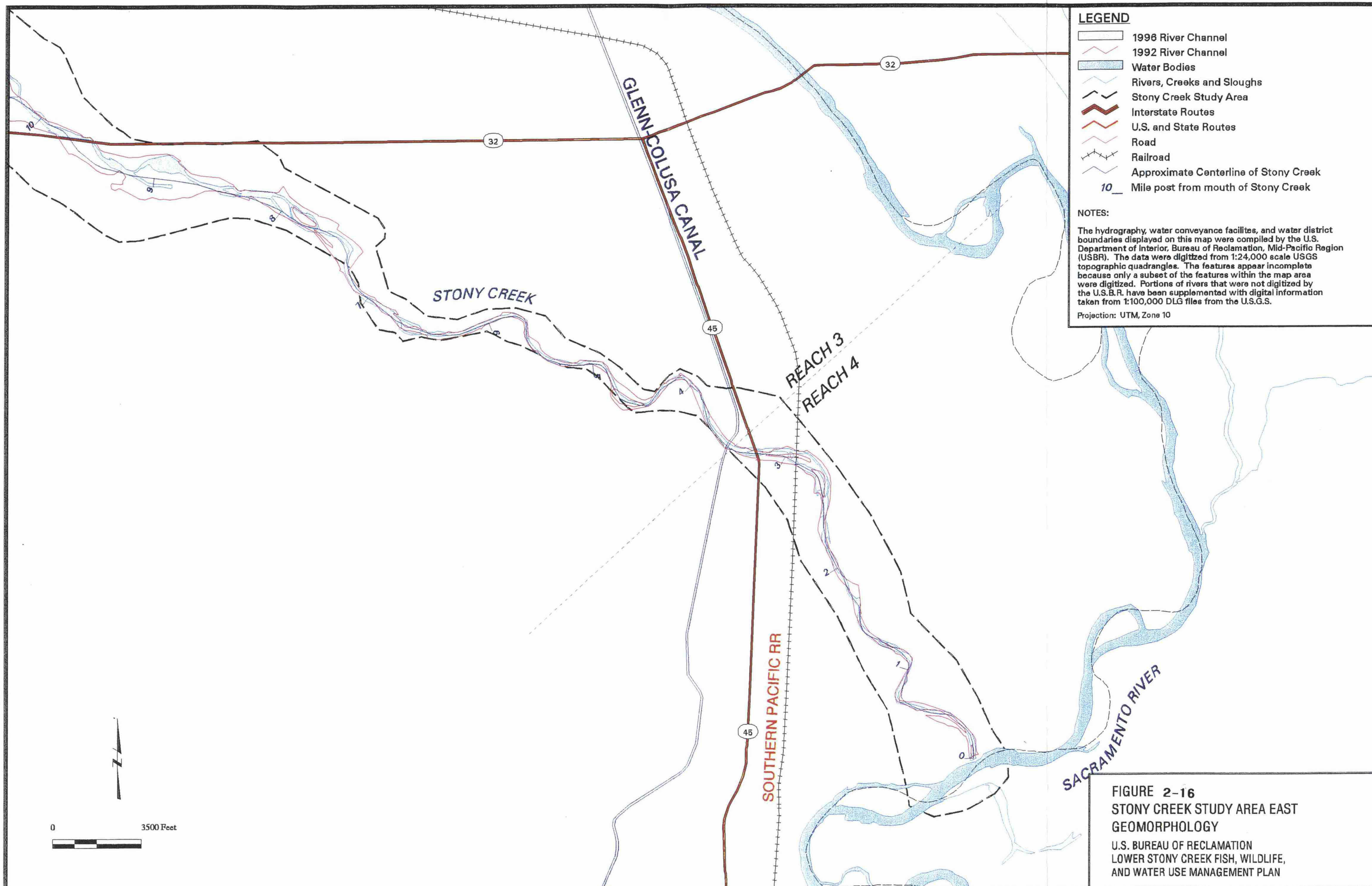


FIGURE 2-16
STONY CREEK STUDY AREA EAST
GEOMORPHOLOGY
U.S. BUREAU OF RECLAMATION
LOWER STONY CREEK FISH, WILDLIFE, AND WATER USE MANAGEMENT PLAN

22-214-0022

Reach 1 (River Mile 24.6 to 15.9). This geomorphic reach extends from the base of Black Butte Dam to the I-5 bridge. It has generally changed planform from a braided to a single meandering channel between 1956 and 1996. The changes discussed below refer only to changes between 1993 and 1996.

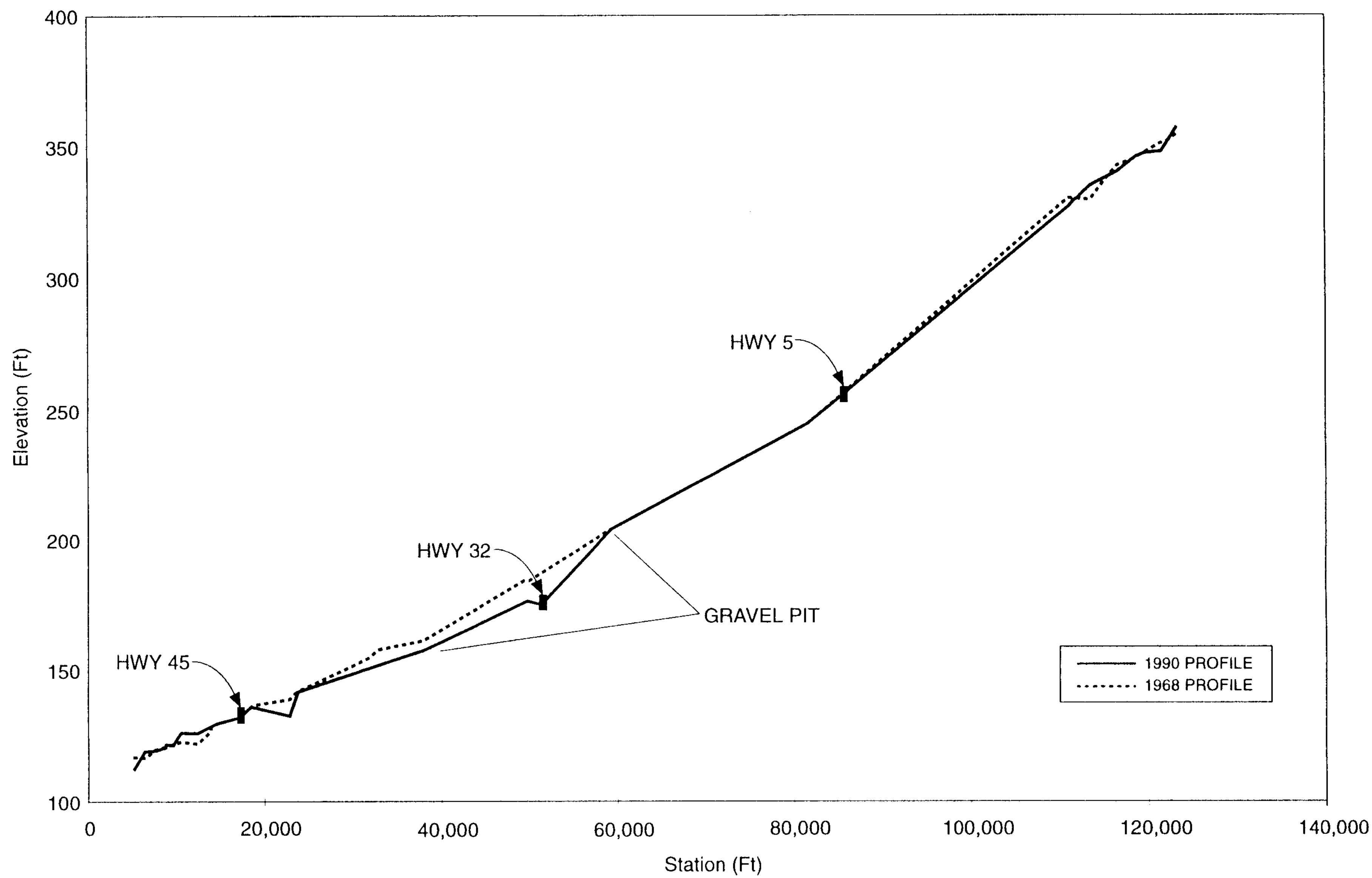
Near River Mile (RM) 22.25, a bend in the creek has changed shape and has devegetated 2.7 acres of former vegetated land on the outside of the bend.

Near RM 22, there is an orchard with associated bank armoring that has altered the planform of the creek. Stony Creek makes a right angle turn at this location. The river will continue to apply force to this area and will require attention if future land erosion is to be prevented. The 1956 aerial photos suggested that the bank constraints have caused accelerated bank erosion and altered the shape of the bend immediately upstream, which has significantly increased in amplitude since 1956. Near RM 20.75, channel migration typical of a meandering channel occurred and removed 2.2 acres of formerly vegetated land.

East of the Northside Diversion Dam, near RM 19.25, there is an area of active channel migration on the north side of the creek. Channel migration removed six acres of formerly vegetated land. On the south side, near RM 18.75, a rapid and large shift in the channel location indicated a highly unstable channel at this location. The migration observed between 1993 and 1996 occurred entirely on active gravel bars and did not remove any riparian vegetation at the location. Downstream near RM 18 to 18.5, another area of channel planform instability exists. The meanders are in different locations in years 1992, 1993, and 1996. This channel migration has occurred in active gravel bars and has not effected mature riparian vegetation.

Upstream from I-5 near RM 17, there is a location of channel migration where the 1993 channel moved significantly, eroding into active gravel floodplain. The movement here appears to be similar to the nature of the pre-dam channel movement. The pre-dam channel in this location was multi-channeled (braided) and probably experienced shifting of the main flow from one channel to another.

Summary of Reach 1. Four locations in Reach 1 seem to be exhibiting a tendency for significant bank erosion and channel migration. The total RMs of these locations is 2.3 miles (26 percent of the total river miles of Reach 1). Of these areas, only one area near RM 22 seems to be related to apparent bank constraints. Seven percent of Reach 1 (0.64 mile) has experienced bank retreat which has caused mature riparian vegetation to be removed, whereas the remaining actively migrating areas (about 19 percent of Reach 1) are eroding and migrating in already existing active gravel bars.



SOURCE: KONDOLF AND SWANSON, 1991

FIGURE 2-17
LONGITUDINAL PROFILE
CHANGES BETWEEN 1968 AND 1990

2476_60 (7/14/98)

The 1956 aerial photos of Reach 1 showed a braided channel where the dominant flows probably shifted from one channel to another. The current trends of channel migration in this reach suggest that the channel migration or avulsion that occurred between 1993 and 1996 are typical of the former pre-dam channel and are likely to continue to occur. The channel migration near RM 22, near an apparent bank constraint, is the one exception in this reach.

Reach 2 (RM 15.9 to 12.3). Reach 2, extending from the I-5 bridge to Road P, was primarily a single-channeled meandering channel in 1956, although there were some mid-channel bars and braiding. In 1996, however, the mid-channel bars and braiding had almost completely disappeared.

Near RM 14.75, typical meandering channel migration caused erosion into agricultural land. Between RM 14 and roughly 13.25, there was active channel migration where 7.7 acres of agricultural land were lost to channel migration.

Summary of Reach 2. Throughout most of this short (3.6 miles) reach, the channel is migrating at a moderate rate (one-half to one channel width in three years). For a total of 0.75 mile, 21 percent of the reach, significant active channel migration occurred between 1993 and 1996. Of the total river RMs, 0.5 mile (14 percent) has migrated into and consumed agricultural lands.

Reach 3 (RM 12.3 to RM 7). This reach, extending 5.3 miles from Road P to Mills Orchard, is characterized by gravel extraction operations. At Road P, there are culverts that pass 2,500 cfs creating a flow restriction.

At RM 12.25, just downstream from Road P, an apparent hard point exists near cultivated land or irrigated pasture. This constraint to lateral movement existed in 1956 and has been maintained ever since. From approximately RM 11.75 to RM 10, there is significant channel lateral migration. It is not clear why this area has experienced such rapid and large-scale channel migration. Possible causes for this could be investigated in further analyses. Within this area, one section, near RM 11.25, has eroded into orchard land.

Summary of Reach 3. The 1956 aerial photos showed a highly braided reach here, which assumably experienced periodic avulsion of the major flow-carrying channel. The current trends may be typical for the existing geomorphic and hydraulic conditions in this reach. It is reasonable to speculate that the channel migration (or avulsion) will continue to occur in this reach.

Between Road P and Highway 32, an extensive reach of lower Stony Creek experiences significant active channel movement. This reach extends approximately 1.75 miles or 28 percent of the total length of Reach 3. Active gravel extraction is associated with additional significant channel migration in roughly the same amount of miles (33 percent) of Reach 3. In general, the 1956 photos showed that Reach 3 was historically a multi-channel, braided reach likely characterized by channel avulsion and shifting. The current channel appears to be similar in nature with about 60 percent of its length actively shifting in the course of 3 years.

Reach 4 (RM 7 to RM 0.0). This reach extends from Mills Orchard to the Sacramento River. Reach 4 has been highly stable between 1993 and 1996. There are no areas of significant channel movement. The 1956 photos showed a similar pattern.

Table 2-4 summarizes the site-specific information about channel migration derived from the comparison of aerial photos.

Table 2-4
Interaction of Significant Channel Migration and Land Use on Lower Stony Creek Between 1993 and 1996

Reach	Length	Significant Channel Migration		Effected Mature Riparian Vegetation		Migration Potentially Associated With Land Use		Migration Effecting Agricultural Land	
	Miles	Miles	%	Miles	%	Miles	%	Miles	%
1	8.7	2.3	26	0.6	7	0.8	9	0.1	1
2	3.6	0.7	21	-	-	-	-	0.5	14
3	5.3	3.5	66			1.7	33	0.1	2
Subtotal	**17.6**	**6.5**	**37**	**0.6**	**3**	**2.5**	**14**	**0.7**	**4**
4	7.0	0	0	0	0	0	0	0	0
Total	**24.6**	**6.5**	**28**	**0.6**	**3**	**2.5**	**11**	**0.7**	**3**

F. Riparian Habitat / Vegetation

Information on riparian habitat along Stony Creek includes previous studies on Stony Creek, primarily conducted by Federal and State agencies, specific information on plant communities and sensitive plant species occurrences contained in DFG's Natural Diversity Database (NDDB), other unpublished information from ecologists working in the area, and aerial photograph interpretation. A reconnaissance level field investigation was conducted on December 13, 1995. No extensive studies have been conducted to evaluate the riparian plant communities, their size structure, species diversity, distribution, or condition along Stony Creek. Limited field access to private land along the creek prevented a thorough assessment of the types of vegetation, species composition, level of native plant species establishment or disturbance, and extent of non-native weedy plant invasion.

The NDDB data do not include any information on riparian vegetation along Stony Creek (NDDB, 1996). All riparian plant community data for the area is for nearby locations on the Sacramento River. Similarly, the NDDB does not include any occurrences of sensitive plant species associated with Stony Creek riparian vegetation.

Riparian plant community composition is fairly uniform over large areas as compared to other habitat communities. Key information was obtained from interpretations of riparian habitat ecology of other creeks and rivers in California, such as Cache Creek in Yolo County and the Sacramento River in the Butte Basin (Jones and Stokes Assoc). Other creeks have experienced similar human-caused modifications that have resulted in changes in stream channel geomorphology leading to losses of native riparian vegetation and invasion by non-native weedy plants. A comparison of current and historical aerial photographs aided in the evaluation of trends in the Stony Creek riparian vegetation. Because the riparian vegetation habitats are dependent on the hydrology and geomorphological stability of the channel, the information from the geomorphological and hydrologic analysis was critical in evaluating condition and trends in the vegetation.

The community classification used in this Plan is based on limited ground investigation. A crosswalk comparison of the community classification used in this Plan and the vegetation series of Sawyer and Keeler-Wolf (1996) is outlined in Table 2-5.

Table 2-5
Plant Community Series in Lower Stony Creek

Common Name	Scientific Name	Zone	Corresponding Map Unit
mulefat	*Baccharis salicifolia*	Active	Willow Riparian Scrub
sandbar willow	*Salix exigua*	Active	Willow Riparian Scrub
giant reed	*Arundo donax*	Active/Border	Giant Reed
arroyo willow	*Salix lasiolepis*	Border	Willow Riparian Scrub
Fremont cottonwood	*Populus fremontii*	Border	Valley oak/Cottonwood Riparian Woodland
valley oak	*Quercus lobata*	Outer	Valley oak woodland
California annual grassland	(multiple herbaceous species)	Outer	California Annual Grassland

Mapping Methods

The mapping of Stony Creek below Black Butte Dam was performed by directly mapping different habitat types onto acetate overlays on aerial photographs. A set of seven 1:12,000 scale black and white aerial photographs taken in 1992 was used as the photographic base. Because of the poor image quality on the enlarged aerial photographs, further refinement was achieved by magnifying a set of recently flown (January 1996) 1:24,000 scale contact prints under a dissecting microscope. Because of the high resolution of the contact prints, additional information regarding species dominance and landscape position could be incorporated into the 1992 map. Even with the 1:24,000 scale contact prints some signatures were not identifiable without field verification. As a result, several broad categories were developed to encompass those areas with unidentifiable signatures. If field verification of some representative photograph signatures is performed, it will be possible to easily incorporate this information into the existing database.

Because of the wet winter of 1995, some of the features mapped on the 1992 photos are no longer present.

Stony Creek Vegetation Map Unit Descriptions

The eight vegetation map units displayed on Figures 2-18, 2-19, and 2-20 are a simplification of the units used to generate the maps and to calculate acreages. Originally, nearly 20 hierarchical units were used to map habitats along Stony Creek. For display purposes, these 20 units were aggregated into eight broader categories to simplify the visual portrayal of the data. If future ground truthing is performed, more detail can be easily incorporated into the hierarchical system used during mapping.

Three zones within Stony Creek were identified during mapping, the active, border, and outer zone. The eight map units fall exclusively into one of these three zones in Stony Creek, with the exception of the giant reed unit, which may occur either in the active or border zones.

Areas that are adjacent to the channel and do not have any vegetation unit indicated are either agricultural or urban areas.

Active Zone Units. Within this zone, sand and gravel bars are frequently deposited and eroded. Vegetation in the active zone is usually sparse because of frequent, scouring flood flows. The active zone can be thought of as the frequently flooded zone. Most of the active aggregate extraction on Stony Creek takes place within this zone. The extent of the active zone was confirmed by reviewing the 1996 photos for areas of scour and overbank flooding that were not evident on the 1992 photos.

- **Open Water.** The open water unit corresponds to the active channel portion of Stony Creek as interpreted from the 1992 aerial photos. The extent and location of open water varies considerably from year to year. In areas of active aggregate extraction, the active channel was not discernable in the 1992 aerial photos used to produce these maps. In these instances, these areas were mapped as gravel bars.

- **Gravel Bar.** This map unit encompasses vegetated and unvegetated gravel bars within the active zone of Stony Creek. Vegetated sand and gravel bars in Stony Creek typically have less than 20 percent cover of vegetation. Gravel bars with greater than 20 percent cover by vegetation were mapped as either willow riparian scrub or giant reed depending on species dominance. Scattered patches and individuals of giant reed can be found to some extent on nearly all gravel bars downstream from the I-5 bridge, and to a lesser extent upstream of the bridge.

Areas of active aggregate extraction are also within this unit. Because of the lack of a defined channel in these areas, it was not possible to map open water; therefore, these areas were mapped as gravel bars to reflect their appearance.

Areas were mapped in this fashion from approximately RM 7.25 to RM 10.5 and near the I-5 bridge crossing.

- **Giant Reed.** This unit indicates vegetated gravel bars with greater than 20 percent cover of giant reed, a weedy non-native grass. In many instances giant reed forms a monoculture stand with virtually no other types of vegetation present. Significant giant reed stands are present between RM 10.5 and RM 16. Caution should be used when interpreting giant reed occurrence from the vegetation map. Giant reed is not limited to areas indicated on the map. Areas mapped as giant reed represent the most severe infestations that were large enough to be mapped. This invasive species is also found as isolated plants, or patches of plants, throughout all four reaches in a variety of landscape positions.

Border Zone Units. This is the zone that roughly corresponds to the low floodplain of Stony Creek. The substrate in this zone is more stable than in the active zone and is consequently more heavily vegetated. This zone is most extensive in the upper one-third to one-half of the creek. In many instances, this zone is restricted to a thin band between the 1996. Areas that did not show evidence of significant flooding in winter 1995 (as interpreted from January 1996 photos) were attributed as border zone cover types in Figures 2-18, 2-19, and 2-20.

- **Willow Riparian Scrub.** Willow riparian scrub is an early seral, shrub dominated riparian vegetation type. Typical shrub species of willow riparian scrub include arroyo willow, sandbar willow, blackberries, mule fat, tamarix, giant reed, and small individuals of Goodding's willow. The majority of cover in this vegetation type is provided by one, or several, species of willow. This

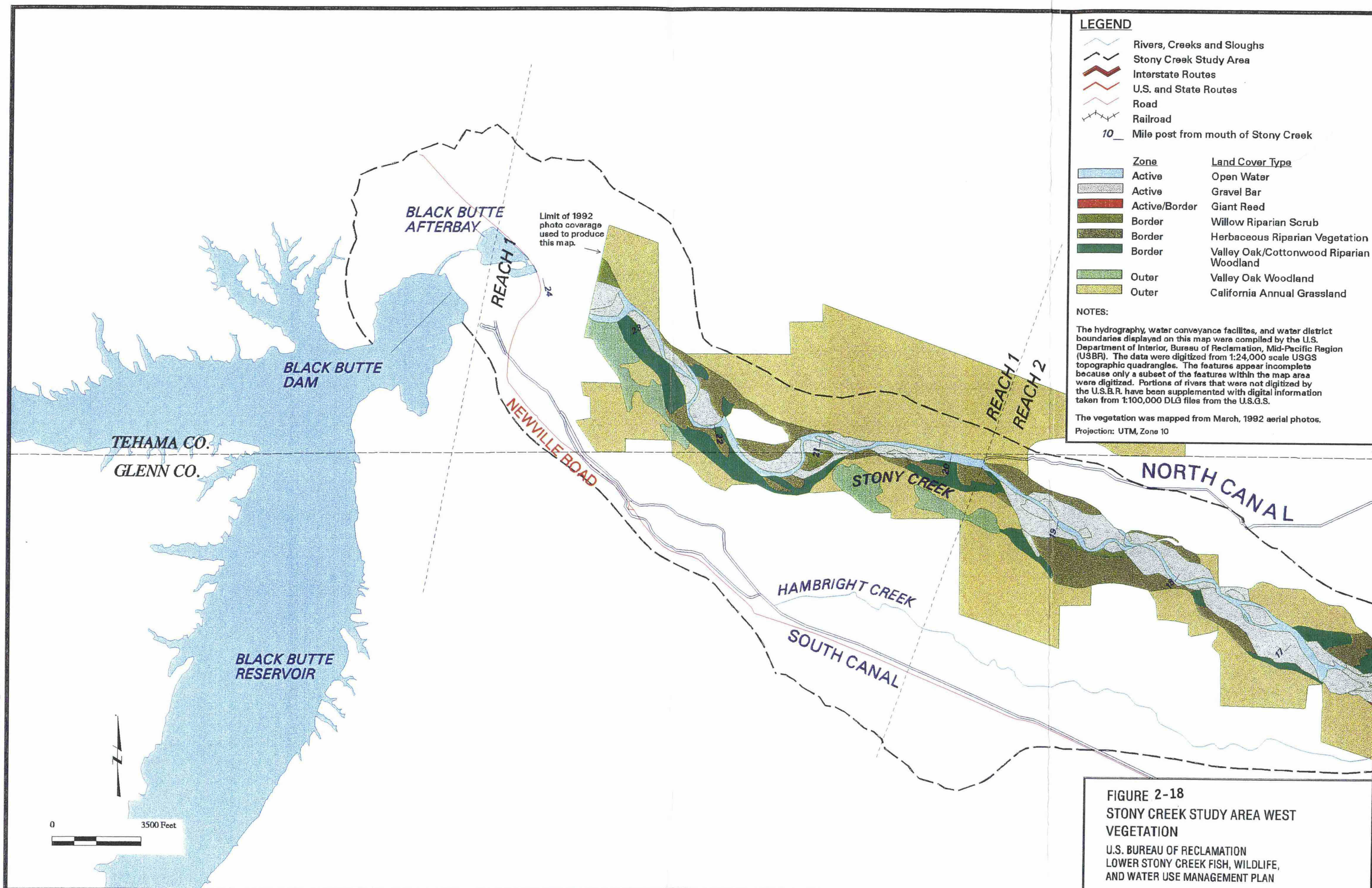


FIGURE 2-18
STONY CREEK STUDY AREA WEST VEGETATION
U.S. BUREAU OF RECLAMATION
LOWER STONY CREEK FISH, WILDLIFE, AND WATER USE MANAGEMENT PLAN

22-214-0024

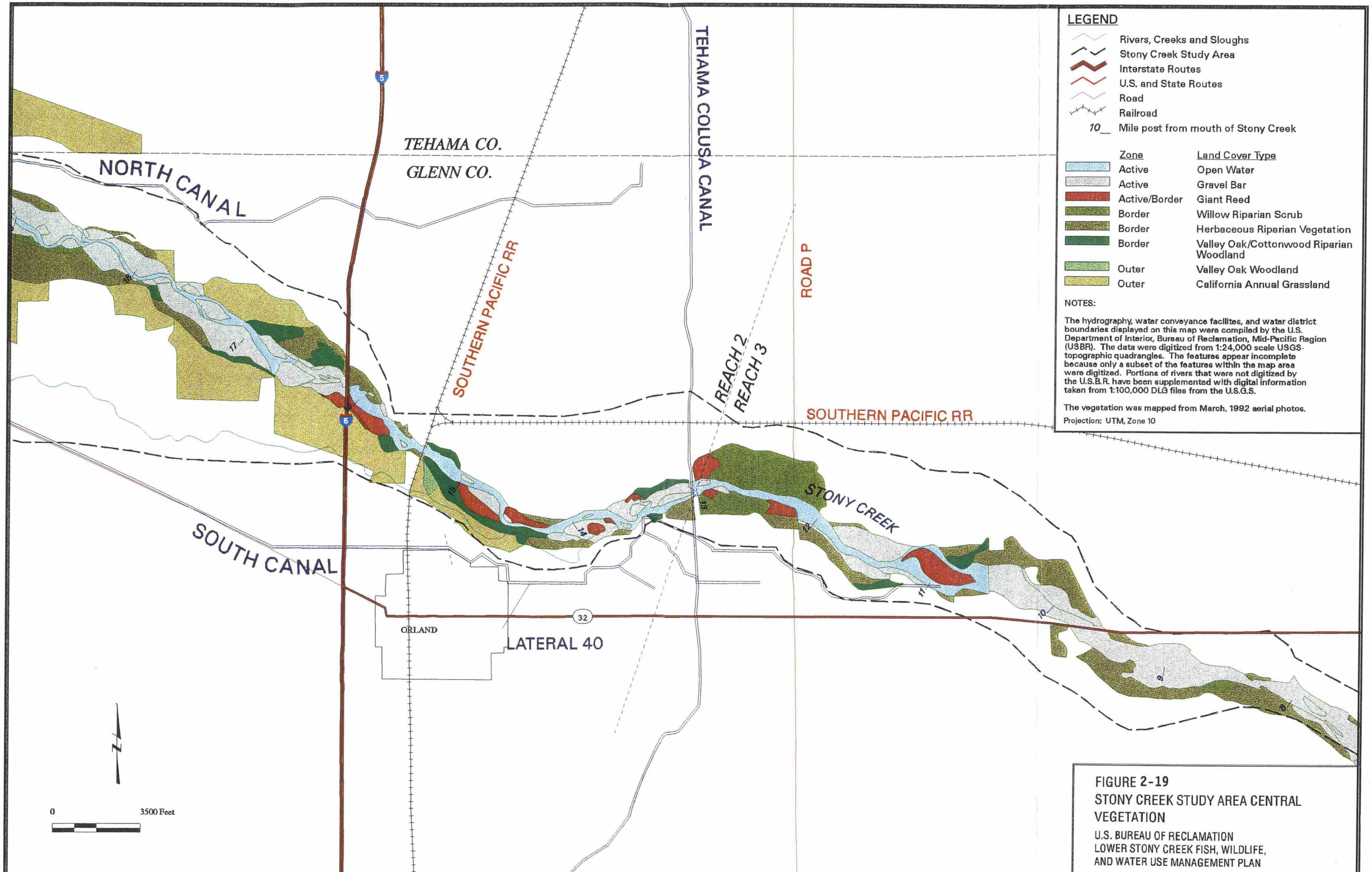


FIGURE 2-19
STONY CREEK STUDY AREA CENTRAL VEGETATION

U.S. BUREAU OF RECLAMATION
LOWER STONY CREEK FISH, WILDLIFE, AND WATER USE MANAGEMENT PLAN

22-214-0025

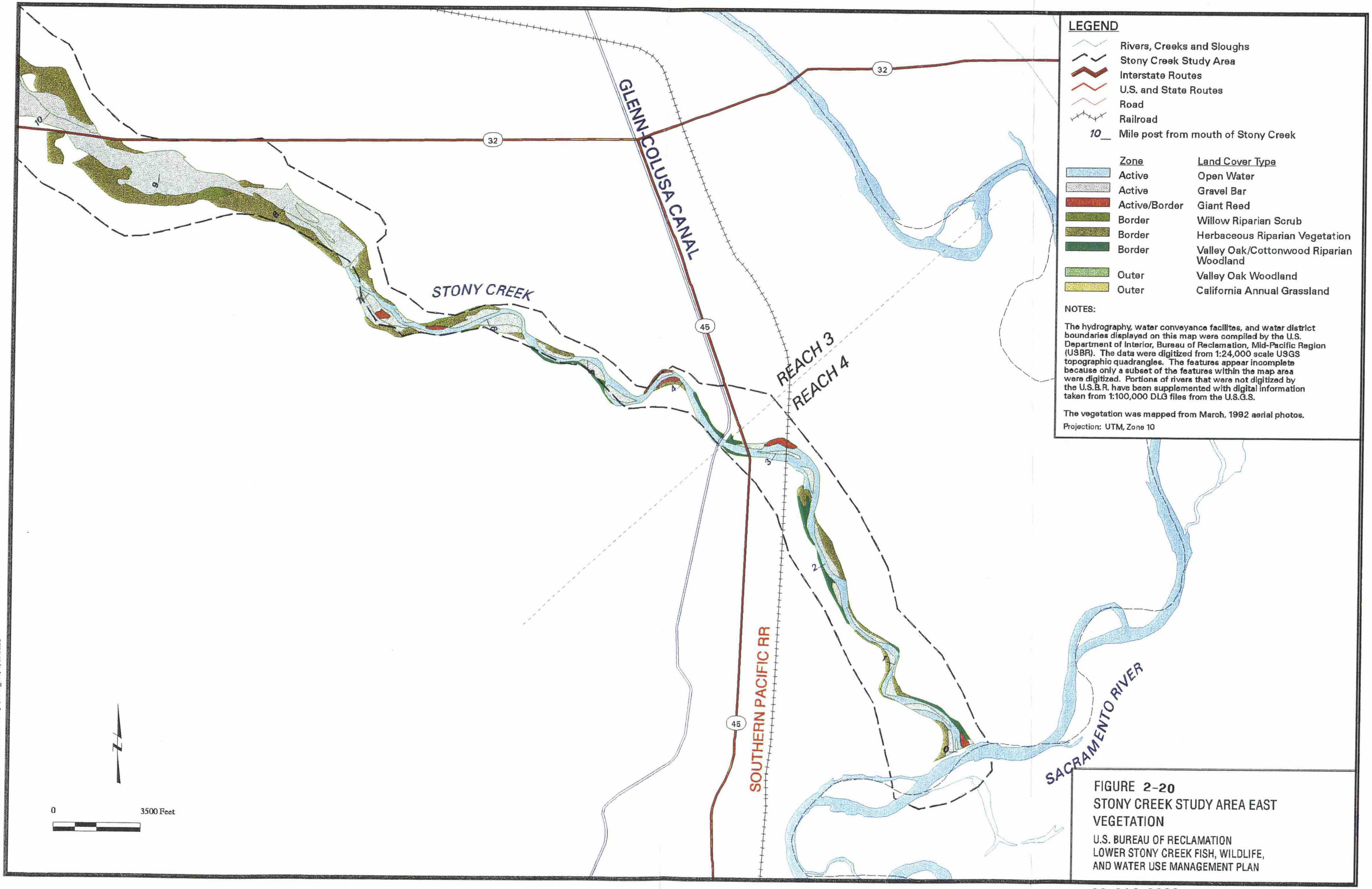


FIGURE 2-20
STONY CREEK STUDY AREA EAST
VEGETATION

U.S. BUREAU OF RECLAMATION
LOWER STONY CREEK FISH, WILDLIFE,
AND WATER USE MANAGEMENT PLAN

22-214-0026

is probably the most under-represented vegetation type on Stony Creek. Most of the willow riparian scrub that once occurred on Stony Creek is likely now dominated by giant reed. The most significant stands of willow riparian scrub are presently found at the old Southern Pacific ponds between RM 12 and RM 13 and in scattered patches in Reach 2. According to the aerial photograph interpretation, the willow riparian scrub at the Southern Pacific ponds is heavily degraded and is being actively invaded by giant reed and tamarix.

- **Valley Oak\Cottonwood Riparian Woodland.** This unit represents the remnant "old growth" riparian forest associated with portions of Stony Creek. Historically, this vegetation type consisted of a closed canopy riparian forest flanking the floodplain of the creek. Currently, this vegetation type is limited to scattered narrow stringers of tall trees. Characteristic trees of this vegetation type may include valley oak, white alder, Fremont cottonwood, Goodding's willow, and an occasional California sycamore. The understory of valley oak/cottonwood riparian woodland is composed of components of willow riparian scrub and herbaceous riparian vegetation. The largest remaining patches of this vegetation type are found in Reaches 1 and 2.

- **Herbaceous Riparian Vegetation.** This unit represents areas within the border zone that are dominated by herbaceous vegetation consisting of forbs and grasses. Common species in this vegetation type may include sweetclovers, star-thistle, thistles, cocklebur, ripgut brome grass, and other opportunistic herbaceous species.

- **Giant Reed.** The giant reed unit in the border zone is identical in structure and composition to the giant reed unit in the active zone. The largest and densest stands of giant reed in the border zone are found in the vicinity of the City of Orland between RM 14 and RM 15.

Outer Zone Units. This is the zone that roughly corresponds to the high floodplain and low terraces of Stony Creek. This zone is composed of annual grassland and valley oak woodland habitats in the upstream reaches (Reaches 1 and 2). In the lower reaches, the outer zone is almost entirely farmland planted as either orchards or row crops.

- **Valley Oak Woodland.** This unit encompasses remnant stands of valley oak woodland on the high floodplain in Reaches 1 and 2. Historically, valley oak woodland occurred within the 100-year floodplain of Stony Creek. Valley oak woodland in the project area consists of an open canopied woodland with scattered individuals or groves of valley oaks in an annual grassland matrix. The majority of valley oak woodland in the project area is savannah-like in structure with widely spaced trees dotting the grassland.

- **California Annual Grassland.** This unit is only present adjacent to Reaches 1 and 2 in areas where soil conditions do not support intensive agriculture. Occasionally, scattered oaks may occur in this vegetation type, however, it is largely treeless. Common species in California annual grassland include soft chess, filaree, blue dicks, and owl's clover. North of Stony Creek in Reaches 1 and 2, the California annual grassland is dotted with vernal pools characteristic of the Red Bluff and Tehama Formations.

Pre-Black Butte Dam Conditions

Prior to the construction of Black Butte Dam in 1963, the upper reaches of Stony Creek supported higher quality riparian vegetation in terms of native species composition and community structure. Riparian vegetation along Stony Creek was present in a more or less continuous band from the Sacramento River upstream into the Coast Ranges in areas where the creek frequently overflowed its banks (USDA, 1909). Aerial photographs from 1956 show a complex riparian forest and savannah extending several miles up Black Butte Valley upstream of the current dam location. The historic riparian corridor, now inundated by the reservoir, averaged 1,500 feet in width.

Tributaries to Stony Creek, such as Salt Creek, Elk Creek, and other minor creeks, contributed fine sediments to Stony Creek that settled downstream along the banks providing good conditions for the establishment and natural regeneration of riparian vegetation. The flow contributions of those tributaries below the dam provided a natural set of water flows that reflected the annual climatic variation of the region. Under the natural flow conditions of creeks on the east side of the North Coast Ranges, the pulses of water flowing down Stony Creek could have provided the conditions under which riparian vegetation often becomes established.

Some species of riparian shrub and tree, such as mule fat and sandbar willow, can become established on banks and near shore gravel bars on a one- to five-year cycle and are considered more opportunistic because of their ability to establish on recently formed gravel bars. Other species, such as white alder and Fremont cottonwood, tend to become established on a longer cycle of 5 to 10 years during the pulses of higher flows (Trush, et al., 1988). Also, these two species often become established on higher elevation zones of gravel bars that have become vegetated and stabilized by mule fat and willows. Increased deposition of fine sediments on the existing gravel bars allows more alders and cottonwoods to become established, further stabilizing the gravel bars and creating a more diverse riparian vegetation with several canopy layers.

A review of the modern soil surveys of Tehama and Glenn Counties provides some idea of the historical extent of riparian vegetation along lower Stony Creek. The Cortina and Orland soil series are well-drained soils derived from recent alluvium. Cortina soils are found along most of the streams west of the Sacramento River while Orland soils are found along Thomes and Stony Creeks (USDA, 1967). These soils flank both sides of Stony Creek from approximately

RM 7.5 to RM 24 varying in width from a few hundred to more than 2,000 feet and historically probably represented the high floodplain. These high floodplains likely supported a mosaic of valley oak woodland and grassland prior to agricultural development. Remnants of this habitat on Cortina and Orland soils can be seen on the south side of Stony Creek between RM 19 and RM 24.

A review of aerial photographs (scale 1:9600) taken on May 11, 1950 reveals a significantly different riparian system than exists today. Riparian conditions prior to Black Butte Dam are summarized by hydrological reach in the following sections (See Figure 2-12 for reach boundaries, page A-2-23).

Reach 4. In 1950, Reach 4 was a sparsely vegetated system with a few mature riparian trees flanking the channel abutting the adjacent farmland. In-channel vegetation was limited to scattered shrubs colonizing the gravel bars and the low flow portions of the channel. The confluence of Stony Creek and the Sacramento River was essentially free of woody vegetation.

Reach 3. Reach 3 was considerably more vegetated than Reach 4; however, the vegetation was still sparsely distributed. Riparian vegetation appears to consist primarily of shrubs with some larger trees on the outer banks. The channel floodplain was covered by deposits of bare gravel. Where woody vegetation was present it formed a dense cover that appeared to have a diverse structure and composition. The most significant stand (approximately 200 acres) of riparian vegetation in this reach existed at the Southern Pacific railroad gravel mine downstream of the future site of the CHO at the boundary of Reaches 2 and 3 (between RM 12 and RM 13). This area appears to consist primarily of even-aged, closed canopy stands of shrubs and tall trees flanking both sides of the creek and abandoned mining pits. Natural scour and reburial, coupled with droughty conditions during the growing season, appeared to support small stands of riparian vegetation in floodplain margins where finer soils provided greater moisture retention.

Reach 2. In 1950, natural riparian vegetation on lower Stony Creek reached its greatest extent in this reach. Well established stands of mature trees dominated riparian vegetation and were abundant within the floodplain of the creek. The largest patches of vegetation were found downstream of the Southern Pacific railroad bridge and north of the City of Orland (RM 14 to RM 16). It appeared that many mature riparian trees were within the floodplain in this area forming a more or less continuous canopy exceeding 60 acres in extent. On the basis of the age and abundance of vegetation, it appeared that the single-thread channel location in this area was fairly stable at this time favoring the establishment of riparian vegetation. Up to 65 percent of the floodplain in this area was covered by riparian vegetation.

Upstream of the Southern Pacific railroad bridge, the channel was braided, and consequently supported less mature vegetation in the floodplain. In this braided system, some channels do have narrow strips of mature riparian vegetation; however, less than 10 percent of the overall floodplain has riparian vegetation.

Reach 1. Aerial photograph coverage for Reach 1 in 1950 was limited; however, riparian vegetation conditions in this reach appeared to be similar to those of the upstream portion of Reach 2. The May 11, 1950, aerial photo coverage starts where the North canal exits Stony Creek and runs upstream along the centerline of the creek to Black Butte Dam for approximately 16,000 lineal feet.

Giant Reed in 1950. Giant reed was largely absent along lower Stony Creek according to the interpretation of the 1950 aerial photographs. Giant reed produces a readily identifiable signature on aerial photographs and is difficult to overlook except where it is obscured by other vegetation. Close inspection of the 1950 aerial photographs revealed only a few individuals of giant reed in an area that is now the most significant monoculture stand on the creek (between RM 14.5 and RM 15.0). It is possible that in 1950 giant reed was already a component of the understory of the riparian forest on the creek; however, it is not possible to determine this from the aerial photographs.

Post-Black Butte Dam Conditions

The establishment of Black Butte Dam caused four primary modifications of the Stony Creek system that affected its natural vegetation:

- Removal of the fine sediments and bedload contributed from the tributaries that formerly were carried downstream
- Loss of the natural seasonal levels and pulses of water flows downstream
- Fine sediment and gravel loss through erosion
- Post-dam hydrologic records show a distinct loss of spring flows

Natural spring flows peak in early spring as native plants begin seed dispersal and declines gradually from March through June, providing moist open areas for seed germination. Controlled releases increase the stage into spring and early summer, affecting seed germination success.

Black Butte Dam intercepts the flows from the remaining major tributaries from the interior North Coast Ranges and prevents sediment from contributing to Stony Creek prior to entering the Sacramento River. This modification probably significantly reduced the fine sediment loads that contributed to the establishment of gravel bars that replaced those lost as a result of natural erosion. Further, the winter and spring high flows that develop the gravel bar elevations and provide suitable habitat for cottonwood and alder colonization were decreased or removed. With fewer channel bars having fine sediment, the replacement of riparian vegetation below Black Butte Dam would be affected, including:

- Fewer bars become established to allow establishment of early succession vegetation such as mule fat and willows

- Loss of fines to build the floodplain elevations of the gravel bars to allow establishment of cottonwoods and alders

- Channel instability that scours the gravel bars preventing the establishment of later successional species such as cottonwood

- Reduction of seedling and sapling colonization excluding exotic species, caused by premature inundation or dewatering of bars

The loss of riparian vegetation as a result of water removal from water supply dams has been observed in coastal rivers, primarily as seen in the Carmel River (Kondolf and Curry, 1981). It is useful to observe that ecophysiological and population studies on riparian plant species that have been exposed to water diversions have found that established mature trees can adapt to reduced water flows, but seedlings do not adapt as readily and decreased establishment has been observed (Smith, et al., 1988). These data indicate that the establishment and maintenance of riparian vegetation is directly related to amounts and timing of seasonal water supplies.

On the basis of interpretation of 1965 aerial photographs, giant reed had begun to spread throughout the Stony Creek system downstream of the new I-5 bridge. Giant reed was seen colonizing disturbed areas that supported woody riparian vegetation in the 1950 photographs.

Current Extent and Quality of Riparian Habitats. Riparian vegetation along Stony Creek below Black Butte Dam extends intermittently along the creek from just below the south side outlet to the Sacramento River. Preliminary information based on documents and field observations determined that four riparian plant community series occur within the creek active zone and bank. In addition, two community series occur outside in the outer floodplain. The giant reed series and California annual grassland series were the only series that include a major non-native plant species component. In Table 2-6, the vegetation series are divided into zones based on their occurrence within Stony Creek, such as the active zone that is within the active channel of the creek, the border zone which includes the banks of the channel, and the outer zone which is the upper terraces of the floodplain. Acreages of riparian habitats on lower Stony Creek as mapped from 1992 aerial photographs are provided in Table 2-6.

The extent of any one series is not completely known because of limited access along Stony Creek during the reconnaissance survey. Aerial photograph interpretation with on-ground investigation will improve the understanding of the extent and types of series currently present. The observations that have been made indicate that the majority of extensive, higher quality riparian series occur above gravel mining and canal diversion areas. Field observations and cursory aerial photograph analysis determined that some relatively recent gravel bars had formed, such as one just above the Northside canal, where riparian plants appearing to be mule fat and sandbar willow had become densely established on a gravel bar within the last two to four years. Also, just below Black Butte Dam a shoreline gravel bar supported a dense growth of 5- to 15-year old riparian vegetation including arroyo and sandbar willow, and mule fat.

Riparian areas that were observed in the field that contained more mature vegetation and greater diversity of species, including white alder and Fremont cottonwood, appeared to be uncommon. Those specific areas observed were not extensive, and the taller, mature trees were restricted to narrow creek banks that were in a state of erosion. Further site-specific field observations of the larger denser riparian areas would be required to determine if white alder and Fremont cottonwood existed in the high-quality sites and if they are becoming established in those sites.

Table 2-6
1992 Stony Creek Vegetation by Reach

Reach	Zone	Unit	Acreage
1	Active	Open Water	99
1	Active	Gravel Bar	189
1	Border	Willow Riparian Scrub	21
1	Border	Herbaceous Riparian	179
1	Border	Valley Oak/Cottonwood Riparian Woodland	196
1	Outer	Valley Oak Woodland	188
1	Outer	California Annual Grassland	1,438
Total			**2,309**
2	Outer	California Annual Grassland	1,336
2	Active	Gravel Bar	506
2	Active/Border	Giant Reed	84
2	Border	Willow Riparian Scrub	13
2	Border	Herbaceous Riparian Scrub	332
2	Border	Valley Oak/Cottonwood Riparian Woodland	189
2	Outer	Valley Oak Woodland	29
2	Active	Open Water	206
Total			**2,696**
3	Active	Open Water	225
3	Active	Gravel Bar	568

Table 2-6 1992 Stony Creek Vegetation by Reach			
Reach	**Zone**	**Unit**	**Acreage**
3	Active/Border	Giant Reed	79
3	Border	Willow Riparian Scrub	225
3	Border	Herbaceous Riparian	398
3	Border	Valley Oak/Cottonwood Riparian Woodland	42
Total			**1,536**
4	Active	Open Water	110
4	Active	Gravel Bar	56
4	Active/Border	Giant Reed	10
4	Border	Herbaceous Riparian	44
4	Border	Valley Oak/Cottonwood Riparian Woodland	33
Total			**253**

Giant reed has become well established along most of lower Stony Creek from RM 0 to approximately RM 17. It has become established as dense thickets in the areas where gravel mining activities create a disturbance threshold that exceeds the maintenance and regeneration capabilities of the native riparian vegetation. The fixed release of summer flows where historically no flows existed in the summer months below the dam, may also promote the establishment of giant reed. Displacement of vegetated bars by unstable channel reaches favors giant reed over native shrubs because it spreads easily from stem and root fragments or entire plants transport downstream. Giant reed has entered the mature riparian vegetation such as Fremont cottonwood, arroyo willow, and white alder stands that persist along the eroding banks. It has been found that giant reed can disturb the normal regeneration cycles of native riparian species and will ultimately form a monoculture (Rieger and Kreager, 1988).

The overall habitat quality of the riparian plant communities observed for lower Stony Creek is low with respect to the species composition, extent, and level of reestablishment and stand maintenance. However, preliminary aerial photograph analysis indicates there are some areas that may have moderate- to high-quality riparian habitat. The higher-quality sites are mostly above the CHO, with the lowest quality sites in the vicinity of the gravel mining operations.

Aerial Photograph Interpretation of Current Vegetation. Currently, riparian habitats along lower Stony Creek exist as scattered patches of shrubs, typically well removed from the active channel. Much of the riparian habitat is now severely infested with invasive non-native species such as giant reed and tamarix. The invasion of non-native species is more prevalent downstream of the I-5 bridge. In Reaches 1 and 2, mature riparian vegetation appears to be restricted to the outer edges of the bank full channel. The frequent migration prohibits the successful establishment of vegetation by either removing the nascent vegetation through scouring or through the isolation of the vegetation from an adequate adjacent water source.

Trends in Quality and Extent of Riparian Vegetation. In reviewing aerial photographs from 1950 to the present, several trends in riparian vegetation on Stony Creek are evident. Since 1950, the number of mature riparian trees in all riparian areas throughout all four reaches has noticeably reduced. The controlled release hydrology of lower Stony Creek, and the temporary berm at the GCID Main Canal (which is scheduled to be discontinued in 1999) and TCC during the growing season, cause changes in water elevation and stage duration that are out of sync with the seed release and growth cycle of native riparian trees and shrubs. The abundance of giant reed and tamarix and their superior adaptation to disturbances such as scour and inundation during the growing season is limiting the ability of desirable native riparian vegetation to establish.

In reviewing several successive years of historical photographs, the spread of giant reed is particularly noticeable. Areas that in 1950 consisted of mature riparian vegetation now exist as monocultures of giant reed. A former gravel bar (RM 14.5 to RM 15.0) illustrates this type of conversion of riparian forest to giant reed monoculture particularly well. In the 1950 aerial photographs, the site consisted of multi-layered riparian forest with only a few individuals of giant reed in the vicinity. In 1965, giant reed was noticeably present at the same site with over 30 individuals occupying more than an acre. By 1968, giant reed had expanded to occupy over two acres on the fringes of the forest. In 1977, over 10 acres were solid giant reed; however, some riparian forest was still present. By 1985, nearly 17 acres were occupied by giant reed with only some riparian trees remaining on the bar. At present, this site consists of nearly 17 acres of pure giant reed without any remaining riparian trees or shrubs. The apparent absence of cottonwood seedlings, even after a favorably wet year such as 1995, indicates that this once abundant species will decline in extent as older trees die of old age or are lost from bank migration.

General Observations of Changes to Riparian Vegetation on Stony Creek, 1950 to 1996:

- The primary channel appears to have incised significantly in Reaches 1 through 3 since 1950 according to the comparison of the heights of cut bank shadow lines between the 1992 and 1996 aerial photographs.

- The lateral migration of the channel over time appears to have "erased" much of the mature riparian vegetation in Reach 2, and to a lesser extent in Reach 3. This was not observed in Reach 4 because so little vegetation existed in this reach in 1950. Because aerial photograph coverage for Reach 1 in 1950 is limited, it is not possible to draw a conclusion regarding channel migration and vegetation losses in this area.

- Giant reed has made dramatic progress throughout the system since 1950, with the greatest increase in its distribution beginning in approximately 1965 and continuing to the present.

- The Southern Pacific ponds created a large amount (over 200 acres) of good quality riparian, marshland, and pond habitat in the 1940's and 1950's. This area now seems considerably drier than in 1950 and is also being actively invaded by giant reed. This 200-acre site is a prime example of accidental habitat creation and subsequent destruction caused by changes in land use and water management.

G. Fisheries Resources and Habitat

This section presents an account of the existing fisheries in the study area, a summary of life history characteristics of Stony Creek fish, and habitat requirements with existing habitat conditions for Stony Creek fish species. This section is provided as information of the fishery resources which may be present in the creek. An envisioned enhancement concept on Stony Creek is also presented.

Existing Fisheries Resources

Three types of native fish assemblages use lower Stony Creek. These include larger migratory species, smaller resident non-migratory species, and salmonid species. The extent of native fish presence is unknown and the following is provided as information. Fish species known to inhabit the study area are shown in Table 2-7. Fish found in Stony Creek prior to development are listed in Table 2-7 as native. Stony Creek below Black Butte Dam extends approximately 24 miles before its confluence with the Sacramento River (study area). The majority of the adjacent riparian corridor of the creek is privately owned and as such fishing access is restricted. The stream bed of the study area has a low gradient and alternates between a meandering single channel and a braided channel. The study area falls within the Sacramento Fish Province, as defined by McGinnis (1984), and the Squawfish-Sucker-Hardhead Zone, as defined by Moyle (1976). The elevation near Black Butte Dam and Afterbay is approximately 390 feet above sea level. Water temperatures in the study area become warm in the summer months, providing suitable habitat conditions for many native and introduced warm-water fish species. Flows in Stony Creek can diminish to extremely low levels during the summer months resulting in segmented stream habitats downstream of the Northside Diversion Dam. During periods of suitable flow and water temperatures, Stony Creek is also seasonally used by salmonids.

Table 2-7
Fish Species Reported In The Stony Creek Watershed

Common Name	Scientific Name	Native/ Exotic (N/E)	Above Black Butte Dam	Below Black Butte Dam	Source
Chinook Salmon	*Oncorhynchus tshawytscha*	N		X	a,c,d
Steelhead Trout	*Oncorhynchus mykiss*	N		X	d
Rainbow Trout	*Oncorhynchus mykiss*	N	X		a,b,c
Sacramento Sucker	*Catostomus occidentalis*	N		X	a,b
Common Carp	*Cyprinus carpio*	E	X	X	a,b,c
Sacramento Squawfish	*Ptychocheilus grandis*	N		X	a,b
California Roach	*Hesperoleucus symmetricus*	N		X	a.b
Speckled Dace	*Rhinichthys osculus*	N		X	a,b
Brown Bullhead	*Ictalurus nebulosus*	E		X	a
Mosquitofish	*Gambusia affinis*	E		X	a,b
Largemouth Bass	*Micropterus salmoides*	E	X	X	a,b,c
Green Sunfish	*Lepomis cyanellus*	E	X	X	a,b,c
Bluegill Sunfish	*Lepomis marcochirus*	E	X	X	a,b,c
Threespine Stickleback	*Gasterosteus aculeatus*	N		X	a,b
Bigscale Logperch	*Percina macrolepida*	E		X	b
Riffle Sculpin	*Cottus gulosus*	N		X	b
Prickley Sculpin	*Cottus asper*	N		X	b
Hitch	*Lavinia exilicauda*	N		X	b
Golden Shiner	*Notemigonus crysoleucas*	E		X	b
Hardhead	*Mylopharodon conocephalus*	N	X	X	b,c
White Crappie	*Pomoxis annularis*	E	X	X	b,c
Black Crappie	*Pomoxis nigromaculatus*	E	X		c
Striped Bass	*Morone saxatalis*	E	X		c
Smallmouth Bass	*Micropterus dolomieu*	E	X	X	b,c
Channel Catfish	*Ictalurus punctatus*	E	X	X	b,c
White Catfish	*Ameiurus catus*	E	X	X	b,c
Black Bullhead	*Ameiurus melas*	E		X	b
Tule Perch	*Hysterocarpus traski*	N		X	b
Warmouth	*Lepomis gulosus*	E		X	b
Threadfin Shad	*Dorosoma petenese*	E	X	X	b,c
Redear Sunfish	*Lepomis microlophus*	E	X		c
Lampery	*Lampetra spp.*	N		X	b

Sources:
a. Puckett, 1969.
b. Brown, 1995.
c. DFG (unpublished files Region II).
d. Maslin and McKinney, 1994.

Approximate spawning periods of the species found in the study area are shown in Table 2-8 (Moyle, 1976). The majority of both native and introduced (exotic) species spawn in the spring and early summer months. Each of the Stony Creek fish assemblages have specific life history requirements and as such use habitats in Stony Creek differently.

Table 2-8
Spawning Period in California for Fishes
Collected from Lower Stony Creek, 1994

Common Name	Scientific Name	Spawning Period											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Late fall-run chinook salmon	*Oncorhynchus tshawytscha*	*	*	*									
Steelhead trout	*Oncorhynchus mykiss*	*	*	*									
Bigscale logperch	*Percina macrolepida*		*?										
Riffle sculpin	*Cottus gulosus*		*	*	*								
Prickly sculpin	*Cottus asper*		*	*	*	*	*						
Sacramento sucker	*Catostomus occidentalis*		*	*	*	*	*						
California roach	*Hesperoleucus symmetricus*			*	*	*	*						
Hitch	*Lavinia exilicauda*			*	*	*	*	*					
Golden shiner	*Notemigonus crysoleucas*			*	*	*	*	*	*				
Sacramento squawfish	*Ptychocheilus grandis*				*	*							
Hardhead	*Mylopharodon conocephalus*				*	*							
White crappie	*Pomoxis annularis*				*	*	*						
Largemouth bass	*Micropterus salmoides*				*	*	*						
Smallmouth bass	*Micropterus dolomieu*				*	*	*						
Channel catfish	*Ictalurus punctatus*				*	*	*						
Common carp	*Cyprinus carpio*				*	*	*	*					
Threespine stickleback	*Gasterosteus aculeatus*				*	*	*	*					
Lamprey larva	*Lampetra species*				*	*	*	*					
Bluegill	*Lepomis marcochirus*				*	*	*	*	*				
Mosquitofish	*Gambusia affinis*				*	*	*	*	*	*			
Tule perch	*Hysterocarpus traski*					*	*						
Warmouth	*Lepomis gulosus*					*	*	*					
Green sunfish	*Lepomis cyanellus*					*	*	*	*				
Threadfin shad	*Dorosoma petenese*					*	*	*	*	*			
Speckled dace	*Rhinichthys osculus*					*	*	*	*	*			
White catfish	*Ameiurus catus*						*	*					
Black bullhead	*Ameiurus melas*						*	*					
Fall-run chinook salmon	*Oncorhynchus tshawytscha*										*	*	*

Adult non-salmonid migratory species. These species such as Sacramento sucker, hardhead, Sacramento squawfish, and hitch, migrate out of the Sacramento River in late winter through spring to spawn in lower Stony Creek. Juveniles of these species rear and remain in Stony Creek for up to several years. To flourish, these species require free movement up and downstream within lower Stony Creek (Maslin, 1995(b)). The abundance of these species in lower Stony Creek is unknown.

Smaller non-migratory native species. These species found in lower Stony Creek include the speckled dace, Tule perch, California roach, and riffle sculpin. These species maintain populations entirely within Stony Creek. Both adult and juveniles of these resident species inhabit pools and riffles that become segmented at times as a result of seasonal low flows. In addition to native non-migratory fish species, introduced species including black bass and smallmouth bass, sunfish, catfish, crappie, and minnows reside in lower Stony Creek. The exotic species known to inhabit Stony Creek is shown in Table 2-7. Many of these species have been transported from Black Butte Reservoir into Stony Creek and have become established in the afterbay and downstream reaches (Brown, 1995). A sport fishery for crappie, catfish, and striped bass exists in the afterbay (DFG, Region II, unpublished files).

Bass and sunfish are well established in ponds along lower Stony Creek, but fishing pressure is light because of limited angler access (USFWS, 1975). The abundance of these species is unknown at the present time.

Salmonids-History. Migratory chinook salmon and steelhead trout have been known to use Stony Creek, although documentation on spawning activities is limited and conflicting, and exact locations are not always provided. Historically, spring-run chinook salmon were found in the Stony Creek watershed above the present dams and reservoirs, and Stony Creek was considered "a very good salmon stream" prior to the placement of irrigation dams (Clark, 1929). In 1844 General John Bidwell's party of explorers camped by Stony Creek (formerly Capay Creek) on Pomo Indian land, near present day Stonyford. The Pomo Indians of the area "lived mostly on acorns, grasshoppers and on the salmon, which were abundant in Stony Creek." (Weldon, 1989). "Kroeber (1932) ...stated that salmon...ran up Stony Creek through Wintun as far as Salt Pomo territory. The downstream (eastern) border of the latter has been placed at the confluence of Stony Creek and Little Stony Creek, approximately 5 miles below Stonyford (McLendon and Oswalt 1978), which would have been the upstream range of the salmon. Stony Creek ...occasionally supported fall-run salmon during the period 1940-1959 in years of early and heavy rains (Fry 1961)." (Yoshiyama et al, 1995). Puckett (1969) stated that at the time of his investigations there had been no recent reports of a salmon run in Stony Creek. Only sporadic use of Stony Creek below Northside Diversion Dam for fall-run chinook spawning has occurred in recent years (Reavis, 1983). The presence of salmonids in lower Stony Creek has been debated. Long-time local landowners have claimed to have never seen salmon in lower Stony Creek in their lifetime.

Salmonids- Recent Status. Salmonids have been known to use lower Stony Creek habitats predominantly by rearing of non-natal juveniles from other spawning areas (chinook salmon and steelhead), and intermittent spawning and rearing of natal juveniles (chinook salmon). The existing opportunistic use by salmonids is currently limited both spatially and temporally, due to their life cycle, water temperature and habitat (Vogel and Marine, 1991).

Salmonid Spawning. Reported observations of adult salmonids by DFG Warden Harrison include January 26, 1973 (an above average storage and outflow year), "salmon reported in Stony Creek at the North Diversion," and January 30, 1973, "steelhead reported at the North Diversion" (DFG Region II, Rancho Cordova, unpublished files). Observations in April 1975 (an above average storage and outflow year) by Warden Harrison noted "two schools of (3-inch) chinook salmon smolts in riffles within Stony Creek" and "larger numbers in April before freshets" (DFG Region II, Rancho Cordova, unpublished files). The specific location within Stony Creek of these observations was not presented in the memorandum to Patrol Inspector C. Matthews dated April 28, 1975. It is unknown whether these fish spawned in Stony Creek or were non-natal rearing juveniles from the Sacramento River.

In spawning surveys conducted in weekly intervals from December 12, 1981, through February 6, 1982, by the DFG, "the estimated spawning population was 393 chinook salmon based on a 9.7% recovery rate. Few fish were seen after early January" (Reavis, 1983). This survey was conducted during a wet water year (above average storage and outflow) on Stony Creek between the confluence of the Sacramento River and the Northside Diversion Dam. The distribution of chinook salmon redds, live fish and carcasses was described in four reaches. Of the 47 observed, 35 redds were located in the reach from Interstate 5 to the North Diversion Dam, with 28 of the observed 35 live fish and 29 of the 36 observed carcasses. In the reach between Highway 32 to Interstate 5, 6 of the 47 redds, 6 of the 35 live fish, and 5 of the 36 carcasses were observed. In the reach from Highway 45 to Highway 32, 6 of the 47 redds, 1 of the 35 live fish and, 2 of the 36 carcasses were observed. No redds, live fish, or carcasses were observed in the reach from the mouth of Stony Creek to Highway 45 (DFG, 1983).

Seining surveys for juvenile chinook salmon conducted in Stony Creek during 1980 through 1982 found the majority of juvenile salmon within approximately 3 miles of the confluence with the Sacramento River. Juvenile chinook salmon were collected as far upstream as approximately 13 miles from the Sacramento River confluence during the survey conducted on February 24, 1981; a wet year. It has not been established whether these juveniles were non-natal or emigrating, although the study is described as being conducted during the 1980, 1981, and 1982 "emigration" (DFG, 1983).

Other spawning surveys conducted in water years 1958 (wet), 1968 (dry), and 1994 (dry) failed to record spawning chinook salmon in Stony Creek (Reclamation, 1995(a)).

From this record, it can be stated that Stony Creek has contained inconsistent periodic fall-run chinook salmon spawning and natal rearing from the Sacramento River system during early wet water years. Lower Stony Creek does not currently support a sustained annual cycle of salmonid production.

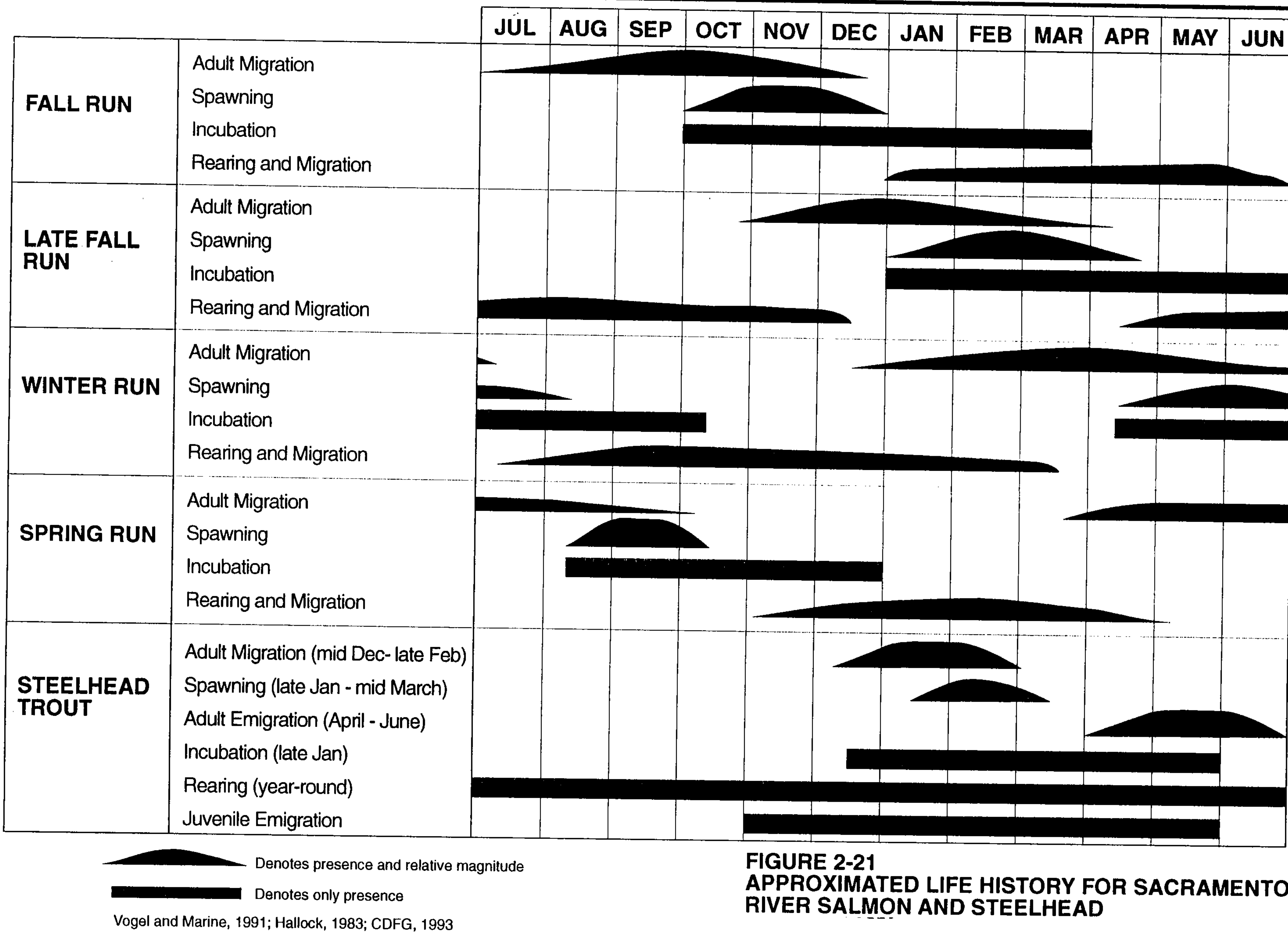


FIGURE 2-21
APPROXIMATED LIFE HISTORY FOR SACRAMENTO RIVER SALMON AND STEELHEAD

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Non-natal juveniles. Maslin and McKinney (1994) collected fall- and spring-run chinook and steelhead juveniles and Brown (1995) collected fall-run chinook salmon juveniles in the lower 3 miles of Stony Creek below the GCID Main Canal in April 1994. Juveniles meeting DFG's size criteria for fall-, spring-, and winter-run chinook salmon were collected in DFG's 1980-1982 seining surveys in Stony Creek below Black Butte Dam (Reavis, 1993). These collections primarily represent non-natal salmonid juveniles spawned elsewhere in the Sacramento River system and indicate the importance of sections of lower Stony Creek as a rearing area for these species (Maslin and McKinney (1994) and Brown (1995)).

Stony Creek Fish Species collected in 1997. A report was published by DFG on April 29, 1997 (Loggins, et al), summarizing stranded fish removal efforts in the vicinity of the GCID Main Canal on lower Stony Creek, between February 26, 1997 and March 29, 1997. It was observed that fish were stranded in several isolated pools. Flows beneath the Highway 45 bridge were estimated to be less than 50 cfs and it was determined that the flow was not contiguous with the Sacramento River, therefore fish were removed from several sample sites and transported, after being acclimated, to the Sacramento River. The largest number of fish collected were 291 fall-run chinook salmon, 53 steelhead, 49 Sacramento squawfish, and 48 Sacramento suckers. In lesser amounts, other collected fish species included spring-run chinook salmon, winter-run chinook salmon, hardhead, hitch, prickly sculpin, gambusia, green sunfish, bluegill, small mouth bass, white catfish and channel catfish.

Life History Characteristics of Stony Creek Fish

Resident and Non-Salmonid Migratory Native Species. Stony Creek's resident native fish species have adapted to California's Central Valley summer conditions of low flow, warm water temperatures and winter high flow, cool water temperatures. While tolerant to the harsh summer habitat conditions, native resident fish in Stony Creek require at least some minimum flow to ensure adequate oxygen and water quality to support continuing populations. Streamflow conditions in lower Stony Creek (crossing its alluvial fan) are reduced to subsurface flows between pools during late summer in many years. While these resident fish populations can survive conditions of segmented habitat, they are more successful and thrive when their movements within the stream are unrestricted.

Salmonids. Figure 2-21 provides a summary of the life history characteristics of Sacramento River hinook salmon (Vogel and Marine, 1991) and steelhead trout (DFG, 1993; Hallock, 1989).

Fall-run. As Figure 2-21 indicates, peak upstream migration of adult fall-run chinook salmon occurs in early October at Red Bluff. Fall-run chinook salmon migrate into tributaries as well as seeking spawning areas in the mainstem Sacramento River. It is estimated that 95% of salmonid spawning occurs in the mainstem of the Sacramento River. Peak spawning for fall-run chinook salmon occurs in late October to early December. Egg incubation and fry rearing occurs in the winter months following spawning. Peak emigration of juvenile fall-run chinook salmon occurs in the spring months, primarily March through May.

Table 2-9

Habitat Requirements for Representative Native Fishes of Stony Creek (Moyle, 1976)

Common Name	Scientific name	Temperature requirements	Preferred Spawning Habitat; Substrate	Adult Food Preference	Preferred Habitat Types	Notes or Comments
Hitch	*Lavinia exilecauda*	Spawning at 57-64 deg. F (14-18 deg. C)	Shallow pools/riffles, low velocity; fine-medium clean gravel	Phytoplankton, planktonic crustaceans, aquatic insects	Sandy bottom pools with moderate vegetation	Have a deep, laterally compressed body-suitable for quiet water
California Roach	*Hesperoleucus symmetricus*	Can tolerate up to 86-95 deg. F.(30-35 deg. C.)	Shallow pools low velocity; small rocks	Filamentous algae, aquatic insects, crustaceans	Rocky bottomed pools	Very tolerant of low flows, high temperatures and organic pollution
Hardhead	*Mylopharodon conocephalus*	Warm water conditons typical of low to mid elevation streams	Low velocity riffles with gravel, (thought to be mass spawners)	Filimentous algae, small invertebrates, aquatic plants	Clear warm streams with large deep, rock and sandy bottom pools;	Found in undisturbed sections of larger streams; move into smaller tributaries to spawn
Sacramento Squawfish	*Ptychocheilus grandis*	Do not flourish in waters less than 59 deg. F. (15 deg. C.); spawn above 57 deg. F.	Gravel riffles, congregate to spawn over rocky-gravely areas	Highly predatory on fishes and crayfish	Clear well shaded sand-rock bottomed pools with rocks/logs	Sedentary habits, often remaining in one pool for long intervals; also known to migrate up-, downstream to spawn, feed
Speckled Dace	*Rhinichthys osculus*	Highly tolerant of temperature up to 91 deg. F (33 deg. C.)	Shallow riffle edges with clean gravel or small rocks	Bottom browsers on small invertebrates, crustaceans	Bottom dwellers of cool rocky bottom riffles	Are known to be nocturnally active, hide between rocks during day
Sacramento Sucker	*Catostomus occidentalis*	Found in wide temperature range, most abundant in cool streams-pools	Congregate over clean gravel	Filamentous algae, detritus, invertebrates associated with the bottom	Feed in small groups at head of pools or edge beds of aquatic vegetation; deep pools	Typically spend 2-3 years in natal stream before migrating into larger rivers with high water (in the fall)

Late fall-run. Peak adult migration and spawning for late-fall-run chinook salmon is December - January and February - March, respectively. Late-fall-run chinook salmon tend to prefer spawning in the northern end of the mainstem Sacramento River and in some northern tributaries. Late- fall-run chinook salmon juveniles remain within the Sacramento River system longer before emigrating than fall-run chinook salmon. Juvenile late-fall-run chinook salmon emigrate from late April through mid-December.

Winter-run. Adult winter run chinook salmon migrate primarily late February to early May and spawn May-July. Juveniles emigrate from rearing areas predominantly from September to January. Winter-run chinook salmon have been listed as an endangered species.

Spring-run. Adult spring-run chinook salmon migrate into tributaries of the Sacramento River in the spring, primarily May and June, and remain in cold holding headwaters throughout the summer. Spring-run chinook salmon spawn in late August and September with juveniles emigrating from these rearing areas from December through April the following year.

Steelhead. Steelhead trout migrate into the upper Sacramento River from July through mid-March peaking in late-September (Hallock, 1989). Spawning occurs in most Sacramento River tributaries from late-December through April or late-May. Unlike chinook salmon, steelhead juveniles remain and rear in the Sacramento River or its tributaries for at least one year following hatch and in some cases two years before emigrating. Peak periods of yearling and two-year-old emigration occur during the first heavy runoff event in the fall and again in the early spring, often as early as January (Hallock, 1989). Steelhead have been listed as a threatened species.

Juveniles. Many factors influence the migratory behavior of juvenile salmonids, including photoperiod, water temperature, flow, turbidity, weather, and location and distance from the ocean. Genetic factors of species, stock, parental origin, as well as degree of smoltification, size, life history stage, and food availability greatly affect the timing of emigration of salmonids to the ocean.

Fishery Habitat Requirements and Existing Habitat Conditions in Stony Creek

Fish species requirements, or limiting factors, include:
(1) suitable, consistent streamflows and depths.
(2) proper temperatures for migration, spawning, emigration and rearing.
(3) suitable spawning substrate.
(4) habitat diversity for protection from predation and production of food sources.
(5) unrestricted upstream and downstream movement.

Non-salmonid fish species needs have adapted to current conditions, as noted above. Table 2-9 summarizes typical habitat preferences for resident and non-salmonid migratory species. Habitat requirements for depth, velocity, temperature, and spawning substrate for various chinook salmon and steelhead trout life stages are summarized in Table 2-10. Much of the

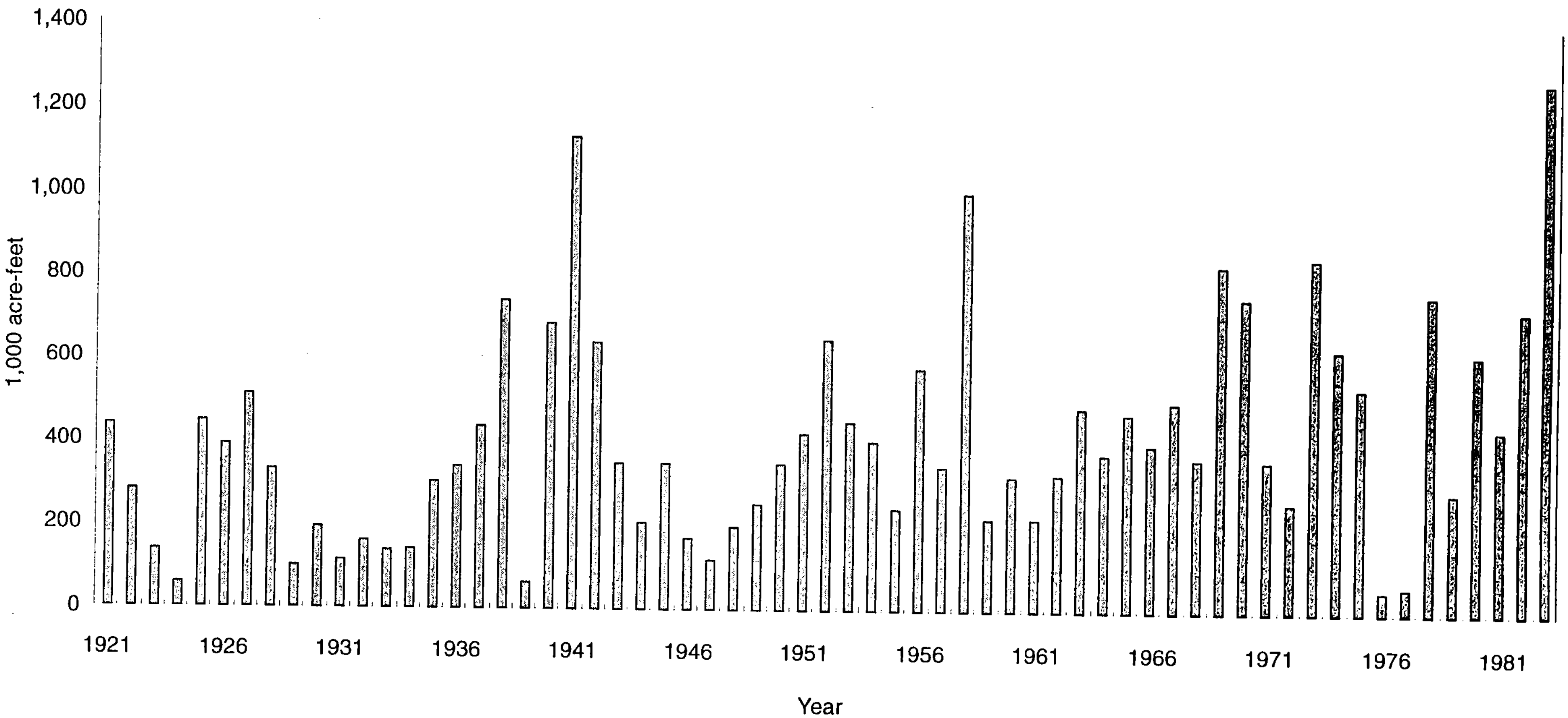

FIGURE 2-22
ESTIMATED ANNUAL STONY CREEK UNIMPAIRED FLOW AT BLACK BUTTE DAM
U.S. BUREAU OF RECLAMATION
LOWER STONY CREEK FISH, WILDLIFE, AND WATER USE MANAGEMENT PLAN

22-214-0027

2476_24 (7/14/98)

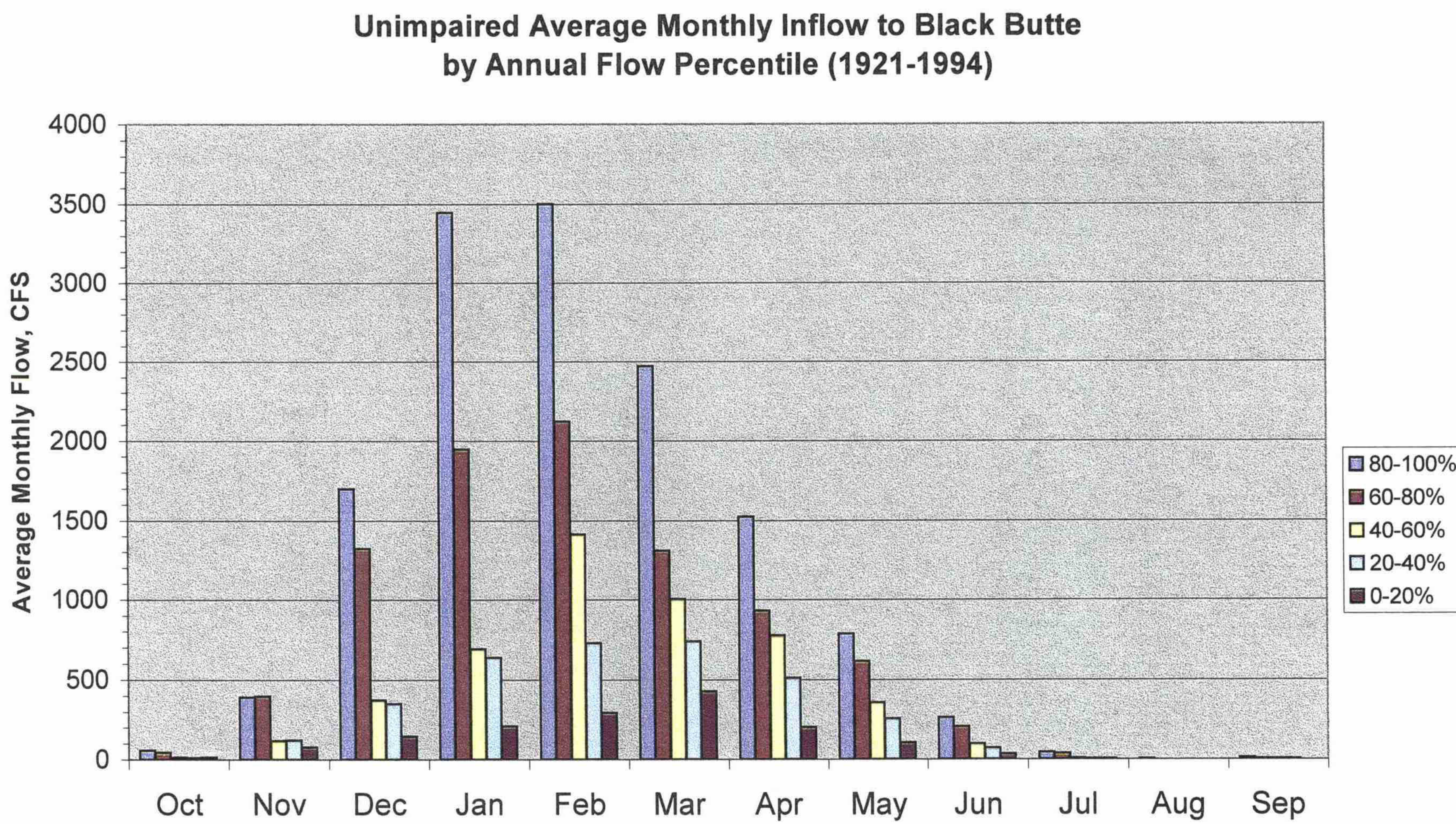

Figure 2-23A

22-214-0028

UF4 - STONY CREEK AT BLACK BUTTE
ESTIMATED UNIMPAIRED FLOW IN TAF

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1921	0	58	115	202	100	57	27	25	11	1	0	0	596
1922	1	1	12	12	68	36	50	41	13	0	0	0	234
1923	2	12	48	43	22	15	34	13	4	0	0	0	193
1924	1	1	3	6	16	4	2	0	0	0	0	0	33
1925	0	6	26	25	202	42	67	81	17	2	0	1	469
1926	2	3	5	22	137	27	72	12	1	0	0	0	281
1927	1	37	83	55	254	77	54	28	8	0	0	0	597
1928	1	9	23	47	87	98	62	18	2	0	0	0	347
1929	1	4	11	8	28	12	11	8	2	0	0	0	85
1930	0	0	33	33	44	69	26	14	4	0	0	0	223
1931	0	2	2	21	13	18	7	3	0	0	0	0	66
1932	0	2	49	48	23	37	21	22	7	0	0	0	209
1933	0	0	3	12	9	33	25	19	12	0	0	0	113
1934	0	1	29	39	37	27	11	5	2	0	0	0	151
1935	0	12	8	64	37	70	87	33	7	1	0	0	319
1936	0	1	4	83	143	48	41	15	9	0	0	0	344
1937	0	0	2	2	73	77	69	29	6	0	0	0	258
1938	1	44	133	51	214	248	101	79	27	5	0	0	903
1939	1	3	10	8	11	22	10	5	0	0	0	0	70
1940	0	0	6	114	225	119	63	21	4	0	0	0	552
1941	1	3	133	252	260	231	180	79	25	4	0	1	1169
1942	1	4	90	155	195	49	110	55	21	2	0	1	683
1943	0	11	39	162	52	69	29	23	6	1	0	0	392
1944	1	1	3	14	33	54	29	33	7	0	0	0	175
1945	1	10	27	25	76	28	32	14	4	0	0	0	217
1946	2	20	148	74	22	22	20	8	2	0	0	0	318
1947	0	8	14	2	36	53	19	2	1	0	0	0	135
1948	1	2	3	28	9	19	75	41	17	2	0	0	197
1949	0	2	6	7	21	134	57	24	5	1	0	0	257
1950	0	1	3	35	59	41	39	26	9	2	0	1	216
1951	5	36	96	102	93	49	24	38	9	4	0	0	456
1952	1	6	97	147	139	94	77	62	17	4	0	1	645
1953	1	2	104	233	39	45	45	47	18	5	0	1	540
1954	0	6	9	94	83	67	75	27	10	5	0	1	377
1955	1	13	29	15	13	16	22	24	3	2	0	0	138
1956	1	2	143	239	147	64	45	54	16	4	0	1	716
1957	5	3	2	17	83	45	45	45	16	5	0	2	268
1958	27	16	42	118	480	156	140	68	21	5	0	3	1076
1959	1	3	4	55	96	41	20	6	2	0	0	1	229
1960	0	0	0	14	139	79	22	16	5	0	0	0	275
1961	0	6	42	32	73	41	25	17	4	0	0	0	240
1962	0	4	24	11	100	75	44	16	5	0	0	0	279
1963	25	7	42	22	168	59	146	44	12	3	0	0	528
1964	3	23	8	30	18	11	9	6	2	0	0	0	110
1965	0	25	277	201	48	27	109	25	4	0	2	0	718
1966	0	36	22	115	64	45	40	17	5	0	0	0	344
1967	0	24	89	182	67	54	70	62	41	5	0	0	594
1968	1	3	15	82	142	47	19	9	3	0	0	0	321
1969	0	5	59	259	210	129	84	47	15	1	0	0	809
1970	2	3	80	406	89	65	19	10	4	0	0	0	678
1971	0	37	123	138	38	87	39	26	11	2	0	0	501
1972	0	5	16	38	37	51	20	11	2	0	0	0	180
1973	3	40	60	207	228	119	53	30	5	0	0	0	745
1974	3	83	123	250	54	166	99	30	11	1	0	0	820
1975	0	4	16	20	149	226	67	44	15	0	0	0	541
1976	4	6	7	4	12	18	12	4	1	0	1	0	69
1977	0	2	2	3	2	6	0	2	0	0	0	0	17
1978	0	4	49	320	190	146	57	28	13	2	0	0	809
1979	1	2	2	30	55	70	30	24	5	0	0	0	219
1980	5	23	45	192	257	95	35	17	7	0	0	0	676
1981	0	2	15	82	51	43	21	8	3	0	0	0	225
1982	5	77	150	109	115	93	163	56	16	5	0	1	790
1983	7	36	122	235	284	461	130	107	40	9	2	2	1435
1984	2	100	304	70	48	40	22	10	0	0	0	0	596
1985	1	54	39	13	27	22	26	2	0	0	0	0	184
1986	1	7	30	70	441	171	36	13	0	0	0	0	769
1987	0	1	2	9	27	47	10	2	0	0	0	0	98
1988	0	2	59	108	31	15	9	5	0	0	0	0	229
1989	0	13	7	16	11	95	26	5	0	0	0	0	173
1990	2	3	2	20	11	17	4	5	6	0	0	0	70
1991	0	2	2	2	3	83	34	6	0	0	0	0	132
1992	0	0	8	9	82	65	51	5	0	0	0	0	220
1993	1	2	43	243	206	108	48	27	18	0	0	0	696
1994	0	0	7	9	28	18	5	4	0	0	0	0	71

Note: Numbers are for the Black Butte Dam site. Significant losses will reduce flows reaching the mouth of Stony Creek.
Source: DWR, April 1997

Figure 2-23B

following discussion of habitat requirements are from Vogel and Marine (1991) and Vogel (1993). Important habitat considerations for salmonids include sufficient cold water flows for adult attraction, holding before and during spawning, egg incubation, and fry rearing. Additionally, at least one half of a foot of depth is required for chinook salmon passage over riffles. According to Puckett (1969) "depths of 0.7 feet and up, and velocities ranging from 1.2 to 3.5 feet per second were considered satisfactory for king salmon spawning." Resting or holding habitat adjacent to spawning areas is required for adults to complete gamete maturation and predator avoidance.

1a) Streamflows. The yearly native variation of historic unimpaired or pre-dam flows in Stony Creek is illustrated in the summary of the simulated historic streamflows in Figure 2-22. Natural flow patterns within Stony Creek have been disturbed since at least 1910 with construction of the East Park Dam. With the completion of Stony Gorge Dam in 1928 and, finally, the Black Butte Dam in 1963, the hydrology of Stony Creek has been drastically altered. Two major changes in hydrology have occurred since the dams were constructed: changes in timing of flows below Black Butte Dam and the magnitude and duration of flood flows in the lower reaches. Flows in Stony Creek below Black Butte Dam are variable, flashy, and dependent upon: water year; groundwater condition; releases from the dam; and diversions. Historic records indicate that before the construction of Black Butte Dam, Stony Creek streamflows diminished to no-flow or nearly no-flow in late-summer months (Figure 23A and B).

Table 2-10
Habitat Requirements for Chinook Salmon and Steelhead Trout

Species and Lifestage	Water Velocity (ft/s)	Water Depth (ft)	Temperature Optimum (degrees F)	Temperature Range (degrees F)	Substrate Preference Size Range (inches)
Chinook Salmon					
Spawning	1.0 to 2.4[a,b,c]	0.8 to 1.4[a,b,c]	42 to 60[d]	35 to 73[d]	1 to 6[d]
Eggs	--	--	42 to 56[d]	38 to 63[d]	--
Fry	0 to 0.3[b,c]	0.9 to 2.3[b,c]	42 to 65[d]	36 to 75[d]	--
Juvenile	--	>1.0	53 to 64[c]	32 to 75[c]	--
Steelhead Trout					
Spawning	1.1 to 2.1	1.0 to 1.2[a,b]	46 to 52[e]	39 to 61[e]	0.25 to 3.0[f]
Eggs	--	--	50[e]	--	--
Fry	0.3 to 1.0[a]	0.2 to 1.3[a]	55 to 60[e]	55 to 72.5[e]	--
Juvenile	0.3 to 1.5[a,b]	0.6 to 2.0[a,b]	44 to 52[e]	53 to 63[e]	--

[a]Bovee, 1978.
[b]Hampton, 1988.
[c]Raleigh et al., 1986.
[d]Vogel and Marine, 1991.
[e]Liedy and Li, 1987.
[f]Reynolds et al., 1993.

Streamflows based on year-type. Since the construction of Black Butte Dam, estimated streamflows did not exist below the North Diversion Dam in a dry water year during some months (Table 2-11a). In January, February, and March of 1991 no flows existed below the

Table 2-11

Table 2-11a
Stony Creek Flows Downstream of Black Butte Dam

Stony Creek Flows Downstream of Black Butte Dam
Dry Water year (1991)

Month	Q_1 (avg. cfs)	Q_2 (avg. cfs)	Q_3 (avg. cfs)	Q_4 (avg. cfs)	Q_5 (avg. cfs)
Jan	8	0	0	0	0
Feb	7	0	0	0	0
Mar	9	0	0	0	0
Apr	43	14	0	0	0
May	95	30	15	0	0
Jun	110	30	15	0	0
Jul	125	30	15	0	0
Aug	120	30	15	0	0
Sep	107	30	15	0	0
Oct	79	30	15	0	0
Nov	44	30	15	0	0
Dec	8	4	0	0	0

Q_1 = at Black Butte Dam.
Q_2 = Below North Diversion Dam.
Q_3 = Below CHO ~ 50 percent losses
Q_4 = Below GCID Main Canal.
Q_5 = At Sacramento River.

Table 2-11b
Stony Creek Flows Downstream of Black Butte Dam

Stony Creek Flows Downstream of Black Butte Dam
Average Water year (1996)

Month	Q_1 (avg. cfs)	Q_2 (avg. cfs)	Q_3 (avg. cfs)	Q_4 (avg. cfs)	Q_5 (avg. cfs)
Jan	1,537	1,537	1,537	1,537	1,537
Feb	3,576	3,576	3,576	3,576	3,576
Mar	1,748	1,748	1,748	1,748	a 1648
Apr	210	186	b 46	0	0
May	456	387	c 36	0	0
Jun	143	30	d 25	0	0
Jul	145	34	29	0	0
Aug	271	191	162	0	0
Sep	170	104	97	0	0
Oct	238	208	177	0	0
Nov	147	147	125	0	0
Dec	1,222	1,222	1,222	1,222	1,222

Q_1 = at Black Butte Dam.
Q_2 = Below North Diversion Dam.
Q_3 = Below CHO.
Q_4 = Below GCID Main Canal.
Q_5 = At Sacramento River.

"a" 100 cfs est. for GCID started March 8
"b" CHO rediversion
"c" CHO rediversion until May 15
"d" 15 percent loss

All figures taken from Black Butte daily computation sheet and the CHO daily rediversion figures.

Table 2-11c
Stony Creek Flows Downstream of Black Butte Dam

Stony Creek Flows Downstream of Black Butte Dam
Wet Water year (1993)

Month	Q_1 (avg. cfs)	Q_2 (avg. cfs)	Q_3 (avg. cfs)	Q_4 (avg. cfs)	Q_5 (avg. cfs)
Jan	3,979	3,979	3,979	3,979	3,979
Feb	3,223	3,223	3,223	3,223	3,223
Mar	491	491	491	491	a 391
Apr	561	561	b 522	0	0
May	203	203	203	0	0
Jun	293	293	293	0	0
Jul	133	30	25	0	0
Aug	500	425	382	0	0
Sep	202	130	111	0	0
Oct	147	118	c 56	0	0
Nov	142	139	d 89	0	0
Dec	130	130	111	0	0

Q_1 = at Black Butte Dam. "a" 100 cfs est. for GCID started March 2
Q_2 = Below North Diversion Dam. "b" CHO rediversion
Q_3 = Below CHO. "c" CHO rediversion
Q_4 = Below GCID Main Canal. "d" CHO rediversion
Q_5 = At Sacramento River.

Table 2-11d
Stony Creek Flows Downstream of Black Butte Dam

Stony Creek Flows Downstream of Black Butte Dam
Average Water year (1997) (unpredictability)

Month	Q_1 (avg. cfs)	Q_2 (avg. cfs)	Q_3 (avg. cfs)	Q_4 (avg. cfs)	Q_5 (avg. cfs)
Jan	4,996	4,996	4,996	4,996	4,996
Feb	1,483	1,483	1,483	a 1,383	1,383
Mar	55	32	b 27	0	0
Apr	155	71	c 24	0	0
May	267	196	36	0	0
Jun	119	30	d 21	0	0
Jul	129	30	21	0	0
Aug	114	30	21	0	0
Sep	99	30	21	0	0
Oct	56	30	21	0	0
Nov	30	30	21	0	0
Dec	233	233	e 210	f 179	g 143

Q_1 = at Black Butte Dam. "a" GCID started Feb 13, est 100 cfs
Q_2 = Below North Diversion Dam. "b" 15 percent loss
Q_3 = Below CHO. "c" CHO rediversion bypass flows
Q_4 = Below GCID Main Canal. "d" 30 percent loss
Q_5 = At Sacramento River. "e" 10 percent loss
"f" 15 percent loss
"g" 20 percent loss

Flows and 20 Highest Rates of Change
By Water Year

Water Year 1996		
Date	CFS	Change
12/23/95	489.4	-768.1
01/17/96	1528.5	1104.4
01/24/96	1008.5	-1184.1
01/26/96	3128.6	1739
01/27/96	4602.7	1474.1
02/03/96	3322.4	-1117.9
02/04/96	4005.9	683.5
02/05/96	7157.6	3151.7
02/06/96	8439.5	1281.9
02/07/96	7543.5	-896
02/08/96	4974.5	-2569
02/09/96	2690.3	-2284.2
02/10/96	1531.2	-1159.1
02/20/96	3584.8	2241
02/21/96	4779	1194.2
02/27/96	3718.8	-754
03/06/96	3499.6	585.8
03/14/96	3612.9	660.2
03/16/96	2126.5	-916.7
03/17/96	1233.8	-892.7

Water Year 1997		
Date	CFS	Change
12/28/96	2195	1049
12/29/96	3718	1523
12/30/96	5121	1403
12/31/96	8945	3824
01/01/97	14339	5394
01/03/97	13548	-1289
01/04/97	12343	-1205
01/05/97	9696	-2647
01/06/97	3356	-6340
01/23/97	2956	1927
01/24/97	4788	1832
01/26/97	2469	-1430
01/27/97	5723	3254
01/28/97	7478	1755
01/29/97	8282	804
02/01/97	6948	-1477
02/02/97	5438	-1510
02/05/97	2948	-1029
02/06/97	1732	-1216
02/07/97	473	-1259

Water Year 1998		
Date	CFS	Change
01/09/98	814.2	321
01/12/98	2259.3	1270
01/13/98	4393.3	2134
01/14/98	4884.3	491
01/18/98	4870.3	273
01/23/98	3691.3	-788.9
01/24/98	2956.3	-735
01/25/98	1964.3	-992
01/27/98	4426.1	2395.9
01/28/98	5899	1472.9
01/31/98	4423.1	-1052.9
02/02/98	5297.1	1392
02/03/98	10922.1	5625
02/04/98	14839	3916.9
02/13/98	13944.1	-1011
02/14/98	11456.1	-2488
02/15/98	9235	-2221.1
02/16/98	7821.1	-1413.9
02/17/98	6994	-827.1
02/18/98	5948	-1046

Table 2-12

Table 2-13. (Vogel, 1996)

Table 1. Number of days for which releases from Black Butte Dam exceeded certain flow values (in cfs) for the period of November through March, Water Years 1965 - 1988.

	WATER YEARS																							
FLOW	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
≥1000	48	14	17	11	63	44	31	0	47	61	36	0	0	43	1	36	6	59	83	42	7	49	0	23
≥2000	26	11	16	8	49	33	24		40	42	31			39	0	32	2	32	76	29	3	36		7
≥3000	12	9	14	7	39	25	19		34	21	22			34		26	0	25	66	25	0	33		4
≥4000	10	5	12	6	33	23	7		29	14	12			31		20		19	63	19		26		2
≥5000	10	0	11	6	12	21	3		20	14	6			20		17		10	44	15		16		0
≥10000	8		0	0	1	4	0		0	4	0			6		12		0	14	7		10		
≥15000	6				0	0				0				0		2			2	0		4		

Table 2. The average number of days, median number of days, and the percent of years in which certain daily flow values were exceeded during November through March, water years 1965 - 1988.

Flow (cfs)	Average Number of Days	Median Number of Days	Percent of Years in Which Daily Flow Value Was Exceeded
≥1000	36	39	83%
≥2000	28	31	79%
≥3000	24	25	71%
≥4000	19	19	71%
≥5000	15	14	62%
≥10000	7	7	38%
≥15000	4	3	17%

North Diversion Dam, in April and December no flows existed below the CHO, and between May and November no flows existed below the GCID main canal.In average (1996) and wet years (1993) no streamflows reached the Sacramento River below the GCID main canal during some months, usually April through at least November (Table 2-11 b and c). It is not assumed that GCID captured all of the water.

For comparison of year-type conditions and releases, another average precipitation year (1997), but low storage year, was used to demonstrate the unpredictability of releases in the system (Table 2-11d). Because heavy rainfall came early in the year (February) flood releases were made according to the flood control diagram, to provide for space in the reservoir. When additional rainfall did not occur, storage was not resupplemented (see Table 3-1) and releases were low, providing low flows below the TCC.

In-stream Flow Releases. Since 1965 a minimum flow of 30 cfs release from the dam has been a Black Butte operational objective. Since approximately 1986 this minimum flow has been fairly consistent. Since 1993,when CHO rediversions began and EA and permit conditions were imposed a minimum flow of 40 cfs bypasses the CHO berm when rediversion of the CHO has occurred, in addition to the 30 cfs minimum flow from the dam. The 40 cfs bypass flow has provided additional benefits to this area in those years when the minimum flow did not reach the CHO by calling for that amount of water which would ensure the required bypass flows.

In-stream Flow Recommendations. According to Puckett (1969) a flow of less than 200 cfs at the dam would be insufficient to attract and allow upstream migration of adult spawners in Stony Creek in all years. Flows higher than 200 cfs have occurred predominantly during wet conditions and during flood control release operations. According to some technical team members (there was no unanimous agreement) a flow of 50 cfs at the mouth (approximately 75-100 cfs released at the dam) would be sufficient to attract upstream migrants. Flow requirements necessary to optimize chinook salmon habitat for all life stages is currently disputed in lower Stony Creek.

Any releases made from November to June would be subject to the current COE Flood Control Diagram (FCD). The primary authorization of Black Butte Dam for flood control currently prevents any release of consistent flows once a major storm has occurred and the FCD is in place. Some pre-flood releases in the fall are possible under certain weather conditions and with the cooperation of the COE.

1b) Daily Streamflow Variation Data.The existing streamflow conditions flows below Black Butte are variable and dependant on water year, releases, seepage, diversions, and other conditions. Fishery resources are dependant on a continuous water supply. Lower Stony Creek exhibits highly variable flows during the winter months.

Daily data for Black Butte outflow was obtained from the COE for water years 1996 to 1998. The twenty most severe flow changes from December through March were tabulated for each of the years. These day to day flow changes can be large, on the order of 50-100 percent of the prior day's flow, and range in magnitude from several hundred to approximately 6,000 cfs (Table 2-12). Consideration should be given to adverse impacts these high flow fluctuations can cause on incubating eggs.

In the analysis of daily instantaneous streamflow Table 2-13 shows the number of days for which releases from Black Butte dam exceeded certain flow values for the period November through March from water years 1965-1988 (Vogel, 1996).Although it is not possible to define a single discharge value which would cause bedload movement and scouring of suffocating redds, interpretation of the data in Table 2-13 suggests the likelihood of some adverse impacts of flows of 1,000-15,000 cfs Flows in the range of 1,000 to 5,000 cfs during the winter months are common. According to Vogel, (TCCA White Paper, March 25, 1996), "flows of this magnitude occurred for several weeks or more in approximately two-thirds to four-fifths of the 24 years of record. Even extreme flow events of greater than 10,000 cfs or 15,000 cfs occurred 38 and 17 percent of the years, respectively." High fluctuating flows have historically, and do commonly occur, in natural environments, during the period when salmon eggs would be incubating in river gravels. The most suitable spawning in lower Stony Creek has been identified as existing in the upper reaches directly below the dam (Puckett, 1969), however the dam has changed the river channel to a confined system, exacerbating the effects of the high fluctuating flows. The adverse effects of rapid fluctuations resulting in the scouring of eggs from redds, dewatering of redds, or substrate deposition during high fluctuating flows releases, could occur within potential spawning areas in Stony Creek, especially during above normal or wet water years. The effects of the fluctuating flows of Black Butte dam on potential redds should be considered.

2) Temperature. In addition to the changes in the timing and magnitude of streamflows in Stony Creek, the water temperatures in Stony Creek are directly affected by streamflow conditions. These temperatures greatly impact successful propagation, rearing, and maturation of both resident and migratory fish species inhabiting Stony Creek. A summary of the daily mean, minimum, and maximum stream temperature of each month beginning in water year 1970 through water year 1994 is shown in Figure 2-24a.

Salmonid Temperature Thresholds - Stony Creek. Mean daily water temperatures in October (65.8°F) have exceeded the maximum threshold of temperature tolerances for prespawning chinook salmon (60°F) during 1970-1994. During 1970-1994, water temperatures in November (54.4°F) in the study area remained below the threshold of prespawning/spawning (60°F) and egg incubation temperatures (56°F). Stream temperatures then remain below the maximal threshold temperature (65°F) for fry/juvenile rearing through at least May.

Salmonid Temperature Thresholds- Cottonwood Creek. It is useful to observe water temperatures in another local westside tributary located north of Stony Creek for which data is available for the same period of time, Cottonwood Creek. It is understood that the following comparison with another westside tributary is for information with regard to creek temperatures only, and is not intended to compare any other limiting factors or make any conclusions. Although there is no dam on Cottonwood Creek, this watershed is similar to the Stony Creek watershed in size and drainage elevations (927 square miles) (USGS, 1996), and exhibits similar geology, topography and hydrology. The anadromous fishery in Cottonwood Creek includes fall, late-fall, and spring-run chinook salmon, and a small run of steelhead trout (DFG, 1993). The average annual return of fall-run chinook in Cottonwood Creek is approximately 1,000 to 5,000 adults but has ranged from a few hundred to over 8,000 adults (DFG, 1993). The late-fall chinook salmon run in Cottonwood Creek is estimated to be approximately 500 adults. No recent estimates of spring-run chinook salmon have been made for Cottonwood Creek but historic estimates indicated runs of this species were approximately 500 adults (DFG, 1993).

Analysis of water temperature data (supplied by DWR) by CH2MHILL collected at the USGS gage near Cottonwood, California (2.5 miles upstream of the mouth, Hydrologic Unit 18020102) for water years 1963 through 1967 and 1977 through 1985 are shown in Figure 2-24b. Temperatures suitable for spawning (<60°F) and egg incubation (<56 °F) are typically reached during November and are maintained throughout the typical fall and late-fall chinook salmon incubation period (generally ending in March-April). The mean daily water temperatures for the months of November through May in Cottonwood Creek are within approximately 1 to 2 °F to those for Stony Creek (Figure 2-24a).

Based on measured daily water temperatures for years in which common data is available, and the data set of biologically important thresholds, it is interesting to observe the following comparison. For the water years 1978 through 1984 the average date in which water temperature dropped below 60 °F (spawning threshold) in Stony and Cottonwood Creeks were October 31 and October 25 respectively. Similarly, the first date in which water temperatures dropped below 56°F (egg incubation threshold) in Stony and Cottonwood Creeks were November 11 and November 10 respectively. The first date in which water temperatures exceeded 65°F (rearing maxima) in the spring in Stony and Cottonwood Creeks were May 19 and May 3 respectively. Based on the analysis of daily water temperature conditions suitable for egg incubation through fry/juvenile rearing in Stony and Cottonwood Creeks average approximately 188 and 175 days per year respectively. This summary is shown in Table 2-14.

Table 2-14
Dates Daily Mean Stream Temperatures Reached Critical Water Temperatures For Various Chinook Salmon Life stages in Lower Stony and Cottonwood Creeks

Corresponding to Chinook Salmon Lifestage	Average Daily Water Temperatures at Black Butte Dam and Cottonwood, USGS Temperature Gage (1978-1984)			
	1st date of <60 F. in fall	1st date of <56 F. in fall	1st date of >65 F. in spring	# of days with suitable temperatures
Stony Creek	October 31	November 11	May 19	175
Cottonwood Creek	October 25	November 10	May 3	188

Table 2-15 Dates Daily Mean Stream Temperatures Reached Critical Water Temperatures For Various Chinook Salmon Lifestages in Lower Stony Creek			
Corresponding to Chinook Salmon Lifestage	Average Date at Black Butte Dam Temperature Gage (1970 to 1994)		
	Average Earliest	Earliest Consistent	Average Latest
Adult Spawning	60°F in fall, October 30	60°F. or less: Oct 30-Nov 15	60°F in fall, Nov 2
Egg Incubation	56°F in fall, November 12	56°F. or less: Nov 6- Nov 25	56°F in fall, Nov 12
Juvenile Rearing	65°F in spring, May 29	65°F. or more: Apr 26-Jun 18	65°F in spring, Jun 3

Table 2-15 provides a summary of the average earliest and latest dates for daily mean stream temperatures in lower Stony Creek to fall below 60°F and 56°F, critical chinook salmon spawning and egg incubation temperatures, respectively. Similarly, the earliest and latest dates in which daily mean stream temperatures exceeded the optimal threshold for chinook fry/juvenile rearing are also shown in Table 2-15.

Consistent suitable temperatures are required to ensure successful life stages. The USGS data was analyzed to reveal the dates to reach consistent temperatures over the same time period (Table 2-15). Consistent temperatures of 60°F or lower in the fall occurred between October 30 (1990 and 1992) and November 15 (1988) in the years of record, 56°F or lower in the fall occurred between November 6 (1978) and November 25 (1987), and 65° F or higher in the spring occurred between April 26 (1994) and June 18 (1993).

During 1970 through 1994, the earliest dates in which Stony Creek reached spawning (60°F) and optimal egg incubation (56°F) temperatures were October 19 and October 27, respectively (Table 2-16). The latest these temperatures were reached were November 10 and November 25, respectively. Also, the optimal temperature for fry/juvenile rearing of 65°F has been exceeded as early as May 4 and as late as June 15. Stream temperature generally did not fall below 60°F between October 19 and November 10 (17 of 25 years). Similarly, stream temperature below Black Butte Dam generally fell below 56°F between October 27 and November 25 (22 of 25 years). Temperatures in Stony Creek generally exceed 65°F between May 13 and June 15, 15 of 25 years (Table 2-16).

Optimal temperature conditions are those that remain below the maximum threshold for migration, spawning, and incubation. Temperatures which remain low beyond the incubation period (January - February) for the fall-run, delay rearing and emigration, which carries the possibility of thwarting emigration if it occurs past May. If salmonid juveniles produced in Stony Creek cannot migrate through the Delta before May to early June in most years, temperatures become lethal in that region and those fish are lost.

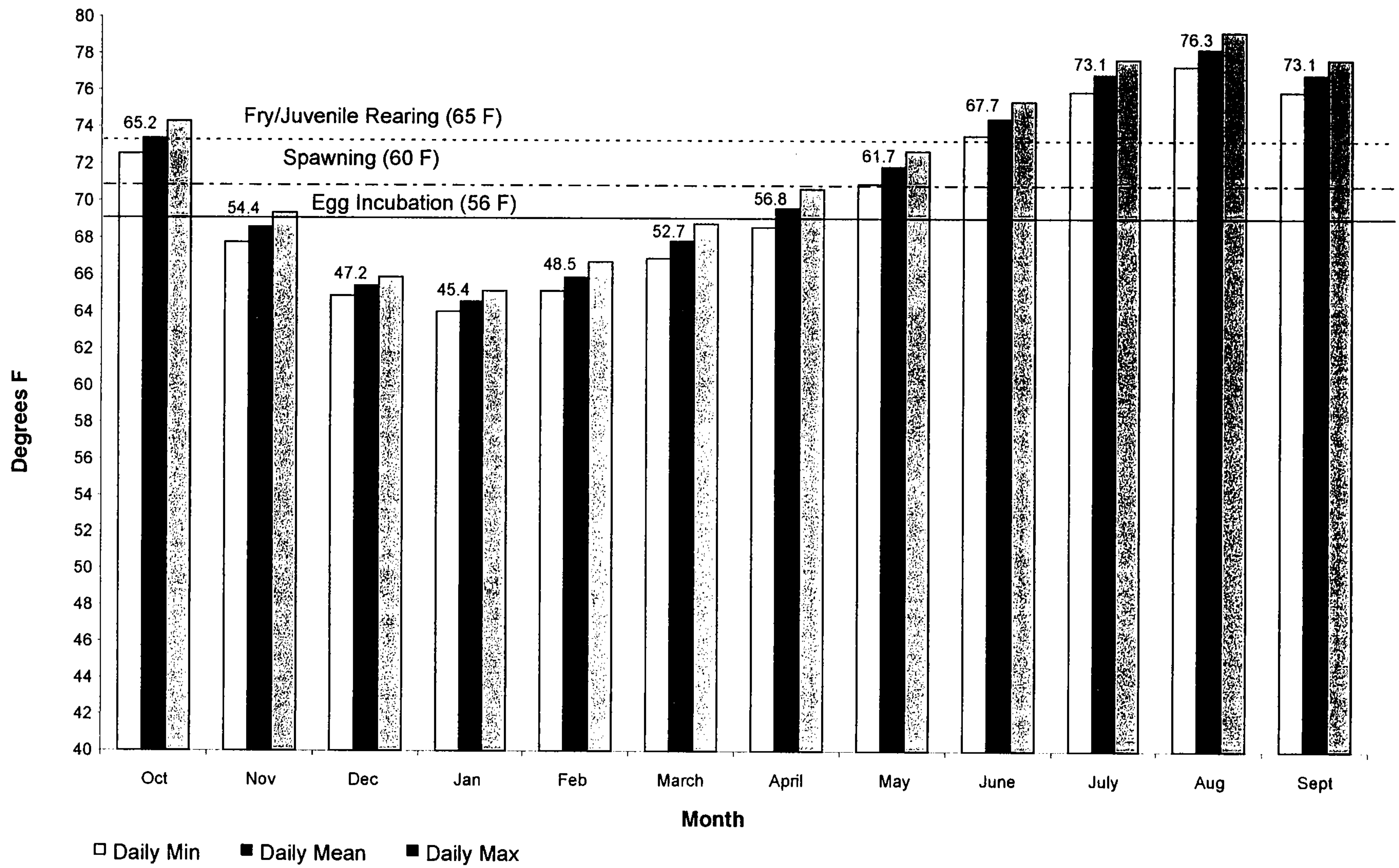

FIGURE 2-24a
STONY CREEK TEMPERATURES AT BLACK BUTTE DAM USGS GAGE WATER YEARS 1970 THROUGH 1994
U. S. BUREAU OF RECLAMATION
LOWER STONY CREEK FISH, WILDLIFE, AND WATER USE MANAGEMENT PLAN

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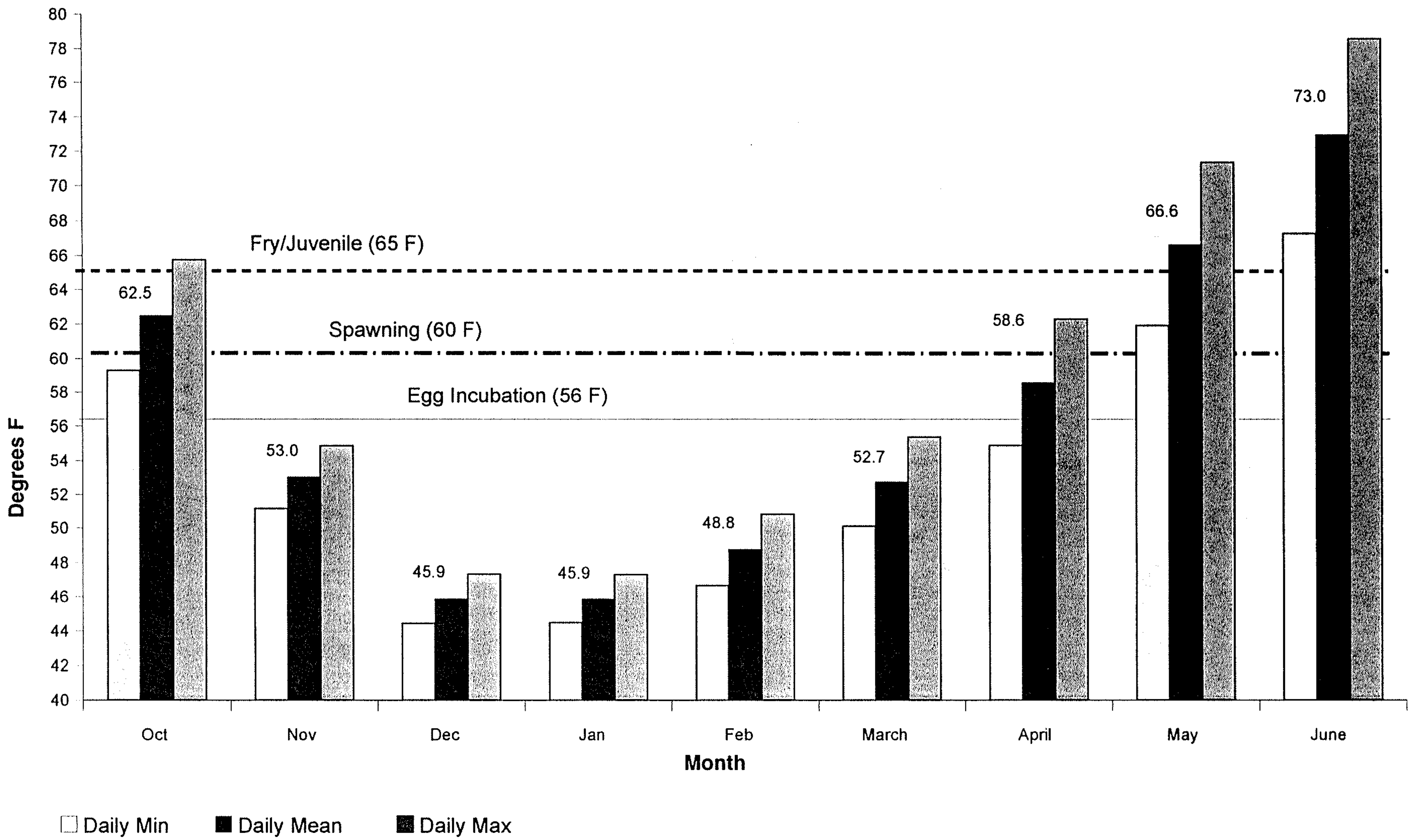

FIGURE 2-24b
COTTONWOOD CREEK TEMPERATURES AT COTTONWOOD USGS GAGE WATER YEARS (1963-1967 AND 1977-1985)
U. S. BUREAU OF RECLAMATION
LOWER STONY CREEK FISH, WILDLIFE, AND WATER USE MANAGEMENT PLAN

22-214-0030

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Table 2-16
Historic Dates for which Stony Creek Stream Temperatures Reached Specific Thresholds
at the Black Butte Dam Gaging Station (1970-1994)

Water Year	Ist Date to Reach 60 F. in Fall	Last Date Above 60 F. in Fall	Ist Date to Reach 56 F. in Fall	Last Date Above 56 F. in Fall	Ist Date to Reach 65 F. in Spring	Last Date Below 65 F. in Spring	Number of Days <60-to <65
1970	7-Nov	10-Nov	20-Nov	20-Nov	8-Jun	8-Jun	213
1971	24-Oct	28-Oct	25-Nov	25-Nov	23-May	20-Jun	211
1972	19-Oct	19-Oct	27-Oct	27-Oct	26-May	11-Jun	219
1973	28-Oct	28-Oct	30-Oct	6-Nov	30-May	30-May	214
1974	29-Oct	29-Oct	3-Nov	12-Nov	10-Jun	10-Jun	224
1975	27-Oct	27-Oct	before 11-Nov	before 11-Nov	after 29_May	after 29_May	214
1976	24-Oct	24-Oct	5-Nov	6-Nov	13-May	30-May	201
1977	28-Oct	16-Nov	after 17-Nov	after 17-Nov	13-May	27-May	200
1978	before 2-Nov	before 2-Nov	before 2-Nov	5-Nov	29-May	29-May	208
1979	31-Oct	31-Oct	9-Nov	9-Nov	29-May	29-May	210
1980	29-Oct	29-Oct	12-Nov	12-Nov	19-May	25-May	202
1981	30-Oct	30-Oct	12-Nov	12-Nov	18-May	18-May	200
1982	29-Oct	29-Oct	20-Nov	20-Nov	27-May	27-May	210
1983	29-Oct	29-Oct	6-Nov	6-Nov	14-Jun	14-Jun	228
1984	7-Nov	7-Nov	10-Nov	11-Nov	7-Jun	7-Jun	212
1985	before 10-Nov	before 10-Nov	before 10-Nov	before 10-Nov	17-May	17-May	192
1986	20-Oct	27-Oct	10-Nov	10-Nov	23-May	25-May	215
1987	before 8-Nov	before 8-Nov	16-Nov	19-Nov	2-Jun	2-Jun	206
1988	10-Nov	14-Nov	23-Nov	23-Nov	1-Jun	7-Jun	203
1989	6-Nov	6-Nov	13-Nov	13-Nov	3-Jun	5-Jun	209
1990	28-Oct	28-Oct	31-Oct	after 11-Nov	before 4-May	14-Jun	188
1991	19-Oct	1-Nov	2-Nov	4-Nov	9-Jun	9-Jun	233
1992	28-Oct	29-Oct	14-Nov	14-Nov	15-Jun	30-Jun	230
1993	31-Oct	3-Nov	9-Nov	9-Nov	12-Jun	12-Jun	224
1994	9-Nov	16-Nov	16-Nov	16-Nov	23-May	23-May	195
Yearly average date:	30-Oct	2-Nov	12-Nov	12-Nov	29-May	3-Jun	210

Influences on Stream Temperatures. Lower Stony Creek stream temperatures are directly influenced by ambient air temperature, solar radiation, shading, channel geometry, the water temperatures of Black Butte Reservoir releases, and, to a lesser degree, the other upstream reservoirs. Releases made from Black Butte Reservoir are made from the outlet located at the bottom of the reservoir, ensuring the coldest temperatures possible. Thermal monitoring within Black Butte Reservoir has indicated that, while there is a slight to moderate thermal stratification during the late spring and summer months (April-September), by the early fall at lowest pool elevations, temperatures within the reservoir are relatively uniform and cool (COE, 1987, DWR, 1988). This indicates that there is little, if any, opportunity to affect current downstream temperature with Black Butte Dam releases in the early fall or late spring to provide more optimal than current temperature conditions for chinook salmon.

Stream Gage Data. Six continuous temperature monitoring locations are located on Stony Creek: below Black Butte Dam, below Northside Diversion Dam, at old Highway 99 bridge near I 5, below TCC, at St. John's Gage, and below GCID Main Canal, near the Nature Conservancy. Approximate locations are shown in Figure 2-1(page 2-5). There is currently no gage located at the confluence of the Sacramento River, although the Nature Conservancy gage is near the confluence. Reclamation's analysis of 4 monitoring locations from July 1995 to December 1997, which contained representative and continuous data, using daily mean temperatures, has determined that temperatures are fairly consistent from year to year indicating consistent operations and little climate variation (Figures 2-25 through 28). From the temperature record, it can be seen that, generally, stream temperatures were not significantly different with regard to location. These temperatures must be consistent within all reaches to benefit each life stage requirement.

With the installation of the GCID Main Canal siphon due to be completed in 1998, a seasonal barrier will no longer exist, and temperatures between the GCID Main Canal and the Sacramento River may differ from recent historic accounts. Following the installation of the siphon, data will be collected to reflect current temperatures. It is unlikely the temperatures of Stony Creek with the siphon installed, will have a significant impact on the Sacramento River.

Current temperature data and suitability for salmonids. It becomes obvious that the interval of optimal stream temperatures for salmonids within Stony Creek generally falls between late October/early November to mid to late April in most years (Figure 2-29). A summary of the approximate number of days per year in which Stony Creek temperatures, as measured below Black Butte Dam, were suitable for chinook salmon is shown in Figure 2-30. These temperatures must be consecutive to benefit each life stage requirement. While November 1 is relatively late for fall chinook migration, it is the midpoint for adult spawning - November 15 (Figure 2-21, page A-2-54). The interval for migration appears to match a small percentage of fall-run chinook salmon lifestage timing requirements. For the small proportion of the fall-run salmon which may enter Stony Creek under optimal conditions, success in spawning, incubation and rearing would be dependent on suitable substrate, optimal flows, and suitable temperatures, to succeed. Temperatures within lower Stony Creek and life-history characteristics of the other runs of chinook salmon and steelhead would generally preclude

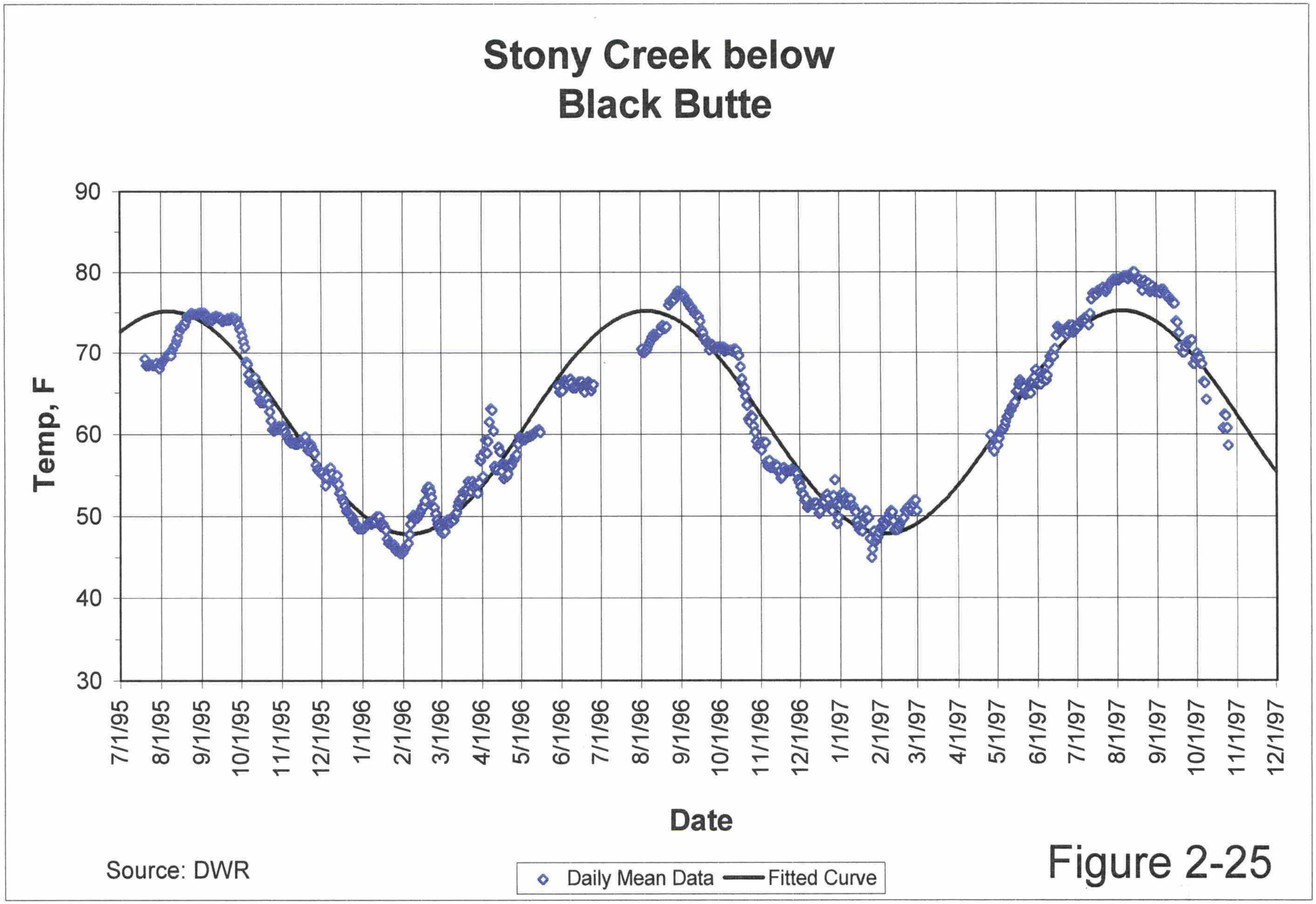


Figure 2-25

22-214-0031

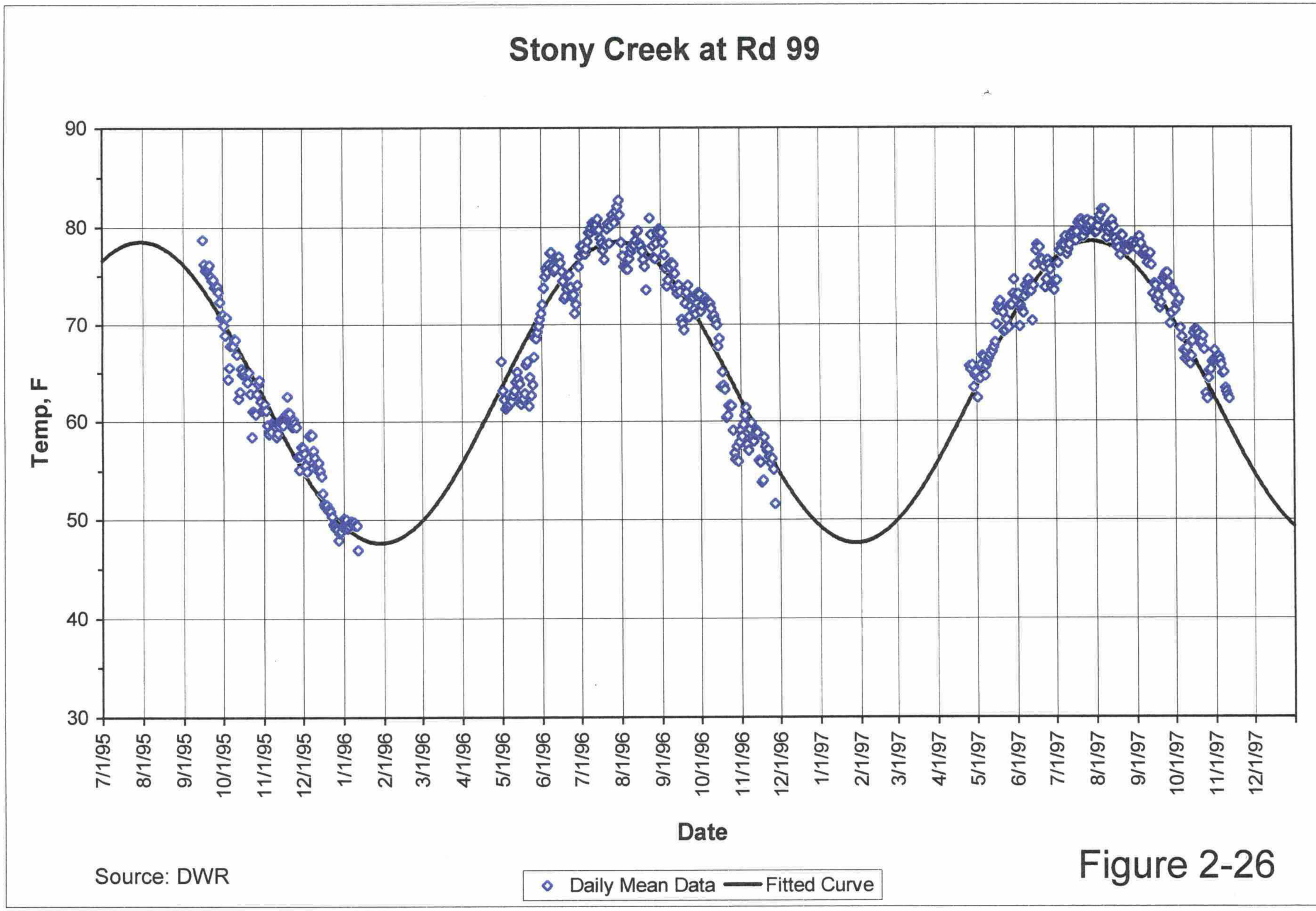
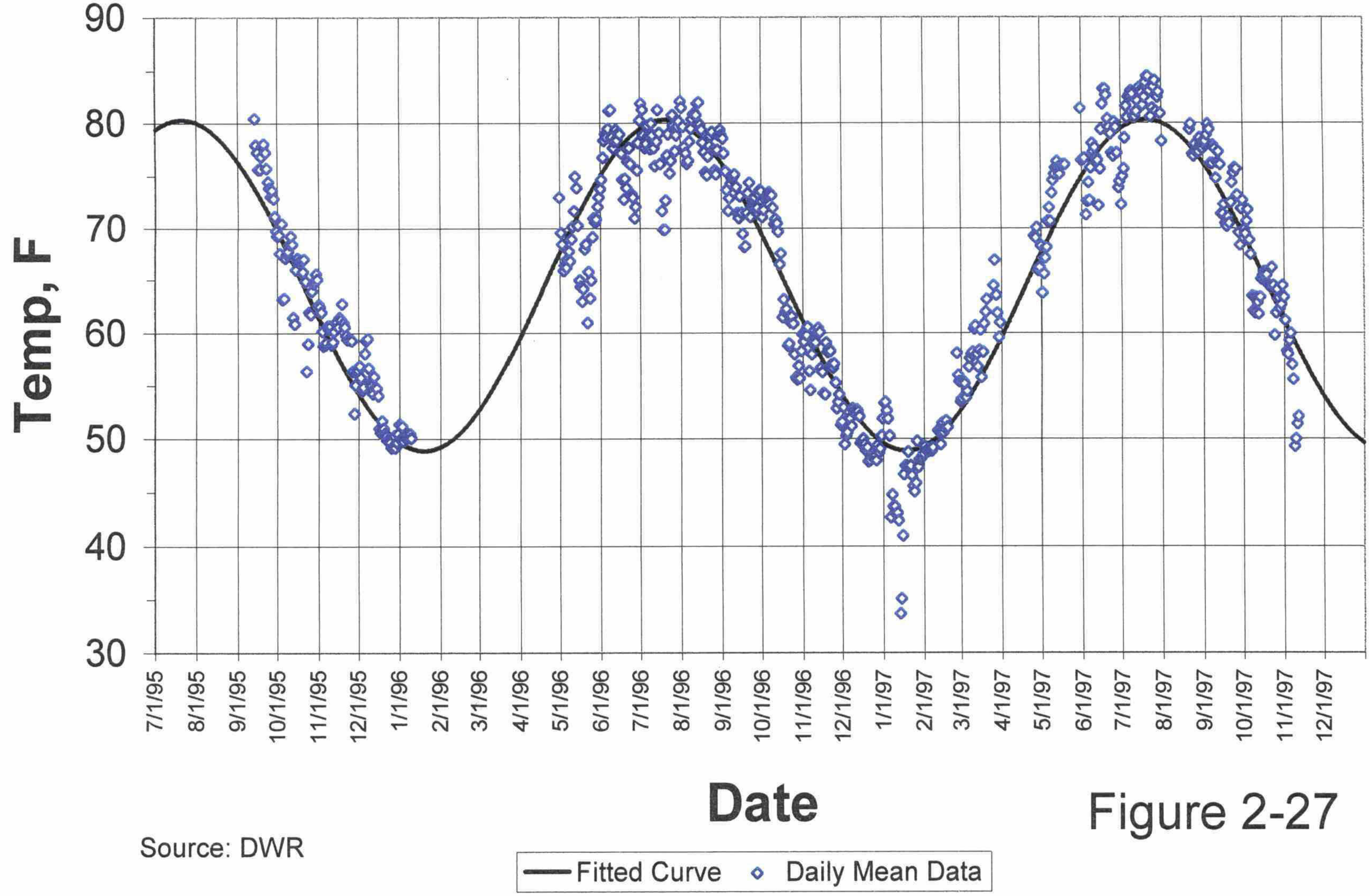


Figure 2-26

22-214-0032

Stony Creek near St. Johns Gage



Source: DWR

Figure 2-27

22-214-0033