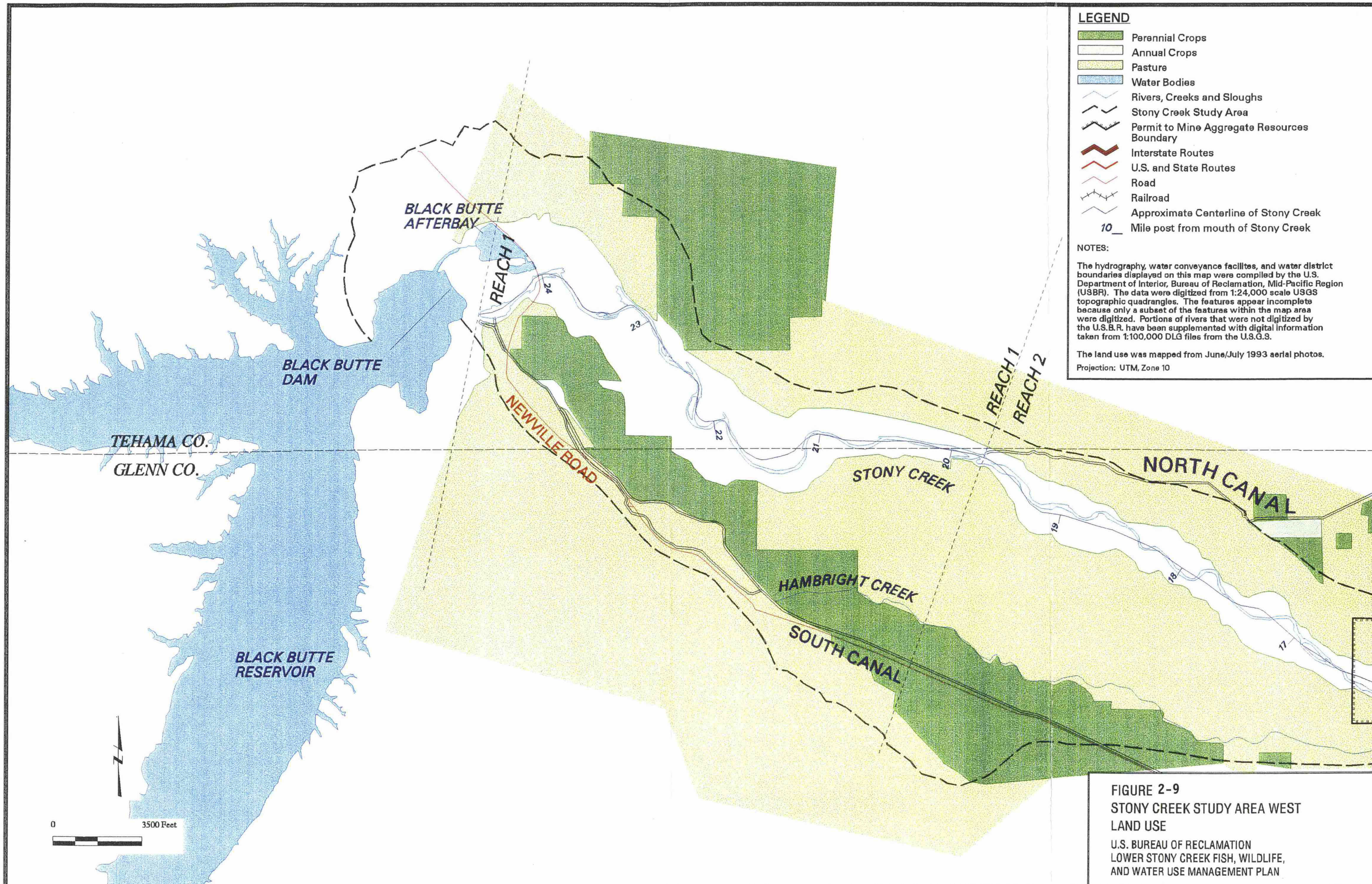

FIGURE 2-9
STONY CREEK STUDY AREA WEST
LAND USE

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

22-214-0016

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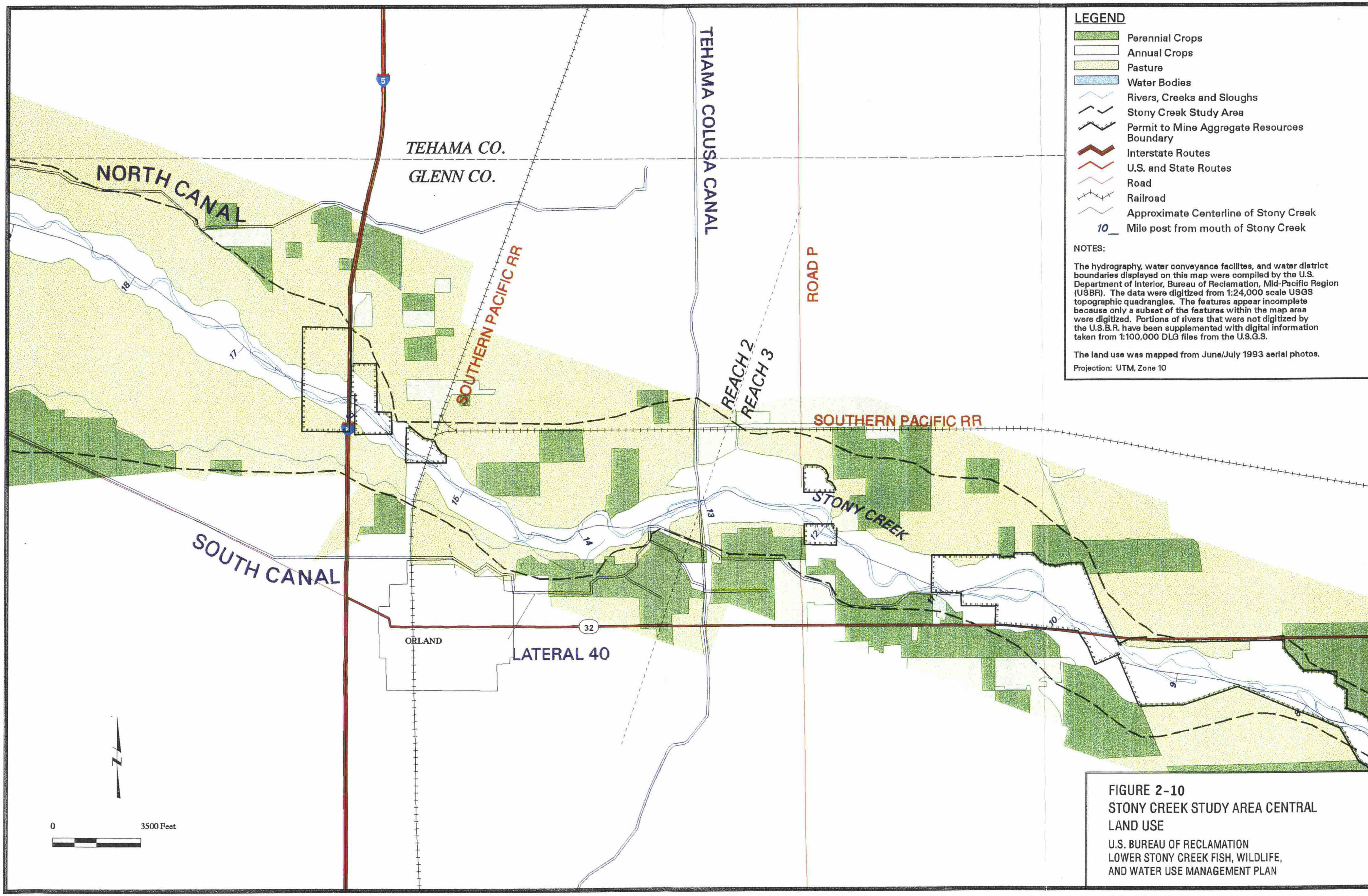

FIGURE 2-10
STONY CREEK STUDY AREA CENTRAL LAND USE
U.S. BUREAU OF RECLAMATION
LOWER STONY CREEK FISH, WILDLIFE, AND WATER USE MANAGEMENT PLAN

22-214-0017

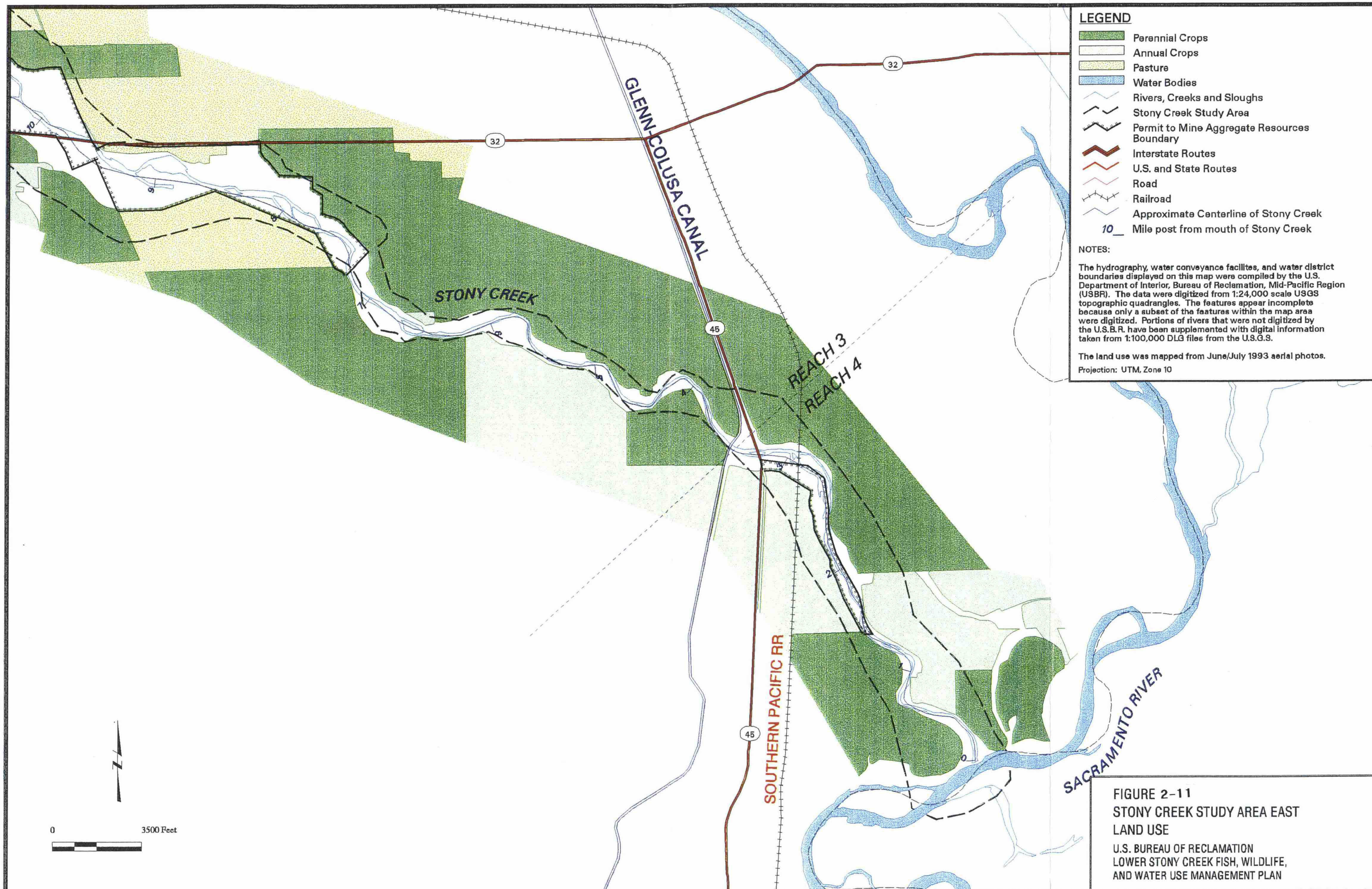

FIGURE 2-11
STONY CREEK STUDY AREA EAST
LAND USE

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

22-214-0018

corridor.aml, '15 Mar 96 22:14:55 Friday', east_ext, 3, J. Case habitat. Simpson adjoins the two animal sanctuaries listed above.

- Private preserves, such as the lands of the Graves family, which have been maintained in pristine condition by the Graves family since the mid-1800's. The Graves lands adjoin those of CCFA, Simpson Timber, and the Reimers Ranch. These neighboring properties together constitute a large informal private preserve along Stony Creek from Black Butte Dam to the North Diversion Dam.

- Ranchers, such as the Reimers Ranch, have done extensive habitat improvement, as well as protect wildlife on their properties along the Stony Creek corridor.

- The Stony Creek Landowners and Business Coalition formed to preserve habitat and encourage educational programs through cooperative methods among landowners and associated stakeholders.

Public Land Uses Within the Study Area

Public land uses within the study area include two closed Glenn County solid waste disposal areas, one at County Road 7 and one along the east side of County Road P adjacent to Stony Creek; one closed City of Orland solid waste disposal area at County Road 7; a 40-acre U.S. Bureau of Land Management site adjacent to Interstate 5 (the California Department of Transportation has mineral extraction rights to this site which has been inactive since the mid-1960's); the TCC operated by the TCCA; the Glenn-Colusa Main Canal operated by the GCID; and the North and South Canals, although public facilities at present, are operated by the OUWUA, a private corporation. A seasonal wetland on Reclamation land exists near the Stony Creek Siphon/CHO.

D. Aggregate Resources

This section presents a summary of existing aggregate resources and describes historical and current gravel mining operations in the study area. According to the "Mineral Land Classification of Concrete Grade Aggregate Resources in Glenn County, California, 1997" (Division of Mines and Geology, DMG), construction aggregate, chromite and manganese have been the only non-fuel mineral commodities commercially produced in Glenn County. This DMG document has further information on the mining history, regional geology, aggregate classification of the area and a 50 year forecast of concrete aggregate.

The data sources used in the preparation of this section include a literature review of the recent works of Swanson, Kondolf, and Chang; a review of pertinent environmental documents; a review of Glenn County's Use Permit and Reclamation Plan files maintained for the permitted aggregate resources operations located within the Stony Creek corridor; and a review of historic and recent aerial photographs. The Aggregate Resource Management Plan Initial Phase Report, dated October 1997, is also available from Glenn County.

Existing Aggregate Resources

Lower Stony Creek traverses its alluvial fan from Black Butte Dam to the Sacramento River, following one of three major fingers of gravelly soil that represent former channel courses. These former channels are represented by the coarse textured, well-drained soils depicted on the Glenn County Soil Conservation Service soils map (Begg, 1968). In-stream gravel mining (Table 2-3) has been particularly intensive in the reach of lower Stony Creek between the Road P crossing and Mills Orchard (Swanson and Associates, 1991). Generally Stony Creek aggregates consist of stream channel deposits, including flood and overbank deposits in the upper reaches, and are classified as MRZ-2a (marginal reserves). Using past consumption rates (1965-1995) adjusted for anticipated changes in market conditions and mining technology, a depletion of reserves is expected by the year 2038 (DMG, 1997).

Description of Gravel Mining Operations

Currently, six in-stream gravel mines operate within the study area. All operations in Glenn County are subject to the Surface Mining and Reclamation Act (SMARA) and have reclamation plans. The DFG has monitored these operations with restrictions on in-channel operations since 1976.

Table 2-3
Gravel Extraction Operations in the Study Area

Extractor (Date of initial operations)	Location and River Mile	Reach	Range of Annual Extractions[a]	Annual Maximum Permitted[a]
Jaxon Enterprises (1985)	Upstream of I-5 bridge; RM 16.5	2	Not available	115.4
Orland Sand & Gravel (1923)	Downstream of I-5 bridge; RM 16	2	2.1 to 21.2	192.3
Calvin Clement	Road P crossing; RM 12	2	Permit expired	NA
Jaxon Enterprises Jasper Pit (1940s)	Upstream of Hwy 32 bridge; RM 12	3	4.2 to 4.2	42.3
Valley Rock Products (1968)	Upstream of Hwy 32 bridge; RM 10	3	192.3 to 384.6	384.6
Baldwin Contracting (1940s)	Downstream of Hwy 32 bridge; RM 9	3	38.5 to 192.3	461.5
Martin Sand & Gravel	Downstream of Hwy 45 bridge; RM 3	4	3.8 to 38.5	38.5
Total			**240.9 to 640.8**	**1,234.6**

[a]In thousands of cubic meters.
Source: Kondolf and Swanson, 1993.

The six operations employ bar skimming in which gravel bars above water level are harvested; the channel is not excavated below the existing thalweg. The thalweg is a line in the stream channel representing the low point of the low water channel. The extent of in-stream mining in the vicinity of Highway 32 has increased nearly threefold since 1965 (Kondolf and Swanson, 1993).

The only proposed gravel operation known to Glenn County is the Arbuckle application for operation located in the Stony Creek channel more than one mile west (upstream) of Interstate 5, and identified as Glenn County Conditional Use Permit Application No. 89-12. According to the Glenn County Planning Commission, issuance of Conditional Use Permit No. 89-12 and the certification of the Environmental Impact Report (EIR) is in abeyance pending resolution of issues raised by the California Department of Transportation regarding the potentially threatened integrity of infrastructures within the Stony Creek channel (Earl D. Nelson & Associates, Draft EIR, 1994). No gravel has ever been extracted from this area.

Table 2-3 identifies six gravel extraction operations, currently operating within the study area, and one additional operation for information. The existing operations occupy a total of 1,179 acres. These operations are identified in the order in which they occur along Stony Creek from west to east.

The Calvin Clement operation, identified above, never commenced operation because of unresolvable use permit requirements, and the Glenn County Planning Commission denied their permit extension without extracting any gravel (Glenn County, 1995).

The goals of the Glenn County Aggregate Resource Management Plan- Initial Phase Report include minimizing and supporting innovative mining techniques which prevent or minimize adverse environmental effects; minimizing changes to stream channels; and reducing conflicts and environmental effects where associated with in-stream channel mining, among others (Glenn County 1997).

CalTrans Bridge Repairs. The California Department of Transportation maintains bridges over Stony Creek in Glenn County for three highways: Interstate 5, State Highway 32, and State Highway 45.

Interstate 5 crosses Stony Creek over two double-lane bridges, one each for northbound and southbound traffic. These bridges were constructed in 1966 and span 335 feet. Each bridge consists of concrete deck supported by 18 sets of 7 circular support columns. Highway 32 crosses Stony Creek on a two-lane bridge spanning 1,500 feet and consists of a concrete deck supported by twenty pier walls. The support pier walls are tied to underlying pilings by footings, originally constructed six feet below the stream bed. Flood flows impinge on the western (right bank) riprapped fill slope, and a component of the flow is directed from this towards the eastern (left bank) end of the bridge. Since construction of the bridge in 1976, the channel has degraded up to 16 feet on the thalweg of the channel, exposing the footings of the five easterly support piers. Highway 45 crosses Stony Creek just downstream of the GCID Main Canal on a 620-foot-long, two-lane concrete bridge supported by seven piers with footings 6 feet below the channel bed. Up to three feet of degradation was observed within several years of bridge construction in 1974, but the bed has remained stable since (Swanson & Associates, 1991).

The fluvial processes of Stony Creek have been influenced by flood control projects and in recent years by in-stream gravel and sand extraction. As a result of these activities and of changes in sediment transport characteristics, Stony Creek has experienced morphological changes. Channel-bed degradation and undermining of bridge piers has occurred. Such changes are the most severe at the Highway 32 bridge, where the bed has degraded up to 16 feet (Chang, 1992).

E. Channel Geomorphology

This section describes the pre- and post-dam fluvial geomorphology of Stony Creek between Black Butte Dam and the Sacramento River. Black Butte Dam, constructed in 1964, altered the flow and sediment transport to lower Stony Creek. Gravel extraction has also changed the sediment transport and the geomorphology of the creek. These changes have had impacts on the land use, vegetation, and fisheries along lower Stony Creek.

Swanson and Kondolph (Kondolph and Swanson, 1992, 1993; Swanson and Associates; 1991) established reach names based on the geomorphic characteristics of lower Stony Creek, which are used in this section of the Plan. Reach 1 extended from Black Butte Dam to the I-5 bridge; Reach 2 extended from I-5 to Road P; Reach 3 extended from Road P to Mills Orchard; and Reach 4 extended from Mills Orchard to the Sacramento River. They analyzed, reported, and summarized the geomorphic characteristics of the creek using this nomenclature. For this reason, their stream reach nomenclature has been maintained in this section of the Plan. Figure 2-12 shows the correspondence of Swanson and Kondolph's reaches to the reaches used in other section of the Plan.

For other sections of the Plan, the reaches are classified according to discharge outflow points. The reaches are also named (1 through 4) in the downstream direction beginning at the dam, but have different beginning and ending points from the Swanson-Kondolph reaches.

The information presented in this section was derived from (1) a reconnaissance field tour, (2) an aerial photograph interpretation, (3) a review and analysis of existing data, and (4) a channel mapping from existing aerial photographs. Members of the geomorphic review team (which included a geomorphologist and biologist from Jones and Stokes Inc., a biologist from CH2MHILL, and three biologists from Reclamation) visited a limited number of accessible locations on Stony Creek on a field tour December 29, 1995. Conditions at access points were observed. Three sets of aerial photographs were used for the current analysis. Three-inch by five-inch color photos from 1993 were assembled, and nine-inch by nine-inch black and white photos from 1996 were photocopied to match the scale of the 1993 photos. Visual comparisons were also made with 9-inch by 9-inch black and white aerial photos from 1956. Numerous reports and memoranda were consulted, but most of the information was taken from the work of Kondolph and Swanson (1992, 1993) and Swanson and Associates (1991). Swanson also supplied rough notes from which his original report was compiled. Channel planform configurations taken from the 1993 and 1996 aerial photographs were hand drawn and compared.

Geomorphic Setting

Stony Creek drains about a 700-square-mile watershed on the east-facing slope of the Coast Range, flowing into the Sacramento River near Hamilton City. The main tributary streams drain eastward from their headwaters into a broad north-south trending valley through which Stony Creek flows northerly for about 30 miles to its confluence with Grindstone Creek. From that confluence, Stony Creek flows northeasterly about 10 miles to Black Butte Reservoir. The valley of upper Stony Creek (above Black Butte Dam) is bounded on the east by a narrow range of north-south trending hills of older sedimentary rocks. Black Butte and the adjacent basaltic ridges are geologic and topographic breaks within this range. At Black Butte Dam, Stony Creek passes through a gap in these hills (Elevation 385 feet). Lower Stony Creek (below Black Butte Dam) flows over its alluvial fan deposits southeastward towards its confluence with the Sacramento River (Elevation 121 feet) (Kondolf and Swanson, 1992, 1993; Swanson and Associates, 1991).

The channel geomorphology of lower Stony Creek has changed since 1950 when an aerial survey was completed. Some of the major changes can be attributed to dam construction in 1964 (Kondolf and Swanson, 1993). The longitudinal bed profile of lower Stony Creek from Black Butte Dam to the Sacramento River is concave facing upwards, typical for alluvial channels. The bed slope tends to decrease from about 0.0024 in the portion near the dam to less than half of that, 0.0010, near the Sacramento River (Swanson and Associates, 1991). The pattern of this longitudinal bed profile has remained largely the same; however, it has increased in concavity because of channel bed lowering in the mid-portions of lower Stony Creek. The planform morphology of lower Stony Creek changed after dam closure from a predominately braided channel to one that is more of a single, meandering channel.

Pre- and Post-Black Butte Dam Conditions

To establish baseline data, the geomorphic conditions prior to dam construction and prior to the major effects of gravel extraction were considered. Hydraulic and fluvial geomorphic conditions that could potentially influence land use, vegetation, and fisheries were identified.

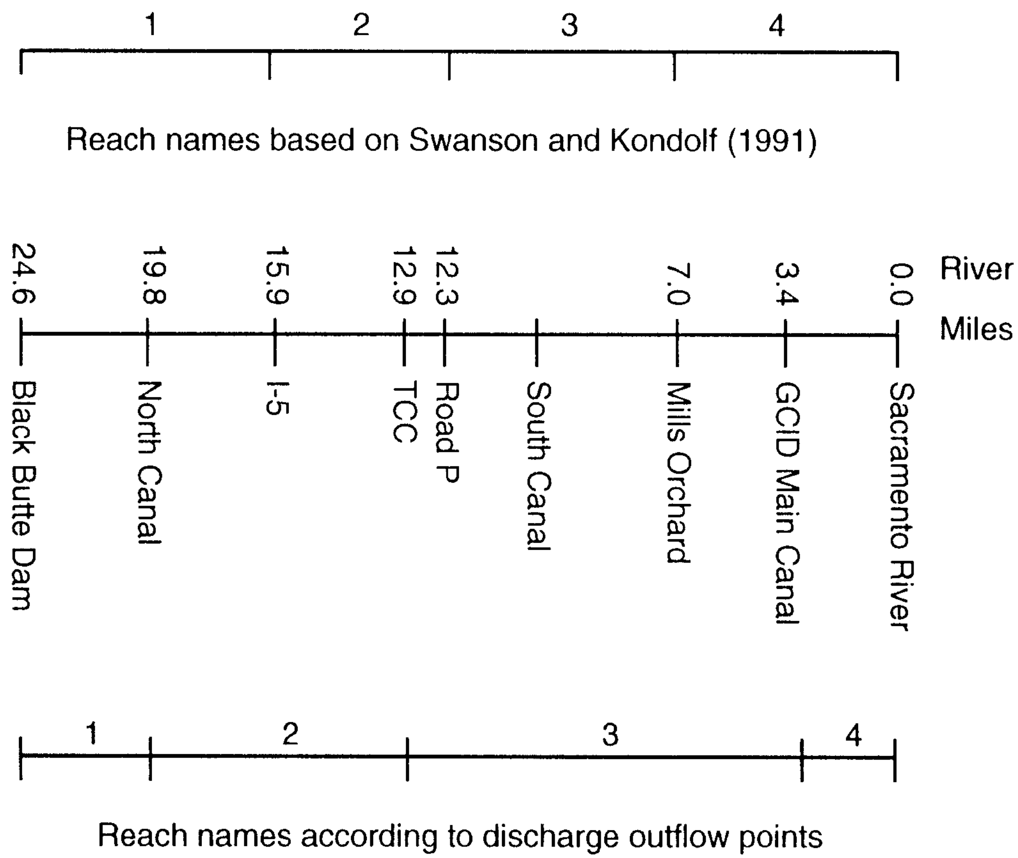

FIGURE 2-12
REACH NAMES COMPARED
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The pre- and post-dam conditions are presented in matrix format in Table H-1 in Appendix H.

Hydraulic Conditions. The North Canal is located in the endpoint of Reach 1 (Figure 2-9, page A-2-15). The hydrograph for part of this reach will differ from the inflow hydrograph from Black Butte Dam depending on the operation of the North Canal. The TCC is located approximately 0.5 mile upstream from the end of Reach 2. The hydrograph for part of this reach will differ from the inflow hydrograph from directly upstream depending on the operation of the TCC. The outfall of the South Canal, located in the mid-portion of Reach 3, and the GCID main canal located at the downstream end of Reach 3, will alter the hydrograph for part of this reach.

Since construction of the dam on Stony Creek channel width and sediment transport have been reduced in the upper reaches. This is offset by the increase in duration of these flows, which would tend to increase the depth of the channel, and transport any fine sediment downstream. In each geomorphic reach of Stony Creek, there are water diversions, leading to reduced flows in each downstream reach. The water release pattern into Stony Creek is less abrupt than a natural pattern but tends to increase bank slope, which increases channelization and bank erosion and decreases channel stability, due to the magnitude of the releases.

Comparing 1956 and 1996 aerial photos shows that channel width has tended to decrease as the stream went from a braided wide channel to a single meandering channel. Channel depth has tended to increase accordingly during this period. Channel slopes have remained relatively the same, except for Reach 1 which has a reduced slope because of the increase in channel sinuosity. Crude estimates of the median size of the bedload were analyzed from data from Kondolph and Swanson (1992, 1993) and Swanson and Associates (1991) for all reaches but Reach 2.

Fluvial Geomorphic Conditions. Lower Stony Creek has tended to become a more sinuous and less braided channel since construction of Black Butte Dam. Pre-dam, the channel was a braided system where the channel carrying the main flow periodically shifted location. The current stability was determined from comparisons of sequential aerial photos from 1993 and 1996. A site-specific discussion of Stony Creek, given below, considers site-specific examples of channel stability. The rate of change of the channel planform could also be assessed with future work using existing data sources. Since construction of Black Butte Dam, the channel has tended to incise below the floodplain except in Reach 2. A theoretical annual sediment transport rate could be calculated considering both the magnitude and duration of the flows comprising a yearly hydrograph. While it is clear that the sediment supply has decreased due to a reduction in recruitment, it is not clear whether the annual transport rate has increased or decreased.

Because Table H-1 (Appendix H) was constructed to identify (quantitatively, where possible) the pre- and post-dam geomorphic changes, the bottom row provides a good overall summary of the tendency of change. This summary can be used as a general guideline for assessing the impacts of pre- and post- Black Butte Dam conditions on channel geomorphology. It is shown that both the two-year and ten-year floods have decreased in magnitude since construction of the dam, but the duration of flood flows have increased. With reservoir releases, more abrupt changes occur in downstream elevations, accelerating bank erosion. The overall slope of the creek channel has not changed except for Reach 1 which is decreasing because of change in planform shape.

Current Longitudinal Changes in Fluvial Geomorphology Along Stony Creek. Because the different reaches of lower Stony Creek display different geomorphic characteristics, understanding the longitudinal changes helps to assess the values for vegetation and fisheries concerns.

Figure 2-13 shows the variation in particle size from the Sacramento River to Black Butte Dam. These data were derived from bulk samples taken and tabulated by Kondolph and Swanson (1992, 1993). A definite coarsening of particle sizes in the upstream direction is apparent. These samples were taken on the upstream end of point bars in a location that characteristically represents the size of the active bedload in the channel. With field studies, the sizes of these samples could be correlated with the sizes of bed material directly on the bed of the stream. It is likely, although not validated, that the bed material size has a similar pattern of variation, going from coarser in the upstream reaches to finer in the downstream reaches. These data are useful for considering longitudinal changes in bed particle sizes that may effect fish spawning habitats.

Streambed substrate samples collected by Vogel (1996, 1997) in the two mile reach downstream of Black Butte Dam indicated that Stony Creek exhibited a considerably lower proportion of fines <0.85 mm than evident in eastside tributaries of the Sacramento River, but the proportion of coarser fines <4.75 mm was considerably higher in Stony Creek as compared to other Sacramento River tributaries.

Aerial photographs from 1956, 1993, and 1996 (with reference to 1992 photos) were used to examine the pattern of change longitudinally and site-specific changes. The 1956 photos showed the channel condition before dam construction. Superposition of 1993 and 1996 planforms, which were photographed at roughly the same discharge, were used to compare the channel locations in those two time periods. The 1992 channel planform, which was digitized for the maps in this report (Figure 2-14, 2-15, and 2-16), was photographed at a significantly higher discharge and did not reveal the same detail for assessing planform change.

Lateral channel migration or longitudinal variation between 1993 and 1996 has not been shown to be statistically significant.

Channel Incision on Lower Stony Creek Since Construction of Black Butte Dam. Channel incision has occurred in Reach 3 associated with gravel extraction (Swanson and Associates, 1991). A local longitudinal profile of the creek bed shows the extent of this incision between 1967 and 1990 (Figure 2-17). This channel incision has possible implications for riparian vegetation near this reach. Channel incision may lower the groundwater table near the channel and affect vegetation growth.

Site-Specific Comparison of Aerial Photographs. This section describes the current trends in changing channel geomorphology that may impact future management options for lower Stony Creek. Aerial photographs from 1956, 1993, and 1996 show channel changes in these time intervals. This section stresses site-specific areas where channel migration was significant between 1993 and 1996. The digitized maps shown in Figures 2-14, 2-15, and 2-16 show the channel in 1992 and in 1996. The 1993 aerial photographs were not digitized. The 1992 aerial photographs were made at a discharge higher than that in 1996 making visual comparisons difficult. The 1993 photos were taken at a discharge that was similar to the 1996 discharge and, therefore, revealed the actual changes in channel morphology better than the 1992 maps.

What this discussion calls "significant channel migration" may, in fact, be channel avulsion. Channel avulsion is the rapid shifting of channel location. A typical meandering river will not move a distance greater than one-half of a channel width in 3 years. All of the areas described here as "significant channel migration" show channel movement greater than one channel width, with most locations showing three to five channel widths of movement over the 3-year period between 1993 and 1996. This could occur because of channel avulsion rather than progressive bank retreat (migration). Broad averages for alluvial river migrations are on the order of one channel width in 50 years (Larsen, 1995). Even if the "natural" meander migration rate of a highly erodible bank were 10 times that amount, that would result in channel migration of one channel width in 5 years. All areas identified as "significant" showed migrations greater than that amount.

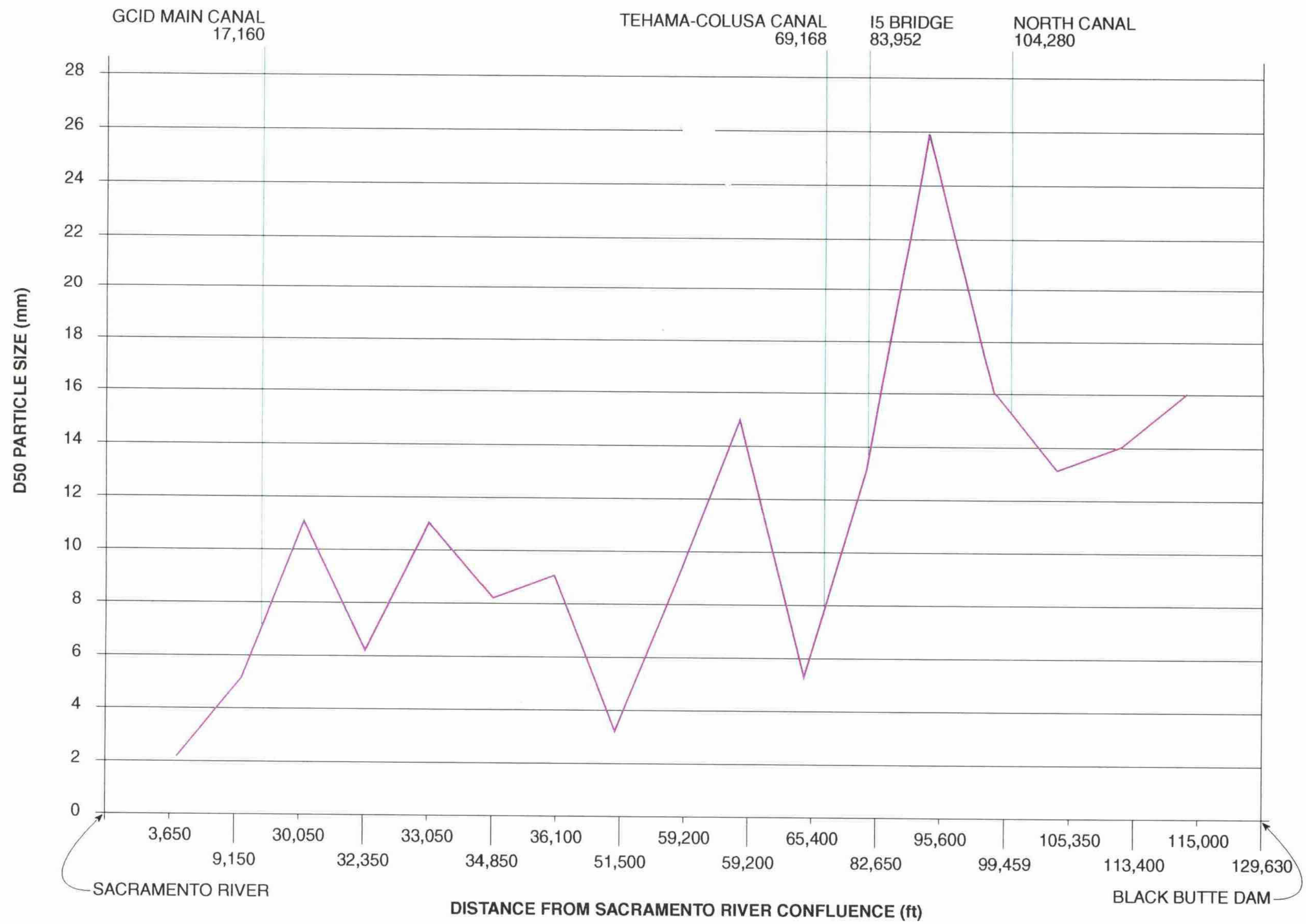

FIGURE 2-13
CHANGE IN PARTICLE SIZE WITH UPSTREAM DISTANCE
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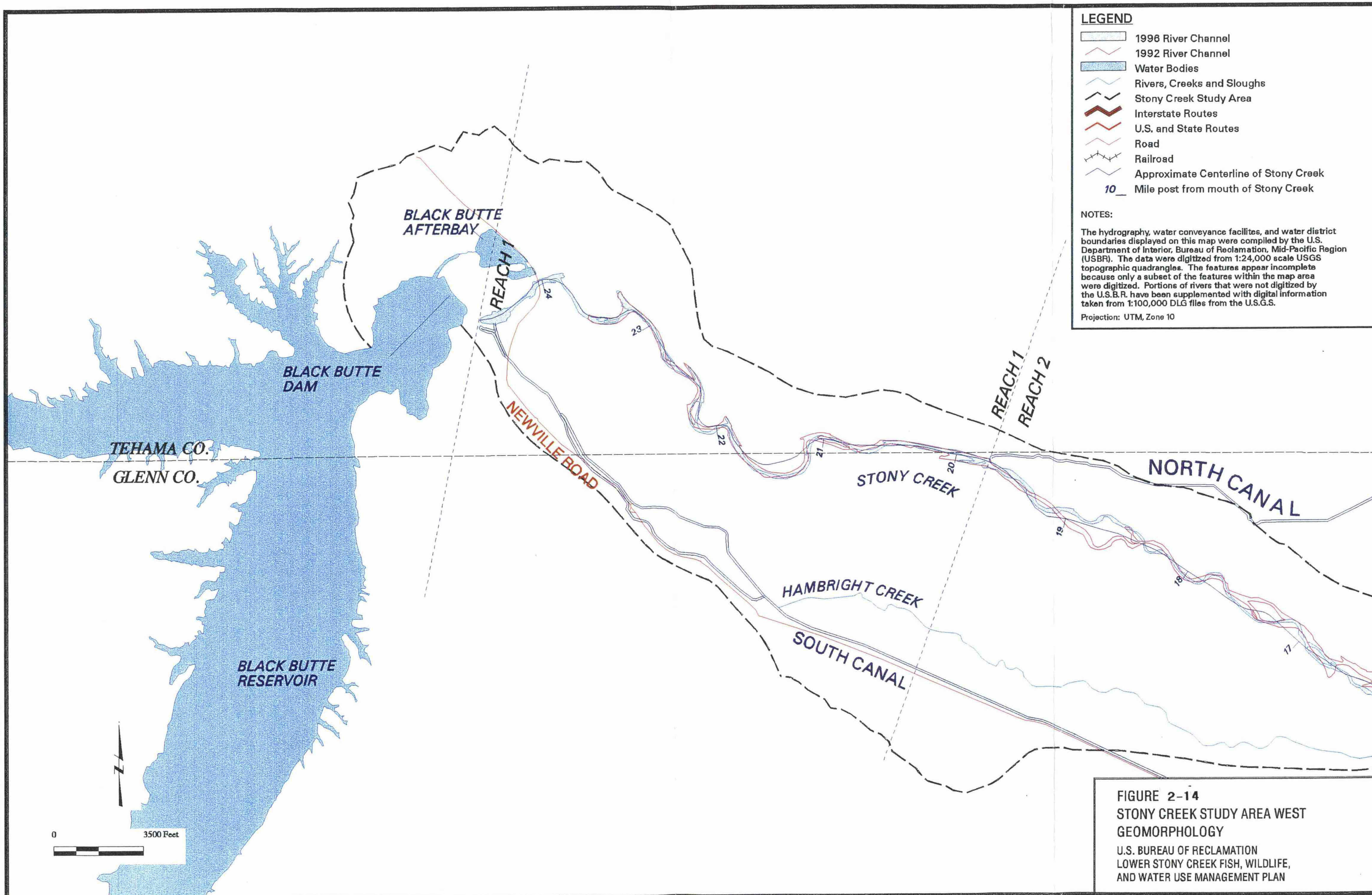

FIGURE 2-14
STONY CREEK STUDY AREA WEST
GEOMORPHOLOGY
U.S. BUREAU OF RECLAMATION
LOWER STONY CREEK FISH, WILDLIFE,
AND WATER USE MANAGEMENT PLAN

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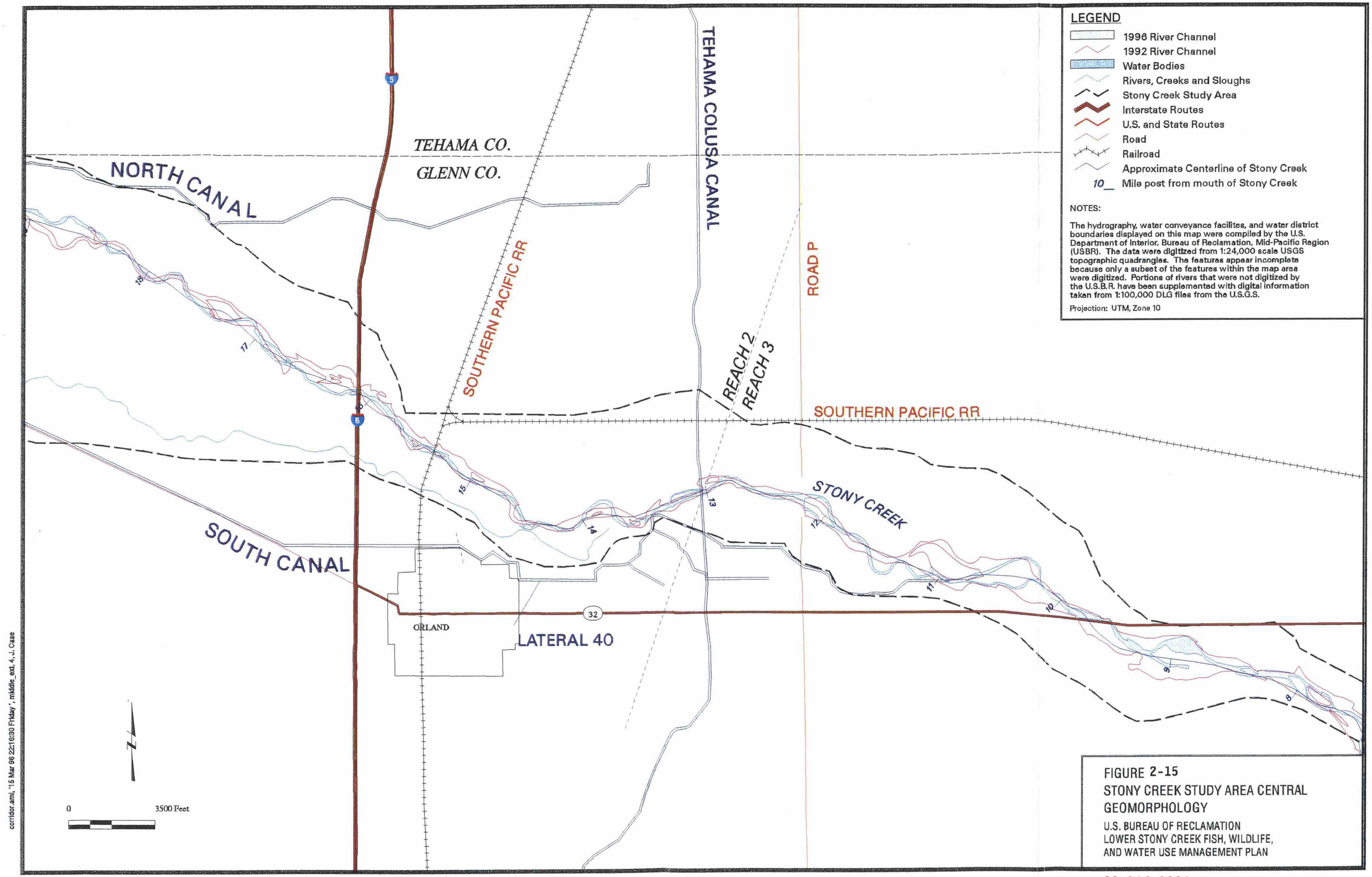

FIGURE 2-15
STONY CREEK STUDY AREA CENTRAL GEOMORPHOLOGY

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