198 | 6.3 | 0.0030 | 12 | 7.4 |
| | 676+00 to 724+00 | | | 850 | Sod | 152 | 5.6 | 0.0030 | 12 | 6.2 |
| | 724+00 to 740+00 | 0.99 | 470 | 470 | Sod | 97 | 4.8 | 0.0030 | 10 | 4.9 |
| Channel #6-C | 615+40 to 646+00 | 5.00 | 1960 | 1500 | Sod & Riprap | 211 | 7.1 | 0.0037 | 12 | 7.7 |
| | 646+00 to 700+00 | | | 1200 | Sod & Riprap | 170 | 7.1 | 0.0043 | 12 | 6.7 |
| | 700+00 to 727+00 | | | 900 | Sod | 153 | 5.9 | 0.0031 | 10 | 6.6 |
| | 727+00 to 743+20 | 1.34 | 610 | 610 | Sod | 146 | 4.2 | 0.0017 | 10 | 6.4 |
| Channel #6-C-3 | 727+00 to 736+40 | 2.57 | 1035 | 505 | Sod | 64 | 7.9 | 0.0104 | 10 | 3.7 |
| Channel #6-F | 675+00 to 736+00 | 0.97 | 464 | 464 | Sod | 112 | 4.2 | 0.0020 | 10 | 5.4 |
| BRUSH CREEK | | | | | | | | | | |
| Channel #40 | 905+00 to 958+00 | 9.92 | 4270 | 3730 | Sod & Riprap | 495 | 7.5 | 0.0024 | 20 | 11.5 |
| | 958+00 to 994+50 | 5.76 | 2370 | 1830 | Sod & Riprap | 223 | 8.2 | 0.0049 | 16 | 7.3 |
| | 994+50 to1069+40 | 3.37 | 1585 | 1305 | Sod & Riprap | 145 | 9.0 | 0.0092 | 16 | 5.4 |
| | 1069+40 to1102+70 | 2.54 | 1290 | 973 | Sod | 108 | 9.0 | 0.0141 | 12 | 5.0 |
| | 1102+70 to1115+50 | 1.10 | 730 | 360 | Sod | 40 | 9.0 | 0.0200 | 10 | 2.6 |
| Channel #41 | 994+50 to1004+40 | 1.81 | 1020 | 600 | Sod | 88 | 6.8 | 0.0063 | 10 | 4.6 |
| | 1004+40 to1029+80 | | | 550 | Sod | 72 | 7.6 | 0.0097 | 10 | 3.9 |
| | 1029+80 to1054+50 | | | 500 | Sod | 64 | 7.8 | 0.0102 | 10 | 3.7 |
| Channel #42 | 963+50 to 990+50 | 1.56 | 650 | 650 | Sod | 91 | 7.1 | 0.0068 | 10 | 4.7 |
| | 990+50 to 997+50 | | | 370 | Sod | 59 | 6.3 | 0.0068 | 8 | 3.8 |
| Channel #42-A | 990+50 to1000+50 | 0.68 | 370 | 370 | Sod | 58 | 6.0 | 0.0063 | 8 | 3.9 |
| Channel #43 | 958+00 to 963+50 | 4.16 | 1838 | 1838 | Sod & Riprap | 204 | 9.0 | 0.0071 | 14 | 7.2 |
| | 963+50 to 989+00 | 2.60 | 1300 | 1300 | Sod & Riprap | 150 | 8.7 | 0.0071 | 12 | 6.2 |
| | 989+00 to1013+00 | | | 1160 | Sod & Riprap | 142 | 8.5 | 0.0071 | 12 | 5.9 |
| | 1013+00 to1037+30 | | | 1012 | Sod & Riprap | 111 | 9.0 | 0.0101 | 10 | 5.4 |

TABLE 3A - CONTINUED

| Area & Channel | Station Numbering For Reach | Watershed Area (Sq. Mi.) | 1%-Frequency Peak Flow w/o Retarding Structures (cfs) | Design Flow w/Retarding Structures (cfs) | Type of Channel | Waterway Area (Sq.Ft.) | Velocity (Ft./Sec.) | Channel Gradient (Ft./Ft.) | Bottom Width (Ft.) | Water Depth (Ft.) |
|---|---|---|---|---|---|---|---|---|---|---|
| SPRING CREEK | | | | | | | | | | |
| Spring Creek | 867+00 to 880+00 | 5.75 | 1850 | 1220 | Sod & Riprap | 174 | 7.0 | 0.0041 | 12 | 6.8 |
| | 880+00 to 888+00 | 3.96 | 1355 | 665 | Sod | 139 | 4.8 | 0.0023 | 10 | 6.2 |
| | 888+00 to 904+70 | 3.38 | 1320 | 640 | Sod | 113 | 5.7 | 0.0036 | 10 | 5.4 |
| | 904+70 to 913+70 | 3.25 | 1270 | 620 | Sod | 80 | 7.8 | 0.0088 | 10 | 4.3 |
| | 913+70 to 935+00 | | | 600 | Sod | 75 | 8.1 | 0.0101 | 10 | 4.1 |
| Channel #7D | 880+00 to 900+60 | 1.11 | 567 | 567 | Sod | 103 | 5.5 | 0.0036 | 10 | 5.1 |
| | 900+60 to 916+00 | | | 550 | Sod | 80 | 6.9 | 0.0071 | 10 | 4.3 |

## TABLE 4 - SUMMARY OF PHYSICAL DATA

Central Sonoma Watershed Project, California

| Item | Unit | Quantity Without Project | Quantity With Project |
|---|---|---|---|
| Watershed area | Sq. mi. | 80 | - |
| Watershed area | Ac. | 50,000 | - |
| Area in Federal Ownership | Ac. | 0 | - |
| Area of Cropland | Ac. | 9,610 | * |
| Area of Grassland | Ac. | 28,100 | * |
| Area of Woodland & Brush | Ac. | 5,870 | * |
| Area of Urban & Misc. | Ac. | 6,420 | * |
| Overflow area subject to damage at 1% frequency | Ac. | 3,377 | 23 |
| Av. ann. equiv. area damaged by | | | |
| Floodwater & sediment | Ac. | 360 | 1 |
| Streambank erosion | Ac. | .925 | .411 |
| Av. annual rainfall | In. | 30 | - |

* The land use acreages will change gradually in the direction of urbanization, but not as a direct result of the project.

February, 1958

## TABLE 5 - SUMMARY OF PLAN DATA

Central Sonoma Watershed Project, California

| Item | Unit | Quantity |
|---|---|---|
| Years to complete program | Year | 6 |
| Total Installation Cost | | |
| Public Law 566 funds | Dollar | 9,858,900 |
| Other | Dollar | 1,967,500 |
| Annual O & M Cost | | |
| Federal | Dollar | 0 |
| Non-Federal | Dollar | 130,200 |
| Average Annual Monetary Benefits | Dollar | 705,500 |
| Agricultural | Percent | 1 |
| Non-Agricultural | Percent | 99 |
| Structural Measures | | |
| Floodwater retarding structures | Each | 6 |
| Channel improvement | Miles | 33.6 |
| Area Inundated by Structures Upland | | |
| Detention pool | Acres | 278 |
| Sediment pool | Acres | 47 |
| Watershed Area Above Structures | Sq. Mi. | 39.3 |
| Reduction of Floodwater Damage | Dollar | 699,600 |
| By land treatment measures | Percent | 0 |
| By structural measures | Percent | 100 |
| Reduction of Sediment Damage | Dollar | 3,700 |
| By land treatment measures | Percent | 0 |
| By structural measures | Percent | 100 |
| Reduction of Erosion Damages | Dollars | 2,200 |
| By land treatment measures | Percent | 0 |
| By structural measures | Percent | 100 |

April, 1958

TABLE 6 - ANNUAL COSTS

Central Sonoma Watershed Project, California

(Dollars)*

| Measures | Amortization of Installation Costs ** | Operation & Main. (Non-Fed.) *** | Total |
|---|---|---|---|
| UNIT AB | | | |
| Santa Rosa Creek Channel Improvement & Floodwater Retarding Struc. | 239,100 | 81,400 | 320,500 |
| UNIT C | | | |
| Matanzas Creek Channel Improvement & Floodwater Retarding Structure | 50,900 | 8,900 | 59,800 |
| UNIT D | | | |
| Piner Creek Channel Improvement & Floodwater Retarding Structure | 49,200 | 17,700 | 66,900 |
| UNIT E | | | |
| Brush Creek Channel Improvement & Floodwater Retarding Structures | 58,500 | 19,000 | 77,500 |
| UNIT F | | | |
| Spring Creek Channel Improvement & Floodwater Retarding Structure | 19,400 | 3,200 | 22,600 |
| TOTAL | 417,100 | 130,200 | 547,300 |

* Price base, 1957.
** Amortized over 50-year period at 2½% interest.
*** Computed at long-term projected prices by application of factor 0.97.

April 1958

## TABLE 7 - MONETARY BENEFITS FROM STRUCTURAL MEASURES FOR FLOOD PREVENTION*

Central Sonoma Watershed Project - California

(Dollars)**

| Item | Estimated Av. Ann. Damage W/O Project | Estimated Av. Ann. Damage W/ Project | Av. Ann. Monetary Benefits |
|---|---|---|---|
| Floodwater damage | | | |
| Agricultural | 3,900 | 100 | 3,800 |
| Non-agricultural | | | |
| Urban | 590,300 | 1,100 | 589,200 |
| Road | 4,600 | 0 | 4,600 |
| Sub-total | 598,800 | 1,200 | 597,600 |
| Sediment damage | | | |
| Deposition | 3,200 | 0 | 3,200 |
| Erosion | | | |
| Streambank | 3,300 | 1,400 | 1,900 |
| Indirect damage | 103,200 | 400 | 102,800 |
| Total, all damage | 708,500 | 3,000 | 705,500 |
| TOTAL PRIMARY BENEFITS | | | 705,500 |

* The project work plan does not specify installation of land treatment measures in addition to those already installed.

** Price base: 1956 adjusted to long term.

## TABLE 8 - BENEFIT COST ANALYSIS

Central Sonoma Watershed Project, California
(Dollars)*

| Measures | Av. Ann. Primary Flood Prevention Benefits | | | | | Average Annual Cost | Benefits Cost Ratio |
|---|---|---|---|---|---|---|---|
| | Floodwater | Sediment | Erosion | Indirect | Total | | |
| UNIT AB | | | | | | | |
| Santa Rosa Cr. Channel Improvement & Floodwater Retarding Structure | 357,300 | 800 | 1,400 | 60,700 | 420,200 | 320,500 | 1.3 |
| UNIT C | | | | | | | |
| Matanzas Cr. Channel Improvement & Floodwater Retarding Structure | 62,500 | 200 | 0 | 9,900 | 72,600 | 59,800 | 1.2 |
| UNIT D | | | | | | | |
| Piner Cr. Channel Improvement & Floodwater Retarding Structure | 68,900 | 1,700 | 0 | 13,100 | 83,700 | 66,900 | 1.3 |
| UNIT E | | | | | | | |
| Brush Cr. Channel Improvement & Floodwater Retarding Structures | 84,800 | 200 | 500 | 15,300 | 100,800 | 77,500 | 1.3 |
| UNIT F | | | | | | | |
| Spring Cr. Channel Improvement & Floodwater Retarding Structure | 24,100 | 300 | 0 | 3,800 | 28,200 | 22,600 | 1.2 |
| PROJECT TOTAL | 597,600 | 3,200 | 1,900 | 102,800 | 705,500 | 547,300 | 1.3 |

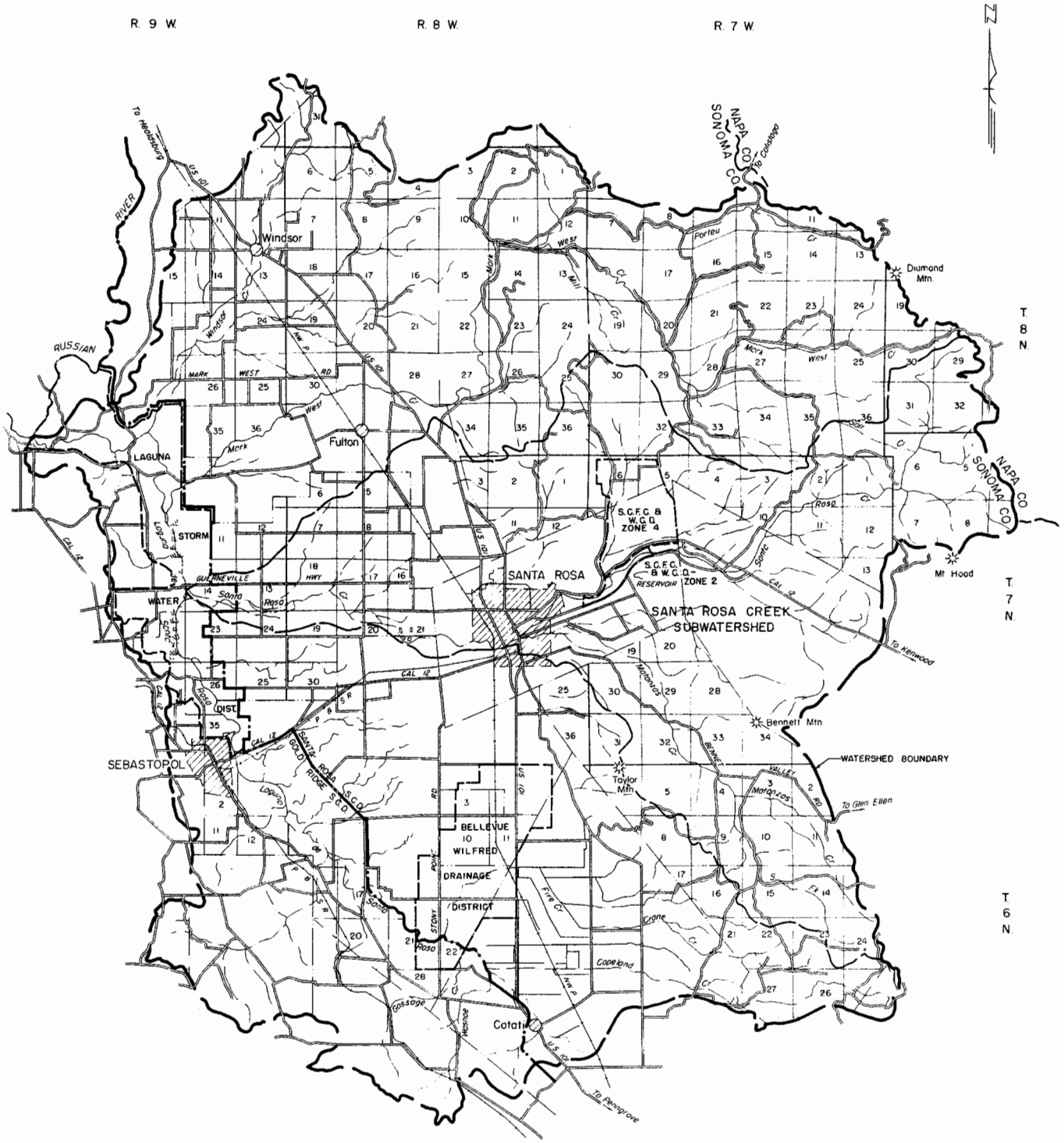
* Price base: Costs, 1957; Benefits, long term.

TABLE 9 - COST SHARING SUMMARY

Central Sonoma Watershed Project, California

| Type of Cost | P.L. 566 Funds Dollars | % | Other Dollars | % | Total Cost Dollars | % |
|---|---|---|---|---|---|---|
| Structural Measures Installation Flood Prevention | 9,858,900 | 83 | 1,967,500 | 17 | 11,826,400 | 76 |
| Total Installation Cost | 9,858,900 | 83 | 1,967,500 | 17 | 11,826,400 | 76 |
| Operation & Maintenance | 0 | 0 | 3,692,800 | 100 | 3,692,800 | 24 |
| Total Structural Cost | 9,858,900 | 64 | 5,660,300 | 36 | 15,519,200 | 100 |
| TOTAL PROJECT COST | 9,858,900 | 64 | 5,660,300 | 36 | 15,519,200 | 100 |

# MAPS AND DRAWINGS




MAP NO. 1

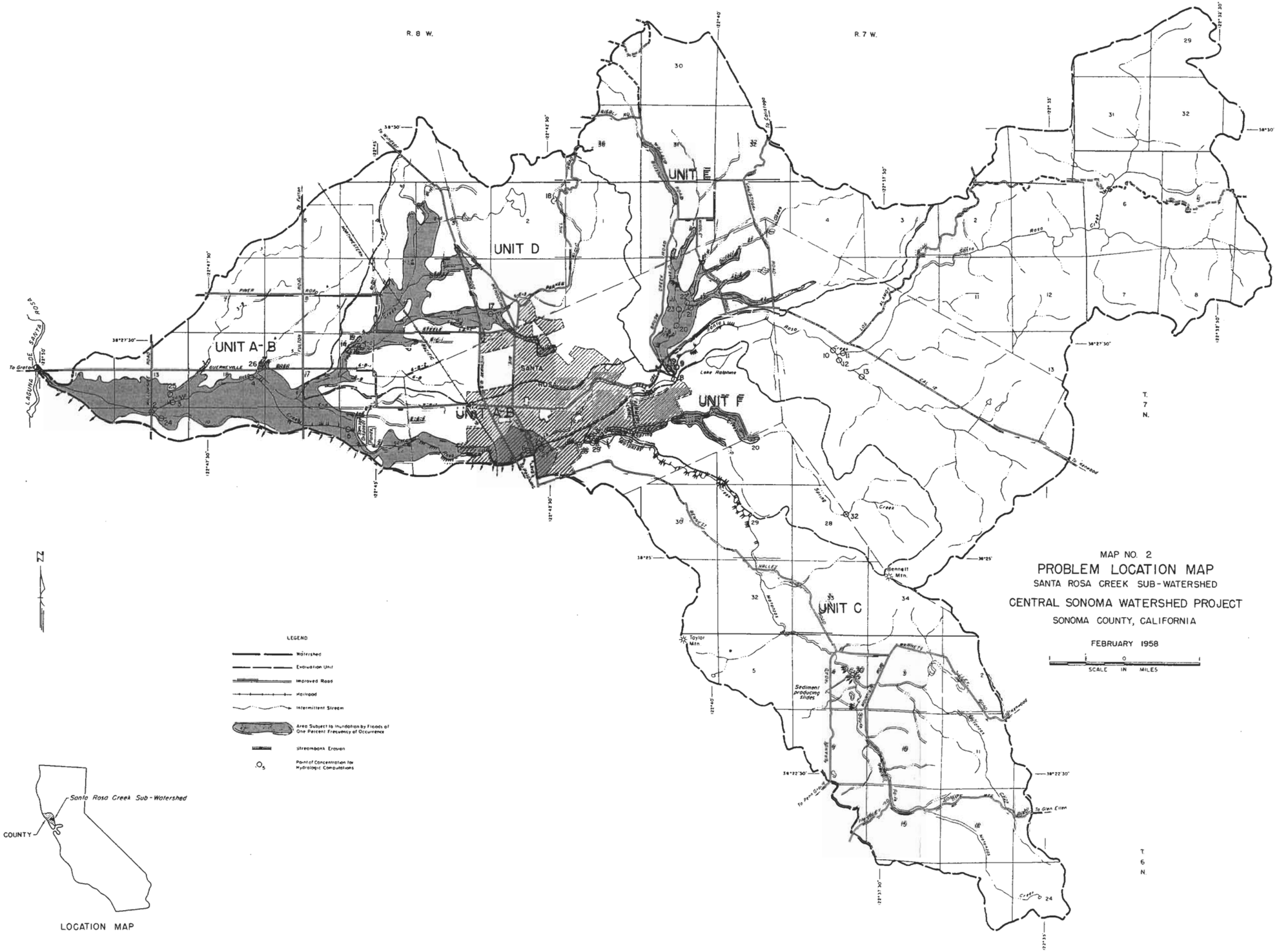
# CENTRAL SONOMA WATERSHED PROJECT

## SONOMA COUNTY, CALIFORNIA

FEBRUARY 1958

1 0 1 2 3 4

SCALE IN MILES




LEGEND

- Watershed
- Evaluation Unit
- Improved Road
- Railroad
- Intermittent Stream
- Area Subject to Inundation by Floods of One Percent Frequency of Occurrence
- Streambank Erosion
- $O_5$ Point of Concentration for Hydrologic Computations




LOCATION MAP

MAP NO. 2

# PROBLEM LOCATION MAP

SANTA ROSA CREEK SUB-WATERSHED

CENTRAL SONOMA WATERSHED PROJECT

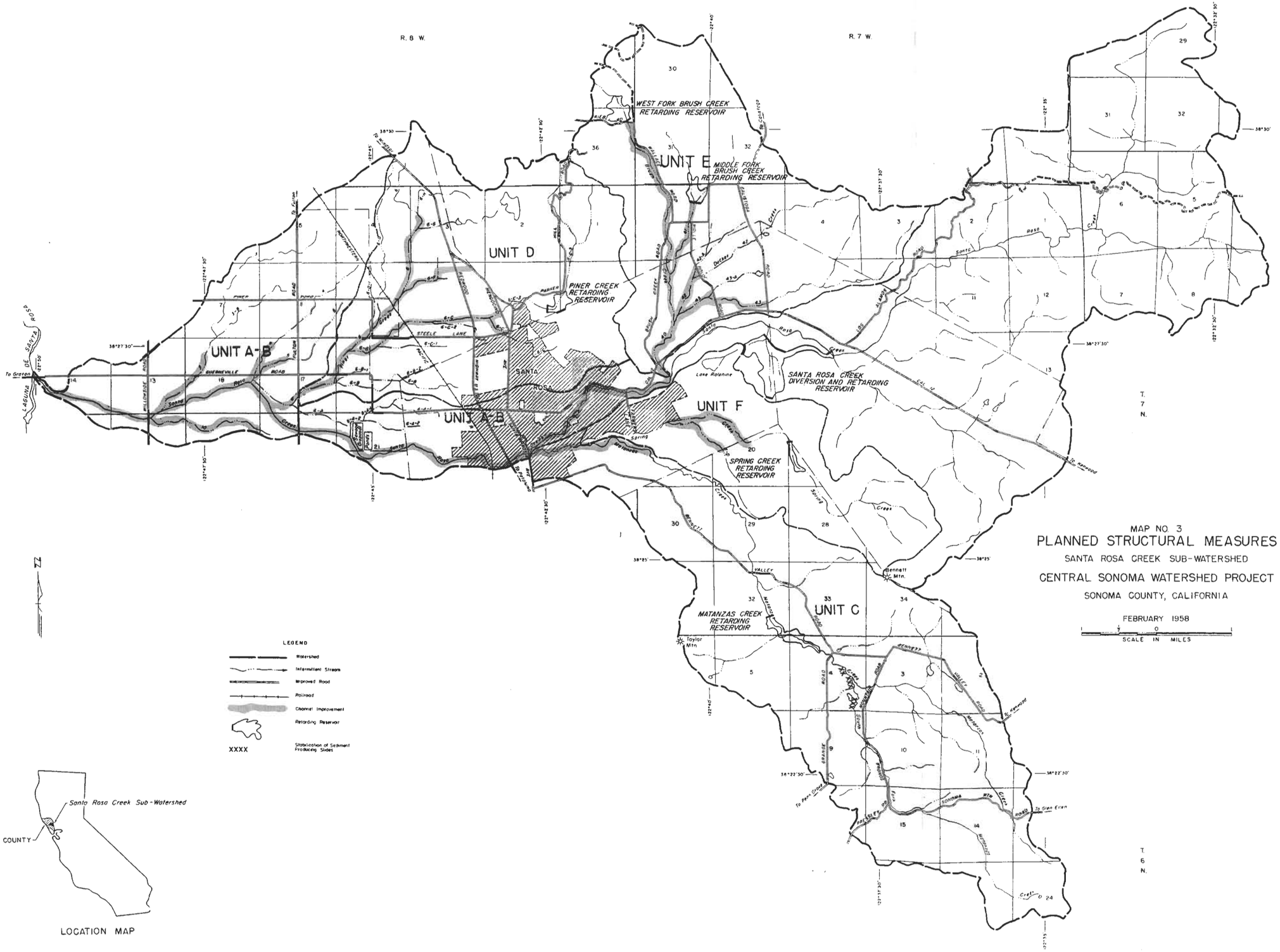
SONOMA COUNTY, CALIFORNIA

FEBRUARY 1958

SCALE IN MILES

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE M-1687

7-R-19190-N




N

LEGEND

- Watershed
- Intermittent Stream
- Improved Road
- Railroad
- Channel Improvement
- Retarding Reservoir
- XXXX Stabilization of Sediment Producing Slides




LOCATION MAP

MAP NO. 3

# PLANNED STRUCTURAL MEASURES

SANTA ROSA CREEK SUB-WATERSHED

CENTRAL SONOMA WATERSHED PROJECT

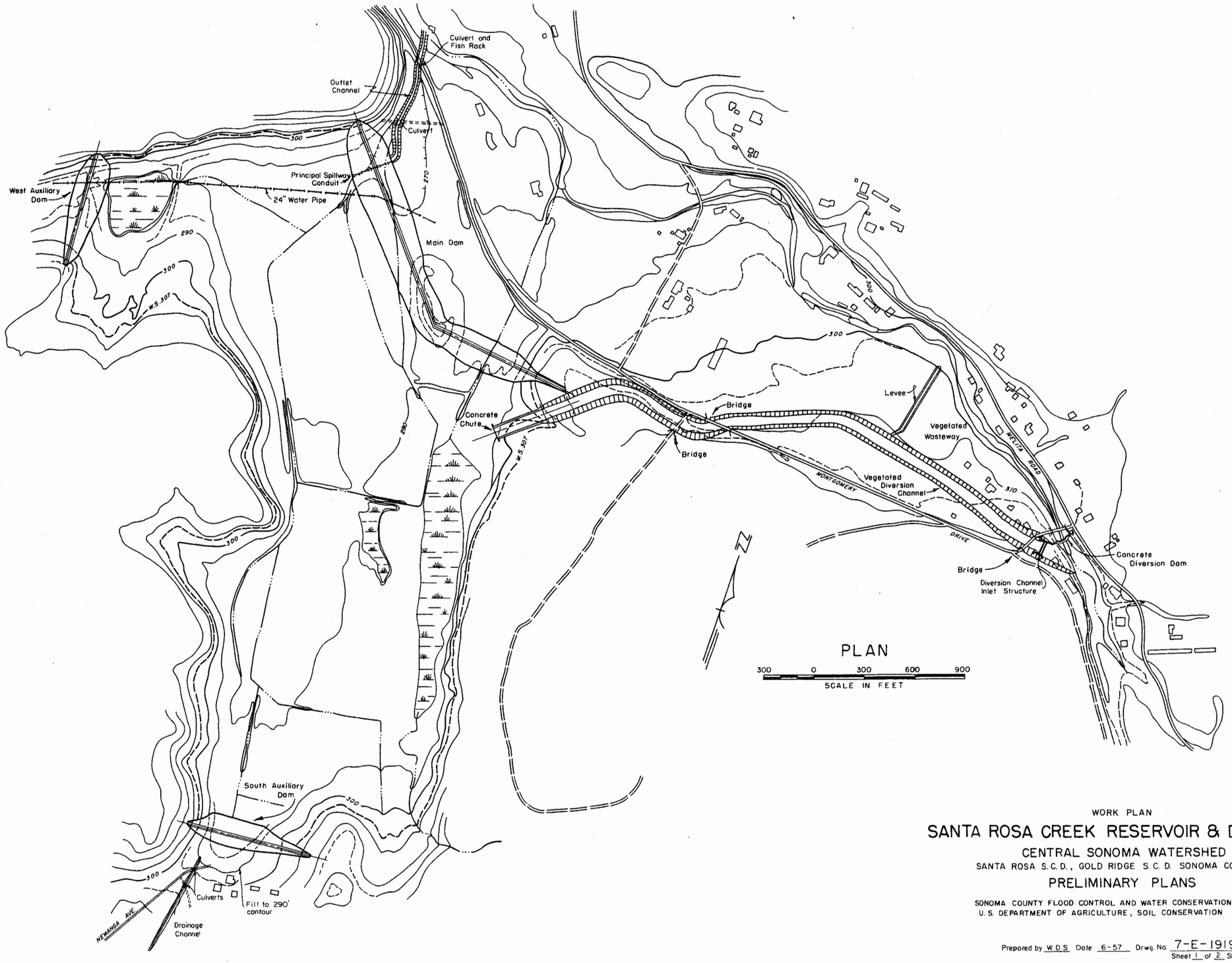
SONOMA COUNTY, CALIFORNIA

FEBRUARY 1958

½ 0 1

SCALE IN MILES

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE M-1687




WORK PLAN

# SANTA ROSA CREEK RESERVOIR & DIVERSION

## CENTRAL SONOMA WATERSHED

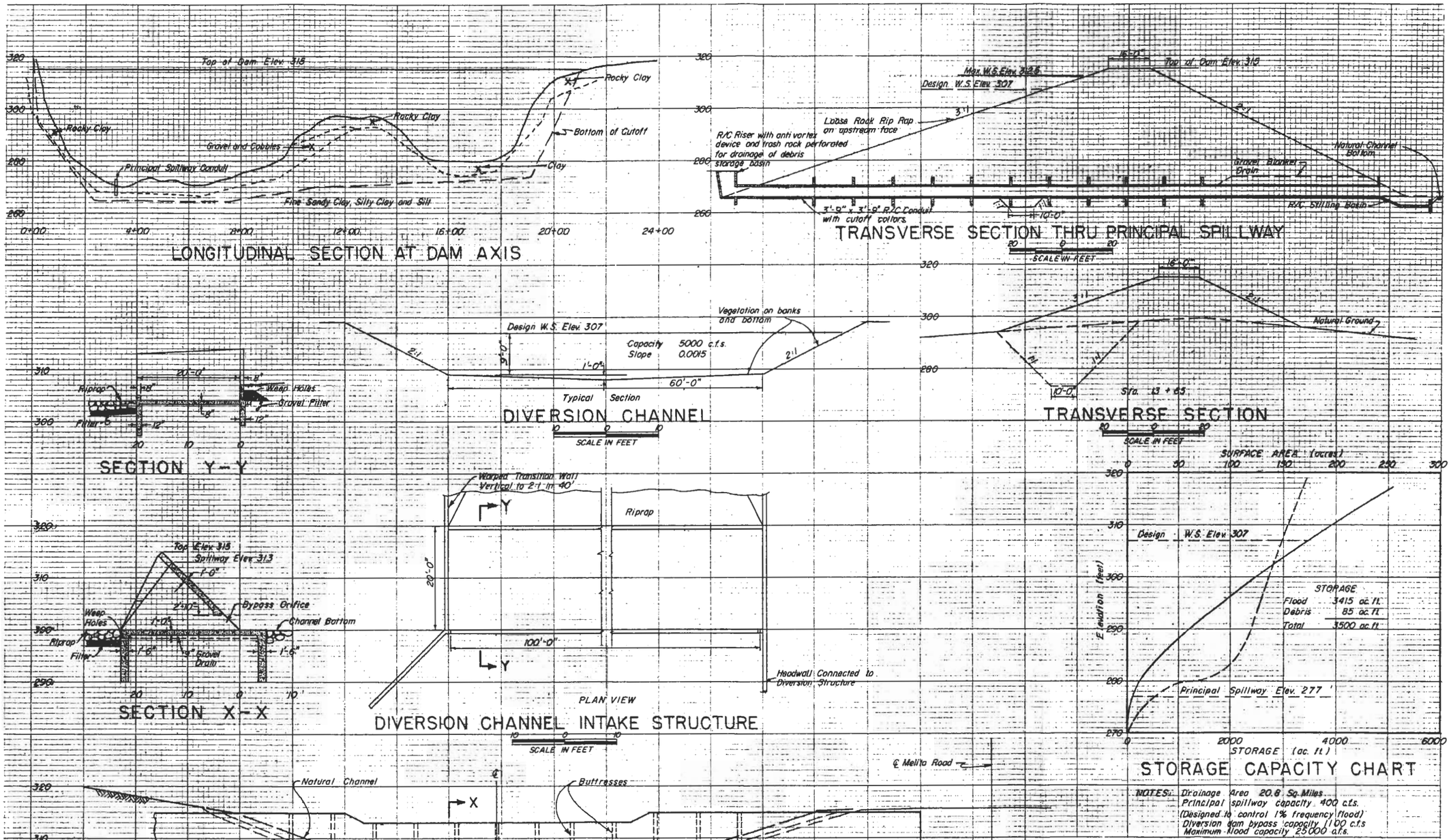
SANTA ROSA S.C.D., GOLD RIDGE S.C.D. SONOMA CO., CALIF

## PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W.D.S. Date 6-57 Drwg. No. 7-E-19192-N
Sheet 1 of 2 Sheets

USDA SCS PORTLAND OREG. 1957 M-1691-2




WORK PLAN

# SANTA ROSA CREEK RESERVOIR & DIVERSION

## CENTRAL SONOMA WATERSHED

SANTA ROSA S.C.D., GOLD RIDGE S.C.D. SONOMA CO., CALIF

## PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W.D.S. Date 6-57 Orwg. No. 7-E-19192-N
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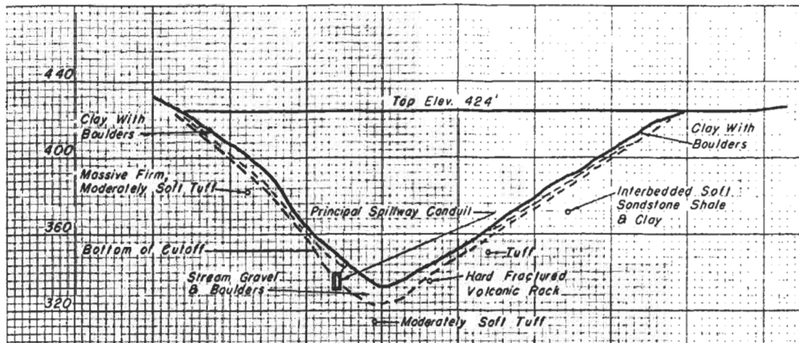
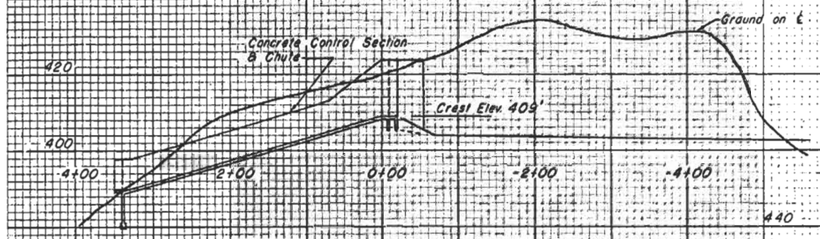
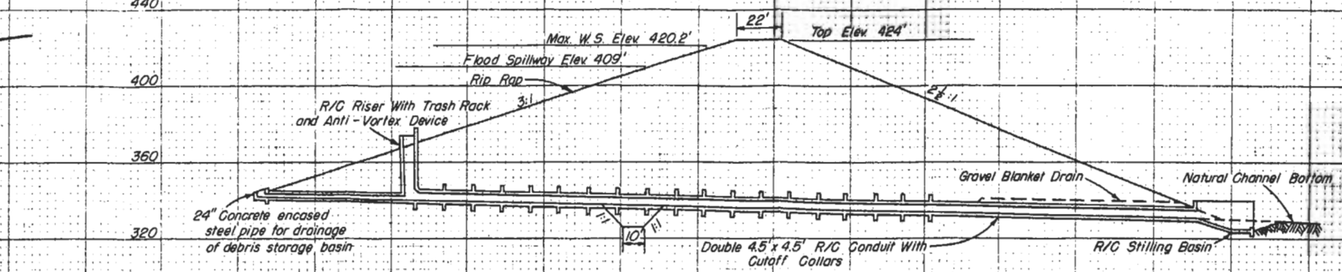
USDA-SCS-PORTLAND, OREG. 1956 M-1691-1



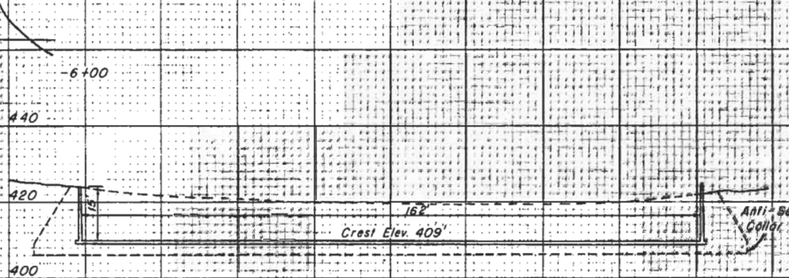

LONGITUDINAL SECTION



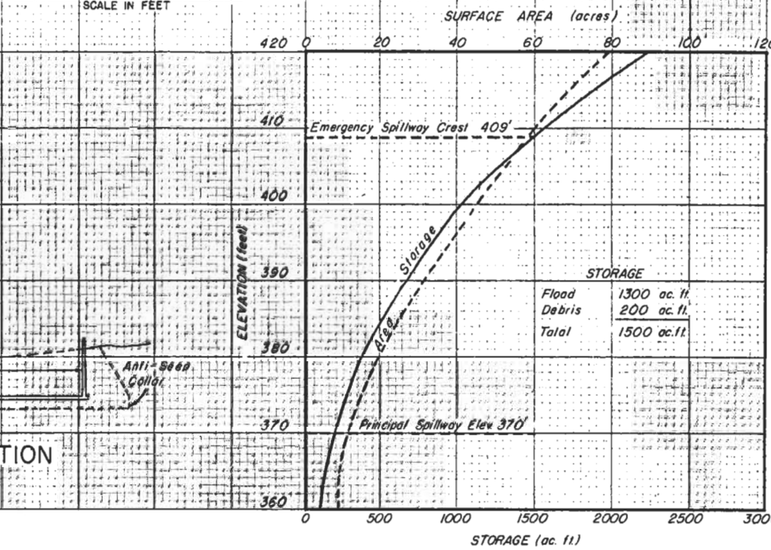

SPILLWAY PROFILE




TRANSVERSE SECTION THRU PRINCIPAL SPILLWAY



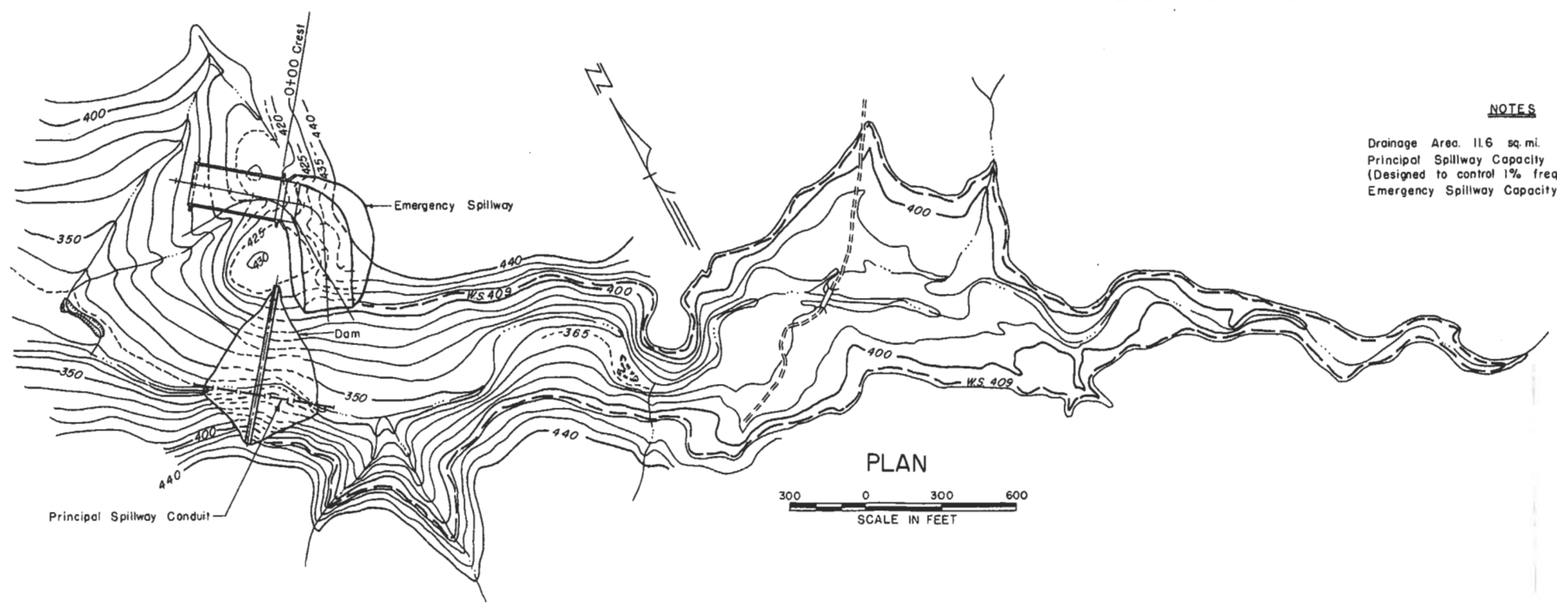

EMERGENCY SPILLWAY CONTROL SECTION




STORAGE

| | |
|---|---|
| Flood | 1300 ac. ft. |
| Debris | 200 ac. ft. |
| Total | 1500 ac. ft. |

STORAGE CAPACITY CHART




PLAN

300 0 300 600
SCALE IN FEET

NOTES

Drainage Area. 11.6 sq. mi.
Principal Spillway Capacity 1500 c.f.s.
(Designed to control 1% frequency flood)
Emergency Spillway Capacity 18,400 c. f. s.

WORK PLAN

# MATANZAS CREEK RESERVOIR

CENTRAL SONOMA WATERSHED

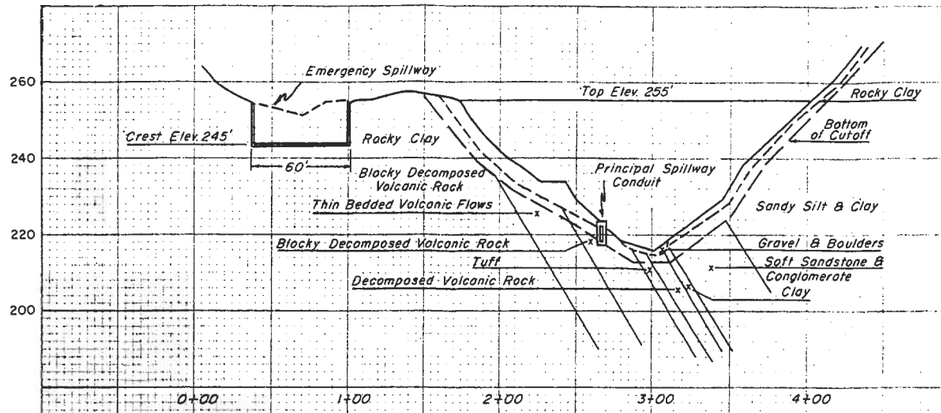
SANTA ROSA S.C.D., GOLD RIOGE S.C.D. SONOMA CO., CALIF

PRELIMINARY PLANS

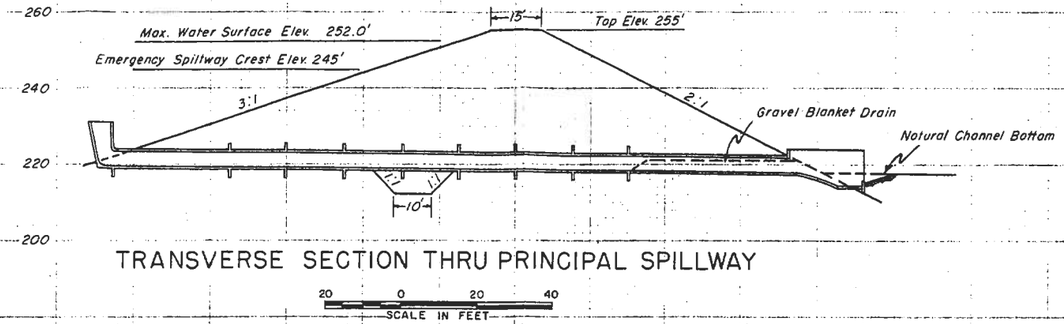
SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W.D.S. Date 6 57 Drwg No 7-E-19193-N
Sheet 1 of 1 Sheets

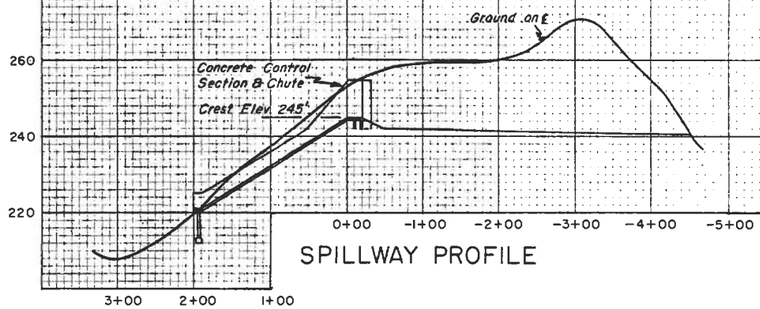
USDA SCS-PORTLAND, ORE. 1958 M-1691-3



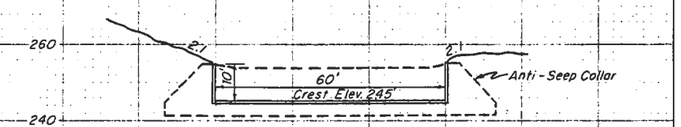

LONGITUDINAL SECTION



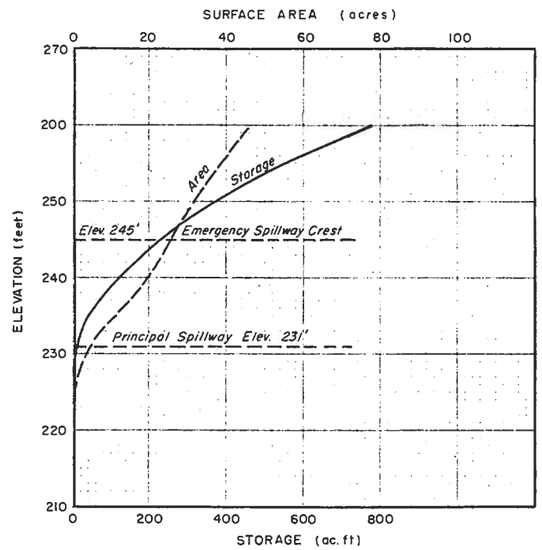

TRANSVERSE SECTION THRU PRINCIPAL SPILLWAY




SPILLWAY PROFILE



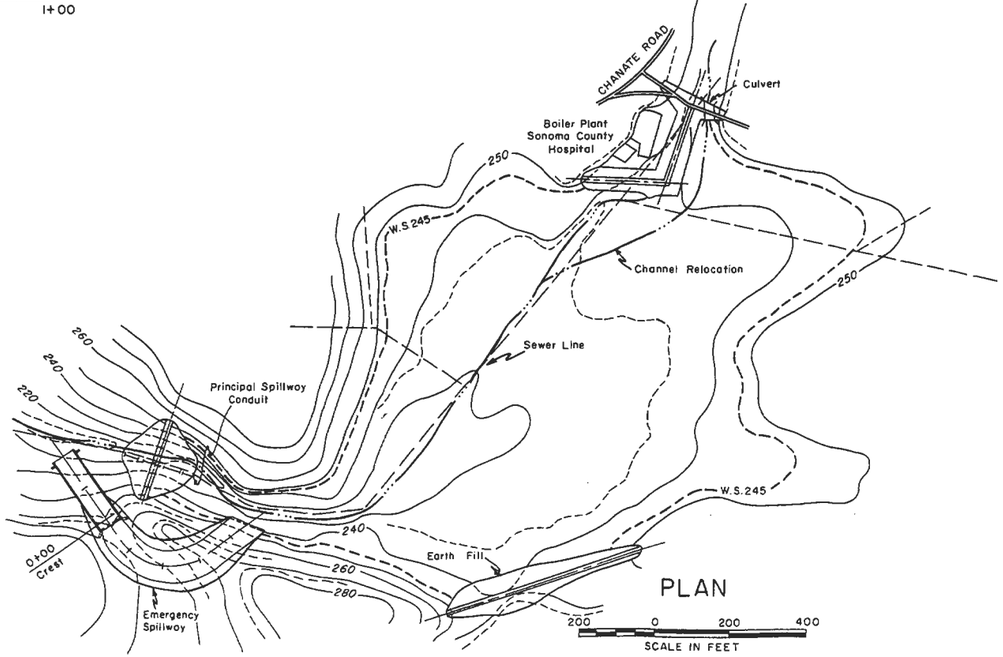

EMERGENCY SPILLWAY CONTROL SECTION




STORAGE CAPACITY CHART

STORAGE

| | |
|---|---|
| Flood | 215 ac. ft. |
| Debris | 15 ac. ft. |
| Total | 230 ac. ft. |




PLAN

NOTES

Drainage Area 2.2 sq.mi.
Principal Spillway Capacity 300 c.f.s. (Designed to control 1% frequency flood)
Emergency Spillway Capacity 3300 c.f.s.

WORK PLAN

# PINER CREEK RESERVOIR

## CENTRAL SONOMA WATERSHED

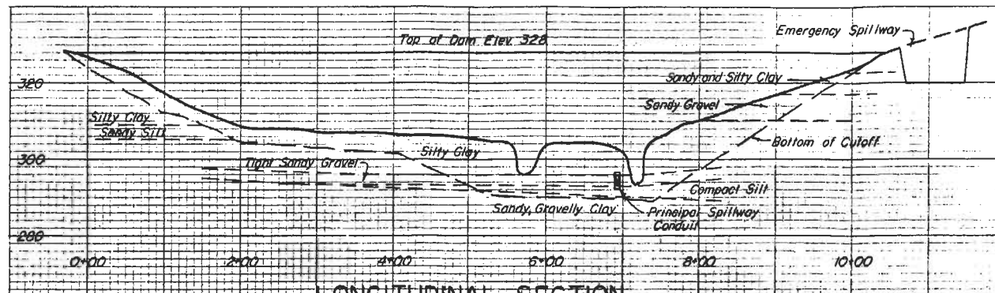
SANTA ROSA S.C.D. GOLD RIDGE S.C.D. SONOMA CO., CALIF.

## PRELIMINARY PLANS

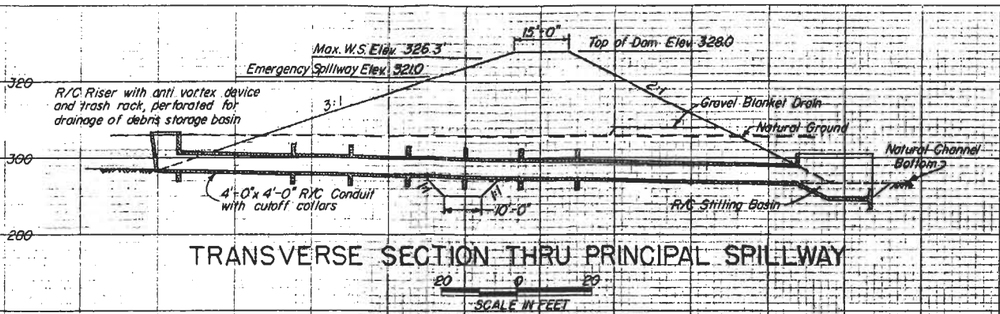
SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W.D.S Date 6-57 Drwg No. 7-E-19194-N
Sheet 1 of 1 Sheets

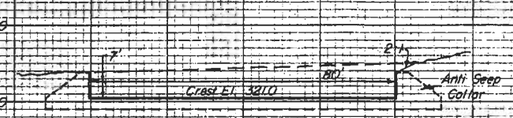
USDA-SCS-PORTLAND OREG. 1958 M-1691-4



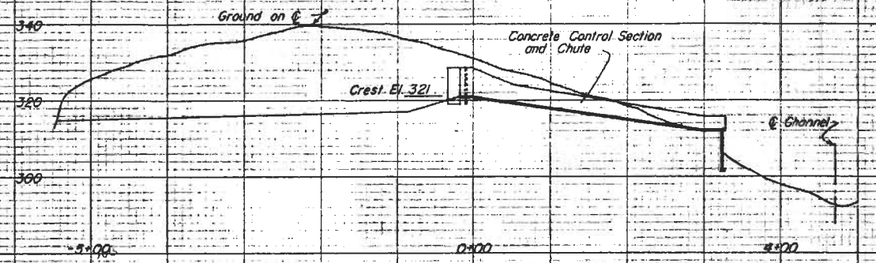

LONGITUDINAL SECTION



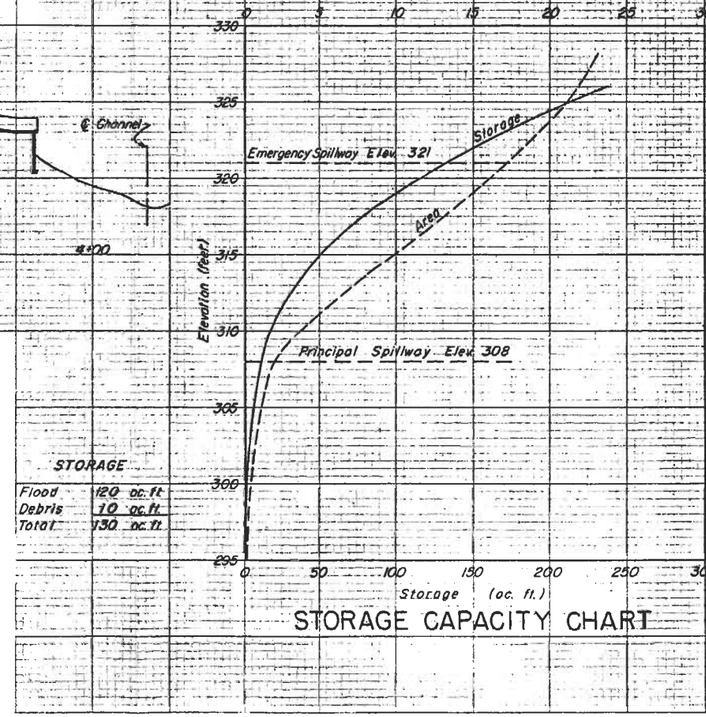

TRANSVERSE SECTION THRU PRINCIPAL SPILLWAY



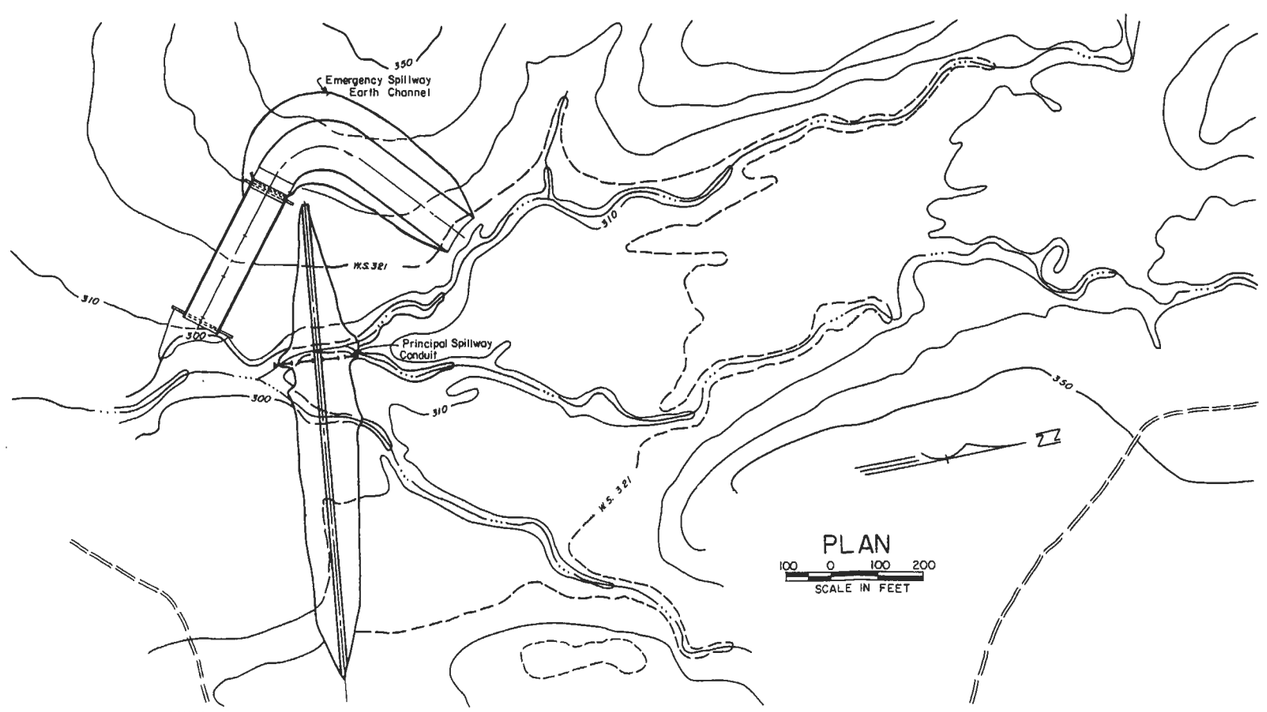

EMERGENCY SPILLWAY CONTROL SECTION




SPILLWAY PROFILE




STORAGE CAPACITY CHART




NOTES

Drainage Area 1.6 sq. mi.
Principal Spillway Capacity 475 c.f.s.
(Designed to control 1% frequency flood)
Emergency Spillway Capacity 2900 c.f.s.

WORK PLAN

# BRUSH CREEK MIDDLE FORK RESERVOIR

## CENTRAL SONOMA WATERSHED

SANTA ROSA S.C.D.; GOLD RIDGE S.C.D. SONOMA CO., CALIF.

## PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W.D.S. Date 6-57 Drwg No. 7-E-19195-N
Sheet 1 of 1 Sheets

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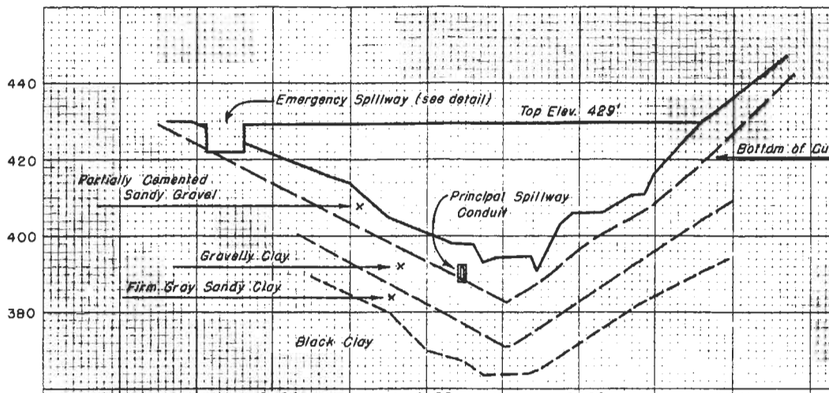
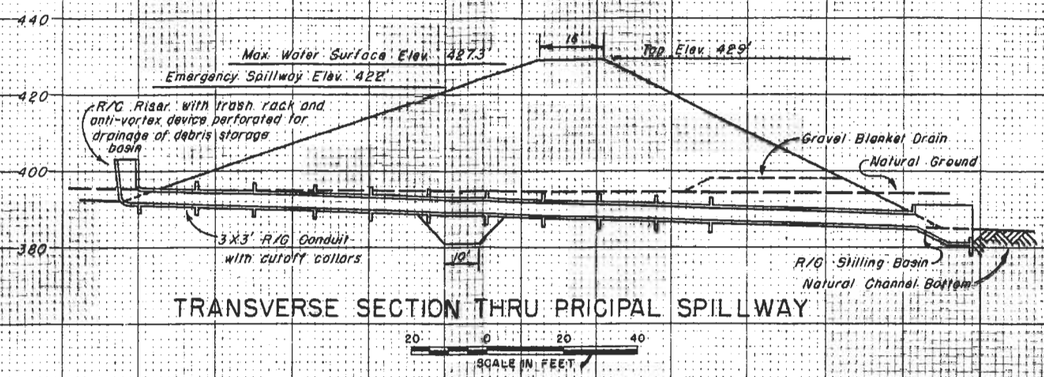
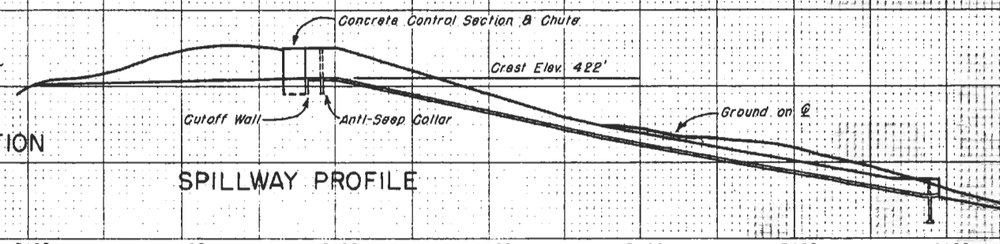



LONGITUDINAL SECTION

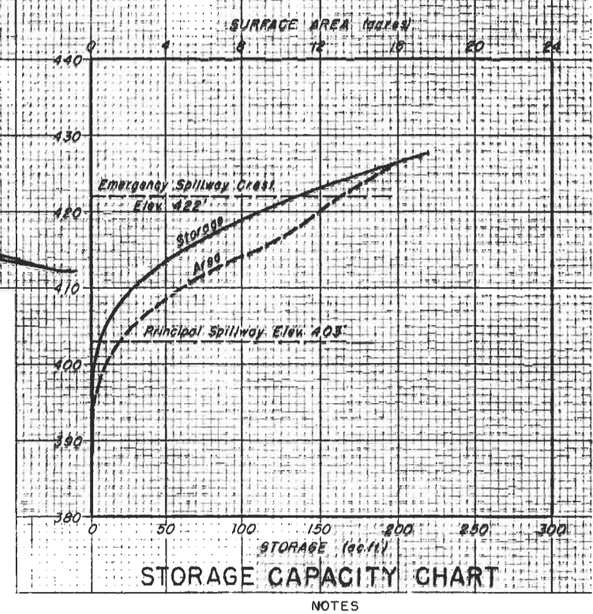



TRANSVERSE SECTION THRU PRICIPAL SPILLWAY

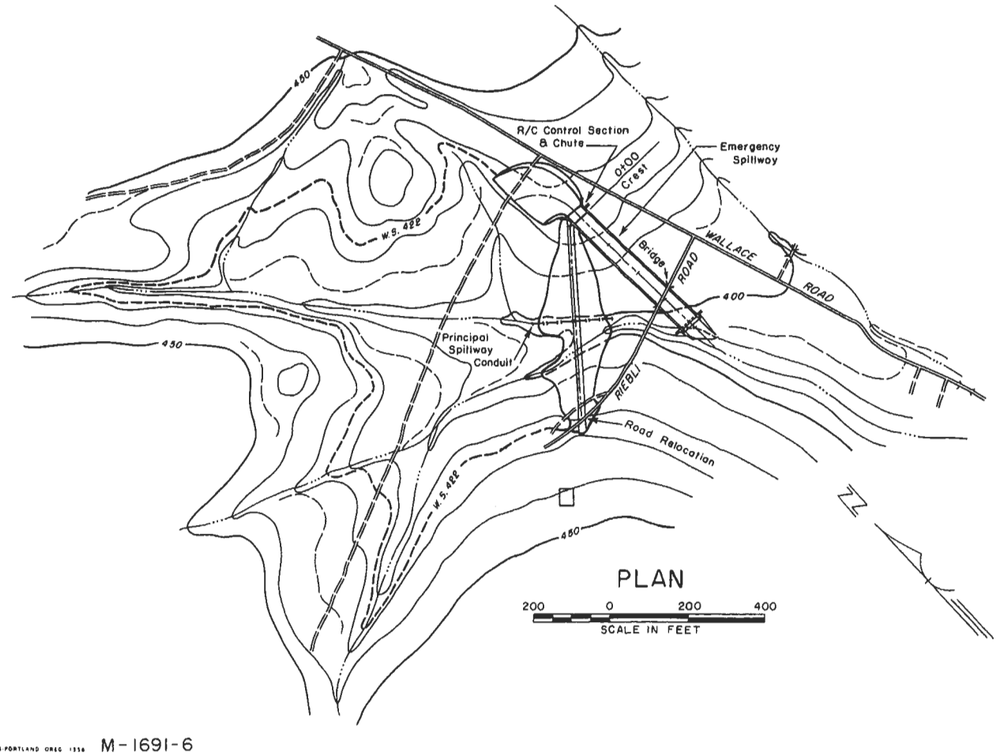

EMERGENCY SPILLWAY CONTROL SECTION




SPILLWAY PROFILE




STORAGE CAPACITY CHART




PLAN

| | |
|---|---|
| Flood | 125 ac. ft. |
| Debris | 5 ac ft. |
| Total | 130 ac. ft. |

NOTES

Drainage Area 0.8 sq. mi.
Principal Spillway Capacity 217 c.f.s.
(Designed to control 1% frequency flood)
Emergency Spillway Capacity 1800 c.f.s.

WORK PLAN

# BRUSH CREEK WEST FORK RESERVOIR

CENTRAL SONOMA WATERSHED

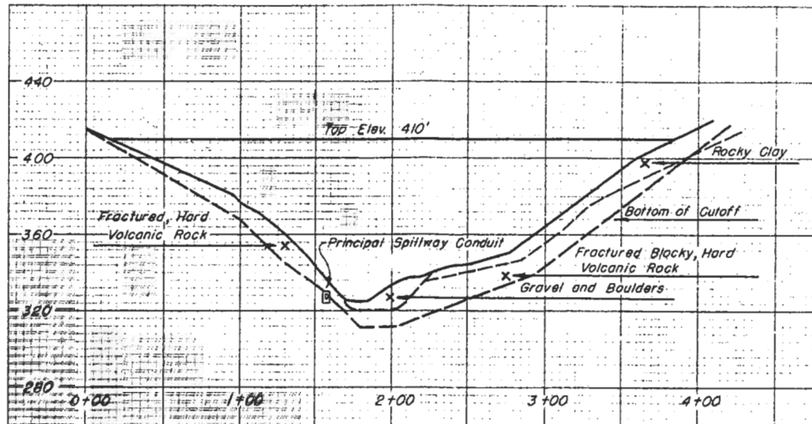
SANTA ROSA S.C.D., GOLD RIDGE S.C.D. SONOMA CO., CALIF.

PRELIMINARY PLANS

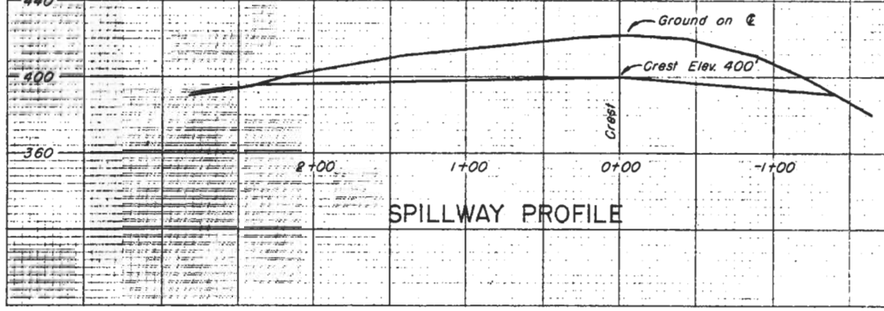
SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W.D.S. Date 6-57 Drwg. No. 7-E-19196-N
Sheet 1 of 1 Sheets

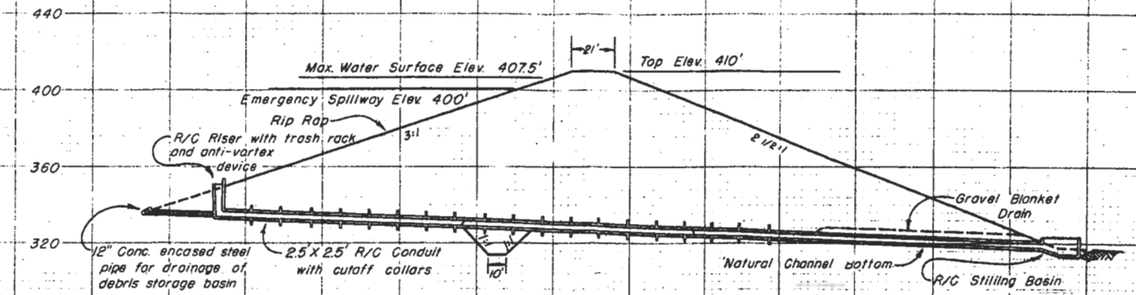
USDA SCS-PORTLAND, OREG. 1958 M-1691-6



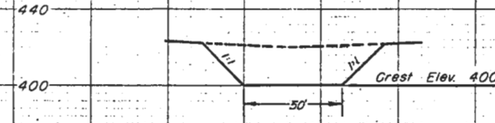

LONGITUDINAL SECTION




SPILLWAY PROFILE



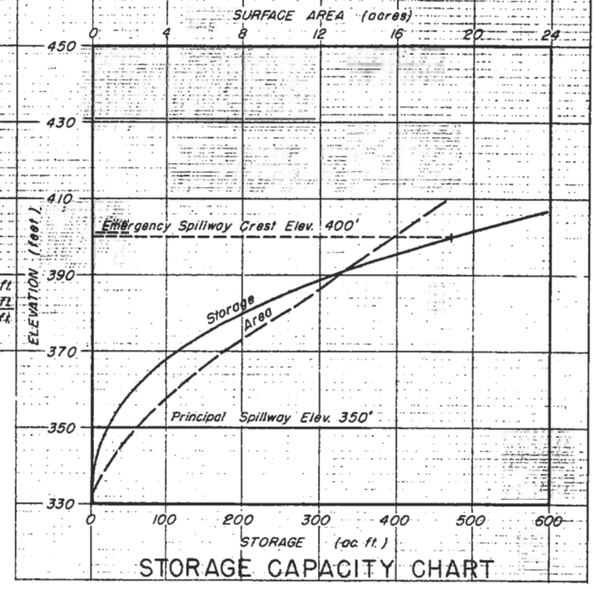

TRANSVERSE SECTION THRU PRINCIPAL SPILLWAY



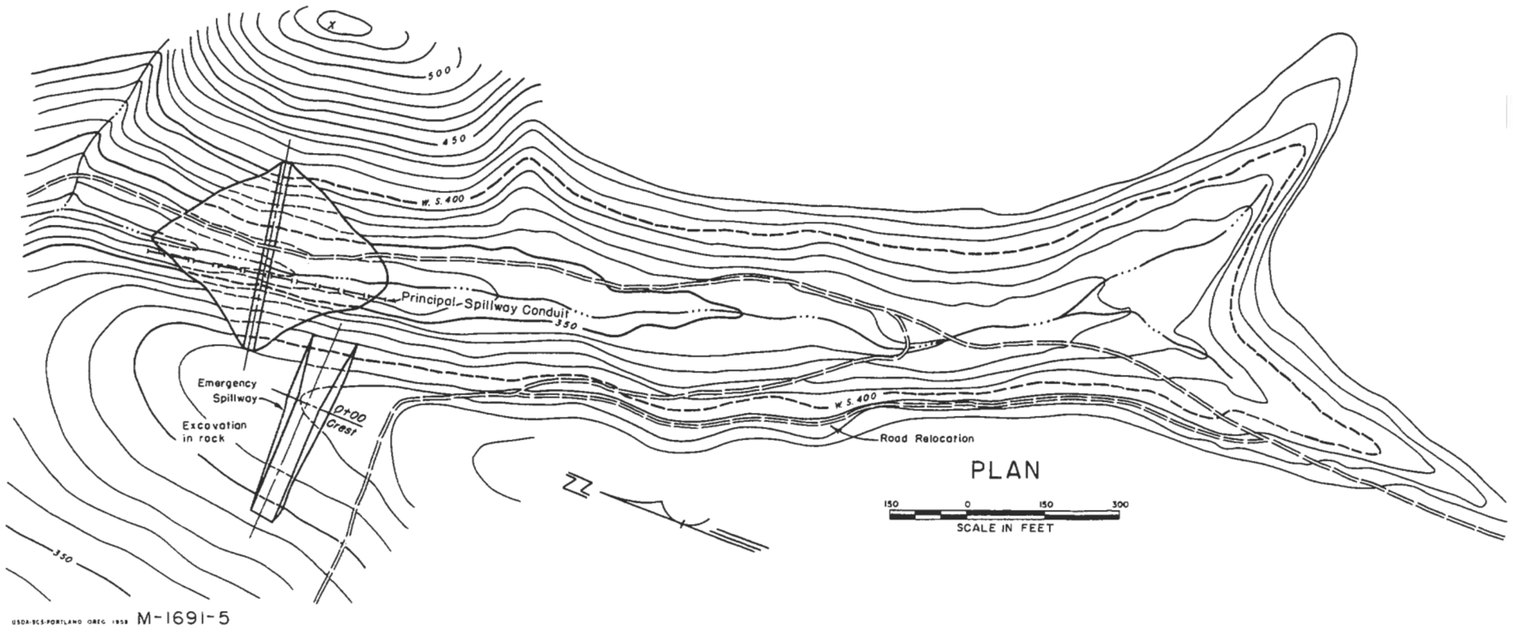

SPILLWAY CROSS SECTION AT CREST

SCALE IN FEET
40 0 40 80

| STORAGE | |
|---|---|
| Flood | 450 ac. ft. |
| Debris | 17 ac. ft. |
| Total | 467 ac. ft. |




STORAGE CAPACITY CHART




PLAN

SCALE IN FEET
150 0 150 300

NOTES

Drainage Area 2.3 sq.mi.
Principal Spillway Capacity 185 c.f.s.
(Designed to control 1% frequency flood)
Emergency Spillway Capacity 3,500 c.f.s.

WORK PLAN

# SPRING CREEK RESERVOIR

## CENTRAL SONOMA WATERSHED

SANTA ROSA S.C.D., GOLD RIDGE S.C.D., SONOMA CO., CALIF.

## PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by W.D.S. Date 6-57 Drwg No 7-E-19197-N
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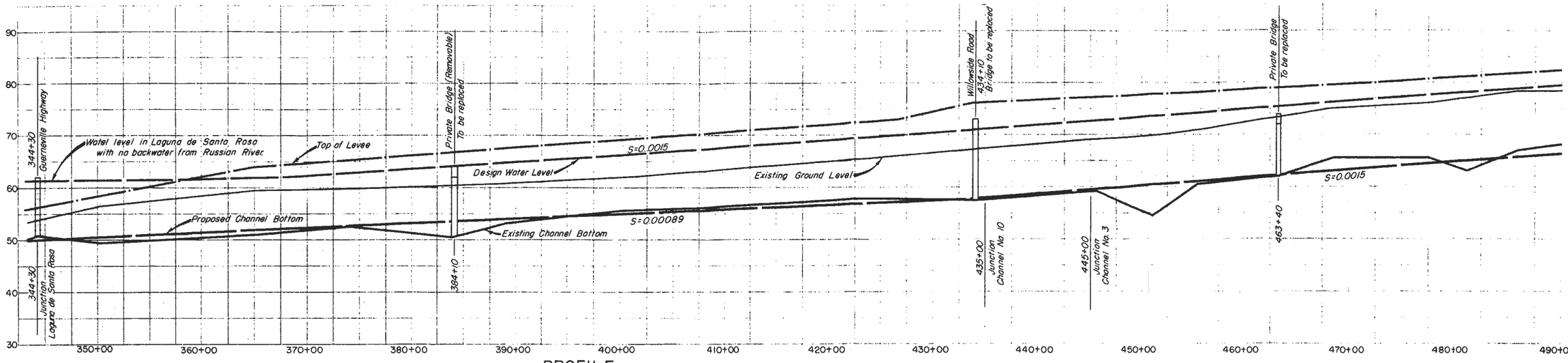
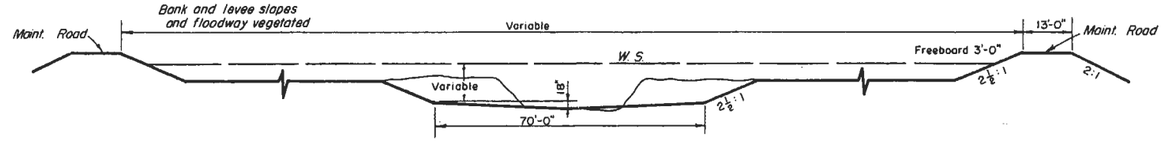
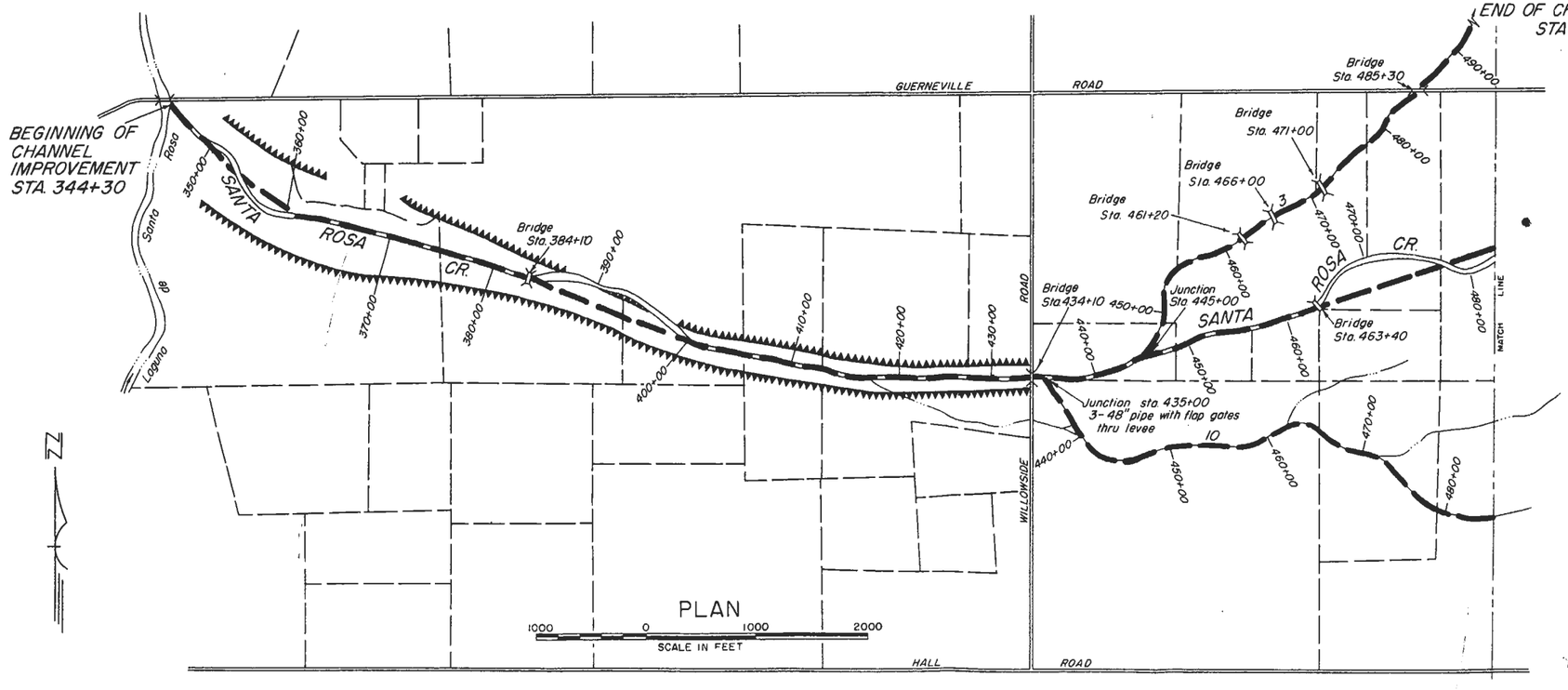
USDA-SCS-PORTLAND OREG. 1958 M-1691-5




PROFILE




TYPICAL CROSS SECTION
STA. 344+30 to STA. 434+10




LEGEND

- Existing Channel
- Channel Improvement (vegetated)
- Levee

All elevations 1929 datum

WORK PLAN

# SANTA ROSA CREEK

## CENTRAL SONOMA WATERSHED

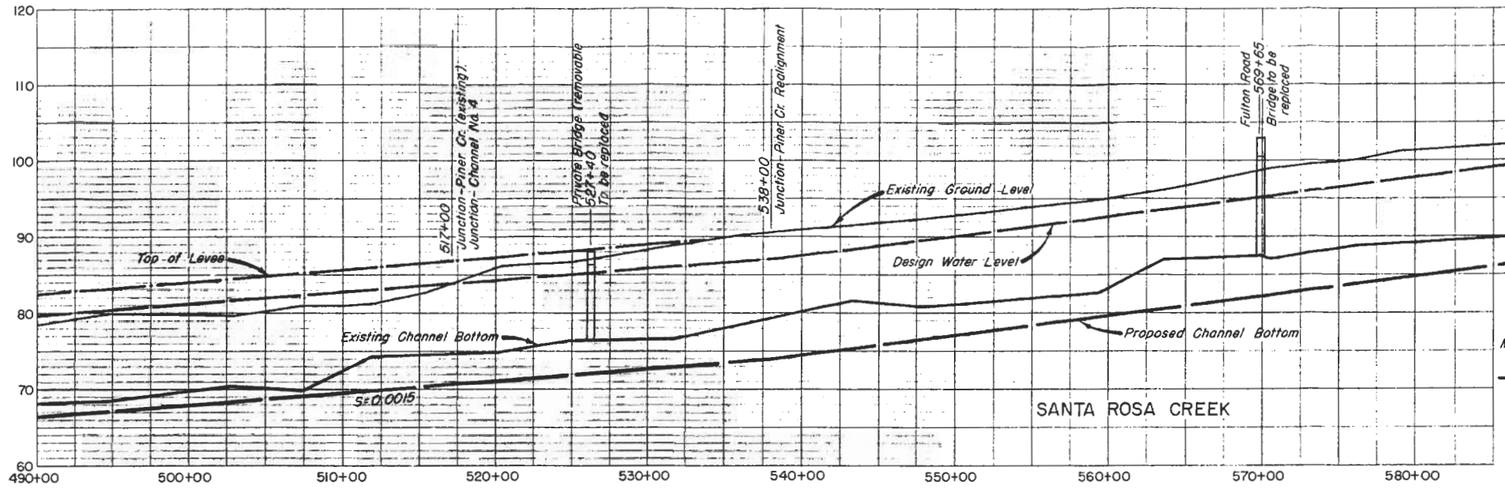
SANTA ROSA S.C.D., GOLD RIDGE S.C.D. SONOMA CO, CALIF.

## PRELIMINARY PLANS

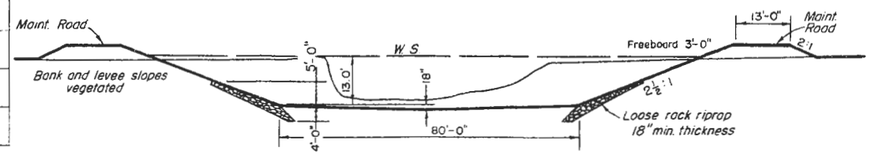
SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by R.T. Date 6-57 Drwg No 7-E-19198-N
Sheet 1 of 4 Sheets

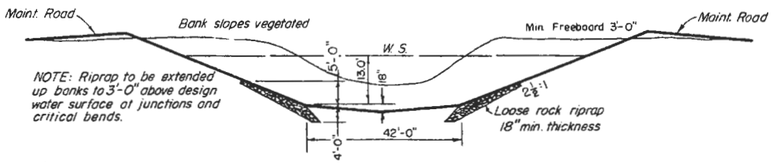
USDA SCS PORTLAND OREG 1958 M-1691-8




PROFILE

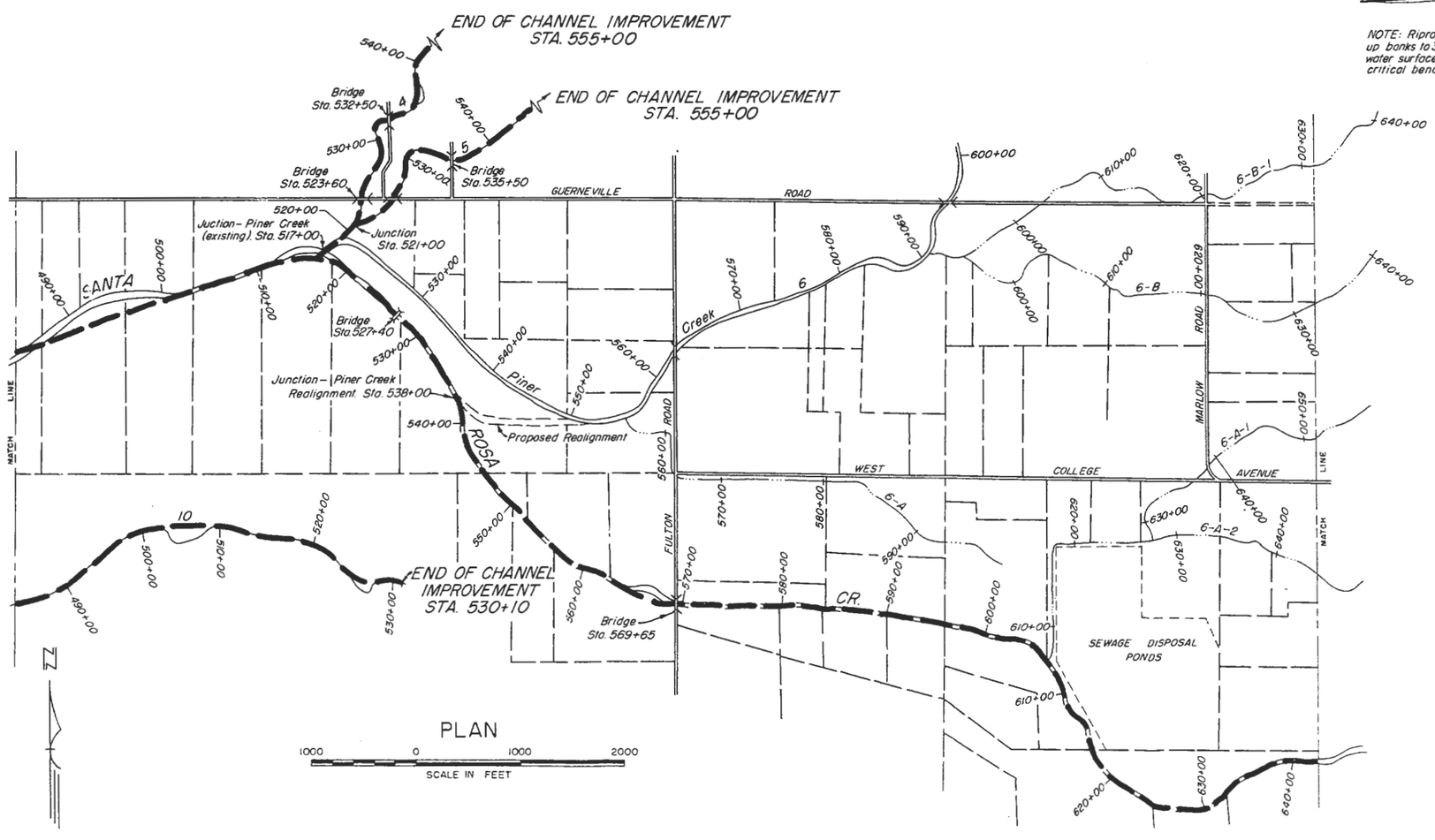



STA. 434+10 to STA. 538+00




STA. 538+00 to STA. 660+00

TYPICAL CROSS SECTIONS




PLAN

1000 0 1000 2000
SCALE IN FEET

LEGEND

Existing Channel

Channel Improvement ( vegetated )

*All elevations 1929 datum*

WORK PLAN

# SANTA ROSA CREEK

## CENTRAL SONOMA WATERSHED

SANTA ROSA S.C.D., GOLD RIDGE S.C.D. SONOMA CO, CALIF

## PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by R.T. Date 6-57 Drwg No 7-E-19198-N
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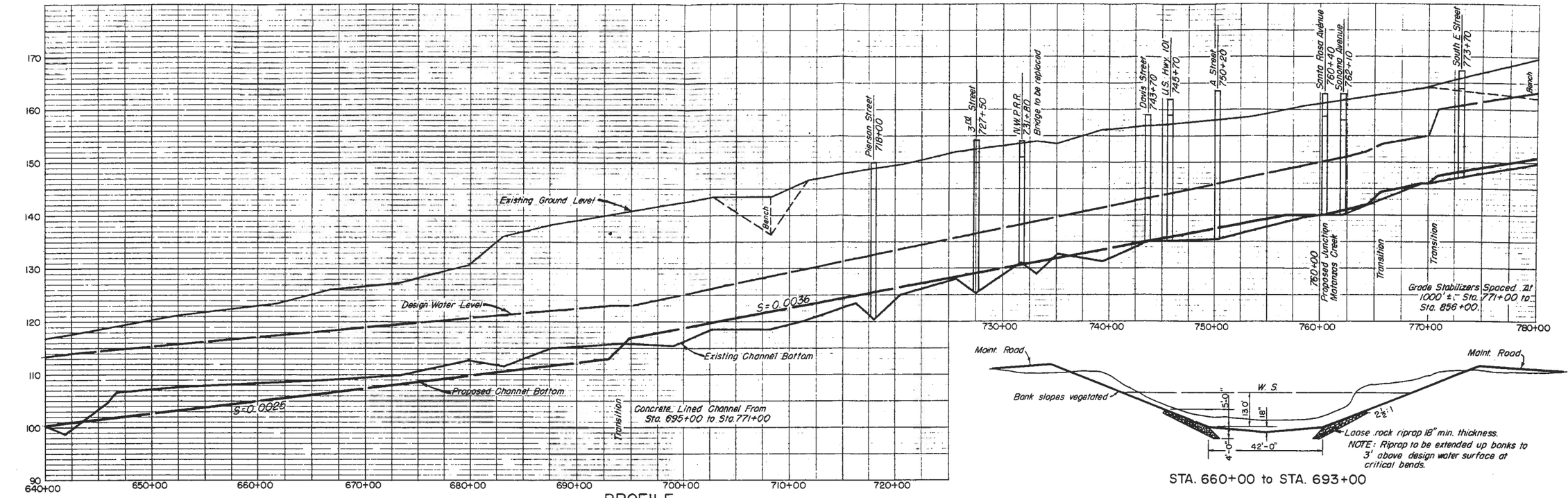
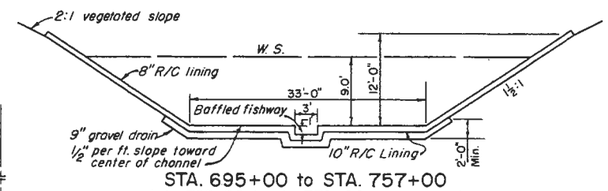
USDA SCS PORTLAND ORE. 1958 M-1691-9



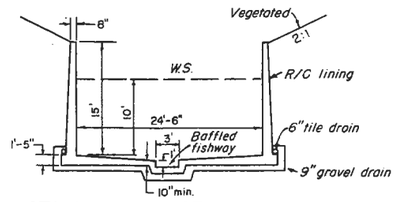




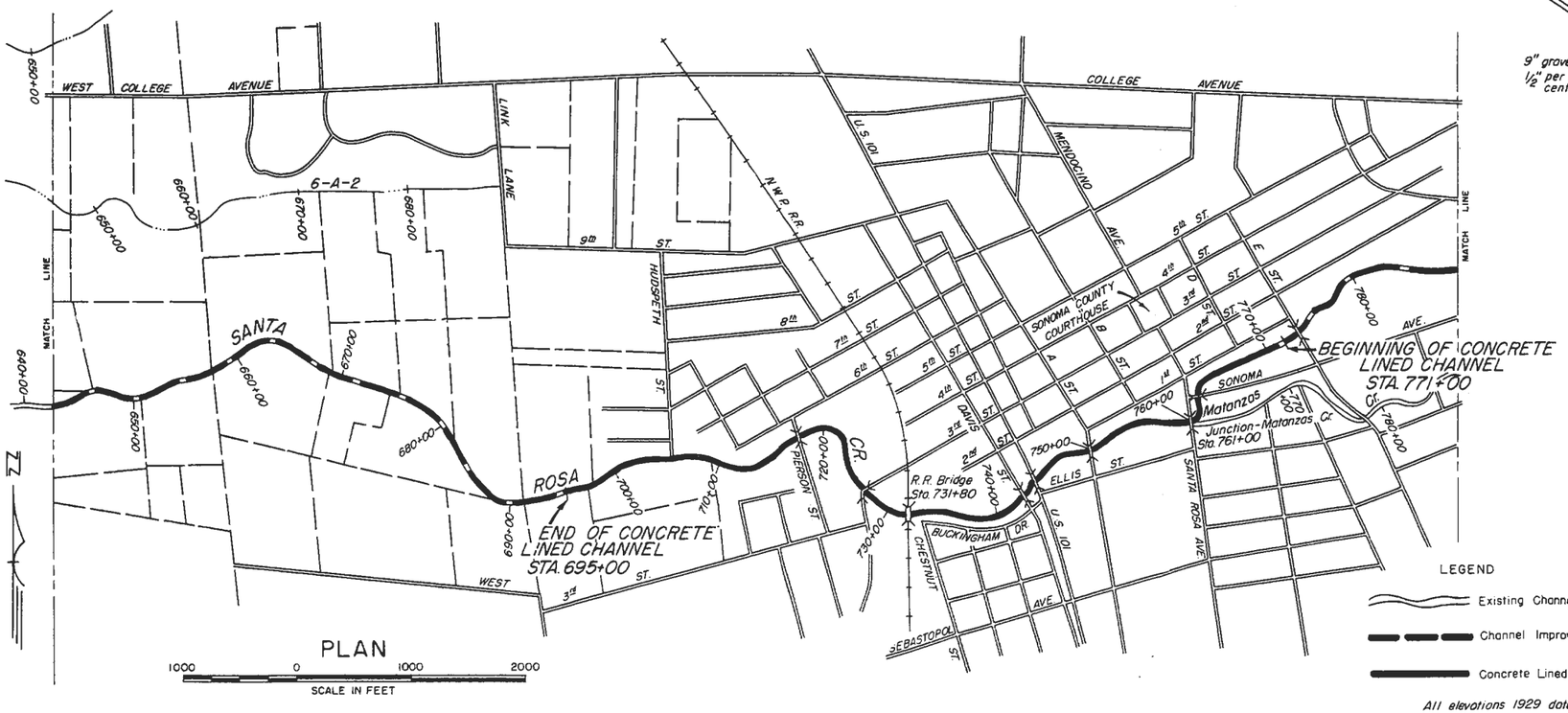
STA. 660+00 to STA. 693+00




STA. 695+00 to STA. 757+00
(sta. 765+50 to sta. 770+00 same except bottom width is 16'-6")




STA. 761+00 to STA. 764+50
CROSS SECTIONS




LEGEND

- Existing Channel
- Channel Improvement (vegetated)
- Concrete Lined Channel

All elevations 1929 datum

WORK PLAN

# SANTA ROSA CREEK

CENTRAL SONOMA WATERSHED

SANTA ROSA S.C.D., GOLD RIDGE S.C.D SONOMA CO., CALIF.

## PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by R.T. Date 6-57 Drwg No 7-E-19198-N
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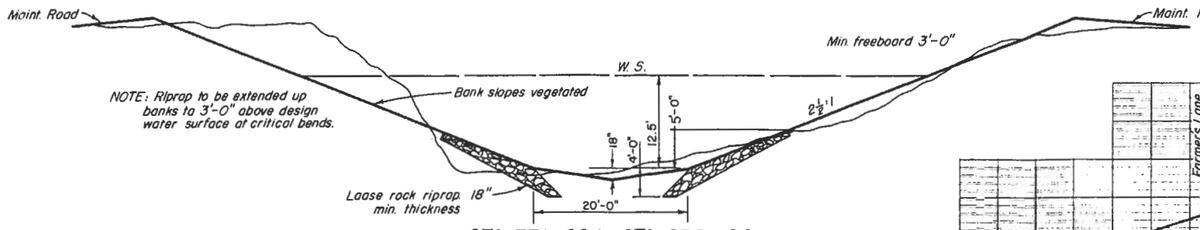
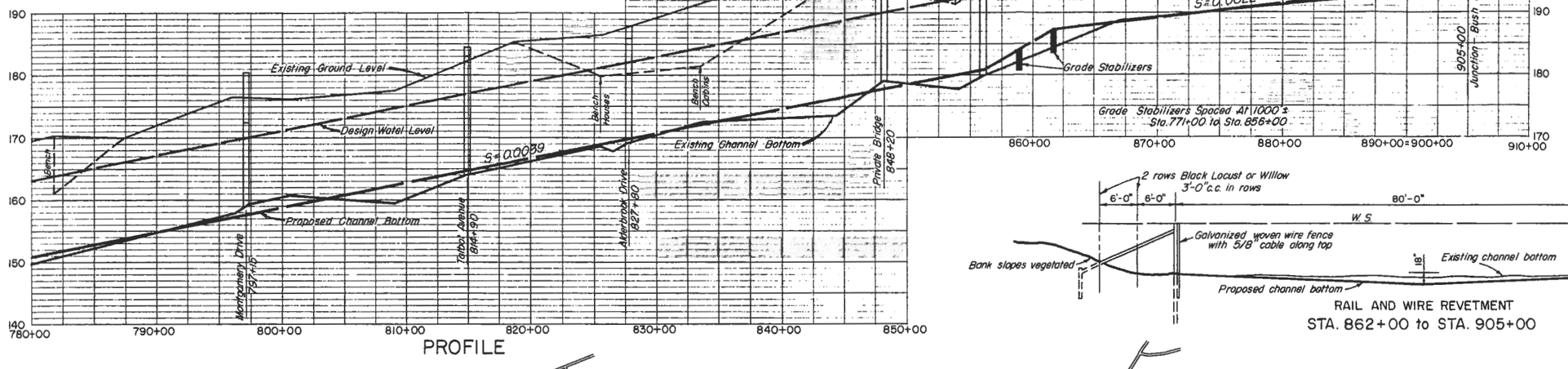
USDA-SCS-PORTLAND OREG. 1956 M-1691-10



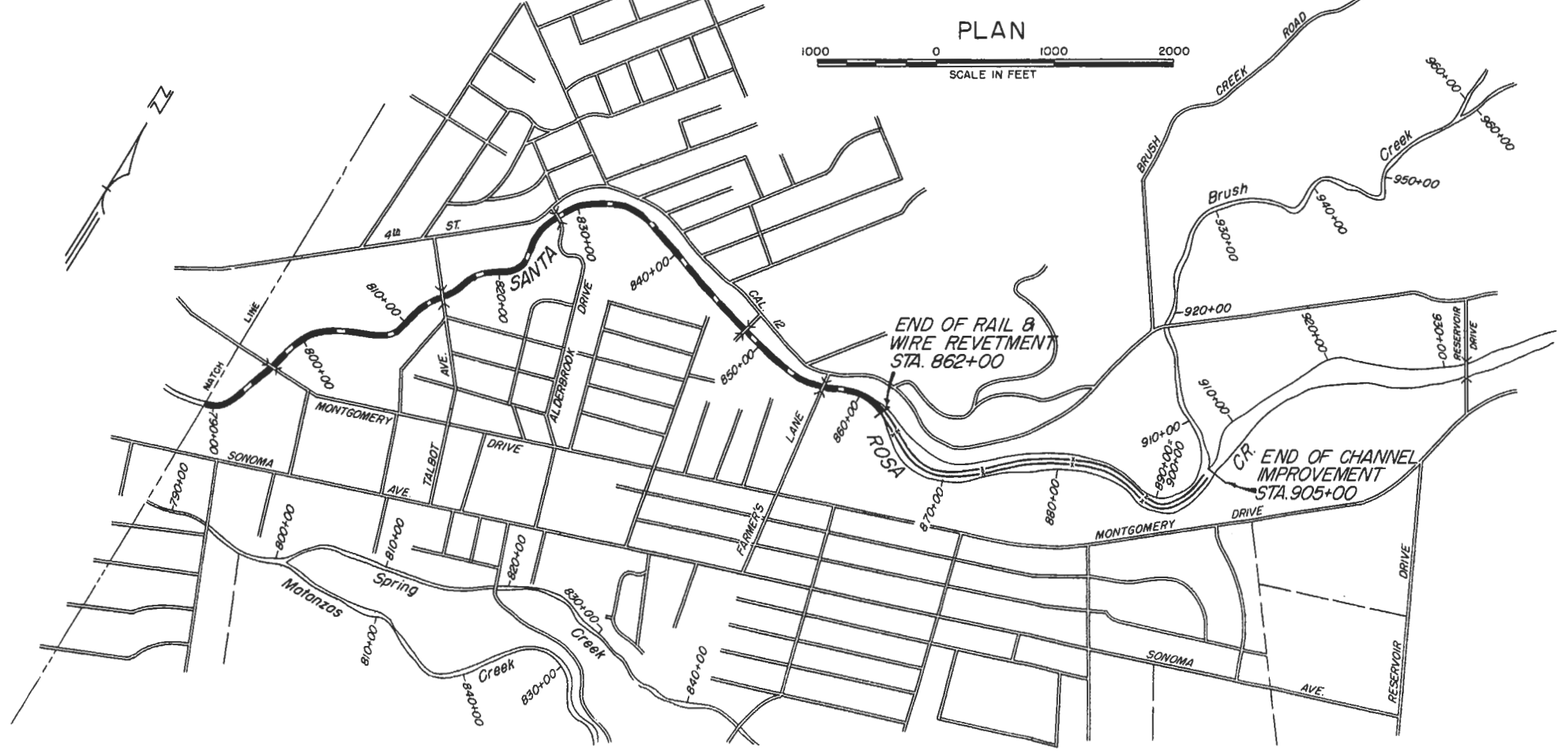

STA. 771+00 to STA. 856+00
TYPICAL CROSS SECTION

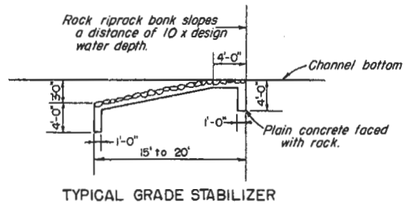



PROFILE




RAIL AND WIRE REVETMENT
STA. 862+00 to STA. 905+00




TYPICAL GRADE STABILIZER

## CROSS SECTIONS

LEGEND

- Existing Channel
- Channel Improvement (vegetated)
- Rail and Wire Revetment

*All elevations 1929 datum*

WORK PLAN

# SANTA ROSA CREEK

## CENTRAL SONOMA WATERSHED

SANTA ROSA S.C.D., GOLD RIDGE S.C.D. SONOMA CO., CALIF.

## PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by R.T. Date 6-57 Drwg. No. 7-E-19198-N
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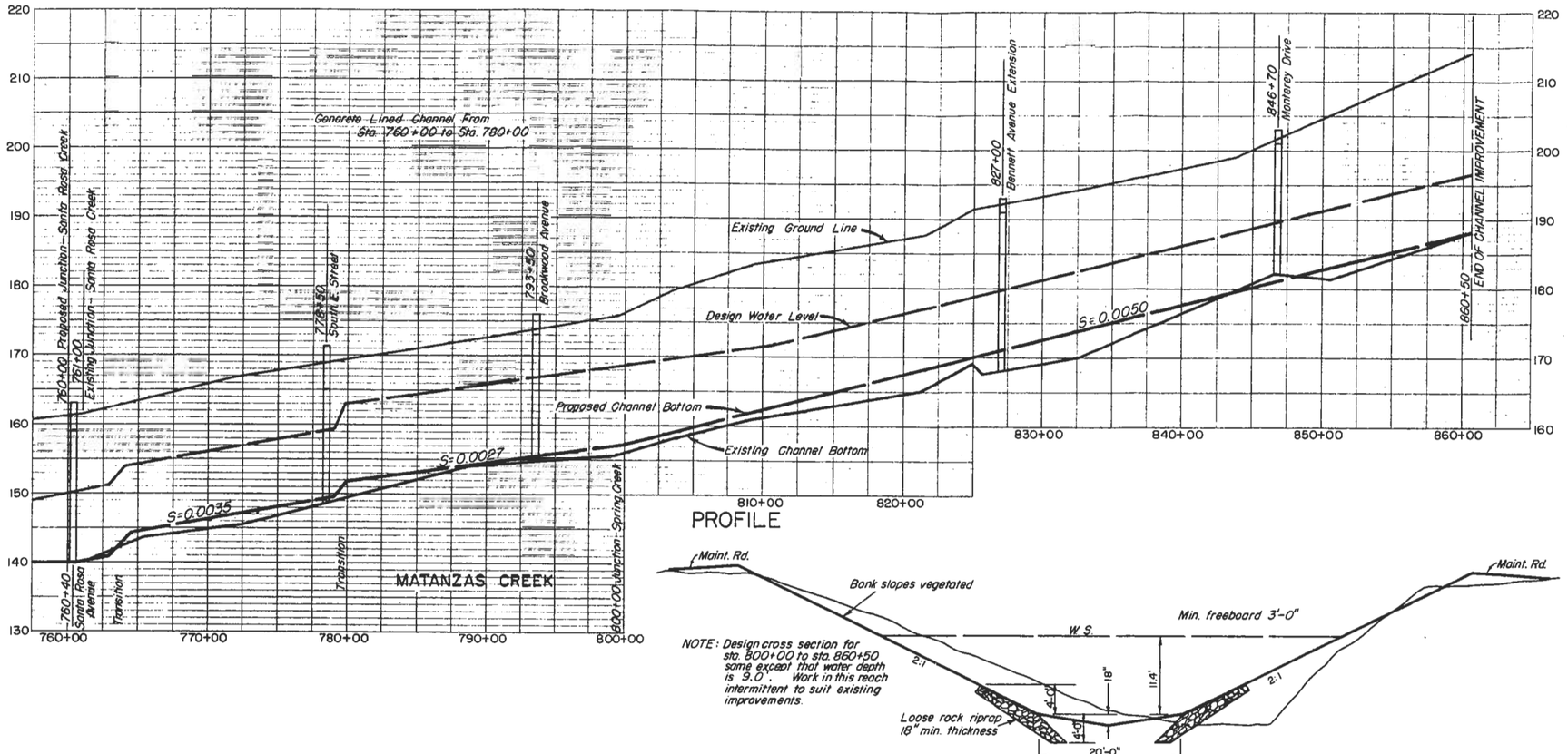
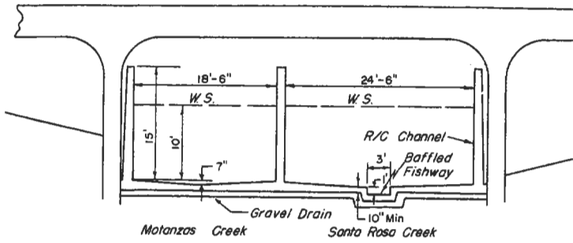
USDA-SCS PORTLAND, OREG. 1958 M-1691-11



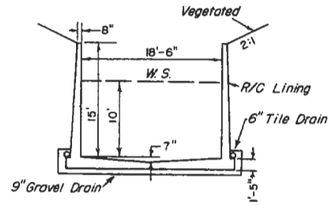




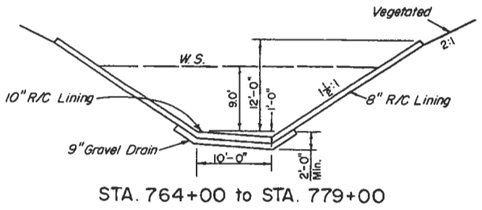
STA. 780+00 to STA. 800+00




AT SANTA ROSA AVENUE BRIDGE
STA. 760+40

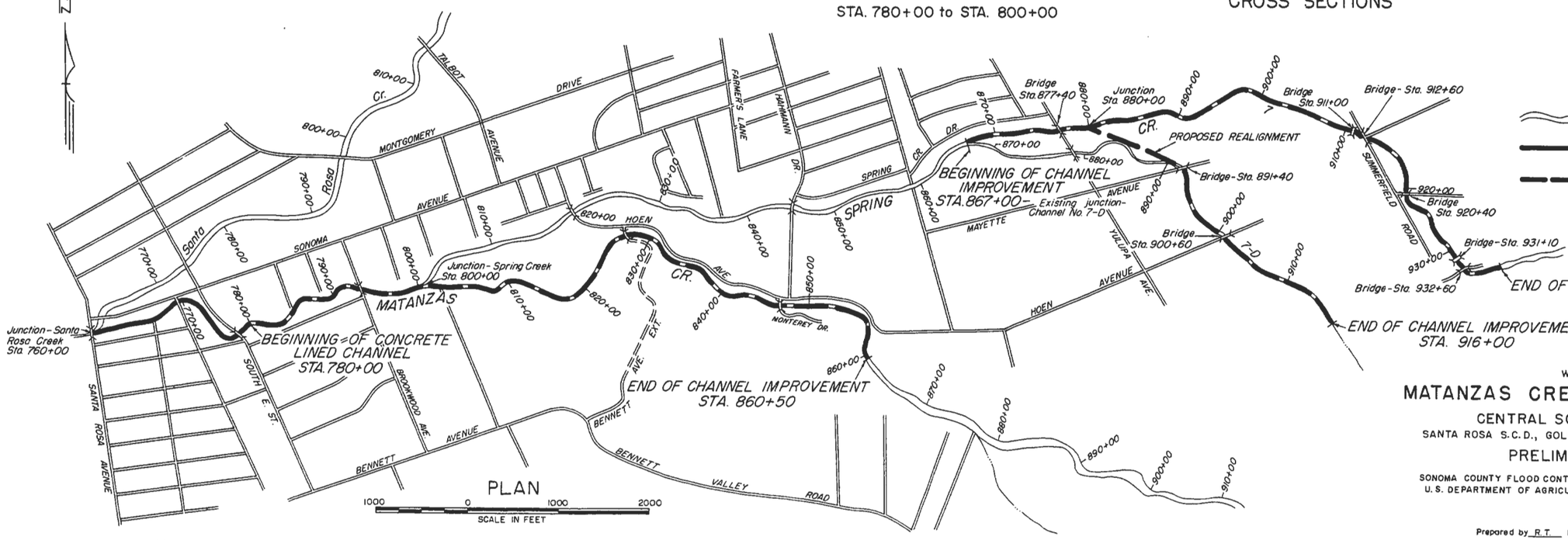



STA. 761+00 to STA. 763+00




STA. 764+00 to STA. 779+00

CROSS SECTIONS




LEGEND

- Existing Channel
- Concrete Lined Channel
- Channel Improvement (vegetated)

All elevations 1929 datum

WORK PLAN

# MATANZAS CREEK & SPRING CREEK

CENTRAL SONOMA WATERSHED

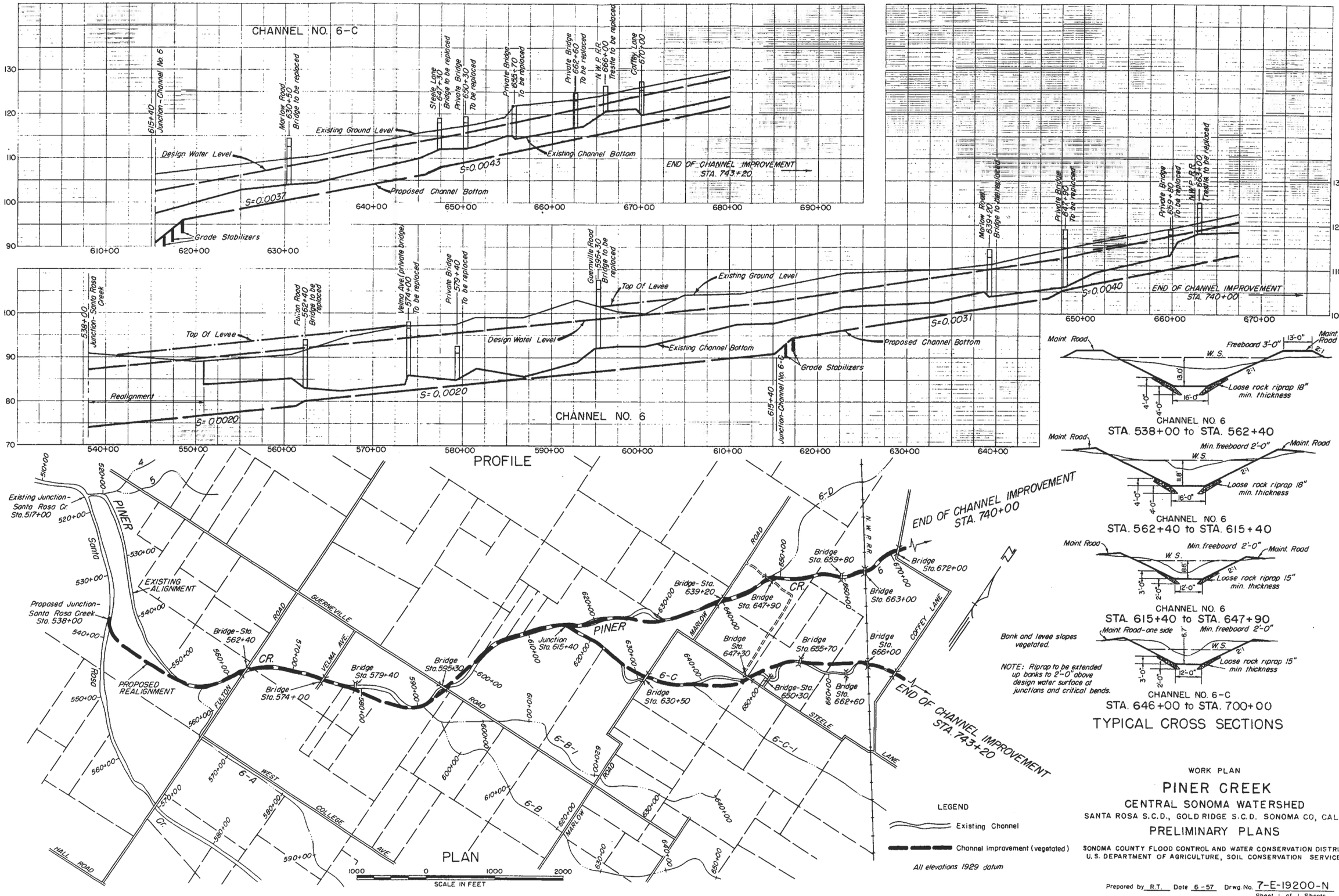
SANTA ROSA S.C.D., GOLD RIDGE S.C.D. SONOMA CO. CALIF.

PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by R.T. Date 6-57 Drwg. No. 7-E-19199-N
Sheet 1 of 1 Sheets

USDA-SCS-PORTLAND OREG 1958 M-1691-12




USDA SCS PORTLAND OREG. 1958 M-1691-13

WORK PLAN

# PINER CREEK

## CENTRAL SONOMA WATERSHED

SANTA ROSA S.C.D., GOLD RIDGE S.C.D. SONOMA CO, CAL

## PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by R.T. Date 6-57 Drwg. No. 7-E-19200-N
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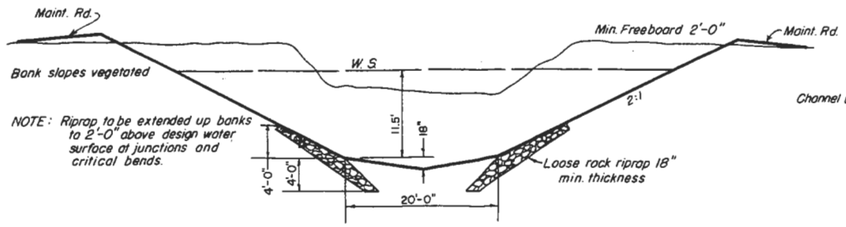
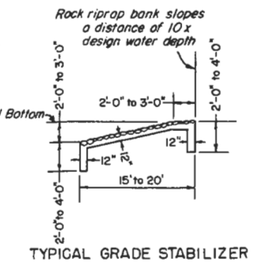
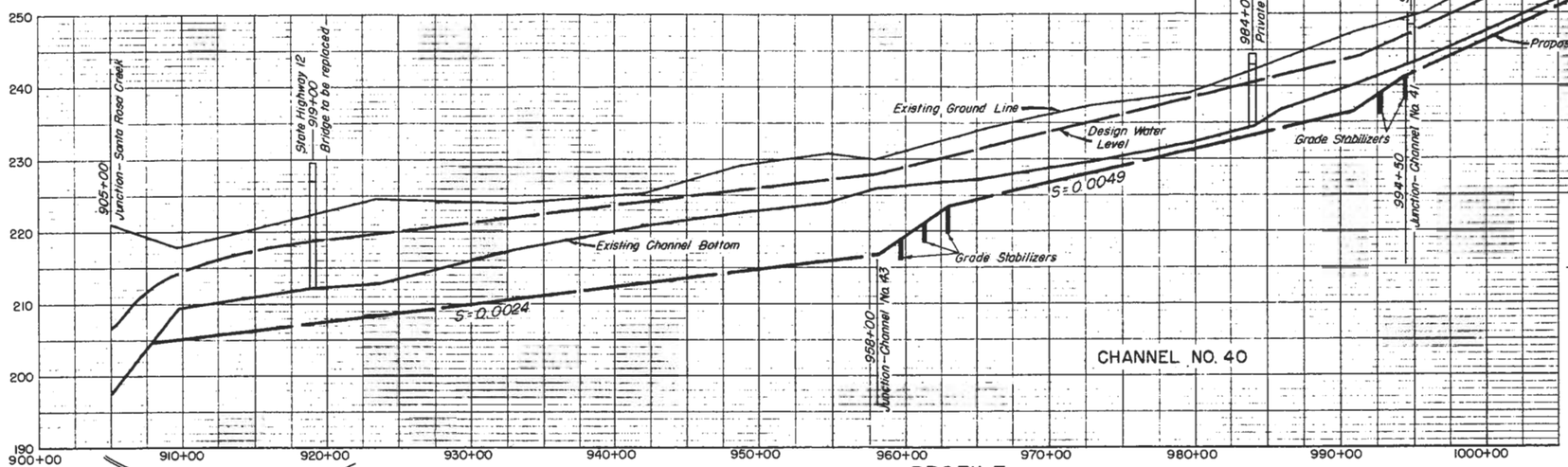



STA. 905+00 to STA. 958+00

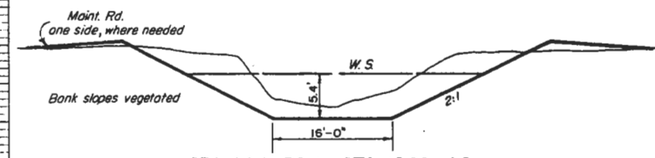



TYPICAL GRADE STABILIZER

CROSS SECTIONS

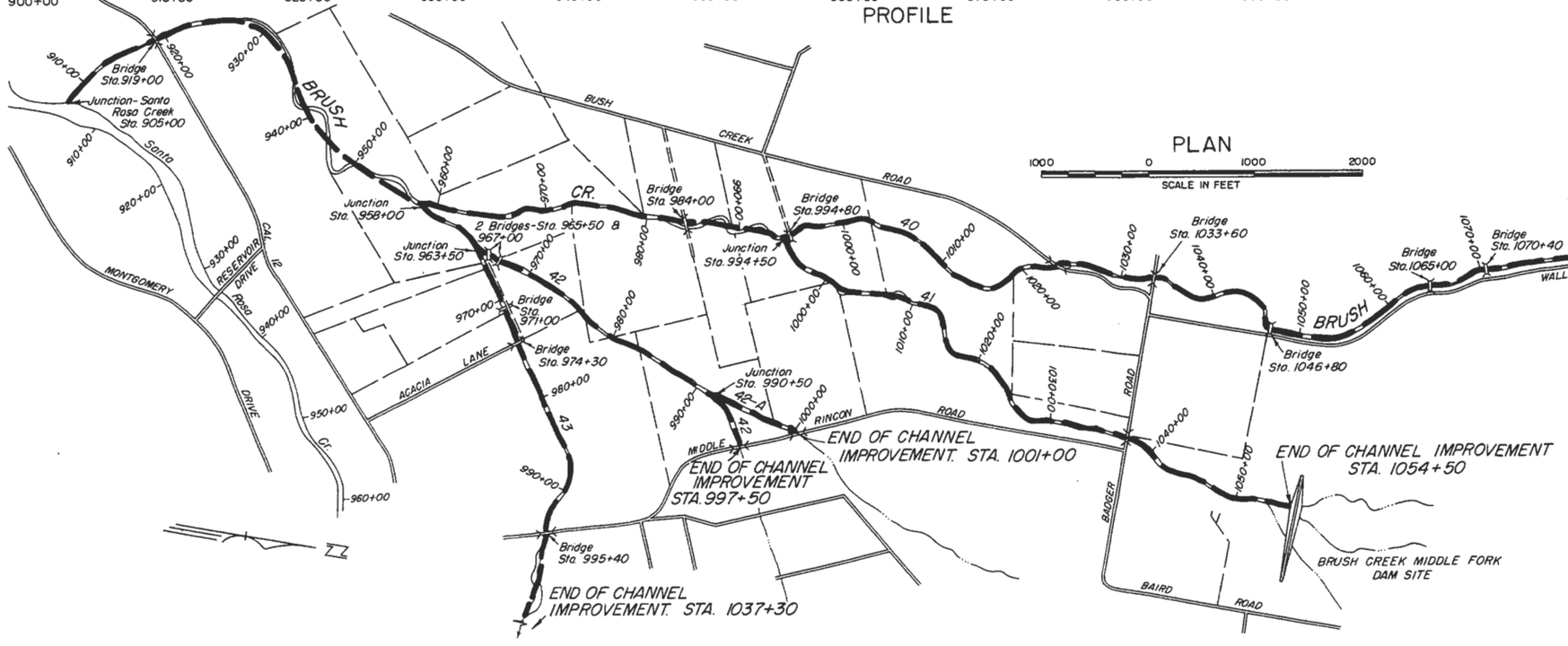



PROFILE




STA. 994+50 to STA. 1069+40

TYPICAL CROSS SECTION




PLAN

1000 0 1000 2000
SCALE IN FEET

LEGEND

Existing Channel

Channel Improvement (vegetated)

All elevations 1929 datum

WORK PLAN

# BRUSH CREEK

## CENTRAL SONOMA WATERSHED

SANTA ROSA S.C.D., GOLD RIDGE S.C.D. SONOMA CO., CALIF.

## PRELIMINARY PLANS

SONOMA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by R.T. Date 6-57 Drwg. No. 7-E-19201-N
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