3.5 CHANGES IN CHANNEL GEOMORPHOLOGY

3.5 CHANGES IN CHANNEL GEOMORPHOLOGY

Introduction

Section 3.2 presented the general geomorphic and geologic background and history of the Cache Creek Basin. Section 3.5 focuses more on the specifics of the study reach and discusses the significant geomorphic changes that have occurred over time.

Methods

The following sections briefly describe the methods used to assess the significant changes that have occurred in the primary study area.

Base Maps

A 1:12,000 base map of the study reach (Figure 3.5-1) was developed from USGS 7.5 minute quadrangle maps enlarged to 12,000 scale (1 inch equals 1,000 feet). River stationing with 10,000 feet between tick points was added to the base mapping. All distances are measured in the upstream direction with station 0+00 located at the crest of the weir in the Corps of Engineers settling basin. The upstream end of the study reach is at the Capay Dam at station 1500+00. Figure 3.5-1 shows the approximate extent of the Cache Creek Streamway Study area with the settling basin and weir at the downstream end. Figure 3.5-1 also shows the river stationing, approximate location of cities and towns, highlights the County's Mineral Resource Zone (MRZ), outlines the approximate lateral extent of the channel boundary according to the 1979 Interim Mining ordinance, shows the locations of major roads, creeks and canals, and indicates the locations of the main study reach and individual subreaches.

The base map was used throughout the field and office investigations to locate in a consistent way key geomorphic features in the study area, field sampling sites, roads, bridges and canals, mining operations and other physiographic information.

Plan Form Changes

Plan form changes in the channel of Cache Creek were mapped from historical aerial photographs and topographic maps listed in Tables 3.5-1 and 3.5-2. The original source data were at various scales, but were mapped onto a consistent basemap at a uniform scale of 1:12,000 (1' = 1,000 feet) using a Bausch and Lomb Zoom Transfer Stereoscope (ZTS). In mapping from aerial photography, key features were located in relation to fixed landmarks (e.g., road intersections, road bends, bridges, buildings, etc.) appearing on the topographic base map. Adjustments to scale, orientation, and stretch were made according to industry standards to keep landmarks properly superimposed. This is particularly important with older photography, which tends to

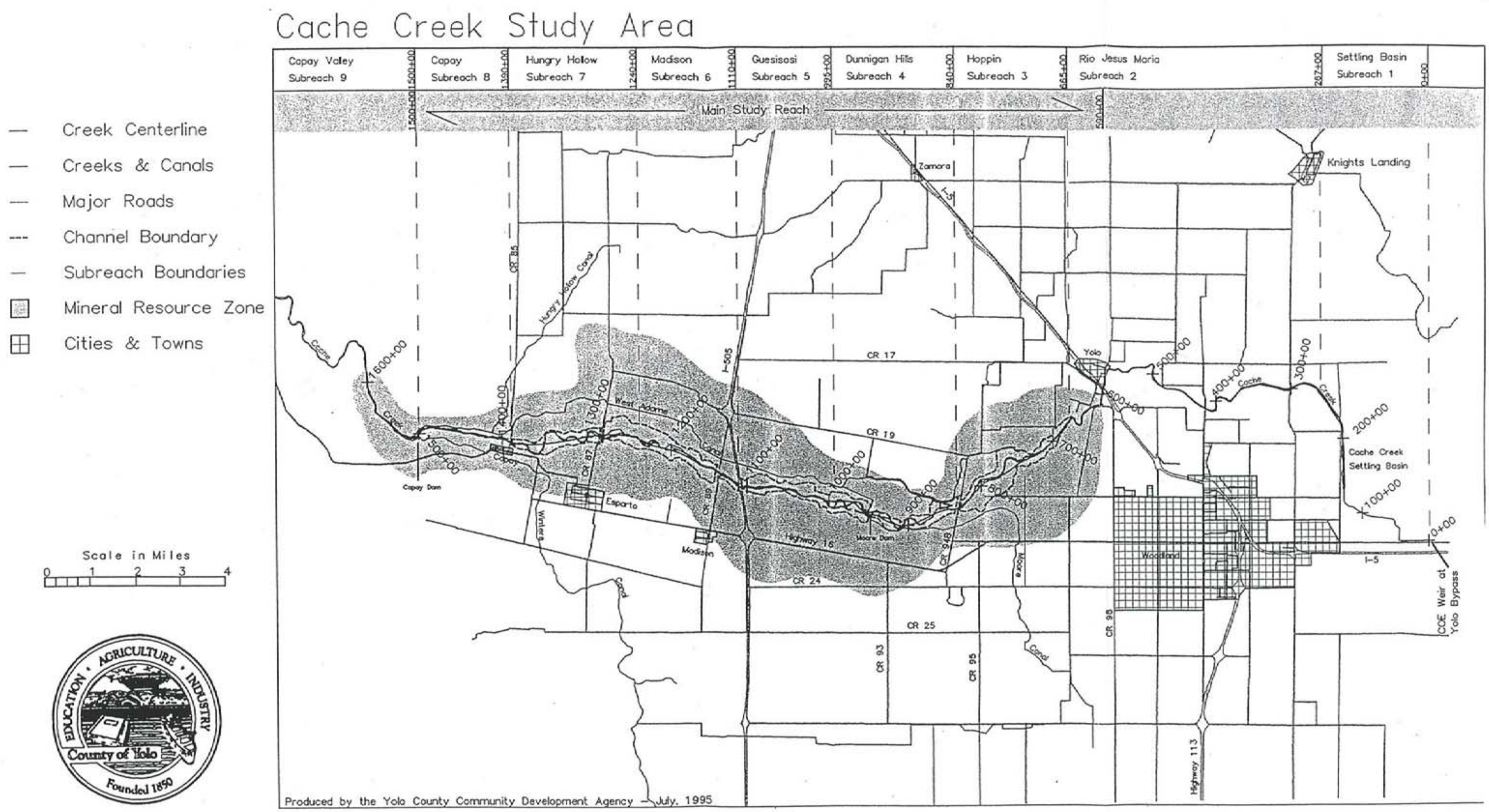


Figure 3.5–1 Cache Creek Study Area

Table 3.5-1 Maps Utilized in This Study

Year Surveyed	Year Published	Scale	Agency	Title	Coverage/Comments
1857	1857	1" = 2,640'	US Surveyor General	Plat of the Rancho Jesus Maria	Stevens Bridge to Sacramento River
1859	1859	1" = 2,640'	Charles F. Reed, Surveyor	Map of a Part of the Rancho Canada de Capay (known as "Arnold and Gillig Subdivision Map")	Brooks to Madison Bridge Site
1857	1857	1" = 2,640'	US Surveyor General	Plat of the Rancho Canada de Capay	Rumsey to Madison Bridge site
1857	1857	1" = 2,640'	US Surveyor General	Plat of the Rancho Guesisosi	Madison Bridge to Stevens Bridge This map includes no detail of river channel or land features.
1905	1907	1" = 5,280'	US Geological Survey	Davisville Quadrangle (15-minute topographic map)	Downstream of Yolo to end of Cache Creek
1905	1907	1" = 5,280'	US Geological Survey	Woodland Quadrangle (15-minute topographic map)	Esparto to Downstream of Yolo
1905 *+	1915	1" = 2,640'	US Geological Survey	Yolo Quadrangle (15-minute topographic map)	Upstream of Stevens Bridge to Downstream of Yolo
1905 *+	1916	1" = 2,640'	US Geological Survey	Jacobs Corner Quadrangle (15-minute topographic map)	Esparto to Upstream of Stevens Bridge
1905 *+	1916	1" = 2,640'	US Geological Survey	Esparto Quadrangle (15-minute topographic map)	Capay to Esparto
1912	1912	1" = 200'	Yolo Water & Power Co.	Map Showing Location of Capay Diverting Canal	About 1 Mile of River Channel at Capay Dam.
1912	1912	1" = 400'	Yolo Water & Power Co.	Maps of Water Dristribution System on which Cache Creek Channel is Shown	Various Reaches from Capay Dam to Yolo
1914	1914	1" = 100'	Yolo County	Map of a Portion of Cache Creek along Proposed Esparto Bridge Crossing	Esparto Bridge Plan & Profile

Table 3.5-1 (cont')

1949 +	1952	1" = 2,000'	US Geological Survey	Woodland Quadrangle	Upstream of Stephens Bridge to Downstream of Yolo
1949 +	1953	1" = 2,000'	US Geological Survey	Madison Quadrangle	Esparto to Upstream of Stevens Bridge
1957 +	1959	1" = 2,000'	US Geological Survey	Esparto Quadrangle	Brooks to Esparto
1978	1981	1" = 2,000'	US Geological Survey	Woodland Quadrangle	Photorevision of 1952 Edition
1978	1980	1" = 2,000'	US Geological Survey	Madison Quadrangle	Photorevision of 1953 Edition
1987	1993	1" = 2,000'	US Geological Survey	Esparto Quadrangle	Photorevision of 1959 Edition
1980 +	1980	1" = 200'	Yolo County	Annual Report	Capay Bridge to Upstream of Yolo
1994 +	1994	1" = 200'	Yolo County	Aggregate Extraction Monitoring Program - Cache Creek	Capay Dam to I-5

+ Indicates map used in documenting cross section changes.
* Indicates map used in mapping of planform changes.

TABLE 3.5-2

AERIAL PHOTOGRAPHS EXAMINED IN THIS STUDY

Year	Date	Scale	BW/C	Agency	Coverage/Comments
1937	9/37	1:20,000	BW	National Archives	Earliest AP's found of study area
1952	9/17	1:20,000	BW	SCS	Yolo County
1964	6/12	1:20,000	BW	SCS	Yolo - Guinda
1969	March/April	1:6,000	BW	Yolo County Flood Control	Yolo - Rumsey/ Oversized, not stereo
1978	2/29	1:12,000	BW	DWR	Yolo to Capay/ Not stereo
1980	2/20	1:6,000	BW	Yolo County/(Aero-Geodetic)	Yolo to downstream of Stevens Bridge
1981	1/14	1:6,000	BW	Yolo County/(Aero-Geodetic)	Moore Dam to Steven's Bridge
1982	4/19	1:12,000	BW	Yolo County/(Aero-Geodetic)	Yolo to Capay
1983	10/19	1:6,000	C	USACE (Cal Aero)	Yolo - Capay - Rumsey
1984	4/24	1:6,000	C	USACE (American Aerial Surveys)	Yolo - Capay Valley
1984	10/31	1:12,000	BW	Yolo County/(Aero-Geodetic)	Yolo to Capay
1985	6/10	1:6,000	BW	USACE (Cal Aero Photo)	Yolo - Capay
1985	11/1	1:12,000	BW	Yolo County/(Aero-Geodetic)	Yolo - Capay (incomplete)/ Missing Moore Dam (2-13, 2-14) and Stevens' Bridge to Teichert (3-1, 3-2, 3-3, 3-4, 3-5, 3-6, 3-7)
1986	2/21	1:12,000	BW	Yolo County/(Aero- Geodetic)	Capay to Esparto/ High Flows
1994	10/21	1:12,000	BW	Yolo County/(Aero Geodetic)	Capay Dam - Yolo/ Post extraction annual photography, base for field mapping and for County photogrammetry/GIS

display more radial distortion. The 1:12,000 mapping scale permitted us always to have several landmarks in the frame of view, whereas a larger scale (such as 1:6,000) would not.

The working maps were digitized for entry into Yolo County's GIS system by Mr. Kevin Yarris of the Yolo County Planning Department, in consultation with NHC. Mr. Yarris and his assistants prepared draft renderings of the historical mapping series, NHC reviewed and refined the draft renderings and returned them to the County for finalization through Mr. Yarris' department. A series of historical maps were developed depicting approximate channel conditions (high bank location, approximate low flow channel location, active and inactive mining operations, levees, pits, gravel processing plants, and roads and bridges) for the time periods of (1) pre-1937 [circa 1850], (2) 1937, (3) 1952/53, (4) 1964, (5) 1978, and (6) 1981-1994. Historical channel changes, active channel boundaries and gravel operations were mapped from several sets of aerial photographs obtained for each period listed above. The circa 1850 channel conditions were approximated from early land grant plats and U.S. Survey General maps of the area (1857-59), geomorphic evidence obtained from the 1937 photo series, 1905 USGS quadrangle maps, and 1912-14 Yolo Water & Power Company mapping.

Early editions of the US Geological Survey topographic maps were used as sources for the channel location (and cartographer's interpretation of channel width). We used the first editions of the 15-minute map series, based on surveys in 1905, as well as the original editions of the 7.5 minute maps based on aerial photography flown in 1905 and published in 1916. In addition, we utilized 1912, 1"=200' scale survey maps prepared by the Yolo Water & Power Co. of local reaches of the channel. See Tables 3.5-1 and 3.5-2 for lists of the maps and photographic series utilized during the study.

Plan form and channel cross section changes are summarized in the six historical map sets shown in Figures 3.5-2 through 3.5-7 for the periods: 1937, 1952/53 (some of these photos were taken in 1952, some in 1953), 1964, 1978, and 1981 through 1994. Information recorded on these plates were also entered into Yolo County's GIS system.

Features mapped onto Figures 3.5-2 through 3.5-7 from each set of aerial photographs include:

Edge of Active Channel

The edge of active channel was defined by an escarpment clearly visible on the aerial photographs viewed stereoscopically and typically corresponding with a significant vertical change in bank elevation and often, in vegetative cover. The active channel was redefined for each year mapped, i.e., as formerly active portions of the channel bed were changed by incision or other activities. The long-term trend observed was that the former extent of the active channel became smaller with time due to agricultural encroachment, levee building, road and bridge construction, installation of irrigation diversion structures and aggregate extraction. Where levees isolated portions of the formerly active channel, we mapped the currently active channel as lying within the levees. However, exclusion of these levied areas from the "active" channel does not imply that large floods would be incapable of overtopping or breaching the levees and reactivating the isolated surfaces.

Channel Conditions for Pre-1937

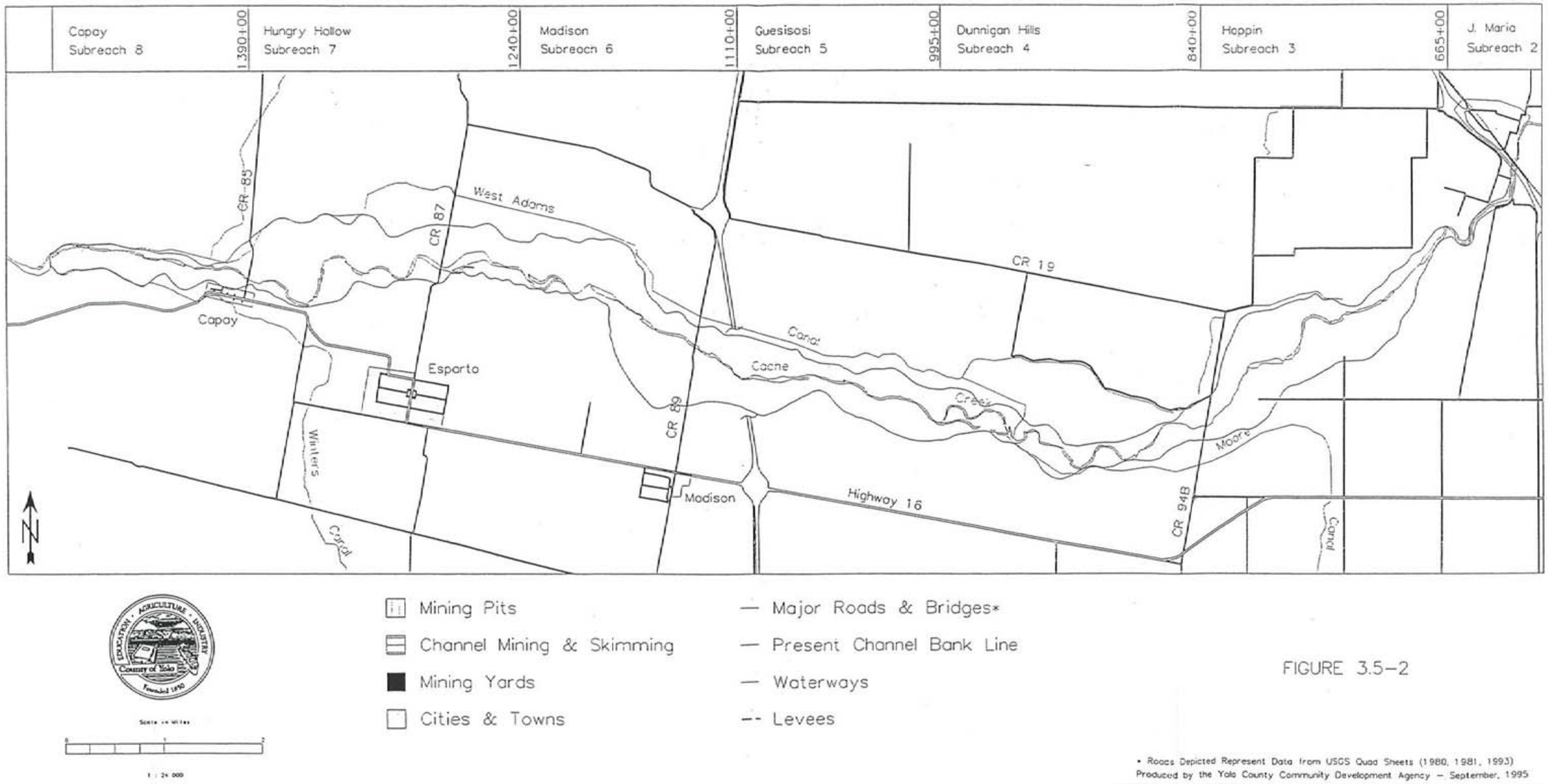


FIGURE 3.5–2

* Roads Depicted Represent Data from USGS Quad Sheets (1980, 1981, 1993)
Produced by the Yolo County Community Development Agency – September, 1995

Channel Conditions for 1937

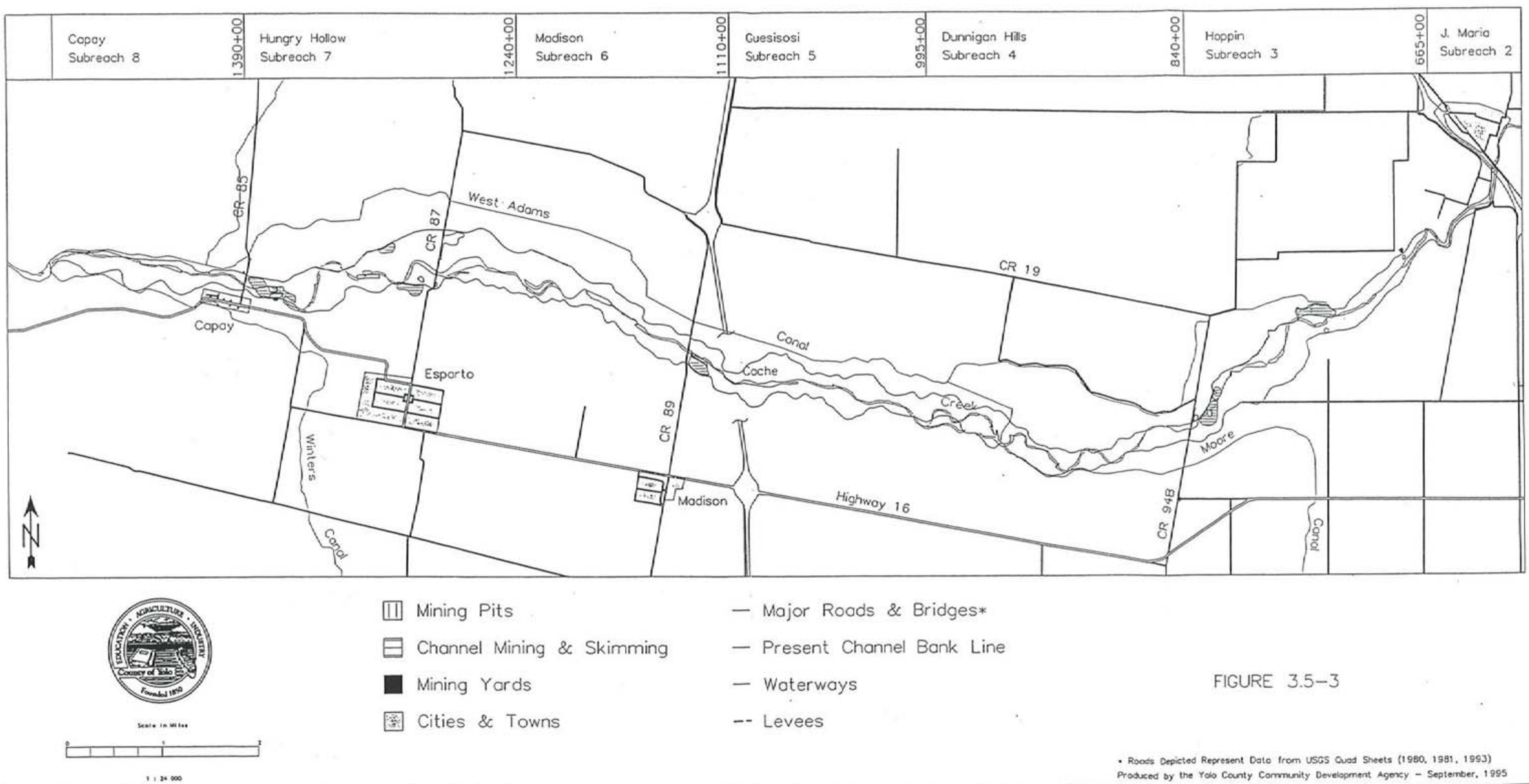


FIGURE 3.5-3

* Roads Depicted Represent Data from USGS Quad Sheets (1980, 1981, 1993)
Produced by the Yolo County Community Development Agency – September, 1995

Channel Conditions for 1952

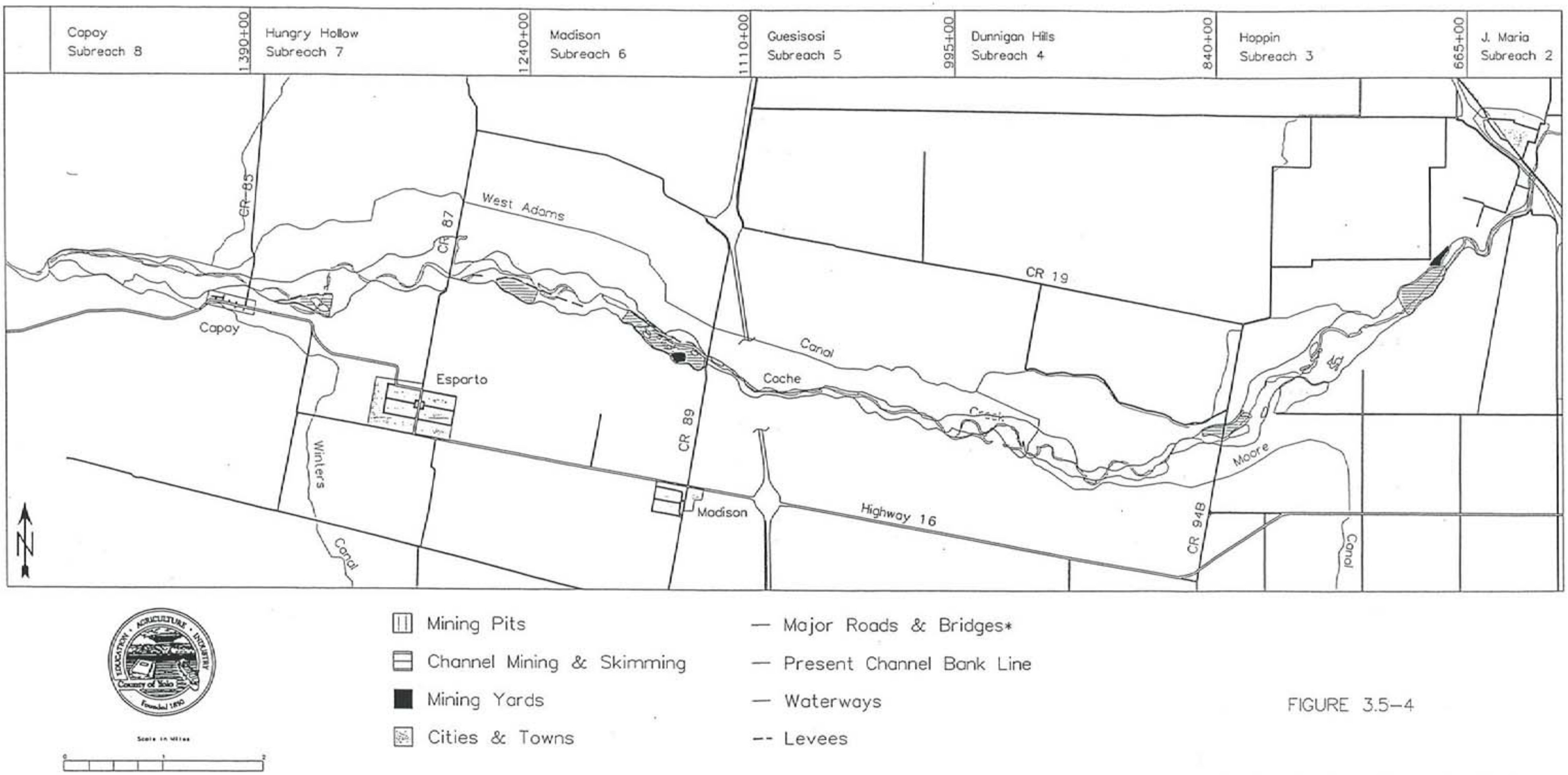
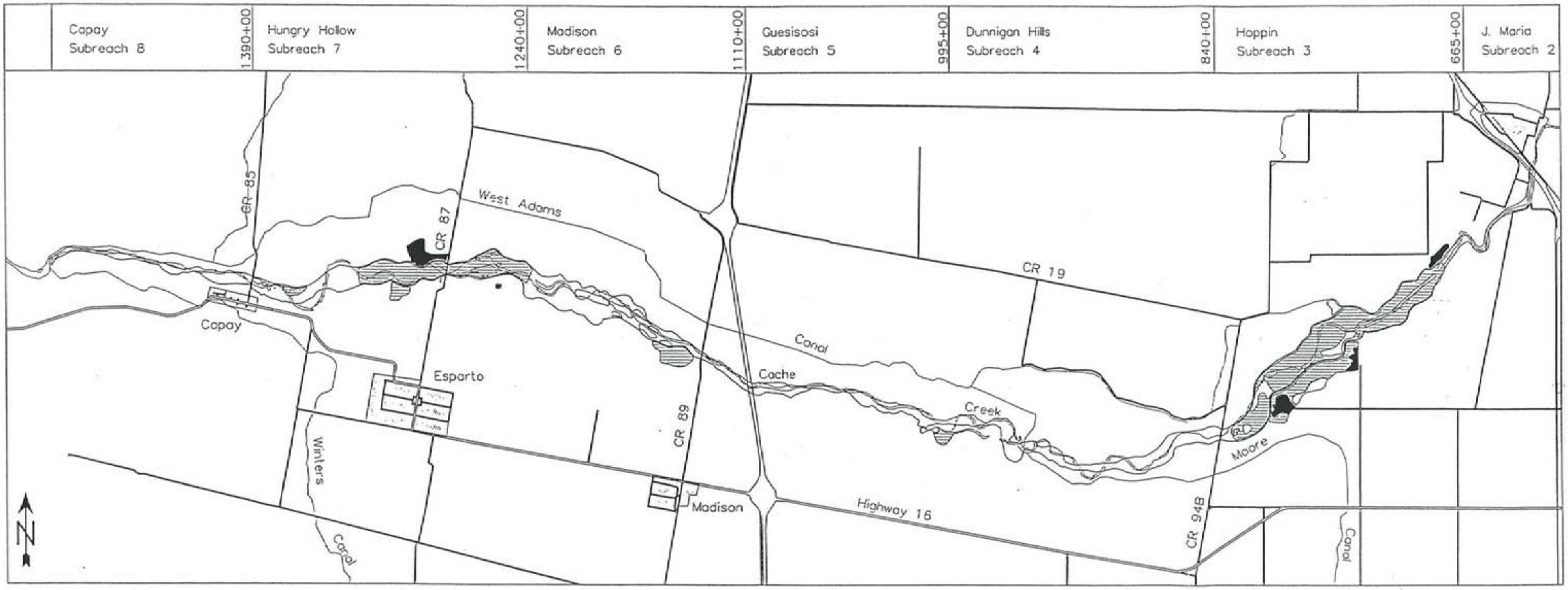


FIGURE 3.5–4

* Roads Depicted Represent Data from USGS Quad Sheets (1980, 1981, 1993)
Produced by the Yolo County Community Development Agency – September, 1995

Channel Conditions for 1964



Mining Pits
Channel Mining & Skimming
Mining Yards
Cities & Towns

— Major Roads & Bridges*
— Present Channel Bank Line
— Waterways
-- Levees

FIGURE 3.5–5

* Roads Depicted Represent Data from USGS Quad Sheets (1980, 1981, 1993)
Produced by the Yolo County Community Development Agency – September, 1995

Channel Conditions for 1978

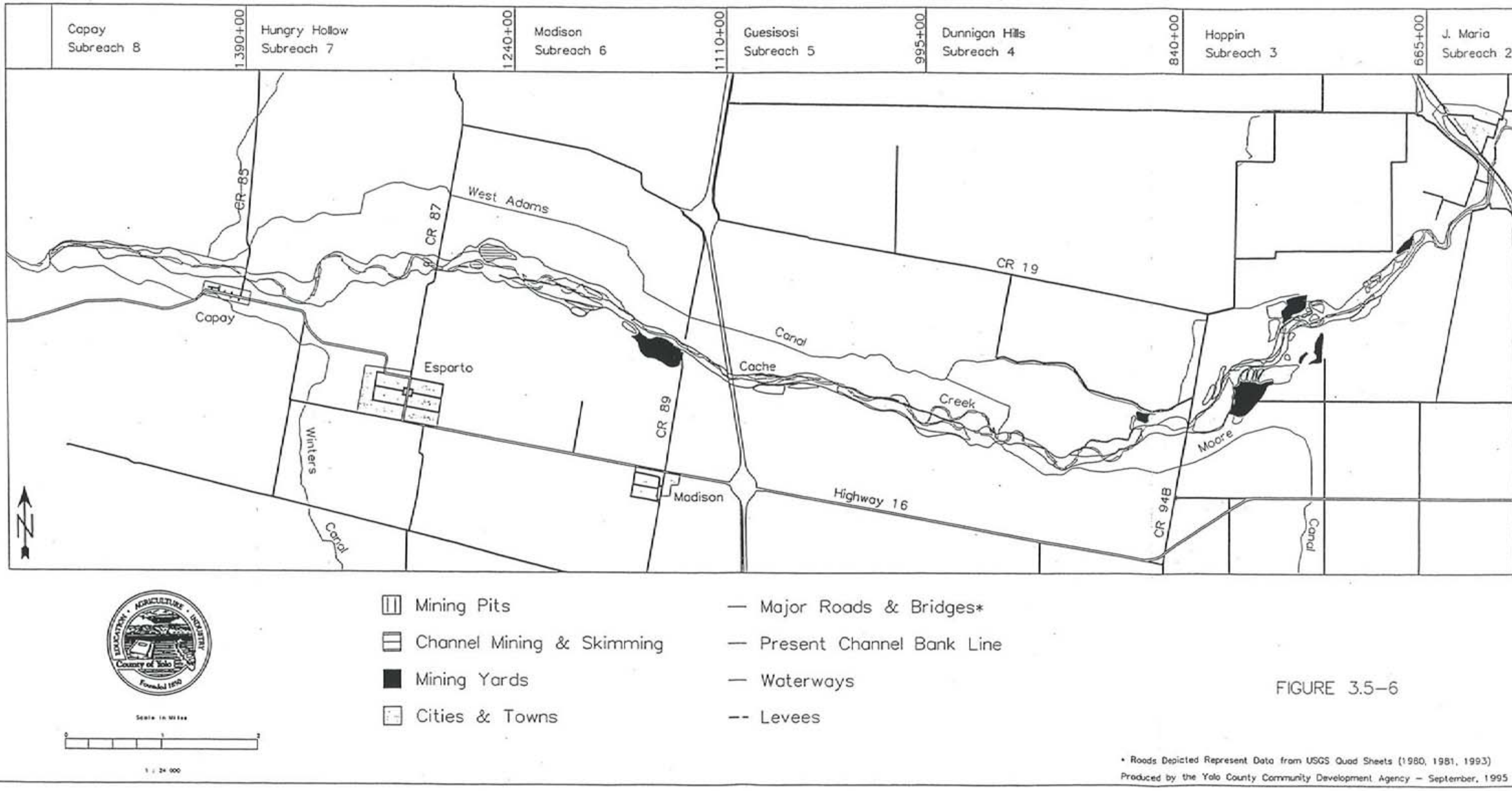
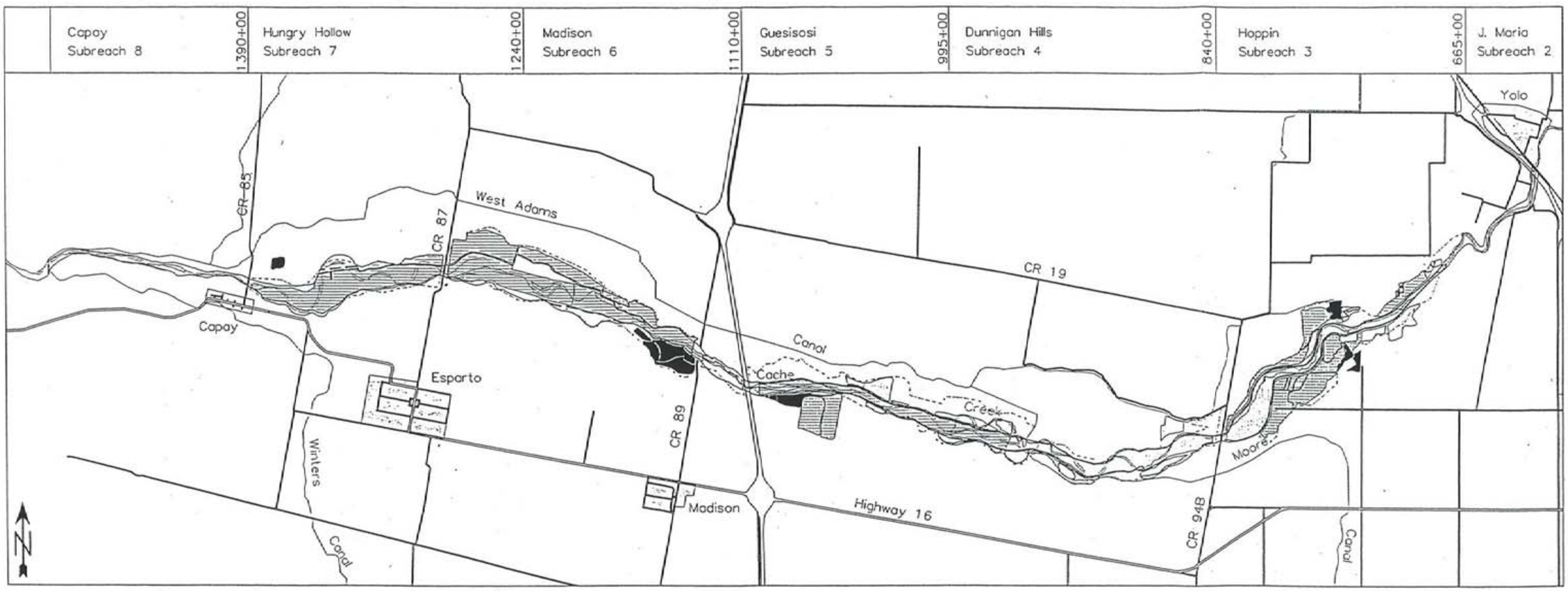


FIGURE 3.5–6

* Roads Depicted Represent Data from USGS Quad Sheets (1980, 1981, 1993)

Produced by the Yolo County Community Development Agency – September, 1995

Channel Conditions for 1981–1994



- Inactive Mining
- Channel Mining & Skimming
- Mining Yards
- Cities & Towns
- Major Roads & Bridges*
- Active Mining Pits
- Present Channel Bank Line
- Waterways
- Levees
- Channel Mining Boundary

Scale in Miles
0 1 2
1 : 24 000

FIGURE 3.5–7

• Roads Depicted Represent Data from USGS Quad Sheets (1980, 1981, 1993)
Produced by the Yolo County Community Development Agency – September, 1995

By using the 1937 photography and early maps, we also mapped an historically active channel for the era referred to as pre-1937. This depiction was intended to indicate the approximate extent of the former historical Cache Creek as it may have appeared in the late 1800s and early 1900s.

While the concept of the "active" channel may seem straightforward enough, the extent and inherent geomorphic complexity of the channel and extensive human modifications rendered identification of the active channel in some locations difficult, requiring considerable interpretation.

Low-flow Channel Course

A low-flow channel course was identified and mapped based on the presence of water in the low flow channel in perennial reaches. In ephemeral reaches during the dry season the low flow channel was determined from the topographic expression of a continuous channel depression. However, in reaches heavily modified by extensive aggregate extraction, this proved difficult except where the channel had been trained by trench excavation, or redirection of the low flow channel by low berms had occurred and/or levees constructed to isolate the gravel workings from the active channel. Photo interpretations were made as much as possible in a consistent manner from year to year.

Active Gravel Pits

Active gravel pits were considered to be locations within the active channel or adjacent to the channel where significant excavated depressions were identified on the aerial photographs. Areas identified as active pits might not extend to depths below the designated "theoretical thalweg," however they did appear in the photos to be of more significant depth than a typical bar skimming operation. Such active pit areas were clearly delineated on the 1978 and 1994 aerial photographs in large part because the pits by this time were being dug in regular geometric shapes, and because extraction was concentrated within the limits of the pits. Although most were dug within the formerly active channel, some pits were separated from the present active channel by levees.

Inactive Gravel Pits

Inactive gravel pits were mapped where they could be clearly identified and delineated. In some cases, where pits had been inactive for some time, they had become partly revegetated and were less distinguishable from surrounding terrain.

Dispersed Gravel Mining Activity

Most of the extraction visible in the 1937, 1952/53, and 1964 is markedly different then present day mining activity. Rather then being confined to well defined pits and more localized areas, earlier gravel operations were dispersed across the channel in a chaotic landscape of small pits and skimming operations. Mapping these extraction areas required creation of an additional category that we called "dispersed gravel mining activity." The limits of these areas were more difficult to distinguish than the limits of more recent, concentrated areas and pits. Included in this category were some areas that had been subject to regrading and leveling, where surface disturbance had clearly occurred but it was difficult to ascertain whether significant material volumes had been removed. This category does not include mixed reaches that have been reworked by floods. The 1981-1994 mapping shows extensive "dispersed gravel mining" regions within the channel boundary because the 1981-1994 mapping attempted to summarize the cumulative extent of and locations where mining had occurred since 1981. In those reaches where annual gravel bars build up above the designated "theoretical thalweg," dispersed mining in the way of seasonal bar skimming takes place. This occurs in the Hungry Hollow, Madison and Guesisosi subreaches.

Gravel Processing Yards

Gravel processing yards were also mapped. This category included aggregate stockpiles as well as those lands used for aggregate sorting, load, and equipment maintenance.

Observed Cross Section Changes

Representative channel cross sections, typically at each of the bridge crossings along Cache Creek were plotted and examined from topographic maps for 1905 and 1953 conditions and bridge files dating back to 1912. Prior to about 1912, there were only a few permanent bridge crossing on Cache Creek (see Section 3.4 for further discussion of the history of bridges). Cross sections for 1981 and 1994 were plotted from topographic data collected and reported by Yolo County in their annual aggregate summary reports. The 1905 and 1953 cross sections were derived from topographic maps with a five foot contour interval. The 1981 and 1994 maps were derived from data with a two foot contour interval. Consequently, the earlier cross sections are more generalized, but given the magnitude of the channel form they serve adequately as baseline data and provide sufficient detail to show aggradation or degradational trends in channel plan and profile.

Examination of Aerial Photographs

General Observations

The historical channel was significantly wider, shallower and less confined than the present day channel. By 1937 the channel had narrowed and incised. Water diversion structures, bridges and levees had been constructed at some locations, intensive grazing occurred in many areas and stream bed gravels were being mined. Section 3.4 provides more detail of the history of many of these activities.

It was observed that aggregate mining usually occurred in reaches near the bridges. From interviews with long-time residents and miners from Yolo County, NHC learned that in the early years in-channel mining near bridges was encouraged because there was limited vertical clearance and channel capacity through the bridge openings. Mining helped to increase flow capacity, thus temporarily protecting the stability of the bridge. Early mining was also done on a relatively small scale without much mechanization, often being performed with horse drawn scrapers or small steam tractors, wagons and trucks with limited capacity. Market demand was less, and the ability to remove materials in one season was much less than it is today. It was also more advantageous to mine near bridges to minimize haul distances and get the product on the road to market more quickly. Also, materials used to construct roads and bridges were often drawn from the readily available sand and gravel at hand. Miners typically built ramps down into the creek near bridges, removed sands and gravels in the dry periods and got out of the creek in the wet season. Before annual extraction rates became significant, sufficient gravel recruitment usually occurred each winter from adjacent upstream reaches to replenish the mined area from the summer before.

Between 1937 and 1964 the stream continued to narrow and incise. Gravel extraction contributed to localized channel incision; however, in the period from 1900 to about 1953, the construction of all-weather roads and bridge crossings may have contributed more to the narrowing and confinement of Cache Creek than did gravel extraction. Construction of the Capay, Esparto, Madison and Stevens Bridges greatly reduced the channel width at the bridge crossings as indicated in the early plans (see Figure 3.4-12 in Section 3.4) for the construction of the new all-weather road and bridge at Esparto. As shown in Figure 3.4-12, the former channel was approximately 4,000 feet wide and only four to five feet deep in most places. It was characterized by a complex system of multiple channels and sloughs with island and bars often covered with vegetation. Construction of permanent all-weather bridges required construction of a raised road bed across a major portion of the active channel width connecting to the bridge which was usually on the order of 300 to 400 feet long. Materials for the construction of the roads were extracted from the channel immediately upstream and downstream from the road alignment. Yolo County designed and built six permanent bridges across Cache Creek in the early 1900s. Asa Proctor was the County's engineer who, with the aid of a company from San Francisco, designed and built the bridges on Cache Creek out of reinforced concrete made with Cache Creek aggregate. Construction of the approach roads and bridges greatly reduced the effective creek width in the vicinity of the bridges and modified the channel hydraulic conditions in those areas, thus interrupting the flow of water and gravel through the system.

The following discussions summarize important observations from the sets of historical aerial photos and historical maps that were examined.

Pre-1937 Channel

The 1937 aerial photos provide evidence of former channel conditions in relic channel locations, sloughs, alluvial fan deposits, vegetation, and drainage patterns. These indicate that the historical channel was wider then the 1937 channel (see Figures 3.5-2 and 3.5-3). In many cases, particularly below Capay, the active channel was not confined between easily identifiable banks, but rather integrated into a larger disbursed riparian and complex distributary system that extended from Hungry Hollow to the north and Willow Creek to the south. Historical flooding involved extensive land areas downstream from Capay and found the creek losing much of its flow and sediment load out onto the broad floodplain. Old maps, surveyors notes and photographs indicate that many of the irrigation canals developed in the late 1800s and early 1900s may have been former distributary channels and sloughs. Periodic flooding was accepted as part of life on the floodplain. Typically shallow, low energy flooding occurred on the floodplains.

Historically, the Capay and West Adams canals defined the lateral extent of the active channel through the Capay reach. The active channel was an average of 700 to 1,000 feet wider than it is today. Just upstream of the Capay Bridge, at the mouth of the Capay Valley, the stream widened considerably where it debouched from the Capay Valley (e.g., moved from the confined valley out onto the wide floodplain and fan). Aerial photographs suggest that the creek often overflowed north of the present channel into Hungry Hollow where it either percolated into alluvial material or drained back into Cache Creek via a network of small channels.

Throughout the Hungry Hollow reach between Capay and Esparto, the active channel was between 2,500 and 5,000 feet wide. In the 1937 aerial photographs, the channel appeared as a massive, denuded gravel wash (much as it does today, only wider). Extensive gravel bars were evident throughout the active channel in this reach. These bars probably moved or were periodically disrupted during high flows and may have been the source of significant channel roughness, causing the primary channel in the creek to avulse and change coarse periodically.

Very little vegetation is evident on the Esparto fan in 1937, but remnants of riparian scrub and disbursed oak trees on each side of the channel suggest that riparian vegetation may have been more abundant at one time. Historical records indicate that this reach of the creek was heavily grazed, which may have contributed to the change in vegetative cover. Standing water is visible in some locations in the October 1937 aerial photographs. Ditch and furrow crop irrigation occurred on lands adjacent to the West Adams Canal. There is evidence that riparian vegetation may not have been as limited by water availability as today. Todd Engineering Consultants and EIP Associates discuss this further in their portions of the present Creek Investigation.

Patterns on the aerial photographs suggest that the creek regularly overflowed its banks in a number of places. Overflow areas were identified on the 1937 photographs by remnant riparian scrub, scour marks, and distributary sloughs and channels. Overflow to the south generally drained into Willow Creek. Overflow to the north drained back into Cache Creek via natural predecessors to the West Adams and East Adams Canals. Overflow areas were identified on the right bank at station 1305+00 near Esparto, on the left bank near station 1250+00, and on the right bank between stations 1150+00 and 1100+00 near the old Madison Bridge. The small community of Madison flooded often.

1937 Channel

By 1937, many human activities and developments had occurred within the active channel. Five bridges had been constructed across the channel: Capay, Esparto, Madison, Stephens, and Yolo. In all cases the abutments and earthen road berms were constructed in the active channel and effectively narrowed the width of the channel. As discussed earlier, the Esparto Bridge, built in 1912, reduced the active channel from about 4,000 feet to 650 feet (see Figure 3.4-12 in Section 3.4). Figure 3.5-8 shows the magnitude of channel narrowing that became measurable by the 1930s and 1940s due primarily to bridge construction, agricultural activities, grazing, and levee building. Aggregate mining had not played as significant a role in early channel changes as these activities did.

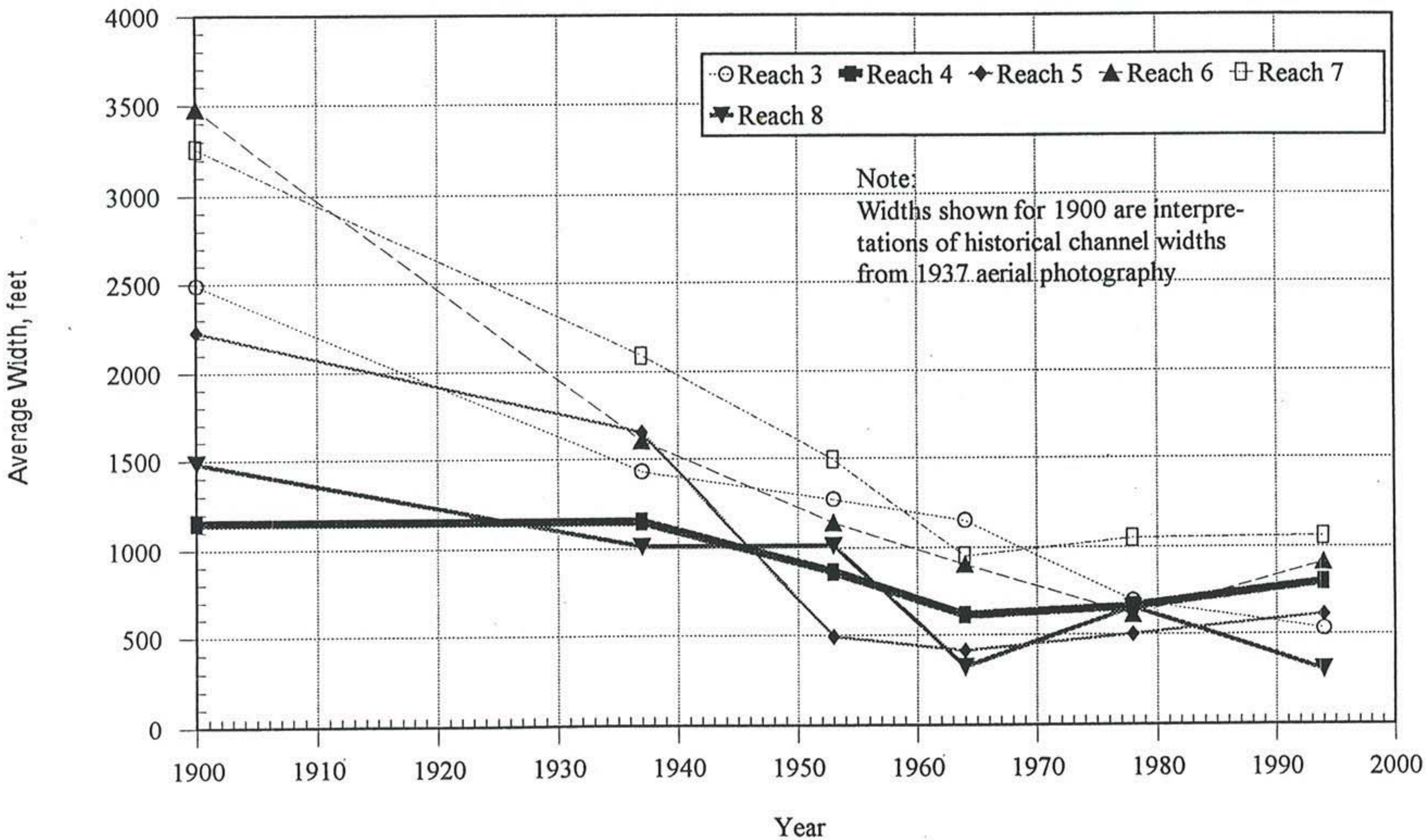


Figure 3.5-8 Average Reach Width Over Time

Levees, which often doubled as roads, were constructed in the active channel to protect other structures and dwellings from flood waters. Earthen levees which totaled approximately 4,000 feet were constructed downstream of the Capay Bridge to protect a structure in the active channel/floodplain. Levees effectively narrowed the channel in this reach by 1,000 to 2,500 feet and may have prevented the creek from overflowing into Hungry Hollow.

Another 2,000 feet of levee was constructed in the upper end of the Madison Reach between stations 1240+00 and 1220+00. It narrowed the channel by approximately 2,000 feet and may have prevented the creek from overflowing into an area once drained by the natural predecessor of the West Adams Canal.

Several gravel mines were operating near bridge crossings by 1937. The most intensive mining activities occurred at in-stream channel and pit operations immediately below the Capay and Madison bridges and at pits just upstream of the old levees near Yolo. Dispersed mining activity occurred near the Esparto and Stevens bridges. Although geomorphically significant, these pits were relatively isolated and small in comparison to today's gravel operations.

Cache Creek had begun to narrow and incise in localized areas by 1937. In addition to the directly induced narrowing imposed by bridge construction and levees, the active channel of Cache Creek was narrower than the inferred pre-1937 channel along most of its length. Clear evidence of a broader flood way channel can be seen on the 1937 aerial photographs, but no evidence from the 1937 photograph suggests that the creek had recently occupied the entire, lateral extent of the pre-nineteenth century channel. Incision of the channel is also evident particularly near the bridges.

By 1937 the Capay reach had narrowed by an average of approximately 500 to 1,000 feet. Remnant terraces on each side of the channel provide evidence that the creek had already incised slightly, perhaps as much as three to five feet. Below Capay bridge the 1937 creek narrowed on the average by approximately 1,500 feet through Subreach 7 and by as much as 2,500 to 3,000 feet in subreach 6. Agricultural encroachment, flow training works, mining and bridges were the primarily contributors to the changes at Capay bridge and the levees downstream of the bridge between stations 1355+00 and 1320+00.

1952/53 Channel

The Capay reach narrowed very slightly between 1937 and 1952. Agricultural fields had been brought under cultivation on the south side of the channel, and a small flood wall structure appears to have been constructed to protect some of these fields at station 1460+00 upstream of Capay.

The 1952 photographs reveal evidence of at least one major flood event between 1937 and 1952 (it was most likely the 1940 flood event). In particular, the left bank levee between 1375+00 and 1350+00 in the Hungry Hollow reach was apparently breached and the area northward had been inundated with evidence of recent flow and sediment transport in that direction. Water must have flowed around all sides of a structure built in this very active and avulsive reach. Extensive gullying of the channel banks is visible in the 1952 aerial photos downstream of the Esparto

Bridge indicating that return flows may have been reentering the channel and causing localized gullying. It is also apparent in the 1952/53 photos that portions of the channel were experiencing incision and the redevelopment of a network of low flow channels after the 1940 event.

By 1937 at least three levees were constructed to protect gravel operations and deposits from high flows. A levee below Capay bridge between stations 1380+00 and 1350+00 effectively narrowed the channel by 250 to 1,000 feet. A 5,000 foot levee between stations 1260+00 and 1210+00 narrowed the channel by 500 to 750 feet. A third set of levees constructed in conjunction with a linear gravel pit trained the flow into a channel about 100 feet wide and 4,000 feet long immediately upstream of the Madison Bridge.

By 1952 the bed elevation of the creek in the Hungry Hollow reach had incised below the 1937 channel bed. The average width of the active channel had narrowed by an additional 750 feet.

Downstream of the gravel operations near Madison Bridge the channel had narrowed and incised considerably. The Guesisosi reach narrowed from an average width of 1,700 feet in 1937 to approximately 500 feet in 1952. From the aerial photographs, one can clearly see that a well developed meander pattern in this reach had been bisected by a nearly linear channel. It is unclear whether this straight new channel was due to incision induced by upstream activities or by in-stream dredging.

Figure 3.5-9 shows the historical bed elevations under the bridges for the period 1905 to 1994. Note that by 1952, mining in the downstream subreaches had contributed to approximately seven feet of bed lowering at Yolo. Bridges upstream from Yolo had not felt the effects of channel incision yet.

1964 Channel

Between 1953 and 1964, the active channel had narrowed and incised throughout the entire study reach. Dramatic narrowing occurred in the Capay reach where the channel width decreased by over 60 percent from an average width of 1,010 feet to an average of 320 feet. Agricultural fields had encroached into the active creek area along the right bank upstream from Capay.

Throughout the Hungry Hollow Reach downstream of the Esparto Bridge, the channel had narrowed and incised even further than was observed in the 1953 channel photographs. In fact, the aerial photos of the Hungry hollow reach from 1964 depict one of the most visible and extreme examples of incision observed during the aerial photo analysis. Extensive mining had been conducted in the Madison reach and to a lessor extent in the Hungry Hollow reach in the 1950s to produce enough aggregate to build the Montecello Dam and several road projects.

The area of gravel mining activity continued to increase between 1953 and 1964. In-stream gravel mining pits had resumed just downstream of Capay Bridge. Dispersed gravel mining and bar skimming extended from station 1340+00 upstream of the Esparto Bridge to 1220+00.

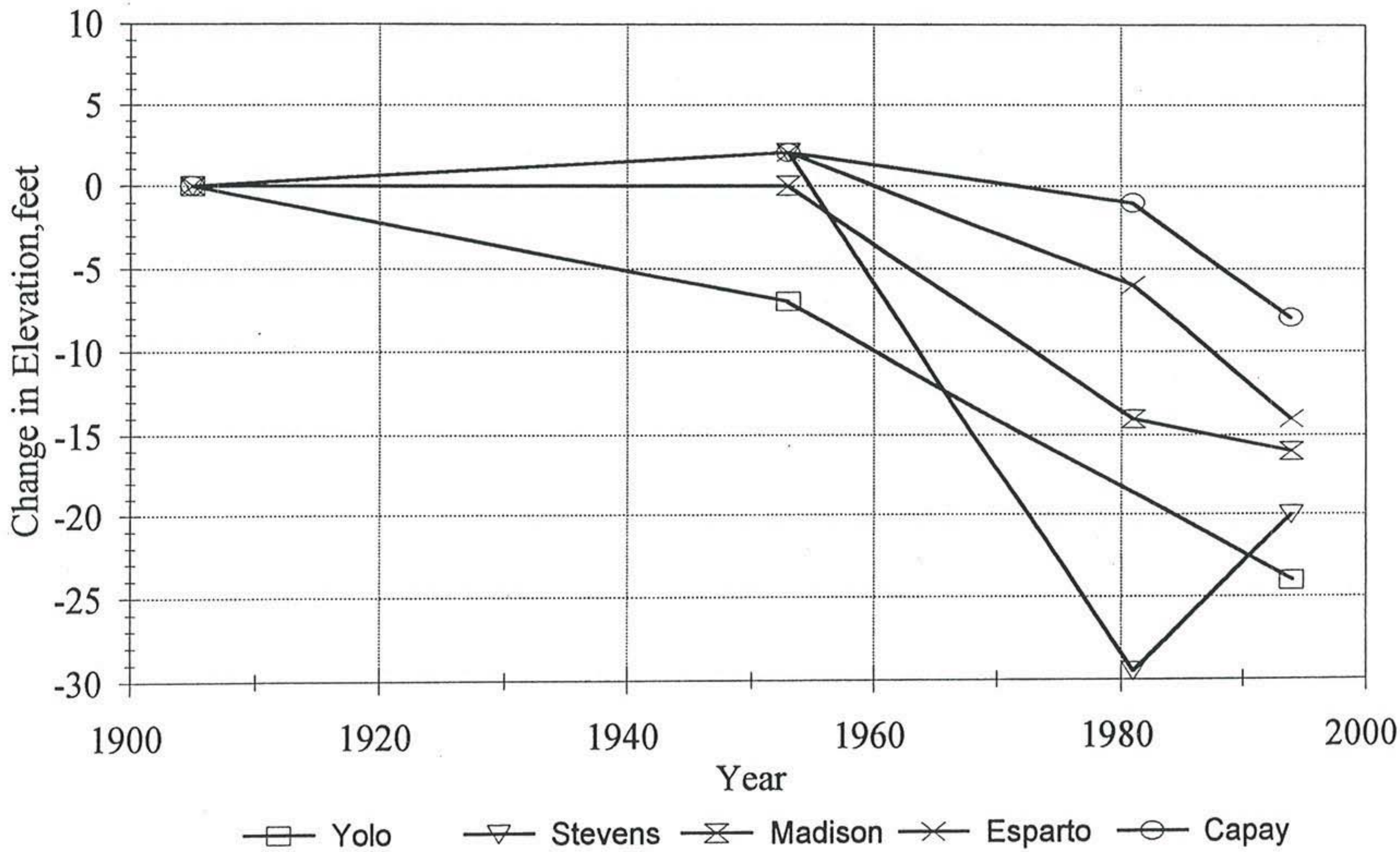


Figure 3.5-9 Change in Thalweg Elevation Under Bridges 1905-1994

The gravel mining operation upstream of the Madison bridge had grown significantly since 1952. The eight small pits that existed in 1952 had become consolidated into six large pits by 1964. Dispersed and intensive gravel mining activity extended throughout the entire reach between Stevens bridge and the narrow channel section upstream from Yolo. Although much of the gravel mining activity was obscured by the previous high flows in 1958, several large pits including a long linear pit just upstream of the leveed reach were evident. The Guesisosi reach remained relatively narrow.

1978 Channel

Significant geomorphic changes occurred between 1964 and 1978. This period showed limited channel widening occurring in some reaches. Widening is attributed to excavation into the banks by aggregate mining operations and extensive annual bar shimmying that reduced the presences of an established low flow channel. The channel widened and/or shifted in many reaches. In the Capay reach, the channel widened 100 to 500 feet between stations 1440+00 and 1420+00. Aerial photos for the upper portion of the Capay reach are not available for 1978.

Below Capay bridge in the Hungry Hollow reach, the active channel shifted by as much as 1,000 feet at station 1350+00. Although the distance from bank to bank was significantly wider in the upper half of the Hungry Hollow reach in 1978, the actual width did not change dramatically because of island building in the middle of the channel.

Between stations 1150+00 and 960+00 in the Guesisosi reach, the channel straightened significantly. Near station 960+00 the right bank shifts approximately 1,000 feet to the south. Sometime between 1964 and 1978, instream gravel mining expanded significantly in and immediately upstream of the straightened portion of the Guesisosi reach.

One of the few places that the channel actually narrowed between 1964 and 1978 is in the lower end of the Madison reach just upstream of the Madison bridge (stations 1200+00 - 1150+00). The channel appears to have been entirely confined by the linear series of pits evident in that reach in the 1964 photos. This relatively short reach was excavated to depths of more than 20 feet to supply the aggregate and road fill necessary for the construction of the I-505 approach berms and bridges. That narrowing may also have been partially influenced by the new pits and training levee evident just upstream in the 1978 photos.

Channel shifts and widening also occurred in the vicinity of the Stevens Bridge between station 960+00 and 850+00. These changes involve increased sinuosity of the low flow channel and widening associated with mining. Downstream of Steven's Bridge the channel narrows significantly between 1964 and 1978, particularly between stations 800+00 and 750+00. This narrowing seems to reflect another cycle of incision in this reach. A linear series of in-channel excavation areas and pits extends throughout this segment. As shown in Figure 3.5-9, by 1981 the thalweg elevation at Steven's Bridge (Rd. 94-B) had lowered by approximately 30 feet. Evidence of bridge stability problems resulting from bed lowering is also shown in Table 3.4-4, Summary of Bridge Histories in Cache Creek Study Area in Section 3.4.

Between 1964 and 1978 gravel mining became more widespread below Madison bridge and many dispersed gravel mining areas had been converted into pits. No gravel extraction was evident in the Capay and Hungry Hollow reach from the 1978 photos except for three small pits immediately upstream of Esparto. Another small pit was located immediately below the bridge. The major gravel mining area visible in 1953 and 1964 immediately upstream of Madison bridge was inactive, but two major new pits had been excavated just upstream between stations 1250+00 and 1200+00. The Guesisosi reach which had not been previously mined except for a small area in 1964, was the site of extensive in-channel mining by 1978. These areas extended between stations 1090+00 and 970+00. Gravel mining in the Hoppin reach had been converted from dispersed but extensive activity in 1964 to a intensive pit extraction in 1974, particularly between stations 850+00 and 740+00.

1981-1994 Channel

The Capay reach appears to have narrowed again and incised between 1981 and 1994. A nick point incision is apparently moving upstream toward the Capay Bridge from about station 1360+00 (see Figure 3.5-9). This nick point may have originated in 1989 when the lower Hungry Hollow reach was extensively mined down to the theoretical thalweg. This resulted in a narrower, deep channel section through the Hungry Hollow reach. Islands in Hungry Hollow reach eroded during the 1993 flows. Mining into the high banks through the Hungry Hollow and Madison reaches resulted in channel widening. Channel gradient adjustment (by mining to the theoretical thalweg) may have caused an increased low flow channel sinuosity just upstream and downstream of the Madison bridge following the 1993 flows. The main channel widened slightly in the previously straightened segment of the Guesisosi reach between stations 1150+00 and 960+00. Slight widening was observed at Moore Dam site. The channel widened and shifted approximately 700 feet to the south between stations 890+00 and 850+00 upstream of the Steven's bridge due to excavation into the banks for terrace deposits. Between stations 850+00 and 840+00 at Steven's bridge, the right bank shifted 200-500 feet to the south resulting in a similar narrowing of the channel. The channel narrowed dramatically in the lower portion of the Hoppin reach between stations 750+00 and 670+00.

Annual bar skimming and visible gravel mining activity shifted from active channel sites to large intensive pits off of the present active channel. Some dispersed gravel mining activity remained in channel between Capay and Esparto bridges in the vicinity of station 1350+00. Very large linear pits were excavated on left bank below Esparto bridge from stations 1350+00 to 1200+00. Another cluster of pits were initiated on the right bank just upstream of the Madison bridge from stations 1280+00 to 125+00. Below Highway 505, at stations 1100+00 to 1060+00, three enormous off-channel pits were installed on the right bank. Since 1978, pretty much the entire reach from Hungry Hollow to Hoppin supported active in-channel skimming, lateral bank excavation into terrace deposits and some off-channel pit excavation.

Summary of Changes in Significant Channel Characteristics

Table 3.2-2 in Section 3.2 summarizes approximate existing channel characteristics which are significantly different than the historic channel characteristics documented from the examination of historic aerial photos and mapping. As shown in Figure 3.5-8, average channel widths since 1905 were reduced by approximately 85 percent in some reaches, from 3,500 feet wide to approximately 500 feet wide. Associated with channel narrowing is also an appreciable channel bed lowering (incision) as shown in Figure 3.5-9 which shows the change in thalweg elevation recorded at the bridge locations since 1905. At Stevens Bridge (Road 94-b) as much as 30 feet of vertical change was observed from the period 1953 to 1981. The channel invert (bottom) at Yolo has also lowered by approximately 24 feet since 1905. Figure 3.5-10 presents historical longitudinal profiles of Cache Creek developed from historical topographic maps. Also shown on Figure 3.5-10 is the longitudinal profile of the County's "theoretical thalweg" which has been used since 1979 as the vertical limit for in-channel mining in the creek. Note that at some locations, the 1981 and 1994 thalweg was below the theoretical thalweg. This is not surprising, because the theoretical thalweg is the vertical limit for mining at any location, but the channel may continue to incise into the bed while adjusting its gradient and establishing a new low flow channel, thus extending below the theoretical thalweg limit at least in the vicinity of the low flow channel.

Figure 3.5-11 shows historical channel cross section changes that were measured along the upstream face of the Highway 505 bridge in the years 1956, 1959, 1966, 1970 and 1974. Note that within 18 years the channel thalweg went down approximately ten feet and the overall cross section shape changed to a wider, more uniform cross section. Over time the bridge pier footings were exposed forcing Caltrans to conduct emergency bridge repairs to protect the footings (see Table 3.4-4 in Section 3.4). Since 1974, the bottom elevation near the Highway 505 bridge has lowered an additional three to five feet.

Figures 3.5-12 through 3.5-16 show historic channel cross section changes since 1905 at typical subreach locations in the reaches between the bridges. They show the dramatic channel shape adjustment that has occurred over time in the reaches between the bridges. While the bottom has gone down, the channel has also narrowed. This has led to the overall adjustment of the creek's bed slope, plan and profile and hydraulic characteristics. The ramifications of these changes will be discussed in the following chapter.

Table 3.2-2 in Section 3.2, and Figures 3.5-2 through 3.5-9 summarize the primary channel characteristics and changes obtained from mapping the historic channel boundaries and mining operations over time.

<u>Changes in Active Channel Area Over Time</u>

Figures 3.5-2 through 3.5-7 summarize the historic changes to plan form, channel cross section and the extent of mining throughout the study area over time. Information shown in the figures was digitized into the Yolo County GIS system. Table 3.5-3 utilizes data developed from the GIS data base to compare changes in total channel area and mined area within the active channel boundary and 1979-designated mining limits for time periods from pre-1937 to 1994. Table 3.5-3 also compares the mined area within the channel to the active channel area as a percentage of the total active channel area (percent mined in Table 3.5-3). The last column in the table compares the original area delineated within the boundary of the County's 1979 Interim Mining Ordinance and compares that area with the mined area in the study reach.

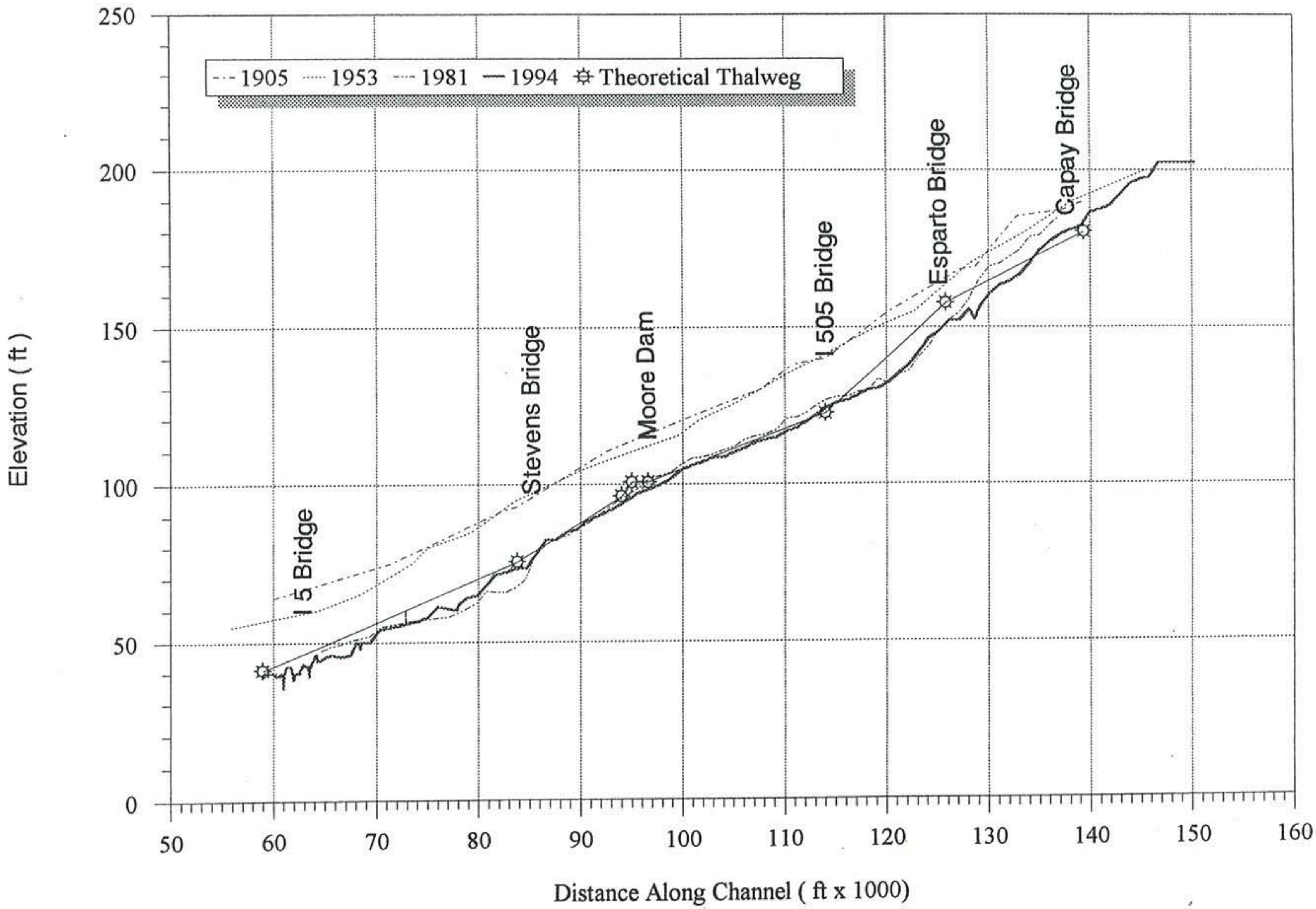


Figure 3.5-10 Longitudinal Profiles From Topographic Maps

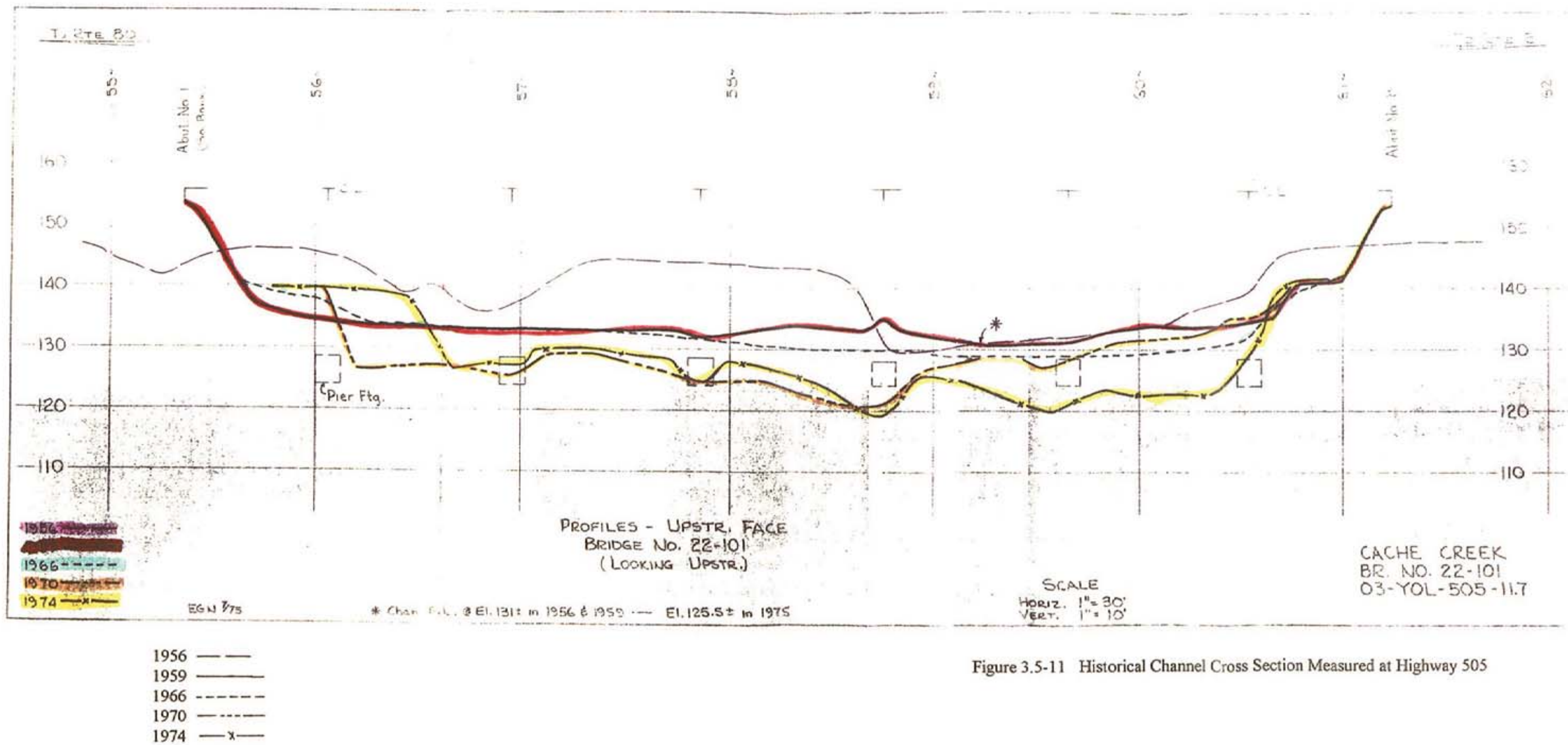


Figure 3.5-11 Historical Channel Cross Section Measured at Highway 505

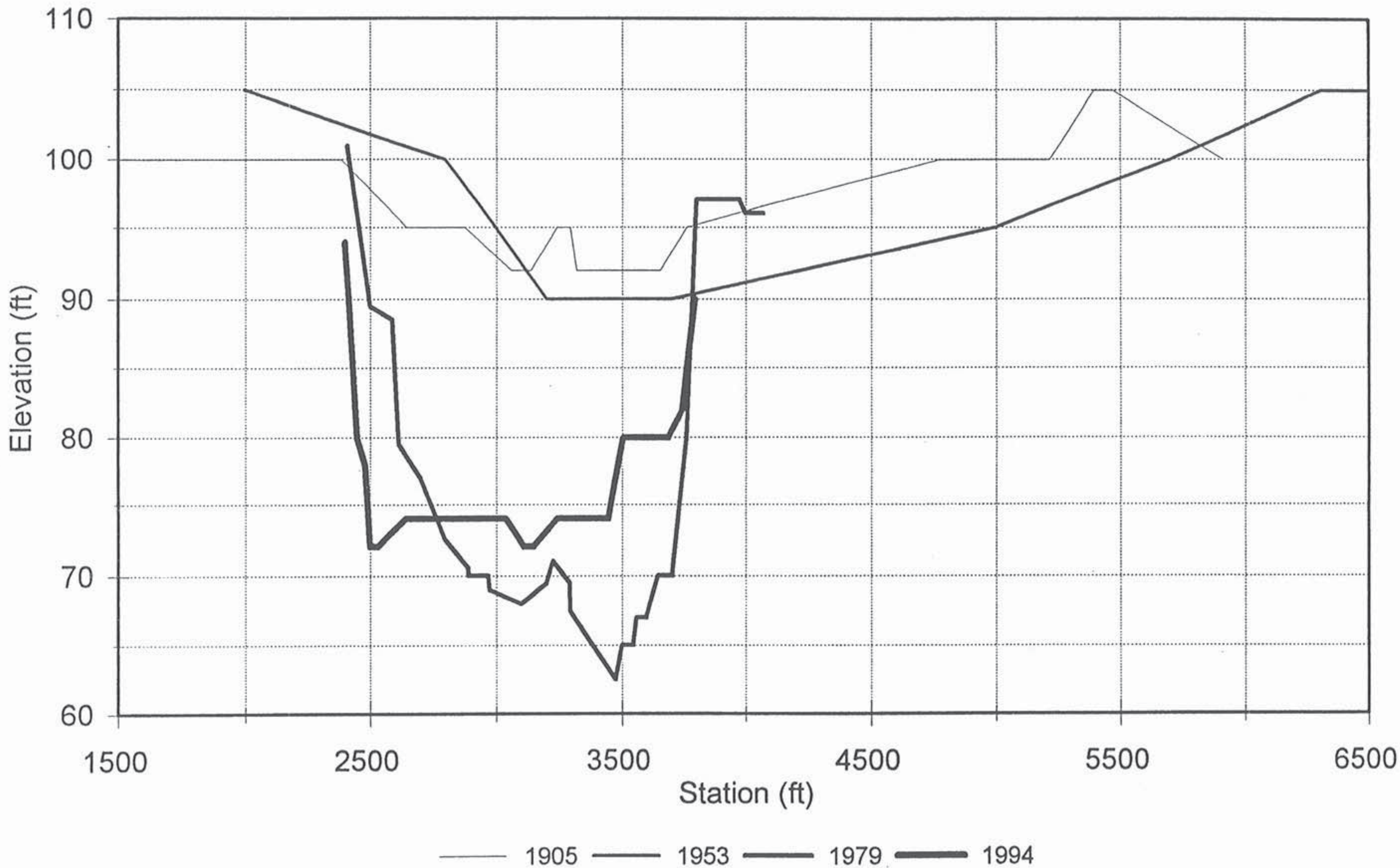


Figure 3.5-12 Historical Cross Section Changes since 1905
Station 818+00, Downstream of Stevens Bridge

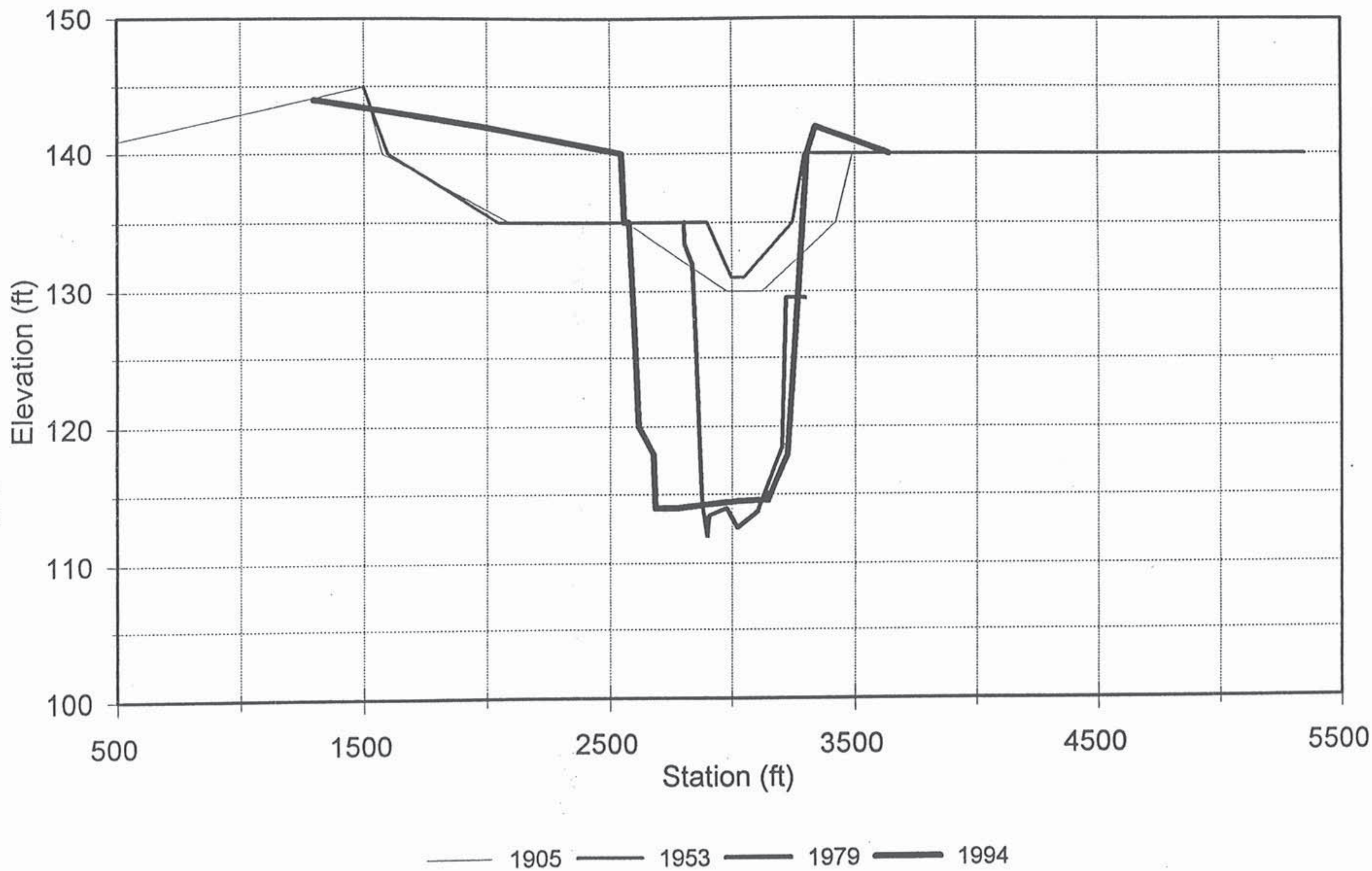


Figure 3.5-13 Historical Cross Section Changes since 1905
Station 1(-00, Downstream of I-505 Bridge

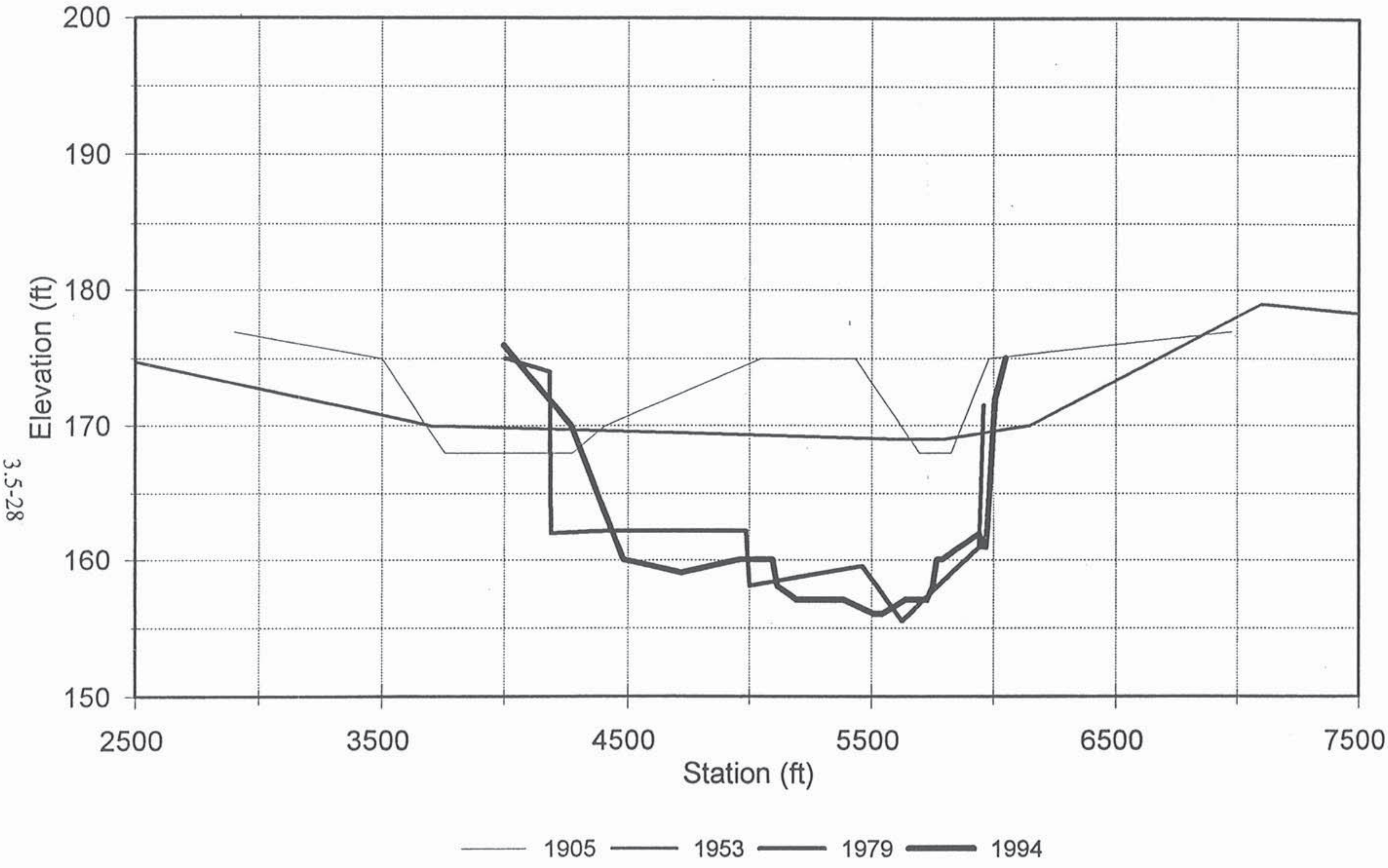


Figure 3.5-14 Historical Cross Section Changes since 1905
Station 1270+00, Downstream of Esparto Bridge

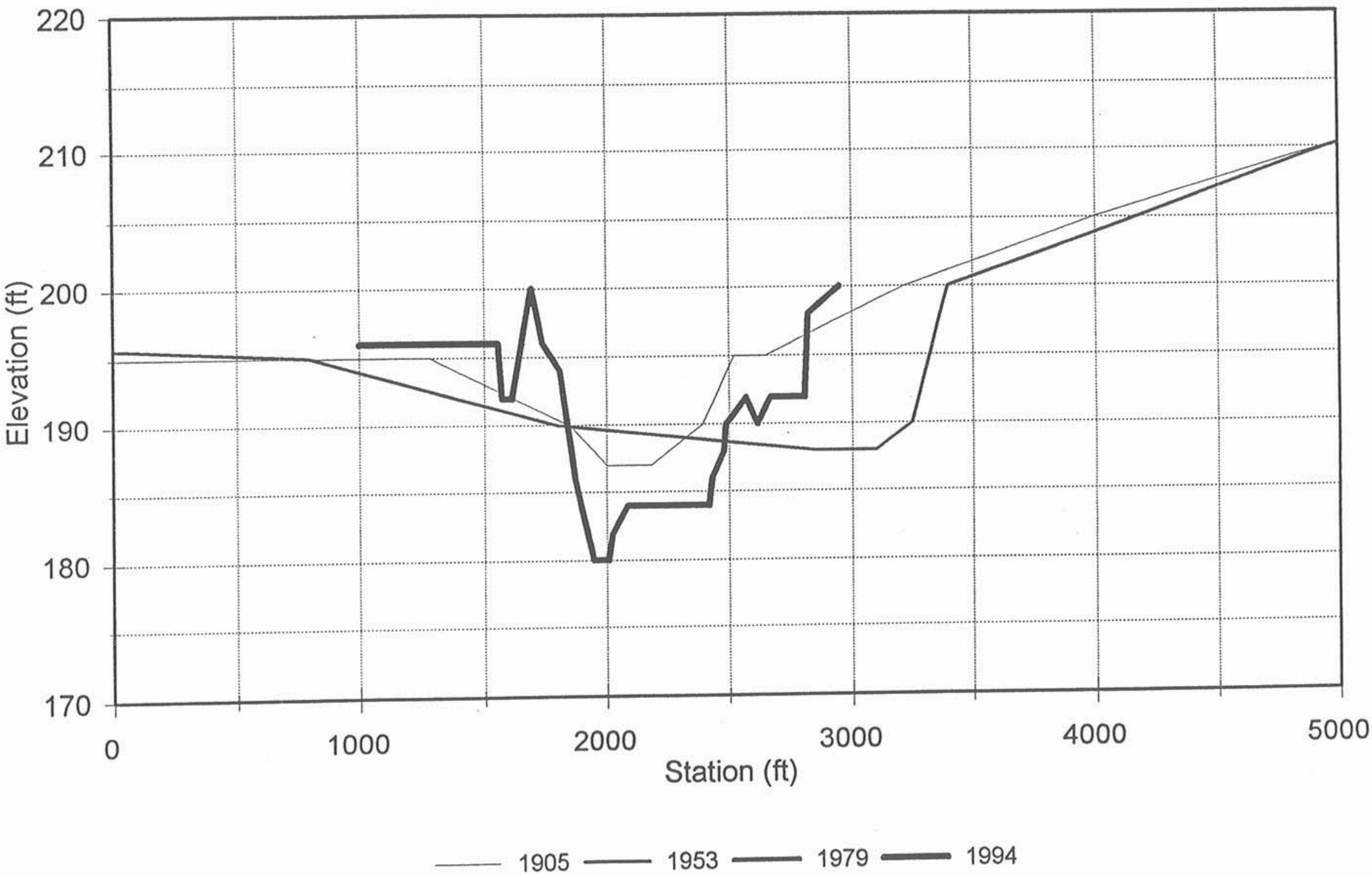


Figure 3.5-15 Historical Cross Section Changes since 1905
Station 1375+00, Downstream of Capay Bridge

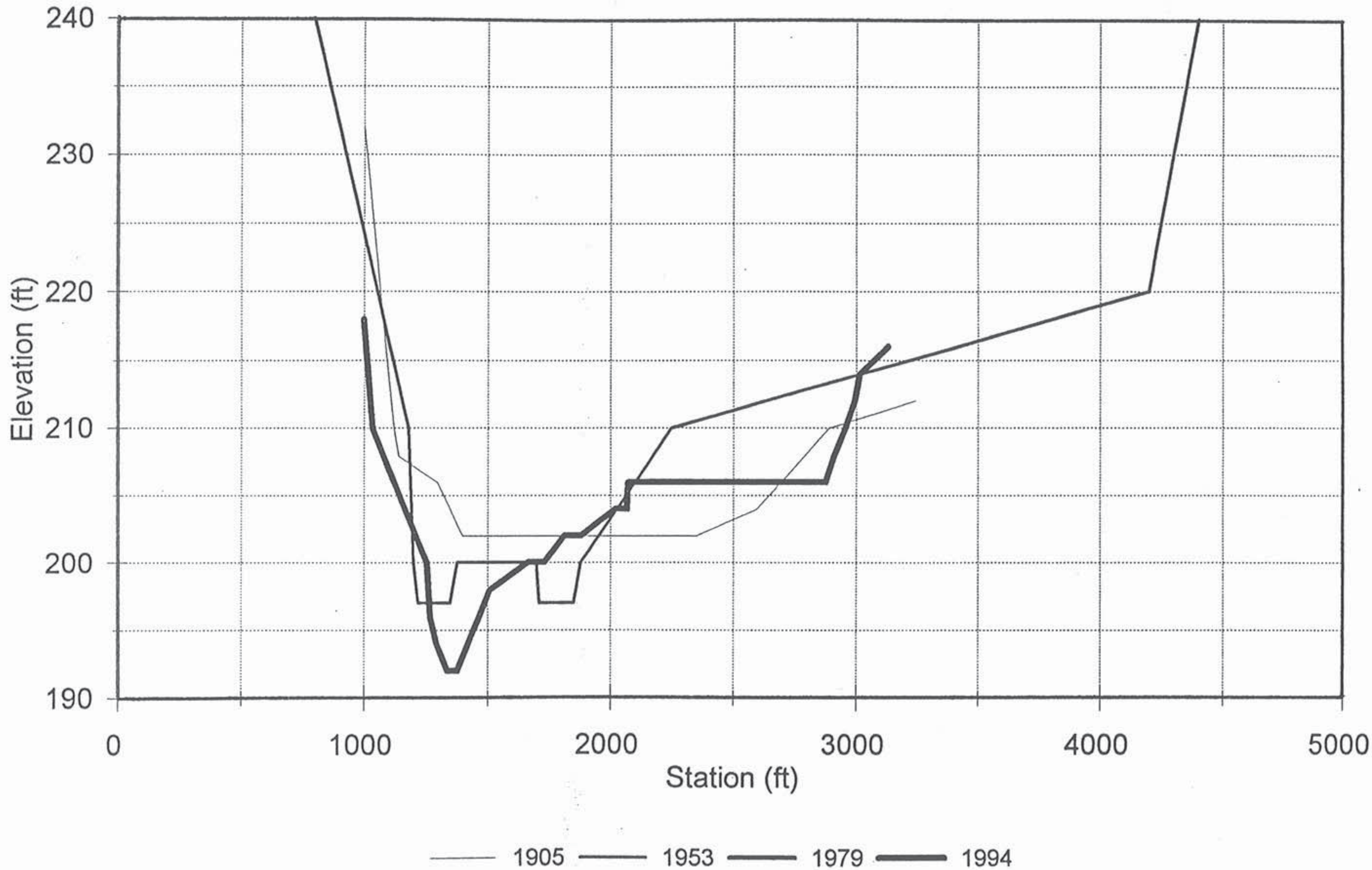


Figure 3.5-16 Historical Cross Section Changes since 1905
Station 1435+00, Upstream of Capay Bridge

TABLE 3.5-3

COMPARISON OF AREA MINED WITHIN THE CHANNEL, PRE-1937 TO 1994

Year	Total Channel Area[1] (Acres)	Area Mined within Channel Boundary[2] (Acres)	Percent Mined Within Channel Bank Limits[3] (%)	Total Area Mined within the 1979 Mining Limits Boundary (Acres)	Percent Mined within the 1979 Mining Limits[4] Boundary (%)
Pre-1937	5,000	N/A	N/A	N/A	N/A
1937	2,980	130	4.4	146	5
1952\53	2,190	270	12.3	335	12
1964	1,550	730	47.1	905	32
1978	1,680	610	36.3	750	27
1981-1994	1,580	1,190	75.3	2005	71

1 From GIS area within present channel bank line.
2 Total acres of mining occurring inside channel bank line.
3 Percent area mined within the channel bank line as of indicated date, mining occurring beyond bank line not included in these values.
4 The total area within the 1979-designated mining limits boundary is 2,820 acres.

As seen in Figures 3.5-3 through 3.5-7 and Table 3.5-3, the aerial extent of mining increases significantly after 1952/53 and had reached the point where approximately 75 percent of the surface area within the active channel was mined between 1981 and 1994. Approximately 71 percent of the total area outlined by the 1979 ordinance limits has also been mined by 1994. As a result of extensive mining, much of the readily available in-channel aggregate supplies are close to exhaustion according to the present interim mining ordinance limits. Therefore, in recent years the aggregate industry has been looking more toward moving to off-channel areas for their future aggregate supply. Three short term off-channel permits were approved by the County in 1995.