Appendix F: Maintenance Requirements and Responsibilities

Appendix F includes background information on the State-federal flood protection system in the Central Valley, maintenance requirements, and maintenance responsibilities as well as federal and State inspection criteria and rating methodology. Inspections include levees, channels, and structures in the State Plan of Flood Control. This information remains relatively static from year to year. Any significant changes in maintenance requirements and maintenance responsibilities that occur in a given year, if any, are noted in Section 1.1 of the main report.

F-1 STATE-FEDERAL FLOOD PROTECTION SYSTEM

The State-federal flood protection system is located in the Central Valley and is composed of many projects along the Sacramento and San Joaquin rivers and tributaries. The system includes federally authorized projects for which the State participated and provided the federal government assurances of continued cooperation.

Congress authorized the Sacramento River Flood Control Project (SRFCP) in 1917, and subsequent supplemental authorizations (e.g. Sacramento River and Major and Minor Tributaries, American River levees, etc.) have added projects to the SRFCP over the years. The San Joaquin River Flood Control Project consists of a number of separate federally authorized flood protection projects, most of which have been built since the 1940's (for example: Merced County Stream Group, Lower San Joaquin River, etc.).

Some existing levees were also incorporated into the Sacramento and San Joaquin flood protection systems through the passage of federal statutes if the USACE believed the levees met or exceeded design standards. The State of California generally provides lands, easements, and right-of-ways for project construction. An exception to this process is the Lower San Joaquin River Flood Control Project that was designed and constructed to federal standards by the State of California (substituting physical works for acquisition of more costly flowage easements required for the authorized federal project).

The major river flood protection systems currently have combined totals of approximately 1,576 miles of federal project levees, 1,200 miles (148,000 acres) of designated floodways, 26 project channels covering several thousand acres, and 56 other major flood protection works including overflow weirs, flood relief structures, outfall gates, and pumping plants.

Since the beginning of federal participation, the Sacramento River and San Joaquin River flood systems have been constructed, expanded, improved, and repaired through a series of subsequent federal authorizations. Projects within these systems, for which the Central Valley Flood Protection Board (formerly the Reclamation Board) or DWR has provided the assurances of nonfederal cooperation to the United States, are considered the State-federal flood protection system in the Central Valley.

F-1.1 Integrated Flood Management

It should be noted that this State-federal flood protection system is a part of an integrated flood protection system in the Central Valley. Parts of this larger system are interdependent and rely on other features operating successfully. For example, many reservoirs, private levees and designated floodways, though not part of the State-federal flood protection system, regulate and contain flood flows to the benefit of the State-federal flood protection system.

Improved and sustainable integrated flood management is a stated goal of FloodSAFE California, specifically the Central Valley Flood Planning (CVFP) Program. Legislation passed in 2007 directs the California Department of Water Resources (DWR) to develop three important documents that will guide improvement of integrated flood management:

- **State Plan of Flood Control (SPFC) Descriptive Document** to inventory and describe the flood management facilities, land, programs, conditions, and mode of operations and maintenance for the State-federal flood protection system in the Central Valley.
- **Flood Control System Status Report** to assess the status of the facilities included in the SPFC Descriptive Document, identify deficiencies, and make recommendations.

- **Central Valley Flood Protection Plan (CVFPP)** to describe a sustainable, integrated flood management plan that reflects a system-wide approach for protecting areas of the Central Valley currently receiving protection from flooding by existing facilities of the SPFC.

These documents can be found at http://www.water.ca.gov/cvfmp/documents.cfm.

F-2 MAINTENANCE REQUIREMENTS

Title 33 of the Code of Federal Regulations, Section 208.10 (33 CFR 208.10) outlines federal regulatory requirements for the maintenance and operation of structures and facilities that comprise the State-federal flood protection system.

33 CFR 208.10 provides general operation and maintenance guidance to obtain the maximum benefits from the following features:

a) Structures and Facilities
b) Levees
c) Floodwalls
d) Drainage
e) Closure Structures
f) Pumping Plants
g) Channels and Floodways

Additionally, Standard and Supplemental O&M Manuals were prepared by USACE, Sacramento District, for project levees and flood protection works in the Central Valley.

A Standard O&M Manual was published for the Sacramento River Flood Control Project in May 1955, and for the Lower San Joaquin River Levees, Lower San Joaquin River and Tributaries Project in April 1959. The purpose of these Standard O&M Manuals is to present general information for use by local interests who maintain and operate the various geographical units comprising the Projects.

Supplemental O&M Manuals were prepared to supplement the respective USACE Standard O&M Manual. These supplemental manuals serve as a project specific guide to assist each LMA in carrying out its responsibilities for levee maintenance. Section 4 of the Standard O&M Manual and Section 2 of the supplements describe some of the standards to be met by LMAs in the performance of their routine maintenance.

F-3 MAINTENANCE RESPONSIBILITIES

As construction of federally authorized project units was completed, the USACE prepared unit-specific operation manuals and transferred the projects by letter to the CVFPB for review and acceptance. Project levees and flood protection works for which the State of California had provided the assurances of non-federal cooperation were formally accepted by the CFVPB on behalf of the State for operation and maintenance in accordance with federal regulations. In many cases, the State officially transferred operation and maintenance responsibilities to local entities.

Local public entities within the Sacramento and San Joaquin river systems have the responsibility, liability, and duty to maintain and operate the levees and other flood protection works on a day-to-day basis in accordance with assurance agreements, guidelines provided in the USACE Standard O&M Manuals, and each applicable supplement for individual project units. Flood protection features for which operation and maintenance are not performed by local entities are those SRFCP works maintained by DWR in accordance with Water Code §8361; and those facilities within Maintenance Areas (MA) that are maintained by DWR, with local beneficiaries paying costs under Water Code §12878. For the Sacramento River Flood Control Project, the LMA responsibilities were set forth in Water Code §8370 with the exception of enumerated works identified under Water Code §8361 and those for which provision is made by federal law. Flood protection project responsibilities in the San Joaquin River basin are based upon assurance agreements between the CVFPB and each LMA.

Currently, operation and maintenance responsibilities for the State-federal flood protection system levees in the Central Valley are carried out by 106 individual State and local maintaining agencies.

F-4 FEDERAL INSPECTION REQUIREMENTS AND CORPS OF ENGINEERS INSPECTION CHECKLIST

This appendix presents federal and state inspection criteria and rating methodology for levees, channels, and structures.

F-4.1 Federal Inspection Requirements and Corps of Engineers Inspection Checklist

Title 33 of CFR, *Navigation and Navigable Waters*, Section 208.10 (33 CFR 208.10) outlines the federal requirements for the periodic inspection of structures and facilities that comprise the State-federal flood protection system. These include inspections:

- Immediately prior to the beginning of the flood season
- Immediately following each major high water period
- At intervals not exceeding 90 days
- At intermediate times as necessary

Title 33 CFR 208.10 can be viewed at: http://www.access.gpo.gov/nara/cfr/waisidx_06/33cfr208_06.html

DWR implements this as:

- The LMAs and DWR patrol and inspect all project levees during high water events.
- Four quarterly inspections are required per year.

To meet this federal requirement, DWR performs comprehensive levee inspections in the spring and fall. Channel and structure inspections are conducted by DWR in the summer. The findings of these inspections make up the results of this report.

The LMAs are required to perform summer and winter levee inspections. LMAs report the condition of their system in relation to the most recent DWR inspection results. They do so by describing any changes in the condition of the system (since the last DWR inspection) or by reporting that none have occurred. The findings of these inspections are reported to the Chief Engineer of the CVFPB through DWR's FPIIB. Pursuant to California Water Code (CWC) Sections 9140 and 9141, LMAs are required to report in greater detail the results of their inspections and O&M activities. With the release of the 2012 version of this report, this information is now available in Appendices A, B, and C. Older versions of this information can be viewed at http://cdec.water.ca.gov/lma.html.

Criteria by which the flood control projects inspections have historically been reported are outlined in the Standard Operation and Maintenance Manuals. Subsequently, the USACE has developed additional inspection criteria for project and non-project systems participating in the federal PL84-99 rehabilitation and inspection program. The USACE checklist, *Flood Damage Reduction Segment/System Inspection Report* includes the USACE inspection criteria. For a copy, see http://www.spk.usace.army.mil/Missions/CivilWorks/LeveeSafetyProgram.aspx.

F-5 DWR MODIFICATION TO USACE CRITERIA

F-5.1 Levee Inspection Criteria

The USACE's *Flood Damage Reduction System Inspection Report* forms the basis of the DWR flood project inspection program. However, changes to some portions of the checklist have been made by DWR. The USACE criteria rates an Area's entire levee as unacceptable if any single inspection category is found to be unacceptable at any point on the levee. Therefore, under USACE criteria, an Area with a few unacceptable trees is rated the same as an Area with unacceptable ratings in several different rating categories. Additionally, strict application of the checklist, considering the unique environmental conditions of vegetation and encroachments on California levees, would result in almost universally unacceptable ratings throughout the system without providing any overall benefit to the system.

DWR believes that its modified criteria described below provide for realistic view of the severity of deficiencies and of the significant differences among LMA maintenance performance. DWR considers the length of each deficiency with respect to the total length of levee maintained by an LMA as well as the LMA's ability and responsibility to address the issue. Since a given reach of levee may have several concurrent deficiencies, the length of total deficiencies can exceed the length of the levee. (See detail of the rating methodology later in this appendix)

DWR's criteria for vegetation and encroachments are aimed at improving public safety by encouraging continued maintenance by LMAs for access and visibility of the flood protection system.

Inspection Criteria - Vegetation

DWR inspects vegetation on levees based upon USACE's checklist criteria with exceptions listed below. More details on DWR's Levee Vegetation Management Strategy can be found in the *2012 Central Valley Flood Protection Plan* and DWR's *Urban Levee Design Criteria*.

- DWR inspectors evaluate and rate all vegetation within the top 20 feet (slope length) of the waterside hinge point (intersection of crown and slope), anywhere on the landside slope, and within 15 feet of the landside toe or to the edge of the easement. Riparian vegetation and other vegetation beyond 20 feet from the waterside hinge point are not evaluated or rated at present. See Figures F-1 through F-4 for further clarification and special cases.
- Grass and weeds on the landside and upper waterside must be maintained at a height of less than 12 inches.
- Trees must be trimmed at least five feet above the ground and 12 feet above the ground over roadways.
- Trees must be thinned sufficiently to allow clear visibility and access for flood fight operations.
- Brush and woody vegetation must be trimmed, thinned, or removed to allow clear visibility and access for flood fight operations.
- Minimal densities of vegetation not meeting these criteria are rated as Minimally Acceptable.
- Significant densities of vegetation not meeting these criteria are rated as Unacceptable.
- Elderberries are evaluated using the same criteria as trees or other vegetation.
- Vegetation on the levee and within the easement must be managed in compliance with the Life Cycle Management policy outlined in the Urban Levee Design Criteria and the Central Valley Flood Protection Plan.

These criteria are shown in Figures F-1 through F-4. The criteria protect levee operability and integrity by requiring open visibility and access to those portions of the levee most susceptible to high water damage while retaining vegetation that possess both habitat and environmental value. Such vegetation may also have positive effects on levee integrity. The Urban Levee Design Criteria and the Central Valley Flood Protection Plan have more information on DWR's vegetation criteria. These documents can be reviewed at http://www.water.ca.gov/floodsafe/leveedesign/ and http://www.water.ca.gov/cvfmp/documents.cfm. These criteria may change in the future as more information becomes available.

Figure F-1: Vegetation Management for Existing Levees with a Long Waterside Slope

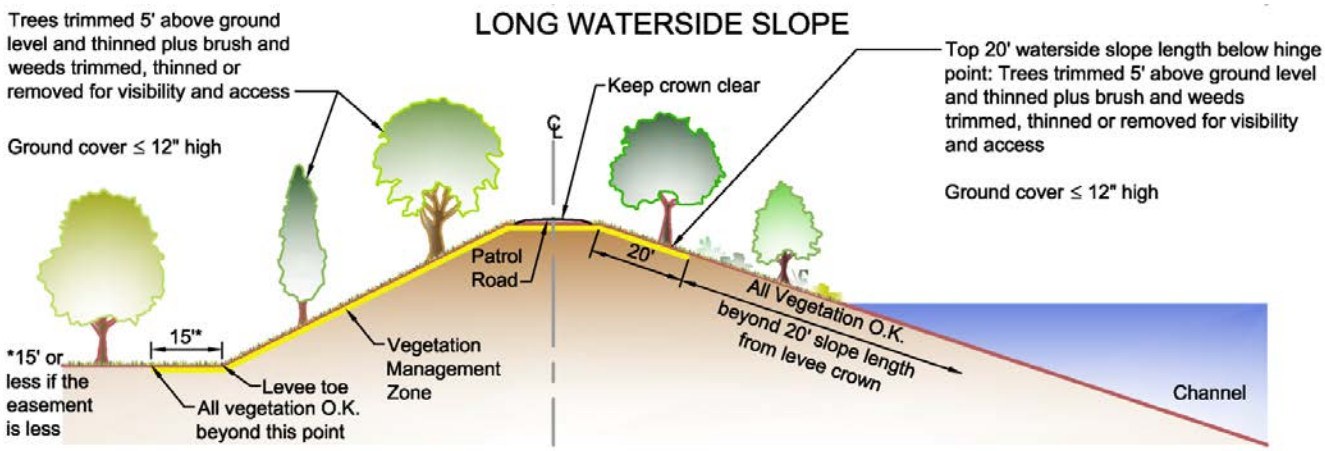


Figure F-2: Vegetation Management for Existing Levees with a Short Waterside Slope

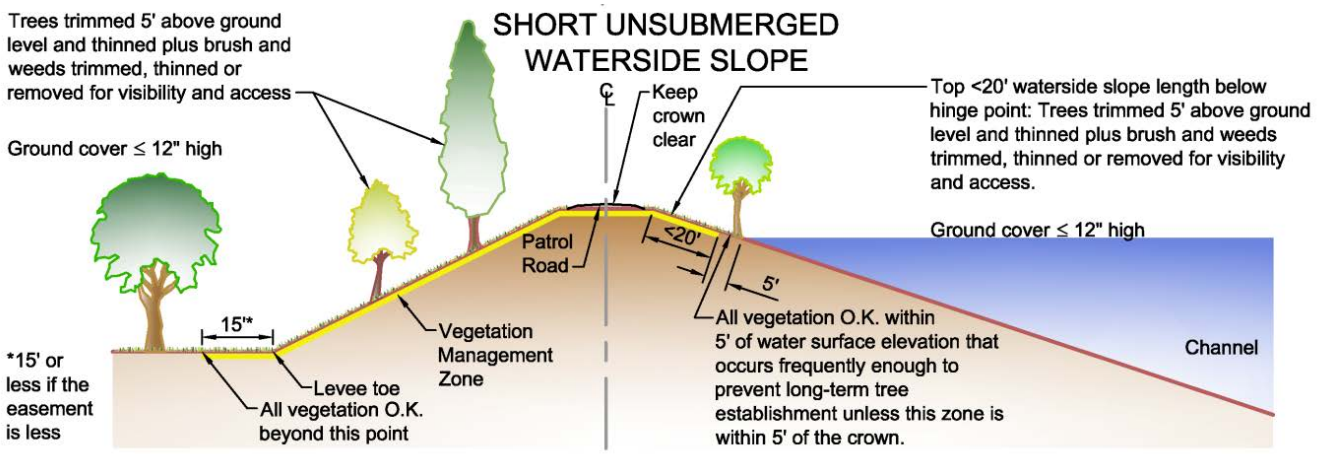


Figure F-3: Vegetation Management for Existing Levees with a Short Waterside Slope above the Water Surface Elevation that Frequently Submerges the Lower Waterside Slope

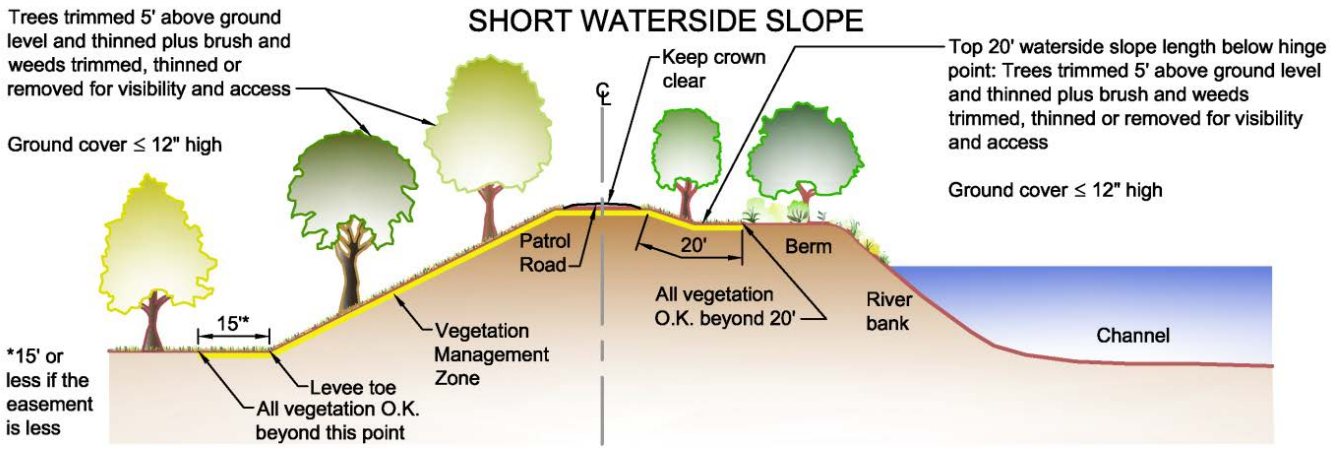
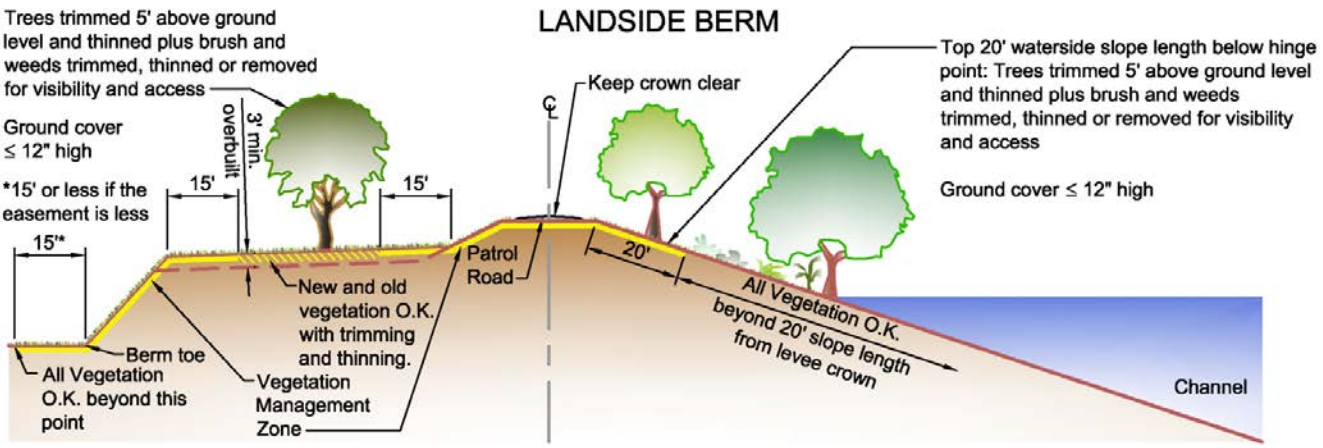


Figure F-4: Vegetation Management for Existing Levees with a Landside Berm



The following photos show examples of Acceptable, Minimally Acceptable, and Unacceptable maintenance of vegetation and trees.

Acceptable Vegetation Maintenance: Good grass coverage with no grass or brush over 12″ tall

Minimally Acceptable Maintenance: Grass or brush partially obstruct visibility and access

Unacceptable Maintenance: Grass or brush completely obstruct visibility and access

Acceptable Tree Maintenance: No limbs within 5′ of the levee obstruct visibility or access

Minimally Acceptable Tree Maintenance: Moderate density of tree limbs partially obstruct visibility and access

Unacceptable Tree Maintenance: Significant density of tree limbs completely obstruct visibility and access

Inspection Criteria - Encroachments

Past USACE inspections identified encroachments that posed a threat to the integrity of the levee, or blocked visibility or access to the levee as unacceptable (U). DWR inspectors followed a similar approach during their inspections since fall 2007.

The DWR approach included documenting and rating three types of encroachments:

a) Encroachments that threaten levee integrity.
b) Encroachments that are inappropriately placed on the levee, such as trash, prunings, abandoned equipment, etc.
c) Encroachments that obstruct visibility and access during the flood fighting efforts.

Inspections completed from 2007 through 2011 rated the first two encroachment types as either Minimally Acceptable (M) or Unacceptable (U). The first two types of encroachments are generally included in the overall ratings and should generally be corrected by the LMAs. The third type of encroachment that the USACE identified as unacceptable may be beyond the current authority of the LMAs to correct because the encroachment may be Board permitted or have other factors associated with it that prevent LMAs from taking action. These Partially Obstructing (PO) and Completely Obstructing (CO) encroachments are not included in the overall ratings (A, M, and U). Instead, they are identified to generate an inventory of those encroachments that the USACE has, in the past, found to be unacceptable and those encroachments that could affect the operation of the system. The permit status of these encroachments may not have been determined.

In the current inspections, as of 2012, DWR inspectors rats all encroachments as A, M, or U instead of PO and CO, but introduced Issue Types. Issue Types are discussed in the next section. Encroachments that LMAs may not be able to address and would have been rated as PO or CO previously are assigned an Issue Type of Enforcement in 2012 and beyond.

Inspection Criteria - Issue Type

The DWR inspection criterion includes three issue types: Maintenance, Enforcement, and Design/System Obsolescence.

- **Maintenance** – These issues include animal control, vegetation, and other deficiencies, as described in Appendix G, where annual maintenance is required by the LMAs to maintain the levees to an acceptable condition to ensure the project will function as designed, intended, or required. Items with this Issue Type are included the overall ratings.
- **Enforcement** – This includes encroachments: that threaten levee integrity, that are inappropriately placed on the levee, or that obstruct visibility and access during the flood fighting efforts. Some of these encroachments may require enforcement action and may have been permitted by the Board. It is recommended that the LMAs collaborate with the Board in addressing situations where they are not able to address the issue without an enforcement action. Items with this Issue Type are not included in the overall ratings but still need to be addressed.
- **Design/System Obsolescence** – This category encompasses deficient conditions that may be a part of or a result of the original design and construction of the project. These conditions may also be due to the age of the project and require actions beyond the ability of the LMA. Items with this Issue Type are not included in the overall ratings but still need to be addressed.

Not all issues are documented with all three of these Issue Types. See Appendix G for further criteria descriptions and what Issue Types are used for individual issues.

F-5.2 Levee Inspection Rating Methodology

This section conveys the rating method (developed in 2007 and revised in 2012) and the associated maintenance guidelines that are applied by the Inspection Section of the FPIIB to generate the *overall* Area ratings which are a representation of the LMAs' annual levee maintenance practices.

The Rating Method

USACE Document ER 500-1-1, paragraph 5-5.b (2) (b) defines the following project condition as presented in EP 500-1-1, Table 5-2:

- **Acceptable** – No immediate work required, other than routine maintenance. The flood protection project will function as designed and intended, with a high degree of reliability, and necessary cyclic maintenance is being adequately performed.
- **Minimally Acceptable** – One or more deficient conditions exist in the flood protection project that need to be improved or corrected. However, the project will essentially function as designed with a lesser degree of reliability than what the project could provide.
- **Unacceptable** – One or more deficient conditions exist that may prevent the project from functioning as designed, intended, or required. Minimally Acceptable issues that have not been addressed within two years may also be rated as Unacceptable. The USACE treats Unacceptable differently, depending on the situation. DWR does not differential Unacceptable items.
- **Acceptable but Monitor and Maintain** – DWR uses this rating to document an item that inspectors want to flag. The item may be something that should be monitored or that some maintenance may be helpful, but it does not violate criteria at the time of inspection.

USACE is in the process of modifying the levee inspection checklist and has requested that DWR use the new Checklist. With revisions to DWR's criteria in 2012 the criteria closely match the USACE's criteria in most categories with few exceptions, including vegetation.

In the past, DWR arrived at each overall unit and Area rating by making an estimation of the number, expanse, and seriousness of the deficient conditions found during the annual inspection and arriving at one of the above project condition ratings. This system was subjective and possibly inconsistent. It did not always reflect the possible negative effect of combined deficiencies.

Under the current USACE ratings directive, a System with a single Minimally Acceptable deficient condition may have received the same overall Minimally Acceptable rating as a System with dozens of Minimally Acceptable deficient conditions throughout its length. DWR believes that the LMAs should be rated by their overall maintenance condition rather than just by the rating of their worst deficient condition.

- In 2007, DWR created a new methodology, whereby 2007 overall ratings were calculated using the percentage of an Area's overall mileage receiving less-than-acceptable ratings. This is known as the threshold percent.
- This methodology has proven to be effective and was again applied for subsequent cycles.
- In 2010, DWR introduced an additional rating, Acceptable/Watch/Monitor (A/W) and uses it to document issues found during inspections that do not yet warrant an M or U rating but that should be monitored or maintained to avoid a maintenance deficiency in the future.

Thresholds

Thresholds were established that determine the overall rating as shown below. If over 20 percent of the total Area mileage was given a Minimally Acceptable rating, the overall rating was deemed Unacceptable.

Greater than 100% Deficient

Since 12 main categories and numerous minor categories were inspected, with most receiving ratings for the landside, waterside, and crown (triple the length of the levee), it is possible for a poorly maintained levee to receive Minimally Acceptable or Unacceptable ratings for well over 100 percent of its length.

Table F-1 and Figure F-5 further explain the rating method.

Table F-1: Overall Rating Thresholds

A = Acceptable, M = Minimally Acceptable, U = Unacceptable

Only M ratings within Unit or Area:

Zero to < 10 % M results in Overall A rating. 10% to < 20% M results in Overall M rating. ≥ 20% M results in Overall U Rating

$$\frac{If\ Miles\ of\ M\ in\ Unit\ or\ LMA}{Total\ Miles\ in\ Unit\ or\ LMA} > 0.00, \quad but < 0.10, \quad Overall\ Rating = A$$

$$\frac{If\ Miles\ of\ M\ in\ Unit\ or\ LMA}{Total\ Miles\ in\ Unit\ or\ LMA} \geq 0.10, \quad but < 0.20, \quad Overall\ Rating = M$$

$$\frac{If\ Miles\ of\ M\ in\ Unit\ or\ LMA}{Total\ Miles\ in\ Unit\ or\ LMA} \geq 0.20, \quad Overall\ Rating = U$$

Only U ratings within Unit or Area:

> Zero to < 5% U rating results in Overall M rating. ≥ 5% U rating results in Overall U rating

$$\frac{If\ Miles\ of\ U\ in\ Unit\ or\ LMA}{Total\ Miles\ in\ Unit\ or\ LMA} > 0.00, \quad but < 0.05, \quad Overall\ Rating = M$$

$$\frac{If\ Miles\ of\ U\ in\ Unit\ or\ LMA}{Total\ Miles\ in\ Unit\ or\ LMA} \geq 0.05, \quad Overall\ Rating = U$$

Both M and U ratings within Unit or Area:

$$Correlation\ of\ Severity = COS = \frac{Only\ M\ Threshold\ \%}{Only\ U\ Threshold\ \%} = \frac{20\%}{5\%} = 4$$

Multiply *Miles of U* by COS of 4 and add to *Miles of M* → $M + 4U$

$$\frac{If\ Miles\ of\ (M + 4U)\ in\ Unit\ or\ LMA}{Total\ Miles\ in\ Unit\ or\ LMA} > 0.00, \quad but < 0.20, \quad Overall\ Rating = M$$

$$\frac{If\ Miles\ of\ (M + 4U)\ in\ Unit\ or\ LMA}{Total\ Miles\ in\ Unit\ or\ LMA} \geq 0.20, \quad Overall\ Rating = U$$

Example 1: Unit length = 10.00 miles, M = 0.60 mile, U = 0.30 mile:
4U = 4(0.30) = 1.20 miles. M + 4U = 0.60 mile + 1.20 mile = 1.80 miles

$$\frac{M + 4U}{Total\ unit\ miles} = \frac{1.80\ miles}{10.00\ miles} = 0.18 < 0.20 \quad so\ Overall\ Rating = M$$

Example 2: Unit length = 10.00 miles, M = 1.10 mile, U = 0.30 mile:
4U = 4(0.30) = 1.20 miles. M + 4U = 1.10 miles + 1.20 miles = 2.30 miles

$$\frac{M + 4U}{Total\ unit\ miles} = \frac{2.30\ miles}{10.00\ miles} = 0.23 > 0.20 \quad so\ Overall\ Rating = U$$

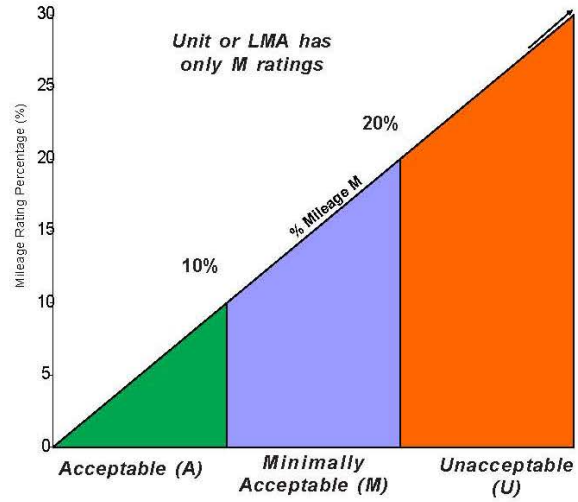
Figure F-5: Overall Maintenance Rating Flow Chart: *The Maintenance Guidelines*

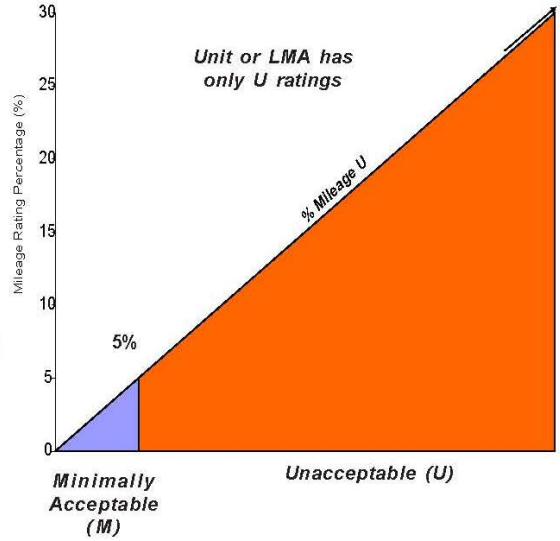
DWR Inspections

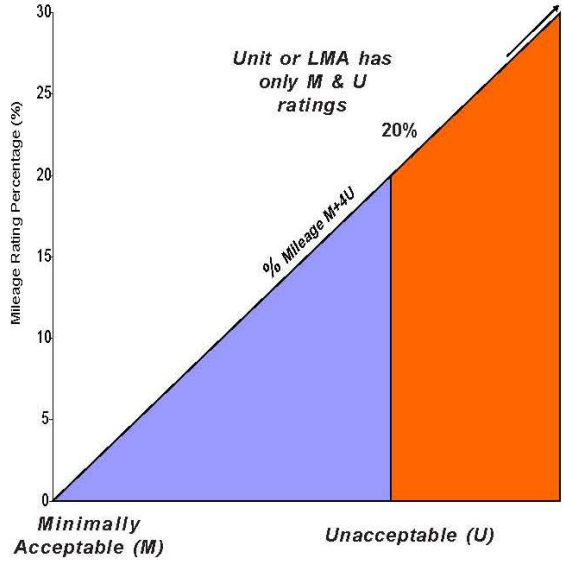
DWR inspectors document location and length of maintenance deficiencies.

Deficiencies are rated either as **Minimally Acceptable (M) or Unacceptable (U).** Total mileages of each rating in each unit and LMA are calculated and divided by total unit and LMA length to determine percentages of M or U. Percentage thresholds are then applied to determine overall unit and LMA ratings as shown at right.

Overall Levee Rating







Overall Maintenance Rating Flow Chart

When applying the ratings described above, a number of maintenance categories pertaining to levee maintenance are considered. These categories are based on maintenance guidelines listed below.

Readiness for Flood Emergency

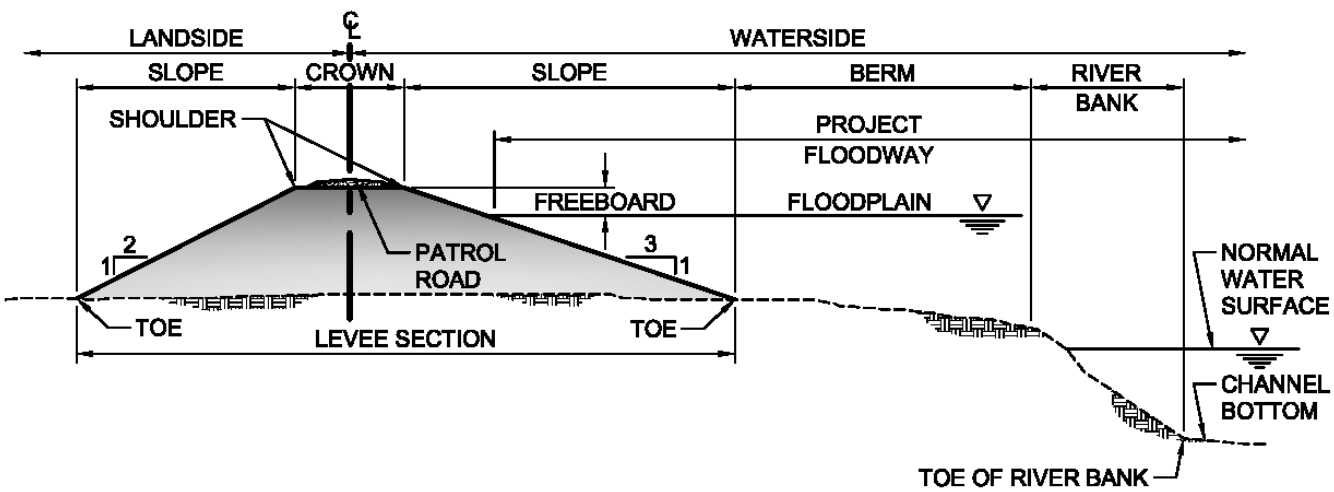
Each LMA shall have an organized plan to effectively combat a flood situation. This should include the appointment of a superintendent to supervise and execute the plan, a copy of applicable O&M Manuals, maintain a stockpile of standard flood-fighting equipment and materials, and have a network of handheld radios or cellular telephones for communication available while patrolling during a flood emergency. DWR started looking at these items again during the 2012 inspections and is including them in the overall Area ratings. Each of three ratings will count as an appropriately rated issue with a length of 1% of the total Area's length, or 0.01 miles, whichever is greater.

The LMA is encouraged to improve the overall quality of the project by addressing the three issue types previously discussed. The overall rating is affected by the number of issues noted during the fall inspection; as the LMA properly addresses the noted issues the overall rating of the project improves. The overall improvement of the project will facilitate increased effectiveness of potential flood-fighting efforts.

Adequate Levee Section and Grade

Each LMA must perform the work necessary to maintain levee side-slopes, grade, and crown width to meet the standards for its particular reach of the levee system. Levee design standards are summarized in Figure F-6.

Figure F-6: Project Levee Terminology



Adequate Encroachment Control

Each LMA is held responsible for preventing the construction of, or requiring the removal of, any illegally encroaching structures or activities on the levee or within the fifteen-foot regulatory easement at the landward toe of the levee. The maintaining agency must also stop any unauthorized modifications or alterations to the levee. If any person or organization deems any construction or modification necessary within the levee regulatory easement, that person or organization must apply for an encroachment permit. The permit may only be issued by the CVFPB. Failure of the LMA to control unauthorized encroachments can threaten the integrity of the levee, interfere with levee patrol visibility, and hamper a flood fight. These may be cause for downgrading the Area's annual rating in this report. More information on Issue Types may be found in the *Inspection Criteria – Issue Types* section of this appendix.

Vegetation

Each LMA shall have a program to selectively control vegetation on the levee slopes and in rock revetments. This requirement provides visibility for inspection and patrol and prevents interference with flood-fighting activities. Some vegetation on oversized levees is permitted in accordance with standards as set forth in CCR, Title 23. However, present

DWR vegetation inspection criteria allow vegetation on standard-sized levees as well, provided that visibility and flood fight capabilities are maintained. Both water-side and land-side slopes are rated for vegetation and obstructions. An un-maintained band of vegetation is allowed anywhere beyond 20 feet (slope length) from the waterside hinge (intersection of levee slope and crown – see Figures F-1 through F-4).

Rodent and Animal Control

It is imperative that each LMA have a rodent control program. Rodent burrows can weaken the structural integrity of a levee by creating a seepage path through the levee. Diligent efforts to eradicate burrowing animals are a necessity, and eliminating them from an infested levee is extremely difficult. Control of these animals must be pursued frequently and persistently to ensure safety of the levee during high water events. Effective filling of the burrows is necessary to maintain the integrity of the levee. This category also includes effective control of grazing animals on the levee or easement.

DWR encourages effective rodent control methods, such as grouting and baiting. The LMAs may request a schematic of an inexpensive grout machine as well as other related literature with methods DWR has found effective by contacting their DWR inspector.

Seepage/Boils

Seepage under or through the levee can cause boils, leading to erosion and possible piping failure of the foundation or structure of the levee. Seepage and boils must be identified, monitored, controlled, and corrected as quickly and effectively as possible.

Slope Stability and Repair of Cracks, Erosion, and Caving

Each LMA shall maintain slope stability and repair cracks, flow current or wave wash erosion, and caving or other structural problems. Timely repair of these problems is critical. Failure to address slope stability problems and repair cracks, erosion, or caving could lead to a levee failure.

The LMA superintendent is required to report to the CVFPB's Chief Engineer any suspected or known structural abnormalities found during his inspections. Such un-repaired structural problems are also cause for downgrading of the Area rating.

Condition of Rock Revetment

Each LMA shall make all repairs to scour, wash, settlement, or failure of any portion of rock revetments. Rock revetments have been installed at locations where stream flow conditions indicate the need for such protection. Early detection and prompt repair will result in a minimum of effort and reduce the cost to restore the revetment.

Condition of Levee Crown and Roadway

Each LMA is required to keep crown roadways shaped and graded to provide proper drainage and all-weather access. Repair of ruts and addition of gravel ensures a serviceable road under adverse conditions.

Condition of Pipes and Interior Drainage System

Each LMA must examine all structures situated through, in, or on the levee for stability and structural soundness and record its observations twice annually. All component parts must be examined for proper operation and reliability before the start of each flood season. New structures should be installed or older structures repaired only in accordance with adopted Board standards and under the supervision of qualified Board personnel. Defective structures must be repaired, replaced, or removed immediately. Although maintenance and repair of pipes and other structures passing through a levee are the responsibility of the owner (e.g., a farmer owning an irrigation pipe), the LMA may be responsible for inspecting the pipes for corrosion, collapse, valve integrity, seepage, and any other condition that could threaten the integrity of the levee. Many of these issues can be discovered through an external examination of the pipe as well as the soil and vegetation around it. Because of its full-time presence, the LMA is most able to discover and identify actual and potential problems and should make all efforts to immediately notify DWR of any problems found and thereafter include the problems on their inspection reports until they are resolved. DWR works with the Board to require the timely repair or removal of pipes or other structures that threaten the levee integrity.

Concrete Floodwalls / Closure Structures

In some instances, a portion of a levee is not built to the design height of the rest of the levee. A floodwall, usually either concrete or driven piling, is built to provide necessary hydraulic capacity. In some cases, due to space constraints, a floodwall may be constructed in lieu of a levee. Where a roadway or railroad passes through a levee or floodwall, a closure structure is built on either side of the roadway to hold gates or barriers to be installed for use during high water events. Floodwalls, closure structures, gates, and barriers must be properly maintained, structurally sound, and of proper height and design. Gates and barriers and installation paths must be readily accessible for timely installation and dependable performance and maintained and operated in compliance with the operations and maintenance (O&M) Manual.

Combining Criteria, Maintenance Guidelines and Methodology

In the field, each inspector documents the location, length, and type of maintenance category (see the guidelines listed above) giving a rating to each category found to be deficient in accordance with the established ratings criteria above. In any field inspection process, there will be some inherent subjectivity. However, DWR believes that training, the use of the new database driven inspection software, new hardware, and the inclusion of the ratings criteria on the inspectors' field computers have led to more accurate and consistent ratings - which are provided by the inspectors themselves. The inspection criteria used in the field can be seen in Table G-1 of Appendix G. Further, the new methodology of determining overall unit and Area ratings, described in Table F-1 and Figure F-5, has resulted in more consistent and objective overall ratings.

Levee Inspection Reporting

Individual levee mile inspection reports that summarize findings and identify deficiencies are distributed to each LMA after the spring and fall DWR inspection cycles. These reports are to be used by LMAs to scope and prioritize maintenance and improvement efforts, and the LMAs have been instructed to use these reports as a baseline for their summer and winter inspections. When requested, DWR levee inspectors may accompany LMAs on joint summer or winter inspections to discuss non-compliance and needed improvements. Spring and fall levee mile reports are submitted to USACE and the CVFPB. Monthly presentation updates and an annual report are also submitted to the CVFPB.

F-5.3 Channel Inspection Criteria

The Sacramento River, San Joaquin River, and other river and stream basins have 26 project channels that are inspected annually by the Flood Project Integrity and Inspection Branch of the Division of Flood Management during the summer months.

The purpose of the annual inspection is to identify and report on any condition which may diminish channel design capacities. Such conditions include: vegetation & obstructions, encroachments, sediment deposition (shoaling), revetments, and erosion / bank caving. Concrete lined channels are further evaluated with respect to the condition of the concrete and other structural appurtenances. Appendix G, Table G-2 Channel Inspection Rating Categories outlines the channel inspection criteria used in the field.

In general, maintaining the channels to the condition that existed after completion of the initial construction will preserve their design capacities. The standard of comparison for the inspection is, therefore, the condition immediately after construction. Design capacities, if applicable, can be found in the operations and maintenance (O&M) manuals for each project channel.

The annual inspections rely upon a qualitative rating system that has been developed based on the USACE O&M manuals. As the annual inspections are qualitative in nature, the existing channel capacities are not evaluated in this report. Ultimately, a single overall rating is assigned to each channel by the DWR. This overall rating is a relative indication of how well maintained each channel is.

The USACE and the State of California constructed the channels included in this report. Local agencies or the State of California agreed to be responsible for the maintenance of these channels at the time of construction or at a later time. The USACE issued the O&M manuals referenced above to each maintaining agency at the time of construction. The results of these annual inspections are shown in Appendix I and are made available to the maintaining agencies, USACE, the CVFPB, and the public.

F-5.4 Channel Inspection Rating Methodology

This section outlines the methodology by which an overall rating is developed from the field applied category ratings for the project channels of the flood protection system:

Step 1). The inspector must assess an initial rating of A (Acceptable), M (Minimally Acceptable), U (Unacceptable), or N (Not Rated) to each category for the flood protection work under inspection. Each of the five categories is weighted equally as a threat to the flood protection works' capacity.

Step 2). In the office, a numeric total is obtained for each flood protection work by valuing each rating given to each of the designated categories. The ratings are valued as follows: A is given zero points, M is given one point, U is given four points and N is given zero points. Note that if a category is not applicable to a flood protection work, then it should not be detrimental to the overall rating; hence, the zero point value for the N rating.

Step 3). This total is then divided by the total number of categories that were found to be applicable (A, M or U) in the field to calculate the average value.

Step 4). Lastly, an overall rating of A, M, or U is found by determining which range that average value falls within. The ranges are: $A \leq 0.2$, $0.2 < M \leq 1.0.$, $1.0 < U \leq 4.0$.

Channel inspection results are shown in Appendix I.

F-5.5 Structures Inspection Criteria

The maintenance effort expended on structures has been the subject of an annual report dating back to 1959. A report entitled, *Location, Description and Inventory of Miscellaneous Project Structures, Sacramento River Flood Control Project, and American River Flood Control Project*, was issued and was followed shortly thereafter by a maintenance status report. Maintenance status reports on flood protection structures have since been made on an annual basis. It was in this Structures Report that the State of California made its inspection results (formerly maintenance status reports) available to the LMAs, the USACE, the CVFPB, and the public. In 2008 the structures report was incorporated into the annual Inspection Report. These inspections are made on behalf of the CVFPB by DWR, Division of Flood Management, Flood Project Inspection Section.

Structures are inspected once annually during the summer months and include forty three flood protection structures and thirteen pumping plants. The summer inspections of these structures and pumping plants are visual field inspections and are based on USACE inspection categories. Category names and rating descriptions are provided in Appendix G; Table G-3 Structure Rating Categories and Table G-4 Pump Station Rating Categories. The inspector must assess an initial rating of A (Acceptable), M (Minimally Acceptable), U (Unacceptable), or N (Not Rated) to each category that is applicable to the flood protection work under inspection.

F-5.6 Structure Inspection Rating Methodology

This section outlines the methodology by which an overall rating is developed from the field applied category ratings for the structural components of the flood protection system:

Step 1). The inspector must assess an initial rating of A (Acceptable), M (Minimally Acceptable), U (Unacceptable), or N (Not Rated) to each category for the flood protection work under inspection. Each category is weighted equally as a threat to the flood protection works' capacity.

Step 2). In the office, a numeric total is obtained for each flood protection work by valuing each rating given to each of the USACE designated categories. The ratings are valued as follows: A is given zero points, M is given one point, U is given four points and N is given zero points. Note that if a category is not applicable to a flood protection work, then it should not be detrimental to the overall rating; hence, the zero point value for the N rating.

Step 3). This total is then divided by the total number of categories that were found to be applicable (rated A, M or U) in the field to calculate the average value.

Step 4). Lastly, an overall rating of A, M, or U is found by determining which range that average value falls within. The ranges are: $A \leq 0.2$, $0.2 < M \leq 1.0$., $1.0 < U \leq 4.0$.

Structure inspection results are shown in Appendix J. Pump Station inspection results are shown in Appendix K.

F-6 SAN JOAQUIN RIVER FLOOD CONTROL SYSTEM RANKING CRITERIA FOR WATERSIDE EROSION

F-6.1 Field Investigation

Field investigations cover some of the major extents of the San Joaquin River system, and include natural channels and manmade diversions. River Miles and Levee Miles used in this report are based on the estimates performed by FPIIB staff, and may be slightly different from the U.S. Army Corps of Engineer (USACE) river mile alignment. All results presented in this report are based upon the 2010 and previous field survey, and DO NOT reflect changes of conditions past the field survey date unless otherwise noted.

F-6.2 Procedure

Prior to the field investigations, a master list of the current inventory of erosion sites was reviewed. This list was used to locate previously identified erosion sites. The most current Levee Inspection report was also reviewed for previously identified erosion sites. Erosion sites reported to have been repaired or scheduled for repair were noted and inspected for verification.

Land-based survey was conducted with FPIIB staff inspecting the waterside levee and berm on a 4x4 vehicle. In waterways where view of the waterside levee was obstructed by wide berm or by thick vegetation and where waterway access was permissible, a jet-driven boat was used to conduct the survey. In both instances, observation and measurements were taken with the use of a portable Trimble GeoXT GPS handheld receiver.

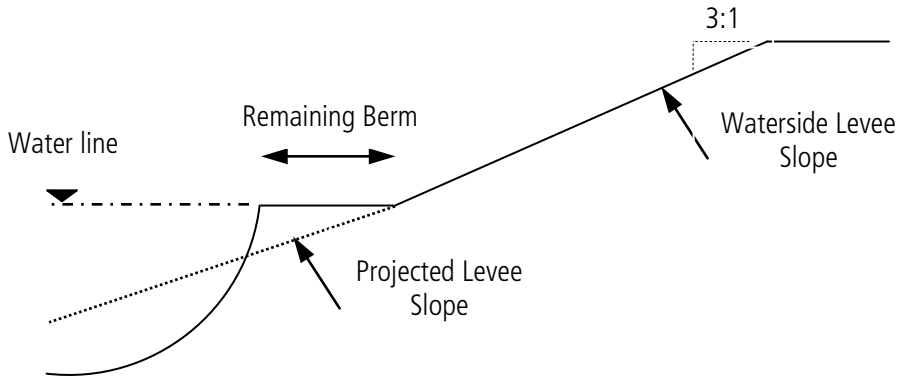
Data collected at each site includes, but are not limited to:

a) GPS coordinates of the levee crown at the midpoint of the erosion site
b) Estimated length of erosion, in feet
c) Estimated height of erosion, in feet
d) Location of erosion relative to the levee slope
e) Estimated waterside berm width, in feet
f) Estimated levee slope (H:V)
g) Animal burrow hole activity
h) Existing vegetation
i) Soil type at the eroded face
j) Condition of surrounding trees
k) Digital photographs of the site

Inclusion of a bank erosion site into the inventory takes into account the severity of the erosion and the threat to the levee integrity. Figure F-7 shows a typical cross section of a levee on the waterside. The following criteria are used as a reference to consider a site as being susceptible to erosion:

a) Bank erosion in the projection of the levee slope
b) Berm width of less than 30 feet

Figure F-7: Typical Cross Section of a Waterside Levee



F-6.3 Rating Methodology

The 2010 SJRFC System Rating Criteria can be found in Table F-2. The criteria reflect quantitative and qualitative analysis used to determine the severity of an erosion site. It is separated into three categories–physical levee characteristics, erosion characteristics, and hydraulics. Each category is further subdivided into factors related to erosion failure, and are used to calculate a final normalized score. Each factor has a potential score of 0, 1, 2, 3, 4, or 5 and is multiplied by a weighted multiplier ranging from 1 to 5. The weighted multiplier reflects qualitative assumptions relating each factor to erosion failure. The total score for an erosion site is collected by summing all the weighted points. It is then normalized to a 100 point scale and is determined by dividing the total score by the maximum possible score of 91. Once all the erosion sites have been assigned a normalized score, they are ranked from highest to lowest. A high score is associated with a high erosion potential, and a low score is associated with a low erosion potential.

Table F-2: San Joaquin River Flood Control System Ranking Criteria for Waterside Erosion

Criteria	Score Definition		Weight	Weighted Score
Physical Levee Characteristics (waterside)				
Berm Width	0 – Greater than 30 feet 1 – 20 to 30 feet 2 – 15 to 20 feet	3 – 10 to 15 feet 4 – 5 to 10 feet 5 – Less than 5 feet	1	5
Vegetation Cover	0 – Ground surrounding site fully covered 1 – 2/3 of ground covered	2 – 1/3 of ground covered 3 – No vegetation	2	6
Burrow Holes	0 – No signs of activity	5 – Signs of activity	1	5
Levee Slope (H:V)	0 – 3:1 or greater 1 – 2.5:1 2 – 2:1	3 – 1.5:1 4 – 1: or less 5 – Near vertical	3	15
Soil Type	1 – Cobbles 2 – Gravel (GP-GW) 3 – Clay (CL, CH, SC, GC)	4 – Sand (SP, SM and mixtures) 5 – Silt (ML)	4	20
Hydraulic Characteristics				
Site Relative to Bend	0 – Inside of bend 1 – Straight reach 2 – immediately downstream of bend	3 – Outside of bend > 90 degrees 4 – Outside of bend @ 90 degree turn 5 – Outside of bend < 90 degrees	1	5
Radius of Curvature (Rc/W)	0 – Greater than 5 or no curve 1 – 4 to 5 2 – 3 to 4	3 – 2 to 3 4 – 1 to 2 5 – less than 1	1	5
Erosion Characteristics				
Length	1 – Less than 50 feet 2 – 50 to 100 feet 3 – 100 to 200 feet	4 – 200 to 300 feet 5 – Greater than 300 feet	2	10
Scarp Height	1 – Less than 50 feet 2 – 50 to 100 feet 3 – 2 to 5 feet & near-vertical	4 – Greater than 5 feet 5 – Greater than 5 feet & near vertical	3	15
Location	1 – Erosion on berm	5 – Erosion affecting levee toe	1	5
			Total Weighted Score:	91

F-6.4 Overall Rating

Overall rating was assigned to each site based on their normalized score. First, an average was found by adding all the scores and dividing them by the number of non-repaired erosion sites in the inventory. The average score is established to be the group threshold and determines the overall rating as described by the following: If the normalized score of a site falls at or below the average, the site is given a rating of M. If it is greater than the average, the site is given a rating of U. Table F-3 summarizes the definition of ratings.

Table F-3: Definition of Ratings

Minimally Acceptable (M)	Unacceptable (U)
If Normalized Score ≤ Average Normalized Score, then Overall Rating = **M**	If Normalized Score > Average Normalized Score, then Overall Rating = **U**
A site that receives a Normalized Score equal to or less than the Average Normalized Score is rated as M, or Minimally Acceptable. This site should be monitored closely and annually, as it may become a serious deficiency in the near future.	A site that receives a Normalized Score greater than the Average Normalized Score is rated as U, or Unacceptable. This site may require immediate attention and corrective action, as it may be a serious deficiency that can fail during normal flow or in the next high water event.