

December 18, 2007

2007 – FIELD RECONNAISSANCE REPORT OF BANK EROSION SITES AND SITE PRIORITY RANKING

SACRAMENTO RIVER FLOOD CONTROL LEVEES, TRIBUTARIES AND DISTRIBUTARIES

Sacramento River Bank Protection Project

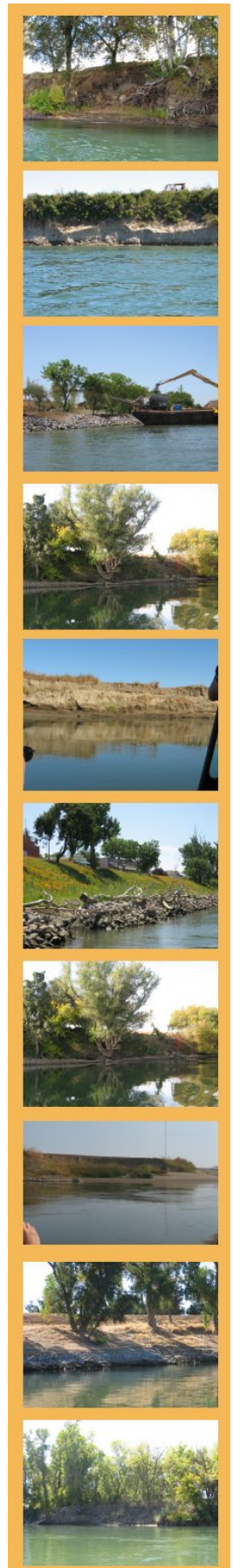
Contract No. WA91238-05-D-0009



Prepared for:



U.S. ARMY CORPS OF ENGINEERS
Sacramento District
1325 J Street
Sacramento, CA 95814-2922



December 18, 2007

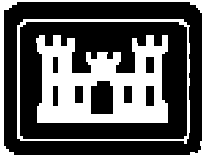
**2007 - FIELD RECONNAISSANCE REPORT OF BANK
EROSION SITES AND SITE PRIORITY RANKING**

**SACRAMENTO RIVER FLOOD CONTROL LEVEES,
TRIBUTARIES AND DISTRIBUTARIES**

Sacramento River Bank Protection Project

Contract No. WA91238-05-D-0009

Prepared for:



**U.S. ARMY CORPS OF ENGINEERS
Sacramento District
1325 J Street
Sacramento CA 95814-2922**

Prepared by:

AYRES
ASSOCIATES

2150 River Plaza Drive
Suite 330
Sacramento, CA 95833
Voice 916.563.7700
FAX 916.563.6972

and

3665 JFK Parkway
Building 2, Suite 200
Fort Collins, CO 80527
Voice 970.223.5556
FAX 970.223.5578

Ayres Project No. 32-1185.15

TABLE OF CONTENTS

1.0	BACKGROUND	1
2.0	AUTHORIZATION AND WORK REQUIREMENTS	4
3.0	RECONNAISSANCE COVERAGE AND PROCEDURES	4
4.0	EROSION INVENTORY CRITERIA AND SITE DATA COLLECTED	5
5.0	SUMMARY OF 2007 FIELD RECONNAISSANCE	6
6.0	SITE PRIORITY RANKING	9
6.1	General.....	9
6.2	Discussion of Reviewed Methodologies	9
6.2.1	Methodology 1: 16 Physical Factors and One Economic Factor	10
6.2.2	Methodology 2: 10 Physical Factors and no Economic Factor	13
6.2.3	Methodology 3: 5 Physical Factors with Revised Economic Factor.....	15
6.2.4	Methodology 4: 5 Physical Factors with no Economic Factor.....	19
6.3	Site Priority Ranking Results	19
7.0	CONCLUSIONS.....	29
8.0	RECOMMENDATIONS.....	29
9.0	REFERENCES.....	30

APPENDIX A

TABLE 1 - Sacramento River Levee System - Current Erosion Sites - 2007
TABLE 2 - Sacramento River Levee System - New Erosion Sites - 2007
TABLE 3 - Sacramento River Levee System - Removed Erosion Sites - 2007
TABLE 4 - Sacramento River Levee System - Critical Erosion Sites - 2007
TABLE 5 - Sacramento River Levee System - GPS Waypoint Locations - 2007

APPENDIX B – Methodology 1 Site Priority Data Sheets

APPENDIX C – Methodology 2 Site Priority Data Sheets

APPENDIX D – Methodology 3 Site Priority Data Sheets

APPENDIX E – Methodology 4 Site Priority Data Sheets

APPENDIX F – Sacramento River Levee System, 2007 Aerial Atlas

(APPENDICES B THROUGH F ON CD ONLY)

1.0 BACKGROUND

Each year, personnel from the U.S. Army Corps of Engineers (Corps), Sacramento District, and their local sponsor, the California Department of Water Resources (DWR), conduct a field reconnaissance review of the Sacramento River Flood Control System. Since 1998, Ayres Associates has assisted the Corps and their local sponsors with this annual review and inventory of erosion sites. **Figures 1** and **2** include the locations of waterways inspected in this field review. Not all of the tributaries were inspected this year because the 2006-2007 water-year had very little runoff and no bank full flows occurred.

The primary purposes of the review are to; a) monitor and document the condition of previously identified erosion sites, b) inventory any new erosion sites and c) identify critical erosion sites that appear to be an imminent threat to the structural integrity of the flood control system.

Specific criteria are used to identify erosion sites within the system, which are described in a subsequent section of this report. In most cases the criteria are consistent from year to year and are based on bank and levee conditions that are threatening the function of the flood control system. An **erosion site** is defined as:

A site that is at risk of an erosional failure during floods and/or normal flow conditions; the term “critical” is used to indicate erosion sites that are an imminent threat to the integrity of the flood control system and of the highest priority for repair.

The project team field identifies erosion sites as being critical based on familiarity with the system and experience with levee failures by the erosion process.

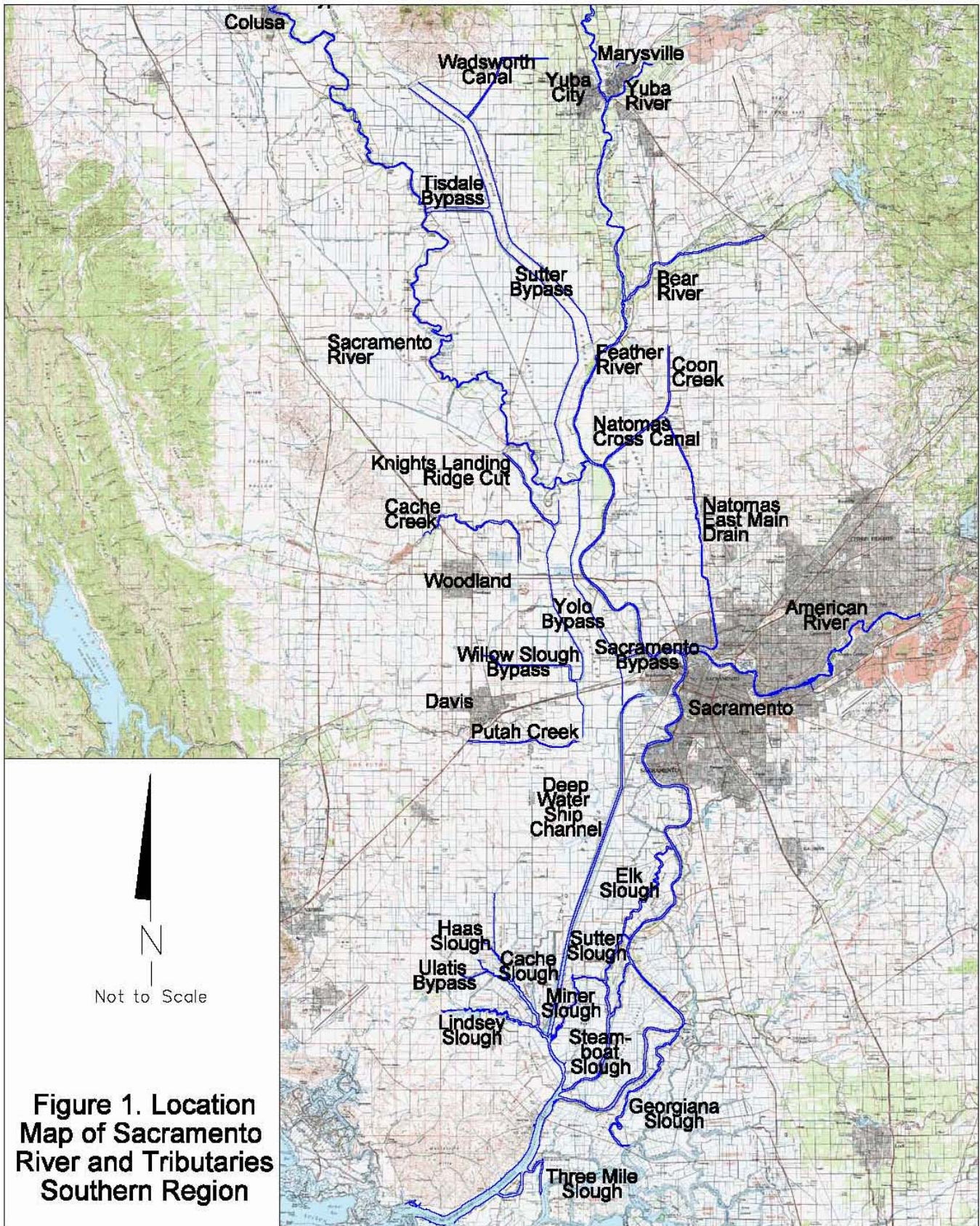


Figure 1. Location Map of Sacramento River and Tributaries Southern Region

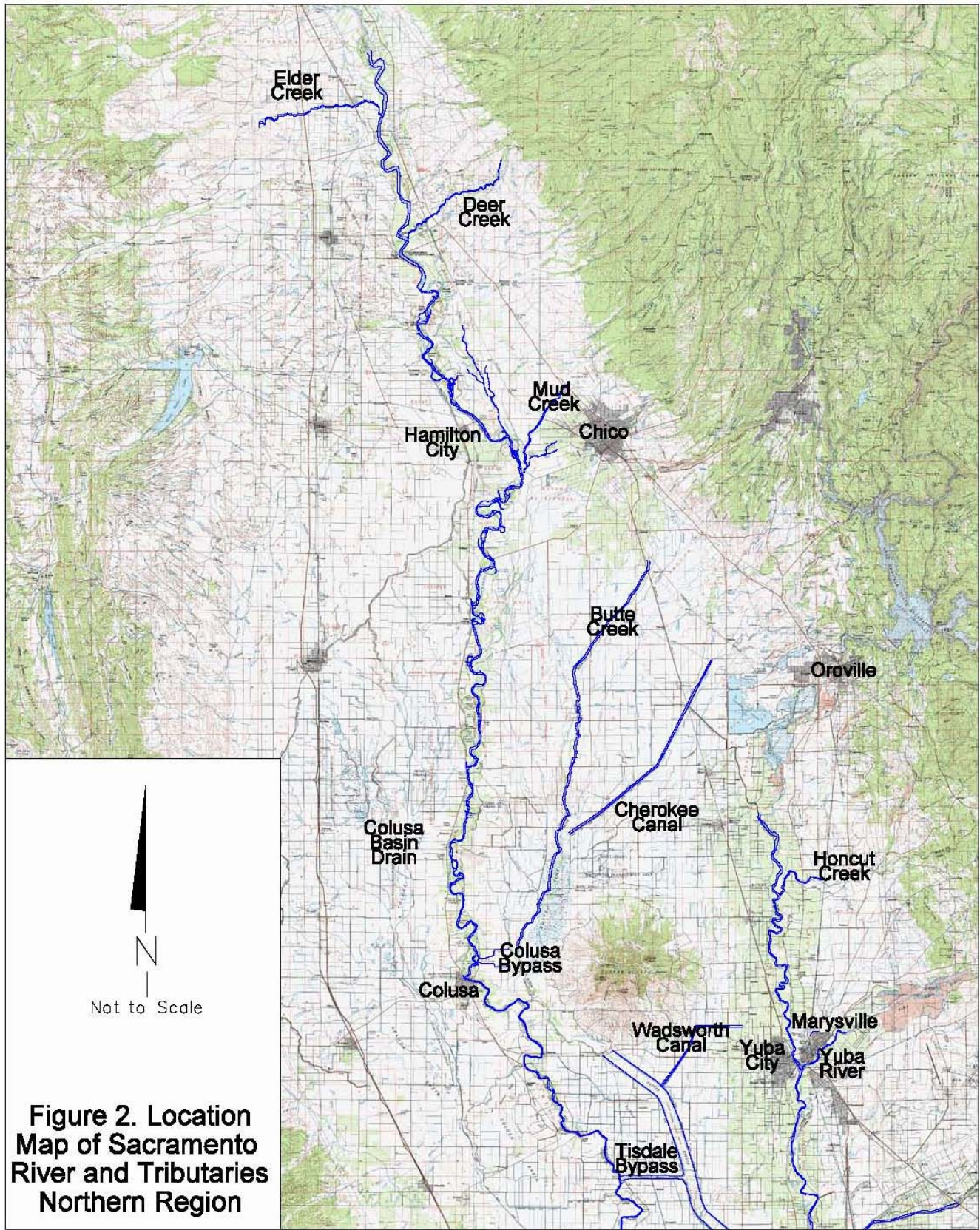


Figure 2. Location Map of Sacramento River and Tributaries Northern Region

2.0 AUTHORIZATION AND WORK REQUIREMENTS

Ayres Associates' work requirements for this project are set forth in a Scope of Work (SOW) dated 30 August 2007, under Contract W91238-07-C-0002, Modification P00004. The Project Manager at the Sacramento District is Mr. Stanley Wallin, PE and the Engineering Technical Lead is Mr. Donald Twiss, PE.

Prior to the field reconnaissance, a master list of all 2006 erosion sites within the Sacramento River Flood Control System was developed by Ayres Associates for use by those participating in the review. The list contained pertinent data associated with the characteristics of each erosion site, and its approximate position, located during previous reconnaissance trips. The list was used by Ayres Associates personnel to identify past erosion sites. Ayres Associates was also required to identify any new erosion sites and add them to the inventory. New sites were located using a portable Trimble Global Positioning System (GPS) receiver. Digital photos were provided for the existing and newly identified erosion sites under a separate submittal to the Corps.

In addition to the inventory list, the 2006 Aerial Atlas of Bank Erosion Sites was used to aid in this years field review. This atlas contained aerial photographs of the Sacramento River, from RM 0 to RM 197, as well as the distributaries of the Sacramento River reviewed during this reconnaissance. Those maps showed all of the erosion sites from the 2006 inventory.

3.0 RECONNAISSANCE COVERAGE AND PROCEDURES

The field reconnaissance of the Sacramento River Flood Control System was conducted by boat except for Cache Creek, Bear River, Butte Creek and the Yuba River, which were too shallow for boat access. Those creeks and rivers were done by using a 4X4 vehicle or ATV on levee access roads. The reconnaissance was performed during the following dates; October 1 – 4, October 10 - 12, and October 15 – 16, 2007. Sacramento District Corps and California DWR personnel accompanied Ayres Associates personnel on all of the days except for the Feather River and Lower American River where space was limited on the shallow draft, jet boat. Also no sponsor representatives were along for the review of the Yuba River. The areas specifically covered included the following:

- Main Sacramento River from Collinsville (RM 4) to Chico Landing (RM 199)
- Steamboat Slough
- Sutter Slough
- Portions of Lindsey Slough
- Cache Slough
- Georgiana Slough
- Threemile Slough
- Miner Slough
- Elk Slough
- American River RM 0 to RM 13)
- Feather River (RM 0 to RM 31)
- Bear River
- Yuba River (RM 0 to RM 5)
- Cache Creek

The field reconnaissance was performed along the rivers and sloughs using a 17-foot boat powered by a 75-Hp prop-driven motor in most of the system. A 17-foot boat with a 90 Hp jet motor was used on the Feather and the Lower American Rivers where a shallow draft boat was

required. The inspections of Cache Creek, Bear River, Yuba River and Butte Creek were conducted by land from the levee access roads using either Ayres' 4X4 pick-up or Polaris ATV's.

Erosion site positions were located and new positional information was logged using a portable Trimble GPS receiver. Specific sites are identified by waypoints, and recorded on the GPS receiver by latitude and longitude. Previously identified sites (Ayres Associates 2006) were located by navigating via the GPS receiver to the waypoints associated with that particular site.

4.0 EROSION INVENTORY CRITERIA AND SITE DATA COLLECTED

The criteria for including a bank erosion site into the inventory included some judgment as to the severity of the erosion and the threat to the levee but most always included one of the following two items:

- a) Bank erosion into the projection of the levee slope,
- b) Berm width of less than 35 feet (original criteria was 10 meters)

Figure 3 shows a schematic illustrating these two criteria.

Specific data collected at each site includes:

- a) Approximate River Mile as per 1991 Corps River Atlas
- b) Right or left bank
- c) GPS Waypoint designation
- d) Estimate site length (visual estimate)
- e) Erosion location on the bank (toe, mid bank, upper slope, etc.)
- f) Erosion mechanism
- g) Existing revetment type, if any
- h) Proximity of erosion to the levee slope
- i) Remaining berm width
- j) Field notes or comments for each inspection year.

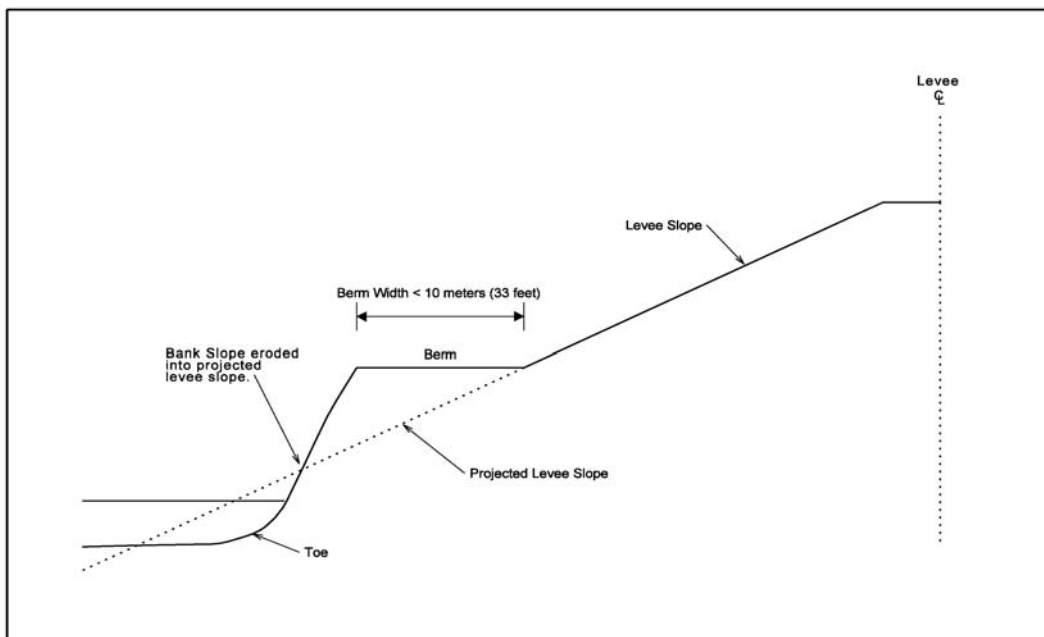


Figure 3. Schematic of Inventory Erosion Site Criteria

5.0 SUMMARY OF 2007 FIELD RECONNAISSANCE

Based upon the findings of the 2007 reconnaissance inventory, the number of documented sites in the inventory has decreased for the first time in many years. Erosion site repairs have been proceeding over the past two construction seasons and between the 2006 and 2007 inventories, a total of fifty-eight (58) sites have been removed from the inventory and most all of these are the result of completed repairs. Also during this period, five (5) new sites have been added even though there was very little runoff during the 2006-2007 water year. The total number of sites for the Sacramento Flood Control System has been reduced from a high of 205 in the year 2006 to 152 in 2007.

The total numbers of 2007 erosion sites by river, stream or slough are summarized in **Table 1** below. The 2006 total is included for comparison.

Table 1. Summary of Erosion Sites by River, Creek or Slough

River, Creek or Slough	2006 Erosion Sites	2007 New Sites	2007 Removed Sites	2007 Erosion Sites
Bear River	4	0	3	1
Butte Creek	-	-	-	0
Cache Creek	7	0	2	5
Cache Slough	4	1	1	4
Cherokee Canal*	2	-	-	2*
Colusa Bypass*	0	-	-	0*
Colusa Main Drain*	0	-	-	0*
Coon Creek, Unit 6	0	-	-	0*
Deep Water Ship Channel, East Levee*	2	-	-	2*
Deer Creek*	2	-	-	2*
Elder Creek*	3	-	-	3*
Elk Slough	1	0	0	1
Feather River	11	0	1	10
Georgiana Slough	18	0	0	18
Honcut Creek*	0	-	-	0*

Table 1. Continued - Summary of Erosion Sites by River, Creek or Slough				
River, Creek or Slough	2006 Erosion Sites	2007 New Sites	2007 Removed Sites	2007 Erosion Sites
Knights Landing Ridge Cut*	5	-	-	5*
Lower American River	4	0	0	4
Marysville, Units 1, 2 & 3	0	-	-	0*
Mud Creek*	0	-	-	0*
Natomas Cross Canal*	1	-	-	1*
Natomas East Main Drain*	0	-	-	0*
Putah Creek*	0	-	-	0*
Sacramento River	115	3	44	74
Sacramento Bypass*	0	-	-	0*
Steamboat Slough	12	1	5	8
Sutter Bypass*	1	-	-	1*
Sutter Slough	4	0	2	2
Tisdale Weir*	0	-	-	0*
Ulatis Ck. Bypass, Unit 2*	0	-	-	0*
Wadsworth Canal*	0	-	-	0*
Willow Slough Bypass*	3	-	-	3*
Yolo Bypass*	5	-	-	5*
Yuba River	1	0	0	1
Totals	205	5	58	152

*These tributaries were not part of the 2007 field reconnaissance and the numbers from the 2006 reconnaissance have been carried forward.

The total number of 2007 critical erosion sites by river, stream or slough is summarized in **Table 2** below along with a comparison of the totals from 2006.

Table 2. Summary of Critical Erosion Sites by River, Creek or Slough

River, Creek or Slough	Total Critical Sites in 2006	Repaired Critical Sites	New Critical Sites in 2007	Total Critical Sites in 2007
Bear River	3	3	0	0
Cache Creek	5	2	0	3
Cache Slough	1	0	0	1
Elk Slough	0	0	0	0
Feather River	0	0	0	0
Georgiana Slough	0	0	0	0
Lower American River	0	0	0	0
Sacramento River	39	39	0	0
Steamboat Slough	5	4	0	1
Sutter Slough	2	2	0	0
Totals	55	50	0	5

Spreadsheets containing site observations for the inventoried erosion sites have been organized into tables as described below and are included in the **Appendix A** to this report.

Table 3. Tables of Inventoried Erosion Sites for 2007 in Appendix A

Table No.	Title	No. of sites
1	Sacramento River Levee System - Current Erosion Sites – 2007	152
2	Sacramento River Levee System - New Erosion Sites - 2007	5
3	Sacramento River Levee System - Removed Erosion Sites - 2007	58
4	Sacramento River Levee System - Critical Erosion Sites – 2007	5
5	Sacramento River Levee System - GPS Waypoint Locations - 2007	152

A general explanation of the terminology used throughout these tables to describe the condition of the different sites is as follows:

- Critical Site: Sites where further erosion may result in a bank failure, which encroaches near or into the levee crown and is recommended as the highest priority for repair.
- Monitor Closely: Denotes sites that are not currently at a potentially critical stage but may become so in the near future if the current erosion rate continues.
- Maintenance Site: Sites that contain small pockets of erosion that can be handled by maintenance activities and a project level approach is not recommended to complete the repair.

The critical erosion sites have been classified in the field based on the combined experience and knowledge of the review team in the field. Actual measurements of erosion rates or bank cross sections were not available for this field classification

6.0 SITE PRIORITY RANKING

6.1 General

The project scope required the development of a ranking methodology that could be used to assist in the establishment of a priority list of which erosion sites should be fixed first. Surveyed levee cross sections were to be provided as a part of the back up data. As of the date of this report, the surveys have not been completed.

In a previous report, only specific critical erosion sites were analyzed. In this report all erosion sites from the 2006 erosion inventory, including the extending inventory covering many side creeks and the bypasses, were ranked. The sites repaired in 2006 and currently under repair in 2007 were removed from the inventory.

6.2 Discussion of Reviewed Methodologies

Four different methodologies were reviewed in the development of the site priority lists. The methodologies differ in the number of physical factors considered and some include economic considerations of the damage due to a levee failure. The methodologies are listed below. Detailed descriptions are provided in the following sections.

- Methodology 1: 16 Physical Factors and One Economic Factor
- Methodology 2: 10 Physical Factors and no Economic Factor
- Methodology 3: 5 Physical Factors and Revised Economic Factor
- Methodology 4: 5 Physical Factors and no Economic Factor

After the initial review process, it was decided to use all 4 methodologies would be used to develop separate ranking lists.

6.2.1 Methodology 1: 16 Physical Factors and One Economic Factor

Methodology 1 was the first attempted at ranking erosion potential at each site and takes into account a total of 17 different factors. These factors are as listed below:

- Bank Slope
- Berm Width
- Length of Erosion
- Location of Erosion
- Bank Stability
- Rc/W
- Site Relative to Bend
- Geomorphologic Processes
- Vegetative Cover
- Tree Hazard
- Soil Type
- Velocity
- Wave Action (Wind/Boat)
- Economic Factor
- Human Usage
- Seepage Potential
- Tidal Fluctuation

The definitions for the rating factors included in Methodology 1 are follows:

Bank Slope – The bank slope is the horizontal to vertical ratio of the eroding slope. (Estimated since actual cross sections were not completed at the time of this report.)

Berm Width – The berm width is the horizontal segment of the bank that extends from the levee toe to the top of the riverbank. (Estimated since actual cross sections were not completed at the time of this report.)

Length of Erosion Site – The length of erosion is the full length along the river over which the erosion occurs.

Location of Erosion – The location of the erosion is the position in the vertical direction where the erosion occurs, the lower on the slope, the greater the potential for failure.

Bank Stability – The bank stability criterion identifies any observed instabilities in the bank, such as near vertical slopes and animal caves.

Rc/W- This factor is the radius of the meander bend divided by the top width length at bank full.

Site Relative to Bend – This factor relates to where within a mender bend an erosion site is located.

Geomorphologic Processes – This criterion takes into account the active erosion and deposition patterns of the channel.

Vegetative Cover – This criterion relates to how much vegetation exists on the site and its role in providing erosion protection.

Tree Hazard – While vegetation can be helpful, large trees can put excessive weight on banks and can result in failures, therefore the older and larger trees result in a higher stability hazard.

Soil Type – Based on the Unified Soil Classification System.

Velocity – The velocity for the Sacramento River sites has been obtained from the existing UNET hydraulic model using the 100-yr discharge, where available.

Wave Action – The wave action accounts for natural (wind) and unnatural (boats) waves that impact the banks.

Economic Factor – This economic factor is based primarily on the estimated population within the potential inundation areas.

Human Usage - The human usage criterion takes into account how much the site is used by humans and accounts for site damage from such usage.

Seepage Potential – The seepage potential takes into account any documented history of seepage.

Tidal Fluctuation – Reaches of the river that are affected by tides have a lower bank zone that is usually devoid of vegetation and more susceptible to erosion.

Each factor can score from 0 points to 5 points, with the exception of velocity, which can score up to 6 points. Five of the most significant factors relating to erosion (bank slope, berm width, soil type, velocity, and economics) are weighted by a factor of 2. The scores are summed resulting in a total in the range of 0 to 107, with 0 meaning no erosion hazard and 107 being the greatest potential erosion hazard. The values and corresponding score definitions are provided in **Figure 4**.

Criteria	Score Definition
Bank Slope (*2)	0 - 3:1 or Greater Slope; 1 - 2.5:1 Slope; 2 - 2:1 Slope; 3 - 1.5:1 Slope; 4 - 1:1 or Less Slope; 5 - Vertical Slope
Berm Width (*2)	0 - Berm Width of 30 ft or Greater; 1 - 20 to 29 ft of Berm; 2 - 10 to 19 ft of Berm; 3 - 5 to 9 ft of Berm; 4 - 1 to 4 ft of Berm; 5 - No Berm Width
Length of erosion	0 - Less than 10 ft; 1 - 10ft to 100ft; 2 - 101ft to 500ft; 3 - 501ft to 1000ft; 4 - 1001ft to 1500ft; 5 - Greater than 1500 ft
Location of erosion	0 - Upper Bank; 1 - Middle Bank; 2 - Lower Bank; 3 - Toe; 4 - Toe and Bank; 5 - Toe and Underwater
Bank Stability	0 - No Vertical Sections or Caves; 1 - Beaver Burrows at Toe (1 to 4 ft in length); 2 - Vertical Slope Sections (less than half the slope height); 3 - Beaver Burrows at Toe (greater than 4 ft); 4 - Vertical Slope Sections (greater than half the slope height); 5 - Vertical Sections and Beaver Burrows
Radius of Curvature (R _c /w)	0 - Greater than 5 or No Curve; 1 - 4 to 5 Range; 2 - 3 to 4 Range; 3 - Less than 3; 4 - 2 to 1 Range; 5 - Less than 1
Site Relative to Bend	0 - Inside of Bend; 1 - Straight Reach; 2 - Just Downstream of a Bend; 3 - Outside of Bend (greater than 90 degrees interior angle); 4 - Outside of Bend (90 degree turn); 5 - Outside of Tight Bend (less than 90 degree interior angle)
Geomorph	0 - No Channel Migration Expected; 2 - Channel Migration Potential on one side, opposite bank; 3 - Channel Migration Potential on one side, erosion side; 5 - Channel Migration Potential on both sides
Vegetation Cover	0 - Dense vegetation (100 - 80% cover); 1 - Medium to Dense Vegetation (80 - 60% cover); 2 - Medium Vegetation (60 - 40% cover); 3 - Slight to Medium Vegetation (40 - 20% cover); 4 - Slight Vegetation (up to 20% cover); 5 - No vegetation
Tree Hazard	0 - No or Small Trees; 1 - Young Trees (with potential to be large); 2 - Medium Trees; 3 - Large Trees; 4 - Trees with Visible Roots; 5 - Trees with Visible Roots and Leaning
Soil Type (*2)	0 - Cemented Soils; 1 - All Clays; 2 - Clays and Silts; 3 - Sands; 4 - Silty Sands; 5 - All Silt
Velocity (*2)	0 - Less than 1.0 ft/s during high flow event; 1 - 1.0 to 2.0 ft/s; 2 - 2.0 to 3.0 ft/s; 3 - 3.0 to 5.0 ft/s; 4 - 5.0 - 8.0 ft/s; 5 - Greater than 8 ft/s (If eddy currents are observed, add an additional point)
Wave Action (Wind/Boat)	0 - Calm Water; 1 - Occasional Wave ; 2 - Low Wave Action; 3 - Moderate Wave Action; 4 - Heavy Wave Action; 5 - Heavy Wave Action with Cargo Ships passing through
Economic Factor (*2)	0 - Parks/No Habitable Structures; 1 - Farms; 2 - Small Town (100+ population); 3 - Rural (5,000+ population); 4 - Suburban (20,000+ population); 5 - Major Metropolitan (100,000+ population)
Human Usage	0 - No or Rare Usage; 1 - Occasional Usage; 2 - Seasonal Usage; 3 - Monthly Usage; 4 - Weekly Usage ; 5 - Daily Usage
Seepage Potential	0 - No Seepage History; 5 - Seepage History
Tidal Fluctuation	0 - Not tide, upstream of RM 80; 1 - Between RM 60 and RM 80; 2 -Between RM 45 and RM 60; 3 - Between RM 30 and RM 45; 4 - Between RM 15 and RM 30 ; 5 - Between RM 0 and RM 15

Figure 4. Score Sheet for Methodology 1.

6.2.2 Methodology 2: 10 Physical Factors and no Economic Factor

This methodology uses the previously discussed methodology but removes selected physical based factors and any economic considerations based on review comments received from California DWR on the Ayres Associates' draft ranking methodology report (Ayres Associates, December 15, 2004). The factors that make up Methodology 2 are:

- Bank Slope
- Berm Width
- Location of Erosion
- Bank Stability
- Site Relative to Bend
- Vegetation Cover
- Tree Hazard
- Soil Type
- Velocity
- Human Usage

The definitions for the factors are the same as described in Section 6.2.1 and the scoring is as shown in **Figure 5**.

The general reasoning given for the removal of the seven factors was as follows: The economic factor was removed because it was not a physical criteria for determining severity. While economics may be a factor in allocation of funding, DWR thought it should not be included when deciding severity. The wave action, tidal fluctuation, and geomorphology were removed since they tend to be reach-specific factors. Length of erosion was removed as it was felt that length did not contribute to failure risk. Radius of curvature was removed since it was believed that the site relative to the bend would be more useful for erosion. Seepage potential was also removed since it could be considered in the bank stability factor.

Criteria	Score Definition
Bank Slope (*2)	0 - 3:1 or Greater Slope; 1 - 2.5:1 Slope; 2 - 2:1 Slope; 3 - 1.5:1 Slope; 4 - 1:1 or Less Slope; 5 - Vertical Slope
Berm Width (*2)	0 - Berm Width of 30 ft or Greater; 1 - 20 to 29 ft of Berm; 2 - 10 to 19 ft of Berm; 3 - 5 to 9 ft of Berm; 4 - 1 to 4 ft of Berm; 5 - No Berm Width
Location of erosion	0 - Upper Bank; 1 - Middle Bank; 2 - Lower Bank; 3 - Toe; 4 - Toe and Bank; 5 - Toe and Underwater
Bank Stability	0 - No Vertical Sections or Caves; 1 - Beaver Burrows at Toe (1 to 4 ft in length); 2 - Vertical Slope Sections (less than half the slope height); 3 - Beaver Burrows at Toe (greater than 4 ft); 4 - Vertical Slope Sections (greater than half the slope height); 5 - Vertical Sections and Beaver Burrows
Site Relative to Bend	0 - Inside of Bend; 1 - Straight Reach; 2 - Just Downstream of a Bend; 3 - Outside of Bend (greater than 90 degrees interior angle); 4 - Outside of Bend (90 degree turn); 5 - Outside of Tight Bend (less than 90 degree interior angle)
Vegetation Cover	0 - Dense vegetation (100 - 80% cover); 1 - Medium to Dense Vegetation (80 - 60% cover); 2 - Medium Vegetation (60 - 40% cover); 3 - Slight to Medium Vegetation (40 - 20% cover); 4 - Slight Vegetation (up to 20% cover); 5 - No vegetation
Tree Hazard	0 - No or Small Trees; 1 - Young Trees (with potential to be large); 2 - Medium Trees; 3 - Large Trees; 4 - Trees with Visible Roots; 5 - Trees with Visible Roots and Leaning
Soil Type (*2)	0 - Cemented Soils; 1 - All Clays; 2 - Clays and Silts; 3 - Sands; 4 - Silty Sands; 5 - All Silt
Velocity (*2)	0 - Less than 1.0 ft/s during high flow event; 1 - 1.0 to 2.0 ft/s; 2 - 2.0 to 3.0 ft/s; 3 - 3.0 to 5.0 ft/s; 4 - 5.0 - 8.0 ft/s; 5 - Greater than 8 ft/s (If eddy currents are observed, add an additional point)
Human Usage	0 - No or Rare Usage; 1 - Occasional Usage; 2 - Seasonal Usage; 3 - Monthly Usage; 4 - Weekly Usage; 5 - Daily Usage

Figure 5. Score Sheet for Methodology 2

6.2.3 Methodology 3: 5 Physical Factors with Revised Economic Factor

After further reviews and comments, the initial ranking was revised to utilize the minimum number of factors. The purpose of this revised methodology was to emphasize the major causes of failure in the Sacramento River Levee System and to place increased emphasis on the economic value of the areas protected by these levees. Methodology 3 takes into account a total of 6 ranking factors for every site. The criteria used to classify and score the erosion hazard at each site are as follows:

- Bank Slope
- Berm Width
- Soil Type
- Velocity
- Bank Stability
- Economic Factor

The definitions for these ranking criteria are as follows:

Bank Slope – The bank slope is the horizontal to vertical ratio of the eroding slope.

Berm Width – Measured from the toe of the levee slope to the top of the riverbank.

Soil Type – Classified using the Uniform Soil Classification System.

Velocity – The velocity for the Sacramento River sites has been obtained from the USACE's existing UNET hydraulic model using the 100-yr discharge, where available. The velocity score is based on the 100-yr event, which might not be the most damaging event on the banks and levees. The 10-yr event and a bankfull event should be looked at also. The event that causes the greatest velocities on the banks should be used.

Bank Stability – The bank stability criterion accounts for observed instabilities in the exposed riverbank and levee. The instabilities are tension cracks, slumping, tree hazard, beaver holes or caves, and seepage history.

Economic Factor – The economic factor is difficult to rate and will likely be highly debated. The ranking system for Methodology 3 is based on an estimated cost of damage, so a flood occurring in a large area will be more expensive than a flood in a smaller area. Land use is also important to consider since a square mile of urban area will be more costly than a square mile of agriculture. The ranking was established by first dividing the entire Sacramento River basin into potential flooded areas, based on if a levee failure occurs what land would be flooded. The basin was divided into 26 sub-basins; these sub-basins are shown in **Figures 6** and **7**, with the name and area displayed. A land use weighted factor was developed based on the percentage of each land use. The land uses in the Sacramento Valley are primarily urban and agricultural (annual crops and orchards). Since the cost of rebuilding is different for these land uses, the urban areas were weighted at 10 times that of annual crops. The orchards were ranked as twice the value of annual crops. The weighted factor was then multiplied by the area of the overbank to establish a ranking order. **Table 3** shows the sub-basins, their size, percent of each land use, the weighted factor, and the final ranking score.

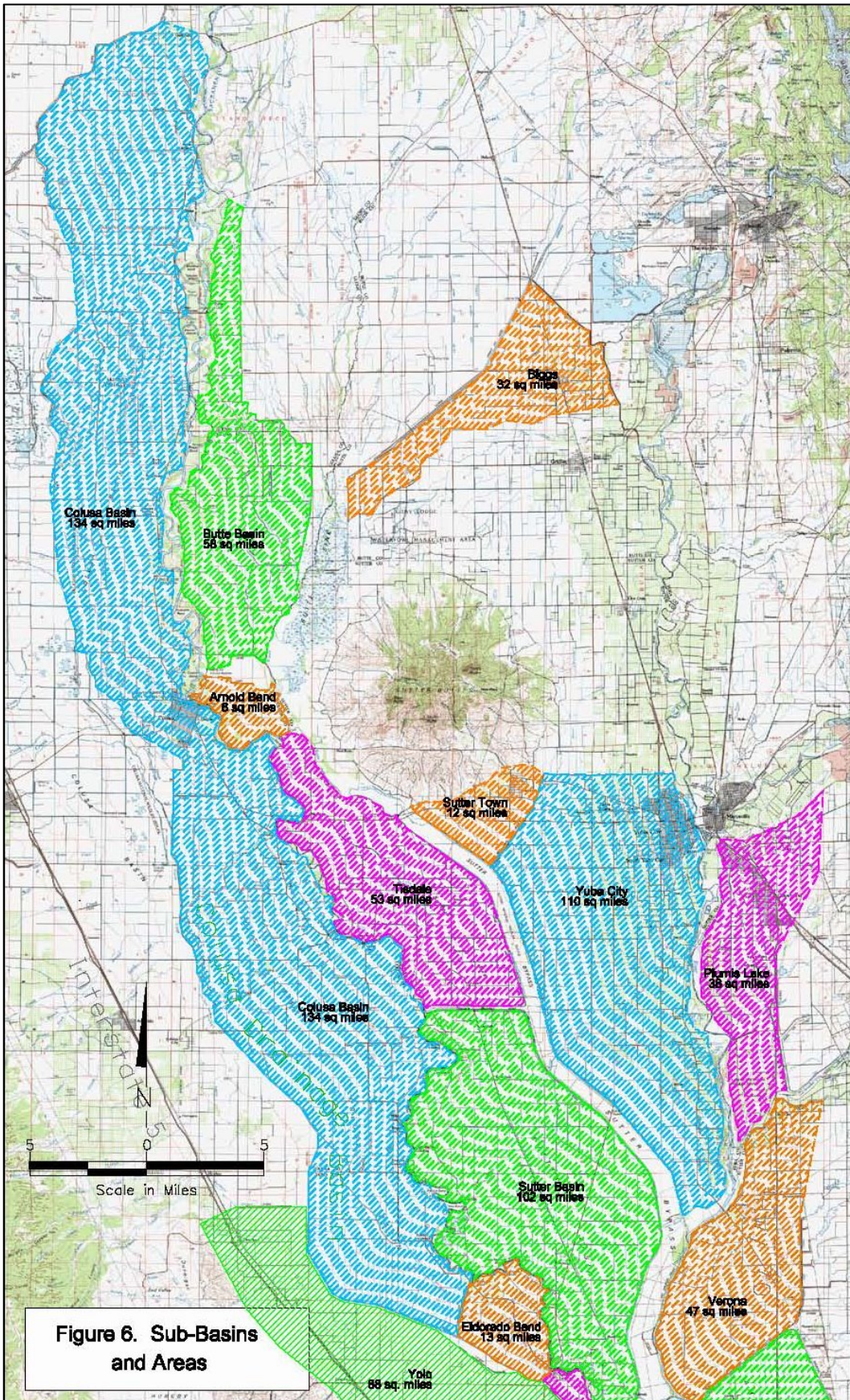


Figure 6. Sub-Basins and Areas

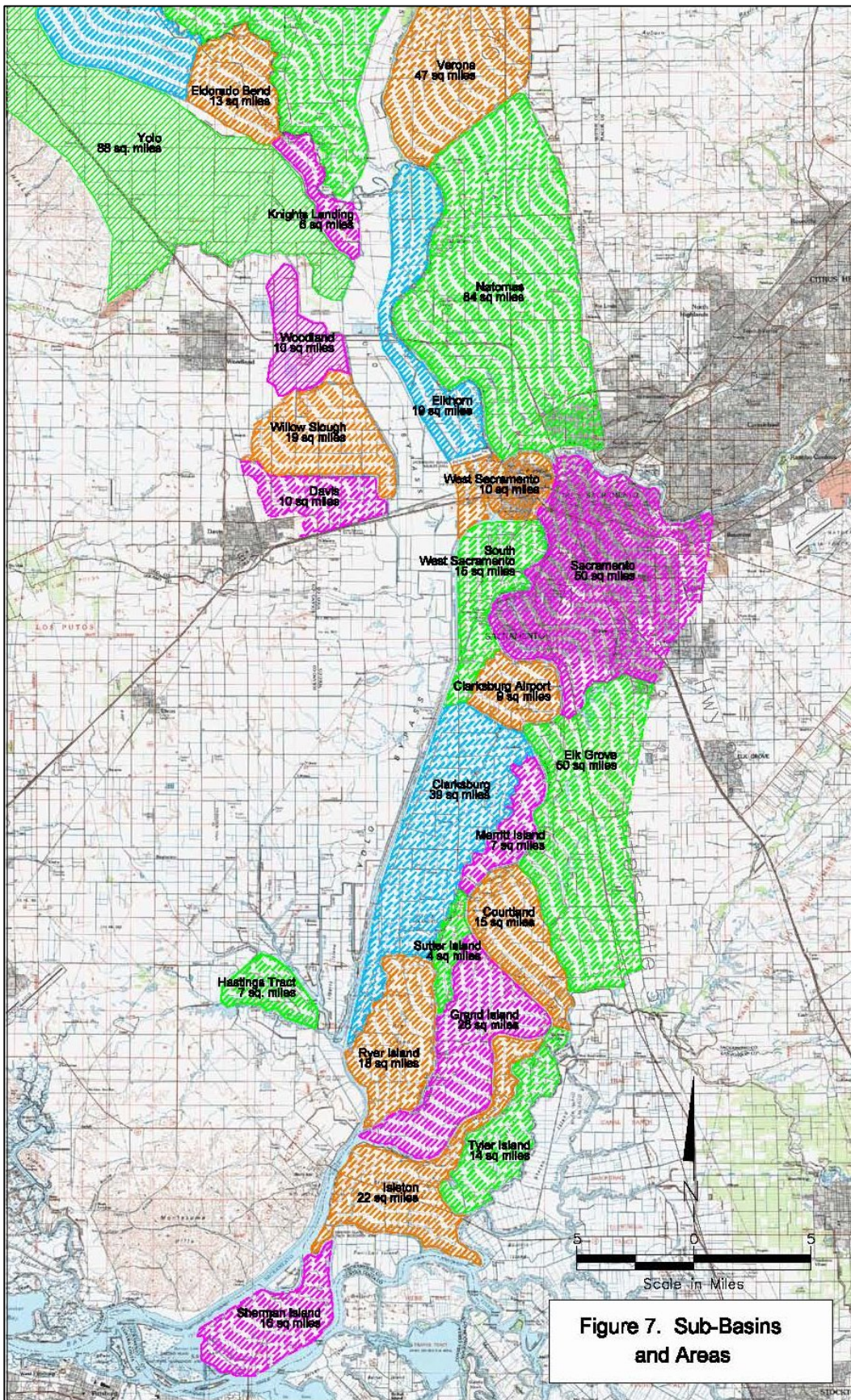


Figure 7. Sub-Basins and Areas

Table 3. Ranking for Revised Economic Factor

Overbank Name	Area (miles ²)	% urban	% agriculture (orchards)	% agriculture (crops)	Land Use weighted factor	Score	Ranking Factor
Sherman Island	16	0	0	100	1	16	4
Isleton	22	5	5	90	1.5	33	7
Tyler Island/ Walnut Grove	14	5	5	90	1.5	21	5
Grand Island/ Walnut Grove	26	5	10	85	1.55	40	8
Ryer Island	18	0	0	100	1	18	4
Sutter Island	4	0	30	70	1.3	5	1
Courtland	15	5	10	85	1.55	23	6
Merritt Island	7	0	10	90	1.1	8	1
Clarksburg	39	10	5	85	1.95	76	12
Elk Grove	50	35	5	60	4.2	210	16
Clarksburg Airport	9	5	0	95	1.45	13	3
South West Sacramento	15	40	5	55	4.65	70	11
West Sacramento	10	90	0	10	9.1	91	13
Sacramento	60	95	0	5	9.55	573	20
Natomas	84	45	0	55	5.05	424	18
Elkhorn	19	0	20	80	1.2	23	6
Verona	47	5	0	95	1.45	68	10
Knights Landing	6	10	0	90	1.9	11	2
Sutter Basin	102	0	0	100	1	102	14
Eldorado Bend	13	0	0	100	1	13	3
Colusa Basin	300	5	5	90	1.5	450	19
Tisdale	53	0	10	90	1.1	58	9
Arnold Bend	8	0	10	90	1.1	9	1
Butte Basin	58	5	10	85	1.55	90	13
Yuba City	110	15	40	45	2.75	303	17
Plumas Lake	38	30	30	40	4	152	15
Hastings Tract	7	0	0	100	1	7	1
Yolo	88	5	5	90	1.5	132	15
Biggs	32	5	20	75	1.65	53	9
Willow Slough	19	0	0	100	1	19	4
Davis	10	20	0	80	2.8	28	7
Sutter Town	12	20	20	60	3	36	8
Woodland	10	0	0	100	1	10	2

The proposed rating system presented here can result in a range of values from 0 to 48, with 0 meaning no erosion hazard and 48 being the greatest possible erosion hazard. The sites with the highest erosion hazard score should be the highest priority for repair.

The factors are not all equally weighted. For instance, since the economics of a failure which depends on the size and land use surrounding the Sacramento River can vary so greatly, it has a higher score range than the other values. The velocity and bank stability factors have a maximum score of one point higher than the remaining factors. The velocity score can be increased if eddies are present, since in addition to the potential erosion the velocity can cause, the eddy will intensify its effect. For the bank stability factor, the score is raised if you have a combination of seepage or slumping and additional stability issues.

All factors are evaluated at each site and given a ranking score based on the definitions provided in **Figure 8**. The values for each site are combined arithmetically and summarized on a score sheet.

6.2.4 Methodology 4: 5 Physical Factors with no Economic Factor

Methodology 4 uses the same factors described in Section 6.2.3 but does not include any economic factor. This places increased emphasis on the factors that will cause failure and disregards the value of the area it will flood. This rating system can result in scores of 0 to 28, with a score of 28 representing the most severe site and most likely to fail. The definitions for the factors are described in Section 6.2.3 and the score sheet is shown in **Figure 9**.

6.3 Site Priority Ranking Results

In late summer of 2005, Ayres Associates personnel performed a field inspection of each of the designated erosion sites (see list in Section 3.0) and collected data to complete an erosion hazard data sheet for each site and each methodology. The ranked order for the reviewed erosion sites, from greatest hazard potential to least, is shown in **Tables 4 – 7** for each of the four methodologies and a summary of the ranking for each site is provided in **Table 8**. Complete erosion hazard data sheets are provided in **Appendices B – E** for each of the four methodologies.

Criteria	Score Definition
Bank Slope	0 - 3:1 or Greater Slope; 1 - 2.5:1 Slope; 2 - 2:1 Slope; 3 - 1.5:1 Slope; 4 - 1:1 or Less Slope; 5 - Vertical Slope
Berm Width	0 - Berm Width of 30 ft or Greater; 1 - 20 to 29 ft of Berm; 2 - 10 to 19 ft of Berm; 3 - 5 to 9 ft of Berm; 4 - 1 to 4 ft of Berm; 5 - No Berm Width
Soil Type	0 - Cemented Soils; 1 - All Clays; 2 - Clays and Silts; 3 - Sands; 4 - Silty Sands; 5 - All Silt
Velocity	0 - Less than 1.0 ft/s during high flow event; 1 - 1.0 to 2.0 ft/s; 2 - 2.0 to 3.0 ft/s; 3 - 3.0 to 5.0 ft/s; 4 - 5.0 - 8.0 ft/s; 5 - Greater than 8.0 ft/s (if eddy currents are observed, add an additional point)
Economic Factor	1 - Arnold Bend, Merritt Island, Hastings Tract, and Sutter Island; 2 - Knights Landing and Woodland; 3 - Eldorado Bend and Clarksburg Airport; 4 - Willow Slough, Ryer Island and Sherman Island; 5 - Tyler Island; 6 - Elkhorn and Courtland; 7 - Isleton and Davis; 8 - Grand Island and Sutter Town; 9 - Tisdale and Biggs; 10 - Verona; 11 - South West Sacramento; 12 - Clarksburg; 13 - Butte Basin and West Sacramento; 14 - Sutter Basin; 15 - Plumis Lake and Yolo; 16 - Elk Grove; 17 - Yuba City; 18 - Natomas; 19 - Colusa Basin; 20 - Sacramento
Bank Stability	0 - No Stability issues; 1 - Tree Hazards; 2 - Beaver Holes or Caves; 3 - Tension Cracks; 4 - Slumping; 5 - Seepage History; 6 - Combination of Seepage/Slumping and one additional stability issue; 7 - Combination of Seepage/Slumping and two additional stability issues

Left Bank		Right Bank	
Location	Overbank Area	Location	Overbank Area
Elk Slough	Merritt Island	Cache Slough, RM 20 - 25	Hastings Tract
Feather River, RM 0 - 12	Verona	Elk Slough	Clarksburg
Feather River, RM 12 - 22	Plumis Lake	Feather River, RM 8 - 22	Yuba City
Georgiana Slough	Tyler Island	Georgiana Slough	Isleton
Miner Slough	Ryer Island	Miner Slough	Clarksburg
Sacramento River, RM 3 - 9	Sherman Island	Sacramento River, RM 15 - 32.4	Grand Island
Sacramento River, RM 9 - 26.5	Isleton	Sacramento River, RM 32.4 - 34	Sutter Island
Sacramento River, RM 26.5 - 28	Tyler Island	Sacramento River, RM 34 - 41.8	Merritt Island
Sacramento River, RM 28 - 36.5	Courtland	Sacramento River, RM 41.8 - 43	Clarksburg
Sacramento River, RM 36.5 - 45	Elk Grove	Sacramento River, RM 43 - 49.5	Clarksburg Airport
Sacramento River, RM 45 - 60	Sacramento	Sacramento River, RM 49.5 - 57.5	South West Sacramento
Sacramento River, RM 60.5 - 79	Natomas	Sacramento River, RM 57.5 - 63.5	West Sacramento
Sacramento River, RM 79 - 80	Verona	Sacramento River, RM 63.5 - 81.5	Elkhorn
Sacramento River, RM 84.5 - 118.5	Sutter Basin	Sacramento River, RM 84 - 90	Knights landing
Sacramento River, RM 118.5 - 138.5	Tisdale	Sacramento River, RM 90 - 98.5	Eldorado Bend
Sacramento River, RM 138.5 - 146	Arnold's Bend	Sacramento River, RM 98.5 - 184	Colusa Basin
Sacramento River, RM 146 - 176	Butte Basin	Sevenmile Slough	Isleton
Steamboat Slough	Grand Island	Steamboat Slough, RM 15 - 22	Ryer Island
Sutter Slough	Sutter Island	Steamboat Slough, RM 22 - 27	Sutter Island
Threemile Slough	Sherman Island	Sutter Slough, RM 22 - 24	Ryer Island
Cache Creek	Yolo	Sutter Slough, RM 24 - 28	Clarksburg
		Threemile Slough	Isleton

Figure 8. Score Sheet for Methodology 3

Criteria	Score Definition
Bank Slope	0 - 3:1 or Greater Slope; 1 - 2.5:1 Slope; 2 - 2:1 Slope; 3 - 1.5:1 Slope; 4 - 1:1 or Less Slope; 5 - Vertical Slope
Berm Width	0 - Berm Width of 30 ft or Greater; 1 - 20 to 29 ft of Berm; 2 - 10 to 19 ft of Berm; 3 - 5 to 9 ft of Berm; 4 - 1 to 4 ft of Berm; 5 - No Berm Width
Soil Type	0 - Cemented Soils; 1 - All Clays; 2 - Clays and Silts; 3 - Sands; 4 - Silty Sands; 5 - All Silt
Velocity	0 - Less than 1.0 ft/s during high flow event; 1 - 1.0 to 2.0 ft/s; 2 - 2.0 to 3.0 ft/s; 3 - 3.0 to 5.0 ft/s; 4 - 5.0 - 8.0 ft/s; 5 - Greater than 8.0 ft/s (if eddy currents are observed, add an additional point)
Bank Stability	0 - No Stability issues; 1 - Tree Hazards; 2 - Beaver Holes or Caves; 3 - Tension Cracks; 4 - Slumping; 5 - Seepage History; 6 - Combination of Seepage/Slumping and one additional stability issue; 7 - Combination of Seepage/Slumping and two additional stability issues

Figure 9. Score Sheet for Methodology 4

Table 4. Methodology 1 Ranking Order

Rank	Site	Score	Rank	Site	Score
1	Sacramento River, RM 77.2L	70	76	Sacramento River, RM 31.6R	48
1	Feather River, RM 28.5R	70	76	Georgiana Slough, RM 1.7L	48
3	Sacramento River, RM 57.2R	68	76	Feather River, RM 0.6L	48
4	Sacramento River, RM 52.3L	67	76	Willow Slough, LM 6.9 (DWR South)	48
5	Sacramento River, RM 177.8R	66	83	Sacramento River, RM 116.5L	47
5	Sacramento River, RM 53.5R	66	83	Sacramento River, RM 114.5R	47
5	Sacramento River, RM 8.0L	66	83	Sacramento River, RM 103.4L	47
5	Feather River, RM 17.8L	66	83	Sacramento River, RM 86.5R	47
9	Lower American River, RM 2.8L	64	83	Sacramento River, RM 74.4R	47
9	Feather River, RM 19.7L	64	83	Sacramento River, RM 23.3L	47
9	Feather River, RM 7.0L	64	83	Steamboat Slough, RM 24.7R	47
12	Sacramento River, RM 26.0L	63	83	Georgiana Slough, RM 6.4L	47
13	Sacramento River, RM 49.7L	62	83	Georgiana Slough, RM 3.6L	47
13	Georgiana Slough, RM 5.3L	62	83	Elk Slough, RM 0.2	47
15	Sacramento River, RM 42.7R	61	83	Cache Creek, LM 2.8L	47
15	Lower American River, RM 10.6L	61	94	Sacramento River, RM 24.8L	46
15	Lower American River, RM 0.3L	61	94	Sutter Slough, RM 24.7R	46
18	Sacramento River, RM 57.0R	60	94	Steamboat Slough, RM 25.0L	46
18	Sacramento River, RM 41.9R	60	94	Georgiana Slough, RM 6.8L	46
18	Sacramento River, RM 22.5L	60	94	Georgiana Slough, RM 3.7L (b)	46
18	Sacramento River, RM 10.8L	60	94	Georgiana Slough, RM 4.0L	46
18	Feather River, RM 3.8L	60	94	Yolo Bypass, LM 2.6 (DWR West)	46
18	Feather River, RM 1.0L	60	101	Sacramento River, RM 77.7R	45
24	Sacramento River, RM 73.5L	59	101	Steamboat Slough, RM 18.8R	45
24	Sacramento River, RM 35.4L	59	101	Georgiana Slough, RM 4.3L	45
24	Lower American River, RM 10.0L	59	101	Georgiana Slough, RM 2.5L	45
27	Sacramento River, RM 55.2L	58	101	Knight's Landing Ridge Cut, LM 0.2 (West)	45
27	Sacramento River, RM 23.2L	58	106	Cherokee Canal, LM 21.9 (DWR East)	44
29	Sacramento River, RM 35.4R	56	106	Yolo Bypass, LM 2.5 (DWR West)	44
30	Sacramento River, RM 130.0L	55	108	Sacramento River, RM 163.0L	43
30	Sacramento River, RM 78.8L	55	108	Sacramento River, RM 122.0R	43
30	Sacramento River, RM 55.5L	55	108	Sacramento River, RM 104.0L	43
30	Sacramento River, RM 22.7L	55	108	Sacramento River, RM 96.2L	43
30	Steamboat Slough, RM 25.8R	55	108	Sacramento River, RM 86.3L	43
30	Georgiana Slough, RM 7.0R	55	108	Knight's Landing Ridge Cutm LM 3.1 (East)	43
36	Sacramento River, RM 138.1L	54	114	Sacramento River, RM 132.9R	42
36	Sacramento River, RM 83.9R	54	114	Sacramento River, RM 127.9R	42
36	Sacramento River, RM 78.3L	54	114	Sacramento River, RM 122.3R	42
36	Sacramento River, RM 71.3R	54	114	Georgiana Slough, RM 3.7L (a)	42
36	Sacramento River, RM 56.7R	54	118	Sacramento River, RM 152.8L	41
36	Feather River, RM 5.5L	54	118	Sacramento River, RM 116.0L	41
36	Georgiana Slough, RM 4.6L	54	118	Sacramento River, RM 95.8L	41
43	Sacramento River, RM 157.7R	53	121	Sacramento River, RM 133.8L	40
43	Sacramento River, RM 86.9R	53	121	Sacramento River, RM 131.8L	40
43	Sacramento River, RM 35.3R	53	121	Sacramento River, RM 101.3R	40
43	Sacramento River, RM 21.5L	53	121	Cache Slough, RM 22.8	40
43	Feather River, RM 3.6L	53	121	Deer Creek, LM 2.4 (Tehama)	40
43	Steamboat Slough, Rm 23.9R	53	126	Sacramento River, RM 99.0L	39
43	Deer Creek, LM 0.9 (Tehama)	53	126	Elder Creek, LM 1.44 (Tehama)	39
43	Cache Creek, LM 3.4L	53	126	Cherokee Canal, LM 14.0 (DWR East)	39
43	Sutter Bypass, LM 0.4 (DWR East)	53	126	Yolo Bypass, LM 0.1 (West)	39
52	Sacramento River, RM 56.6L	52	130	Knight's Landing Ridge Cut, LM 5.3 (East)	38
52	Sacramento River, RM 56.5R	52	131	Sacramento River, RM 168.3L	37
52	Georgiana Slough, RM 9.3L	52	131	Sacramento River, RM 123.7R	37
52	Georgiana Slough, RM 6.6L	52	131	Sacramento River, RM 104.5L	37
52	Georgiana Slough, RM 6.1L	52	131	Elder Creek, LM 3.0 (Tehama)	37
52	Cache Slough, RM 15.9L	52	131	Deep Water Ship Channel, LM 5.01 (East)	37
52	Sutter Slough, RM 26.5L	52	131	Deep Water Ship Channel, LM 5.0 (East)	37
52	Bear River, RM 0.8L	52	131	Willow Slough, LM 0.6 (North)	37
52	Yuba River, LM 2.3 (DWR South)	52	138	Knights Landing Ridge Cut, LM 4.3 (East)	36
61	Sacramento River, RM 172.0L	51	139	Knights Landing Ridge Cut, LM 3.0 (East)	35
61	Sacramento River, RM 136.7R	51	139	Yolo Bypass, LM 3.8 (West)	35
61	Sacramento River, RM 87.0L	51	141	Cache Slough, RM 23.6R	34
61	Sacramento River, RM 75.3R	51	141	Willow Slough, LM 2.2 (North)	34
61	Sacramento River, RM 63.0R	51	141	Yolo Bypass, LM 2.0 (West)	34
61	Feather River, RM 4.9L	51	144	Sacramento River, RM 133.0L	33
61	Georgiana Slough, RM 8.3L	51	144	Sacramento River, RM 123.3L	33
61	Georgiana Slough, RM 0.3L	51	146	Sacramento River, RM 136.6L	31
61	Cache Creek, LM 3.9L	51	147	Natomas Cross Canal, 3.0 (North)	30
70	Sacramento River, RM 136.9R	50	148	Elder Creek, LM 4.1 (Tehama)	28
70	Georgiana Slough, RM 4.5L	50			
72	Sacramento River, RM 93.7L	49			
72	Sacramento River, RM 25.2L	49			
72	Steamboat Slough, RM 23.2L	49			
72	Steamboat Slough, RM 26.0L	49			
76	Sacramento River, RM 92.8L	48			
76	Sacramento River, RM 62.9R	48			
76	Sacramento River, RM 38.5R	48			

Table 5. Methodology 2 Ranking Order

Rank	Site	Score	Rank	Site	Score
1	Feather River, RM 28.5R	53	76	Georgiana Slough, RM 9.3L	36
2	Sacramento River, RM 57.2R	51	76	Georgiana Slough, RM 6.4L	36
2	Sacramento River, RM 8.0L	51	76	Georgiana Slough, RM 3.6L	36
4	Sacramento River, RM 42.7R	50	76	Feather River, RM 3.6L	36
5	Lower American River, RM 2.8L	49	76	Knights Landing Ridge Cut, LM 3.1 (East)	36
5	Deer Creek, LM 0.9 (Tehama)	49	76	Yolo Bypass, LM 2.6 (West)	36
7	Sacramento River, RM 177.8R	48	76	Yolo Bypass, LM 2.5 (West)	36
7	Sacramento River, RM 77.2L	48	86	Sacramento River, RM 96.2L	35
7	Sacramento River, RM 52.3L	48	86	Sacramento River, RM 78.8L	35
7	Georgiana Slough, RM 5.3L	48	86	Sacramento River, RM 56.6L	35
11	Sacramento River, RM53.5R	47	86	Sacramento River, RM 25.2L	35
11	Sacramento River, RM 35.4L	47	86	Georgiana Slough, RM 1.7L	35
13	Sacramento River, RM 41.9R	46	86	Steamboat Slough, RM 25.0L	35
13	Sacramento River, RM 35.4R	46	86	Elk Slough, RM 0.2	35
13	Sacramento River, RM 26.0L	46	93	Sacramento River, RM 122.3R	34
13	Sacramento River, RM 10.8L	46	93	Sacramento River, RM 122.0R	34
13	Lower American River, RM 10.6L	46	93	Sacramento River, RM 116.0L	34
18	Sacramento River, RM 71.3R	45	93	Sacramento River, RM 101.3R	34
18	Sacramento River, RM 49.7L	45	93	Sacramento River, RM 86.3L	34
18	Sacramento River, RM 22.5L	45	93	Steamboat Slough, RM 24.7R	34
18	Feather River, RM 19.7L	45	93	Steamboat Slough, RM 18.8R	34
18	Feather River, RM 1.0L	45	93	Sutter Slough, RM 24.7R	34
18	Lower American River, RM 0.3L	45	93	Feather River, RM 4.9L	34
18	Cache Creek, LM 3.9L	45	102	Sacramento River, RM 78.3L	33
25	Sacramento River, RM 86.9R	44	102	Sacramento River, RM 62.9R	33
25	Sacramento River, RM 83.9R	44	102	Sacramento River, RM 23.3L	33
25	Sacramento River, RM 57.0R	44	102	Georgiana Slough, RM 6.8L	33
25	Lower American River, RM 10.0L	44	102	Georgiana Slough, RM 4.3L	33
25	Feather River, RM 7.0L	44	102	Georgiana Slough, RM 3.7L (b)	33
25	Cache Creek, LM 3.4L	44	102	Cherokee Canal, LM 14.0 (East)	33
31	Sacramento River, RM 35.3R	43	102	Deer Creek, LM 2.4 (Tehama)	33
31	Sacramento River, RM 23.2L	43	102	Elder Creek, LM 1.44 (Tehama)	33
31	Steamboat Slough, RM 25.8R	43	111	Sacramento River, RM 152.8L	32
31	Georgiana Slough, RM 7.0R	43	111	Sacramento River, RM 131.8L	32
31	Feather River, RM 3.8L	43	111	Sacramento River, RM 95.8L	32
36	Sacramento River, RM 87.0L	42	111	Georgiana Slough, RM 4.0L	32
36	Sutte Slough, RM 26.5L	42	111	Feather River, RM 0.6L	32
36	Feather River, RM 17.8L	42	111	Cherokee Canal, LM 21.9 (DWR East)	32
36	Yuba River, LM 2.3 (South)	42	117	Sacramento River, RM 163.0L	31
36	Sutter Bypass, LM 0.4 (East)	42	117	Sacramento River, RM 24.8L	31
41	Sacramento River, RM 130.0L	41	117	Willow Slough, LM 6.9 (South)	31
41	Sacramento River, RM 136.7R	41	120	Sacramento River, RM 104.0L	30
41	Sacramento River, RM 114.5R	41	120	Sacramento River, RM 99.0L	30
41	Sacramento River, RM 22.7L	41	120	Georgiana Slough, RM 3.7L (a)	30
41	Georgiana Slough, RM 6.6L	41	120	Georgiana Slough, RM 2.5L	30
41	Georgiana Slough, RM 4.6L	41	120	Knights Landing Ridge Cut, LM 0.2 (West)	30
41	Cache Creek, LM 2.8L	41	125	Sacramento River, RM 123.7R	29
48	Sacramento River, RM 136.9R	40	125	Cache Slough, RM 22.8R	29
48	Sacramento River, RM 75.3R	40	125	Knights Landing Ridge Cut, LM 4.3 (East)	29
48	Sacramento River, RM 55.2L	40	128	Knights Landing Ridge Cut, LM 5.3 (East)	28
51	Sacramento River, RM 138.1L	39	129	Sacramento River, RM 133.8L	27
51	Sacramento River, RM 86.5R	39	129	Sacramento River, RM 132.9R	27
51	Sacramento River, RM 55.5L	39	129	Sacramento River, RM 127.9R	27
51	Sacramento River, RM 21.5L	39	129	Sacramento River, RM 123.3L	27
51	Georgiana Slough, RM 4.5L	39	129	Elder Creek, LM 3.0 (Tehama)	27
51	Cache Slough, RM 15.9L	39	129	Knights Landing Ridge Cut, LM 3.0 (East)	27
51	Georgiana Slough, RM 8.3L	39	129	Willow Slough, LM 0.6 (North)	27
51	Sacramento River, RM 77.7R	39	136	Sacramento River, RM 168.3L	26
59	Sacramento River, RM 116.5L	38	136	Sacramento River, RM 104.5L	26
59	Sacramento River, RM 93.7L	38	138	Deep Water Ship Channel, LM 5.01 (East)	25
59	Sacramento River, RM 56.7R	38	138	Deep Water Ship Channel, LM 5.0 (East)	25
59	Sacramento River, RM 38.5R	38	138	Yolo Bypass, LM 0.1 (West)	25
59	Sacramento River, RM 31.6R	38	138	Willow Slough, LM 2.2 (North)	25
59	Steamboat Slough, RM 26.0L	38	142	Yolo Bypass, LM 3.8 (West)	24
59	Steamboat Slough, RM 23.9R	38	142	Yolo Bypass, LM 2.0 (West)	24
59	Steamboat Slough, RM 23.2L	38	144	Sacramento River, RM 136.6L	22
59	Georgiana Slough, RM 6.1L	38	144	Sacramento River, RM 133.0L	22
59	Feather River, RM 5.5L	38	144	Elder Creek, LM 4.1 (Tehama)	22
59	Bear River, RM 0.8L	38	147	Cache Slough, RM 23.6R	21
70	Sacramento River, RM 172.0L	37	148	Natomas Cross Canal, 3.0 (North)	20
70	Sacramento River, RM 157.7R	37			
70	Sacramento River, RM 92.8L	37			
70	Sacramento River, RM 74.4R	37			
70	Sacramento River, RM 63.0R	37			
70	Georgiana Slough, RM 0.3L	37			
76	Sacramento River, RM 103.4L	36			
76	Sacramento River, RM 73.5L	36			
76	Sacramento River, RM 56.5R	36			

Table 6. Methodology 3 Ranking Order

Rank	Site	Score	Rank	Site	Score
1	Sacramento River, RM 55.2L	40	76	Sacramento River, RM 35.4L	24
1	Sacramento River, RM 49.7L	40	76	Sacramento River, RM 31.6R	24
1	Lower American River, RM 2.8L	40	76	Sacramento River, RM 25.2L	24
1	Lower American River, RM 0.3L	40	76	Georgiana Slough, RM 4.0L	24
1	Feather River, RM 28.5R	40	83	Sacramento River, RM 168.3L	23
6	Sacramento River, RM 55.5L	38	83	Sacramento River, RM 75.3R	23
7	Sacramento River, RM 177.8R	37	83	Sacramento River, RM 22.7L	23
7	Sacramento River, RM 77.2L	37	83	Sutter Slough, RM 24.7R	23
7	Sacramento River, RM 56.6L	37	83	Cache Slough, RM 15.9L	23
10	Sacramento River, RM 114.5R	36	88	Sacramento River, RM 104.5L	22
10	Sacramento River, RM 52.3L	36	88	Sacramento River, RM 74.4R	22
10	Cache Creek, LM 3.9L	36	88	Sacramento River, RM 23.2L	22
10	Cache Creek, LM 3.4L	36	88	Sacramento River, RM 22.5L	22
14	Sacramento River, RM 157.7R	35	88	Sacramento River, RM 8.0L	22
14	Sacramento River, RM 136.9R	35	88	Sacramento River, RM 21.5L	22
14	Sacramento River, RM 136.7R	35	88	Steamboat Slough, RM 23.2L	22
14	Lower American River, RM 10.6L	35	88	Georgiana Slough, RM 9.3L	22
14	Lower American River, RM 10.0L	35	88	Cherokee Canal, LM 14.0 (DWR East)	22
14	Yuba River, LM 2.3 (DWR South)	35	88	Deer Creek, LM 0.9 (Tehama)	22
20	Sacramento River, RM 122.3R	34	88	Natomas Cross Canal, LM 3.0 (North)	22
20	Sacramento River, RM 101.3R	34	99	Sacramento River, RM 136.6L	21
20	Sacramento River, RM 78.8L	34	99	Sacramento River, RM 133.8L	21
20	Sacramento River, RM 78.3L	34	99	Georgiana Slough, RM 8.3L	21
20	Sacramento River, RM 73.5L	34	99	Georgian Slough, RM 5.3L	21
20	Sacramento River, RM 57.2R	34	99	Georgiana Slough, RM 2.5L	21
20	Sacramento River, RM 42.7R	34	99	Sutter Slough, RM 26.5L	21
20	Feather River, RM 19.7L	34	105	Sacramento River, RM 35.4R	20
28	Sacramento River, RM 116.5L	33	105	Georgiana Slough, RM 6.6L	20
28	Sacramento River, RM 87.0L	33	105	Georgiana Slough, RM 3.7L (a)	20
28	Feather River, RM 17.8L	33	105	Georgiana Slough, RM 3.7L (b)	20
28	Cache Creek, LM 2.8L	33	105	Georgiana Slough, RM 3.6L	20
32	Sacramento River, RM 53.5R	32	105	Georgiana Slough, RM 1.7L	20
33	Sacramento River, RM 172.0L	31	105	Steamboat Slough, RM 26.0L	20
33	Sacramento River, RM 127.9R	31	105	Steamboat Slough, RM 25.0L	20
33	Sacramento River, RM 123.7R	31	105	Willow Slough, LM 6.9 (DWR South)	20
33	Sacramento River, RM 103.4L	31	105	Yolo Bypass, LM 2.5 (DWR West)	20
33	Feather River, RM 1.0L	31	115	Sacramento River, RM 133.0L	19
38	Sacramento River, RM 93.7L	30	115	Sacramento River, RM 86.9R	19
38	Sacramento River, RM 86.3L	30	115	Sacramento River, RM 24.8L	19
38	Feather River, RM 7.0L	30	115	Georgiana Slough, RM 6.4L	19
38	Feather River, RM 3.8L	30	115	Georgiana Slough, RM 6.1L	19
38	Knights Landing Ridge Cut, LM 0.2 (West)	30	115	Georgiana Slough, RM 4.3L	19
43	Sacramento River, RM 163.0L	29	115	Georgiana Slough, RM 0.3L	19
43	Sacramento River, RM 132.9R	29	115	Steamboat Slough, RM 24.7R	19
43	Sacramento River, RM 96.2L	29	123	Sacramento River, RM 83.9R	18
43	Sacramento River, RM 62.9R	29	123	Sacramento River, RM 38.5R	18
43	Sacramento River, RM 41.9R	29	123	Steamboat Slough, RM 18.8R	18
43	Elk Slough, RM 0.2	29	123	Yolo Bypass, LM 3.8 (West)	18
49	Sacramento River, RM 152.8L	28	123	Yolo Bypass, LM 2.6 (DWR West)	18
49	Sacramento River, RM 122.0R	28	123	Yolo Bypass, LM 2.0 (West)	18
49	Sacramento River, RM 116.0L	28	123	Willow Slough, LM 0.6 (DWR North)	18
49	Sacramento River, RM 63.0R	28	123	Knights Landing Ridge Cut, LM 3.1 (East)	18
49	Sacramento River, RM 26.0L	28	131	Sacramento River, RM 123.3L	17
49	Sacramento River, RM 10.8L	28	131	Sacramento River, RM 35.3R	17
49	Feather River, RM 5.5L	28	131	Sacramento River, RM 23.3L	17
49	Feather River, RM 4.9L	28	131	Georgiana Slough, RM 6.8L	17
49	Feather River, RM 3.6L	28	131	Knights Lnading Ridge Cut, LM 5.3 (East)	17
49	Deep Water Ship Channel, LM 5.01 (East)	28	131	Knights Landing Ridge Cut, LM 4.3 (East)	17
49	Deep Water Ship Channel, LM 5.0 (East)	28	137	Deer Creek, LM 2.4 (Tehama)	16
60	Sacramento River, RM 130.0L	27	137	Elder Creek, LM 1.44 (Tehama)	16
60	Sacramento River, RM 104.0L	27	137	Yolo Bypass, LM 0.1 (West)	16
60	Sacramento River, RM 57.0R	27	140	Sacramento River, RM 86.5R	15
60	Sacramento River, RM 56.7R	27	140	Steamboat Slough, RM 25.8R	15
60	Sacramento River, RM 56.5R	27	140	Knights Landing Ridge Cut, LM 3.0 (East)	15
60	Georgiana Slough, RM 7.0R	27	143	Steamboat Slough, RM 23.9R	14
60	Bear River, RM 0.8L	27	143	Cache Slough, RM 23.6R	14
60	Sutter Bypass, LM 0.4 (DWR East)	27	145	Cache Slough, RM 22.8R	13
68	Sacramento River, RM 138.1L	26	145	Elder Creek, LM 3.0 (Tehama)	13
68	Sacramento River, RM 95.8L	26	145	Willow Slough, LM 2.2 (North)	13
68	Sacramento River, RM 92.8L	26	148	Elder Creek, LM 4.1 (Tehama)	9
68	Sacramento River, RM 71.3R	26			
68	Feather River, RM 0.6L	26			
73	Georgiana Slough, RM 4.6L	25			
73	Georgiana Slough, RM 4.5L	25			
73	Cherokee Canal, LM 21.9 (East)	25			
76	Sacramento River, RM 131.8L	24			
76	Sacramento River, RM 99.0L	24			
76	Sacramento River, RM 77.7R	24			

Table 7. Methodology 4 Ranking Order

Rank	Site	Score	Rank	Site	Score
1	Sacramento River, RM 57.2R	23	60	Georgiana Slough, RM 2.5L	16
1	Feather River, RM 28.5R	23	60	Feather River, RM 0.6L	16
3	Sacramento River, RM 42.7R	22	60	Cherokee Canal, LM 21.9 (DWR East)	16
4	Sacramento River, RM 53.5R	21	60	Deep Water Ship Channel, LM 5.01 (East)	16
4	Sacramento River, RM 26.0L	21	60	Deep Water Ship Channel, LM 5.0 (East)	16
4	Sacramento River, RM 10.8L	21	60	Yolo Bypass, LM 2.6 (DWR West)	16
4	Feather River, RM 1.0L	21	60	Knights Landing Ridge Cut, LM 3.1 (East)	16
4	Cache Creek, LM 3.9L	21	86	Sacramento River, RM 152.8L	15
4	Cache Creek, LM 3.4L	21	86	Sacramento River, RM 131.8L	15
4	Deer Creek, LM 0.9 (Tehama)	21	86	Sacramento River, RM 122.3R	15
11	Sacramento River, RM 71.3R	20	86	Sacramento River, RM 101.3R	15
11	Sacramento River, RM 55.2L	20	86	Sacramento River, RM 63.0R	15
11	Sacramento River, RM 49.7L	20	86	Sacramento River, RM 23.2L	15
11	Georgiana Slough, RM 7.0R	20	86	Sacramento River, RM 22.5L	15
11	Georgiana Slough, RM 4.6L	20	86	Sacramento River, RM 21.5L	15
11	Georgiana Slough, RM 4.5L	20	86	Georgiana Slough, RM 6.6L	15
11	Sutter Slough, RM 26.5L	20	86	Georgiana Slough, RM 3.7L (a)	15
11	Lower American River, RM 2.8L	20	86	Georgiana Slough, RM 3.7L (b)	15
11	Lower American River, RM 0.3L	20	86	Georgiana Slough, RM 3.6L	15
11	Feather River, RM 7.0L	20	86	Georgiana Slough, RM 1.7L	15
11	Feather River, RM 3.8L	20	86	Lower American River, RM 10.6L	15
11	Yuba River, LM 2.3 (DWR South)	20	86	Lower American River, RM 10.0L	15
23	Sacramento River, RM 116.5L	19	86	Deer Creek, LM 2.4 (Tehama)	15
23	Sacramento River, RM 87.0L	19	86	Elder Creek, LM 1.44 (Tehama)	15
23	Sacramento River, RM 77.2	19	86	Knights Landing Ridge Cut, LM 5.3 (East)	15
23	Sacramento River, RM 35.4R	19	86	Knights Landing Ridge Cut, LM 4.3 (East)	15
23	Georgiana Slough, RM 4.0L	19	86	Knights Landing Ridge Cut, LM 0.2 (West)	15
23	Cache Slough, RM 15.9L	19	106	Sacramento River, RM 116.0L	14
23	Feather River, RM 19.7L	19	106	Sacramento River, RM 95.8L	14
23	Sutter Bypass, LM 0.4 (DWR East)	19	106	Sacramento River, RM 92.8L	14
31	Sacramento River, RM 177.8R	18	106	Georgiana Slough, RM 6.4L	14
31	Sacramento River, RM 172.0L	18	106	Georgiana Slough, RM 6.1L	14
31	Sacramento River, RM 130.0L	18	106	Georgiana Slough, RM 4.3L	14
31	Sacramento River, RM 93.7L	18	106	Georgiana Slough, RM 0.3L	14
31	Sacramento River, RM 83.9R	18	106	Steamboat Slough, RM 25.8R	14
31	Sacramento River, RM 77.7R	18	106	Steamboat Slough, RM 23.2L	14
31	Sacramento River, RM 55.5L	18	106	Steamboat Slough, RM 18.8R	14
31	Sacramento River, RM 35.4L	18	106	Willow Slough, LM 0.6 (DWR North)	14
31	Sacramento River, RM 8.0L	18	106	Yolo Bypass, LM 3.8 (West)	14
31	Steamboat Slough, RM 24.7R	18	106	Yolo Bypass, LM 2.0 (West)	14
31	Feather River, RM 17.8L	18	106	Yolo Bypass, LM 0.1 (West)	14
31	Feather River, RM 5.5L	18	120	Sacramento River, RM 104.0L	13
31	Feather River, RM 4.9L	18	120	Sacramento River, RM 86.5R	13
31	Feather River, RM 3.6L	18	120	Steamboat Slough, RM 23.9R	13
31	Cache Creek, LM 2.8L	18	120	Cache Slough, RM 23.6R	13
31	Yolo Bypass, LM 2.5 (DWR West)	18	120	Cherokee Canal, LM 14.0 (DWR East)	13
47	Sacramento River, RM 138.1L	17	120	Willow Slough, LM 6.9 (DWR South)	13
47	Sacramento River, RM 114.5R	17	120	Knights Landing Ridge Cut, LM 3.0 9East)	13
47	Sacramento River, RM 103.4L	17	127	Sacramento River, RM 136.6L	12
47	Sacramento River, RM 96.2L	17	127	Sacramento River, RM 133.8L	12
47	Sacramento River, RM 86.9R	17	127	Sacramento River, RM 127.9R	12
47	Sacramento River, RM 75.3R	17	127	Sacramento River, RM 123.7R	12
47	Sacramento River, RM 56.6L	17	127	Sacramento River, RM 99.0L	12
47	Sacramento River, RM 41.9R	17	127	Sacramento River, RM 24.8L	12
47	Sacramento River, RM 38.5R	17	127	Steamboat Slough, RM 25.0L	12
47	Sacramento River, RM 25.2L	17	127	Steamboat Slough, RM 26.0L	12
47	Georgiana Slough, RM 9.3L	17	127	Cache Slough, RM 22.8R	12
47	Bear River, RM 0.8L	17	127	Georgiana Slough, RM 6.8L	12
47	Elk Slough, RM 0.2	17	127	Elder Creek, LM 3.0 (Tehama)	12
60	Sacramento River, RM 163.0L	16	127	Natomas Cross Canal, LM 3.0 (North)	12
60	Sacramento River, RM 157.7R	16	139	Sutter Slough, RM 24.7R	11
60	Sacramento River, RM 136.9R	16	140	Sacramento River, RM 168.3L	10
60	Sacramento River, RM 136.7R	16	140	Sacramento River, RM 133.0L	10
60	Sacramento River, RM 86.3L	16	140	Sacramento River, RM 132.9R	10
60	Sacramento River, RM 78.8L	16	140	Sacramento River, RM 23.3L	10
60	Sacramento River, RM 78.3L	16	144	Sacramento River, RM 122.0R	9
60	Sacramento River, RM 74.4R	16	144	Willow Slough, LM 2.2 (North)	9
60	Sacramento River, RM 73.5L	16	146	Sacramento River, RM 123.3L	8
60	Sacramento River, RM 62.9R	16	147	Sacramento River, RM 104.5L	8
60	Sacramento River, RM 57.0R	16	148	Elder Creek, LM 4.1 (Tehama)	8
60	Sacramento River, RM 56.7R	16			
60	Sacramento River, RM 56.5R	16			
60	Sacramento River, RM 52.3L	16			
60	Sacramento River, RM 35.3R	16			
60	Sacramento River, RM 31.6R	16			
60	Sacramento River, RM 22.7L	16			
60	Georgiana Slough, RM 8.3L	16			
60	Georgiana Slough, RM 5.3L	16			

Table 8: Rankings Per Site				
Site	Ranking Under Methodologies			
	Methodology 1	Methodology 2	Methodology 3	Methodology 4
Bear River, RM 0.8L	52	59	60	47
Cache Creek, LM 3.9L	61	18	10	4
Cache Creek, LM 3.4L	43	25	10	4
Cache Creek, LM 2.8L	83	41	28	31
Cache Slough, RM 15.9L	52	51	83	23
Cache Slough, RM 22.8R	121	125	145	127
Cache Slough, RM 23.6R	141	147	143	120
Cherokee Canal, LM 14 (East)	126	102	88	120
Cherokee Canal, LM 21.9 (East)	106	111	73	60
Deep Water Ship Channel, LM 5.0 (East)	131	138	49	60
Deep Water Ship Channel, LM 5.01 (East)	131	138	49	60
Deer Creek, LM 0.9 (North)	43	5	88	4
Deer Creek, LM 2.4 (South)	121	102	137	86
Elder Creek, LM 1.44 (North)	126	102	137	86
Elder Creek, LM 3.0 (South)	131	129	145	127
Elder Creek, LM 4.1 (North)	148	144	148	148
Elk Slough	83	86	43	47
Feather River, RM 0.6L	76	111	68	60
Feather River, RM 1.0L	18	18	33	4
Feather River, RM 3.6L	43	76	49	31
Feather River, RM 3.8L	18	31	38	11
Feather River, RM 4.9L	61	93	49	31
Feather River, RM 5.5L	36	59	49	31
Feather River, RM 7.0L	9	25	38	11
Feather River, RM 17.8L	5	36	28	31
Feather River, RM 19.7L	9	18	20	23
Feather River, RM 28.5 (LM 14.5 West)	1	1	1	1
Georgiana Slough, RM 0.3L	61	70	115	106
Georgiana Slough, RM 1.7L	76	86	105	86
Georgiana Slough, RM 2.5L	101	120	99	60
Georgiana Slough, RM 3.6L	83	76	105	86
Georgiana Slough, RM 3.7L (a)	115	120	105	86
Georgiana Slough, RM 3.7L (b)	94	102	105	86
Georgiana Slough, RM 4.0L	94	111	76	23
Georgiana Slough, RM 4.3L	101	102	115	106
Georgiana Slough, RM 4.5L	70	51	73	11
Georgiana Slough, RM 4.6L	36	41	73	11
Georgiana Slough, RM 5.3L	13	7	99	60
Georgiana Slough, RM 6.1L	52	59	115	106
Georgiana Slough, RM 6.4L	83	76	115	106
Georgiana Slough, RM 6.6L	52	41	105	86
Georgiana Slough, RM 6.8L	94	102	131	127
Georgiana Slough, RM 7.0R	30	31	60	11
Georgiana Slough, RM 8.3L	61	51	99	60
Georgiana Slough, RM 9.3L	52	76	88	47
Knight's Landing Ridge Cut, LM 0.2 (West)	101	120	38	86
Knight's Landing Ridge Cut, LM 3.0 (East)	139	129	140	120
Knight's Landing Ridge Cut, LM 3.1 (East)	108	76	123	60
Knight's Landing Ridge Cut, LM 4.3 (East)	138	125	131	86
Knight's Landing Ridge Cut, LM 5.3 (East)	130	128	131	86
Lower American River, RM 0.3L	15	18	1	11

Table 8: Rankings Per Site				
Site	Ranking Under Methodologies			
	Methodology 1	Methodology 2	Methodology 3	Methodology 4
Lower American River, RM 2.8L	9	5	1	11
Lower American River, RM 7.3R	108	125	43	144
Lower American River, RM 10.0L	24	25	14	86
Lower American River, RM 10.6L	15	13	14	86
Natoma Cross Canal, LM 3.0 (North)	147	148	88	127
Sacramento River, RM 8.0L	5	2	88	31
Sacramento River, RM 10.8L	18	13	49	4
Sacramento River, RM 21.5L	43	51	88	86
Sacramento River, RM 22.5L	18	18	88	86
Sacramento River, RM 22.7L	30	41	83	60
Sacramento River, RM 23.2L	27	31	88	86
Sacramento River, RM 23.3L	83	102	131	140
Sacramento River, RM 24.8L	94	117	115	127
Sacramento River, RM 25.2L	72	86	76	47
Sacramento River, RM 26.0L	12	13	49	4
Sacramento River, RM 31.6R	76	59	76	60
Sacramento River, RM 35.3R	43	31	131	60
Sacramento River, RM 35.4L	24	11	76	31
Sacramento River, RM 35.4R	29	13	105	23
Sacramento River, RM 38.5R	76	59	123	47
Sacramento River, RM 41.9R	18	13	43	47
Sacramento River, RM 42.7R	15	4	20	3
Sacramento River, RM 49.7L	13	18	1	11
Sacramento River, RM 52.3L	4	7	10	60
Sacramento River, RM 53.5R	5	11	32	4
Sacramento River, RM 55.2L	27	48	1	11
Sacramento River, RM 55.5L	30	51	6	31
Sacramento River, RM 56.5R	52	76	60	60
Sacramento River, RM 56.6L	52	86	7	47
Sacramento River, RM 56.7R	36	59	60	60
Sacramento River, RM 57.0R	18	25	60	60
Sacramento River, RM 57.2R	3	2	20	1
Sacramento River, RM 62.9R	76	102	43	60
Sacramento River, RM 63.0R	61	70	49	86
Sacramento River, RM 71.3R	36	18	68	11
Sacramento River, RM 73.5L	24	76	20	60
Sacramento River, RM 74.4R	83	70	88	60
Sacramento River, RM 75.3R	61	48	83	47
Sacramento River, RM 77.2L	1	7	7	23
Sacramento River, RM 77.7R	101	51	76	31
Sacramento River, RM 78.3L	36	102	20	60
Sacramento River, RM 78.8L	30	86	20	60
Sacramento River, RM 83.9R	36	25	123	31
Sacramento River, RM 86.3L	108	93	38	60
Sacramento River, RM 86.5R	83	51	140	120
Sacramento River, RM 86.9R	43	25	115	47
Sacramento River, RM 87.0L	61	36	28	23
Sacramento River, RM 92.8L	76	70	68	106
Sacramento River, RM 93.7L	72	59	38	31
Sacramento River, RM 95.8L	118	111	68	106
Sacramento River, RM 96.2L	108	86	43	47

Table 8: Rankings Per Site				
Site	Ranking Under Methodologies			
	Methodology 1	Methodology 2	Methodology 3	Methodology 4
Sacramento River, RM 99.0L	126	120	76	127
Sacramento River, RM 101.3R	121	93	20	86
Sacramento River, RM 103.4L	83	76	33	47
Sacramento River, RM 104.0L	108	120	60	120
Sacramento River, RM 104.5L	131	136	88	147
Sacramento River, RM 114.5R	83	41	10	47
Sacramento River, RM 116.0L	118	93	49	106
Sacramento River, RM 116.5L	83	59	28	23
Sacramento River, RM 122.0R	108	93	49	144
Sacramento River, RM 122.3R	114	93	20	86
Sacramento River, RM 123.3L	144	129	131	146
Sacramento River, RM 123.7R	131	125	33	127
Sacramento River, RM 127.9R	114	129	33	127
Sacramento River, RM 130.0L	30	41	60	31
Sacramento River, RM 131.8L	121	111	76	86
Sacramento River, RM 132.9R	114	129	43	140
Sacramento River, RM 133.0L	144	144	115	140
Sacramento River, RM 133.8L	121	129	99	127
Sacramento River, RM 136.6L	146	144	99	127
Sacramento River, RM 136.7R	61	41	14	60
Sacramento River, RM 136.9R	70	48	14	60
Sacramento River, RM 138.1L	36	51	68	47
Sacramento River, RM 152.8L	118	111	49	86
Sacramento River, RM 157.7R	43	70	14	60
Sacramento River, RM 163.0L	108	117	43	60
Sacramento River, RM 168.3L	131	136	83	140
Sacramento River, RM 172.0L	61	70	33	31
Sacramento River, RM 177.8R	5	7	7	31
Steamboat Slough, RM 18.8R	101	93	123	106
Steamboat Slough, RM 23.2L	72	59	88	106
Steamboat Slough, RM 23.9R	43	59	143	120
Steamboat Slough, RM 24.7R	83	93	115	31
Steamboat Slough, RM 25.0L	94	86	105	127
Steamboat Slough, RM 25.8R	30	31	140	106
Steamboat Slough, RM 26.0L	72	59	105	127
Sutter Bypass, LM 0.4 (East)	43	36	60	23
Sutter Slough, RM 24.7R	94	93	83	139
Sutter Slough, RM 26.5L	52	36	99	11
Willow Slough, LM 0.6 (North)	131	129	123	106
Willow Slough, LM 2.2 (North)	141	138	145	144
Willow Slough, LM 6.9 (South)	76	117	105	120
Yolo Bypass, LM 0.1 (RD 2035 Unit 2 West)	126	138	137	106
Yolo Bypass, LM 2.0 (RD 2035 Unit 2 West)	141	142	123	106
Yolo Bypass, LM 2.5 (DWR Unit 1 West)	106	76	105	31
Yolo Bypass, LM 2.6 (DWR Unit 1 West)	94	76	123	60
Yolo Bypass, LM 3.8 (RD 2035 Unit 2 West)	139	142	123	106
Yuba River, LM 2.3 (South)	52	36	14	11

7.0 CONCLUSIONS

Based upon our observations from the 2007 field reconnaissance and our previous experience on the Sacramento River Flood Control System, we offer the following conclusions:

1. Significant progress has been made in reducing the number of erosion site in the past two years. Through an aggressive repair effort, lead by the DWR and the Corps, the total number of erosion sites and especially the critical erosion sites have dropped. Since the 2006 report, erosion sites went from 205 to 152 and the number of critical sites went from 55 to only 5.
2. The system continues to deteriorate and even with a low runoff year (2006-2007), five (5) new erosion sites were added.
3. Even though much of the information that went into the ranking methodologies is based on estimated data, they provide significant insight into setting priorities for repair of the remaining sites.
4. This inventory should not be thought of as the only locations where a failure to the system may occur. This inventory is limited to what is visible above the waterline. Other major factors that can affect the integrity of the levees include other factors such as; below water scour and geotechnical considerations such as large slope failures along with potential seepage and piping problems.

8.0 RECOMMENDATIONS

Based upon our field reconnaissance and conclusions above, we offer the following recommendations:

1. Using the ranking methodologies as a guide, a list of highest priority erosion sites should be developed for the next round of repairs.
2. In order to improve the accuracy of the ranking methodologies, a more detailed review should be performed on the top 40 sites and the rankings recomputed.

9.0 REFERENCES

Ayres Associates, 2002, Bathymetric Survey and Associated Engineering Work, Sacramento River at Verona, California, RM 77 to 79, Prepared for Montgomery Watson Harza in support of a task order from US Army, Corps of Engineers, Sacramento District, California, June 2002.

Ayres Associates, 2003, Draft Report, Lower American River, FEMA Certification, Prepared for US Army, Corps of Engineers, Sacramento District, and July 2003.

Ayres Associates, 2002, Field Reconnaissance Report of Bank Erosion Sites, Sacramento River Bank Protection Project, Prepared for US Army, Corps of Engineers, November 2002.

Ayres Associates, 2001, Memorandum for Hydraulic Study of Erosion Site on Sacramento River at RM 60, Prepared for US Army, Corps of Engineers, Sacramento District, August 2001.

Ayres Associates, 2003, Summary of Field Review of Erosion Sites, Sacramento River, RM 60 to RM 46, Prepared for US Army, Corps of Engineers, Sacramento District, July 21, 2003.

California Department of Water Resources, CDEC Website, Mean Daily Flows for Ord Ferry, Colusa and Verona Stream Gages, September 1, 2002 to September 30, 2003, January 2004.

California Department of Water Resources, 1985, Flood Channel Design Flows, Maps of the Central Valley Flood Control System, May 1985.

US Army, Corps of Engineers, 1991 Aerial Atlas, Collinsville to Shasta Dam, Sacramento River, Sloughs, and Tributaries, California, July 15, 1991.

US Army, Corps of Engineers, 2004, City and County of Sacramento, American and Sacramento Rivers – FEMA Certification Project, List of Erosion Sites, January 2004

US Army, Corps of Engineers, 2003, Memo of Site Visit, Deep Holes in Waterside Levee, December 2003.

US Army, Corps of Engineers, 1999, Post - Flood Assessment, Sacramento and San Joaquin River Basins, California, Sacramento District, March 1999.

APPENDIX A

TABLE 1 - Sacramento River Levee System - Current Erosion Sites - 2007

TABLE 2 - Sacramento River Levee System - New Erosion Sites - 2007

TABLE 3 - Sacramento River Levee System - Removed Erosion Sites - 2007

TABLE 4 - Sacramento River Levee System - Critical Erosion Sites – 2007

TABLE 5 - Sacramento River Levee System - GPS Waypoint Locations - 2007

APPENDIX B – Methodology 1 Site Priority Ranking Sheets (on CD only)

APPENDIX C – Methodology 2 Site Priority Ranking Sheets (on CD only)

APPENDIX D – Methodology 3 Site Priority Ranking Sheets (on CD only)

APPENDIX E – Methodology 4 Site Priority Ranking Sheets (on CD only)

APPENDIX F – Sacramento River Levee System, 2007 Aerial Atlas (on CD only)