Appendix D. Vegetation Management Strategy

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STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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Table of Contents

List of Figures

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1.0 Introduction

When the 2012 Central Valley Flood Protection Plan (2012 CVFPP) and Conservation Framework were adopted by the Central Valley Flood Protection Board (CVFPB), the CVFPB considered the levee vegetation management strategy contained in the 2012 CVFPP as interim. CVFPB Resolution No. 2012-25 directed the California Department of Water Resources (DWR) to further develop the interim strategy into a more comprehensive approach. Resolution No. 2012-25 further directed that the approach be adaptive and responsive to the results of ongoing and future research regarding vegetation on levees, knowledge gained from levee performance during high-water events, and the need to conserve critical riparian habitat. The DWR vegetation management approach described in this appendix reflects efforts to develop a more comprehensive levee vegetation management strategy that consists of efforts to manage levee vegetation, channel vegetation, and invasive plants. Levee vegetation management is particularly important because levee vegetation can impede visibility and accessibility for inspections and flood fighting, and in some limited cases, it may pose an unacceptable threat to levee integrity. In channel areas in between State Plan of Flood Control (SPFC) levees, the floodplain and channel may provide opportunities for important riparian and wetland habitat, as well as agricultural operations. However, land uses in these areas also need to be managed to maintain the channel's ability to convey high flows during flood events. Finally, invasive plants can adversely affect operations and maintenance (O&M) of the SPFC and are a documented stressor on the species, habitats, and ecosystem processes targeted by this Conservation Strategy. Management of invasive species, and eradication of them where feasible, reduces O&M needs by increasing channel capacity and provides important ecosystem benefits.

DWR water resources managers have been implementing the interim strategy to balance public safety with environmental quality. Current and future work will focus on improving public safety by providing for integrity, visibility, and accessibility for inspections, maintenance, and flood fight operations; at the same time, protecting important and critical environmental resources. DWR's approach also includes ongoing policy discussions regarding potential compatibility with United States Army Corps of Engineers (USACE) levee vegetation guidance through recognition of regional variations and prioritization of levee remediation based on risk assessment. Retaining lower waterside vegetation is a leading example of how risk assessment is coupled with recognition that widespread loss of habitat on levees, particularly on the lower waterside slope, is unmitigable. The Conservation Framework identified roughly two-thirds of the riparian habitat that occurs on SPFC levees is found on the lower waterside slope. On-going DWR analyses are further evaluating this assumption. In addition, risk assessment has shown that removing this vegetation, and conducting required levee remediation, likely would not be a worthwhile investment of flood risk reduction dollars. On the contrary, vegetation in this area has long been recognized as offering protection to levees from wind and wave wash erosion (USACE 1955). Expending resources to address factors contributing to lower risk would have to be considered against expending these resources to address other levee conditions that pose a significantly higher risk (DWR 2011). Similarly, DWR is assessing how to identify trees that may pose an unacceptable risk to levee integrity in a manner that retains the majority of existing habitat over its normal life span. Ongoing research, as well as knowledge gained from levee performance

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during high water events, will continue to inform how vegetation management within and around the SPFC may continue to evolve toward meeting multiple objectives, including sustainability of critical environmental resources. DWR anticipates revising vegetation management policy and guidance as needed in the ongoing five year updates to the CVFPP.

2.0 Levee Vegetation Management Strategy

The State's levee vegetation management strategy described in the 2012 CVFPP and Conservation Framework (DWR 2012a) is built on concepts embodied in *California's Central Valley Flood System Improvement Framework* (Framework Agreement), signed in 2009 by participants in the California Levees Roundtable (CLR) (CLR 2009). In summary, the strategy allows for existing (or "legacy") trees and other woody vegetation beyond a certain size to live out their normal lifespan on the levee, unless they pose an unacceptable threat. The refined strategy described below contains clarifications to the interim vegetation management strategy contained in the 2012 CVFPP and describes a limited managed recruitment concept. This concept is presented at this time for consideration by DWR flood managers, resource agency staff members, and other stakeholders for discussion as an approach that may provide management flexibility where needed. This concept would allow for limited recruitment of woody vegetation, in areas of the lower waterside slope, to maintain the existing habitat baseline. Should trees become an unacceptable threat to levee integrity, they will be identified and evaluated to determine management actions. Actions to manage these trees (which could involve removal, thinning, topping, coppicing, and similar actions) would be accomplished in consultation with the appropriate resource agencies. This appendix describes the State's refined vegetation management strategy in further detail.

At this time, DWR is aware that the recent enactment of Public Law 113-121, the Water Resources Reform and Development Act of 2014, directs USACE to provide new guidance for management of vegetation on levees, due for release in November 2015. This effort may result in an update to the USACE Engineering Technical Letter (ETL) 1110-2-583, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams and Appurtenant Structures* (2014), that, in short, states that vegetation on the levee and within 15 feet of the levee toe does not meet USACE engineering standards. It is hoped that the review will also lead to substantial changes in the Program Guidance Letter published in the Federal Register on February 17, 2012, describing the process for requesting a variance from vegetation standards for levees and floodwalls.

DWR appreciates the need for, and benefits of, broad nationwide guidance from USACE to meet a variety of objectives. However, DWR also believes that there is a clear need for nationwide guidance to be flexible and adaptable to regional conditions. A flexible strategy recognizes the pitfalls of one-size-fits-all approaches to protecting public safety, and it improves the efficiency of local solutions in addressing local risks. A limitation of the current USACE ETL is that it is written strictly in terms of new levee construction and cannot accommodate the attributes presented by

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legacy vegetation. DWR suggests that the necessary flexibility in levee vegetation policy could be achieved through a collaboratively developed and implementable variance procedure.

The State's levee vegetation management strategy will be reviewed during the 5-year updates to the CVFPP and revised as needed. The State's levee vegetation management strategy is focused on improving public safety while protecting and enhancing important and critical environmental resources, such as shaded riverine aquatic (SRA) habitat. The management strategy first draws an important distinction between new and legacy levees.

2.1 Newly Constructed Levees

DWR will preclude woody vegetation on new levee construction, which typically would be new setback, bypass, or ring levees located away from the river channel. Vegetation would be limited to native grass species on levee crowns and slopes and within 15 feet of the levee toe (or less, if the existing easement is less than 15 feet).

To minimize impacts on SRA habitat, new levees along the river should be specially designed and constructed to include a waterside planting berm that accommodates trees and other woody vegetation to sustain continuous SRA habitat. Such berm designs are intended not only to offset the impacts of vegetation removal required for project construction but also to minimize erosion and provide opportunities for improving connectivity of SRA habitat while conforming to USACE engineering standards. The planting berm must represent an overbuilt section with respect to minimum geometries required for the levee. The planting berm also must be of a size and configuration sufficient to mitigate potential negative impacts on levee safety with respect to seepage, stability, and erosion criteria if large woody vegetation (e.g. a tree) were to uproot.

2.1.1 Setback Levees

In certain situations, improvements to the Central Valley State/federal levee system may achieve multiple objectives through use of setback levees, where practical, to separate the flood control system from the riverbanks and their attendant riparian vegetation. Setback levees increase channel capacity, while avoiding loss of important riparian and SRA habitat and improving floodplain habitat quality. Where implementable, this approach is expected to result in flood system and habitat improvements. Engineering requirements for new setback levees are the same as for new levees. The expanded floodways provided by setting levees back would be designed to accommodate vegetation while still meeting channel conveyance and therefore may reduce O&M costs.

2.2 Levees with Preexisting Vegetation

DWR recognizes that existing woody vegetation on levees must be adaptively managed. DWR defines legacy levee vegetation as trees and other woody vegetation that was inspected by USACE and for which there is no documentation stating that the nonfederal sponsor was notified before 2007 that the vegetation needed to be removed. This includes vegetation present on

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State/federal project levees at the time the project was turned over by USACE in the 1950s, vegetation that was planted for mitigation as part of a cost-shared USACE project, and vegetation that has been allowed by USACE to remain to meet federal Endangered Species Act (ESA) or other requirements. The challenge faced by flood managers is determining the level of risk posed by this existing vegetation.

Because currently accepted methods of risk analysis cannot fully take into account the potential risk and effects of woody vegetation, USACE ETL 1110-2-583, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams and Appurtenant Structures* (2014), states that vegetation introduces unacceptable uncertainties that must be remediated through removal or engineering works. However, an approach that may call for removal of all levee vegetation is at odds with State and federal environmental laws. State and federal resource agencies find that the potential impacts of widespread vegetation removal represent a major threat to protected species and their recovery.

Levee with preexisting vegetation

Given that USACE Engineer Research and Development Center's (ERDC's) research report (July 2011) shows that woody vegetation has the potential to increase or reduce risk, depending on a variety of factors, DWR believes it is appropriate to characterize woody vegetation as only a "potential risk factor" that should be considered in relation to the unequivocal risk factors and to site-specific conditions. One of the findings of DWR's Flood Control System Status Report (DWR 2011) was that, although risk factors such as seepage, stability, and erosion were rated as medium to high relative threats, levee vegetation was rated as a low threat to levee integrity, consistent with the fact that no documented levee failures in California's history have been attributed to vegetation (California Levee Vegetation Research Program [CLVRP] 2014). Local agencies are concerned about the negative impacts on public safety associated with using limited financial resources to address lower priority risks related to vegetation rather than the greater risks posed by other factors. For this reason, widespread vegetation removal is unlikely and will not be a feasible management action for many of California's levees.

Levees with preexisting vegetation should be maintained according to the levee vegetation inspection criteria described below. DWR's levee inspection program first developed "interim criteria" for use in the fall 2007 levee inspections. These criteria were later described as "interim criteria for visibility and accessibility" in the Framework Agreement.

The inspection criteria established the concept of the Vegetation Management Zone (VMZ), illustrated in Figures 2-1 and 2-2. The VMZ is the area on and near a levee in which vegetation is

managed for visibility and accessibility and to provide some habitat value over the life span of the woody vegetation. Trees in this zone are trimmed up to 5 feet above the ground and 12 feet above the crown road and are thinned for visibility and access. Brush, weeds, or other such vegetation more than 12 inches tall is removed by DWR in a manner authorized by routine maintenance agreements. The VMZ includes the entire landside levee slope plus 15 feet beyond the landside toe (or less if the existing easement is less than 15 feet), the levee crown, and the top 20 feet (slope length) of the waterside levee slope.

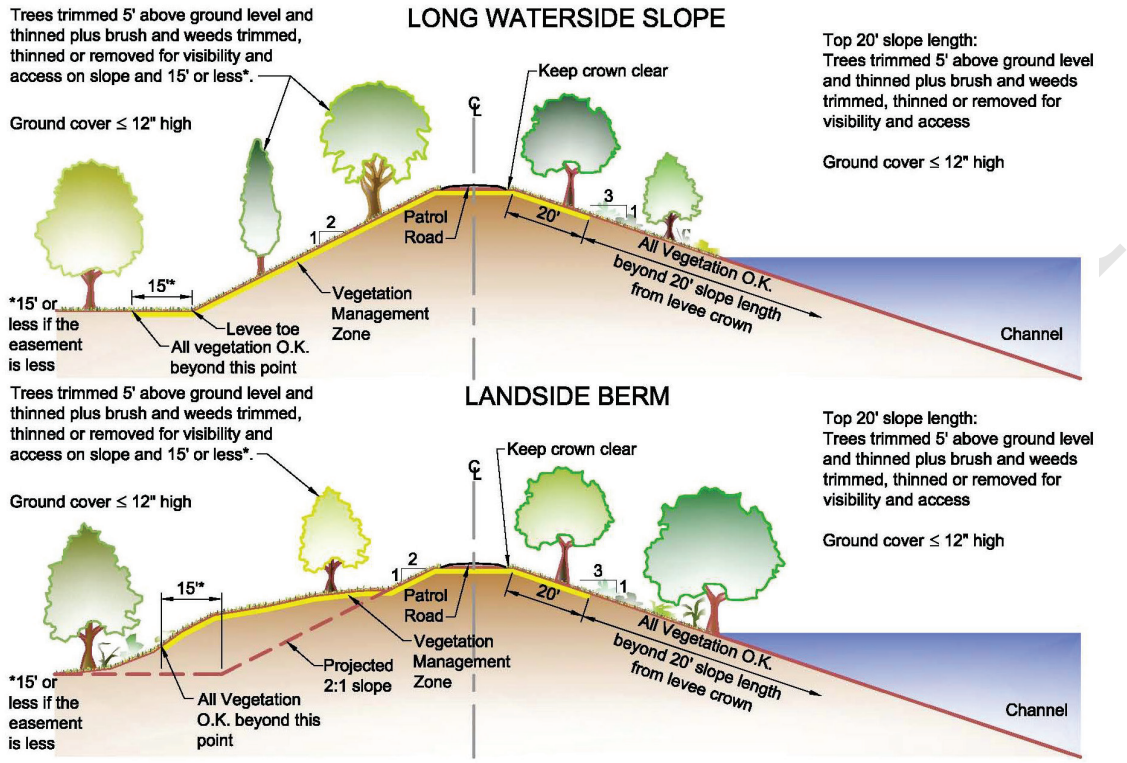

Figure 2-1. DWR Vegetation Inspection Criteria for Standard Levees—Long Waterside Slope and Landside Berm

For levees that have a waterside slope of less than 20 feet, the VMZ includes the entire waterside slope plus the extent of berm within 20 feet of the crown, as measured along the ground surface. For levees with a short waterside slope above the water surface elevation that submerges the lower waterside slope frequently enough to prevent long-term tree establishment, the lower 5 feet (slope distance) of the waterside slope immediately above that water surface elevation is not included in the VMZ and should remain unmanaged. For levees with a landside berm, the VMZ is determined by using the projected landside levee slope instead of the actual landside levee slope (see Figures 2-1 and 2-2). These criteria have been implemented by Local Maintaining Agencies (LMAs) since 2008 and have been successful in achieving visibility and accessibility along the levee system to meet public safety goals.

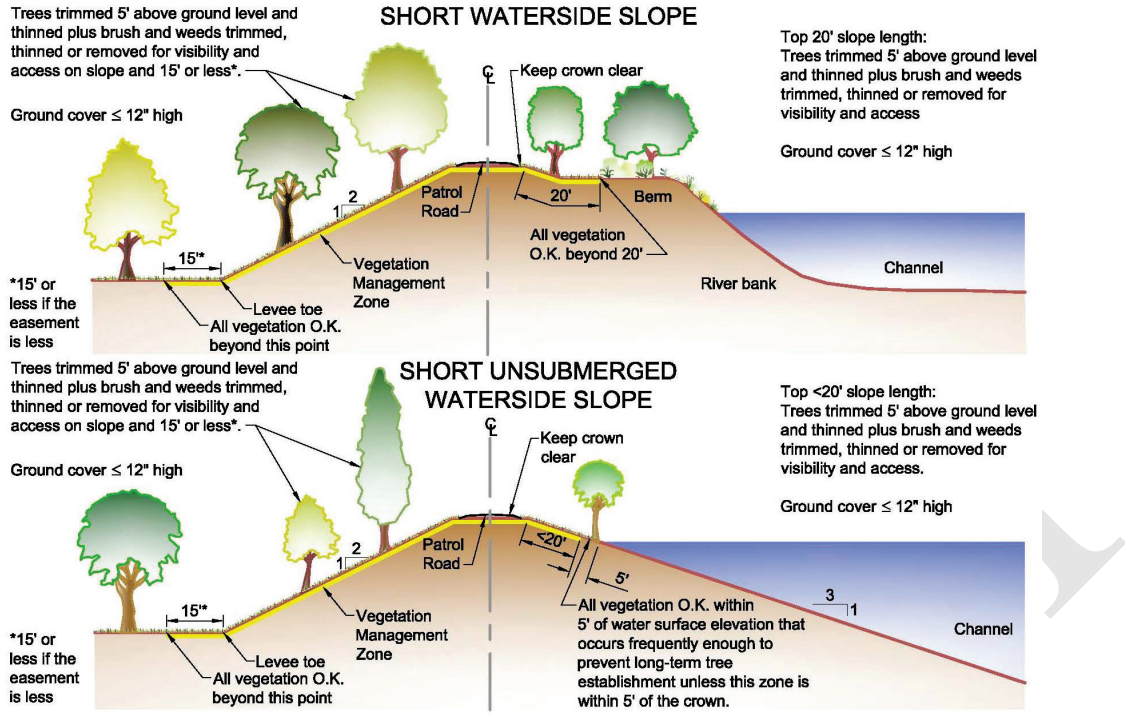

Figure 2-2. DWR Vegetation Inspection Criteria for Standard Levees—Short Waterside Slope and Short Unsubmerged Waterside Slope

Vegetation that was introduced, allowed, required as mitigation, or endorsed by a previous USACE action as necessary to comply with environmental requirements, and/or was present when the levee system was transferred from USACE to a nonfederal sponsor, will not be removed unless changed conditions cause such vegetation to pose an unacceptable threat, or it creates a visibility problem within the VMZ.

2.2.1 Lower Waterside Vegetation—Benefits and Risk Assessment

The lower waterside slope is defined as the portion of the waterside slope that is below the VMZ (which typically extends 20 feet from the crown of the levee down the waterside slope but may be shorter on low levees). The majority of lower waterside vegetation below the VMZ would remain relatively unmanaged and in place for a variety of reasons. The levees that confine river systems in California support some of the last remnants of once-great riparian forest ecosystems. This is especially true in the Central Valley, where more than 95 percent of the riparian habitat has been lost. Many of

Lower waterside vegetation

California's native fish and wildlife resources evolved in this complex and dynamic natural community, and many are now State listed and/or federally listed as threatened or endangered species, largely because of the cumulative loss of habitat along riparian corridors.

Woody vegetation found on and near Central Valley levees is a significant portion of the remaining riparian community that provides nesting, foraging, and cover habitat for migratory birds (including Neotropical migrants, raptors, and others); vegetation on the lower waterside slope of the levee provides overhead cover and shade that moderate water temperatures and energy input to river productivity at all trophic levels and contribute greatly to fish habitat (DWR 2012a). This habitat feature is critically important in protection and recovery efforts for special-status species along California's riparian corridors and adjacent waterways, and its loss, particularly the loss of SRA habitat, can result in ecological impacts that are considered essentially "unmitigable" due to the unique nature of this landscape feature. The USACE has acknowledged that: "Clearly, in many instances, clearing vegetation could be considered an adverse modification to critical habitat and possible adverse effect on listed species" (USACE 2007). For some species, the widespread loss of this habitat and its benefit cannot be mitigated by off-channel or off-site locations; specific locations are essential for many species that use this ecosystem for all or part of their life cycles. California currently contains more than 400 species that are listed under the California Endangered Species Act (CESA) or ESA. Many of these species are wholly or partially dependent on riparian habitat for their life history requisites, as are many nonlisted species.

From a flood-threat perspective, lower waterside slope vegetation rarely presents an unacceptable threat to levee integrity or systemwide hydraulic performance. Rather, lower waterside slope vegetation more typically provides beneficial functions, such as slowing nearshore water velocities and holding soil in place, which reduce erosion (Shields 1992); also, in the case of larger vegetation, it may provide an additional stabilizing force to the levee itself (Shields 1991). The USACE ERDC report titled *Initial Research into the Effects of Woody Vegetation on Levees* (July 2011) included a finding that trees can increase or decrease levee safety, depending on their location on levees. ERDC modeling of trees at the levee toe showed a reinforcing effect caused by the tree acting as an anchor and counterweight to sliding. Although ERDC called for additional research, its report did not characterize levee vegetation—particularly on the lower waterside slope—as a major risk factor.

Lower waterside slope vegetation is generally considered to be beneficial or, in the worst case, to pose a low threat to levee integrity based on the following:

- Because of its position on the levee, it does not interfere with flood fight, inspection, or access. It is at the greatest distance from the landside levee slope, which reduces concerns about (1) erosion that might occur should a tree fall and expose erodible levee soils and (2) seepage that might travel along rotten tree roots.

DRAFT

Measuring plantings on levee

- CLVRP research shows that in some cases, vegetation may impede seepage; this research was unable to confirm the theory that rotten roots promote piping (CLVRP 2014).

- A University of California, Davis, tree-root architecture research study showed that roots of the two predominant native tree species growing on levee slopes in California, valley oak (*Quercus lobata*) and Fremont cottonwood (*Populus fremontii* ssp. *fremontii*), did not penetrate all the way through levees in the study. Exceptional roots of large cottonwoods were observed growing some distance into the levee, paralleling the waterside slope surface or following soil lenses (CLVRP 2014).

- Woody vegetation may have beneficial functions, such as holding soil in place and preventing erosion, recruiting sediment, and aiding slope stability.

Lastly, vegetation in the lower waterside slope has long been recognized to provide benefit as articulated in the 1955 Sacramento Flood Control Operations Maintenance Manual (USACE 1955) that states "brush and small trees may be retained on the waterward slope where desirable for the prevention of erosion and wave wash." Similarly, USACE regulations recognize benefits of vegetation near the lower waterside slope as well. Specifically, Section 208.10(b)(1) of Title 33 of the Code of Federal Regulations states: a "Where practicable, measures shall be taken to retard bank erosion by planting of willows or other suitable growth on areas riverward of the levees."

In consideration of the low potential threat to public safety and high potential impact on State- and federally protected species, the CVFPP considers removal of lower waterside vegetation, or levee improvements designed for the specific purpose of minimizing lower waterside vegetation, to be among the lowest priorities for use of public funding to reduce flood risk. In contrast, multi-benefit projects that attract multiple sources of funding to foster both lower waterside vegetation, as well as levee improvements designed to address public safety, are considered a high priority for the use of public funding.

2.2.2 Trees That Pose an Unacceptable Threat to Levee Integrity

An essential element of the vegetation management strategy is the fundamental provision that trees that pose an unacceptable threat to levee integrity will be identified and removed, or managed, to reduce their threat to an acceptable level. The challenge is developing an effective assessment tool for identifying and evaluating trees that pose an unacceptable threat and providing guidance on appropriate remedial actions. Such an assessment must be objective and technically and scientifically defensible.

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This assessment is currently being developed through a collaborative effort under the auspices of the CLVRP. A working group composed of DWR staff members, CLVRP principal research investigators and advisors, and consultant support was convened and tasked with developing the assessment tool. The assessment tool includes a survey and identification component intended to identify trees that may pose an unacceptable threat to levee integrity primarily because of their location on the levee cross section and several other factors (e.g., size, deciduous versus evergreen, nut and fruit bearing). Additional multifaceted evaluation of identified trees that considers a variety of criteria/factors (e.g., tree species, tree health) would follow and lead to a decision about threat level and appropriate management action (e.g., trimming, topping, coppicing, removal).

Managing trees that pose an unacceptable threat to levee integrity can be resource intensive, particularly if removal is necessary. Removal may require excavation and remediation of the levee cross section, plus compensation or mitigation for the loss of habitat, and may be very costly. Levee maintainers will be faced with balancing these costs with the resulting benefits and considering these actions in the context of other levee risk factors in making decisions about tree removal.

DWR will coordinate with CVFPB and the LMAs tasked with implementing the vegetation management strategy to develop and implement a plan to record data on riparian vegetation lost or removed with implementation of the vegetation management strategy and to ensure adequate compensation for losses of riparian habitat functions and values (DWR 2012b). Removal of levee vegetation through the vegetation management strategy will need to comply with environmental regulations, including necessary permit and mitigation requirements.

Establishing riparian corridors, and other details of implementation of the vegetation management strategy, will be determined through collaboration with the appropriate agencies as part of Conservation Strategy implementation and will be tracked. It is expected that future research will build upon this assessment to better address how to determine (in advance of and during high-water events) whether a tree poses an unacceptable threat.

2.2.3 Early Establishment of Riparian Forest Corridors and Managed Recruitment

To minimize the effects of habitat loss resulting from the vegetation management strategy, DWR would further explore implementing, and encourage LMAs to explore implementing, riparian forest corridors in the vicinity of existing levees. The intention is that these riparian forest corridors will be established next to existing and new levees, such that the net effect will be to maintain and improve riparian corridor functions and connectivity as wildlife habitat. In order to maximize habitat values to the widest range of conservation targets, riparian corridors should be established on the waterside of levees as the preferred approach. However, certain locations within the SPFC may face flood capacity limitations, or physical space may simply not be available to establish a riparian corridor. If hydraulic analyses indicate these limitations exist, a less preferred approach that provides less habitat value to fewer conservation targets would be establishment of corridors on the land side of the SPFC facilities. Establishing riparian corridors will allow replacement habitat to develop and mature over time while the existing trees in the

DRAFT

Adaptive Levee Vegetation Management

Implementation of the State's strategy to manage levee vegetation will be adaptive and responsive to (1) the results of ongoing and future research and (2) knowledge gained from levee performance during high-water events. The strategies outlined below for the lower waterside slope and for the VMZ provide a path forward for CVFPP implementation.

Lower Waterside Slope

In order to sustain critical habitat, the CVFPP levee management strategy retains lower waterside legacy vegetation (below the VMZ). Vegetation would be removed (in coordination with resource agencies) only when it presents an unacceptable threat.

VMZ

The VMZ approach achieves "visibility and accessibility" criteria and public safety by removing woody vegetation that is or becomes an unacceptable threat to levee integrity while gradually (over many decades) allowing remaining habitat to live out its normal life span to maintain existing habitat values.

VMZ live out their normal life spans on the levee slopes. The approach could result in a near-term net increase in habitat if the replacement vegetation corridors are established in the near term. In some cases, establishing riparian corridors may not be feasible, and an alternative approach to compensating for local habitat loss over time, and maintaining and improving habitat connectivity, may be needed.

An additional concept for consideration by DWR Flood Managers, resource agencies, and other stakeholders, but has not been fully developed or agreed to.and will not be implemented at this time, is managing for limited natural recruitment of native habitat at specific locations on the lower waterside slope of the levee Managed recruitment involves gradually (over decades) allowing woody vegetation to grow on levees in acceptable waterside locations while maintaining current standards of visibility and accessibility on levees, and removing woody vegetation that is, or becomes, an unacceptable threat to levee integrity. Managed recruitment can help address resource agency objectives to protect and improve the quantity, quality, and continuity of riparian habitat. A promising opportunity for managed recruitment is areas within the lower waterside slope not currently occupied by riparian vegetation. One potential avenue for managed recruitment is within the context of planning and implementation of ongoing maintenance and repairs. This concept is under consideration forexisting levees as opposed to newly constructed projects, and this approach is intended to place no additional maintenance burden on maintaining agencies.

Establishment of habitat through the creation of riparian corridors or limited managed recruitment would have to be closely coordinated with, and informed by, efforts evaluating channel capacity across the SPFC. A mutually developed and agreed upon planning approach is needed that provides assurances for both flood managers as well as resource managers to meet multiple goals for channel capacity and riparian habitat corridors.

2.2.4 Levee Repair or Improvement

For levee repair or improvement, vegetation can be removed to meet the objectives of a specific project. An effort should be made to replace any vegetation removed as part of direct

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construction activities at that location, consistent with visibility and accessibility criteria, if possible. To the extent that it is not possible to replace it at that location, off-site, in-kind mitigation, to be determined in consultation with the appropriate resource agencies, would be required. However, vegetation on other sections of the levee not affected by construction activity should remain in place. Lower waterside slope vegetation should also remain in place where possible. If removed for the purposes of the repair, lower waterside woody vegetation (below the typical 20-foot VMZ) should be allowed to reestablish and may be restored (subject to regulatory approval). Root mitigation alternatives, such as described below, may be included as part of any levee improvement program:

- The overall width of the levee may be widened landward by at least 15 feet beyond the standard minimum levee dimensions, where feasible.

- An effective root or seepage barrier may be installed within the upper 10–15 feet of the levee crown to mitigate potential impacts caused by tree roots.

This approach is consistent with the *Sacramento River Bank Protection Project Programmatic Biological Opinion* (U.S. Fish and Wildlife Service [USFWS] 2008), which states that "existing riparian vegetation will be protected on site to the maximum extent possible where it does not affect flood system safety."

In summary, the long-term management of vegetation will be accomplished through adaptive management of vegetation on the levee—both within the VMZ and on the lower waterside slope (outside the VMZ). This strategy:

- Allows legacy trees and other woody vegetation to live out their normal life cycles unless they pose an unacceptable threat

- Allows visibility for inspection and access for maintenance and flood fight to be maintained

- Precludes growth of new woody vegetation on newly constructed levees

- Allows retention of lower waterside legacy vegetation (below the VMZ)

- Emphasizes implementation of riparian corridors as a preferred approach for providing compensatory habitat in the short term for loss of habitat on the levee profile in the longer term

- Considers limited managed recruitment of woody vegetation within areas of the lower waterside slope not currently occupied by riparian habitat, thus extending continuity of legacy vegetation.

DRAFT

2.3 Continued and Expanded Research

Phase one of the State-sponsored and local agency–sponsored research by the CLVRP is complete, and a summary report, as well as individual research papers by principal investigators, will be posted on a DWR FloodSafe website for distribution. The results of completed CLVRP research, along with USACE-sponsored research by ERDC, have been integrated into development of this vegetation management strategy. Consequently, findings of these research programs are informing current policy development and will continue to do so for future CVFPP updates. A second phase of the CLVRP is in progress and is sponsoring additional research to address data gaps and information needs, as well as to develop implementation guidance based on research already completed. As part of this effort, CLVRP has commissioned development of a "synthesis report" that will summarize and synthesize levee vegetation research (CLVRP, ERDC, and European efforts) to help identify data gaps and unanswered questions. The CLVRP will use that report to help guide future research direction.

The CLVRP has also commissioned new research, "Evaluation of the Incremental Probability of Levee Failure Due to the Effects of Woody Vegetation." This study, conducted by the University of California, Berkeley, will use a peer-informed risk assessment methodology to evaluate the probability of failure of selected representative levee reachess in California's Central Valley. Updated analytical tools will be used and the most recent scientific knowledge from CLVRP studies and others will be incorporated. The primary outcome of the study is a quantification of the change in probability of failure correlated with vegetation and animal burrows as risk factors. A second outcome will be the identification of the relative impact of vegetation in comparison to other risk factors (e.g. animal burrows) for different failure modes (e.g. underseepage, through-seepage, slope instability, and erosion). In addition, a description and discussion of analytical methods and tools will support the findings.

3.0 Channel Vegetation

A number of multiple-purpose projects within the Central Valley have begun to implement new channel vegetation management strategies that reduce costs, improve public safety, and improve natural resource values. These new strategies include controlling invasive weeds and establishing specific native plant communities while considering channel conveyance capacity and flood risk reduction. These projects begin with a "best planning practice" whereby habitat conservation needs within the channel are accounted for in the early stages of project formulation. It is standard practice to reflect habitat through the input of roughness values within hydraulic models used for water resource planning and project formulation. In a single-purpose project approach, standard practice is to apply relatively simple one-dimensional hydraulic modeling. These models indicate where channel capacity is deemed sensitive to the model input values used to represent habitat, and the commonly applied solution in single-purpose projects is to then remove habitat until some conveyance capacity threshold value is met. In a single-purpose flood control

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system, these less specific modeling capabilities were more than sufficient to inform water resource decision making in the past.

However, water resources managers and planners are now meeting a public safety needs while also incorporating habitat values into multiple-purpose projects. Maximizing the planning capabilities to best meet multiple purposes generally requires more sophisticated approaches including two-dimensional modeling. These more advanced modeling approaches are able to account for the additional complexity of designing for these multiple objectives. Water managers nationwide, including USACE and the U.S. Bureau of Reclamation, are recognizing the need for more sophisticated planning and are developing new tools to meet the need, and DWR may leverage this progress to best meet the needs of the State Systemwide Investment Approach.

Most relevant to channel habitat considerations, new planning approaches include developing model input values that better characterize roughness that may be more specifically attributed to habitat. These approaches also recognize that roughness varies based on the type of vegetation (e.g., forest trees versus herbaceous scrub) and that factoring in specific planting designs up front in project formulation may minimize O&M costs into the future. Habitat may be designed into multiple-purpose projects such that active management within the habitat itself may be minimized because the full effects on channel capacity have been accounted for. However, similar to the discussion regarding riparian corridor establishment, the appropriate interagency agreements could help better support meeting multiple objectives.

4.0 Invasive Plant Species

The Conservation Strategy recognizes invasive plants as a primary stressor on the habitats, species, and ecosystem processes that are the focus of conservation planning. Invasive species also adversely affect the O&M of the flood control system. For this reason, the development of the Invasive Plant Management Plan (IPMP) (Appendix E, “Invasive Plant Management Plan”) has been guided by the multipurpose goals to reduce the impact of invasive plants as a stressor on conservation targets and on the O&M of the SPFC to maintain public safety. DWR will consider success toward this goal as a measured reduction in the extent and spread of priority invasive plant species on State-managed lands within the Systemwide Planning Area (SPA). DWR will also facilitate complementary management efforts by other entities operating within the SPA.

Appendix E summarizes the IPMP in greater detail, but in short, the IPMP has a threefold approach to reducing invasive plant impacts:

- Increase institutional support for an SPA-wide invasive plant treatment program for DWR-maintained areas.

- Develop and implement a coordinated, systemwide invasive plant treatment approach within Channel Maintenance Areas, and effectively track results.

- Further develop partnerships through which the use of DWR resources can be optimized, and provide resources that facilitate consistency with DWR's approaches beyond its maintenance areas.

DWR has already initiated implementation of this approach:

- DWR is developing BMPs specific to areas for which it has maintenance responsibilities.

- DWR has selected four Initial Priority Species for control: giant reed, red sesbania, Himalayan blackberry, and saltcedar. These species were selected because they are widespread within the SPA; have documented, adverse effects on native species and riparian ecosystems; affect O&M of the SPFC because of their growth habitats; and have been mapped at a level of spatial detail sufficient to facilitate systemwide planning and prioritization. New fine-scale mapping was combined with other data to develop a baseline inventory of plant communities dominated by these species. This new baseline indicates that these species dominate approximately 3,800 acres in the SPA, of which approximately 1,100 acres are within Channel Maintenance Areas comanaged by DWR and LMAs.

- DWR is adapting an existing geographic information system–based computational model (developed by DWR staff members), the Weed Heuristics Invasive Population Prioritization for Eradication Tool (WHIPPET), to support DWR's treatment of invasive plant populations. WHIPPET prioritizes treatment areas in settings with infestations of multiple species.

DWR has described available resources (Appendix E) to facilitate actions by other land managers. These resources include broadly applicable BMPs, species life history information, best available treatment methods, common permitting requirements, a catalog of existing efforts to control invasive plants, and descriptions of legislative directives.

5.0 Regulatory Compliance

DWR developed and certified a Program Environmental Impact Report (PEIR) for the 2012 Central Valley Flood Protection Plan and Conservation Framework (DWR 2012b) that identified impacts of implementing the VMS. For the 2017 CVFPP Update and the Conservation Strategy, a Supplemental Program Environmental Impact Report (SPEIR) has been prepared which provides additional information relating to the VMS. Specifically, levee vegetation management actions resulting in loss of habitat values in the Central Valley have the potential to adversely affect the following anadromous fishes and terrestrial species listed under the ESA and CESA and their critical habitat: valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), Chinook salmon (*Oncorhynchus tshawytscha*), California Central Valley steelhead (*Oncorhynchus mykiss*), riparian brush rabbit (*Sylvilagus bachmani riparius*), riparian woodrat (*Neotoma fuscipes riparia*) least Bell's vireo (*Vireo bellii pusillus*), western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), Swainson's hawk (*Buteo swainsoni*), bank swallow (*Riparia riparia*), and willow flycatcher (*Empidonax traillii*). The final recovery plan for

Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and California Central Valley steelhead highlights riparian corridor protection and enhancement as high priorities for recovery of these fish species (National Marine Fisheries Service [NMFS] 2014). In addition, levee vegetation management actions in the Central Valley could adversely affect Essential Fish Habitat for Pacific salmon, as designated by the Magnuson-Stevens Fishery Conservation and Management Act.

Blue elderberry
(*Sambucus nigra* ssp. *caerulea*)

The Conservation Framework suggested that habitat replacement plans will be negotiated with the appropriate resource agencies in conjunction with, or in advance of, implementing management actions that propose to remove vegetation. Future projects proposing to remove vegetation that is considered essential to the protection and recovery of listed species will likely need to be compensated for onsite and in kind, possibly through accommodating planting berms or other features into project design.

DWR and the LMAs will work collaboratively with the appropriate resource agencies to fill information gaps on threatened and endangered species and other species of concern. For more information, see Appendix G of the Conservation Strategy, "Identification of Target Species and Focused Conservation Plans." Relevant information from other planning efforts will be used, as appropriate.

Compensatory mitigation for unavoidable impacts may include establishing conservation banks and compensation-site protection mechanisms (such as conservation easements) and will require a dedicated long-term funding strategy for maintenance, management, and monitoring of areas used for this purpose (see Section 7.0, "Regulatory Compliance and Regional Permitting," of the Conservation Strategy). DWR and the LMAs will work with the appropriate resource agencies on future vegetation management activities with the goal of minimizing adverse effects on State-listed and federally listed species, on federally designated critical habitat, and on riparian habitat and the species that depend on it.

DWR and LMAs should continue to work with the appropriate resource agencies (California Department of Fish and Wildlife [CDFW], NMFS, and USFWS) to obtain and update permits as necessary for routine maintenance under which vegetation management and appropriate minimization and mitigation measures can occur on a regular basis. This should be accomplished through the use of more efficient regulatory mechanism, such as habitat conservation planning and regional permitting approaches, in addition to already streamlined routine maintenance agreements. A process for assisting the LMAs in achieving environmental compliance and obtaining necessary permits is expected to be addressed as part of near-term initiatives included in the State Systemwide Investment Approach. Support for this activity is described in the

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Conservation Strategy in Section 7.0, "Regulatory Compliance and Regional Permitting," and Appendix A, "Regulatory Setting."

Two projects were recommended for funding as a result of the first Proposal Solicitation Package under the Conservation Framework and Strategy Guidelines that are expected to provide replacement habitat by planting riparian vegetation within the floodway (See Appendix B, Advanced Mitigation for further detail). DWR is currently working with the CDFW and the CVFPB to permit this action. Challenges associated with planting mitigation vegetation within the floodway need to be resolved before permits will be issued and the projects will be implemented. Primary among these challenges is the need to balance multiple goals of maintaining flood conveyance capacity while maintaining habitat values for riparian habitats occurring within the SPFC.

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