Santa Rosa Subregional Long-Term Wastewater Project

AQUATIC BIOLOGICAL RESOURCES IMPACT ANALYSIS REPORT

SANTA ROSA SUBREGIONAL LONG-TERM WASTEWATER PROJECT

Prepared for

City of Santa Rosa
and
U.S. Army Corps of Engineers

June 1996

Prepared by:

Merritt Smith Consulting
Environmental Science and Communication
3675 Mt. Diablo Blvd. #120 Lafayette, CA 94549

For

HARLAND BARTHOLOMEW & ASSOCIATES, INC.

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1.0 PURPOSE

The purpose of this technical report is to identify potential impacts on aquatic life of project components related to construction and operational impacts of storage reservoirs, irrigation, pipelines, and direct discharge components. Potential loss of individual sensitive aquatic organisms due to project impacts is evaluated in the Biological Resources Technical Memorandum, Volume I (Harland Bartholomew & Associates 1996). An ecological risk assessment has been conducted to evaluate potential impacts on aquatic and terrestrial ecosystems from reclaimed water through bioaccumulation and toxicity. These potential impacts are addressed in the *Ecological Risk Assessment* (Parsons ES 1996). “Aquatic biological resources” in this report refers to aquatic plants, invertebrates, fish, amphibians, and reptiles. Birds and mammals are addressed in other reports.

2.0 EVALUATION CRITERIA

Evaluation criteria were developed to provide a basis for assessing potential project impacts on aquatic habitat. Potential impacts of five relevant project components are described in a later section of this report, and are addressed for: storage reservoirs, agricultural irrigation, urban irrigation, pipelines, and discharge. This section provides a description of the development of evaluation criteria and their application. Other project components would not affect aquatic habitat and are not considered further.

Potential project actions could result in changes to aquatic habitat through eliminating the habitat (e.g., by diverting the water away from a site and building a structure there), by converting habitat of one type to another type (e.g., a portion of a stream becomes a reservoir), or by creating habitat. In either case, the abundance or diversity of organisms found in a certain type of habitat may be changed if portions of that habitat are changed or destroyed. Habitat can also be lost to a population if barriers to movement are erected (i.e., so that migratory animals can no longer reach areas with habitat needed for reproduction, feeding, rearing, or other functions). In addition, habitat can be lost to some species or altered from a change in the stream bed due to sedimentation or a change in the chemical composition of the water. Evaluation criteria were developed to express the degree to which habitat is impacted.

2.1 HABITAT TYPES

Aquatic habitat was classified into six categories, four of which apply to streams, one to ponds, and one to estuaries. The four stream categories are based on the type of assemblage of fish species likely to be found in stream habitat having certain characteristics. The four stream categories are: *coolwater-A*, *coolwater-B*, *warmwater-A*, and *warmwater-B*. The *pond* category includes natural or man-made perennial standing water bodies of any size, including irrigation and stock ponds, and municipal or other agency reservoirs. The estuary category includes Estero Americano and Estero de San Antonio. Each of the habitat categories is described in detail and mapped in the *Aquatic Habitat Survey Results* Technical Report (MSC 1996a).

Each of the habitats listed above has value to some aquatic organisms. *Coolwater-A* or *coolwater-B* habitat is essential spawning and rearing habitat for salmonids: steelhead trout (*Oncorhynchus mykiss*), coho salmon (*O. kisutch*), and chinook salmon (*O. tshawytscha*), and necessary or of high value to other fishes (e.g., sculpins), many insects, and some amphibians: foothill yellow-legged frog (*Rana boylii*), and the Pacific giant salamander (*Dicamptodon ensatus*). *Warmwater-A* habitat is unsuitable for salmonids (except as a migratory corridor), but valuable to some native fishes (and many introduced fishes), frogs, turtles, and salamanders. *Warmwater-B* habitat, which usually dries up completely for several months each year, is unsuitable for any fishes and most amphibians and reptiles, but is suitable habitat for some aquatic species (e.g., insects), particularly ones with larval or adult stages which are especially vulnerable to predation by fishes. Organisms using *warmwater-B* habitat must have either good dispersal abilities or some other means of surviving dry periods (e.g., encystment (sealing oneself into an impermeable capsule) or estivation (burrowing into the mud and becoming dormant until wet weather returns)). *Warmwater-B* may also serve as a migratory corridor for salmonids. Ponds are used by many of the same species that use *warmwater-A* habitat. Estuaries usually harbor a variety of aquatic species that include some adapted specifically to life in estuaries, plus others that are more typically found in either marine or freshwater environments. Tides and salinity are important features of estuarine habitat.

Of the sensitive species (i.e., those having some state or federal listing status) of aquatic animals known to exist in the project area, most occur in the first three stream categories. Steelhead trout and coho salmon occur in *coolwater-A* or *coolwater-B* habitat. California red-legged frog (*Rana aurora draytoni*), northwestern pond turtle (*Clemmys marmorata marmorata*), some fishes, including hardhead (*Mylopharodon conocephalus*), Russian River tule perch (*Hysterocarpus traskii pomo*), Navarro roach (*Lavinia symmetricus navarroensis*), Pacific lamprey (*Lampetra tridentata*), and two invertebrates, California freshwater shrimp (*Syncaris pacifica*), and Tomales isopod (*Caeidotea tomalensis*) occur in *warmwater-A* or *coolwater-B*. *Pond* habitat is important to California red-legged frog, northwestern pond turtle, and Tomales isopod, but not to any known sensitive fishes. One sensitive species of fish, the tidewater goby (*Eucyclogobius newberryi*), occurs in both Estero Americano and Estero de San Antonio.

2.2 DEVELOPMENT OF EVALUATION CRITERIA

Potential project impacts to aquatic habitat were assessed with respect to different types of evaluation criteria: changes in habitat type, barriers to movement, changes in salinity, changes in streamflow, stream bed alteration, and changes in migration corridors.

2.2.1 Changes in Habitat Type

The amount and type of aquatic habitat in each reservoir site watershed and within the footprint of each reservoir site was estimated (see appendix maps in MSC 1996a). A watershed is defined as extending from the headwaters of the drainage system to the upper limit of tidal influence. The level of significance for potential impacts was chosen based on the fraction of the total amount of habitat in the watershed that would be lost. A threshold percentage of habitat loss (for an impact to be significant) was determined for each of the habitat types as follows:

- *Coolwater-A*, 0 percent loss
- *Coolwater-B*, 0 percent loss
- *Warmwater-A*, 15 percent loss
- *Warmwater-B*, 25 percent loss
- *Pond*, 25 percent loss

These threshold percentages are based on our professional judgment of the relative importance of these habitat types within the region of the project area. Since *coolwater-A* and *coolwater-B* habitat is critically important to salmon and steelhead, and in short supply throughout the region, the threshold is set at 0 percent loss for these types. The threshold of significance of *warmwater-A* loss is 15 percent. For *warmwater-B* and *ponds*, the threshold is 25 percent loss.

The fractional watershed evaluation approach described above is considered to be appropriate because watersheds are a key factor affecting the distribution of aquatic organisms and habitat and to be consistent with resource agency policy promoting identification of impacts and mitigation within project watersheds. The fractional watershed approach has several limitations as follows that are important to understand when evaluating results.

- The fractional watershed approach creates a bias against project components (e.g., a storage reservoir) located in a small watershed (e.g., Lakeville) when they are being compared within a much larger watershed (e.g., Stemple Creek).
- This approach also does not include in the evaluation of significance the amount of a particular habitat that is present throughout the region. For example, the impact of a particular component is evaluated in terms of the fraction of the watershed total amount, not regional total amount, of a particular habitat.

2.2.2 Barriers to Movement

In the case of potential barriers to movement of migratory species, the threshold value for significance is set at 0 barriers (i.e., any barrier would represent a significant impact).

2.2.3 Changes in Salinity

Potential effects on the existing salinity regimes of estuaries within the Gulf of the Farallones National Marine Sanctuary (Estero Americano and Estero de San Antonio) are also addressed in this report. In estuaries, the salinity regime is usually the major determinant of the distribution and abundance of aquatic plants and animals. Typically, an estuary has a region of high salinity near the mouth, with a biotic community composed of a mixture of marine and estuarine species. The central portion of a typical estuary features variable salinity dependent on tidal conditions and freshwater runoff, and a community dominated by estuarine species of plants and animals: pickleweed (*Salicornia sp.*) and cordgrass (*Spartina sp.*) in shallow mudflats around the edges, beds of eelgrass (*Zostera marina*) subtidally, and many species of bivalves, crustaceans, worms, and fishes that spend all, or nearly all, of their lives in the estuarine environment. The upper ends of estuaries usually have brackish, or low salinity water, but may be entirely freshwater during high runoff events, or hypersaline in the dry season (if runoff stops and tidal exchange is limited). The biotic community in the brackish area may have a mixture of freshwater and estuarine plants and animals, but may also have a few species adapted only to the brackish environment. In the Estero de San Antonio and Estero Americano, one

such species that can live only in the brackish environment is the endangered tidewater goby.

Under the NOAA regulations applicable to Estero de San Antonio and Estero Americano (15 CFR 922), any change to existing habitat or aquatic life in a marine sanctuary constitutes a significant impact. Therefore, the significant impact threshold for salinity change in the two estuaries is 0 percent change.

2.2.4 Changes in Stream Flow

Project components have potential impacts on the flow of streams in the project area. Storage reservoirs will intercept streamflow during the wet season, such that flow immediately downstream from the dam may be greatly reduced or eliminated. Further downstream from a dam, groundwater discharge and discharge from lateral tributaries will restore flow depending on local geology, amount of rainfall, and other factors (see Questa Engineers 1996a). In the dry season, average flow downstream from a dam is likely to be increased relative to existing conditions, because of leakage from the base of the dam, irrigation runoff, and other factors. The extent to which flow may be affected at different locations downstream from a reservoir site will also depend on other variables, including meteorological conditions in a given year (e.g., dry vs. wet years, cool vs. hot summers), irrigation practices, and the amount of reclaimed water discharged to the Russian River (which will affect the remaining amount that must be disposed of by other means). The impacts of irrigation and storage on streamflow that were estimated in RMA (1996a) are used in this technical report to estimate associated impacts on aquatic life. The results from RMA (1996a) were used to generate tables showing the expected flow at different locations in each affected watershed under different project scenarios and combinations of the variables discussed above. The complete tables are provided in Appendices B through D and are discussed in detail in later sections of this report.

The thresholds chosen to represent significant impacts to aquatic life vary with habitat type and season. If the change is positive (increased flow), it is considered a beneficial impact; if negative (decreased flow), a detrimental impact. In the case of *coolwater-A* or *coolwater-B* habitat, any project-related change in flow is considered a significant impact due the flow-limited conditions in the project area. For *warmwater-A* and *warmwater-B*, the threshold value is a 50 percent change during the wet season, and a 0 percent change for *warmwater-A*in the dry season, based on the following rationale.

In the wet season, the main effect of any project storage reservoir is to intercept flow, so flow will be decreased below the dam. A change from 30 cfs to 25 cfs would probably have no measurable impact on resident aquatic life in streams. However, a 50 percent decrease from 30 cfs to 15 cfs could reasonably be expected to result in measurable impacts on stream habitat, sediment transport, and minimum flows necessary for fish movement in some cases. In salmonid streams, average wet season flow may just be enough to allow passage of large adult spawners in a few cases, so any decrease in flow is considered significant.

Summer flows in project area streams are generally much more critical to aquatic life than are the wet season flows. A flow of 0.1 cfs during the dry season may mean the difference between *warmwater-A* habitat which can support a variety of fishes, amphibian larvae, and other aquatic life through the dry period, and *warmwater-B* habitat which is either totally dry in the dry season, or stagnant and overheated, and cannot support fishes and most other aquatic animals. Therefore, any project-related *decrease* in summer flow must be considered a significant impact. Any *increase* in summer flow within project area streams would be considered a beneficial impact for aquatic life. A 50 percent increase in summer flow is conservatively considered the point at which a significant beneficial impact occurs.

The threshold values for changes in stream flow that would result in significant impacts to aquatic life are summarized in Table 1.

Table 1.

Stream Flow Thresholds of Significance

Habitat Type	Threshold of Significance
Coolwater-A	0 percent decrease at any time
Coolwater-B	0 percent decrease at any time
Warmwater-A	50 percent decrease in wet season
Warmwater-A	0 percent decrease in dry season
Warmwater-B	50 percent decrease in wet season
Warmwater-B	Not applicable in dry season

2.2.5 Stream Bed Alteration

Evaluation criteria for assessing impacts from pipelines and discharges on aquatic habitat are similar to the narrative-based criteria established for surface water quality (see MSC 1996b). Stream beds may be altered when suspended sediment is introduced into streams or scoured from streams, and changes in substrate texture can affect the type and amount of benthic biota. These impacts may result from construction of the pipelines, from a rupture of a pipeline along a geologic fault, or from reclaimed water discharges. In time, stream beds will likely recover the original type of substrate owing to upstream sources of either sediment or scouring flows (unless upstream sources are blocked by diversions or dams). However, the timing of this recovery may be critical for certain aquatic life to sustain their populations in their original locations.

Benthic organisms are specialized in their feeding and other behaviors and require a consistent substrate for survival. Changing the substrate with the introduction or loss of different size sediments would change habitat for benthic organisms. Fishes require certain types of spawning gravels to lay their eggs. Covering these gravels with finer sediment after egg-laying and before emergence would reduce effective spawning habitat for fish. Likewise, benthic invertebrates require certain substrate conditions for shelter and feeding.

Benthic invertebrates include larval, nymphal, and adult stages of insects, crustaceans, worms, molluscs, and other animals.

Potential impacts from pipelines (construction or ruptures), or discharge will be considered significant if the project causes any alteration in a stream bed.

2.2.6 Changes in Migration Corridors

A migration corridor is a route used by migrating salmonid fishes (i.e., steelhead trout or coho salmon). Existing populations of both species use the Green Valley/Atascadero Creek system, and steelhead (and possibly coho) use the Laguna de Santa Rosa system. Small numbers of steelhead may use the Americano Creek-Carroll Road tributary, at least occasionally. Splittail migrate up the slough of the Petaluma River to spawn in marshes. Any project-related impacts that could negatively affect use of these corridors would be considered significant.

3.0 METHODOLOGY

The methods used to collect data for the project components varied between components. These methods are described as follows:

3.1 STORAGE RESERVOIRS

Aquatic habitat at potential storage sites was assessed and mapped during field surveys conducted in 1994 and 1995. The information was then transferred to project base maps (1 inch to 1000 feet scale). The completed base maps and field survey forms are included in the appendix of MSC (1996a). The amounts of each existing habitat type (lineal feet for stream habitat, acreage for ponds) at the storage reservoir sites was determined from these maps.

3.2 IRRIGATION

Aquatic habitat in the irrigation areas was mapped as described above for Storage Reservoirs. Impacts on flow were projected based on the effects of irrigation and storage on stream flow (RMA 1996a) and the effects of agriculture on stream habitat (Questa 1995). Potential effects of irrigation and storage reservoirs on salinity in Estero Americano and Estero de San Antonio are analyzed in RMA (1996a).

3.3 PIPELINES

All stream crossings along the proposed pipeline alignments were surveyed for aquatic habitat. Surveys were conducted from June 12 through August 3, 1995 at the end of a wet winter with record rainfall. Many streams still had flow, which is probably related to the high antecedent rainfall. In a typical rainfall year, some of these streams would likely have intermittent or no surface flow during summer months. A survey form was completed at all proposed crossings for streams with suitable habitat and flow to support aquatic life. Data from the completed forms appear in MSC (1996c). Small seasonal streams with no habitat (including gullies, and drainage ditches) were surveyed to confirm the absence of aquatic habitat

The surveys were conducted without entering the streams to avoid crossing onto private property, and the forms were developed to describe the aquatic habitat at pipeline crossings with this constraint in mind. In most cases, the surveys were conducted from the bridge crossing the streams. Information collected on the forms (e.g., type of substrate, embeddedness, percent canopy) was used in characterizing aquatic habitat.

The impacts analysis for potential pipeline component impacts (described in Section 4.3) was developed using information collected during the stream crossings surveys. Each stream surveyed has been designated an aquatic habitat type per the evaluation criteria (e.g., *coolwater-A* and *-B*, *warmwater-A* and *-B*). Stream crossings were typed based on the surveys completed in the field, photographs taken of the stream crossings during the survey, and general knowledge of the area. The habitat type assigned to a given stream crossing reflects an assessment of that stream only at that location and approximately fifty feet above and below the pipeline crossing. The habitat typing is not intended to characterize other sections of the streams.

3.4 DISCHARGE

Direct discharge to the Laguna de Santa Rosa would occur at the 1 percent design discharge rate with implementation of the irrigation alternatives (Alternatives 2 or 3), and at the 20 percent design discharge rate (Alternative 5B). Direct discharge to the Russian River (with a small portion of the discharge released to the Laguna) would occur at the 20 percent rate for the Russian River Discharge Alternative (Alternative 5A). Discharge to the Laguna would also occur with implementation of the Geysers Alternative (Alternative 4), at a maximum discharge rate of 0.65 percent. The No Project Alternative (Alternative 1) would involve discharge at a maximum daily average discharge rate of approximately 10 percent of river flow. The potential impacts of design discharge rates of 5 and 10 percent are also considered in this technical report to provide points of reference point between the 1 and 20 percent design discharge rates.

The Laguna system has been studied intensively every year since 1987 by MSC in relation to possible reclaimed water discharge effects on fish resources, fish migration, water quality, and related issues, resulting in numerous reports (e.g., MSC 1995, 1996d; Roth et al 1991, 1992, 1993). The Russian River itself has been surveyed repeatedly for fish resources by CDFG (1954, 1955, 1968, 1984--unpublished file reports), recently by Goodwin et al. (1994), and is currently the subject of a continuing study by MSC of aquatic plants, benthos, and water quality, as part of the long-term project, summarized in MSC (1996e, f, g). Potential impacts of the discharge alternative to the Laguna de Santa Rosa and the Russian River will be analyzed by reference to the results of the studies cited above.

4.0 POTENTIAL IMPACTS TO AQUATIC HABITAT

The distribution of aquatic habitat is summarized in the appendix of MSC (1996a) and in MSC (1996c). Potential project impacts on this habitat are analyzed based on the evaluation criteria for five relevant project components: storage reservoirs, agricultural irrigation, pipelines, urban irrigation, and discharge. These impacts are described in three categories: construction, operation and maintenance, and emergency events. Construction impacts may occur due to excavation of reservoirs, and building of the dams, pipelines, access roads, pump stations, and diversion channels. Impacts due to operation and maintenance may include changes in downstream flow from reservoir operation and irrigation, and changes in water chemistry from discharge. Emergency event impacts may include dam failures and pipeline ruptures leading to inundation of downstream areas, and potentially resulting in flooding, scouring, and sedimentation.

4.1 STORAGE RESERVOIRS

4.1.1 West County

West County storage reservoirs include: Bloomfield, Huntley, Two Rock, Valley Ford, and Carroll Road.

Construction

Table 2 shows the amount of each habitat type that would be lost by construction of each proposed West County storage site, the total amount of habitat available in the corresponding watershed, and the fractional loss of habitat represented by each storage site. Construction of the proposed Bloomfield storage reservoir and associated facilities would result in the loss of 1,800 lineal feet of *Warmwater-A* habitat, 14,500 lineal feet of *warmwater-B* habitat and 1 acre of *pond* habitat, which represent 3, 14 and 3 percent of those types of habitat in the watershed, respectively. Thus, under the 15 percent impact threshold for *Warmwater-A* habitat and the 25 percent threshold for *warmwater-B* and *pond* habitat, this impact is considered to be less than significant. By the same analysis, no significant impacts would be expected to result from construction of the Huntley or Valley Ford storage reservoirs. For the Carroll Road site, a significant impact would be expected because of the loss of 100 percent of the *coolwater-B* habitat available in the watershed (significant impacts are underlined in Table 2). For the Two Rock site, a significant impact would be expected because of the loss of 7 percent of the *Coolwater-B* habitat available in the watershed.

No impacts would be expected to result from the proposed dams acting as barriers to movements of migratory fish for the Huntley, Two Rock, Bloomfield, or Valley Ford sites. At the Carroll Road site, which is the only site known to be currently used by migratory fish (steelhead), the proposed dam would be a barrierAll of the habitat used by steelhead in the watershed would be lost by inundation if the dam were constructed, so there would be no spawning habitat left for returning adults. Thus, at Carroll Road, a significant impact would be expected through habitat loss, and secondarily, by the dam acting as a barrier to movement of migratory fish.

Table 2.

Summary of Aquatic Habitats and Impacts in West County Waterways

	Cool A	Cool B	Warm A	Warm B	Total	Pond
At West County Storage Sites	**lin. ft.**	**lin. ft.**	**lin. ft.**	**lin. ft.**	**lin. ft.**	**acres**
Bloomfield	0	0	1,800	14,500	16,300	1.0
Huntley	0	0	5,300	7,000	12,300	1.0
Two Rock	0	550	6,000	7,700	14,250	7.5
Valley Ford	0	0	6,500	4,000	10,500	4.0
Carroll Road	0	2,700	3,400	6,900	13,000	3.0
In West County Watershed	**lin.ft.**	**lin.ft.**	**lin.ft.**	**lin.ft.**	**lin.ft.**	**acres**
Bloomfield	0	2,700	61,900	113,400	178,000	34.0
Huntley	0	7,800	102,900	226,700	337,400	108.5
Two Rock	0	7,800	102,900	226,700	337,400	113.5
Valley Ford	0	2,700	61,900	113,400	178,000	34.0
Carroll Road	0	2,700	61,900	113,400	178,000	34.0
Impact West County	**percent**	**percent**	**percent**	**percent**	**-**	**percent**
Point of Significance[a]	0	0	15	25	-	25
Bloomfield	-	0	3	13	-	3
Huntley	-	0	5	3	-	1
Two Rock	-	7	6	3	-	5
Valley Ford	-	0	10	4	-	12
Carroll Road	-	100	5	6	-	9

Source: Merritt Smith Consulting, 1996a, Appendix Figure 1

[a] Underlined values exceed point of significance and denote a significant impact.

Operation and Maintenance

Streams

Operation of the proposed storage reservoirs could result in impacts to aquatic life downstream of the reservoirs through changes in stream hydrology. In the wet season, the reservoirs would be expected to cause a reduction in average and peak flows downstream, because the dams would intercept all flow coming from upstream areas, except in cases where runoff causes the reservoir to fill beyond its capacity. If such an event occurs, water would spill to downstream waters via a spillway. The frequency of such events is extremely rare and has not been estimated. A spill would be rare because two conditions must be coincident before a spill can occur: An extremely large (and infrequent) runoff event must occur at the time that the reservoir is nearly at nominal reclaimed water storage capacity (which would occur in spring when extremely large storms are especially infrequent)

Post-construction, wet season flow downstream of the dams would be supplied by lateral tributaries and groundwater discharge, but peak and average flows would be somewhat reduced relative to pre-construction flows. During the dry season, storage reservoirs would intercept base flows, but reservoir seepage could partially offset the downstream flow reduction caused by the dams. Any reclaimed water quality-related impacts to aquatic life caused by dam leakage are addressed in Parsons ES (1996).

Predicted average wet (December through March) and dry (June through September) season flows at various locations in the Americano Creek watershed are provided in Appendix A. The locations are shown in the Appendix of MSC (1996a), and the method for estimating these flows is described in RMA 1996a and MSC 1996b. The predicted flows in Appendix A include the combined effects of both the storage reservoirs and irrigation-related groundwater incremental discharge to surface waters. The effects of irrigation and storage are separated only in the cases of “No Storage” (i.e., no storage reservoir in the watershed) scenarios and at the sites immediately downstream from the bases of proposed dams (AVF2, ACR2, AB2). Using the change in flow criteria for significant impacts to aquatic life, the data in Appendix A have been reduced (see Table 3) to show only the cases where a significant impact would be expected. Table 3 shows that only the Bloomfield Reservoir would result in a significant impact on flow (an increase in the dry season) in the mainstem of Americano Creek (Location A1), whereas, each of the reservoirs would cause a significant decrease in wet season flow in their respective tributaries. The increased dry season flow at site A1 resulting from operation of the Bloomfield Reservoir would be a significant beneficial impact, whereas the decreases in wet season flow would be negative impacts. The magnitude of the predicted project impact depends on the proportion of the watershed upstream of the particular location that would be irrigated (RMA 1996a). As the proportion that would be irrigated increases, so does the magnitude of the predicted flow impact.

Stemple creek watershed flows are provided in Appendix B and the significant impacts are shown in Table 4. In the Stemple Creek watershed, irrigation without any reservoirs would result in significant increases in dry season flow at sites S1, S2, S3, S4, S5, and STR1. The Huntley Reservoir and associated irrigation would result in a significant increase in dry weather flow at site S1 and a significant decrease in wet season flow only at site SH2, just below the base of the dam. The Two Rock reservoir would cause significant increases in dry season flow at sites S1, S2, and S3, and a significant decrease in wet season flow only at site STR2, just downstream from the dam.

Esteros

Predicted wet and dry season flows at various locations in the Americano Creek and Stemple Creek watersheds under different project components are discussed above. Any project-related flow changes in tributaries of Estero Americano or Estero de San Antonio could potentially result in changes in the salinity regime in the esteros. Any project-related change in salinity in either estero would constitute a significant impact (see Evaluation Criteria above).

Predicted effects of project components on salinity at different locations in Estero Americano and Estero de San Antonio are analyzed in detail MSC (1996b). The general result is that all of the West County project components analyzed would lead to increases of up to 2.5 parts per thousand (ppt) in salinity in the upper reach of the esteros during summer. Increases in salinity would occur both in the wet season and in the dry season, although for different reasons. In the dry season, inflow to the esteros would be slightly increased relative to the existing condition, but salinity would be greatly increased (up to 2.5 ppt) because of the elevated TDS of the inflowing water. Irrigation is the cause of the predicted elevated TDS of the inflowing water. In the wet season, estero inflow would be slightly decreased, and estero salinity would increase because there would be less fresh water available to dilute the sea water entering from the mouths of the esteros.

Thus, each of the West County project alternatives analyzed would result in impacts to biological resources of Estero Americano and/or Estero de San Antonio that would be considered significant under the zero percent change in salinity threshold. The actual ecological effect would be to change the physical distribution of the salinity and thus aquatic organisms in the esteros. While this change is not necessarily adverse, it is considered significant under the strict evaluation criteria that have been established in recognition of the esteros' status as a marine sanctuary.

Table 3.

Americano Creek Watershed (West County): Significant Impacts on Streamflow by Component

Site[a]	Component	Discharge %[b]	Hydrological Condition[c]	Season	Flow (cfs)[d]		Flow	Affected Habitat	
				Wet / Dry	no project	with component	Inc / Dec	lin. ft.	
A1	Bloomfield	1,5,10	3	dry	0.38	0.58-0.59	increase	23,000	WW-A
AVF1	Valley Ford	1,5,10	1,2,3,4	wet	3.02-8.59	0.56-1.61	decrease	3,600	WW-A
AVF2	Valley Ford	1,5,10	1,2,3,4	wet	2.44-6.96	0.04	decrease	N/A (base of dam)	
ACR1	Carroll Rd	1,5,10	1,2,3,4	wet	3.68-10.49	1.28-3.62	decrease	2,250 4,550	WW-A WW-B
ACR2	Carroll Rd.	1,5,10	1,2,3,4	wet	2.42-6.88	0.06	decrease	N/A (base of dam)	
AB1	Bloomfield	1,5,10	1,2,3,4	wet	2.64-7.53	0.86-2.42	decrease	4,900	WW-A
AB2	Bloomfield	1,5,10	1,2,3,4	wet	1.79-5.10	0.09	decrease	N/A (base of dam)	

Data Source: Appendix A

a Locations shown in MSC (1996a) Appendix maps.
b Design discharge rate to Laguna de Santa Rosa.
c 1: dry year, normal irrigation; 2: average year, normal irrigation; 3: average year, cool summer irrigation; 4: wet year, normal irrigation
d Range of values reflects effect of different hydrologic conditions on flows

Table 4.

Stemple Creek Watershed (West County): Significant Impacts on Streamflow by Component

Site[a]	Component	Discharge %[b]	Hydrological Condition[c]	Season Wet / Dry	Flow (cfs)[d] no project	Flow (cfs)[d] w / component	Flow Inc / Dec	Affected Habitat lin. ft.	
S1	No Storage	1, 5, 10	1, 3	dry	0.46-0.77	0.76-1.25	increase	17,900	WW-A
S1	Huntley	1, 5, 10	1, 3	dry	0.46-0.77	0.77-1.26	increase	17,900	WW-A
S1	Two Rock	1, 5, 10	1, 3	dry	0.46-0.77	0.76-1.24	increase	17,900	WW-A
S2	No Storage	1, 5, 10	1, 3	dry	0.36-0.62	0.59-1.06	increase	28,000	WW-A
S2	Two Rock	1, 5, 10	1, 3	dry	0.36-0.62	0.58-1.04	increase	28,000	WW-A
S3	No Storage	1, 5, 10	1, 3	dry	0.25-0.42	0.39-0.70	increase	17,300 34,500	WW-A WW-B
S3	Two Rock	1, 5, 10	1, 3	dry	0.25-0.42	0.39-0.69	increase	12,100 4,700	WW-A CW-B
S4	No Storage	1, 5, 10	1, 3	dry	0.09-0.16	0.15-0.27	increase	5,300 28,500	WW-A WW-B
S5	No Storage.	1, 5, 10	1, 2, 3,	dry	0.09-0.15	0.16-0.28	increase	12,000 6,000	WW-A WW-B
SH2	Huntley	1, 5, 10	1, 2, 3, 4,	wet	0.82-2.85	0.02	decrease	N/A (base of dam)	
STR2	Two Rock	1, 5, 10	1, 2, 3, 4	wet	1.53-5.35	0.01	decrease	N/A (base of dam)	

Data Source: Appendix B

[a] Locations shown in MSC (1996a) Appendix maps.
[b] Design discharge rate to Laguna de Santa Rosa.
[c] 1: dry year, normal irrigation; 2: average year, normal irrigation; 3: average year, cool summer irrigation; 4: wet year, normal irrigation
[d] Range of values reflects effect of different hydrologic conditions on flows

Emergency Events

The hydrological and hydraulic consequences of partial or total failure of each of the proposed storage site dams have been analyzed by Dames and Moore (1996a). Any of the failure scenarios analyzed would result in inundation of downstream areas, probable scouring or destruction of stream channels, banks, and riparian vegetation, and deposition of sediment released from the reservoir. Therefore, the impacts of dam failure to aquatic life are considered to be highly significant according to the streambed alteration criterion described in Section 2.2.5 for all of the proposed West County storage sites.

4.1.2 South County

South County storage reservoirs include: Tolay A, Tolay C, Adobe Road, Lakeville and Sears Point.

Construction

Table 5 shows the amount of each habitat type that would be lost by construction of each proposed South County storage site, the total amount of habitat available in the corresponding watershed, and the fractional loss of habitat represented by each site; significant impacts are underlined. Significant impacts on aquatic habitat would be expected to result from construction of any of the proposed south county storage reservoirs, with exception of Tolay C. This result is largely because each of the proposed storage sites is situated in a small watershed (compared to the West County sites, above), and the reservoirs themselves (with exception of Tolay C) would occupy a large fraction of the aquatic habitat within each watershed.

No impacts are expected to result from any of the proposed South County storage reservoirs acting as barriers to movements of migratory fish, since migratory fish species are not known to use any of those stream systems.

Table 5.

Summary of Aquatic Habitat and Impacts in South County Waterways

	Cool A	Cool B	Warm A	Warm B	Total	Pond
At South County Storage Sites	**lin. ft.**	**lin. ft.**	**lin. ft.**	**lin. ft.**	**lin. ft.**	**acres**
Adobe Road	0	0	0	8,000	8,000	4.5
Lakeville	0	0	0	11,200	11,200	1.0
Tolay A	0	0	1,850	27,300	29,150	1.0
Tolay C	0	0	1,850	12,500	14,350	1.0
Sears Point	0	0	6,800	13,100	19,900	0.5

Table 5. continued

Summary of Aquatic Habitat and Impacts in South County Waterways

	Cool A	Cool B	Warm A	Warm B	Total	Pond
In South County Watershed	**lin.ft.**	**lin.ft.**	**lin.ft.**	**lin.ft.**	**lin.ft.**	**acres**
Adobe Road	0	0	15,400	19,900	62,000	4.5
Lakeville	0	0	0	19,700	19,700	1.0
Tolay A	0	0	13,250	90,610	103,860	17.0
Tolay C	0	0	13,250	90,610	103,860	17.0
Sears Point	0	0	13,250	90,610	103,860	17.0
Impact South County	**percent**	**percent**	**percent**	**percent**	**-**	**percent**
Point of Significance[a]	0	0	15	25	-	25
Adobe Road	-	-	0	17	-	<u>100</u>
Lakeville	-	-	-	<u>57</u>	-	<u>100</u>
Tolay A	-	-	14	<u>30</u>	-	6
Tolay C	-	-	14	14	-	6
Sears Point	-	-	<u>51</u>	14	-	3

Source: Merritt Smith Consulting, 1996a. Appendix, Figure 1

[a] Underlined values exceed point of significance and denote a significant impact.

Operation and Maintenance

Predicted average wet (December through March) and dry (June through September) season flows at various locations in the Tolay watershed and the unnamed watersheds of the proposed Adobe Road and Lakeville storage sites are evaluated in this section. These are the watersheds of the proposed South County storage sites, and some watersheds in which irrigation is proposed are not addressed in this analysis because Questa (1996a) determined that irrigation in South County areas, except Tolay and Bayflats, would not affect surface waters.

Predicted wet and dry season flows at various locations in the watersheds potentially affected by South County storage and/or irrigation are provided in Appendix C and significant impacts are also shown in Table 6. The locations are at which flow impacts were estimated are shown in the Appendix of MSC (1996a). In the Tolay watershed where irrigation and storage potentially affect stream flows, the effect of storage is represented in Appendix C by the difference between the "No Storage" flows and flows under other conditions.

Table 6 shows that the Tolay A reservoir would result in significant decreases in wet season flow at all of the locations analyzed, under each of the hydrological conditions that were evaluated. Tolay A reservoir would reduce downstream flows even though runoff from upstream of the reservoir and the western shore of the reservoir would be diverted around the reservoir. Interception by the reservoir of the runoff from the eastern shore is estimated to cause the reduced downstream flow. In contrast to the West County analysis, the effect of different discharge rates to the Laguna de Santa Rosa (which determines irrigation acreage requirement) has not been included in the Tolay watershed analysis. This is because the amount of suitable acreage available for irrigation in the Tolay watershed is less than that necessary for even the 10 percent discharge scenario (which would require the least irrigation area). This approach was taken because it provides a conservative estimate of potential irrigation impact.

The Sears Point reservoir would cause no significant flow changes. The Lakeville reservoir would result in significant decreases in wet weather flow downstream from the dam at locations LV1 and LV2 as shown in Table 6. An Adobe Road reservoir (with its runoff diversion structure) would not result in any significant changes in stream flow at sites AD1 and AD2.

The analysis of aquatic biological impacts of South County project components is restricted to the non-tidal portions of the watersheds, because it is judged that any project effects on the salinity regimes of San Pablo Bay (Tolay watershed) or the Petaluma River (which would potentially be affected by Bayflats irrigation or storage in the Lakeville and Adobe Road watersheds) would be so small and localized as to have no significant impacts on biological resources.

Table 6.

South County: Significant Impacts on Streamflow by Component

Site[a]	Component	Discharge %[b]	Hydrological Condition[c]	Season	Flow (cfs)[d]		Flow	Affected Habitat	
				Wet / Dry	no project	w/ component	Inc / Dec	lin. ft.	
TT	Tolay A	N/A	1,2,3,4	wet	13.2-35.8	6.2-17	decrease	9,700 6,900	WW-A WW-B
TS	Tolay A	N/A	1,2,3,4	wet	12.8-35.0	5.9-16	decrease	8,450 13,100	WW-A WW-B
TA	Tolay A	N/A	1,2,3,4	wet	8.5-23.2	1.6-4.3	decrease	N/A (base of dam)	
LV1	Lakeville	N/A	1,2,4	wet	1.0-2.6	0.4-0.9	decrease	5,600	WW-B
LV2	Lakeville	N/A	1,2,4	wet	0.7-1.8	0.1	decrease	N/A (base of dam)	

Data Source: Appendix C

a Locations shown in MSC (1996a) Appendix maps.
b Laguna discharge rate not relevant to South county components, since all available acreage would be irrigated regardless of discharge rate.
c 1: dry year, normal irrigation; 2: average year, normal irrigation; 3: average year, cool summer irrigation; 4: wet year, normal irrigation
d Range of values reflects effect of different hydrologic conditions on flows

Emergency Event

The hydrological and hydraulic consequences of partial or total failure of each of the proposed storage site dams have been analyzed by Dames and Moore (1996a). Any of the failure scenarios analyzed would result in inundation of downstream areas, probable scouring or destruction of stream channels, banks, and riparian vegetation, and deposition of sediment released from the reservoir. Therefore, the impacts of dam failure are considered to be significant according to the streambed alteration criterion described in Section 2.2.5 for all of the proposed South County storage sites.

4.2 AGRICULTURAL IRRIGATION

4.2.1 West County

Construction

No impacts on aquatic habitat are expected to result from construction of agricultural irrigation systems.

Operation and Maintenance

Streams

Impacts of irrigation on streamflow associated with each West County project component have been analyzed above for West County Storage Reservoirs. Water quality-related impacts of irrigation on aquatic life are analyzed in Parsons ES (1996). Discussion in this section is restricted to the beneficial impacts to aquatic life expected to result from the performance standards that irrigators must meet to protect stream corridors on their irrigated properties. The performance standards that must be met are expected to result in fencing to exclude livestock from stream corridors, and implementation of measures to prevent manure and other substances from entering streams.

Both of the practices described above would benefit aquatic life where such practices are not already employed. Even if habitat is not actively restored, simply excluding livestock from stream corridors eventually leads within a few years to re-establishment of riparian plants, stabilization of stream banks, reduced siltation of the streambed, improved water quality, and often the resumption of perennial flow in streams that have become seasonal streams as a result of loss of riparian vegetation (Winegar 1977, Elmore and Beschta 1987, Marcuson 1977, Buell and Associates 1988). Preventing spills of manure, fertilizers or pesticides into streams has beneficial implications for water quality and aquatic life by reducing nitrogen concentration, algal biomass, dissolved oxygen depletion, ammonia and other toxins.

Esteros

Predicted impacts of West County irrigation scenarios on the salinity regimes of Estero Americano and Estero de San Antonio have been analyzed above, in combination with

West County reservoirs. All of the proposed West County alternatives analyzed, including irrigation with or without West County reservoirs, would result in increased salinity in Estero Americano and/or Estero de San Antonio. Under the zero percent change in salinity criterion for esteros, such increases in salinity would constitute significant impacts to the biological resources of the esteros.

Emergency Events

For purposes of evaluating the potential effect of an irrigation emergency, a 34,000 runoff event is assumed to be of 12-hour duration during summer, and all of the runoff is assumed to enter surface water. This volume and duration equate to an average flow increase of 0.1 cfs in the adjacent stream. Although under the criteria established, this flow increase would be considered beneficial depending on the type of habitat affected, the short duration of the discharge would preclude meaningful environmental benefit. Potential adverse impacts due to the quality of reclaimed water are addressed in Parsons ES (1996) and MSC (1996).

4.2.2 South County

Construction

No impacts to aquatic habitat are expected to result from construction of agricultural irrigation systems.

Operation and Maintenance

Questa (1996a) identified Tolay Creek as the only surface waterway potentially affected by irrigation in the South County project area, and the impacts are described above in the South County Storage Reservoirs impacts. In addition, Bayflats (Reyes soils) would be irrigated and drainage that requires management, possibly by disposal into the Petaluma River, would be produced (Questa 1996b). Impacts of the potential Bayflats discharge are evaluated in MSC (1996b). Beneficial impacts to stream corridors expected to result from the acceptance by South County irrigation users of the performance standards that irrigators must meet would be the same as those described above for West County irrigation.

Emergency Events

See West County section.

4.2.3 Sebastopol

Construction

No impacts to aquatic habitat or aquatic life are expected to result from construction of agricultural irrigation systems in the Sebastopol area.

Operation and Maintenance

No impacts to aquatic habitat or aquatic life are expected to result from runoff or groundwater discharge of reclaimed water used for irrigation in the Sebastopol area, because the soil geology in this area is such that none of the water used for irrigation is expected to reach the streams in this area (Questa 1996a). Beneficial impacts to stream corridors expected to result from the acceptance of Sebastopol area irrigation users of contractual obligations regarding protection of stream corridors would be the same as those described above for West County and South County irrigation.

Emergency Events

See West County section.

4.3 PIPELINES

4.3.1 Russian River and Santa Rosa Plain

Construction

Suspended sediment could be introduced into streams when pipeline construction methods disturb stream beds and banks. Introduction of suspended sediment into streams could result in downstream impacts when sediments settle out of the water column onto benthic organisms and spawning gravels. Pipelines will be constructed across streams using one of two methods depending on the presence of water in the stream during summer construction. Seasonal streams (ones without flow in the dry season) will be excavated to install pipe from bank to bank in a trench across the stream. The top layer of substrate in streams subject to excavation would be removed, set aside during installation of the pipe, and replaced after the pipe had been reburied. This temporary stream bed disturbance could result in impacts to benthic habitat. A jack and bore method will be used for perennial streams (ones with flow year-round) to tunnel pipe underneath the stream. This method will not disturb the stream bed or adjacent banks (any disturbance to banks would be outside the riparian corridor), therefore no impacts are associated with jack and bore construction.

Seasonal streams will be excavated to install pipe from bank to bank in a trench across the stream. The top layer of the stream bed will be preserved during excavation, then replaced to minimize the potential for sediment to be suspended when rainfall creates stream flow (as described in the EIR Section 2.2 Compliance with Measures and Standards in the Project Description). While this construction method will disturb stream beds and banks, replacement of the surface substrate (which is typically more coarse than underlying material) will minimize transport of sediment. Potential from excavation are considered less than significant impacts according to the streambed alteration criterion, and therefore mitigation is not required.

Operation and Maintenance

Reclaimed water discharged from pipelines to the Laguna and the Russian River has the potential to alter stream bed habitat. These potential impacts are discussed in Section 4.5 Discharge. There are no aquatic habitat impacts associated with operation and maintenance of pipelines.

Emergency Events

A pipeline rupture at a stream crossing would displace substrate in the stream bed and on banks, resulting in suspended sediment that could travel downstream with flows. Two geologic faults lie within the project area and are crossed by pipeline alignments. The Maacama Fault is crossed by the Geysers alternative pipeline alignment on Pine Flat Road. The Rodgers Creek Fault is crossed by the Urban Irrigation alternative pipeline alignment on Farmers Lane. The presence of these faults introduces the potential for seismic damage to pipelines within the fault zones. The force required to pump reclaimed water through the pipelines results in significant pressure within the pipes. Sudden release of this pressure in or adjacent to a stream could scour the stream bed and banks effectively displacing aquatic habitat at that location. The scoured sediment would be carried with flow downstream where it would be deposited thereby altering other habitats.

Seismic activity could result in a pipeline rupture on an alignment along a geologic fault zone. The Russian River/Santa Rosa Plain project area contains the Rodgers Creek Fault. While a rupture of a pipeline would potentially influence suspended sediment transport, and alter the stream bed, the chance of a rupture occurring in or adjacent to a stream is minimal. In addition, the brief period of time that the rupture would release reclaimed water (30 minutes or less) further minimizes the potential impacts to the substrate. Potential impacts from a pipeline rupture are considered less than significant according to the streambed alteration criterion, and therefore mitigation is not required.

4.3.2 West County

Construction

See the construction impacts analysis described in the Russian River/Santa Rosa Plain section above.

Operation and Maintenance

There are no aquatic habitat impacts associated with operation and maintenance of pipelines.

Emergency Events

No pipeline rupture scenarios have been identified in the West County project area, therefore impacts are not assessed.

4.3.3 South County

Construction

See the construction impacts analysis described in the Russian River/Santa Rosa Plain section above.

Operation and Maintenance

There are no aquatic habitat impacts associated with operation and maintenance of pipelines.

Emergency Events

No pipeline rupture scenarios have been identified in the South County project area, therefore impacts are not assessed.

4.3.4 Sebastopol

Construction

See the construction impacts analysis described in the Russian River/Santa Rosa Plain section above.

Operation and Maintenance

There are no aquatic habitat impacts associated with operation and maintenance of pipelines.

Emergency Events

No pipeline rupture scenarios have been identified in the Sebastopol project area, therefore impacts are not assessed.

4.3.5 Geysers

Construction

See the construction impacts analysis described in the Russian River/Santa Rosa Plain section above.

Operation and Maintenance

There are no aquatic habitat impacts associated with operation and maintenance of pipelines.

Emergency Events

See the emergency events impacts analysis described in the Russian River/Santa Rosa Plain section above. The Maacama Fault occurs in the Geysers project area and a release of reclaimed water due to a rupture along the fault would last up to four hours. Impacts due to seismic activities would be considered less than significant due to the brief exposure period and the unlikelihood of a rupture in or adjacent to a stream. Mitigation is not required.

4.4 URBAN IRRIGATION

Urban irrigation would be conducted on lands that are currently being irrigated, and irrigation practices on these lands are such that irrigation supply is not now reaching surface waters (Questa 1996c). Best Management Practices are included in the project description that preclude management changes upon conversion to reclaimed water for irrigation supply without additional CEQA review (see Section 2.2.1 of the EIR). Thus, adding urban irrigation land would be expected to have no impact on aquatic habitat.

4.5 DISCHARGE

4.5.1 Russian River and Santa Rosa Plain

Construction

The construction of the Russian River discharge structure (outfall) would occur during low flow periods only. Under low flow conditions, the outfall is not located in aquatic habitat, but rather on dry gravel. Therefore, no impacts from outfall construction on aquatic habitatatare expected.

Operation and Maintenance

Potential Impacts to Stream Beds

Reclaimed water discharged to the Laguna and the Russian River has the potential to alter stream bed habitat owing to the velocity and volume of the discharge. Stream bed substrate may be displaced during discharges (at the location of the discharge pipe) when reclaimed water flows onto sediment. No new construction is required for a Laguna outfall (the existing discharge locations will be used). The proposed outfall for the Russian River will include measures to reduce any potential discharge impacts to the river bed (e.g., a concrete baffle outlet structure to anchor the pipe and reduce foaming and turbulence prior to discharge to the river; and concrete erosion control wings and ramp to the river channel), and the flow rate during discharges is carefully monitored to minimize stream bed disturbance. A description of the outfall and its construction appears in Section 3.5 of the EIR. The impact of discharge on sediment movement is evaluated in Dames and Moore (1996b), and was found to be insignificant. Potential habitat impacts to stream beds from discharges are reduced to less than significant with the appropriate construction and maintenance of outfall structures.

Potential Impacts to Fish Migration Corridors

The Subregional System has sponsored annual studies of aquatic ecology of the Laguna drainage in relation to potential impacts of reclaimed water discharge since 1987. Beginning in 1991, these studies have included intensive analysis of upstream and downstream movements of anadromous fishes during the discharge season, combined with surveys of reproduction and juvenile rearing throughout the Laguna watershed, and in nearby reference watersheds (Roth, et al 1991, 1992, 1993, MSC 1995, 1996d). These studies have focused on steelhead trout and coho salmon with the primary methodology consisting of fyke netting to intercept migrating fish during the discharge season, seining to sample juvenile fish throughout the watersheds following hatching (July surveys) and at the end of the dry season prior to smolt outmigration (October-November surveys), and evaluation of habitat factors affecting juvenile fish abundance. The studies have also included sampling of non-anadromous fishes, reptiles, amphibians, and invertebrates, daily monitoring of stream flow and discharge concentration, and analysis of fish movements during experimental windows of no discharge. The studies have included very dry years and very wet years (the amount and timing of rainfall has large effects on fish movements, on habitat conditions throughout the watersheds, and on the relationship between flow and discharge concentration).

Key findings of the studies described above are the following:

- There is no apparent relationship between fish movements and reclaimed water concentration in the streams; migrating salmonids in Santa Rosa Creek and Mark West Creek have shown no preference for low concentrations of reclaimed water, nor avoidance of high reclaimed water concentrations. Total number of fish caught and fish caught per day of upmigrating steelhead in Maacama Creek (which receives no reclaimed water)were about the same as in Santa Rosa Creek and Mark West Creek.

- Spawned-out steelhead adults in good condition were captured moving downstream in each of the main study streams, demonstrating that a critical phase in the life cycle (spawning) has been completed.

- The presence of large numbers of young-of-the-year steelhead in the middle and upper reaches of Santa Rosa Creek and Mark West Creek each summer indicates that reclaimed water discharged in the previous winters does not prevent steelhead from successfully spawning in these streams.

- Steelhead smolts were captured migrating downstream in each of the main study streams, which shows that the freshwater phase of the life cycle has been successfully completed.

- Habitat surveys indicate that each of the study streams has suffered loss of salmonid habitat due to a variety of human influences, which is typical of small streams throughout the western United States. The lower reach of Santa Rosa Creek has been greatly modified by channelization and removal of riparian vegetation, resulting in low habitat diversity and summer water temperatures that are lethal to salmonids. In contrast, the middle and upper reaches of Santa Rosa Creek have relatively high quality habitat compared to the other study streams. Water diversions by agricultural and other users have severe impacts in dry years on juvenile salmonid survival in the upper reaches of Mark West Creek and Maacama Creek (see Figure 4-1, page 31 in MSC 1996d), whereas the water supply in Santa Rosa Creek is relatively stable because of low-intensity land development and the protection provided by Hood Mountain Regional Park, and juvenile survival through the summer is better than in the other streams. Summer survival of juveniles following wet years is greatly improved (Figure 4-1, page 31,in MSC 1996d).

- Coho may also be limited by habitat and by depressed stock coast-wide. The number of coho found in the Laguna system is very low relative to steelhead, and no conclusions can be drawn about possible effects of reclaimed water on coho use of the Laguna system except that coho are generally no more sensitive to water quality impacts than steelhead and are often less sensitive, depending on the substance

Another question with regard to discharge is whether or not salmonid adults returning to spawn in Laguna tributaries use olfactory cues contributed by reclaimed water as part of the system that guides them to their natal stream. Through the process of “imprinting,” salmonid smolts moving downstream on their way to sea memorize olfactory signals in the stream water as they pass through it. If reclaimed water is part of the stream the smolts swim through, then when they return as adults to spawn, they could be confused if the reclaimed water signal was missing or reduced. However, imprinting involves recognition of a variety of constituents in combination, and alteration of one or two of them usually does not produce impairment of the ability of salmon to find their home stream, and all of the results obtained to date from the Laguna fish studies discussed in the previous section indicate that the numbers and timing of returning adults have no relationship to the presence or absence or concentration of reclaimed water in the Laguna. Therefore, changes to the Laguna design discharge rate would be expected to have no significant impact on the homing instinct of salmonids.

The overall conclusion of the Laguna studies discussed above is that the discharge of reclaimed water into the migration corridor in Santa Rosa Creek and Mark West Creek does not constitute impairment of these streams with respect to migration, reproduction, or rearing of steelhead trout. These streams have self-sustaining steelhead populations whose numbers are limited by habitat factors such as drought and water diversions in the rearing areas, not by reclaimed water. The carrying capacity of rearing habitat probably limits steelhead production in these streams considerably.

Many other species of fish, amphibians, reptiles, and invertebrates were sampled by the fyke netting and seining techniques employed in the anadromous fish studies discussed above, and none of these other species' abundance, distribution, or movements have shown any relationships to the reclaimed water discharged to the Laguna system. In general, salmonid fishes, along with stickleback and sculpins, are considered highly sensitive to water quality conditions, and the absence of any findings of impacts of reclaimed water to salmonids in the Laguna system suggests that significant impacts are even less likely for other, hardier aquatic species. Based on the studies described above, the discharge alternative would be expected to have no significant impact on migrations of anadromous fishes, and probably no significant impacts on movements or other activities of resident fishes, amphibians, reptiles, or invertebrates. Parsons ES (1996) includes an evaluation of potential reclaimed water impacts on toxicity and bioaccumulation for aquatic species.

Some of the discharge components involve higher design discharge rates than were permitted during the migratory fish study period. The existing daily maximum discharge rate is 5 percent of River flow, whereas design discharge at a rate of up to 20 percent of River flow is a proposed alternative. However, the estimated reclaimed water concentration during the study period was as high as 92 percent in Santa Rosa Creek (MSC 1996d), and the predicted maximum daily concentration in Santa Rosa Creek under any of the discharge components being considered is 89 percent (which is estimated to occur under contingency discharge operations under the 20 percent design Laguna discharge alternative). Figures 4-1 through 4-3 in MSC (1996b) compare the distribution of reclaimed water concentrations in Santa Rosa Creek under existing and proposed design discharge conditions. These graphs show the following:

- The peak discharge rate in a dry year under existing conditions is similar to or less than that under any future condition including contingency irrigation. This is consistent with the comparison of the 92 and 89 percent concentrations identified above.

- The median discharge rate is higher for the 20 percent design Laguna discharge and the No Project alternative than the existing condition. The median discharge rate for the 1, 5 and 10 percent discharge components are less than under existing conditions.

The absence of any apparent relationship between reclaimed water concentration and fish movement leads to the conclusion that reclaimed water discharge will not create a migratory barrier in the Laguna system.

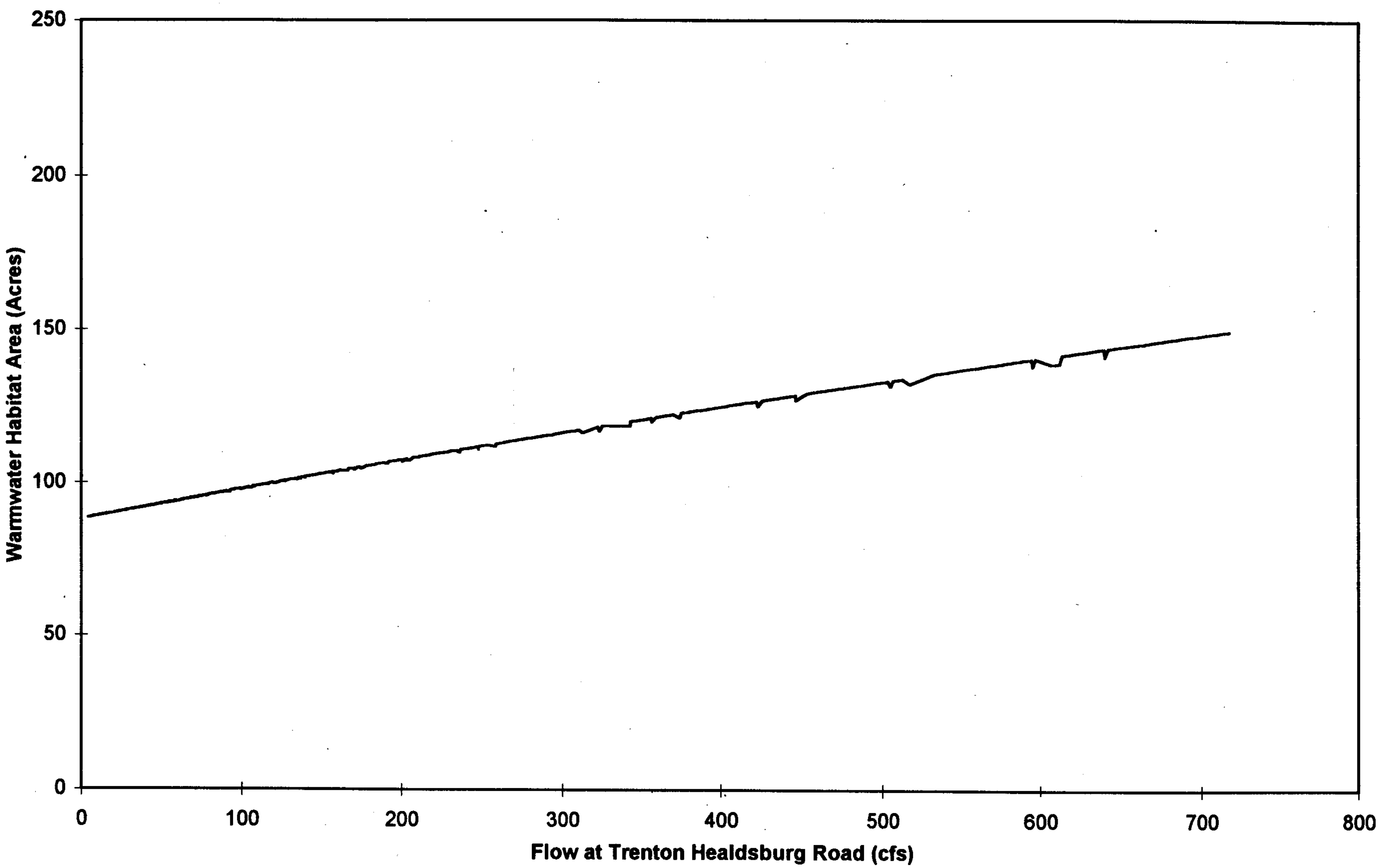
Alternative Discharge Rates

In this section, the potential impacts to aquatic life expected to result from changes in the design discharge rate (from the existing 1 or 5 percent rates) of reclaimed water to the Laguna de Santa Rosa are analyzed. Direct discharge to the Laguna could occur at design rates ranging from 0.65 percent to 20 percent under different project alternatives.

The primary result to be expected from changing the rate of discharge to the Laguna would be a change in the amount of *warmwater-A* habitat available in the Laguna during the discharge period (November 1 to May 15). Any change in reclaimed water flow in the Laguna would result in a corresponding change in the amount of the Laguna channel flooded by water at the time. The relationship between Laguna water surface area and flow measured at Trenton Healdsburg Road is shown in Figure 1. The slope of the line shown in Figure 1 indicates that a change of 1 cubic feet per second (cfs) in flow causes a corresponding change of about 0.10 acres of water surface area in the Laguna. As an example of this effect, the maximum combined reclaimed water discharge was 242.1 cfs on 5 December 1994, which provided 24.2 acres of warmwater-A habitat that would not have existed if there were no discharge.

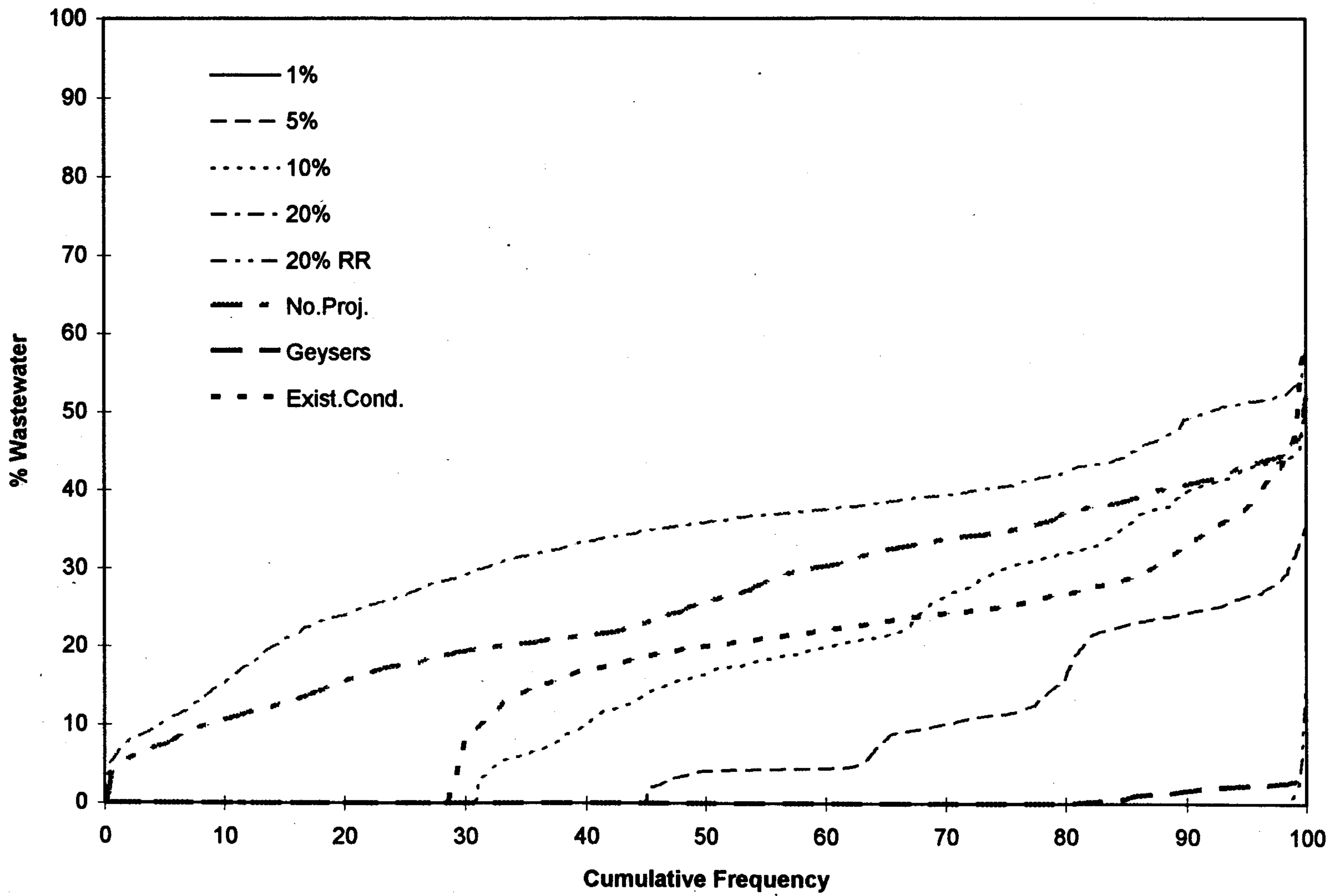
Assuming that reclaimed water has the same value to aquatic life as naturally occurring water, project alternatives that include a reduction in the design discharge rate to the Laguna will result in a net loss of *warmwater-A* habitat during the discharge season, and alternatives that increase the design discharge rate will result in a net gain of *warmwater-A* habitat. Figure 2 illustrates the effect of reclaimed water discharges on Laguna flow at River Road (located near Trenton Healdsburg Road) in a dry year. The source of data for Figure 2 is explained in and is the same as Figure 4-4 in MSC (1996b). Figure 2 shows that the No Project, 10, and 20 percent Laguna design discharge components would result in greater Laguna flows (and thus more aquatic habitat) than under existing conditions. Figure 2 shows that the 1 percent, 5 percent, Geysers and 20 percent River discharge components would result in less flow in the Laguna than existing conditions. The effect of reclaimed water discharges

Figure 1. Effect of Flow on Habitat Area in Laguna de Santa Rosa



DWS\201\AREA\WOWW.XLS

Figure 2. Incremental Flow in the Laguna at River Road During Dry Year (1976) due to Project Alternatives



on aquatic habitat area in the Laguna would be more pronounced in a drier year, and less pronounced in a wetter year.

The change in surface area of the Russian River due to reclaimed water discharges is not as pronounced because the incremental flow due to reclaimed water is much less than in the Laguna and because of its hydraulic characteristics (i.e., slope of the stream bottom and banks). Therefore, the effect of the reclaimed water discharge components on River habitat is not considered further.

The Russian River has also been the subject of numerous studies in recent years, sponsored by CDFG, SCWA, and the Subregional System (reports cited under Methodology, above). A general conclusion that can be drawn from these studies is that the mainstem of the river is a *warmwater-A* habitat for at least five months of each year, and is occupied by the same assortment of aquatic species as occurs in the Laguna system. Upper reaches of Laguna tributaries have *coolwater-A or coolwater-B* habitat. During the winter, the river serves as a migration corridor for anadromous fishes moving to or from the Laguna drainage and other spawning and juvenile rearing areas. Based on the Russian River and Laguna studies discussed above, any impacts of the discharge alternative to aquatic resources of the Russian River are considered to be less than significant.

Emergency Events

No emergency eventsassociateddischargehave been identified for evaluation

4.6 CONTINGENCY

4.6.1 Discharge

The 10 and 20 percent design discharges to the Laguna include a short-duration contingency discharge. The contingency discharge would result in greater flows than would design discharge or the existing condition (RMA 1996b). Thus, the contingency discharge component of the 10 and 20 percent design discharge components would increase the amount of habitat in the Laguna.

4.6.2 Irrigation

In average or wet rainfall years, irrigation using reclaimed water is normally practiced only during the dry season. But in dry years, winter irrigation may be practiced as part of the contingency program. Potential impacts of contingency irrigation on aquatic habitat are analyzed in Section 4.6.2 in terms of changes in stream flow and salinity (for West County alternatives). The significance criteria for changes in stream flow and salinity are the same as described above (see Section 2.0 Evaluation Criteria).

West County

Streams

Appendix A shows the expected flow at different locations in the Americano Creek watershed, under different project scenarios and combinations of variables. Winter irrigation is represented in Appendix A by hydrologic condition 5. Using the 50 percent flow change criterion for significance, the data from Appendix A have been reduced to show only the cases where a significant impact would be expected under winter irrigation (Table 7). In a contingency irrigation mode, the Bloomfield reservoir would result in a significant increase in dry season flow at site A1, which would be a significant beneficial impact. Significant decreases in wet season flow (negative impacts) would occur at sites AVF1 and AVF2 with a Valley Ford reservoir, at sites ACR1 and ACR2 with a Carroll Road reservoir, and at sites AB1 and AB2 with a Bloomfield reservoir.

For the Stemple Creek watershed, significant impacts on stream flow under winter irrigation are listed in Table 8 (data extracted from Appendix B). Significant increases in dry season flow would result at sites S1, S2, S3, S4, S5, and STR1 under the components as shown in Table 8, including the two potential reservoirs as well as irrigation with no

Table 7.

Americano Creek Watershed (West County): Significant Impacts on Streamflow by Component with Winter Irrigation

Site[a]	Component	Discharge %[a]	Season	Flow cfs		Flow	Affected Habitat	
			Wet / Dry	no project	w / component	Inc / Dec	lin. ft.	
A1	Bloomfield	1,5	dry	0.38	0.58	increase	23,000	WW-A
AVF1	Valley Ford	1,5,10	wet	3.02	0.64-0.65	decrease	3,600	WW-A
AVF2	Valley Ford	1,5,10	wet	2.44	0.04	decrease	N/A (base of dam)	
ACR1	Carroll	1,5,10	wet	3.68	1.35	decrease	2,250 4,550	WW-A WW-B
ACR2	Carroll	1,5,10	wet	2.42	0.06	decrease	N/A (base of dam)	
AB1	Bloomfield	1,5,10	wet	2.64	0.09	decrease	4,900	WW-A
AB2	Bloomfield	1,5,10	wet	1.79	0.09	decrease	N/A (base of dam)	

Source: Appendix A

[a] Locations shown inMSC (1996a) Appendix maps.
[b] Design discharge rate to Laguna de Santa Rosa.

TABLE 8.

StempleCreek Watershed (West County): Significant Impacts on Streamflow by Component with Winter Irrigation

Site[a]	Component	Discharge %[b]	Season	Flow cfs		Flow	Affected Habitat	
			Wet / Dry	no project	with component	Inc / Dec	lin. ft.	
S1	No Storage	1,5,10	dry	0.46	0.70-1.07	increase	17,900	WW-A
S1	Huntley	1,5,10	dry	0.46	0.71-1.08	increase	17,900	WW-A
S1	Two Rock	1,5,10	dry	0.46	0.70-1.07	increase	17,900	WW-A
S2	No Storage	1,5,10	dry	0.36	0.60-0.94	increase	28,000	WW-A
S2	Two Rock	1,5,10	dry	0.36	0.60-0.94	increase	28,000	WW-A
S3	No Storage	1,5,10	dry	0.25	0.40-0.62	increase	17,300 34,500	WW-A WW-B
S3	Two rock	1,5,10	dry	0.25	0.40-0.62	increase	12,100 4,700	WW-A CW-B
S4	No Storage	1,5,10	dry	0.09	0.15-0.24	increase	5,300 28,500	WW-A WW-B
S5	No Storage	1,5,10	dry	0.09	0.16-0.26	increase	12,000 6,000	WW-A WW-B
SH2	Huntley	1,5,10	wet	0.82	0.02	decrease	N/A (base of dam)	
STR1	No Storage	1,5	dry	0.06	0.11-0.12	increase	12,100 4,700	WW-A CW-B
STR2	Two Rock	1,5,10	wet	1.53	0.01	decrease	N/A (base of dam)	

Source: Appendix B

[a] Locations shown inMSC (1996a) Appendix maps.
[b] Design discharge rate to Laguna de Santa Rosa.

reservoirs. Significant decreases in wet season flow would occur only at sites SH2 (base of Huntley dam) and STR2 (base of Two Rock dam).

Esteros

Winter irrigation would result in increased salinity in both Estero Americano and Estero de San Antonio (see MSC 1996b).The increase in salinity would not be any greater than under other irrigation scenarios analyzed, but would be more widespread throughout the esteros. Under the zero percent change in salinity criterion (see Section 2.0 Evaluation Criteria), contingency irrigation would result in significant impacts to the biological resources of Estero Americano and Estero de San Antonio.

South County

Significant impacts on stream flow associated with winter irrigation and South County project components are shown in Table 9 (data from Appendix C). The Tolay A reservoir would cause significant decreases in wet season flow at sites TT, TS, and TA.

TABLE 9.

South County: Significant Impacts on Streamflow by Component with Winter Irrigation

Site[a]	Component	Discharge %[b]	Season	Flow cfs			Affected Habitat	
			Wet / Dry	no project	w / component	Inc / Dec	lin. ft.	
TT	Tolay A	N.A.	wet	13.15	6.2	decrease	9,700 6,900	WW-A WW-B
TS	Tolay A	N.A.	wet	12.82	5.9	decrease	8,450 13,100	WW-A WW-B
TA	Tolay A	N.A.	wet	8.5	1.6	decrease	N/A (base of dam)	

Source: Appendix C

[a] Locations shown inMSC (1996a) Appendix maps.
[b] Laguna discharge rate not relevant to South County components, since all available acreage would be irrigated regardless of discharge rate.

5.0 REFERENCES

Buell and Associates 1988. Estero Americano Study, Reclamation Alternative Evaluation: Freshwater Resident/Anadromous Fisheries Development Potential. Report prepared for David W. Smith Consulting and CH2M Hill, Inc. 70p.

CDFG 1954, 1955, 1968, 1984. Unpublished file reports on Russian River fish surveys.

Dames and Moore 1996a. *Dam Break Inundation Analysis* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Dames and Moore 1996b. *Potential Streambank Erosion Laguna de Santa Rosa and Russian River.* Santa Rosa Subregional Long-Term Wastewater Project.

David W. Smith Consulting 1990. *History, Land Uses, and Natural Resources of the Laguna de Santa Rosa*. Report prepared for the Santa Rosa Subregional Water Reclamation System.

Elmore, W. and R. L. Beschta 1987. Riparian Areas: Perceptions in Management. Rangelands, 9(6): 260-265.

Goodwin, P., C. K. Cuffe, J. L. Nielsen, and T. Light 1994. *Russian River Estuary Study 1992-1993*. Report prepared for Sonoma County Planning Department and the CSCC. 186 p. + appendices.

Harland Barththolomew & Associates 1996. *Biological Resources Technical Memorandum, Volume I* Santa Rosa Subregional Long-Term Wastewater Project.

Marcuson, P. E. 1977. The Effect of Cattle Grazing on Brown Trout in Rock Creek., Montana. In: Symposium on Livestock Interactions with Wildlife, Fisheries and Their Environments. U.S.D.A. Forest Serv., Reno, NV.

Merritt Smith Consulting 1995. *Anadromous Fish Migration Study Program, 1991-1994.* Santa Rosa Subregional Long-Term Wastewater Project.

Merritt Smith Consulting 1996a. *Aquatic Habitat Survey Results* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Merritt Smith Consulting 1996b. *Water Quality Impact Analysis* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Merritt Smith Consulting 1996c. *Stream Crossings Assessment* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Merritt Smith Consulting 1996d. *Anadromous Fish Migration Study Program, 1991-1995.* Santa Rosa Subregional Long-Term Wastewater Project.

Merritt Smith Consulting 1996e. *Laguna Water Quality Monitoring Results* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Merritt Smith Consulting 1996f. *Russian River Algae and Macrophytes* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Merritt Smith Consulting 1996g. *Russian River Water Quality Monitoring Results* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

NOAA 15 CFR 922. Marine Sanctuary regulations in the United States Code of Federal Register

Parsons ES 1996. *Ecological Risk Assessment* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Questa Engineering 1995. *Irrigation Management Guidelines* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Questa Engineering 1996a. *Baseline Hydrology and Irrigation Drainage Evaluation for West and South County Reclamation Alternatives* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Questa Engineering 1996b. *Hydrologic/Water Quality Evaluation of Irrigation of Baylands (Reyes Soils) with Reclaimed Water* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Questa Engineering 1996c. *Hydrologic and Water Quality Impacts from Irrigation Component* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Resource Management Associates 1996a. *Water Quality and Flow Model for Irrigation/Storage Area Streams* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Resource Management Associates 1996b. *Russian River Water Quality Model* Technical Report. Santa Rosa Subregional Long-Term Wastewater Project.

Roth, J. C., M. L. Commins, and M. H. Fawcett 1991. Steelhead Trout Migration in Mark West Creek and Santa Rosa Creek, 1991. Laguna de Santa Rosa Intensive Monitoring Program, Technical Memorandum.

Roth, J. C., M. L Commins, and M. H. Fawcett 1992. Steelhead Trout Migration in Mark West Creek and Santa Rosa Creek, 1992. Laguna de Santa Rosa Intensive Monitoring Program, Technical Memorandum.

Roth, J. C., M. L Commins, M. H. Fawcett, and R. W. Maddox 1993. Steelhead Trout Migration in Mark West Creek and Santa Rosa Creek, 1991-1993. Laguna de Santa Rosa Intensive Monitoring Program, Technical Memorandum.

Smith D. W., M. L. Commins, M. H. Fawcett, A. J. Horne, and J. C. Roth 1989. Preliminary Estero Americano Discharge Criteria, Long-term Detailed Wastewater Reclamation Studies. Santa Rosa Subregional Water Reclamation System. Technical Memo E5.

Winegar, J. J. 1977a. Camp Creek Channel Fencing -- Plant, Wildlife, Soil and Water Response, Rangeman's Journal, 4(1): 10-12.

6.0 APPENDICES

Appendix A: Storage and Irrigation Impacts on Flow in Americano Watershed (West County)

Appendix B: Storage and Irrigation Impacts on Flow in Stemple Watershed (West County)

Appendix C: Storage and Irrigation Impacts on Flow in South County Watersheds

Note that in Appendices A through C, storage components associated the No Project alternative are identified in association with the 1, 5 and 10 percent discharge components. In this context, No Project means no irrigation. No Project is associated with the 1, 5 and 10 percent discharge components due to a quirk in the output program of the computer model used to do the simulations. The flow values associated with each No Project condition is identical within each hydrologic condition.

Appendix A. Storage and Irrigation Impacts on Flow in Americano Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Flow (cfs) Q.dry
A1	No Project	1%	2	64.84	0.38
A1	No Storage	1%	2	63.29	0.50
A1	Bloomfield	1%	2	60.17	0.54
A1	Carroll Road	1%	2	58.95	0.52
A1	Valley Ford	1%	2	58.91	0.50
A1	No Project	5%	2	64.84	0.38
A1	No Storage	5%	2	63.29	0.50
A1	Bloomfield	5%	2	60.17	0.54
A1	Carroll Road	5%	2	58.95	0.52
A1	Valley Ford	5%	2	58.91	0.50
A1	No Project	10%	2	64.84	0.38
A1	No Storage	10%	2	63.47	0.49
A1	Bloomfield	10%	2	60.28	0.54
A1	Carroll Road	10%	2	59.10	0.51
A1	Valley Ford	10%	2	59.03	0.49
A1	No Project	1%	1	35.33	0.38
A1	No Storage	1%	1	34.11	0.40
A1	Bloomfield	1%	1	32.47	0.44
A1	Carroll Road	1%	1	31.78	0.42
A1	Valley Ford	1%	1	31.75	0.40
A1	No Project	5%	1	35.33	0.38
A1	No Storage	5%	1	34.11	0.40
A1	Bloomfield	5%	1	32.47	0.44
A1	Carroll Road	5%	1	31.78	0.42
A1	Valley Ford	5%	1	31.75	0.40
A1	No Project	10%	1	35.33	0.38
A1	No Storage	10%	1	34.25	0.38
A1	Bloomfield	10%	1	32.55	0.44
A1	Carroll Road	10%	1	31.89	0.41
A1	Valley Ford	10%	1	31.85	0.40
A1	No Project	1%	4	100.63	0.49
A1	No Storage	1%	4	99.10	0.60
A1	Bloomfield	1%	4	94.16	0.63
A1	Carroll Road	1%	4	92.31	0.61
A1	Valley Ford	1%	4	92.24	0.59
A1	No Project	5%	4	100.63	0.49
A1	No Storage	5%	4	99.10	0.60
A1	Bloomfield	5%	4	94.16	0.63
A1	Carroll Road	5%	4	92.31	0.61
A1	Valley Ford	5%	4	92.24	0.59
A1	No Project	10%	4	100.63	0.49
A1	No Storage	10%	4	99.28	0.58
A1	Bloomfield	10%	4	94.27	0.63
A1	Carroll Road	10%	4	92.45	0.59
A1	Valley Ford	10%	4	92.36	0.58
A1	No Project	1%	3	64.84	0.38
A1	No Storage	1%	3	63.32	0.55
A1	Bloomfield	1%	3	60.20	0.59
A1	Carroll Road	1%	3	58.97	0.57

Appendix A. Storage and Irrigation Impacts on Flow in Americano Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
A1	Valley Ford	1%	3	58.93	0.55
A1	No Project	5%	3	64.84	0.38
A1	No Storage	5%	3	63.32	0.55
A1	Bloomfield	5%	3	60.20	0.59
A1	Carroll Road	5%	3	58.97	0.57
A1	Valley Ford	5%	3	58.93	0.55
A1	No Project	10%	3	64.84	0.38
A1	No Storage	10%	3	63.50	0.53
A1	Bloomfield	10%	3	60.30	0.58
A1	Carroll Road	10%	3	59.12	0.55
A1	Valley Ford	10%	3	59.05	0.54
A1	No Project	1%	5	35.33	0.38
A1	No Storage	1%	5	36.07	0.54
A1	Bloomfield	1%	5	34.33	0.58
A1	Carroll Road	1%	5	33.70	0.56
A1	Valley Ford	1%	5	33.64	0.54
A1	No Project	5%	5	35.33	0.38
A1	No Storage	5%	5	36.07	0.54
A1	Bloomfield	5%	5	34.33	0.58
A1	Carroll Road	5%	5	33.70	0.56
A1	Valley Ford	5%	5	33.64	0.54
A1	No Project	10%	5	35.33	0.38
A1	No Storage	10%	5	35.98	0.51
A1	Bloomfield	10%	5	34.28	0.56
A1	Carroll Road	10%	5	33.63	0.54
A1	Valley Ford	10%	5	33.58	0.52
A2	No Project	1%	2	33.25	0.19
A2	No Storage	1%	2	32.52	0.25
A2	No Project	5%	2	33.25	0.19
A2	No Storage	5%	2	32.52	0.25
A2	No Project	10%	2	33.25	0.19
A2	No Storage	10%	2	32.60	0.25
A2	No Project	1%	1	18.12	0.19
A2	No Storage	1%	1	17.54	0.20
A2	No Project	5%	1	18.12	0.19
A2	No Storage	5%	1	17.54	0.20
A2	No Project	10%	1	18.12	0.19
A2	No Storage	10%	1	17.61	0.19
A2	No Project	1%	4	51.61	0.25
A2	No Storage	1%	4	50.88	0.30
A2	No Project	5%	4	51.61	0.25
A2	No Storage	5%	4	50.88	0.30
A2	No Project	10%	4	51.61	0.25
A2	No Storage	10%	4	50.96	0.30
A2	No Project	1%	3	33.25	0.19
A2	No Storage	1%	3	32.53	0.28
A2	No Project	5%	3	33.25	0.19
A2	No Storage	5%	3	32.53	0.28
A2	No Project	10%	3	33.25	0.19

Appendix A. Storage and Irrigation Impacts on Flow in Americano Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
A2	No Storage	10%	3	32.61	0.27
A2	No Project	1%	5	18.12	0.19
A2	No Storage	1%	5	18.47	0.27
A2	No Project	5%	5	18.12	0.19
A2	No Storage	5%	5	18.47	0.27
A2	No Project	10%	5	18.12	0.19
A2	No Storage	10%	5	18.43	0.25
A3	No Project	1%	2	11.84	0.07
A3	No Storage	1%	2	11.55	0.09
A3	No Project	5%	2	11.84	0.07
A3	No Storage	5%	2	11.55	0.09
A3	No Project	10%	2	11.84	0.07
A3	No Storage	10%	2	11.58	0.09
A3	No Project	1%	1	6.45	0.07
A3	No Storage	1%	1	6.22	0.07
A3	No Project	5%	1	6.45	0.07
A3	No Storage	5%	1	6.22	0.07
A3	No Project	10%	1	6.45	0.07
A3	No Storage	10%	1	6.25	0.07
A3	No Project	1%	4	18.38	0.09
A3	No Storage	1%	4	18.09	0.11
A3	No Project	5%	4	18.38	0.09
A3	No Storage	5%	4	18.09	0.11
A3	No Project	10%	4	18.38	0.09
A3	No Storage	10%	4	18.12	0.11
A3	No Project	1%	3	11.84	0.07
A3	No Storage	1%	3	11.56	0.10
A3	No Project	5%	3	11.84	0.07
A3	No Storage	5%	3	11.56	0.10
A3	No Project	10%	3	11.84	0.07
A3	No Storage	10%	3	11.59	0.10
A3	No Project	1%	5	6.45	0.07
A3	No Storage	1%	5	6.59	0.10
A3	No Project	5%	5	6.45	0.07
A3	No Storage	5%	5	6.59	0.10
A3	No Project	10%	5	6.45	0.07
A3	No Storage	10%	5	6.57	0.09
AVF1	No Project	1%	2	5.53	0.03
AVF1	No Storage	1%	2	5.41	0.04
AVF1	Valley Ford	1%	2	1.02	0.04
AVF1	No Project	5%	2	5.53	0.03
AVF1	No Storage	5%	2	5.41	0.04
AVF1	Valley Ford	5%	2	1.02	0.04
AVF1	No Project	10%	2	5.53	0.03
AVF1	No Storage	10%	2	5.42	0.04
AVF1	Valley Ford	10%	2	1.03	0.04
AVF1	No Project	1%	1	3.02	0.03
AVF1	No Storage	1%	1	2.92	0.03
AVF1	Valley Ford	1%	1	0.56	0.04

Appendix A. Storage and Irrigation Impacts on Flow in Americano Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
AVF1	No Project	5%	1	3.02	0.03
AVF1	No Storage	5%	1	2.92	0.03
AVF1	Valley Ford	5%	1	0.56	0.04
AVF1	No Project	10%	1	3.02	0.03
AVF1	No Storage	10%	1	2.93	0.03
AVF1	Valley Ford	10%	1	0.56	0.04
AVF1	No Project	1%	4	8.59	0.04
AVF1	No Storage	1%	4	8.46	0.05
AVF1	Valley Ford	1%	4	1.60	0.05
AVF1	No Project	5%	4	8.59	0.04
AVF1	No Storage	5%	4	8.46	0.05
AVF1	Valley Ford	5%	4	1.60	0.05
AVF1	No Project	10%	4	8.59	0.04
AVF1	No Storage	10%	4	8.48	0.05
AVF1	Valley Ford	10%	4	1.61	0.04
AVF1	No Project	1%	3	5.53	0.03
AVF1	No Storage	1%	3	5.41	0.05
AVF1	Valley Ford	1%	3	1.02	0.05
AVF1	No Project	5%	3	5.53	0.03
AVF1	No Storage	5%	3	5.41	0.05
AVF1	Valley Ford	5%	3	1.02	0.05
AVF1	No Project	10%	3	5.53	0.03
AVF1	No Storage	10%	3	5.42	0.04
AVF1	Valley Ford	10%	3	1.03	0.05
AVF1	No Project	1%	5	3.02	0.03
AVF1	No Storage	1%	5	3.08	0.05
AVF1	Valley Ford	1%	5	0.65	0.05
AVF1	No Project	5%	5	3.02	0.03
AVF1	No Storage	5%	5	3.08	0.05
AVF1	Valley Ford	5%	5	0.65	0.05
AVF1	No Project	10%	5	3.02	0.03
AVF1	No Storage	10%	5	3.07	0.04
AVF1	Valley Ford	10%	5	0.64	0.05
AVF2	No Project	1%	2	4.49	0.03
AVF2	No Storage	1%	2	4.43	0.03
AVF2	Valley Ford	1%	2	0.04	0.03
AVF2	No Project	5%	2	4.49	0.03
AVF2	No Storage	5%	2	4.43	0.03
AVF2	Valley Ford	5%	2	0.04	0.03
AVF2	No Project	10%	2	4.49	0.03
AVF2	No Storage	10%	2	4.44	0.03
AVF2	Valley Ford	10%	2	0.04	0.03
AVF2	No Project	1%	1	2.44	0.03
AVF2	No Storage	1%	1	2.40	0.02
AVF2	Valley Ford	1%	1	0.04	0.03
AVF2	No Project	5%	1	2.44	0.03
AVF2	No Storage	5%	1	2.40	0.02
AVF2	Valley Ford	5%	1	0.04	0.03
AVF2	No Project	10%	1	2.44	0.03

Appendix A. Storage and Irrigation Impacts on Flow in Americano Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
AVF2	No Storage	10%	1	2.41	0.02
AVF2	Valley Ford	10%	1	0.04	0.03
AVF2	No Project	1%	4	6.96	0.03
AVF2	No Storage	1%	4	6.91	0.04
AVF2	Valley Ford	1%	4	0.04	0.03
AVF2	No Project	5%	4	6.96	0.03
AVF2	No Storage	5%	4	6.91	0.04
AVF2	Valley Ford	5%	4	0.04	0.03
AVF2	No Project	10%	4	6.96	0.03
AVF2	No Storage	10%	4	6.91	0.04
AVF2	Valley Ford	10%	4	0.04	0.03
AVF2	No Project	1%	3	4.49	0.03
AVF2	No Storage	1%	3	4.43	0.03
AVF2	Valley Ford	1%	3	0.04	0.03
AVF2	No Project	5%	3	4.49	0.03
AVF2	No Storage	5%	3	4.43	0.03
AVF2	Valley Ford	5%	3	0.04	0.03
AVF2	No Project	10%	3	4.49	0.03
AVF2	No Storage	10%	3	4.44	0.03
AVF2	Valley Ford	10%	3	0.04	0.03
AVF2	No Project	1%	5	2.44	0.03
AVF2	No Storage	1%	5	2.47	0.03
AVF2	Valley Ford	1%	5	0.04	0.03
AVF2	No Project	5%	5	2.44	0.03
AVF2	No Storage	5%	5	2.47	0.03
AVF2	Valley Ford	5%	5	0.04	0.03
AVF2	No Project	10%	5	2.44	0.03
AVF2	No Storage	10%	5	2.47	0.03
AVF2	Valley Ford	10%	5	0.04	0.03
ACR1	No Project	1%	2	6.76	0.04
ACR1	No Storage	1%	2	6.68	0.05
ACR1	Carroll Road	1%	2	2.33	0.06
ACR1	No Project	5%	2	6.76	0.04
ACR1	No Storage	5%	2	6.68	0.05
ACR1	Carroll Road	5%	2	2.33	0.06
ACR1	No Project	10%	2	6.76	0.04
ACR1	No Storage	10%	2	6.69	0.05
ACR1	Carroll Road	10%	2	2.34	0.06
ACR1	No Project	1%	1	3.68	0.04
ACR1	No Storage	1%	1	3.62	0.04
ACR1	Carroll Road	1%	1	1.28	0.06
ACR1	No Project	5%	1	3.68	0.04
ACR1	No Storage	5%	1	3.62	0.04
ACR1	Carroll Road	5%	1	1.28	0.06
ACR1	No Project	10%	1	3.68	0.04
ACR1	No Storage	10%	1	3.63	0.04
ACR1	Carroll Road	10%	1	1.29	0.06
ACR1	No Project	1%	4	10.49	0.05
ACR1	No Storage	1%	4	10.41	0.06

Appendix A. Storage and Irrigation Impacts on Flow in Americano Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
ACR1	Carroll Road	1%	4	3.61	0.07
ACR1	No Project	5%	4	10.49	0.05
ACR1	No Storage	5%	4	10.41	0.06
ACR1	Carroll Road	5%	4	3.61	0.07
ACR1	No Project	10%	4	10.49	0.05
ACR1	No Storage	10%	4	10.42	0.06
ACR1	Carroll Road	10%	4	3.62	0.07
ACR1	No Project	1%	3	6.76	0.04
ACR1	No Storage	1%	3	6.68	0.05
ACR1	Carroll Road	1%	3	2.33	0.06
ACR1	No Project	5%	3	6.76	0.04
ACR1	No Storage	5%	3	6.68	0.05
ACR1	Carroll Road	5%	3	2.33	0.06
ACR1	No Project	10%	3	6.76	0.04
ACR1	No Storage	10%	3	6.69	0.05
ACR1	Carroll Road	10%	3	2.34	0.06
ACR1	No Project	1%	5	3.68	0.04
ACR1	No Storage	1%	5	3.72	0.04
ACR1	Carroll Road	1%	5	1.35	0.06
ACR1	No Project	5%	5	3.68	0.04
ACR1	No Storage	5%	5	3.72	0.04
ACR1	Carroll Road	5%	5	1.35	0.06
ACR1	No Project	10%	5	3.68	0.04
ACR1	No Storage	10%	5	3.72	0.04
ACR1	Carroll Road	10%	5	1.35	0.06
ACR2	No Project	1%	2	4.44	0.03
ACR2	No Storage	1%	2	4.41	0.03
ACR2	Carroll Road	1%	2	0.06	0.04
ACR2	No Project	5%	2	4.44	0.03
ACR2	No Storage	5%	2	4.41	0.03
ACR2	Carroll Road	5%	2	0.06	0.04
ACR2	No Project	10%	2	4.44	0.03
ACR2	No Storage	10%	2	4.41	0.03
ACR2	Carroll Road	10%	2	0.06	0.04
ACR2	No Project	1%	1	2.42	0.03
ACR2	No Storage	1%	1	2.39	0.02
ACR2	Carroll Road	1%	1	0.06	0.04
ACR2	No Project	5%	1	2.42	0.03
ACR2	No Storage	5%	1	2.39	0.02
ACR2	Carroll Road	5%	1	0.06	0.04
ACR2	No Project	10%	1	2.42	0.03
ACR2	No Storage	10%	1	2.40	0.02
ACR2	Carroll Road	10%	1	0.06	0.04
ACR2	No Project	1%	4	6.88	0.03
ACR2	No Storage	1%	4	6.85	0.04
ACR2	Carroll Road	1%	4	0.06	0.04
ACR2	No Project	5%	4	6.88	0.03
ACR2	No Storage	5%	4	6.85	0.04
ACR2	Carroll Road	5%	4	0.06	0.04

Appendix A. Storage and Irrigation Impacts on Flow in Americano Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
ACR2	No Project	10%	4	6.88	0.03
ACR2	No Storage	10%	4	6.86	0.04
ACR2	Carroll Road	10%	4	0.06	0.04
ACR2	No Project	1%	3	4.44	0.03
ACR2	No Storage	1%	3	4.41	0.03
ACR2	Carroll Road	1%	3	0.06	0.04
ACR2	No Project	5%	3	4.44	0.03
ACR2	No Storage	5%	3	4.41	0.03
ACR2	Carroll Road	5%	3	0.06	0.04
ACR2	No Project	10%	3	4.44	0.03
ACR2	No Storage	10%	3	4.41	0.03
ACR2	Carroll Road	10%	3	0.06	0.04
ACR2	No Project	1%	5	2.42	0.03
ACR2	No Storage	1%	5	2.43	0.02
ACR2	Carroll Road	1%	5	0.06	0.04
ACR2	No Project	5%	5	2.42	0.03
ACR2	No Storage	5%	5	2.43	0.02
ACR2	Carroll Road	5%	5	0.06	0.04
ACR2	No Project	10%	5	2.42	0.03
ACR2	No Storage	10%	5	2.43	0.02
ACR2	Carroll Road	10%	5	0.06	0.04
AB1	No Project	1%	2	4.85	0.03
AB1	No Storage	1%	2	4.67	0.04
AB1	Bloomfield	1%	2	1.55	0.09
AB1	No Project	5%	2	4.85	0.03
AB1	No Storage	5%	2	4.67	0.04
AB1	Bloomfield	5%	2	1.55	0.09
AB1	No Project	10%	2	4.85	0.03
AB1	No Storage	10%	2	4.69	0.04
AB1	Bloomfield	10%	2	1.56	0.08
AB1	No Project	1%	1	2.64	0.03
AB1	No Storage	1%	1	2.50	0.03
AB1	Bloomfield	1%	1	0.86	0.08
AB1	No Project	5%	1	2.64	0.03
AB1	No Storage	5%	1	2.50	0.03
AB1	Bloomfield	5%	1	0.86	0.08
AB1	No Project	10%	1	2.64	0.03
AB1	No Storage	10%	1	2.52	0.03
AB1	Bloomfield	10%	1	0.87	0.08
AB1	No Project	1%	4	7.53	0.04
AB1	No Storage	1%	4	7.35	0.05
AB1	Bloomfield	1%	4	2.41	0.09
AB1	No Project	5%	4	7.53	0.04
AB1	No Storage	5%	4	7.35	0.05
AB1	Bloomfield	5%	4	2.41	0.09
AB1	No Project	10%	4	7.53	0.04
AB1	No Storage	10%	4	7.37	0.05
AB1	Bloomfield	10%	4	2.42	0.09
AB1	No Project	1%	3	4.85	0.03

Appendix A. Storage and Irrigation Impacts on Flow in Americano Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
AB1	No Storage	1%	3	4.67	0.05
AB1	Bloomfield	1%	3	1.55	0.09
AB1	No Project	5%	3	4.85	0.03
AB1	No Storage	5%	3	4.67	0.05
AB1	Bloomfield	5%	3	1.55	0.09
AB1	No Project	10%	3	4.85	0.03
AB1	No Storage	10%	3	4.69	0.05
AB1	Bloomfield	10%	3	1.56	0.09
AB1	No Project	1%	5	2.64	0.03
AB1	No Storage	1%	5	2.73	0.05
AB1	Bloomfield	1%	5	0.99	0.09
AB1	No Project	5%	5	2.64	0.03
AB1	No Storage	5%	5	2.73	0.05
AB1	Bloomfield	5%	5	0.99	0.09
AB1	No Project	10%	5	2.64	0.03
AB1	No Storage	10%	5	2.72	0.05
AB1	Bloomfield	10%	5	0.99	0.09
AB2	No Project	1%	2	3.29	0.02
AB2	No Storage	1%	2	3.21	0.03
AB2	Bloomfield	1%	2	0.09	0.07
AB2	No Project	5%	2	3.29	0.02
AB2	No Storage	5%	2	3.21	0.03
AB2	Bloomfield	5%	2	0.09	0.07
AB2	No Project	10%	2	3.29	0.02
AB2	No Storage	10%	2	3.22	0.02
AB2	Bloomfield	10%	2	0.09	0.07
AB2	No Project	1%	1	1.79	0.01
AB2	No Storage	1%	1	1.73	0.02
AB2	Bloomfield	1%	1	0.09	0.07
AB2	No Project	5%	1	1.79	0.01
AB2	No Storage	5%	1	1.73	0.02
AB2	Bloomfield	5%	1	0.09	0.07
AB2	No Project	10%	1	1.79	0.01
AB2	No Storage	10%	1	1.74	0.02
AB2	Bloomfield	10%	1	0.09	0.07
AB2	No Project	1%	4	5.10	0.02
AB2	No Storage	1%	4	5.03	0.03
AB2	Bloomfield	1%	4	0.09	0.07
AB2	No Project	5%	4	5.10	0.02
AB2	No Storage	5%	4	5.03	0.03
AB2	Bloomfield	5%	4	0.09	0.07
AB2	No Project	10%	4	5.10	0.02
AB2	No Storage	10%	4	5.04	0.03
AB2	Bloomfield	10%	4	0.09	0.07
AB2	No Project	1%	3	3.29	0.02
AB2	No Storage	1%	3	3.21	0.03
AB2	Bloomfield	1%	3	0.09	0.07
AB2	No Project	5%	3	3.29	0.02
AB2	No Storage	5%	3	3.21	0.03

Appendix A. Storage and Irrigation Impacts on Flow in Americano Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
AB2	Bloomfield	5%	3	0.09	0.07
AB2	No Project	10%	3	3.29	0.02
AB2	No Storage	10%	3	3.22	0.03
AB2	Bloomfield	10%	3	0.09	0.07
AB2	No Project	1%	5	1.79	0.01
AB2	No Storage	1%	5	1.83	0.03
AB2	Bloomfield	1%	5	0.09	0.07
AB2	No Project	5%	5	1.79	0.01
AB2	No Storage	5%	5	1.83	0.03
AB2	Bloomfield	5%	5	0.09	0.07
AB2	No Project	10%	5	1.79	0.01
AB2	No Storage	10%	5	1.82	0.03
AB2	Bloomfield	10%	5	0.09	0.07

Appendix B. Storage and Irrigation Impacts on Flow in Stemple Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
S1	No Project	1%	2	121.91	0.77
S1	No Storage	1%	2	118.2	1.08
S1	Huntley	1%	2	116.5	1.09
S1	Two Rock	1%	2	114.9	1.07
S1	No Project	5%	2	121.91	0.77
S1	No Storage	5%	2	118.9	1.03
S1	Huntley	5%	2	117.2	1.03
S1	Two Rock	5%	2	115.6	1.02
S1	No Project	10%	2	121.91	0.77
S1	No Storage	10%	2	120.1	0.93
S1	Huntley	10%	2	118.4	0.93
S1	Two Rock	10%	2	116.8	0.91
S1	No Project	1%	1	55.96	0.46
S1	No Storage	1%	1	55.33	0.76
S1	Huntley	1%	1	54.53	0.77
S1	Two Rock	1%	1	53.81	0.76
S1	No Project	5%	1	55.96	0.46
S1	No Storage	5%	1	55.4	0.68
S1	Huntley	5%	1	54.7	0.69
S1	Two Rock	5%	1	53.9	0.68
S1	No Project	10%	1	55.96	0.46
S1	No Storage	10%	1	55.7	0.55
S1	Huntley	10%	1	54.9	0.56
S1	Two Rock	10%	1	54.1	0.55
S1	No Project	1%	4	195.49	1.00
S1	No Storage	1%	4	191.3	1.30
S1	Huntley	1%	4	188.5	1.30
S1	Two Rock	1%	4	186.0	1.28
S1	No Project	5%	4	195.49	1.00
S1	No Storage	5%	4	192.1	1.25
S1	Huntley	5%	4	189.2	1.25
S1	Two Rock	5%	4	186.7	1.23
S1	No Project	10%	4	195.49	1.00
S1	No Storage	10%	4	193.4	1.15
S1	Huntley	10%	4	190.6	1.15
S1	Two Rock	10%	4	188.1	1.13
S1	No Project	1%	3	121.91	0.77
S1	No Storage	1%	3	118.29	1.25
S1	Huntley	1%	3	116.53	1.26
S1	Two Rock	1%	3	114.97	1.24
S1	No Project	5%	3	121.91	0.77
S1	No Storage	5%	3	118.94	1.17
S1	Huntley	5%	3	117.19	1.17
S1	Two Rock	5%	3	115.6	1.16
S1	No Project	10%	3	121.91	0.77
S1	No Storage	10%	3	120.1	1.01
S1	Huntley	10%	3	118.4	1.01
S1	Two Rock	10%	3	116.8	1.00
S1	No Project	1%	5	55.96	0.46
S1	No Storage	1%	5	58.74	1.07
S1	Huntley	1%	5	57.94	1.08
S1	Two Rock	1%	5	57.22	1.07
S1	No Project	5%	5	55.96	0.46
S1	No Storage	5%	5	58.24	0.94
S1	Huntley	5%	5	57.44	0.95

Appendix B. Storage and Irrigation Impacts on Flow in Stemple Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
S1	Two Rock	5%	5	56.72	0.94
S1	No Project	10%	5	55.96	0.46
S1	No Storage	10%	5	57.32	0.70
S1	Huntley	10%	5	56.53	0.71
S1	Two Rock	10%	5	55.80	0.70
S2	No Project	1%	2	97.12	0.62
S2	No Storage	1%	2	93.8	0.90
S2	Two Rock	1%	2	90.4	0.89
S2	No Project	5%	2	97.12	0.62
S2	No Storage	5%	2	94.4	0.85
S2	Two Rock	5%	2	91.1	0.84
S2	No Project	10%	2	97.12	0.62
S2	No Storage	10%	2	95.5	0.76
S2	Two Rock	10%	2	92.2	0.74
S2	No Project	1%	1	44.58	0.36
S2	No Storage	1%	1	44.00	0.65
S2	Two Rock	1%	1	42.48	0.65
S2	No Project	5%	1	44.58	0.36
S2	No Storage	5%	1	44.11	0.59
S2	Two Rock	5%	1	42.59	0.58
S2	No Project	10%	1	44.58	0.36
S2	No Storage	10%	1	44.3	0.46
S2	Two Rock	10%	1	42.8	0.46
S2	No Project	1%	4	155.74	0.79
S2	No Storage	1%	4	151.9	1.07
S2	Two Rock	1%	4	146.6	1.05
S2	No Project	5%	4	155.74	0.79
S2	No Storage	5%	4	152.6	1.02
S2	Two Rock	5%	4	147.3	1.00
S2	No Project	10%	4	155.74	0.79
S2	No Storage	10%	4	153.9	0.93
S2	Two Rock	10%	4	148.5	0.91
S2	No Project	1%	3	97.12	0.62
S2	No Storage	1%	3	93.81	1.06
S2	Two Rock	1%	3	90.48	1.04
S2	No Project	5%	3	97.12	0.62
S2	No Storage	5%	3	94.40	0.98
S2	Two Rock	5%	3	91.08	0.96
S2	No Project	10%	3	97.12	0.62
S2	No Storage	10%	3	95.5	0.83
S2	Two Rock	10%	3	92.2	0.82
S2	No Project	1%	5	44.58	0.36
S2	No Storage	1%	5	47.13	0.94
S2	Two Rock	1%	5	45.61	0.94
S2	No Project	5%	5	44.58	0.36
S2	No Storage	5%	5	46.67	0.82
S2	Two Rock	5%	5	45.15	0.82
S2	No Project	10%	5	44.58	0.36
S2	No Storage	10%	5	45.83	0.60
S2	Two Rock	10%	5	44.31	0.60
S3	No Project	1%	2	65.49	0.42
S3	No Storage	1%	2	63.3	0.60
S3	Two Rock	1%	2	60.0	0.59
S3	No Project	5%	2	65.49	0.42
S3	No Storage	5%	2	63.7	0.57

Appendix B. Storage and Irrigation Impacts on Flow in Stemple Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
S3	Two Rock	5%	2	60.4	0.56
S3	No Project	10%	2	65.49	0.42
S3	No Storage	10%	2	64.4	0.51
S3	Two Rock	10%	2	61.1	0.49
S3	No Project	1%	1	30.06	0.25
S3	No Storage	1%	1	29.68	0.43
S3	Two Rock	1%	1	28.16	0.43
S3	No Project	5%	1	30.06	0.25
S3	No Storage	5%	1	29.75	0.39
S3	Two Rock	5%	1	28.23	0.39
S3	No Project	10%	1	30.06	0.25
S3	No Storage	10%	1	29.9	0.31
S3	Two Rock	10%	1	28.4	0.31
S3	No Project	1%	4	105.01	0.54
S3	No Storage	1%	4	102.5	0.72
S3	Two Rock	1%	4	97.2	0.70
S3	No Project	5%	4	105.01	0.54
S3	No Storage	5%	4	103.0	0.68
S3	Two Rock	5%	4	97.6	0.67
S3	No Project	10%	4	105.01	0.54
S3	No Storage	10%	4	103.8	0.62
S3	Two Rock	10%	4	98.4	0.61
S3	No Project	1%	3	65.49	0.42
S3	No Storage	1%	3	63.32	0.70
S3	Two Rock	1%	3	60.00	0.69
S3	No Project	5%	3	65.49	0.42
S3	No Storage	5%	3	63.71	0.65
S3	Two Rock	5%	3	60.39	0.64
S3	No Project	10%	3	65.49	0.42
S3	No Storage	10%	3	64.4	0.56
S3	Two Rock	10%	3	61.1	0.54
S3	No Project	1%	5	30.06	0.25
S3	No Storage	1%	5	31.72	0.62
S3	Two Rock	1%	5	30.20	0.62
S3	No Project	5%	5	30.06	0.25
S3	No Storage	5%	5	31.42	0.54
S3	Two Rock	5%	5	29.90	0.54
S3	No Project	10%	5	30.06	0.25
S3	No Storage	10%	5	30.87	0.40
S3	Two Rock	10%	5	29.35	0.40
S4	No Project	1%	2	25.61	0.16
S4	No Storage	1%	2	24.8	0.23
S4	No Project	5%	2	25.61	0.16
S4	No Storage	5%	2	24.9	0.22
S4	No Project	10%	2	25.61	0.16
S4	No Storage	10%	2	25.2	0.20
S4	No Project	1%	1	11.75	0.09
S4	No Storage	1%	1	11.61	0.17
S4	No Project	5%	1	11.75	0.09
S4	No Storage	5%	1	11.64	0.15
S4	No Project	10%	1	11.75	0.09
S4	No Storage	10%	1	11.7	0.12
S4	No Project	1%	4	41.06	0.21
S4	No Storage	1%	4	40.1	0.28
S4	No Project	5%	4	41.06	0.21

Appendix B. Storage and Irrigation Impacts on Flow in Stemple Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
S4	No Storage	5%	4	40.3	0.27
S4	No Project	10%	4	41.06	0.21
S4	No Storage	10%	4	40.6	0.24
S4	No Project	1%	3	25.61	0.16
S4	No Storage	1%	3	24.78	0.27
S4	No Project	5%	3	25.61	0.16
S4	No Storage	5%	3	24.93	0.25
S4	No Project	10%	3	25.61	0.16
S4	No Storage	10%	3	25.2	0.22
S4	No Project	1%	5	11.75	0.09
S4	No Storage	1%	5	12.39	0.24
S4	No Project	5%	5	11.75	0.09
S4	No Storage	5%	5	12.27	0.21
S4	No Project	10%	5	11.75	0.09
S4	No Storage	10%	5	12.07	0.15
S5	No Project	1%	2	24.35	0.15
S5	No Storage	1%	2	23.41	0.23
S5	No Project	5%	2	24.35	0.15
S5	No Storage	5%	2	23.6	0.22
S5	No Project	10%	2	24.35	0.15
S5	No Storage	10%	2	23.9	0.19
S5	No Project	1%	1	11.18	0.09
S5	No Storage	1%	1	11.01	0.18
S5	No Project	5%	1	11.18	0.09
S5	No Storage	5%	1	11.04	0.16
S5	No Project	10%	1	11.18	0.09
S5	No Storage	10%	1	11.1	0.12
S5	No Project	1%	4	39.05	0.20
S5	No Storage	1%	4	38.0	0.28
S5	No Project	5%	4	39.05	0.20
S5	No Storage	5%	4	38.2	0.26
S5	No Project	10%	4	39.05	0.20
S5	No Storage	10%	4	38.5	0.24
S5	No Project	1%	3	24.35	0.15
S5	No Storage	1%	3	23.42	0.28
S5	No Project	5%	3	24.35	0.15
S5	No Storage	5%	3	23.59	0.26
S5	No Project	10%	3	24.35	0.15
S5	No Storage	10%	3	23.9	0.22
S5	No Project	1%	5	11.18	0.09
S5	No Storage	1%	5	11.89	0.26
S5	No Project	5%	5	11.18	0.09
S5	No Storage	5%	5	11.76	0.22
S5	No Project	10%	5	11.18	0.09
S5	No Storage	10%	5	11.53	0.16
SH1	No Project	1%	2	5.26	0.03
SH1	No Storage	1%	2	5.1	0.05
SH1	Huntley	1%	2	3.3	0.05
SH1	No Project	5%	2	5.26	0.03
SH1	No Storage	5%	2	5.1	0.05
SH1	Huntley	5%	2	3.3	0.05
SH1	No Project	10%	2	5.26	0.03
SH1	No Storage	10%	2	5.2	0.04
SH1	Huntley	10%	2	3.4	0.05
SH1	No Project	1%	1	2.42	0.02

Appendix B. Storage and Irrigation Impacts on Flow in Stemple Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
SH1	No Storage	1%	1	2.4	0.04
SH1	Huntley	1%	1	1.6	0.05
SH1	No Project	5%	1	2.42	0.02
SH1	No Storage	5%	1	2.4	0.03
SH1	Huntley	5%	1	1.6	0.04
SH1	No Project	10%	1	2.42	0.02
SH1	No Storage	10%	1	2.4	0.03
SH1	Huntley	10%	1	1.6	0.04
SH1	No Project	1%	4	8.44	0.04
SH1	No Storage	1%	4	8.2	0.06
SH1	Huntley	1%	4	5.4	0.06
SH1	No Project	5%	4	8.44	0.04
SH1	No Storage	5%	4	8.3	0.06
SH1	Huntley	5%	4	5.4	0.06
SH1	No Project	10%	4	8.44	0.04
SH1	No Storage	10%	4	8.3	0.05
SH1	Huntley	10%	4	5.5	0.05
SH1	No Project	1%	3	5.26	0.03
SH1	No Storage	1%	3	5.1	0.06
SH1	Huntley	1%	3	3.3	0.06
SH1	No Project	5%	3	5.26	0.03
SH1	No Storage	5%	3	5.1	0.05
SH1	Huntley	5%	3	3.4	0.06
SH1	No Project	10%	3	5.26	0.03
SH1	No Storage	10%	3	5.2	0.05
SH1	Huntley	10%	3	3.4	0.05
SH1	No Project	1%	5	2.42	0.02
SH1	No Storage	1%	5	2.6	0.05
SH1	Huntley	1%	5	1.8	0.06
SH1	No Project	5%	5	2.42	0.02
SH1	No Storage	5%	5	2.5	0.05
SH1	Huntley	5%	5	1.7	0.06
SH1	No Project	10%	5	2.42	0.02
SH1	No Storage	10%	5	2.5	0.03
SH1	Huntley	10%	5	1.7	0.05
SH2	No Project	1%	2	1.78	0.01
SH2	Huntley	1%	2	0.02	0.02
SH2	No Project	5%	2	1.78	0.01
SH2	Huntley	5%	2	0.02	0.02
SH2	No Project	10%	2	1.78	0.01
SH2	Huntley	10%	2	0.02	0.02
SH2	No Project	1%	1	0.82	0.01
SH2	Huntley	1%	1	0.02	0.02
SH2	No Project	5%	1	0.82	0.01
SH2	Huntley	5%	1	0.02	0.02
SH2	No Project	10%	1	0.82	0.01
SH2	Huntley	10%	1	0.02	0.02
SH2	No Project	1%	4	2.85	0.01
SH2	Huntley	1%	4	0.02	0.02
SH2	No Project	5%	4	2.85	0.01
SH2	Huntley	5%	4	0.02	0.02
SH2	No Project	10%	4	2.85	0.01
SH2	Huntley	10%	4	0.02	0.02
SH2	No Project	1%	3	1.78	0.01
SH2	Huntley	1%	3	0.02	0.02

Appendix B. Storage and Irrigation Impacts on Flow in Stemple Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
SH2	No Project	5%	3	1.78	0.01
SH2	Huntley	5%	3	0.02	0.02
SH2	No Project	10%	3	1.78	0.01
SH2	Huntley	10%	3	0.02	0.02
SH2	No Project	1%	5	0.82	0.01
SH2	Huntley	1%	5	0.02	0.02
SH2	No Project	5%	5	0.82	0.01
SH2	Huntley	5%	5	0.02	0.02
SH2	No Project	10%	5	0.82	0.01
SH2	Huntley	10%	5	0.02	0.02
STR1	No Project	1%	2	15.53	0.10
STR1	No Storage	1%	2	15.1	0.13
STR1	Two Rock	1%	2	11.8	0.12
STR1	No Project	5%	2	15.53	0.10
STR1	No Storage	5%	2	15.2	0.13
STR1	Two Rock	5%	2	11.9	0.11
STR1	No Project	10%	2	15.53	0.10
STR1	No Storage	10%	2	15.3	0.12
STR1	Two Rock	10%	2	12.0	0.10
STR1	No Project	1%	1	7.13	0.06
STR1	No Storage	1%	1	7.1	0.09
STR1	Two Rock	1%	1	5.5	0.09
STR1	No Project	5%	1	7.13	0.06
STR1	No Storage	5%	1	7.1	0.08
STR1	Two Rock	5%	1	5.6	0.08
STR1	No Project	10%	1	7.13	0.06
STR1	No Storage	10%	1	7.1	0.07
STR1	Two Rock	10%	1	5.6	0.07
STR1	No Project	1%	4	24.90	0.13
STR1	No Storage	1%	4	24.4	0.16
STR1	Two Rock	1%	4	19.1	0.14
STR1	No Project	5%	4	24.90	0.13
STR1	No Storage	5%	4	24.5	0.15
STR1	Two Rock	5%	4	19.2	0.14
STR1	No Project	10%	4	24.90	0.13
STR1	No Storage	10%	4	24.7	0.14
STR1	Two Rock	10%	4	19.3	0.13
STR1	No Project	1%	3	15.53	0.10
STR1	No Storage	1%	3	15.1	0.15
STR1	Two Rock	1%	3	11.8	0.14
STR1	No Project	5%	3	15.53	0.10
STR1	No Storage	5%	3	15.2	0.14
STR1	Two Rock	5%	3	11.9	0.13
STR1	No Project	10%	3	15.53	0.10
STR1	No Storage	10%	3	15.3	0.12
STR1	Two Rock	10%	3	12.0	0.11
STR1	No Project	1%	5	7.13	0.06
STR1	No Storage	1%	5	7.43	0.12
STR1	Two Rock	1%	5	5.9	0.12
STR1	No Project	5%	5	7.13	0.06
STR1	No Storage	5%	5	7.38	0.11
STR1	Two Rock	5%	5	5.9	0.11
STR1	No Project	10%	5	7.13	0.06
STR1	No Storage	10%	5	7.3	0.08
STR1	Two Rock	10%	5	5.8	0.08

Appendix B. Storage and Irrigation Impacts on Flow in Stemple Watershed

Location	Storage Component	Design Discharge Rate	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
STR2	No Project	1%	2	3.34	0.02
STR2	Two Rock	1%	2	0.01	0.01
STR2	No Project	5%	2	3.34	0.02
STR2	Two Rock	5%	2	0.01	0.01
STR2	No Project	10%	2	3.34	0.02
STR2	Two Rock	10%	2	0.01	0.01
STR2	No Project	1%	1	1.53	0.01
STR2	Two Rock	1%	1	0.01	0.01
STR2	No Project	5%	1	1.53	0.01
STR2	Two Rock	5%	1	0.01	0.01
STR2	No Project	10%	1	1.53	0.01
STR2	Two Rock	10%	1	0.01	0.01
STR2	No Project	1%	4	5.35	0.03
STR2	Two Rock	1%	4	0.01	0.01
STR2	No Project	5%	4	5.35	0.03
STR2	Two Rock	5%	4	0.01	0.01
STR2	No Project	10%	4	5.35	0.03
STR2	Two Rock	10%	4	0.01	0.01
STR2	No Project	1%	3	3.34	0.02
STR2	Two Rock	1%	3	0.01	0.01
STR2	No Project	5%	3	3.34	0.02
STR2	Two Rock	5%	3	0.01	0.01
STR2	No Project	10%	3	3.34	0.02
STR2	Two Rock	10%	3	0.01	0.01
STR2	No Project	1%	5	1.53	0.01
STR2	Two Rock	1%	5	0.01	0.01
STR2	No Project	5%	5	1.53	0.01
STR2	Two Rock	5%	5	0.01	0.01
STR2	No Project	10%	5	1.53	0.01
STR2	Two Rock	10%	5	0.01	0.01

Appendix C. Storage and Irrigation Impacts on Flow in South County Watersheds

Loc	Storage Component	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
TT	No Project	1	13.15	0.08
TT	No Storage	1	12.77	0.09
TT	Sears Pt.	1	8.77	0.07
TT	Tolay (A)	1	6.22	0.03
TT	Tolay (C)	1	10.16	0.07
TT	No Project	2	24.14	0.1
TT	No Storage	2	23.57	0.09
TT	Sears Pt.	2	16.23	0.07
TT	Tolay (A)	2	11.42	0.04
TT	Tolay (C)	2	18.72	0.07
TT	No Project	3	24.14	0.1
TT	No Storage	3	23.58	0.13
TT	Sears Pt.	3	16.25	0.11
TT	Tolay (A)	3	11.42	0.04
TT	Tolay (C)	3	18.73	0.1
TT	No Project	4	35.85	0.16
TT	No Storage	4	35.21	0.14
TT	Sears Pt.	4	24.32	0.11
TT	Tolay (A)	4	16.95	0.06
TT	Tolay (C)	4	27.92	0.11
TT	No Project	5	13.15	0.08
TT	No Storage	5	13.43	0.14
TT	Sears Pt.	5	9.44	0.12
TT	Tolay (A)	5	6.22	0.03
TT	Tolay (C)	5	10.56	0.1
TS	No Project	1	12.82	0.08
TS	No Storage	1	12.44	0.09
TS	Sears Pt.	1	8.44	0.07
TS	Tolay (A)	1	5.89	0.03
TS	Tolay (C)	1	9.83	0.07
TS	No Project	2	23.54	0.09
TS	No Storage	2	22.97	0.09
TS	Sears Pt.	2	15.63	0.07
TS	Tolay (A)	2	10.81	0.04
TS	Tolay (C)	2	18.12	0.07
TS	No Project	3	23.54	0.09
TS	No Storage	3	22.98	0.13
TS	Sears Pt.	3	15.64	0.11
TS	Tolay (A)	3	10.81	0.04
TS	Tolay (C)	3	18.12	0.1
TS	No Project	4	34.96	0.16
TS	No Storage	4	34.32	0.14
TS	Sears Pt.	4	23.42	0.11
TS	Tolay (A)	4	16.06	0.06
TS	Tolay (C)	4	27.03	0.11
TS	No Project	5	12.82	0.08
TS	No Storage	5	13.1	0.13
TS	Sears Pt.	5	9.11	0.12
TS	Tolay (A)	5	5.89	0.03

Appendix C. Storage and Irrigation Impacts on Flow in South County Watersheds

Loc	Storage Component	Hydrological Condition	Flow (cfs) Q.wet	Q.dry
TS	Tolay (C)	5	10.23	0.1
TAC	No Project	1	8.5	0.05
TAC	No Storage	1	8.12	0.07
TAC	Tolay (A)	1	1.57	0.01
TAC	Tolay (C)	1	5.51	0.05
TAC	No Project	2	15.61	0.06
TAC	No Storage	2	15.04	0.06
TAC	Tolay (A)	2	2.88	0.01
TAC	Tolay (C)	2	10.19	0.05
TAC	No Project	3	15.61	0.06
TAC	No Storage	3	15.05	0.1
TAC	Tolay (A)	3	2.88	0.01
TAC	Tolay (C)	3	10.19	0.07
TAC	No Project	4	23.18	0.1
TAC	No Storage	4	22.54	0.1
TAC	Tolay (A)	4	4.28	0.02
TAC	Tolay (C)	4	15.25	0.07
TAC	No Project	5	8.5	0.05
TAC	No Storage	5	8.78	0.12
TAC	Tolay (A)	5	1.57	0.01
TAC	Tolay (C)	5	5.91	0.08
LV1	Lakeville	2	0.6	0.0
LV1	No Project	1	1.0	0.0
LV1	Lakeville	1	0.4	0.0
LV1	No Project	4	2.6	0.0
LV1	Lakeville	4	0.9	0.0
LV2	No Project	2	1.2	0.0
LV2	Lakeville	2	0.1	0.0
LV2	No Project	1	0.7	0.0
LV2	Lakeville	1	0.1	0.0
LV2	No Project	4	1.8	0.0
LV2	Lakeville	4	0.1	0.0
AD1	No Project	2	4.92	0.02
AD1	Adobe Rd.	2	3.62	0.01
AD1	No Project	1	2.68	0.02
AD1	Adobe Rd.	1	1.97	0.01
AD1	No Project	4	7.31	0.03
AD1	Adobe Rd.	4	5.38	0.02
AD2	No Project	2	4.11	0.02
AD2	Adobe Rd.	2	2.81	0.01
AD2	No Project	1	2.24	0.01
AD2	Adobe Rd.	1	1.53	0.01
AD2	No Project	4	6.1	0.03
AD2	Adobe Rd.	4	4.17	0.02