M E M O R A N D U M

23 January 1995

To: Andy Hauge and Robin Cort

From: Rich Maurer

Re: Santa Rosa Subregional Long-term Wastewater Project
BPU Adopted Alternative 5 - Geysers Recharge
Water Balance and Operation Considerations

INTRODUCTION

Discharge of treated wastewater effluent to the Geysers power plant area for injection into the steam fields is the basis for BPU Adopted Alternative 5 - Geysers Recharge.

The purpose of this alternative (for the BPU) is to discharge the effluent independent of constraints associated with the continued discharge to surface water (i.e., need to meet the dilution requirements for the Russian River and, therefore, the need to continue to add more storage to the system to accommodate periods when river discharge is not possible) or the requirements for disposal by irrigation (i.e., need to expand the existing storage and irrigated acreage system).

The purpose of this alternative (for the Geysers' Operators; i.e., Unocal, PG&E, Calpine and others) is to provide a supplementary source of water for injection into the steam fields to reduce the current declining output of the steam fields and thereby prolong the useful life of the power plants. Representatives of the Geysers Operators have stated that the value of additional water injected into the steam fields equates to about 8,700 Kilowatts per MG.

Many considerations regarding project financing, management, permitting, construction, and operation are important for a project of this nature and magnitude. This memorandum will concentrate on the water balance and facility capacity considerations, which are critical to establishing the construction cost and operations cost, and the cost sharing, for this alternative.

SUMMARY

This memorandum outlines the considerations associated with developing a design water balance scenario for the Geysers discharge alternative. The effect of water balance on the monthly distribution of flows delivered to the Geysers and to the irrigation system is presented. The relationship between monthly delivery variations and the required storage capacity is revealed. These considerations are critical to the sizing of the Geysers delivery system pipeline and pumping stations and to the determination of the required storage capacity necessary to operate the Geysers alternative.

In a subsequent memorandum, the considerations of possible separate storage for the Geysers supply, and the implications of producing two effluent qualities, will be presented. The issues of sizing the Geysers pipeline and pump stations, providing separate storage capacity, and producing effluent of two qualities are the basis for determining the capital and operational costs for the Geysers alternative.

WASTEWATER FLOWRATE

Treated wastewater is being produced on a continuous basis by the Laguna Subregional Wastewater Treatment Plant. The wastewater flowrate leaving the plant varies throughout the year, from summer dry weather low flows to winter wet weather peak flows (due to infiltration/inflow into the collection system).

The projected average daily flowrate, by month, for the years 1995 and 2010 (the project design year), is presented in Table 1. For this report, year 1995 flows will be considered the "initial condition" for a Geysers project, and year 2010 flows will be considered the "design condition".

For year 1995, the minimum average daily flow is estimated to be 16.8 MGD for the month of August, and the maximum average daily flow is estimated to be 31.2 MGD for the month of January. For project year 2010, the minimum average daily flow is projected to be 22.5 MGD in August, and the maximum average daily flow to be 41.8 MGD in January. The average daily wastewater flowrate by month is shown in Table 1. Night time minimum flows of half these values, and rainy period peak flows of double these values, are possible.

Currently, treated effluent from the Laguna Plant is either discharged to the Russian River or is disposed of by irrigation. Typically, one half of the total annual flow goes to the river, and the other half goes to irrigation. The annual pattern of wastewater generation and disposal is displayed approximately in Figure 2.

WASTEWATER STORAGE WITH CURRENT SYSTEM

Currently, treated effluent from the Laguna Plant is pumped into a series of large volume ponds before being either discharged to the Russian River in the winter season or disposed of by land application (mostly by spray irrigation of pasture and fodder crops) in the spring-summer season. The ponds serve the very important function of storing freshly treated wastewater during periods when disposal cannot be used, and to maximize disposal when it can.

Storage also provides the important function of attenuating the daily and seasonal fluctuations in wastewater flowrate, which can reach a maximum ratio of 5:1 or more for the Santa Rosa system (from dry season minimum hourly flows to wet season peak hourly flows).

Currently, discharge to the Russian River is not permitted between May 15 and October 1; after October 1 discharge is permitted only after the River reaches 1,000 cfs flowrate. Disposal to the irrigated fields is impractical during wet periods. Because there are gaps between the season of allowable river discharge and the season of active irrigation disposal, the net volume in the storage ponds rises during these periods. Storage volume in the ponds, therefore, follows an annual cyclic pattern of maximum accumulated volume in the spring (just before the beginning of the next irrigation season), to minimum volume by the end of the irrigation season, to maximum volume again prior to significant river flow, allowing start of discharge. This cyclic pattern is displayed in the simplified storage volume graph, for the current disposal system, presented in Figure 3.

Current total storage capacity is about 1,540 MG, distributed among several ponds (of which Meadowlane and Delta are the most significant), and located remote from each other but connected by large diameter reclaimed water distribution pipelines. The current reclamation system main pipelines and irrigated properties are shown in Figure 4. Plant effluent pumps pressurize the reclaimed water distribution pipelines which also deliver treated plant effluent into the remote ponds. Separate pumps lift some plant effluent directly into the Meadowlane Ponds, which are the only storage ponds located adjacent to the plant.

The current system is operated by releasing water from storage to the river in winter, and from storage to the irrigation system in the summer, to approximately follow the projected storage curve shown in Figure 3.

The current system operates with two goals; to not exceed the discharge allowance to the Russian River and, to empty the storage ponds by the end of the irrigation season. A secondary goal of meeting the contractual commitments to provide water to the private irrigators creates a self-imposed limit on the release of "too much" water to the river during wet periods. These goals are met by the system operators by regularly monitoring the net storage volume and controlling releases to match an "ideal" operational storage volume graph.

The discharge allowance to the Russian River is, generally, 1 percent of river flows, but during unusually wet periods the system is allowed to discharge up to 5 percent of river flows. The actual amount is determined by daily monitoring the output of an automated gaging station on the Russian River and adjusting discharges from the storage ponds accordingly.

WASTEWATER STORAGE WITH GEYSERS PROJECT

A change in wastewater disposal practice from the current river discharge and irrigation disposal system to implementation of discharge to the Geysers would impose a change in role for storage. Some storage would still be needed to attenuate the daily and seasonal fluctuations in flowrate, but the total storage capacity required and the pattern of net volume in storage throughout the year would be different from the current practice.

Basically, with disposal by river discharge or irrigation reuse, storage is a necessity to accommodate those periods when neither can be used. With a change to Geysers discharge, which could take place year round, the need for storage is reduced, and becomes a matter of tradeoff between the additional cost for storage to obtain a more nearly constant pumping rate (and, therefore, less costly pipelines and pumping stations) versus the cost for a larger capacity pipeline and pump stations to handle the peak flowrate.

The selected storage capacity and storage pattern would also be influenced by whether or not irrigation disposal continues to be practiced. The more irrigation is practiced, the greater the storage requirement. It is assumed for this report that some irrigation disposal will continue even if the Geysers disposal alternative is implemented. Initially, satisfaction of existing long-term irrigation contracts with private property owners will be necessary. Once these contracts expire, and if the Geysers disposal facilities prove reliable, more water could be diverted to the Geysers. It is assumed that the BPU will still want to continue landscape irrigation for golf courses and parks, while reducing the amount of pasture irrigation.

For purposes of this report, it is assumed that, upon startup of a Geysers wastewater disposal project, discharge to the Russian River will cease (although retained for an emergency disposal option) and wastewater reuse by irrigation will be reduced by 50 percent from current levels. The level of irrigation would be held constant, even for the design year of 2010, so as to make a commitment of providing a substantial water supply to the Geysers Operators and, thereby, attract their financial participation in the project. Initially (1995 flows), about 78 percent of the total wastewater volume would be sent to the Geysers. This would rise with time until, for the design year 2010 flows, it reaches about 83 percent. These percentages can be derived from the tables of alternate water balances displayed below in this memorandum.

For economy, it is desirable to size the Geysers delivery pipeline and pump stations to handle a uniform flowrate year-round (rather than the peak flowrate which occurs during the wet months). However, if the uniform flowrate selected is less than the wet season flows, then there would be a need for storage to attenuate the wet season flows and make them available to the Geysers pumps (or to irrigation) at a later time (when the current monthly flows are less than the uniform delivery rate). If, on the other hand, the uniform flowrate selected is more than current generation rate some months, then the difference between the pumping rate and the current generation rate must be made up from storage. This function can most economically be served by the existing storage facilities if it is agreed to deliver currently produced tertiary wastewater to the Geysers and if the Geysers pumps are located to be able to take water from existing storage during some months.

If, on the other hand, the volume of water delivered to the Geysers is varied by month so that it is always less or equal to the wastewater generation rate (for every month), then there is no need for substantial storage for the Geysers supply. The pumps can simply pump it directly from the plant or a relatively small flowrate attenuation pond.

WATER BALANCE OPTIONS

The monthly pattern of discharge of wastewater for a Geysers project can vary depending on the assumptions made about irrigation flows and the use of storage. Some of these possible water balance patterns or options are presented in Tables 2 through 6. Options 1 through 4 (Tables 2 through 5) present water balance scenarios based on 1995 year flows, assumed to be the "initial condition" for a Geysers project. Although the project facilities would be sized for the design year 2010 flows (Table 6), presentation and comparison of these tables serves to reveal the tradeoffs involved in sizing the Geysers pipeline and pump stations, and operating these facilities at less than design capacity.

Option 1 (Table 2) is based on the assumption that the volume discharged to the Geysers, and the volume disposed of by irrigation, is varied by month, with the goal of maintaining a constant minimal level in storage (assumed here to be 100 MG). Furthermore, irrigation disposal is assumed limited to 50 percent of current levels. This minimal storage goal may be important if separate or new storage will need to be provided for Geysers effluent treated only to the secondary level while irrigation effluent continues to be treated to the tertiary level. Option 1 is based on the goal of sending as much water to the Geysers as possible, as it is generated, allowing for irrigation commitments. The result is a wide range of monthly flows to the Geysers, from a high of 933 MG in January to a low of 126 MG in July. The consequence of this option is that the Geysers pipeline and pump stations, sized to handle the January flows, would be substantially oversized to handle the lower flows much of the year. This would not be the most cost-effective option.

Option 2 (Table 3) is based on the assumption that the volume discharged to the Geysers would be held constant throughout the year, about 520 MG/Month or 17.3 MGD. The total annual flow delivered to the Geysers would be approximately equal to Option 1 (Table 2), about 6,240 MG (or 19,000 acre-feet). Irrigation disposal is assumed limited to 50 percent of current levels. Storage would vary throughout the year, reaching a peak requirement in April of about 1590 MG which is somewhat above the current storage capacity. The consequence of this option is that the Geysers pipeline and pump stations would be sized for a constant flowrate and, therefore, would be very cost-effective, especially considering that the same total annual volume would be delivered to the Geysers.

Option 3 (Table 4) is based on the assumption that the volume discharged to the Geysers would be held constant on a seasonal basis, with about 680 MG/month during the winter months and about 350 MG/month during the summer months. These values were estimated by iteration to satisfy the storage requirements for the irrigation demand while limiting the maximum storage requirement to less than the existing system storage capacity. The total annual flow delivered to the Geysers would be approximately equal to Options 1 and 2. Irrigation disposal is again assumed limited to 50 percent of current levels. Storage would vary throughout the year, reaching a peak requirement in May of about half that required in Option 2 and well within the current storage capacity. The consequence of this option is that the Geysers pipeline and pump stations would be sized for a peak flow of 680 MG/month, considerably less than for Option 1 but more than for the constant flowrate for Option 2. Therefore, the cost-effectiveness of this option would also lie between Options 1 and 2.

Option 4 (Table 5) is very similar to Options 1 and 3, except the monthly Geyser delivery has less variation than Option 3, and much less than Option 1, with the consequence that the cost-effectiveness of this option would be better than those two options, and the storage requirement would be well within the current storage capacity. The total annual flow delivered to the Geysers would be approximately equal to the previous options (6,330 MG or 19,000 acre-feet). Irrigation disposal is again assumed limited to 50 percent of current levels. Storage would vary throughout the year, reaching a peak requirement in March and April of about 1,000 MG, still less than the current storage capacity, but making more effective use of the current capacity. The consequence of this option is that the Geysers pipeline and pump stations would be sized for a peak flow of about 733 MG/month, nearly equal to that for Option 3, but more cost-effective because the minimal monthly deliveries would be higher than for Option 3, and current storage capacity would be more fully utilized. Therefore, the cost-effectiveness of this option would be higher than for all previous options.

Option 5 (Table 6) is presented for the design year 2010. The same considerations revealed above for Options 1 through 4 for the year 1995 flow options apply to the higher year 2010 flows. The rationale for developing Option 5 is similar to that for Option 4 and is considered to be close to the ideal water balance design condition for the Geysers project. Option 5 requires a storage capacity very close to the current capacity.

If the design capacity delivery to the Geysers were fixed at a constant monthly rate similar to Option 2 for the 1995 flows, the maximum storage requirement for 2010 would exceed the current system maximum storage capacity by 500 to 750 MG. For this reason a table was not prepared for this option, and this option is considered to not be cost-effective.

Option 5 (like all the options considered above) assumes that the existing storage system would be utilized to supply both the Geysers pumps and the irrigation reuse system; i.e., only one quality of plant effluent (tertiary) would be utilized for both disposal uses. The subject of utilizing the same or different water quality for the Geysers and the irrigation system, and the impact on storage considerations and costs, will be covered in a subsequent memorandum.

TABLE 1

LAGUNA PLANT FLOWRATE

	1995 (1)		2010 (2)	
	Daily (MGD)	Monthly (MG)	Daily (MGD)	Monthly (MG)
January	31.2	950	41.8	1,270
February	26.9	820	36.0	1,100
March	22.8	690	30.5	930
April	19.2	580	25.7	780
May	18.3	560	24.5	750
June	17.4	530	23.3	710
July	17.0	520	22.8	690
August (3)	16.8	510	22.5	680
September	17.0	520	22.8	690
October	17.5	530	23.4	710
November	21.1	640	28.2	860
December	22.3	680	29.9	910

(1) Estimated from 1993 and 1994 plant flow records.

(2) Year 2010 flows estimated as 1.339 times 1995 flows (approximately 2 percent growth per year for 15 years), based on ratio of flows for month of August (i.e., dry weather flow).

(3) Dry weather flow (ADWF) for year 2010 taken as 22.5 MGD from Screenings Report. This approximately agrees with 2 percent per year growth projection.

TABLE 2

OPTION 1 - GEYSERS PROJECT WATER BALANCE (1995 Flows)

Month	Wastewater Effluent Generated (MG/month) (1)	Discharge To Geysers (MG/month) (2)	Irrigation Reuse (MG/month) (3)	Effluent To Storage (MG/month) (4)	Net In Storage (MG) (5)
N	607	607	0	0	100
D	733	733	0	0	100
J	933	933	0	0	100
F	816	816	0	0	100
M	895	895	0	0	100
A	726	726	0	0	100
M	631	381	250	0	100
J	585	185	400	0	100
J	576	126	450	0	100
A	545	145	400	0	100
S	539	319	220	0	100
O	590	370	120	0	100
	8,176 MG	6,336 MG	1,840 MG		

(1) Projected wastewater effluent generation flows taken from Table 1.

(2) Discharge to Geysers fixed at difference between the wastewater effluent generated and the flowrate committed to irrigation reuse.

(3) Assumes irrigation flows limited to 50 percent of 1992 flows, as estimated from Subregional Reclamation Storage Curve in Reclamation System 1992 Annual Report. This is assumed to be "initial condition" of Geysers project, necessary to accommodate flow commitments to irrigators.

(4) No water is sent to storage as all fresh flow is immediately sent to geysers or to irrigation.

(5) Storage fixed at nominal 100 MG to provide attenuation of daily flow variations and provide supply to Geysers fixed speed delivery pumps.

TABLE 3

OPTION 2 - GEYSERS PROJECT WATER BALANCE (1995 Flows)

Month	Wastewater Effluent Generated (MG/month) (1)	Discharge To Geysers (MG/month) (2)	Irrigation Reuse (MG/month) (3)	Effluent To Storage (MG/month) (4)	Net In Storage (MG) (5)
N	607	520	0	87	87
D	733	520	0	213	300
J	933	520	0	413	713
F	816	520	0	296	1,009
M	895	520	0	375	1,384
A	726	520	0	206	1,590
M	631	520	250	-139	1,451
J	585	520	400	-335	1,116
J	576	520	450	-394	722
A	545	520	400	-375	347
S	539	520	220	-201	146
O	590	520	120	-50	96
	8,176 MG	6,240 MG	1,840 MG		

(1) Projected wastewater effluent generation flows taken from Table 1.

(2) Discharge to Geysers fixed constant, and as large as possible without denying sufficient storage to satisfy irrigation demand.

(3) Assumes irrigation flows limited to 50 percent of 1992 flows, as estimated from Subregional Reclamation Storage Curve in Reclamation System 1992 Annual Report. This is assumed to be "initial condition" of Geysers project, necessary to accommodate flow commitments to irrigators.

(4) Flow sent to storage is selected to accumulate sufficient storage to satisfy irrigation demand, and to maintain a minimum net storage capacity of about 100 MG, at end of irrigation season.

(5) Some minimum storage must be available to attenuate daily flow variations and to equalize supply to Geysers delivery pumps. Maximum storage of 1590 MG is consequence of fixing constant discharge to Geysers, and may be larger than existing combined storage capacity.

TABLE 4

OPTION 3 - GEYSERS PROJECT WATER BALANCE
(1995 Flows)

Month	Wastewater Effluent Generated (MG/month) (1)	Discharge To Geysers (MG/month) (2)	Irrigation Reuse (MG/month) (3)	Effluent To Storage (MG/month) (4)	Net In Storage (MG) (5)
N	607	680	0	-73	6
D	733	680	0	53	53
J	933	680	0	253	306
F	816	680	0	136	442
M	895	680	0	215	657
A	726	680	0	46	703
M	631	350	250	31	734
J	585	350	400	-165	569
J	576	350	450	-224	345
A	545	350	400	-205	140
S	539	350	220	-31	109
O	590	500	120	-30	79
	8,176 MG	6,330 MG	1,840 MG		

(1) Projected wastewater effluent generation flows taken from Table 1.

(2) Discharge to Geysers fixed constant for ease of control and to better pace the effluent flow generation (i.e.,, higher in the wet months and lower in the dry months) and to limit the maximum storage required to the existing available storage capacity. 680 MG/Month = 22.4 MGD which is the annual average daily flowrate projected for 1995. 350 MG/Month = 11.5 MGD.

(3) Assumes irrigation flows limited to 50 percent of 1992 flows, as estimated from Subregional Reclamation Storage Curve in Reclamation System 1992 Annual Report. This is assumed to be "initial condition" of Geysers project, necessary to accommodate flow commitments to irrigators.

(4) Flow sent to storage is difference between flows generated and discharge to Geysers and to irrigation.

(5) Some minimum storage must be available to attenuate daily flow variations and provide equalization of supply to Geysers delivery pumps. Maximum storage requirement of 734 MG is less than existing combined available storage capacity.

TABLE 5

OPTION 4 - GEYSERS PROJECT WATER BALANCE
(1995 Flows)

Month	Wastewater Effluent Generated (MG/month) (1)	Discharge To Geysers (MG/month) (2)	Irrigation Reuse (MG/month) (3)	Effluent To Storage (MG/month) (4)	Net In Storage (MG) (5)
N	607	607	0	0	100
D	733	633	0	100	200
J	933	683	0	250	450
F	816	516	0	300	750
M	895	595	0	300	1,050
A	726	726	0	0	1,050
M	631	420	300	-89	961
J	585	420	400	-235	726
J	576	420	450	-294	432
A	545	420	400	-275	157
S	539	420	220	-101	56
O	590	420	120	50	106
	8,176 MG	6,330 MG	1,840 MG		

(1) Projected wastewater effluent generation flows taken from Table 1.

(2) Discharge to Geysers fixed at difference between the wastewater effluent generated and the flowrate committed to storage and irrigation reuse.

(3) Assumes irrigation flows limited to 50 percent of 1992 flows, as estimated from Subregional Reclamation Storage Curve in Reclamation System 1992 Annual Report. This is assumed to be "initial condition" of Geysers project, necessary to accommodate flow commitments to irrigators.

(4) Flow into storage (during winter months) necessary to assure adequate volume to meet irrigation commitments in irrigation season and, at the same time, maintain more uniform discharge throughout the year to the Geysers.

(5) Minimum storage of about 100 MG selected to provide attenuation of daily flow variations and equalization of supply to Geysers delivery pumps. Maximum storage requirement of 1000 MG can be accommodated by existing storage capacity.

TABLE 6

OPTION 5 - GEYSERS PROJECT WATER BALANCE (2010 Flows)

Month	Wastewater Effluent Generated (MG/month) (1)	Discharge To Geysers (MG/month) (2)	Irrigation Reuse (MG/month) (3)	Effluent To Storage (MG/month) (4)	Net In Storage (MG) (5)
D	962	962	0	0	100
J	1,224	824	0	400	500
F	1,071	671	0	400	900
M	1,175	775	0	400	1,300
A	953	953	0	0	1,300
M	828	650	250	-72	1,228
J	767	650	400	-283	945
J	757	650	450	-343	602
A	716	650	400	-334	268
S	707	650	220	-163	105
O	774	650	120	4	109
N	797	797	0	0	100
	10,731 MG	8,882 MG	1,840 MG		

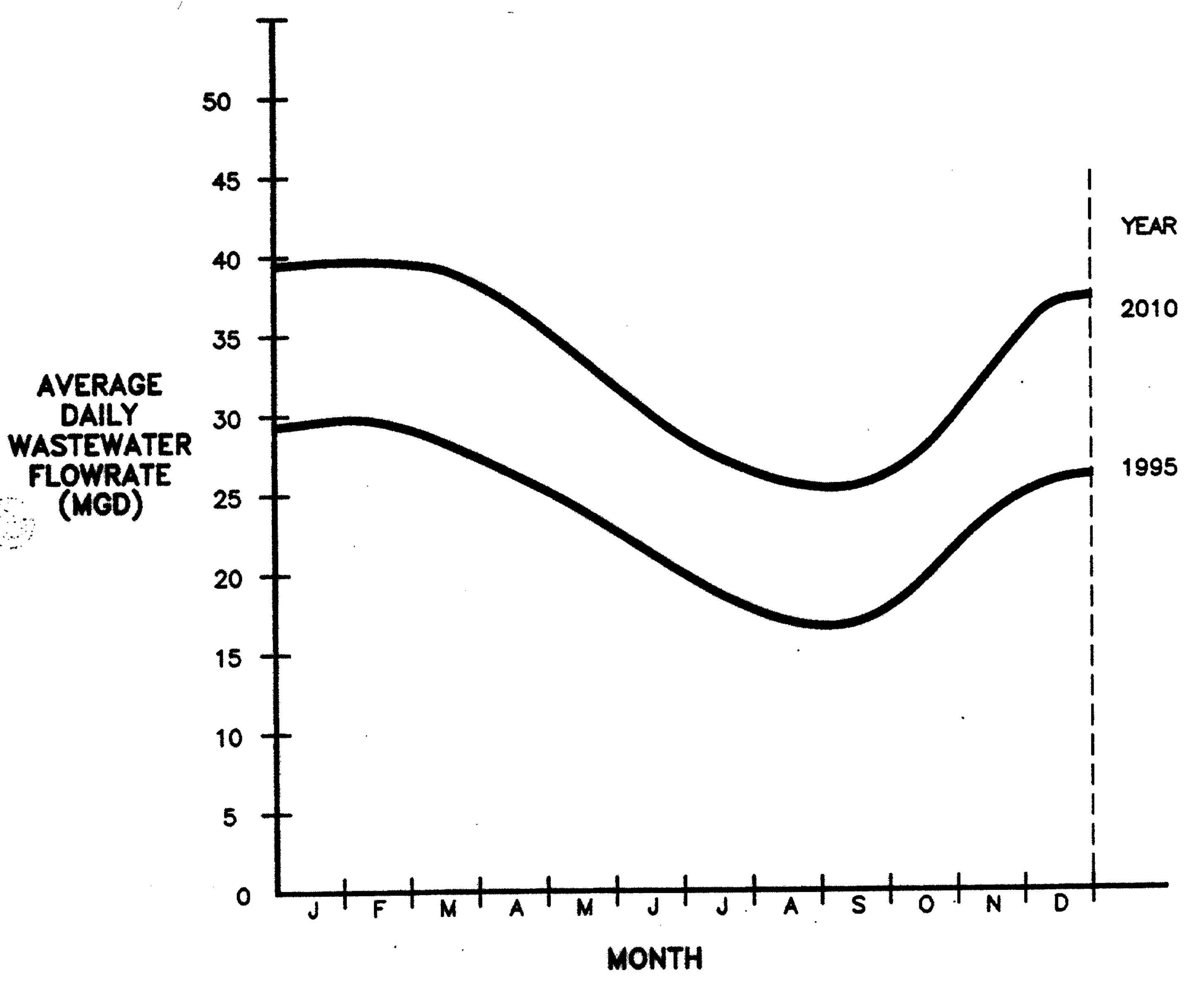
(1) Projected wastewater effluent generation flows taken from Table 1.

(2) Discharge to Geysers fixed at difference between the wastewater effluent generated and the flowrate committed to storage and irrigation reuse.

(3) Assumes irrigation flows limited to 50 percent of 1992 flows, as estimated from Subregional Reclamation Storage Curve in Reclamation System 1992 Annual Report. This is assumed to be "design condition" of Geysers project, necessary to maintain reliable irrigation disposal system and continue substantial level of irrigation reuse.

(4) Flow into storage (during winter months) necessary to assure adequate volume to meet irrigation commitments in irrigation season and, at the same time, maintain more uniform supply throughout the year to the Geysers.

(5) Minimum storage of about 100 MG selected to provide attenuation of daily flow variations and equalization of supply to Geysers delivery pumps. Maximum storage requirement of 1300 MG can be accommodated by existing storage capacity.

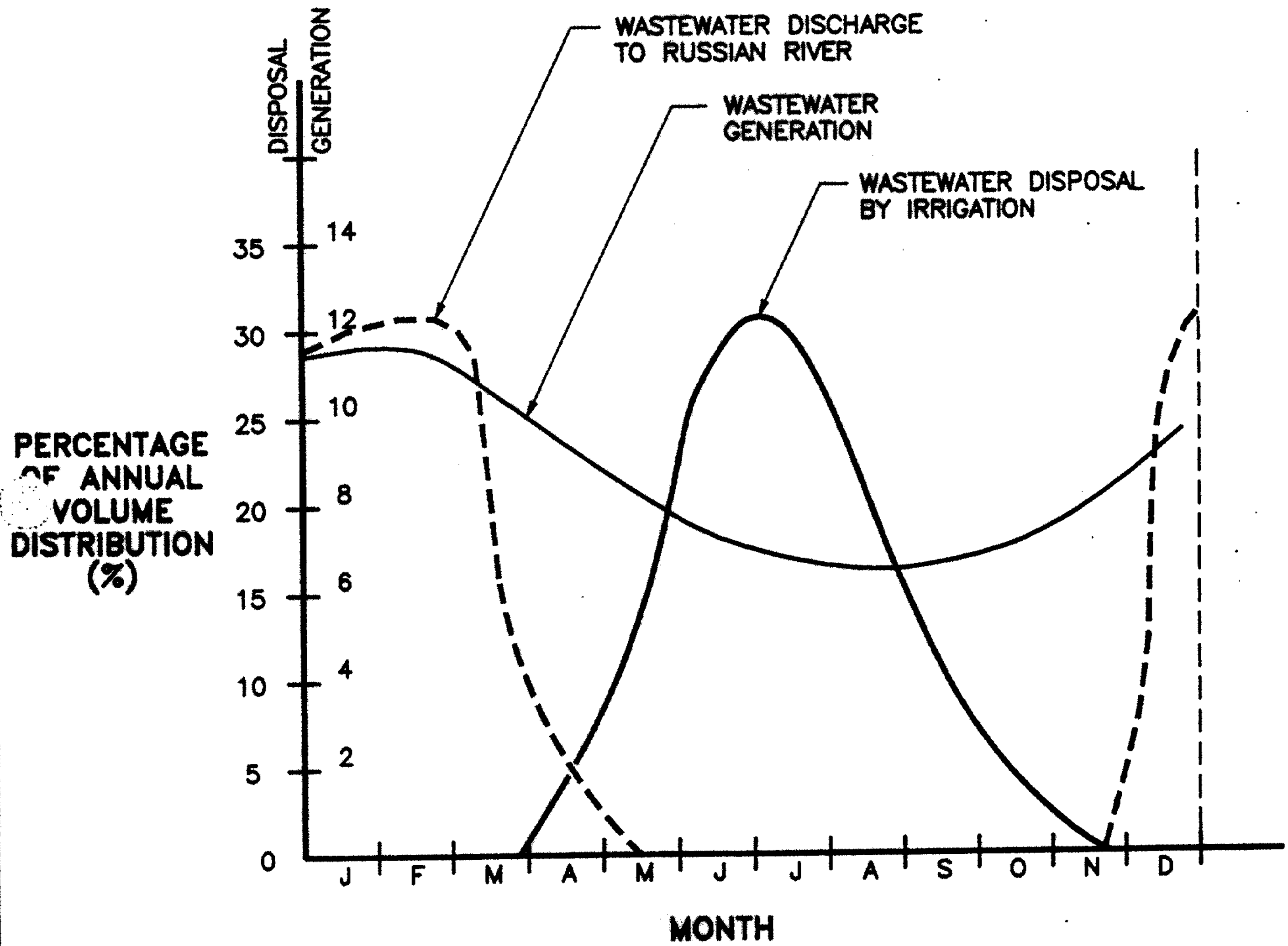


SANTA ROSA
SUBREGIONAL LONG-TERM
WASTEWATER PROJECT

PROJECTED WASTEWATER
GENERATION

FIGURE 1

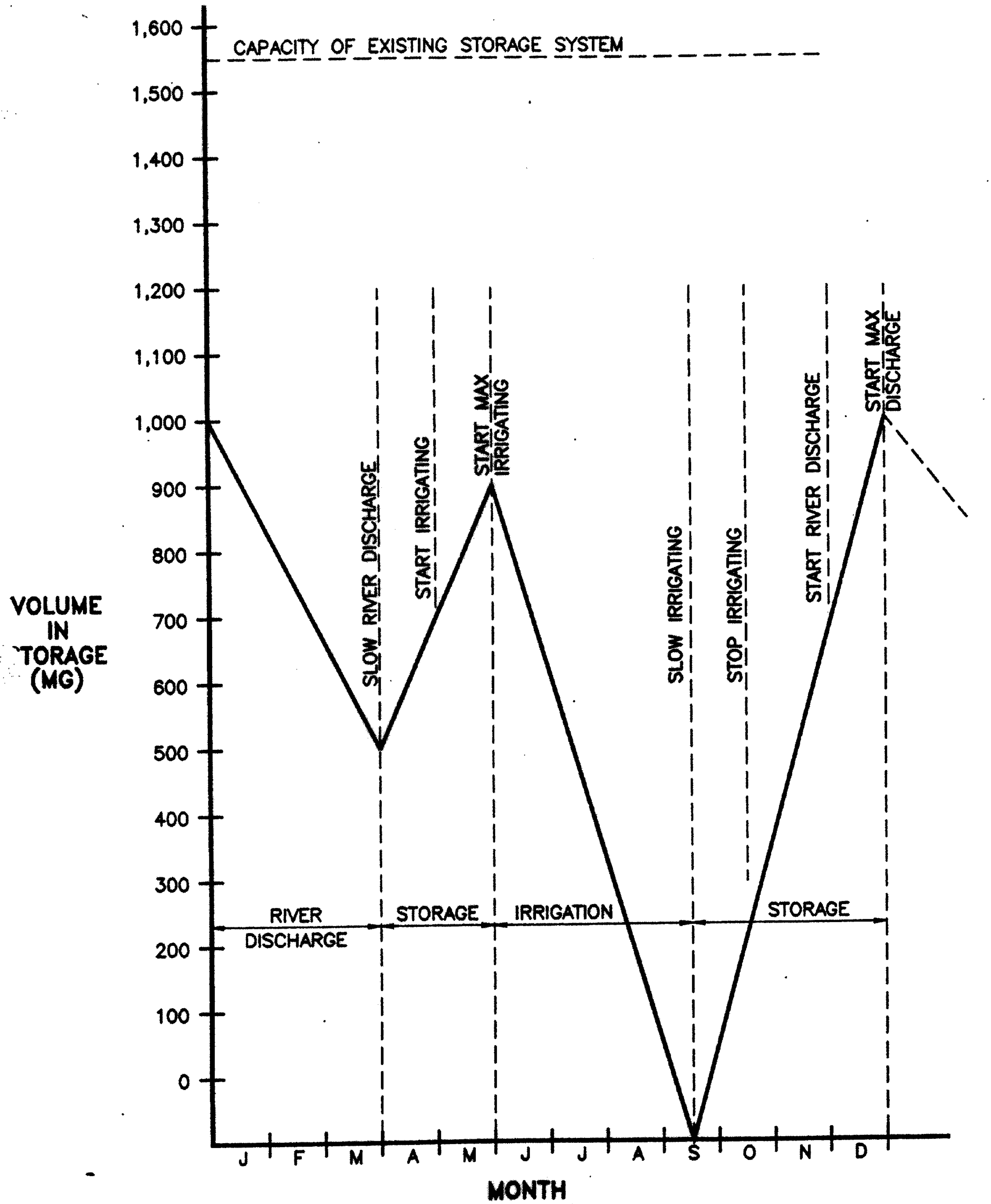
JAN 23, 1995 – 10:34:28 ENG_DWG\STR\FIG-1F



SANTA ROSA
SUBREGIONAL LONG-TERM
WASTEWATER PROJECT

GENERALIZED EXISTING WASTEWATER GENERATION AND DISPOSAL DISTRIBUTION

FIGURE 2



SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

SUBREGIONAL RECLAMATION SYSTEM GENERALIZED STORAGE CURVE (FOR EXISTING RIVER DISCHARGE AND IRRIGATION DISPOSAL SYSTEM)

FIGURE 3

JAN 23, 1995 – 10:35:08 ENG_DWG\STR\FIG-3R

Revised: October 25, 1994

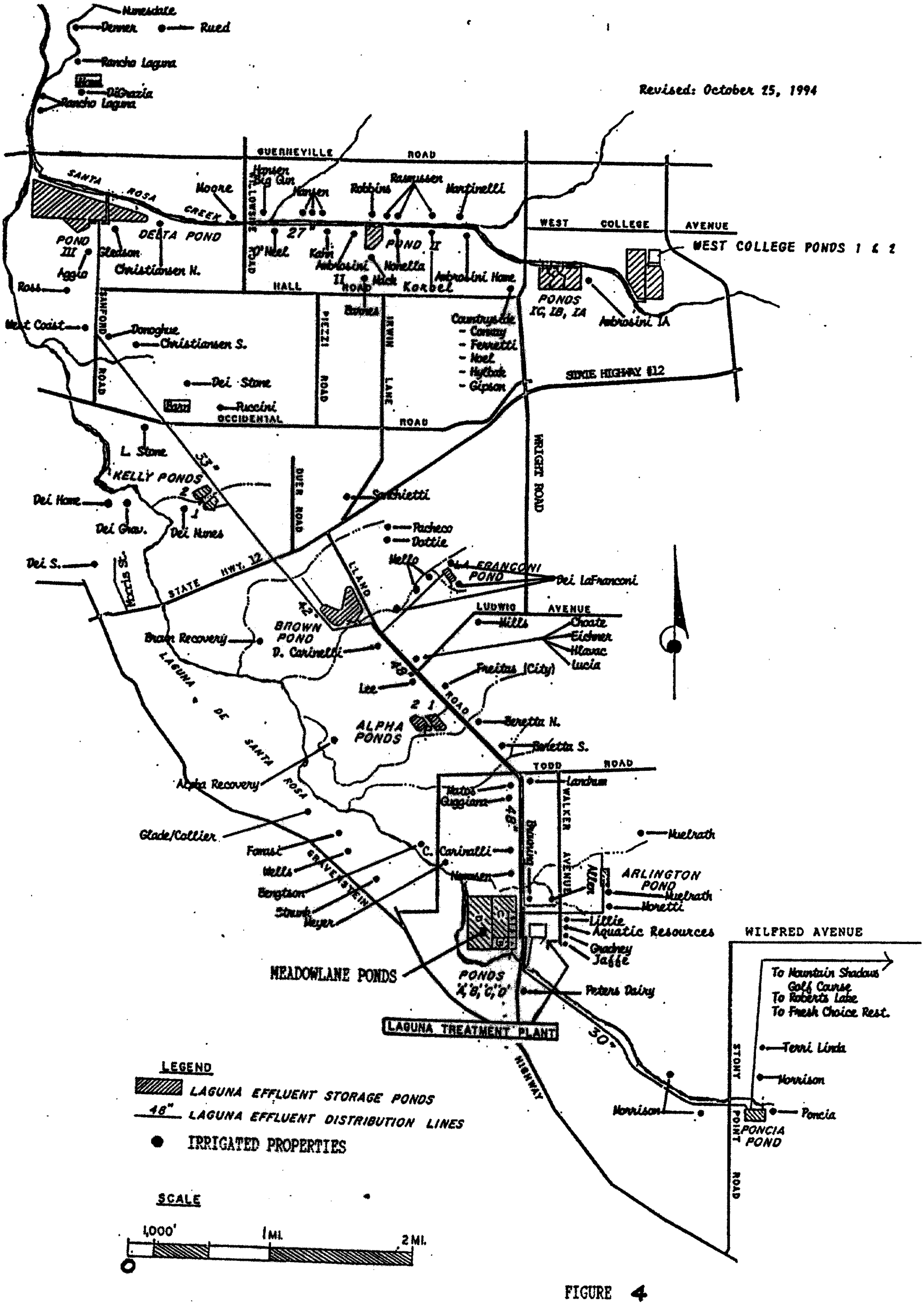


FIGURE 4

SANTA ROSA SUBREGIONAL WASTEWATER SYSTEM
EXISTING RECLAMATION SYSTEM.