We recommend that the bank and bed conditions of the rest of the mainstem channel of San Antonio Creek be quantified with the same methodologies that were used in the Study Reach. Tributary channels and hillsides for the entire watershed should also be assessed to develop a sediment budget and to determine changes in drainage density. An historical ecology assessment of the watershed should be developed and documented in a much more rigorous and thorough way. SFEI's Historical Ecology Program has developed a methodology for conducting this kind of analysis. Such a perspective would improve our ability to direct management initiatives and to understand the effects of past and present land uses upon the geomorphic changes that we have reported. The longitudinal profile of the mainstem channel should be surveyed to establish monitoring stations that will show changes in bed incision and/or aggradation in the future. A water budget should be constructed for the watershed as a whole to evaluate the potential for restoration that might include re-establishment of the laguna, "disconnection" of small tributaries from the mainstem channel, realignment of lower San Antonio Creek into its original tidal slough, and reduction in total amount of water withdrawal. Finally, we recommend that even if no further research is conducted, that funds be developed to produce a report that explains the graphics contained in this document, that the report include photographs and historical maps, and that the information be placed on the world wide web for public access

10. Because of increased rates of bank erosion and draw down of the adjacent water table, there has been a loss of riparian vegetation along the terrace banks. The loss of root strength along some reaches has greatly accelerated the rate of bank erosion. The channel has had a reduction in sinuosity.

11. Peak flows may have remained elevated until the mid 1900's, when increases in the number of cattle and stricter regulations on water quality required more diversion and retention of water in small reservoirs throughout the watershed. This contributed to a significant reduction in total flow to the channel. As a result of seepage from these artificial retention basins, base flow may have increased locally, and may have been greater than when the Chileno Valley was initially drained, but it would still be much less than the historical condition that featured the natural laguna. Today, peak flows are probably much higher than they were 160 years ago. Total flow is probably much less. Base flows are slightly higher than they were between 1890's to mid 1950's, but much lower than they were before the onset of non-native land practices.

12. Prior to the mid 1900's, plowing of fields for agriculture was a common practice leading to highly disturbed and erodable soil surface. Such activities may have substantially increased the amount of fine sediments supplied to the mainstem channel. Plowing for cattle feed has diminished as the water table has dropped and as dependency on imported feed has increased. If local trends in land use conversion from pasture to vineyards occurs in this watershed, we would expect to see more soil disturbance and soils that will be purposely maintained to lack soil cover. These practices will generate more runoff and supply of fine sediments to the mainstem channel.

13. As an effect of the increased draw down along the entrenched mainstem channel, we suggest that the water table may be lower throughout all the valleys in San Antonio Creek watershed because most of the tributaries are deeply entrenched. Consequently, it takes much more rainfall to saturate the soils and generate runoff throughout the mainstem channel. This, in combination with the retention and consumption of water throughout the watershed, has caused the mainstem channel to change from perennial to intermittent.

14. San Antonio Creek was historically diverted from its natural tidal slough, which we will refer to as San Antonio Slough although it is still called San Antonio Creek, to the much smaller and shorter Schultz Slough. This diversion may have been done in the late 1930's (Don Vachini personal communication). From the place of this historical diversion, the present course of San Antonio Creek along Schultz Slough is about 2.9 mi long to the Petaluma River. Its previous course along San Antonio Slough to Petaluma River was about 6.6 mi.long. Furthermore, the entrance of Schultz Slough is 5.2 mi upstream on Petaluma Creek than the entrance of San Antonio Slough. This would mean that the base level to which the channel is graded is now much higher than it was historically. Because of this diversion, the entire channel gradient of San Antonio Creek has flattened. The extent of maximum tidal influence has moved nearly a mile downstream from its historical position. Deposition of gravel to sand-sized sediments has caused substantial aggradation of the bed, thereby contributing to further loss of channel capacity in the downstream reaches of San Antonio Creek.

15. Loss of channel capacity, exacerbated by high tides during peak storm flows and the backwater effects of San Antonio Bridge, have lead to increased flooding along Guernsey and Highway Reaches. Historical accounts from Kay Sweeney confirm the cycle of entrenchment and subsequent aggradation at San Antonio Bridge.

16. Some of the reaches along San Antonio Creek may be functioning as "losing" reaches rather than "gaining" reaches in terms of total discharge. This is due to the over-widened geometry and extreme aggradation of sediments in the "losing" reaches, and to the overall reduction in height of the water table.

17. We consider that anthropogenic activities within the watershed have lead to greatly increased rates of sediment production, greatly reduced base flow, and greatly increased peak flows to the channel. Without a complete watershed analysis, we are unable to quantify the percent change, although we expect that it is at far greater than 50% increase in sediment supply and a 50% decrease in water supply.

18. We expect that the very high proportion of fine sediment contained in the bed has been directly increased by land use activities.

Recommendations

Data Presentation

The data are presented in a variety of graphic and tabular displays. The planform of the channel, the location of distance stations, and the locations of the sub-reaches are shown on the Photo Maps, pages 1-6. The Study Reach was subdivided into 10 component reaches based upon obvious morphological changes. Streamline Graphs depict existing conditions along a continuum of the bed and banks of the Study Reach. Discrete volumes of sediment supply from bank erosion, volume of pools, and location of culverts and bridges are noted. Changes in channel parameters are also graphically summarized for each reach, and for the entire Study Reach as a whole. These are found under separate headings within the report. The component reach within the Study Reach for which access was denied is called Gap Reach. Data pertaining to sediment supply from Gap Reach were extrapolated from other sub-reaches of similar morphology. It is important to note that the volumes of sediment supply reported in the graphs for San Antonio Creek do not represent the total sediment supply from the mainstem channel as a whole, because 2.5 mi of the upper mainstem channel have not been studied.

Key Notes

1. Stream incision and bank erosion have been pervasive along most of the mainstem channel of the Study Reach upstream of Guernsey Reach. Yet, some of the most severe bank and bed erosion was observed along the 2.5 mi of the mainstem channel that was reconnoitered but not quantitatively studied. We expect that the highest volumes of sediment supply per linear foot of channel occur along this unquantified portion of the mainstem channel.
2. Before the period of intensive dairying and cattle ranching, a natural laguna or shallow lake existed at the headwaters of San Antonio Creek. This should not be confused with Laguna de San Antonio, which exists to the west at the headwaters of Chileno Creek. Based upon review of historical documents, we expect that the laguna for San Antonio Creek was drained for agricultural purposes sometime between 1860 and 1885. Additional ditching and deepening of existing ditches may have occurred during the early 1950's (personal communication from Don Moreda).
3. Historical accounts seem to indicate that the mainstem of San Antonio Creek used to be a perennial stream, at least through its lower reaches, and perhaps through a much greater portion of its entire length.
4. A significant steelhead fishery existed historically, with common sightings of fish until the mid 1900's. According to local residents, steelhead are no longer observed in the creek. Furthermore, we did not observe any fish within the Study Reach.
5. Although water quality data were not collected by SFEI, Mike Rug, of the Ca Department of Fish and Game, reports that ammonia levels are high year-round.
6. We propose that the ditching and draining of the natural laguna caused a reduction in the level of the water table throughout the broad relatively flat Chileno Valley of San Antonio Creek. This had profound effects upon increasing the magnitude and frequency of peak flows on the mainstem channel. Summer/fall base flow would have substantially diminished. Historical accounts suggest that the laguna may have stayed wet year round, but when it was at certain high levels, it would drain into a small channel at its eastern outlet. Historically the position of the headwaters was down valley of the laguna, perhaps near our distance station 47823 ft.
7. Increased shear stress on the bed and banks from increased magnitude and frequency of peak flows induced a self-perpetuating cycle of bed incision and bank erosion throughout the mainstem channel during the late 1800s, perhaps until the mid 1900's.
8. The ditching of tributary channels that were previously disconnected from mainstem San Antonio Creek augmented these effects by increasing the drainage density. We hypothesize that most the tributaries that are now ditched to connect to mainstem San Antonio Creek in Chileno Valley did not historically convey their water or sediment directly to the mainstem channel. Instead, their sediment load was deposited as small fans at the base of hillsides, and their water went subsurface, adding to the reportedly high water table of the Valley.
9. We expect that the effects of conversion of native perennial grasses to European annual grasses, combined with the effects of intense cattle grazing (soil compaction, reduced thatch cover generating more runoff, more bare soil generating fine sediment) contributed to increased peak flows and supply of fine sediment.

Telescoping survey rods were used to measure bankful width, height of terraces, and heights and depths of bank and terrace erosion. Bank measurements were separated into sections below and above bankful height, which, in concept, is equivalent to the height of the floodplain. Bankful discharge occurs every 1.3 to 1.7 years on average and is regarded as the channel-forming flow that maintains the hydraulic geometry of the channel to move the most water and sediment over time. The threshold for measuring bank erosion was at least 1/4 ft retreat for the overall height of the bank.

Level-line surveying methods were used to measure cross sections that helped determine bankful height. Standard sieve sizes were used to establish sediment size classes to characterize the channel bed into "D50" size classes, where 50% of the particles are either finer or equal to this size category.

All pools greater or equal to 1 ft deep were measured and documented at the time of initial data collection that coincided with the time of lowest seasonal flow. Pool depths were determined for potential, minimum flow conditions by subtracting the height of the water at the crest of pool tails. Pool volumes were determined by multiplying average width x length x 1/2 maximum depth. The width and length measured in the field accounted for potential, minimum flow conditions

Photographs of the channel were taken at places of obvious changes in channel conditions. Photographs were referenced to distance stations, placed in a notebook, and arranged from downstream to upstream order.

Data were entered in field books specifically designed for the WSA, and were later entered into data templates linked to analytical and graphics programs to calculate or display the desired stream parameters. The raw data and channel photographs are on file at the SFEI Watershed Science Department.

Accomplishments

Data Collection

The mainstem channel of San Antonio Creek is presently about 9.1 mi long upstream of the usual extent of higher high tide, which corresponds to distance station 0.0. Its drainage area upstream of station 0.0 is about 30.8 sq mi. Data on all factors listed above were continuously measured and recorded within our 6.6 mi-long Study Reach, except for two areas. One was a 0.4 mi-long component reach to which access was denied by the landowner. The second area was along the 0.4 mi-long diversion ditch at the downstream end of the Study Reach. Since we did not know the original dimensions of the ditch, we were unable to estimate sediment supply from bank erosion. The Study Reach consists of about 70% of the entire mainstem channel, including its entire downstream portion to the influence of the tides at Petaluma Marsh.

Training and Education

The SFEI watershed team provided ongoing opportunities for SSCRCD technical staff to participate in the field studies. A variety of methodologies for collecting data on bank and bed conditions was demonstrated to Jennifer Allen of the SSCRCD, who also helped record the field data. SFEI expects to give a brief presentation of findings at a future meeting of the Sonoma Watershed Conservancy

Interviews with Long-term Landowners

Several dairy operators and ranchers who have lived in the San Antonio Creek watershed from 30 to 90 years were interviewed about their observations of local landscape change. Their time, access to their land, and information is gratefully acknowledged. Interviewees included Joe and Wally Tognalda, Don Vachini, Mark Traverna, Kay Sweeney, Hank Corda, Henry Barboni, Donald Moreda, Mable Sonnichsen, and Leo Lavio. The interview notes are on file at SFEI's Watershed Science Department.

APPLICATION OF THE SFEI WATERSHED SCIENCE APPROACH TO SAN ANTONIO CREEK, SONOMA AND MARIN COUNTIES, CALIFORNIA

Draft

December 2000

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Project Description

The San Francisco Estuary Institute (SFEI) conducted a survey of stream bank and bed physical conditions and sediment supply along 6.6 mi of San Antonio Creek during the months of September through November of year 2000. The analysis was performed for the Southern Sonoma Resource Conservation District (SSCRCD) with funds provided by the US Environmental Protection Agency through CALFED. Deliverables include: 1) a photographic base map of the study area along the mainstem channel; 2) tables and graphs for displaying the analyses of field data; and 3) a brief discussion of objectives, general methods, accomplishments, key notes, and recommendations for future study.

A full written report of findings was not within the scope of this project. Many of the findings are only represented as graphs and tables without explanatory text. If additional funding becomes available to complete geomorphic analyses of the mainstem channel and/or the entire watershed, then a full written report should be prepared.

Objectives

The primary objective of this project was to transfer the approach and methodology of SFEI's Watershed Science Approach (WSA) to staff of the SSCRCD in order to advance their understanding of watershed processes and the effects of land use practices on San Antonio Creek since the time of European settlement. We have estimated the time period for landscape response to non-native land uses in the San Antonio watershed to be the last 160 years.

Within the limitations of available funding and a three month time constraint, as much of the mainstem San Antonio Creek as possible was to be documented and analyzed for the following factors: length, location, and volume of sediment sources associated with bank and terrace erosion; length, location, condition, and type of bank revetment; location, type and size of culvert outlets and other engineered structures crossing the creek; distribution and percent of particle size classes on the bed including the D50 size class; volume of sediment generated by bed incision; number, volume, cause and spacing of pools greater than 1 ft deep; number, spacing, species, and recruitment processes of woody debris. I addition, the amounts of sediment that have been generated by anthropogenic influences versus natural processes have been estimated. Additional objectives included training in field assessment methods for technical staff of the SSCRCD, and graphing of existing US Geological Survey gage data on peak flows.

Methodology

The SFEI WSA, on line at www.sfei.org, discusses, from a general perspective, some watershed concepts used for this project. A very brief discussion of methods follows.

A photographic base map was created using aerial photos at scale 1:7,200.

A centerline tape was pulled continuously along the channel. All data were referenced to distance stations along the tape. Flagging, annotated with distance stations, was tied every 100 ft. These distance stations, when combined with the Photo Map, could be used to re-occupy the same stations during future monitoring. The distances between engineered structures such as bridges and culverts were noted.