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7.0 MONITORING AND ADAPTIVE MANAGEMENT

7.1 OVERVIEW

This chapter describes the framework for monitoring and how the anticipated results will direct management on the Solano Habitat Conservation Plan (HCP) reserve system. The overall goals of the Monitoring and Adaptive Management Program for the Solano HCP are:

- To preserve, protect, and enhance natural communities in the Solano HCP reserve system for the benefit of Covered Species, Special Management Species, and other native plants and animals.
- Minimize the uncertainty associated with managing Covered Species and natural communities where there are gaps in the available scientific information on their biological requirements.
- Incorporate new information on the life history or ecology of Covered Species, Special Management Species, and natural communities generated through continuing research.

7.1.1 Adaptive Management

Adaptive management provides a framework for confronting uncertainty in natural resource issues and incorporating new information into ongoing management activities (Holling 1978; Walters 1986). An adaptive management approach acknowledges that managed resources will always change as a result of human intervention, that surprises are inevitable, and that new uncertainties will emerge. Uncertainties do not paralyze management actions nor are they ignored. Instead, uncertainties are dealt with via an active learning approach.

Since its development in the early 1970s, adaptive management has been defined in various ways. Different people and organizations continue to have somewhat differing views of the best definition. The California Natural Community Conservation Planning Act (NCCPA) of 2002 defines adaptive management as the use of results of new information gathered through the monitoring program of the Plan and from other sources to adjust management strategies and practices to assist in providing for the conservation of Covered Species. The United States Fish and Wildlife Service (USFWS) Habitat Conservation Planning and Incidental Take Permit Handbook (1996) and its Five-Point Addendum (USFWS 2000) defines adaptive management as a method for examining alternative strategies for meeting measurable biological goals and objectives, and then, if necessary, adjusting future management actions according to what is learned. The USFWS further argues that the key component in making the adaptive process meaningful includes careful planning through identification of uncertainties, incorporating a range of alternatives, implementing a sufficient monitoring program to determine success of the alternatives, and a feedback loop from the results of the monitoring program that allows for change in the management strategies. Figure 7-1 presents a conceptual model of the adaptive management feedback loop. The purpose of the adaptive management feedback loop is to ensure that the biological goals and objectives for Covered Species and Natural Communities are being met.

Although the adaptive management strategy anticipates future modifications to implementing the Conservation Program, the alternative conservation strategies are subject to the same limits as other provisions of the Solano HCP consistent with the USFWS "No Surprises" policy (i.e., that is,

mitigation measures and management schemes may be modified or new measures substituted as long as the new measures are of roughly equivalent cost and are consistent with approved take assumptions). Procedures for modifications and amendments to the Section 10(a) permit are described in Section 10.10.

7.1.2 Monitoring

Monitoring is mandated under the Federal Endangered Species Act (FESA) (USFWS 1996, 2000) to demonstrate compliance with the respective incidental take conditions and to provide "feedback" information for adaptive management actions implemented under the HCP. The two main components of monitoring are: *compliance monitoring* and *effectiveness monitoring*. *Compliance monitoring* is verifying that the terms of the HCP, 2081 Incidental Take Permit, and Implementing Agreement (IA) are being carried out. In other words, compliance monitoring tracks the status of HCP implementation, ensuring that planned actions (e.g., avoidance, minimization, and mitigation measures) are being properly executed as written in the HCP (see Section 10.6). *Effectiveness monitoring* evaluates the effectiveness of the operating Conservation Program of the HCP and whether the assumptions and predictions made during the development of the Plan hold true (USFWS 2000). Based on the USFWS "Five-Point Policy" for HCPs, there are several components to effectiveness monitoring, including the evaluation of incidental take. However, this chapter of the Solano HCP deals with effectiveness monitoring associated with achieving the biological goals and objectives. In this Plan, this component of effectiveness monitoring is referred to as Biological Effectiveness Monitoring.

Biological Effectiveness Monitoring is the measurement of variables that allow the program to assess the success of the HCP in meeting its stated biological goals and objectives. Biological Effectiveness Monitoring evaluates the effects of the planned actions, by measuring biologically meaningful variables and determining whether the operating Conservation Program of the HCP (i.e., implementation of the avoidance and minimization measures, mitigation measures, and preserve management plans) are successfully achieving the biological objectives. The assumption made in the Conservation Program is that if that all requirements are properly implemented, these actions will collectively achieve the stated biological goals and objectives. The purpose of Biological Effectiveness Monitoring is to track the validity of this assumption (USFWS 2000).

7.1.3 Scientific Principles

Monitoring is an important tool in an adaptive management approach and should be designed in a way that ensures data will be properly collected, analyzed, and used to adjust conservation and management strategies. The Five-Point Policy guidance (USFWS 2000) states: "In order to obtain meaningful information, the applicant and the Service should structure the monitoring and standards so that the results from one reporting period can be compared to another period or compared to different areas, and the monitoring protocol result in data that can be used to answer the question(s) asked by the monitoring plan." In addition, it states that, "The monitoring program will be based on sound science." To ensure that the monitoring program will be based on sound science, the specific monitoring protocols developed will employ a set of scientific principles that will establish the standard for collection, analysis, and interpretation of data generated from the program. These principles include:

1. Define monitoring objectives as specific hypotheses or questions.
2. Further define hypotheses using conceptual, statistical, or other types of models. This will ensure that the assumptions in the hypotheses are stated *a priori* to data collection.
3. Whenever possible, use power analyses[1] and probability-based sampling techniques to select the number and location of sampling units. This will ensure sufficient rigor in the monitoring protocols and targeted studies so that the results may be able to robustly address the question(s) asked.
4. Replicate in space and time the number of sites surveyed during monitoring and those receiving a treatment/management action and avoid pseudoreplication[2].
5. Explicitly describe the methods and assumptions of the methods used to collect and analyze data.
6. Adjust the sensitivity of the data to reflect true changes in the resources being sampled. For example, adjust count data or measurements of occupancy with an estimate of detection probability.

Employing the use of sound science in the monitoring program is critical for ensuring the success of adaptive management because monitoring and targeted studies are integral tools when employing an adaptive approach.

7.2 STRUCTURE OF MONITORING AND ADAPTIVE MANAGEMENT FOR THE SOLANO HCP RESERVE SYSTEM

Implementation of the Monitoring and Adaptive Management Program for the Solano HCP will be administered at two levels: over the entire Plan Area and on individual reserves (Figure 7-2). A Plan-wide Biological Effectiveness Monitoring Program will be administered by the Solano County Water Agency (SCWA) (see Section 7.4), encompass all three levels of monitoring (i.e., landscape, natural community, and species), and will be funded through user fees. Section 7.4 provides the basic framework, objectives, and methodology for this Program.

Management of reserves, baseline surveys of mitigation areas, and any additional monitoring (e.g., invasive species monitoring and post-construction maintenance and performance monitoring for restored wetlands) will be administered by individual mitigation banks and/or private-project specific mitigation lands (see Sections 7.3 and 10.5; Figure 7-2). In order to maintain consistency of management on reserves and preserves, all reserves and preserves established under the Solano HCP will be required to have a Resource Management Plan and, if applicable, a Restoration and Enhancement Plan approved by the SCWA in consultation with the Resource Agencies (see also Section 10.5). The SCWA will develop a more specific template for these Plans.

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1 A power analysis determines the power of a statistical test to reject the null hypothesis when the specified alternative is true. Power for a specified alternative hypothesis is defined as 1-β, where β is the probability of making a type II error (Underwood 1997).

2 Pseudoreplication is defined as the use of inferential statistics to test for treatment effects with data from experiments where either treatments are not replicated (though samples may be) or replicates are not statistically independent (Hurlbert 1984).

7.2.1 Framework for Adaptive Management on Reserves

All existing mitigation banks in the County are required to include funding in their endowments to modify management activities in response to new information (e.g., adaptive management). The types of potential modifications that are anticipated and funded for established reserves include but are not limited to:

- Changes in management, harvest schedules, or types of crops in agricultural reserves,
- Changes in stocking rates or livestock,
- Modification of grazing seasons,
- Elimination of grazing, and
- Increased weed abatement or changes in control methods.

The adaptive management funding for the existing banks, however, is generally insufficient to test management hypotheses across the full spectrum of resources at the individual banks. As a result, the Solano HCP provides the basic framework and approach for the Monitoring and Adaptive Management Program. SCWA will oversee and implement the Biological Effectiveness Monitoring Program, which will be focused on the success of the reserve system in meeting biological goals and objectives with funding provided through user fees (see Section 11.1.3). SCWA will further provide guidance to participating mitigation banks and private reserves/mitigation sites regarding changes in the management plans that need to be implemented to maximize conservation values. Funding for existing banks and reserves is currently held by other third parties (generally either the California Department of Fish and Game [CDFG] or Solano Land Trust). In the future, SCWA may seek to acquire and administer the endowment funds from CDFG in order to pool the funds with reserves and mitigation sites under the HCP administration. This would allow for more efficient implementation of adaptive management on established reserves.

Other changes in management activities that may be required to address potential broader, regional issues such as disease and predation will be directed by SCWA and funded through user fee funds (see Section 11.2 for further discussion of applicable HCP programs and funding commitments).

7.3 INDIVIDUAL RESERVE MONITORING AND ADAPTIVE MANAGEMENT

The management of individual reserves as well as baseline surveys of mitigation areas and any additional monitoring (e.g., invasive species monitoring and post-construction maintenance and performance monitoring for restored wetlands) will be administered by individual mitigation banks and/or private project-specific mitigation lands (see Section 10.5; Figure 7-2). In order to maintain consistency of management on reserves and preserves, all reserves and preserves established under the Solano HCP will be required to have a Resource Management Plan and, if applicable, a Restoration and Enhancement Plan approved by the SCWA in consultation with the Resource Agencies (see also Sections 10.5.3 and 10.5.4). There are standard monitoring requirements for the Resource Management Plans and Restoration and Enhancement Plans for all reserves established under the HCP (see Sections 7.3.1 and 7.3.2). Additional management and monitoring requirements for individual reserves will also depend on which avoidance and minimization measures or mitigation measures were applicable in the reserve's establishment (e.g., is the reserve a riparian buffer area or does it provide Swainson's hawk foraging or nesting habitat mitigation?)

(Table 7.1). In general, effectiveness monitoring associated with avoidance and minimization measures and mitigation measures will be the responsibility of individual mitigation banks and/or private project-specific mitigation lands. For mitigation banks, the effectiveness monitoring (to be conducted in perpetuity; see Figure 7-3) for any credit that is established and sold to meet the requirements of the HCP Conservation Program will be the responsibility of the bank.

7.3.1 Resource Management Plans

All reserves and preserves established under the Solano HCP shall have a Resource Management Plan, which is reviewed and approved by SCWA in consultation with the Resource Agencies, that includes the following minimum requirements described in Section 10.5.3.1 and consistent with the applicable species/community conservation strategies required in Chapters 5.0 and 6.0 and further described in Section 10.5.3.2.

7.3.1.1 General Requirements

The following measures or standards are applicable to essentially all Resource Management Plans:

1. A prioritized list of all potential threats to the natural communities present in the preserve/reserve.
2. Prepared by a qualified person(s) experienced in the development and implementation of restoration, mitigation, and management plans for the respective communities.
3. Control measures and programs for highly invasive exotic and noxious weeds. These programs shall be conducted in perpetuity and shall include annual surveys to visually assess and identify weed infestations and annual control measures.
4. Control measures for invasive and destructive nonnative animal species (e.g., wild pigs, bullfrog). These programs shall be conducted in perpetuity and shall include annual surveys to visually assess and identify new infestations. All control measures shall be conducted in compliance with all applicable local, State, and Federal regulations in force at the time of the control program.
5. Control measures for mosquitoes and other vectors of concern for human health and agricultural pests and pathogens.
6. Rodent control on reserves/preserves shall be limited to the maximum extent practicable. Habitat and species reserves and preserves[1] shall set aside zones where no rodent control will occur. Control activities shall be limited to reserve/preserve edges where ground squirrels and other rodents conflict with adjacent land uses. The control zone width[2] shall be no more than 250 feet (ft), unless approved by the Resource Agencies. If this distance is reduced, Resource Management Plans shall include additional control efforts to confine rodent activity to the reserve as part of a Good Neighbor Policy.

[1] Irrigated Agriculture lands preserved for Swainson's hawk and burrowing owl habitat are exempt from rodent control restrictions.

[2] The 250 ft control zone for a California ground squirrel is based on a typical home range of 150 ft radius from a burrow system.

Table 7.1: Monitoring Requirements for Individual Mitigation Banks and/or Private Project-Specific Mitigation Lands and the Associated Avoidance and Minimization Measures or Mitigation Measures

Reserve Monitoring Requirement	Applicable Avoidance and Minimization Measures or Mitigation Measures
Avoidance and Minimization Monitoring for the effectiveness of buffers in preserving avoided habitat areas.	**Valley Floor Grassland and Vernal Pools:** • Avoidance and Minimization Measure VPG 3 – Buffer Criteria • Avoidance and Minimization Measure VPG 4 – Buffer Zones for Extremely Rare and/or Range-Limited Species • Avoidance and Minimization Measure VPG 6 – Corridors **California Red-Legged Frog:** • Avoidance and Minimization Measure RLF 2 – Aquatic Habitat Buffers **Callippe Silverspot Butterfly:** • Avoidance and Minimization Measure CSB 1 – Monitoring of Avoided Core Habitat Areas and Buffers **Riparian, Stream, and Freshwater Marsh:** • Avoidance and Minimization Measure RSM 2 – Setbacks and Buffer Zones **Coastal Marsh:** • Avoidance and Minimization Measure CM 3 – Buffers • Avoidance and Minimization Measure CM 6 – Salt Marsh Harvest Mouse
Post-construction Maintenance and Performance Monitoring (5-year minimum monitoring period)	**Valley Floor Grassland and Vernal Pools:** • Mitigation Measure VPG 1 – Habitat Mitigation; restoration requirement • Mitigation Measure VPG 4 – California Tiger Salamander Breeding Habitat Creation **California Red-Legged Frog:** • Mitigation Measure RLF 2 – Mitigation for Long-Term Impacts to Riparian, In-Stream, Pond, and Freshwater Marsh Habitats Within California Red-Legged Frog Conservation Area • Mitigation Measure RLF 3 – Temporary Impacts to Upland, Marsh, Pond/Aquatic, and Riparian Habitats • Mitigation Measure RLF 4 – Mitigation for Breeding and Non-Breeding Aquatic Habitat Outside of the California Red-Legged Frog Conservation Area **Riparian, Stream, and Freshwater Marsh:** • Mitigation Measure RSM 1 – Riparian Restoration and Enhancement • Mitigation Measure RSM 2 – Restoration of Pond or Freshwater Marsh Habitat Not Associated with Streams • Mitigation Measure RSM 3 – Construction/ Restoration of Seasonal Wetlands in the Inner Coast Range • Mitigation Measure RSM 4 – Temporary Impacts • Mitigation Measure RSM 7 – Restoring Naturalized Channel Processes. • Mitigation Measure RSM 12 – Planting of Elderberry Shrubs **Giant Garter Snake:** • Mitigation Measure GGS 1 – Operations and Maintenance Habitat Mitigation • Mitigation Measure GGS 2 – Long-Term Impact Habitat Mitigation

Table 7.1: Monitoring Requirements for Individual Mitigation Banks and/or Private Project-Specific Mitigation Lands and the Associated Avoidance and Minimization Measures or Mitigation Measures

Reserve Monitoring Requirement	Applicable Avoidance and Minimization Measures or Mitigation Measures
	Coastal Marsh: • Mitigation Measure CM 1 – Construction and/or Restoration of Tidally-Influenced Coastal Marsh • Mitigation Measure CM 3 – Creation or Restoration of Shallow Water Habitat • Mitigation Measure CM 4 – Mitigation for Direct, Temporary Habitat Loss • Mitigation Measure CM 8 – Delta Smelt and Sacramento Splittail Habitat Restoration
Hydrology and Water Quality Monitoring	**California Red-Legged Frog:** • Mitigation Measure RLF 5 – Nonnative Predator Habitat **Riparian, Stream, and Freshwater Marsh:** • Mitigation Measure RSM 5 – Base Flow • Mitigation Measure RSM 6 – Development within Watersheds of Priority Drainages • Mitigation Measure RSM 8 – Prevent the "Perennialization" of Ponds and Intermittent Creeks • Mitigation Measure RSM 9 – Storm Water Discharge **Coastal Marsh:** • Mitigation Measure CM 5 – Dry Season Nuisance Flows
Contra Costa Goldfield Reestablishment	• Mitigation Measure VPG 3 – Contra Costa Goldfield Mitigation Requirements for Impacts to Occupied Habitat
Johnny Jump-up Restoration	• Mitigation Measure CSB 2 – Mitigation for the Conversion of Breeding Habitat
Swainson's Hawk Nest Trees	• Mitigation Measure SH 4 – Nesting Habitat Mitigation
Burrowing Owl Artificial Nest Boxes and Burrow Densities	• Mitigation Measure BO 2 – Nesting Habitat Mitigation

7. Procedures and Best Management Practices (BMPs) for chemical applications shall be established in order to avoid and minimize effects to covered species.
8. Installation and maintenance of artificial burrowing owl burrows/nest boxes shall be identified in the Resource Management Plan and funded as a line item of the long-term management funding.
9. For banks, monitoring programs shall be included to monitor the effectiveness of any habitat or species value (e.g., credit type) that is established and sold to meet the requirements of the HCP Conservation Program. The monitoring program shall follow a schedule similar to that outlined in Figure 7-3.
10. Monitoring programs shall be included to document the status and continued persistence of Covered Species. Covered Species monitoring shall be conducted in accordance with the Natural Community and Covered Species monitoring requirements specified in this chapter. Additional monitoring could be required if unforeseen problems arise that require more frequent monitoring.

11. Management and restoration plans shall incorporate measures to protect extant populations of other Covered Species on the reserve/preserves. Reserve and preserve managers are also encouraged to establish other Covered Species native to on-site habitats as part of any restoration and enhancement actions. Successful establishment of populations will be allocated additional credit or value for the applicable species and additional occupied habitat.
12. A management endowment or other funding mechanism shall be established that is acceptable to the long-term management entity and SCWA and is of sufficient size to manage the property in perpetuity consistent with the approved management plan. Guarantees for funding for the interim management period (i.e., reserve establishment until the third-year anniversary of full funding of the long-term management endowment) will also be required.
13. The management plan shall specify maintenance requirements and responsibilities for implementation, interim and long-term ownership and/or management, annual reporting requirements, and a funding mechanism consistent with the HCP reserve design and management standards.
14. Management plans shall include provisions for implementing adaptive management on established reserves (see Section 10.5.5).
15. Reserves shall provide annual monitoring reports summarizing management activities over the preceding year.

7.3.1.2 Additional Management Requirements for Natural Communities and Covered Species

The following additional specific management requirements are required for Resource Management Plans to fulfill Natural Community and Covered Species management goals and objectives for reserves in Valley Floor Grassland and Vernal Pool Natural Communities (see Sections 5.3, 5.10, and 5.11), Callippe Silverspot Butterfly Conservation Areas (Section 5.5), and in Irrigated Agriculture lands (see Sections 5.9, 5.10, and 5.11).

Valley Floor Grassland and Vernal Pool Reserves. The primary management objective for reserves within the Valley Floor Grassland and Vernal Pool Natural Community is to control or remove thatch and annual grass heights. Secondary objectives are to incorporate management actions that promote native grasses and results in a patchwork of lightly to moderately grazed pastures, with occasional patches of ungrazed or taller vegetation. Livestock grazing is the preferred method of control. Grazing requirements shall specify stocking rates, desired grass maximum heights by season, end of grazing season residual dry matter requirements, and applicable grazing seasons.

In smaller urban reserves, fencing requirements shall be sufficient to exclude dogs to minimize harassment/harm to livestock. Where livestock grazing is not practicable, provisions and funding for regular vegetation mowing shall be required. In general, mowing shall be conducted two to three times per year: (1) at the end of the rainy season to reduce thatch and wild fire fuels; and (2) once or twice during the growing season to maintain grass heights between 2 and 6 inches in order to promote forb emergence and conditions preferred by burrowing owls (see Valley Floor Grassland and Vernal Pool Natural Community, callippe silverspot butterfly and burrowing owl conceptual models in Appendix B).

Callippe Silverspot Butterfly Conservation Area. Reserve Management Plans for reserves containing callippe silverspot butterfly breeding habitat shall include vegetation management strategies that promote establishment of native grasses and low residual cover of introduced annual grasses (700 to 1,000 pounds [lbs] or less of residual dry matter) in core breeding areas.

Irrigated Agriculture Lands. Resource Management Plans for reserves established in Irrigated Agriculture lands for Swainson's hawk and burrowing owl conservation shall identify set-asides and locations of the other required species habitat components. The set-aside lands are for current and future Swainson's hawk nest trees, artificial burrows and short grass cover areas for burrowing owl, and dense vegetation stands for tricolored blackbird and Special Management Species (see species objectives in Sections 5.9, 5.10, and 5.11). The Resource Management Plan shall also specify procedures and timelines for establishing, maintaining, and replacing potential nest trees in perpetuity.

Resource Management Plans for Irrigated Agriculture reserves shall also incorporate annual reporting requirements for planned crops for the upcoming season (e.g., pre-planting reports) as well as information on compliance with set-aside area management requirements. In situations where a specific reserve wishes to deviate from the minimum 50 percent alfalfa (or similar crop type) requirement (Objective SH 1.2), the reserve must receive prior approval for this change from the SCWA to ensure that the minimum 50 percent alfalfa (or a crop type with similar irrigation and harvesting regimes) requirement throughout the reserve system will be met in the coming year.

SCWA will track the contribution of each specific reserve toward the 50 percent alfalfa/irrigated hay and 5 percent naturalized herbaceous and woody/shrub cover system-wide reserve requirements. The contribution of each reserve to the overall requirements will be specified in the reserve's approved Resource Management Plan and annual planting plans. If an individual Resource Management Plan calls for less than 5 percent naturalized herbaceous and woody/shrub cover or less than 50 percent alfalfa/irrigated hay contributions to the overall system-wide goals, then the difference must be made up at another reserve. SCWA, in consultation with the regulatory agencies, must approve all deviations from the minimum reserve requirements (50 percent alfalfa/irrigated hay and 5 percent naturalized herbaceous and woody/shrub cover) prior to planting to ensure that the minimum requirements are met system-wide each year. In general, the percentage of alfalfa crop in any given subzone (see Figure 4-27) shall not deviate more than 20 percent from the base requirement.

For long-term flexibility, SCWA will establish a program for trading crop-type credits between individual reserves if the minimum 50 percent criterion for alfalfa (or other irrigated hay crops with similar management requirements) is achieved throughout the Irrigated Agriculture reserve system in any given year (see Section 10.5.3 for further information).

7.3.2 Restoration and Enhancement

Creation of wetlands and restoration of natural communities and species populations are important components of the Solano HCP Conservation Strategy. The Solano HCP generally follows the definitions for creation, enhancement, restoration, and establishment as defined by the Society for Ecological Restoration:

- **Creation** is defined as the construction or establishment of a habitat or plant community within a different habitat or plant community that previously did not support that community. Created communities are also referred to as artificial habitats.
- **Enhancement** is the increase in biological values of an existing habitat area or feature through changes in management, vegetation, or specific structural features to increase one or more functions based on management objectives. Typically, enhancement involves improving functions in a degraded community or habitat (e.g., after enhancement, an area that technically functions as a wetland but does not possess any particular values for native species now supports native species and/or other desirable wetland functions).
- **Establishment** entails the manipulation of the physical, chemical, or biological characteristics of the site to develop a resource that does not currently exist. Establishment increases resource area and functions. Establishment associated with restoration is preferable to creation.
- **Restoration** is the return of an ecosystem to its condition prior to disturbance. In principle, restoration is similar to enhancement and involves converting a severely degraded or altered community through the implementation of management actions, land grading, and revegetation activities to promote the reestablishment of the habitat conditions, functions, and values associated with the site prior to its disturbance. Restoration is distinguished from enhancement in that restoration is conducted where all evidence of the targeted natural community has been eliminated by prior disturbance (e.g., vernal pools and swales have been converted to uplands).

A number of the Solano HCP mitigation measures refer to "construction" as part of required actions. As referred to in the Solano HCP, construction involves activities such as excavation, grading, and revegetation necessary to create, restore, establish, and enhance natural communities/habitats. To achieve HCP goals and objectives, only restoration, establishment, and enhancement activities will be accepted for natural communities/habitats. Creation of habitats (e.g., construction of wetlands in historically upland soil types where wetlands would not naturally occur) will not be accepted as meeting Solano HCP goals and objectives. This exemption, however, does not extend to the placement of artificial features such as nest boxes, nesting platforms, or artificial burrows that may be desirable or required to establish specific habitat elements that a reserve may be lacking.

7.3.2.1 Restoration and Enhancement Plans

Restoration and Enhancement Plans shall be submitted to SCWA for review and approval in consultation with the Resource Agencies (Section 10.2.6). All Restoration and Enhancement Plans shall comply with all applicable construction and performance assurances (10.5.1.3) and management, funding, and long-term protection requirements for Resource Management Plans and Endowments (see Sections 10.5.3 and 10.5.4) and Conservation Easements/Land Dedications (see Section 10.5.2). Restoration and Enhancement Plans shall be required for unconstructed or phased restoration at existing banks, mitigation banks that have not been previously approved under the Federal and/or State approval process, or institutional or private mitigation actions (see Sections 10.5.2 and 10.5.3) involving habitat restoration and/or enhancement to fulfill the requirements of the Solano HCP. This condition does not apply to restoration and enhancement actions previously implemented on mitigation banks approved and/or operating prior to adoption of the HCP. However, previously approved restoration projects that have not been implemented may be required to update their plans and monitoring and performance requirements to meet current standards.

All Restoration and Enhancement Plans shall follow the general format and meet the content requirements of the United States Army Corps of Engineers (Corps), San Francisco and Sacramento Districts, Mitigation and Monitoring Proposal Guidelines (December 30, 2004; available at http://www.spn.usace.army.mil/regulatory/policy/mitigationfinal.pdf) or applicable updates. In general, acceptable Restoration and Enhancement Plans shall comply with the following guidelines:

1. Restoration/enhancement shall occur in similar soil types or in soil types typically associated with the applicable natural community (e.g., vernal pool habitats should not be constructed in upland soil types unless it can be demonstrated that wetlands would naturally occur in such conditions).
2. The size, shape, and depth of the target community/vegetation (e.g., wetlands/vernal pools) shall be of similar size, shape, and relative density as natural communities on similar soil types.
3. Restoration of uplands through construction and placement of mounds may also be necessary in many reserves, particularly in the Valley Floor Grassland and Vernal Pool Natural Community. In many areas, past agricultural cultivation has tended to reduce the topographic distinction between wetland and uplands. The pools and swales have become shallower and the surface of the uplands is closer to the winter groundwater table. The loss or reduction of distinct uplands has greatly reduced habitat for fossorial rodents (e.g., California ground squirrel, pocket gopher, kangaroo rat, meadow vole) and many of the other native species such as California tiger salamander and burrowing owl, which depend on other species for burrows.
4. Plans shall describe site grading, erosion control, channel stabilization, preservation methods, fishery enhancement, and revegetation. Any revegetation program shall use plants indigenous to this region.
5. Construction activities for restoration and enhancement shall be avoided in areas of high-quality habitat and relatively natural topography. Construction activities shall be limited to areas where the natural community structure has been eliminated or severely disturbed/altered by past land uses.
6. Revegetation activities shall be limited to native or widespread, non-invasive naturalized plant species common to the region.
7. Specific, measurable criteria shall be established to assess the success of restoration/ enhancement activities in meeting desired goals and objectives. Any salvage (e.g., collection and relocation of Covered Species from impacted sites to reserves) or restoration requirements shall include clearly defined goals focusing on vegetation establishment (stability, succession, reproduction) and shall follow requirements identified in Section 10.5.4.2.
8. Reserves shall not establish or restore habitats within or adjacent to easements or other properties where the requirements for avoiding and/or minimizing take of Covered Species would interfere with their normal operations and management.
9. Monitoring to assess performance shall occur for a minimum of 5 years (certain habitats or species may require longer monitoring periods) or until final performance criteria have been met for at least 2 years without significant human intervention (e.g., irrigation, replanting, regrading). The monitoring program shall include a provision for remedial action as needed to correct deficiencies.
10. Annual reports and a final report, prepared by the property owner and subject to approval by SCWA, shall document the success of all restoration and enhancement efforts. If such efforts

are not achieving prescribed performance, an additional period of correction and monitoring shall be specified. Monitoring reports shall be submitted annually to SCWA for review and approval and for annual reporting to the Regulatory Agencies.

7.3.2.2 Species Relocation and Establishment Plans

Several objectives from Chapter 5.0 and mitigation measures in Section 6.4 require the establishment of new populations of Covered Species or a relocation of Covered Species from impacted areas. Because natural burrows excavated by California ground squirrels are essential to the maintenance, expansion, and long-term viability of burrowing owl populations within the Plan Area, re-establishment/relocation of ground squirrels may be required to achieve burrow objectives for burrowing owl and to increase burrow availability for California tiger salamander in certain reserves.

Relocation or establishment plans for Covered Species or ground squirrels shall be prepared and submitted to SCWA and the Resource Agencies for review and approval prior to implementation. Translocations, relocation, and establishment plans shall include:

- Identification and qualifications of the biologist(s) implementing the plan.
- Analysis of issues or concerns for mixing genetically distinct populations.
- Methods for capturing, moving, and expanding distribution of or collecting of applicable animals or seeds/cysts. The plan will specify the location(s) where the species will be collected, numbers of animals/material to be collected, time frames for collection and release/planting, locations of release or planting, procedures for release or planting, and monitoring requirements and performance standards.
- Written approval from landowners where collections will occur as well as at release sites. Good Neighbor Policy requirements may apply (see Section 10.5.6).

7.3.3 Valley Floor Grassland and Vernal Pool

The reserve system for the Valley Floor Grassland and Vernal Pool Natural Community will consist of between 13,000 and 15,000 acres (ac) of habitat within High Value Vernal Pool Conservation Areas (Figure 4-9) and/or priority areas for future protection identified in Figure 4-26. The majority of the Valley Floor Grassland and Vernal Pool Reserve System, between 11,140 ac and 13,220 ac, will be located within Subarea 1A or other potential vernal pool reserve areas outlined on Figures 4-8 and 4-26. A substantial component will also occur in areas in close proximity to urban development: 380 to 400 ac in Subarea 1B, 700 to 760 ac in Subarea 1C, 60 ac in Subarea 1D, 170 ac in Subarea 1E, 120 ac in Subarea 1G, and a minimum of 350 ac in Subarea 1F. These smaller areas will encompass the majority of the Contra Costa goldfield reserves. In addition to habitat preservation, a large component of the Conservation Strategy will consist of restoring vernal pool wetlands within High and Medium Value Vernal Pool Conservation Areas (estimated to be approximately 200 ac of restored vernal pools). Given the range of conservation activities and reserve locations in the overall reserve system for this natural community, each reserve will have slightly different monitoring and management goals.

7.3.3.1 Management

The primary management goal of the Monitoring and Adaptive Management Program is to protect and/or enhance the biological values of the Valley Floor Grassland and Vernal Pool Natural Community by maintaining habitats that support native plants and animals associated with this Natural Community. Specific management goals intended to achieve this primary goal are: minimizing the accumulation of thatch from annual grasses, reducing the occurrence of noxious weeds, maintaining and enhancing the hydrological integrity of preserved and restored wetlands and preventing accelerated erosion, and expanding the population levels of Covered Species and other native plants and animals on the site. The management prescriptions that will be implemented to achieve these goals are livestock grazing, weed control (e.g., herbicides, manual removal, and mowing), and possibly prescribed burning.

Resource management plans for sites in annual grasslands shall include measures for removal of thatch and standards for reducing or controlling annual grass height. Livestock grazing is the generally preferred method for control. Grazing requirements shall specify stocking rates, desired grass maximum heights by season, end of grazing season residual dry matter requirements, and applicable grazing seasons. In smaller urban reserves, reserve fencing requirements shall be sufficient to exclude dogs from accessing reserves (to minimize harassment/harm to livestock). Where livestock grazing may not be practicable, provisions and funding for regular mowing of vegetation shall be required. In general, mowing shall be conducted two to three times per year: at the end of the rainy season (to reduce thatch and reduce wild fire fuel buildup), and once to twice during the growing season to maintain grass heights between 2 and 6 inches in order to promote forb emergence and conditions preferred by burrowing owls.

7.3.3.2 Effectiveness Monitoring

Avoidance Monitoring. Reserve areas for this natural community may be established as a result of Avoidance and Minimization Measures VPG 2 and VPG 3 (i.e., site design standards and buffer criteria). All avoided habitat areas and associated buffers must be preserved and managed in perpetuity. The Resource Management Plans of these preserved areas shall include and fund provisions for monitoring the hydrology of avoided wetlands to ensure that no significant adverse changes in water quality or timing and duration of inundation have occurred for a minimum of 10 years. In addition to water quality and hydroperiod, vegetation monitoring will be conducted for a minimum of 10 years to show no significant changes in species composition as a result of the adjacent development.

Restored Wetlands. A large component of the Valley Floor Grassland and Vernal Pool Conservation Strategy involves the restoration of vernal pool wetlands (approximately 200 ac; Objective VPG 1.3 and Mitigation Measure VPG 1). All restoration activities and subsequent performance monitoring (for the first 5 years at minimum) will be the responsibility of the individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plan. This also includes the monitoring of created California tiger salamander breeding habitat (Objective VPG 2.16 and Mitigation Measure VPG 4). Following this initial monitoring period, long-term monitoring of a subset of these restored wetlands will be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA (see Section 7.4.5).

Monitoring of Vegetation Management Strategies. Reserves and preserves in grasslands shall conduct annual monitoring to assess the effectiveness of vegetation management strategies (i.e. livestock grazing). Methods for assessing range utilization will be detailed in the preserves/reserves Resource Management Plans. The primary method for assessing range utilization is through the monitoring of residual dry matter (RDM) and the pattern mapping of heavy, moderate, light, and no grazing use. Permanent RDM plots will be established to track changes in cover and occurrence of plant species and guide management activities used on reserves/preserves. These plots should be located in the different plant communities. Sample variables include: elevation, slope position (swale, mound, slope, etc.), slope aspect, amount of thatch, identification and percent cover of every species in the plot, soil type, and soil texture. The primary measure is RDM.

These plots will be 0.25-meter square in size and will be randomly placed in selected pastures to assess the effects of grazing and burning. The number of plots, which will be determined by the variability of the species composition of the plots, would consist of 10 to 30 for each pasture that is monitored. Control plots will be located in portions of the pastures that are not grazed or burned. Representative photographs of the sampling plots in each community type will be taken annually. This monitoring is designed to demonstrate the effectiveness of biological Objective VPG 1.4.

Contra Costa Goldfield Re-establishment. The other restoration component that will occur on vernal pool reserves is the reestablishment of 100 ac of new, self-reproducing Contra Costa goldfield populations within known or potential habitat areas (Objective VPG 2.2). Monitoring of reestablished populations will be conducted by individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plans. Re-established populations will be considered self-reproducing when plants reestablish annually for a minimum of 5 years with no human intervention, such as supplemental seeding, with an occupied area and flower/plant density comparable to existing occupied wetlands that are similar in type (see Mitigation Measure VPG 3). If these criteria are not achieved within 10 years of when the original project impacts occurred, the third party applicant shall increase the preserved wetland reestablishment acreage requirement by 50 percent (see Mitigation Measure VPG 3). The applicant shall provide bonds or other financial assurances, subject to approval by SCWA, to ensure implementation of such measures (see Section 10.5).

7.3.4 California Red-Legged Frog

The reserve system for California red-legged frogs will consist of approximately 3,300 ac of Inner Coast Range upland, riparian, and aquatic habitats within the California Red-Legged Frog Conservation Area. Implementation of the Conservation Strategy will result in the construction and restoration of additional breeding habitat that will be managed for the benefit of California red-legged frogs. Invasive species control includes measures to passively control them by preventing the creation of new permanent water features and the "perennialization" of intermittent creeks and other existing aquatic features, and to actively control them through control programs established as part of the Resource Management Plans of the reserves.

7.3.4.1 Management

The primary goal of the adaptive management program is to protect existing populations of California red-legged frogs by reducing threats and expanding populations through the restoration

and creation of habitat. Specific management goals intended to achieve this primary goal are: eradicating invasive exotic species, such as bullfrogs and introduced predatory fish from breeding habitat; reducing the occurrence of noxious weeds; maintaining and enhancing the hydrological integrity of preserved and restored wetlands and preventing accelerated erosion; and expanding the population levels. The management prescriptions that will be implemented to achieve these goals are predator eradication programs, livestock grazing, selectively excluding cattle from sensitive riparian areas, weed control (herbicides, manual removal, and mowing), and the creation of additional breeding habitat. For vegetation management, Reserve Management Plans shall include vegetation management strategies that promote establishment of native grasses and that result in a patchwork of lightly to moderately grazed pastures, with occasional patches of ungrazed or taller vegetation (Objective RLF 1.3).

7.3.4.2 Effectiveness Monitoring

Effectiveness monitoring for the California red-legged frog consists of four elements:

1. **Hydrology Monitoring:** The Conservation Program of the HCP incorporates measures to minimize the potential spread of invasive aquatic species by preventing the creation of new permanent water features and the "perennialization" of existing aquatic features, such as avoided ponds and intermittent creeks (Mitigation Measure RLF 5). The hydrology of avoided aquatic habitat features will be monitored annually in perpetuity to ensure that no changes in hydrology occur. In addition to existing aquatic features, the hydrology of detention basins and other storm water features shall be monitored to ensure they do not become perennial. These features shall also be monitored for the presence of nonnative species.
2. **Invasive Species Monitoring:** The largest management component for reserves established for California red-legged frogs is the control of invasive species. Reserves established in the California Red-Legged Frog Conservation Area shall implement and fund, in perpetuity, programs designed to control nonnative species such as bullfrog, crayfish, and warm water fish. If nonnative predators are present, control activities will be conducted annually until they have been locally eradicated from the breeding habitat and absent for 3 consecutive years. Once nonnative predators have been successfully eliminated from individual aquatic habitat areas, long-term monitoring will occur annually in perpetuity to prevent the reestablishment of these species. Aquatic breeding habitat will be surveyed during the early summer through the fall for the presence of bullfrogs and exotic fish species.
3. **Constructed Breeding Habitat:** A component of the California Red-Legged Frog Conservation Strategy involves the construction of new breeding habitat (Objective RLF 1.2 and Mitigation Measure RLF 2). The initial restoration activities and subsequent monitoring (for the first 5 years at a minimum) will be conducted by individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plan.
4. **Monitoring of Vegetation Management Strategies:** Reserves and preserves within the California Red-Legged Frog Conservation Area shall implement the same monitoring to assess range utilization as described for Valley Floor Grassland and Vernal Pool preserves (Section 7.3.3.2). This monitoring is designed to demonstrate the effectiveness of biological Objective RLF 1.3.

7.3.5 Callippe Silverspot Butterfly

The reserve system for the callippe silverspot butterfly will consist of approximately 3,300 ac of Inner Coast Range habitat within the Callippe Silverspot Butterfly Conservation Area and is expected to be largely integrated with California red-legged frog conservation. The primary conservation actions for this species involve protecting existing breeding habitat and corridors for dispersal of adults, enhancing stands of the adult nectar plant, and, if possible, restoring additional areas of the larval host plant.

7.3.5.1 Management

The primary management goal of the Monitoring and Adaptive Management Program is to protect and expand existing callippe silverspot butterfly populations on existing and future reserves/preserves in the Plan Area. A specific management goal intended to achieve this primary goal is the enhancement of callippe silverspot butterfly habitat by increasing the distribution and abundance of the larval host plant (Johnny jump-up) and adult nectar plants. This will be accomplished through minimizing the accumulation of thatch from annual grasses and reducing the occurrence of noxious weeds, both of which may out-compete Johnny jump-up and the adult nectar plants. The management prescriptions that will be implemented to achieve this goal are livestock grazing, weed control (herbicides, manual removal, and mowing), and possibly prescribed burning.

7.3.5.2 Effectiveness Monitoring

Effectiveness monitoring for the callippe silverspot butterfly evaluates the effectiveness of required avoidance measures (see Section 6.3.4), restoration of the larval host plant, and the effectiveness of management strategies for providing adult nectar sources as well as promoting conditions for the larval host plant.

Avoidance Monitoring. Reserve areas containing core breeding habitat for the species will likely be established as a result of Avoidance and Minimization Measure CSB 1. All avoided habitat areas and associated buffers must be preserved and managed in perpetuity. The Resource Management Plans of these preserved areas shall include and fund provisions for monitoring the distribution and density of Johnny jump-up annually, for a minimum of 10 years, to ensure that no significant adverse changes have occurred to the core breeding area.

Restoration of Johnny Jump-up and Adult Nectar Plants. Mitigation Measure CSB 2 requires the restoration/enhancement of stands of Johnny jump-up and nectar plants for direct and indirect impacts to existing stands. The monitoring of restored stands will be conducted by individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plan. Restoration will be considered successful when plants reestablish annually for a minimum of 5 years with no human intervention, such as supplemental seeding, with an occupied area and flower/plant density comparable to adjacent core breeding areas or that meet the criteria for being considered core breeding habitat (i.e., a minimum of 1 ac of habitat with a Johnny jump-up density of at least 10 percent).

Monitoring of Vegetation Management Strategies. Reserves and preserves within the Callippe Silverspot Butterfly Conservation Area shall implement the same monitoring to assess range utilization as described for Valley Floor Grassland and Vernal Pool preserves (Section 7.3.3.2). This monitoring is designed to demonstrate the effectiveness of biological Objective CSB 1.3.

7.3.6 Riparian, Stream, and Freshwater Marsh

The primary goal of the Riparian, Stream, and Freshwater Marsh Natural Community is to maintain and enhance the natural hydrogeomorphic processes; essential ecological processes, functions, and values; species diversity; and habitat heterogeneity of riparian, stream, and freshwater marsh habitat in the Plan Area. The three main conservation activities to be conducted on reserves for this Natural Community are preservation, restoration, and enhancement. Resource Management Plans and Restoration and Enhancement Plans for this Natural Community will focus monitoring and adaptive management on demonstrating the effectiveness of these conservation actions.

7.3.6.1 Management

The primary adaptive management goal is to balance the natural hydrogeomorphic and ecological functions of riparian, stream, and freshwater marsh habitats with the need to maintain channel capacity for flood control. The control and management of invasive plant and animal species is also a key management consideration.

7.3.6.2 Effectiveness Monitoring

A large component of the Riparian, Stream, and Freshwater Marsh Conservation Strategy involves the restoration and enhancement of riparian and in-stream habitat, preferably within Priority Drainages (Objectives RSM 1.1, RSM 1.3, and RSM 2.3; see Table 7.1 for applicable avoidance and minimization measures and mitigation measures). Individual mitigation banks and/or private project-specific mitigation lands are responsible for all initial restoration activities and subsequent monitoring (for the first 5 years at a minimum) as part of their Restoration and Enhancement Plan. The long-term monitoring of a subset of these restored riparian areas will then be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA (see Section 7.4). In addition to the minimum requirements for Restoration and Enhancement Plans, plans for riparian, stream, and freshwater marsh habitats shall:

1. Have clearly defined restoration goals that focus on vegetation, fishery, wildlife, and channel stability issues; and
2. Provide detailed specifications for vegetation, site preparation, exotic species removal, site grading, erosion control, channel stabilization, preservation methods, fishery enhancement, and revegetation.

Water Quality and Hydrology Monitoring. There are several mitigation measures associated with maintaining and improving the hydrology and water quality of streams (Mitigation Measures RSM 5, RSM 6, RSM 8, and RSM 9). Mitigation Measure RSM 5 involves maintaining base flood elevation. Mitigation Measure RSM 6 involves maintaining 2-year recurrence, 24-hour storm event discharges at pre-project levels. Mitigation Measure RSM 8 involves preventing the

"perennialization" of existing aquatic habitat or creating new perennial aquatic habitat. Finally, Mitigation Measure RSM 9 involves complying with National Pollutant Discharge Elimination System (NPDES) permit requirements established by the Regional Water Quality Control Board (RWQCB) for discharge. All third-party applicants that obtain project approvals under the Solano HCP will be required to monitor for compliance with these mitigation measures for at least a minimum of 5 years, and longer if performance criteria are not met.

Tricolored Blackbird Nesting Habitat. Reserves established for Swainson's hawk foraging habitat in irrigated agricultural areas must also set aside land and establish suitable nesting habitat for tricolored blackbirds (Objective RSM 2.4). Restoration plans shall include specific, measurable criteria (i.e., performance criteria) to assess success of the restoration/enhancement in meeting the goals and objectives of the Solano HCP Conservation Strategy. Monitoring to assess performance shall occur for a minimum of 5 years or until fifth year/final performance criteria have been met for a minimum of 2 years without significant human intervention (e.g., irrigation, replanting). The monitoring program shall include provision for remedial action as needed to correct deficiencies.

Reserves shall also monitor suitable nesting habitat for their use by tricolored blackbirds. If a colony becomes established on a reserve for 2 consecutive years, it will be considered an active tricolored blackbird nest colony and will meet the requirements of a nesting habitat credit specified in Objective RSM 2.5. Reserves with tricolored blackbird nesting habitat credits shall conduct monitoring to determine the success of the colony in perpetuity.

7.3.7 Giant Garter Snake

The reserve system for giant garter snakes will encompass approximately 175 ac of restored and enhanced aquatic habitat, and 121 ac of associated upland habitat. These reserve areas will be managed for the benefit of giant garter snakes.

7.3.7.1 Management

The primary management objective for giant garter snakes in reserve areas is to provide for the essential habitat requirements of the species. These habitat features include:

1. An abundance of emergent, herbaceous wetland vegetation (e.g., cattails and bulrushes) to provide escape cover and foraging habitat during the active season;
2. Adjacent upland habitat for basking, shelter, and retreat sites;
3. Adjacent upland habitat (levees or banks) high enough to provide refuge from winter floodwaters;
4. A suitable prey base (fish and/or frogs); and
5. Adequate water during the giant garter snake active period (i.e., April through October).

7.3.7.2 Effectiveness Monitoring

The main conservation activity for this species is the restoration of aquatic habitat plus restoration of upland habitat adjacent to the restored aquatic habitat. Restoration and Enhancement Plans for

giant garter snake reserves shall comply with the minimum requirements listed in Section 7.3.2, the requirements for the Riparian, Stream, and Freshwater Marsh Natural Community, and have specific performance criteria for the key habitat requirements for giant garter snakes listed in Section 7.3.7.1. This monitoring is designed to show the effectiveness of the Plan' Mitigation Measures in meeting biological Objectives GGS 1.2 and GGS 1.3.

7.3.8 Coastal Marsh

The Coastal Marsh Natural Community Conservation Strategy involves a mixture of conservation actions designed to: maintain the water and sediment quality standards, hydrology, and ecological functions of the Natural Community; contribute to the restoration of tidally influenced coastal marsh habitat; and contribute to the conservation and recovery of associated Covered Species. The primary conservation actions include preservation (primarily through avoidance), restoration, invasive species control, and improvement of water quality and hydrogeomorphic processes through the implementation of avoidance and minimization measures and BMPs.

7.3.8.1 Management

Multiple agencies are actively involved in the management of Suisun Marsh (USBR et al. 2011). Therefore, the primary goal of the Coastal Marsh Monitoring and Adaptive Management Program for the Solano HCP is to support and complement existing management activities. Specific management goals intended to achieve this primary goal are: the adoption of an invasive species control program as a regular part of the ongoing operations and maintenance activities associated with public facilities (flood control facilities, parks, trails, bike paths, linear parks, etc.) within the Natural Community; the annual funding of a grant program for invasive plant and animal control in Coastal Marsh habitats in the County; and the development and implementation of public education programs that address the effects of nonnative predators and domestic and feral pets on salt marsh wildlife species.

7.3.8.2 Effectiveness Monitoring

Reserve monitoring requires the following:

- **Avoidance Monitoring:** Development projects that result in avoided marsh habitat must also implement enhancement and restoration plans and provide funding for the long-term management of these areas consistent with the HCP reserve design and management standards (see also Section 10.5). The quality of avoided marsh habitat will be monitored for a minimum of 5 years to ensure that the established buffers are sufficiently precluding changes to water and soil salinity and the flood/inundation regime in the marsh (Avoidance and Minimization Measures CM 2 and CM 5). If soft bird's-beak or Suisun thistle were avoided and preserved as part of an individual project, preserved populations shall be monitored every year for the first 5 years. Long-term monitoring of these populations will be conducted every 3 years in perpetuity.
- **Hydrology Monitoring:** Under Mitigation Measure CM 5, urban development projects shall incorporate source control and treatment measures to evaporate or infiltrate all dry season runoff. All third-party applicants that obtain project approvals under the Solano HCP will be required to monitor for compliance with these mitigation measures for at least a minimum of 5 years, and longer if performance criteria are not met.

7.3.9 Swainson's Hawk

The reserve system for Swainson's hawk will consist of 5,970 ac of agricultural foraging habitat within the Swainson's Hawk Irrigated Agriculture Potential Reserve Areas, 6,800 ac of Valley Floor Grassland habitat, 5,400 ac of Inner Coast Range Habitat, and 1,000 ac of additional foraging habitat within the Swainson's Hawk Irrigated Agriculture, Valley Floor Grassland, or Inner Coast Range Potential Reserve Areas. The reserve system for Swainson's hawk will also provide sufficient nesting habitat in proximity to suitable foraging habitat through the planting of new potential nest trees on reserves.

7.3.9.1 Management

The conservation strategy is based on intensive studies of Swainson's hawk in California and their well-documented reliance on having a diversity of Irrigated Agriculture crops for foraging and numerous small, isolated groups of trees or woody riparian habitat zones for nesting. Each agricultural reserve established for Swainson's hawk under the Solano HCP shall implement the following additional management requirements:

1. At least 50 percent of cultivated lands in the reserve system, measured on a system-wide basis, shall be planted and managed in any given year for alfalfa or other irrigated hay crops with similar management requirements (e.g., regular irrigation and harvesting throughout the Swainson's hawk nesting season). The remaining 50 percent of cultivated lands may be planted in any annual or biennial crop type that provides an acceptable rotation crop typical of or suitable for alfalfa production in this region (see Figure 5-1).
2. Five (5) percent of the reserve system, measured on a system-wide basis, shall be set aside and established in permanent, naturalized herbaceous and woody/shrub cover. The locations of these areas shall be determined on a reserve-specific basis to maximize distribution throughout the reserve, minimize interference to agricultural operations, and make best use of the naturalized vegetation areas to provide habitat for a variety of Covered Species and Special Management Species in addition to Swainson's hawk. These areas may be used for preserving or planting nest trees (Objective SH 2.1), establishing burrowing owl habitat and artificial nest burrows[1] (50 percent of the 5 percent set aside) (Objectives BO 2.2 and BO 2.3), tricolored blackbird nesting habitat (25 percent of the 5 percent set-aside) (Objective RSM 2.4), nesting habitat for other Special Management Species (Section 5.11), and providing vegetated filter strips for water quality enhancement (see Figure 5-1 for a reserve design example).

In order to allow for long-term flexibility, SCWA will establish a program that would allow for crop-type credits and set-aside credits to be traded between individual reserves as long as the minimum 50 percent criteria for alfalfa (or other irrigated hay crops with similar management requirements) and 5 percent for set-asides are met in the overall irrigated agriculture reserve system in any given year (see Section 10.5 for further information).

[1] Artificial nest burrows for burrowing owls will be located at least 650 ft (0.125 mi) from existing or planted Swainson's hawk nest trees.

7.3.9.2 Effectiveness Monitoring

Each reserve established for Swainson's hawk within the Irrigated Agriculture Conservation Area shall show annual compliance with the reserve design standards outlined above and in Objective SH 1.2. Under Objective SH 2.1, each Swainson's hawk reserve within the Irrigated Agriculture Conservation Area is required to provide a minimum of 1 suitable nest tree/grove per 40 ac of reserve. Reserve management plans shall incorporate monitoring and funding to maintain reserve-specific established nest tree numbers and replace potential nest tress in perpetuity. Reserves shall also monitor nest trees for their use by Swainson's hawk. If a tree on a reserve becomes used as a nest tree with successful reproduction (i.e., confirmed fledging) for 3 consecutive years, it will be considered an active Swainson's hawk nest and will qualify as meeting the requirement of Objective SH 2.2. Reserves with Swainson's hawk nest credits shall conduct monitoring to determine the success of the nest in perpetuity. If the reserve is established as a commercial or institutional mitigation bank, failure to document use may result in removal of the site from the approved mitigation reserve system (e.g., the purchase of credits from an unapproved site would not fulfill the incidental take mitigation requirements).

7.3.10 Burrowing Owl

Burrowing owls use a variety of natural, uncultivated, and agricultural habitats, any of which can support owls depending on the availability of burrows for cover and nesting and the presence of prey. As such, the Monitoring and Adaptive Management Program for burrowing owls is applicable to all lands in the Irrigated Agriculture region of the County, the Valley Floor Grassland and Vernal Pool Natural Community, and the grasslands and oak savanna habitat in the Inner Coast Range. However, monitoring efforts will focus on the Irrigated Agriculture and Valley Floor Grassland and Vernal Pool Conservation Areas designated for Swainson's hawk (Figure 4-22) because the majority of the owl population in the Plan Area occurs in these areas.

7.3.10.1 Management

The following management actions shall be required for reserves established for burrowing owls:

1. **Grassland Reserve Criteria.** Reserves established for burrowing owls shall be at least 80 ac in size, provide suitable foraging habitat, and meet the basic reserve management standards identified in Section 10.5.3 and the following additional management requirements:

    a. **Vegetation Height:** Management measures shall be implemented and adequately funded to maintain an average effective vegetation height[1] less than or equal to 6 inches over 80 percent of the reserve. This average effective vegetation height shall be sustained from February 1 to April 15, when owls typically select mates and nest burrows. To achieve this standard, the average effective height of residual vegetation at the end of the dry season (September to October) shall not exceed 4 inches. In addition, less than 30 percent tree and shrub canopy cover shall be maintained in perpetuity.

    b. **Restrictions on Rodent Control:** Reserves in grassland habitats shall allow ground squirrel control only along existing irrigation canals/drains. Ground squirrel control on the

[1] Effective vegetation height is the height at which 90 percent of a white board is obscured by vegetation when viewed 3 ft from the ground at a distance of 33 ft (Green and Anthony 1989).

perimeter of the reserves will be accomplished on adjacent properties, not on the reserve itself (see Sections 7.3 and 10.5.3).

c. **Burrow Density:** Valley Floor Grassland reserves shall provide at least 28 suitable burrows per 280 ac of Valley Floor Grassland and Vernal Pool preserves. Where natural burrows do not occur in sufficient density, at least three artificial burrow complexes per 280 ac of reserves shall be installed, monitored, and maintained until the sufficient burrow density is achieved. Artificial burrow complexes shall be provided at a rate of three multi-entrance nest burrow/chambers and 9 temporary burrows per 280 ac of reserve until suitable, natural burrow densities reach a minimum of 28 burrows per 280 ac.

2. **Agricultural Reserves Criteria.** In agricultural reserves established for Swainson's hawk, burrowing owl mitigation may also be satisfied if the reserve area meets the following additional criteria:

a. **Suitable Burrow and Cover Habitat:** At least 2 ac (or 140 ac total) of reserve land, measured on a system-wide basis, shall be permanently taken out of production to provide suitable nesting habitat and cover for burrowing owls on each 80 ac reserve that is used for burrowing owl mitigation. These 2 ac shall consist of one continuous block of habitat and shall not be located adjacent to a County road, highway, or Swainson's hawk nest tree (see Figure 5-1 for an example).

b. **Artificial Burrows:** At least two burrow complexes (three burrows per complex) shall be installed and maintained in perpetuity within the 2 ac of habitat set aside for burrowing owls. Artificial burrows will be monitored annually for effectiveness. Biological monitors will report on the colonization of the nest burrows by owls and the number of owls fledged per nest.

c. **Vegetation Height:** Within the 2 ac of habitat set aside for burrowing owls, management measures shall be implemented and adequately funded to maintain an average effective vegetation height of less than or equal to 6 inches from February 1 to April 15, when owls typically select mates and nest burrows. In addition, the 2 ac of habitat must be kept free of tree and shrub canopy cover in perpetuity.

7.3.10.2 Effectiveness Monitoring

Artificial burrows and burrow density on grassland reserves will be monitored annually for the first 10 years and every 3 years in perpetuity. Annual monitoring will include the collection of data pertaining to the ability of artificial burrows to provide suitable breeding habitat for burrowing owls. The average effective vegetation height will be measured around all artificial burrow complexes established on a reserve or five natural potential nest burrows. Vegetation will be sampled along four 50-meter transects radiating from each burrow. The transects will be spaced 90 degrees apart with the first direction selected randomly. Effective height will be measured at forty 0.25-square-meter quadrats distributed every 5 meters along the transects. Habitat information will be collected from June–September of each monitoring year to allow for the collection of additional observations of burrowing owl baseline habitat use. Additional biological information on the number of breeding pairs, number of fledged juveniles, and number of wintering owls will be collected on reserves. If the reserve is established as a commercial or institutional mitigation bank, failure to document use may result in removal of the site from the approved mitigation reserve system (e.g., the purchase of credits from an unapproved site would not fulfill the incidental take

mitigation requirements). Failure to document use and/or declining population statistics may require amendment to the management plans for the individual reserves.

Each reserve established within the Swainson's Hawk Irrigated Agriculture Conservation Area shall show annual compliance with the reserve design standards outlined above and in Objective BO 1.1 to receive credit for burrowing owls as well. Reserve management plans shall incorporate monitoring and funding to maintain reserve-specific established artificial burrow complexes and repair and replace them as needed in perpetuity. Reserves shall also monitor burrows for their use by owls. If a burrow on a reserve becomes used as a nest with successful reproduction for 2 consecutive years, it will be considered an active burrowing owl nest and will qualify as meeting the requirement of Objective BO 2.1. Reserves with burrowing owl nest credits shall conduct monitoring to determine the success of the nest in perpetuity.

7.3.11 Special Management Species

Special Management Species (Appendix C) will receive substantial conservation benefits associated with habitat preservation and restoration, water quality protection, invasive species control, and reserve management associated with the basic Natural Community and many of the associated Covered Species' goals and objectives. However, several of the species in this group require implementation of additional or special management on reserves in order to maximize their conservation benefits. Reserve Managers shall evaluate the additional management actions specified in the following subsections for inclusion into the required Reserve Management Plans (see also Section 10.5.3). These special management actions shall be implemented on each reserve as appropriate and to the extent they do not significantly conflict with the management requirements for Covered Species.

7.3.11.1 Northern Harrier and Short-Eared Owl

Both the northern harrier and short-eared owl are widespread in Solano County and are associated with multiple natural communities, including Valley Floor Grassland and Vernal Pool, Irrigated Agriculture lands, Coastal Marsh, and Inner Coast Range Natural Communities. Both species benefit from maintaining a habitat mosaic that includes agricultural crops with suitable prey species, lush ungrazed to lightly grazed grasslands, and weedy fields (Shuford and Gardali 2008). Both species are ground nesters that typically nest in areas of fairly tall and dense grass, weeds, marshy vegetation, or shrubs. Meadow voles (*Microtus* sp.), which are a primary food source for these two raptors, also thrive in wet, ungrazed to lightly grazed grasslands (Fehmi and Bartolome 2002). Voles are also a main food source for Swainson's hawk, and the management requirements for establishing 50 percent of the Swainson's hawk reserve system in alfalfa (or a similar crop type, Objective SH 1.2) will greatly benefit these species. Standard management requirements for Valley Floor Grassland and Vernal Pool Natural Community-associated Covered Species typically focus on having moderate grazing levels in order to reduce annual grass herbaceous cover in order to promote native vegetation growth (see Natural Community Model in Appendix B). In grassland and agricultural communities, the availability of nesting cover is likely the primary factor limiting the populations of both species.

The following special management actions shall be incorporated into required Reserve Management Plans (see Section 10.5.3) to increase habitat values for northern harrier and short-eared owl:

1. **Establish Patches of Tall and Dense Nesting Cover.** Typical nest cover includes fairly tall (2 to 4 ft) and dense grass, weeds, marshy vegetation, or shrubs.

    a. In Valley Floor Grassland and Vernal Pool, California red-legged frog, and callippe silverspot butterfly reserves, nesting cover will be allowed to establish itself in suitable areas. Suitable areas include: old homesteads, corrals, or barn areas; ditches, streams, stock ponds, or marshy areas; and other areas separated from high-value vernal pools, callippe silverspot butterfly larval host plant stands, or native grassland habitats. Potential nesting habitat should be fenced to exclude regular livestock access but may be periodically grazed to promote new vegetation growth and control invasive exotic vegetation.

    b. In Irrigated Agriculture reserves for Swainson's hawk, dense nesting cover should be allowed to establish itself in 1 ac per 80 ac of reserve lands (see Objective SH 1.2). Dense shrubby cover established as tricolored blackbird nesting habitat (see Objective RSM 2.4) may also satisfy this requirement (see Figure 5-1 for an example).

2. **Implement Grazing Schemes That Result in a Patchwork of Ungrazed or Lightly to Moderately Grazed Pastures.** In most Valley Floor Grassland and Vernal Pool, California red-legged frog, and callippe silverspot butterfly reserves, moderate grazing levels are desired to maximize habitat values for Covered Species. On larger reserves, periodically ungrazed or lightly grazed pastures may be appropriate to promote vole populations where multiple pastures are present and where limited grazing would not degrade habitat conditions for Covered Species associated with vernal pools or callippe silverspot butterfly breeding and larval habitat. Areas where reduced grazing could be implemented include riparian pastures, vernal pool, and seasonal wetland restoration areas where Covered Species have not yet established, wet or alkali meadows, or pastures that lack or have minimal vernal pools. In general, no more than 20 percent of a reserve shall be ungrazed or lightly grazed in any given year.

The above requirements have been incorporated into Objectives VPG 1.4 and RLF 1.2, addressing reserve management within the Valley Floor Grassland and Vernal Pool Natural Community and California Red-Legged Frog Conservation Area, respectively.

7.3.11.2 Loggerhead Shrike

Loggerhead shrike may use grasslands and agricultural areas for foraging and breeding, but prefer microhabitats such as the edges of riparian corridors and other areas with trees and shrubs (i.e., along roads or fence lines in agricultural areas). In addition to breeding, loggerhead shrikes also travel between habitat patches via these sheltered corridors. Areas of open agriculture or grassland habitat without trees and shrubs have experienced reduced shrike use and dispersal (Haas 1995). The following special management requirement shall be implemented to establish shrubby nesting cover for loggerhead shrike:

- **Establish Shrub Nest Cover.** Typical nest cover includes small trees and shrubs.
    - In Valley Floor Grassland and Vernal Pool, California red-legged frog, and callippe silverspot butterfly reserves, nesting cover for loggerhead shrikes will be established in suitable areas. Suitable areas for establishing nesting cover include: old homesteads, corrals, or barn areas; edges of ditches, streams, stock ponds, or marshy areas; or other waste areas.

- In Irrigated Agriculture reserves for Swainson's hawk, shrubs should be established in association with tree and shrub plantings in portions of the reserve lands specified in Objective SH 1.2 (see Figure 5-1 for an example). Shrub plantings shall not occur in areas reserved for burrowing owl habitat (Objective BO 2.2). Dense shrubby cover established as tricolored blackbird nesting habitat (see Objective RSM 2.4) would also provide suitable nesting habitat for loggerhead shrike.

7.3.11.3 Grasshopper Sparrow

Grasshopper sparrows prefer breeding habitat comprised of open, native bunch-grass grasslands (versus sod-type); however, throughout California, nonnative annual grasslands and fallow agricultural fields are used for breeding in the absence of native bunch-grass ecosystems. Open grasslands allow the birds to forage and move freely, whereas sod-type grasses hinder these activities (Whitmore 1981). A negative correlation has been identified between proximity to woodland areas and grasshopper sparrow use. This is likely due to an increase in predation and nest parasitism (Thogmartin 2006). Grasshopper sparrows are also considered area-sensitive, meaning they prefer interior habitat areas with a high interior-to-edge ratio (Renfrew 2005, Davis 2004).

Primary habitat for grasshopper sparrows occurs in the larger tracts of grassland within the Valley Floor Grassland and Vernal Pool and Inner Coast Range Natural Communities. Specific information on optimal grazing regimes is limited (Shuford and Gardali 2008); however, life history data suggest that light grazing resulting in a patchy environment that includes bare ground, scattered shrubs, and dense residual grass cover is desirable.

Implement Grazing Schemes That Result in a Patchwork of Ungrazed, Lightly to Moderately Grazed Pastures. Grazing management that results in a patchwork of ungrazed, lightly, and moderately grazed pastures as recommended for northern harrier and short-eared owl would also apply to the grasshopper sparrow. The above requirements have been incorporated into Objectives VPG 1.4 and RLF 1.2, addressing reserve management within the Valley Floor Grassland and Vernal Pool Natural Community and California Red-legged Frog Conservation Area, respectively.

7.3.11.4 Native Perennial Grassland

Native perennial grassland is limited to small stands of relict native perennial grasses. Generally, researchers have classified an area with 10 percent relative cover of native grasses as a sensitive natural community. Stands of native grasses are threatened by habitat loss, fragmentation, and invasion by nonnative annual plants caused by urbanization, crop cultivation, disking and tilling, improper livestock grazing, rodent control, and climate change. Moderate grazing can be used to control nonnative annual grasses. In Valley Floor Grassland and Vernal Pool, California red-legged frog, and callippe silverspot butterfly reserves, locations where native grasses and associated native forbs comprise at least 10 percent of the cover shall be identified. As part of the required Reserve Management Plan, feasible management objectives shall be established and management actions implemented to preserve and expand native grass and forb stands. Actions to promote native grasses have been incorporated into Objectives VPG 1.4 and RLF 1.2.

7.4 BIOLOGICAL EFFECTIVENESS MONITORING PROGRAM ADMINISTERED BY SCWA

Effectiveness monitoring evaluates the effectiveness of the operating conservation program of the HCP and whether the assumptions and predictions made during the development of the Plan hold true (USFWS 2000). Based on the USFWS Five-Point Policy for HCPs, there are several components to effectiveness monitoring, including the evaluation of incidental take. However, this section deals primarily with effectiveness monitoring associated with achieving the biological goals and objectives. This component of effectiveness monitoring in the Solano HCP is referred to as Biological Effectiveness Monitoring.

Biological Effectiveness Monitoring evaluates the effects of the planned actions by measuring biologically meaningful variables and determining whether the operating conservation program of the HCP (i.e., implementation of the mitigation measures and preserve management) are successfully achieving the biological objectives. The assumption made in the Conservation Strategy is that if the mitigation measures are properly implemented, these actions will collectively achieve the stated biological goals and objectives. The purpose of Biological Effectiveness Monitoring is to track the validity of this assumption (USFWS 2000). This section outlines the Biological Effectiveness Monitoring Program to be administered by the SCWA.

7.4.1 Implementation Schedule

Atkinson et al. (2004) identifies three phases in the development of a monitoring program in an adaptive management context. These phases include:

- Phase 1 – Identifying Relationships and Inventorying Resources;
- Phase 2 – Pilot Testing of Long-Term Monitoring and Resolving Critical Management Uncertainties; and
- and Phase 3 – Implementing Long-Term Management and Monitoring.

The Solano HCP has adopted the Atkinson et al. (2004) implementation schedule for the Biological Effectiveness Monitoring Program. In the HCP (Figure 7-4), however, the phases are referred to as:

- Phase 1 – Develop and Test Monitoring Protocols;
- Phase 2 – Intensive Monitoring Period; and
- Phase 3 – Long-Term Monitoring.

In addition to these three phases, a programmatic review of the current monitoring and management practices is embedded in the implementation schedule every 5 years for the duration of the Permit and every 10 years in perpetuity (Figure 7-4). Management will be conducted on reserves during all three phases and will be directed from the results of the Biological Effectiveness Monitoring (Figure 7-3).

7.4.1.1 Phase 1 – Develop and Test Monitoring Protocols

During Phase 1 – Develop and Test Monitoring Protocols, the proposed monitoring techniques for each natural community and Covered Species will be further developed and tested in the field at

least once. During this phase of refining the monitoring protocols, statistical methods to be used to analyze the monitoring data will also be developed and key statistical parameters, such as detection probabilities, will be identified and estimated.

7.4.1.2 Phase 2 – Intensive Monitoring Period

The second phase in the Monitoring and Adaptive Management Program involves an intensive monitoring period in which Biological Effectiveness Monitoring is conducted every year for the first 10 years. The purpose of a more intensive monitoring period is to further test and evaluate the effectiveness of survey protocols and to begin to establish statistically valid baseline data (e.g., population estimate or population index value) for the development of biologically meaningful significance thresholds. Since the reserve system will continue to grow throughout Plan implementation, not all areas in the reserve system will be included in this intensive monitoring phase. The intent of the data collected during this period is not designed to be reserve specific, but rather to inform the nature of variation within the biological system (e.g., population levels of Covered Species or composition of the natural community) intended to be preserved and managed. The 10-year time frame of intense monitoring should also allow sufficient time to experience a range of climatic conditions, typically one drought and one wet rainy season cycle, plus variations in timing and duration. This should provide a reasonable assessment of the annual population fluctuations for Covered Species and Natural Community-level variables to develop more biologically meaningful management thresholds and comparisons to interpret data during the long-term monitoring phase.

7.4.1.3 Phase 3 - Long-Term Monitoring

This phase involves implementation of the long-term monitoring program, which consists of a continuation of the monitoring protocols developed during Phase 1 and further refinement during Phase 2, only conducted at 3-year intervals instead of every year as in Phase 2.

7.4.1.4 Programmatic Review of Monitoring and Adaptive Management Program

This additional component of the Biological Effectiveness Monitoring Program involves a programmatic review of the monitoring techniques, assessment of reserve management practices and an overall assessment of the effectiveness of the operating Conservation Program. These reviews are integral to the process of adaptive management. A programmatic review will occur every 5 years for the permit duration (i.e., 30 years) and every 10 years after that in perpetuity. The first review will assess the results of the initial tests of the monitoring protocols, use these results to modify monitoring as necessary in Phase 2, and further define biologically meaningful performance criteria and significance thresholds. Data from the intensive monitoring during reviews in years 10 and 15 will be used to further refine performance criteria and significance thresholds. The final review in year 30 will assess the effectiveness of the Plan in achieving all of the biological goals and objectives. After this review, review frequency will decrease to every 10 years in perpetuity. This frequency will allow for three monitoring cycles during the Long-Term Monitoring Phase. All reviews will summarize the results of targeted studies and incorporate results into the Monitoring and Adaptive Management Program.

7.4.2 Monitoring Components

Pressures operate at different and often multiple scales concurrently, and the effect of a pressure can differ between scales. For example, large-scale disturbances (floods, droughts, and fires) might have negative effects at the species or community level but can have positive effects at the landscape level. Therefore, it is important to tailor the monitoring program to multiple ecological scales: landscape, natural community, and species. It is necessary to create a system that is flexible enough to adjust to the needs of each species but is formal enough to allow for the evaluation of the entire preserve system (i.e., an ecosystem approach). For each phase of the Biological Effectiveness Monitoring Program, a hierarchical approach involving landscape, Natural Community, and species-level monitoring has been developed.

7.4.2.1 Landscape-Level Monitoring

Landscape-level monitoring focuses on large geographical areas, coarse-scale conservation targets, and monitoring variables representative of large-scale ecological processes. Landscape monitoring can include regional processes such as weather and fire or other extreme events. This scale of monitoring focuses on processes that affect the condition and dynamics of landscapes that models predict will affect Covered Species and Natural Communities, but is more effectively monitored at a larger scale. Potential landscape-level monitoring variables include:

- Natural disturbance regimes such as weather and fire (e.g., rainfall data),
- Habitat disturbance levels[1],
- Surrounding land use practices, and
- Invasive species.

7.4.2.2 Natural Community-Level Monitoring

Natural community-level monitoring focuses on monitoring community composition, structure, and ecological function as well as monitoring potential effects of local-scale threats to the Natural Community. Natural Community-level monitoring variables include community composition variables (e.g., species richness or measures of similarity), vegetation structure and function variables (e.g., percent cover, substrate type or soil type), or variables that measure ecological function (e.g., stream flow hydrographs, duration of inundation, or soil stability). Natural Community-level monitoring also addresses quantification of variables that are or may be important to the distribution and abundance of individual Covered Species. In addition, quantitative characterizations of the Natural Community will be obtained that can be used to detect both natural and anthropogenic changes in community structure in time and space. Potential Natural Community-level monitoring variables could include:

- Edaphic variables, including soil series, soil pH (alkalinity), soil salinity, slope, and aspect;
- Hydrological and water quality variables, including the duration and area of inundation, pH, dissolved oxygen, and turbidity;

[1] See Section 4.3.2.2 for an example of habitat disturbance parameters used to measure habitat quality for vernal pools.

- Plant community and vegetation monitoring variables, potentially including total absolute vegetation cover, relative vegetation cover by native vernal pool species (native species richness), plant species composition, species with at least 20 percent relative cover per pool, estimation of absolute, and relative abundance of native and nonnative species and thatch height or residual dry matter (amount of dead and decaying herbaceous vegetation); and
- Other potential surrogates for ecological function that may include the presence of important pollinator species, amphibian species or other upland species, or species that are potential indicators of habitat quality.

7.4.2.3 Species-Level Monitoring

Species-level monitoring will provide data on the extent to which biological goals and objectives for Covered Species are being met. Species monitoring will involve tracking populations of Covered Species. It will also involve collecting information on the ecology of species to better manage them and increase the probability of conservation. This level of monitoring needs to sample in both space and time, to address both distribution and trends in Covered Species. It also tracks species responses to resource fluctuations, management actions, and the level at which threats are affecting species (i.e., identifying thresholds).

Effective sampling methods, site-specific distributions, and species natural history parameters are all needed to develop effective monitoring protocols for Covered Species. During Phase 1 (see Section 7.4.1), monitoring techniques, and sampling methods and protocols for each Covered Species or species group will be developed and tested. Baseline surveys will also be used to test *a priori* hypotheses about the factors affecting the distribution of species. Species-level monitoring should also be designed to identify mechanisms controlling the distribution of Covered Species, population levels, groups of species, and a means to track the response of Covered Species to management actions. The development of sampling protocols and a sampling design should include the identification of a sample unit or "point" (i.e., auditory or visual counts, small grids, traps and short transects). The sample unit will vary in size but should be able to integrate with sampling of physical features of the environment (i.e., soil, temperature, pH). The size of the sample unit will also determine the appropriate metric to use in describing species occurrence and distribution. In general, monitoring to comply with the Covered Species objectives will consist of presence/absence data or the proportion of area occupied (PAO) (MacKenzie et al. 2003). Additional potential species-level monitoring variables for Covered Species may include: home range and seasonal movement patterns, number of populations, distribution and range of Covered Species, relative abundance or estimates of population size, apparent recruitment, seed survival or seed bank longevity, and seedling establishment.

Proportion of Area Occupied. In general, monitoring to comply with the Covered Species objectives will consist of presence/absence data or the PAO (MacKenzie et al. 2003). The PAO was chosen in most cases because it is becoming a widely used, useful, cost-effective metric for large-area monitoring programs. For example, PAO has been adopted by the Amphibian Research and Monitoring Initiative (ARMI) as the metric by which many amphibian populations nationwide will be measured. The PAO statistical approach, developed by MacKenzie et al. (2003), evaluates the fraction of the landscape that is occupied by a species of interest but not the actual abundance of the population across the landscape. This is useful for species, such as amphibians, where actual abundance estimates are more difficult and costly to obtain. However, for certain species, such as

plants, additional data will be collected on densities. In addition to POA, data will also be collected to assess the overall health and status of these occurrences to see if their population levels and distribution are actually increasing throughout the Plan Area.

PAO is based on population models that incorporate detection probabilities along with the number of habitat areas in which each species is detected to estimate the area occupied by each species. A quantitative measure of the detection probability of the survey methods is necessary because even though presence is easily defined, absence is not. The number of individuals observed or captured at points in a survey area invariably underestimates the number of individuals actually present. If population numbers are low, which they often are for listed species, no detection does not necessarily preclude presence. Therefore, it is necessary to also estimate detectability, which is the probability that the Covered Species will be observed at a point if it is, in fact, present. To estimate species-specific detection probabilities during Phase 1 of the monitoring program, a sub-sample of sites will be visited more than twice within a short time period (e.g., 2 weeks). Collection of data in this manner is necessary to estimate the proportion of the sampling area occupied by each species (MacKenzie et al. 2006).

7.4.2.4 Targeted Studies

Targeted studies, a special subset of Biological Effectiveness Monitoring and an integral component to adaptive management, increase the effectiveness of monitoring and management by improving knowledge of the ecological system and management techniques. Targeted studies may be implemented as short-term studies rather than long-term monitoring, and typically include resolving critical uncertainties and improving knowledge of natural systems under management or applying experimental management treatments (Atkinson et al. 2004). It is not the intent of the Solano HCP to fund research to resolve all uncertainties and data gaps for all species and communities. SCWA and the other Plan Participants will provide funding for targeted studies that identify experimental adaptive management activities that may be undertaken in response to specific issues identified as a result of preserve management and monitoring efforts and/or to provide data to fill in data gaps and address conceptual community model uncertainties (see Appendix B). Such adaptive management activities may involve basic and applied research undertaken by preserve managers, other applicable third parties, and scientists and their students participating in on-the-ground work as part of their own research programs. Decisions to support or fund such programs will be determined by the permit holders in consultation with the Solano HCP Advisory Committee, the Resource Agencies, and other applicable agencies and organizations. Criteria for supporting such research will be based on the merits/applicability of the specific research proposals submitted to SCWA with respect to HCP goals and objectives and the availability of funds.

7.4.3 General Monitoring Design

Monitoring for several of the natural communities and Covered Species on reserves established under the Solano HCP will follow a sampling design similar to that established for the monitoring program of the arroyo toad on Marine Corps Base Camp Pendleton (USGS 2003). This monitoring program is used as an example because it is one of the first monitoring programs developed following the monitoring framework promulgated by Atkinson et al. (2004) and is designed to monitor large areas over extended periods of time.

As part of their approval process, the mitigation banks and/or private-project specific mitigation lands have to conduct baseline surveys of the mitigation area and a general inventory of their resources. SCWA will utilize this existing data to identify the different habitat types and suitable habitat for Covered Species present on the HCP reserve system. Using this information in combination with the anticipated amount of habitat to be preserved under the Plan, different habitat types and suitable habitat areas for each Natural Community or Covered Species will be divided up into six monitoring groups (i.e., one permanent monitoring group and five rotating monitoring groups) such that two groups (one permanent and one on a rotating basis) will be monitored in any given monitoring year (Table 7.2). Each monitoring group will consist of a representative sample of each habitat type. For Covered Species monitoring, the permanent monitoring group will consist of known occupied habitat areas and suitable habitat areas only if the known occupied habitat areas consist of less than 1/6th of the total suitable habitat.

Table 7.2: General Monitoring Schedule for Natural Communities and Covered Species

Monitoring Group	Monitoring Schedule[1,2,3]															
	Phase 1 Years	Phase 2 Years										Phase 3 Years				
	1 through 5	6	7	8	9	10	11	12	13	14	15	18	21	24	27	30
Permanent	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
1		●					●					●				
2			●					●					●			
3				●					●					●		
4					●					●					●	
5						●					●					●

[1] Phase 1 – Develop and Test Monitoring Protocols
[2] Phase 2 – Intensive Monitoring Period
[3] Phase 3 – Long-Term Monitoring

The reserve/preserve areas will be divided up into monitoring groups during Phase 1 of the monitoring program, and monitoring of the permanent group will be conducted at least once to refine the monitoring protocols. During the Intensive Monitoring Period (Phase 2), the permanent monitoring group will be monitored annually. The remaining groups will be monitored on a rotating basis such that all areas will be monitored twice during Phase 2. During the Long-Term Monitoring (Phase 3), the permanent group will be monitored every 3 years, and all of the remaining groups will be monitored at least once in a 15-year cycle in perpetuity. Based on this 15-year rotation, all habitat areas will have been monitored twice during the long-term monitoring phase prior to the end of the permit duration (Table 7.2).

Sampling will be conducted in private mitigation banks selling credits for projects approved under the Solano HCP and private project-specific mitigation lands. As additional lands become established as part of the reserve system, new habitat areas will be assigned to a monitoring group and monitored according to the specified monitoring rotation schedule.

Additional monitoring may be required in the event of a population crash or other unexpected event. If this occurs, then additional monitoring and targeted studies will be initiated to evaluate potential causes of this decline, followed by an adjustment of management actions as appropriate to offset the effects of the decline. Following these adjustments in management actions, the

monitoring frequency will continue at an increased frequency (i.e., annually) until the populations of Covered Species in question return to the specified conditions/performance criteria outlined in the Plan. If failure to meet performance criteria is a result of insufficient conservation efforts instead of landscape factors outside of the control of the Plan Participants, then additional conservation actions followed by an additional period of monitoring shall be specified.

7.4.4 Landscape-Level Monitoring

Landscape-level monitoring focuses on large geographical areas, monitors variables representative of large-scale ecological processes, and focuses on coarse-scale conservation targets. Landscape monitoring includes regional processes (e.g., weather), essential ecological processes (e.g., hydrological processes and natural disturbance regimes), and groundwater levels. This scale of monitoring focuses on processes that affect the condition and dynamics of landscapes that models predict will affect Covered Species and natural communities. The following variables will be monitored to address key landscape-level assumptions and processes. The collection of this data will also continue into the long-term monitoring program.

1. **Climatic Variables.** The amount, timing, and duration of rainfall will likely have a more significant influence on population levels of Covered Species on an annual basis than ongoing management activities or other environmental pressures. Tracking of local climatic data over time will assist in interpreting potential variations in species population index monitoring results.

    a. **Monitoring Objective LAN 1.** Monitor rainfall and temperature, and note any extremely hot or cold periods throughout the Plan Area.

        1) **Biological Effectiveness Monitoring.** SCWA will collect and record the following climatic information:

            a) Monthly rainfall,
            b) Average monthly temperature,
            c) Average day and night temperatures, and
            d) Any extreme weather events such as droughts or extremely hot or cold periods.

2. **Extreme Events.** Large fires, floods, and other assorted types of events can have regional effects on Covered Species. For migratory species, such events outside of Solano County can also adversely affect species populations in the Plan Area.

    a. **Monitoring Objective LAN 2.** Document the occurrence of large fires, floods, droughts, chemical spills, and other assorted types of events throughout the Plan Area and in key areas outside of Solano County.

        1) **Biological Effectiveness Monitoring.** SCWA will document and record extreme events in the County and will also document such events in key wintering areas for Covered Species as they become aware of such issues.

3. **Vegetation Community/Habitat Condition Assessment**

    a. **Monitoring Objective LAN 3.** What is the distribution of vegetation communities throughout the Plan Area? What is the condition of these vegetation communities?

        1) **Biological Effectiveness Monitoring.** The vegetation community/habitat condition monitoring will be accomplished through a quantitative mapping effort that identifies

stands, or polygons, of vegetation using aerial photographs and/or satellite images once every 5 years. The program will consist of geographic imagery analysis without on-the-ground assessment, except in areas where access is permitted (such as on existing reserves and preserves). On existing reserves and preserve, more detailed habitat mapping will be conducted on the ground using global positioning system (GPS) units. This "on the ground" data will also be used to assess the accuracy of the geographic imagery analysis applied to the entire Plan Area. Landsat Thematic Mapper imagery, other high-resolution aerial photography or satellite products, and/or digital orthophoto quads (DOQs) will be used to support the mapping. Vegetation and land cover mapping will follow the standards developed by the Interagency Vegetation Mapping Group and the CDFG Vegetation Mapping Program. Mapping will also be consistent with the HCP baseline community mapping with respect to community designations and minimum polygon size.

This consistency will allow the updated vegetation community maps to be compared to HCP baseline maps (i.e., the most current version at the time of HCP implementation) to assess and document changes in vegetation community/habitat extent related to both Solano HCP Covered Activities as well as non-regulated activities. Such information will be useful in assessing the effectiveness of the Solano HCP Conservation Strategy, evaluating conformance with take and habitat threat assumptions (Chapter 8.0), assurances (Chapter 10.0), and the potential need to alter or shift locations or emphasis of conservation efforts.

4. **Land Use.** One of the key assumptions regarding the regional risk of change or loss of various natural communities (see Section 3.6) is that the broader, County-wide land use patterns will not change significantly over the life of the HCP. Urban development will continue to be focused in defined urban areas. While agricultural practices may fluctuate over time in response to various market conditions, the overall mix of crop types is likely to remain consistent with current conditions.

   a. **Monitoring Objective LAN 4.** Are there significant changes in County-wide land use patterns?

      1) **Biological Effectiveness Monitoring.** The vegetation mapping, above, provides the basic information to assess land use changes, particularly in agricultural crop patterns. The Plan Participants will further monitor and assess changes in local, County, and State regulations that may affect these basic land use assumptions.

7.4.4.1 Targeted Studies

A specific landscape-level conceptual model was not developed similar to the Natural Community and Covered Species Models in Appendix B; however, many of the Natural Community models consider actions that are more representative of large-scale or landscape-level ecological processes. Potential landscape-level targeted studies include:

- Effects of regional climatic patterns on Covered Species,
- Effects of habitat disturbance levels and surrounding land use practices on Covered Species,
- Occurrences and distribution of special-status species,
- Presence of unique or distinct habitat features, and

- A measure of the potential magnitude of impact of identified barriers to movement, dispersal, or hydrology and the effectiveness of habitat corridors.

7.4.5 Valley Floor Grassland and Vernal Pool

Biological Effectiveness Monitoring evaluates the success of the Plan in meeting its stated biological goals and objectives (Noss and Cooperrider 1994). The main biological goals for the Valley Floor Grassland and Vernal Pool Natural Community are to: (1) maintain a reserve system that enhances the essential ecological processes, functions, values, and species diversity of the community; and (2) maintain and, where possible through restoration, increase population levels and distribution of vernal pool-associated Covered Species. The presence and/or relative abundance of particular species, such as vernal pool crustaceans and native plant species, can act as a good surrogate for the ecological processes, functions, and values of the Natural Community. If management actions are successfully maintaining the integrity of the Natural Community, then the Natural Community should maintain high native species diversity. The primary focus of the Biological Effectiveness Monitoring Program is to establish the presence of and, in some cases, obtain estimates of relative abundance of, species diversity and percent cover for: (1) covered vernal pool plants, (2) covered vernal pool crustaceans, (3) Delta green ground beetles, and (4) California tiger salamanders (larvae). In addition to monitoring for these targeted species, incidental observations of Special Management Species as well as all other plant and wildlife species will be noted during field surveys, and other management activities shall be recorded and reported in the annual monitoring reports for each reserve.

7.4.5.1 Natural Community Monitoring

The primary goal of the Valley Floor Grassland and Vernal Pool Conservation Strategy is to establish and maintain a reserve system that enhances essential ecological processes, functions, and values, and maintains species diversity and the ecosystem's potential for adaptation and evolutionary change. The measurable components of the biological objectives (Objectives VPG 1.1 and VPG 1.2) consist of: preserving between 13,000 to 15,000 ac of Valley Floor Grassland and Vernal Pool habitat (VPG 1.1); and preserving corridors linking the vernal pool complexes and reserves between the upper Union Creek/northeastern McCoy Creek watersheds (Subareas 1B, 1C, and 1D) and the Jepson Prairie (Subarea 1A) and between the Jepson Prairie (Subarea 1A) and the Potrero Hills (Subarea 2F) (Figure 4-8; Objective VPG 1.2). To determine if the preserved area is meeting the stated goal of establishing a reserve system that enhances the essential ecological processes, functions, and values, and maintains species diversity and the ecosystem's potential for adaptation and evolutionary change, monitoring of the status and health of that ecosystem needs to be conducted. The relative abundance and diversity of vernal pool endemics and percent cover of native versus nonnative plant species provides a good measure of the overall health of the ecosystem[1]. Therefore, part of the Biological Effectiveness Monitoring Program for the Valley Floor Grassland and Vernal Pool Natural Community will include general vegetation monitoring.

[1] Hydrology and water quality monitoring to show compliance with specific avoidance and minimization and mitigation measures will be done on individual reserves/preserves as part of their Resource Management Plans (see Section 7.3.3)

In addition to preservation, a large component of the Valley Floor Grassland and Vernal Pool Conservation Strategy involves the restoration of vernal pool wetlands within High and Medium Value Vernal Pool Conservation Areas (Objective VPG 1.3). The initial restoration activities and subsequent monitoring (for the first 5 years at a minimum) will be conducted by individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plans (see Section 7.3.3). Following this initial monitoring period, long-term monitoring of a subset of these restored wetlands will be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA. The monitoring of the restored wetlands will be conducted during the same monitoring season and will use techniques similar to those used in the vegetation monitoring of existing vernal pool wetlands. This will allow for a comparison of the restored pools with existing pools (i.e., reference pools).

1. **Vegetation Monitoring.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal VPG 1 and Objectives VPG 1.1, VPG 1.2, and VPG 1.3 (see Chapter 5.0):

    a. **Monitoring Objective VPG 1.** What is the relative abundance and diversity of vernal pool endemics and percent cover of native versus nonnative plant species in existing and restored vernal pools?

        1) **Biological Effectiveness Monitoring.** Quantitative sampling methodology will be used to monitor vegetation parameters such as relative abundance, species diversity, and percent cover in vernal pool, playa pool, seasonal wetland, and other vegetation associations. Pools to be monitored in any given year will be selected depending on the monitoring group in which they are placed. Vegetation monitoring will follow the methods developed by and used in Barbour et al. (2007). These methods were developed to characterize vernal pool vegetation in California and provide standardized methods for assessing the success of restored pools. All pools sampled in a given monitoring year will be visually divided into different vegetation subtypes, and one 10-square-meter plot will be placed in each vegetation subtype. In each plot, every species will be identified and recorded along with its estimated percent cover (use direct estimate; no cover classes). The total number of plots will depend on the number of vegetation association/community types present on a preserve. Plot locations will vary each sampling year, but the locations of the sampled pools will remain the same as that set up in the initial sampling groups (see Table 7.2). Any locations of Covered Species or Special Management Plant Species that are encountered incidentally during these surveys will be mapped using a GPS unit.

        2) **Performance Criteria**

            a) *Preserved Vernal Pools*

                (1) The diversity and relative abundance of native vernal pool plant species shall remain constant or increase over time.

                (2) The absolute and relative percent cover of native vernal pool plant species shall remain constant or increase over time.

            b) *Restored Vernal Pools*

                (1) Vernal Pool Endemics. Absolute and relative cover of each vernal pool endemic in restored pools shall be statistically similar to the range of values of each species found in the reference pools.

(2) Vernal Pool Endemics. The number of vernal pool endemics in restored pools shall be statistically similar to the average number of those taxa among reference pools.

(3) Nonnative Species. The number and cover of nonnative species in any restored pool shall be statistically similar to or lower than the average among reference pools.

(4) Community Similarity. The identity of community types in created pools and the mixture in which they occur should match that of reference pools. In other words, constructed pools should collectively contain deep, shallow, and edge community types if reference pools have those community types (i.e., the depth, side slope, shape, and area of created pools should be as diverse as that of reference pools). Vegetation plots from the restored pools and reference pools shall be divided into groups (or vegetation alliances) based on a cluster analysis[1] (see Barbour et al. 2007). Groups will be categorized based on dominant and diagnostic species and matched to the closest vegetation alliances found in Sawyer et al. (2009) or Barbour et al. (2007). Based on similar vernal pool data, we expect cluster analyses to yield at least three significant groups corresponding to deep, shallow, and edge community types. The vegetation alliances found in the restored pools shall be similar to those found in the reference pools.

(a) *Performance Criterion*. There shall be no significant difference in the ratio of restored and reference plots observed versus the ratio of restored and reference plots expected between the first three groups formed in the cluster analysis corresponding to deep, shallow, and edge community types.

2. **Problematic Invasive Species.** The establishment and expansion of invasive plants may be the greatest long-term threat to Natural Communities in the reserves established under the HCP because these aggressive exotic plants have significant potential to displace native species and impact sensitive species habitat.

While aggressive, exotic species are present in most reserve areas, the majority of the species occur as small and often isolated populations that are typically in or adjacent to disturbed areas such as roadways, livestock watering sites, and utility rights-of-way. Moody and Mack (1988) modeled the weed invasion process and clearly showed that, to slow the overall area invaded, it was more effective to eradicate smaller founding populations before attempting to eradicate larger populations. The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal VPG 1 and Objectives VPG 1.1 and VPG 1.3 (see Chapter 5.0):

a. **Monitoring Objective VPG 2.** What is the distribution and relative abundance of problematic invasive species on each reserve/preserve?

[1] The cluster analysis shall be similar to that conducted by Barbour et al. (2007), who used an agglomerative hierarchical cluster analysis with a Sorensen distance measure and a Flexible Beta linkage method (beta = -0.25).

1) **Biological Effectiveness Monitoring.** Areas sampled during the vegetation monitoring will also be visually assessed to identify the locations of aggressive, exotic species. Aggressive, exotic species are those classified as an immediate management concern (i.e., A1 Species) by the California Invasive Plant Council[1] (Cal-IPC) (CalEPPC 1999) and as Noxious Weeds by the California Department of Food and Agriculture[2] (CDFA).

2) **Performance Criterion.** Aggressive, exotic species (those classified as an immediate management concern [A1 Species] by Cal-IPC and as Noxious Weeds by CDFA) shall show a downward trend in abundance and distribution in all reserves.

7.4.5.2 Covered Species Monitoring

The second goal of the Valley Floor Grassland and Vernal Pool Conservation Strategy consists of maintaining and, where possible through restoration, increasing population levels and distribution of covered vernal pool-associated species (Goal VPG 2). There is an objective for each Covered Species that specifies how many occurrences will be either preserved or established in the Solano HCP reserve system. The state of preserved occurrences will be assessed during the baseline surveys of individual mitigation areas as they become part of the Solano HCP Reserve System. During baseline surveys, the location and general condition (abundance, density, etc.) of each occurrence of a Covered Species will be assessed. In addition to the occurrence data, suitable habitat areas for Covered Species will also be mapped during the baseline surveys. In general, Covered Species monitoring will be correlated with the Natural Community monitoring to allow for an analysis of correlations between community data and the status of the Covered Species occurrences.

1. **Contra Costa Goldfields.** SCWA received a FESA Section 6 grant from the USFWS to address the life history and status of Contra Costa goldfields in Solano County to assist in the development of the Solano HCP. One of the objectives of the population assessment was to develop a cost-effective sampling program that can provide repeatable and statistically valid density estimates for assessing the effects of management strategies and for monitoring long-term population trends. Monitoring has been conducted in selected areas in 2006, 2007, 2008, and 2009; the following monitoring methods are taken from these initial studies. The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal VPG 2 and Objectives VPG 2.1 and VPG 2.2 (see Chapter 5.0):

   a. **Monitoring Objective VPG 3.** What is the distribution and relative abundance of Contra Costa goldfields within the preserves?

      1) **Biological Effectiveness Monitoring.** Population estimates for Contra Costa goldfields shall be completed for all reserves in the range of this species established under the Solano HCP. During the initial inventory phase and for each monitoring period, all potential habitats in the preserve will be surveyed for the presence of Contra Costa goldfields. Each preserve area will be lumped into regions based on hydrological connectivity or similarity in growing conditions. In each reserve, all stands of Contra

[1] http://www.cal-ipc.org, accessed 24 October 2012.

[2] http://www.cdfa.ca.gov/plant/ipc/noxweedinfo/noxweedinfo_hp.htm, accessed 24 October 2012.

Costa goldfields will be mapped using a GPS unit with minimum submeter accuracy during the peak blooming period.

Transects will be established in mapped concentration areas, and five to ten 0.25-square-meter quadrats will be randomly selected along the transect. The total number of transects (and plots) per mapped area will be determined by the size of the Contra Costa goldfield area. If the mapped areas are too small to run transects, individual plots will be counted instead, and the locations of the plots will be selected by randomly placing the quadrat into the pool. A minimum of fifty 0.25-square-meter quadrats will be sampled per reserve region, as identified by hydrological connectivity, similarity in growing conditions, or other pertinent environmental factor. The total number of quadrats may increase depending on the variation in densities within a region.

Within each 0.25-square-meter quadrat, all Contra Costa goldfield plants identified as individuals will be counted. An individual plant that has several stems originating from the same root base shall be counted as one plant. Additional data collected for each quadrat shall include a visual estimate of the percent cover by Contra Costa goldfields, the average number of flowers per plant, an estimate of percent cover of other goldfield species (*Lasthenia* sp.), and an estimate of percent cover for other dominant plant species observed in the quadrat (at least the three other dominant plant species in the quadrat).

All of the plots from each designated region will be combined to calculate a mean density and the total number of plants. The total number of plants will be estimated by multiplying the mean density of Contra Costa goldfields by the total goldfield area mapped in the field. As an annual species, substantial year-to-year fluctuations in population numbers are expected based on the timing of rainfall and the duration of vernal pool inundation. Populations will be surveyed at least once during Phase 1, every year during Phase 2, and every 3 years after that in perpetuity. The 10-year baseline survey period should provide a reasonable range of seasonal fluctuations to establish threshold levels for adaptive management.

2) **Performance Criteria**

a) *Preserved Stands*

(1) Contra Costa goldfields shall occur in the same or greater percentage of pools sampled during the monitoring year as during the baseline surveys.

b) *Planted/Restored Stands*

(1) The number of Contra Costa goldfields in each planted pool shall show an increasing trend over time until the restored population is comparable in density to existing populations.

2. **Covered Vernal Pool Plant Species.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Objectives VPG 2.3 through VPG 2.10 (see Chapter 5.0):

a. **Monitoring Objective VPG 4.** What is the distribution and status of populations/ occurrences of covered vernal pool plant species in the reserve system?

1) **Biological Effectiveness Monitoring.** Vernal pool plant species covered under this Plan occur in similar habitats, therefore, there will likely be overlap between monitoring efforts for each species. However, how they occur within these habitats

differs (i.e., they have different life forms and ecologies); therefore, sampling techniques will differ depending on the species. For all Covered Plant Species, occupied and suitable habitat areas will be divided up into monitoring groups (Table 7.2). The permanent monitoring group will consist of only known occupied habitat areas and suitable habitat areas only if the known occupied habitat areas consist of less than 1/6th of the total suitable habitat. Sampling groups for each Covered Plant Species will be correlated with each other and with the vegetation monitoring as possible to maximize efficiency. During Phase 1 of the Biological Effectiveness Monitoring Program, techniques will be developed for each vernal pool plant covered under the Plan to quantitatively assess the overall health and status of each occurrence and of their overall population levels throughout the reserve system. At minimum, the monitoring technique will collect presence/absence data or estimates of the PAO (MacKenzie et al. 2003).

2) **Performance Criteria.** Each Covered Species is observed in the same or greater percentage of pools sampled during the monitoring year as were sampled during the baseline survey.

3. **Delta Green Ground Beetle.** Biological Objective VPG 2.11 states that the Plan will preserve 2,500 ac of natural vernal pool grassland in the Plan Area that contain a self-sustaining colony of Delta green ground beetles. The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Objective VPG 2.11 (see Chapter 5.0):

   a. **Monitoring Objective VPG 5.** What is the distribution and relative abundance of Delta green ground beetles in the preserve system?

      1) **Biological Effectiveness Monitoring.** All preserved suitable habitat area will be divided up into six monitoring groups as described above (Table 7.2). Observation posts/sites within preserve areas adjacent to known and suitable habitat areas will be established. A few surveys (five) will be performed in known occupied areas on a few warm winter days in January to determine when adult Delta green ground beetles first become active. In late January to early February, each observation site will be surveyed for a minimum of 30 minutes. The number and activity of all Delta green ground beetles will be noted. Data to be recorded include GPS location, basic vegetation composition (vegetation height, dominant plant types, percentage of bare ground, etc.) and distance to water. If beetles are not found during the first survey, additional surveys will be conducted toward the end of February, March, and the beginning of April. The number of return visits will be determined based on the species' detection probability estimated during Phase 1.

      2) **Performance Criteria.** The proportion of sites occupied by Delta green ground beetle will not decrease significantly on preserves.

4. **Vernal Pool Crustaceans.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Objectives VPG 2.12 through VPG 2.15 (see Chapter 5.0):

   a. **Monitoring Objective VPG 6.** What is the distribution and relative abundance of vernal pool crustaceans in the preserve system?

      1) **Biological Effectiveness Monitoring.** Vernal pool crustaceans will be monitored at sites that will be standardized to ensure their populations are remaining extant on the

preserves and to provide a baseline index for long-term population abundance. Vernal pool crustaceans shall also be monitored at standard sites in restored pools in order to assess effectiveness of habitat restoration and community development. For all covered vernal pool crustaceans, occupied and suitable habitat areas will be divided up into six monitoring groups (i.e., one permanent monitoring group and five rotating monitoring groups) following the monitoring protocol outlined in Table 7.2. The permanent monitoring group will consist of known occupied habitat areas only, unless known occupied habitat areas comprise less than 1/6th of the suitable habitat areas. Sampling groups for each species will be correlated as much as possible to maximize survey efficiency.

Generally, *Branchinecta* sp. are present and detectable in an occupied pool from about the third week after it fills until approximately 8 weeks after it fills. Approximately 3 to 4 weeks after pools fill (i.e., contain more than one inch of standing water) they will be sampled for fairy shrimp. Volume-standardized "plankton tow samples," using a standard, hand-held rectangular net frame fitted with 500-micron-mesh plankton netting will be used for the sampling. Pool depth at the deepest portion of the pool will also be measured during each survey. If fairy shrimp are not detected during the first survey, pools will be re-sampled approximately 2 to 3 weeks later (i.e., 6 weeks after the pool has filled) and again if necessary during the eighth week after the pool has filled.

Vernal pool tadpole shrimp (*Lepiduras packardi*) typically require at least 6 weeks after pools fill with water to reach maturity. However, they will remain detectable (present) in a feature until the feature dries up. Sampling will be conducted for vernal pool tadpole shrimp using the same method described for fairy shrimp approximately 8 weeks after a pool has filled. If vernal pool tadpole shrimp are not detected during the first survey, pools will be re-sampled approximately 2 to 3 weeks later (or just before the pools dry up). If tadpole shrimp are observed in pools during surveys for other fairy shrimp, then these pools need not be resurveyed.

Additional data to be collected will include maximum pool depth and water temperature. Visual observations of other potential water quality problems (e.g., presence of oil film, trash or other unnatural debris, or algae mats [if not a natural occurrence based on pre-project surveys]) will also be recorded.

2) **Performance Criteria**

a) *Preserved Vernal Pools*

(1) Each listed vernal pool crustacean species is observed in the same or greater percentage of pools sampled during the monitoring year as during the baseline survey.

b) *Restored Vernal Pools*

(1) Should show establishment of self-reproducing populations of covered vernal pool crustaceans.

5. **California Tiger Salamanders.** The following monitoring objectives and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Objectives VPG 2.15 and VPG 2.16 (see Chapter 5.0):

a. **Monitoring Objective VPG 7.** What is the proportion of area occupied and relative abundance of California tiger salamanders at suitable breeding habitat on each reserve/preserve?

b. **Monitoring Objective VPG 8.** Do occupied breeding sites on preserves/reserves hold water long enough to support successful recruitment into the population?

1) **Biological Effectiveness Monitoring.** California tiger salamanders will be monitored at sites that will be standardized to ensure their populations are remaining extant on the preserves and to provide a baseline index for long-term population abundance. California tiger salamanders shall also be monitored in created pools in order to assess their effectiveness. All currently occupied and suitable breeding habitat areas (i.e., any seasonal aquatic habitat that retains ponded water for a minimum of 10 consecutive weeks) will be divided up into six monitoring groups (i.e., one permanent monitoring group and five rotating monitoring groups) following the monitoring protocol outlined in Table 7.2. Each group will consist of a representative sample of the full range of suitable habitat present in the preserve/reserve system. The permanent monitoring group shall consist of known occupied habitat areas only, unless known occupied habitat areas comprise less than 1/6th of the suitable habitat areas. Aquatic larval surveys will be conducted in the permanent monitoring group and one additional monitoring group in any given monitoring year (i.e., one-third of the occupied and suitable habitat areas within preserves/reserves).

Larval surveys will be conducted starting in March. If larval salamanders are not detected during the first survey, pools will be re-sampled in April and again in May, with at least 10 days between surveys. If pools are likely to dry prior to the completion of three surveys, the sampling schedule should be shifted accordingly. For breeding sites smaller than 0.25 ac or larger sites where seines are not practicable, sampling shall be completed using D-shaped or similar (minimum size of 12 inches in width by 6 inches in height) long-handled dip nets with 0.125-inch or finer mesh. For breeding sites larger than 0.25 ac (10,000 square feet [sf]), minnow seines comprising 0.125-inch or finer mesh with weights along the bottom and floats along the top edge shall be used. The following table shall be used to determine the minimum number of dip-net samples per breeding site:

Pool Area[1] (sf)	Shallow Samples[2]	Medium Samples	Deep Samples	Total Samples[2]
< 100	2	0	2	4
100 – 500	4	0	4	8
500 – 1,000	4	4	4	12
1,000 – 1,500	6	6	6	18
1,500 – 2,000	8	8	8	24
2,000 – 5,000	10	10	10	30
5,000 – 10,000	20	20	20	60

[1] For sites greater than 10,000 sf (approximately 0.25 ac), seines shall be used to sample a minimum of 30 percent of the shallow, medium, and deep depth portions of the breeding site.

[2] Each sample consists of sweeping the dip net through the same 1 m section of the pond approximately four times.

ac = acres
sf = square feet

Index values based on the number of larvae captured and the volume of the pool sampled shall be calculated for each breeding site to estimate abundance. A representative number of larvae shall also be measured for length.

A subset of the shallower occupied breeding areas (i.e., areas with the shortest average hydroperiod) will be sampled during all three larval survey efforts. The first sampling will be to determine occupancy. The second sampling shall be to estimate the approximate time required for the larvae to successfully metamorphose and approximately how long the pool will contain water. The final sampling shall be timed to determine whether larvae were able to complete metamorphoses prior to the pool drying.

All sampling should adhere to current standard USFWS (2003b) sampling protocols with respect to general sampling protection measures (limiting habitat disturbance, disinfecting equipment, etc.).

2) **Performance Criteria**

a) *Preserved Breeding Habitat*

(1) The proportion of occupied breeding habitat shall not decrease significantly for more than 3 consecutive monitoring years during normal or above-average rainfall years.

(2) In an average rainfall year, the majority of the occupied breeding habitat shall have successful recruitment into the population.

b) *Created Breeding Habitat*

(1) Created breeding habitat shall be occupied by California tiger salamanders with the same frequency as pre-existing breeding habitat.

(2) Created breeding habitat shall show successful recruitment into the population during average to normal rainfall years (minimum 5 out of every 10).

7.4.5.3 Targeted Studies

Potential targeted studies needed for implementation of the Monitoring and Adaptive Management Program for the Solano HCP are divided into eight categories based on topic. Conforming to the scientific principles established in Section 7.1.3, these potential study objectives are stated as specific hypotheses or questions. Not all studies listed below are anticipated to be funded. This list is intended to be a guide for potential research questions for proposals, submitted to SCWA as part of their research program, to address.

- **General:**
  - How reliable are monitoring protocols for Covered Species in determining presence? What are the detection probabilities of various monitoring protocols?
  - For most vernal pool plant species, little information is available on population trends and dynamics, species interactions, genetics, and connections to regional habitats to carefully quantify the probability of long-term persistence. Targeted studies designed to fill these data gaps are needed.

- **Dispersal and Corridors:**
  - What are the dispersal patterns and capabilities of vernal pool species? Where is concentrated movement most likely (along swales, significant slope breaks, near breeding sites, etc.)?
  - How wide do corridors have to be to provide "livable habitat" for species? What size and condition do corridors have to be in to allow for animal movement, seed dispersal, and long-term genetic interchange between populations?
- **Vernal Pool Genetic Studies:**
  - What is the genetic diversity and "evolutionary potential" of vernal pool species, particularly vernal pool plants and crustaceans?
  - Where are the boundaries between local genetic population complexes?
- **Response to Management Regimes:**
  - What are the responses of vernal pool plant communities to various management regimes, including grazing, burning, and mowing? In particular, research is needed that relates specifically to Covered Species or that provide relevant information on managing these species. Research efforts should focus on the temporal and spatial dimensions and intensity of these management regimes. Long-term research is also required to account for changes in vegetation caused by weather variables that can confound the results of changes caused by manipulating the management regime (Ford and Huntsinger 2004).
- **Invasive Species Control:**
  - What methods are most effective in controlling or reducing problematic invasive species?
- **Restoration:**
  - What are the best methods for restoring vernal pools? More research is needed on the extent to which vernal pool plant communities can be restored. Most efforts to restore vernal pool ecosystems have failed to fully replace natural system functions (De Weese 1998), although it does appear that at least some functions and characteristics can be re-established (Collinge 2003).
  - What are the optimum seeding rates for introduction/reintroduction efforts of covered plant species?
  - What are the optimum methods for introduction/establishment of vernal pool crustaceans into restored/constructed vernal pools?
  - Is there a need for and to what extent or priority should artificial seed banking be used?
  - Are there adaptive management measures to supplement natural seed production?
  - Where should seeds that are salvaged from a specific location be used for restoration efforts without affecting the genetic structure of the population?
- **Contra Costa Goldfields:**
  - Are there adaptive management measures to supplement natural seed production?
  - What are the optimum seeding rates for introduction/reintroduction efforts?

- **California Tiger Salamanders:**
  - What are the most important fossorial rodents for providing underground burrows, and what density of accessible burrows is required to support a viable population of California tiger salamanders?
  - What are the best methods to promote key fossorial species through restoration and management?
  - How do various diseases impact different life stages, and how does disease play a role in population dynamics?

7.4.6 California Red-Legged Frog

The main biological goals for the California red-legged frog is to re-establish or increase California red-legged frog populations through preservation and management of interconnected blocks of upland and aquatic habitats that support natural movement patterns, breeding, and metapopulation dynamics within the California Red-Legged Frog Conservation Area and Inner Coast Range Natural Community. This will be primarily accomplished through the preservation, management, and enhancement of 3,300 ac of Inner Coast Range upland, riparian, and aquatic habitats within the California Red-Legged Frog Conservation Area. Populations will be re-established and expanded through the control of nonnative predators and competitors (e.g., bullfrog, crayfish, and warm water fish) and the direct transplanting of frogs either from reserves or salvaged from habitats impacted by Covered Activities.

The Biological Effectiveness Monitoring Program for California red-legged frogs focuses on two parameters: (1) the percent of suitable breeding habitat occupied by California red-legged frogs, and (2) the percent of habitat occupied by introduced predators. The Monitoring and Adaptive Management Program for California red-legged frogs will be implemented on preserves within the California Red-Legged Frog Conservation Area (Figure 4-16).

1. **California Red-Legged Frog Population Monitoring.** Monitoring of California red-legged frog populations will follow the general monitoring design outlined in Section 7.4.3. As part of the approval processes for a reserve to be established under the Solano HCP, an assessment of potential habitat for California red-legged frogs and surveys using standard protocols (USFWS 2005b) must be conducted. During these initial surveys, suitable breeding habitat will be identified and their locations recorded and mapped using a GPS unit, and important microhabitat variables will be collected (estimate of total pond area, hydroperiod, percent cover of emergent and submerged vegetation, dominant plant species present, other species observed, the presence of introduced predators [i.e., bullfrogs, crayfish and introduced fish], and any native predators observed). Landscape-level variables, such as distance to nearest occupied breeding habitat and surrounding land use practice, will be estimated using a geographic information system (GIS). All suitable breeding habitat will then be surveyed during the appropriate time of year for larvae and recently metamorphosed frogs to document breeding. This initial assessment of each reserve prior to becoming established under the Solano HCP will provide the background data for the Biological Effectiveness Monitoring Program administered by SCWA.

   One component of the California Red-Legged Frog Conservation Strategy involves the construction of new breeding habitat (Mitigation Measures RLF 2, RLF 3, and RLF 4). The initial construction activities and subsequent monitoring (for the first 5 years at a minimum)

will be conducted by individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plan (see Section 7.3.4). Following this initial monitoring period, long-term monitoring of these created breeding habitats will be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA. After the initial 5-year monitoring period, the created breeding habitat will be monitored as part of the regular population monitoring for occupancy.

The following monitoring objectives and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Objectives RLF 1.1 and 1.2 (see Chapter 5.0):

a. **Monitoring Objective RLF 1.** What is the proportion of breeding habitat occupied by California red-legged frogs in a monitoring year?

b. **Monitoring Objective RLF 2.** What proportion of breeding habitat is occupied by California red-legged frog metamorphs in a monitoring year?

    1) **Biological Effectiveness Monitoring.** California red-legged frogs will be monitored at all suitable breeding habitat in the reserve system. One day survey and at least one night survey will be conducted for adults during the breeding season (see USFWS 2005c for appropriate survey times). If adult frogs are not detected during the first survey, up to two additional night surveys will be conducted or whatever is determined necessary to reasonably estimate PAO. Egg masses will also be surveyed for during the first day survey. All suitable breeding habitat areas will then be resurveyed during the appropriate time of year for larvae and recently metamorphosed frogs to document successful breeding. During surveys, important microhabitat variables will be collected (i.e., estimate of total pond area, hydroperiod, percent cover of emergent and submerged vegetation, dominant plant species present, other species observed, the presence of introduced predators [i.e., bullfrogs, crayfish and introduced fish], and any native predators observed).

        The Solano HCP will adopt a strategy for monitoring California red-legged frog populations that is similar to that of ARMI. ARMI has adopted PAO (MacKenzie et al. 2003) as a standardized metric for mid-level monitoring of amphibian populations. The PAO statistical approach (MacKenzie et al. 2003) evaluates the fraction of the landscape that is occupied by a species of interest, but not the actual abundance of the population across the landscape. It is therefore a monitoring technique that is less costly than methods that attempt to estimate population sizes and also ideal for large-area monitoring programs that seek to identify areas where species may be in decline. Once identified, these areas could then be monitored more closely and appropriate management actions taken to halt the decline.

        A windows-based software program has been developed called PRESENCE (http://www.mbr-pwrc.usgs.gov/software) that incorporates the statistical method described in MacKenzie et al. (2003) for estimating site occupancy rates. This statistical model also permits the direct estimation of rate of change in PAO and estimations of seasonal colonization and local extinction probabilities, thus facilitating the mechanistic modeling of factors influencing population change.

    2) **Performance Criteria.** The proportion of habitat occupied by California red-legged frog shall either remain the same or show an increasing trend from the proportion of habitat occupied during baseline surveys.

2. **Establish New or Augment Existing Breeding Populations.** Objective RLF 1.4 is to maintain connectivity between existing habitat areas and to periodically translocate frogs among the three disjunct blocks of the California Red-Legged Frog Conservation Area. The following monitoring objectives and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Objective RLF 1.4 (see Chapter 5.0):

   a. **Monitoring Objective RLF 3.** Are California red-legged frogs successfully establishing and reproducing in ponds where translocation has occurred?

   b. **Monitoring Objective RLF 4.** In occupied ponds where additional California red-legged frogs were translocated, are populations increasing after the translocation?

      1) **Biological Effectiveness Monitoring.** The California red-legged frog population will be monitored at sites where translocation has occurred using standard protocols (USFWS 2004b). During surveys, important microhabitat variables will be collected (i.e., estimate of total pond area, hydroperiod, percent cover of emergent and submerged vegetation, dominant plant species present, other species observed, the presence of introduced predators [i.e., bullfrogs, crayfish and introduced fish], and any native predators observed). All suitable breeding habitat will then be surveyed during the appropriate time of year for breeding adults, eggs, larvae, and recently metamorphosed frogs to document successful breeding. These populations will be monitored annually for 5 years to determine the effects of the translocation on the population. After 5 consecutive years, these populations will be monitored consistent with the regular population monitoring for the species.

      2) **Performance Criteria.** The population levels of California red-legged frog in ponds where they have been relocated shall show an increasing trend over time.

3. **Hydrology Monitoring.** Objective RLF 1.5 prohibits activities that would increase or create new aquatic habitat for introduced predators and competitors of California red-legged frogs and other native amphibians (e.g., bullfrog, crayfish, and warm water fish) within the entire Inner Coast Range Natural Community, with an emphasis in the California Red-Legged Frog Conservation Area.

   This is designed to be achieved passively by implementing Mitigation Measure RLF 5, which prevents the establishment of new perennial ponds, small lakes, or other perennial water bodies that could provide habitat for nonnative species such as bullfrogs, crayfish, and warm water fish species. The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Objective RLF 1.5 (see Chapter 5.0):

   a. **Monitoring Objective RLF 5.** Is there a net change in hydrology in adjacent streams following a development project?

      1) **Biological Effectiveness Monitoring.** Plan Participants shall establish monitoring sites in second order streams supporting riparian vegetation, and in third, fourth, and higher order streams that are currently intermittent, either occupied by or could potentially support California red-legged frog in the Inner Coast Range, and either adjacent to or downstream of development projects to be authorized under the HCP. Hydrographs of these drainages will be monitored to ensure that historically intermittent creeks do not become perennial from excess storm water runoff. This monitoring will be conducted in addition to the water quality monitoring conducted for the Riparian, Stream, and Freshwater Marsh Natural Community. Potentially affected

streams will be identified and monitoring sites will be established within the first 5 years following adoption of the Plan. Baseline monitoring will be conducted annually during Phase 2 and then every 3 years thereafter in perpetuity during Phase 3. Hydrology monitoring of detention basins or other aquatic habitat features established on reserves/preserves or as part of development projects will be conducted by each individual project as part of their long-term operation and maintenance programs (see Section 7.3.4).

2) **Performance Criteria.** No net change in the hydrology of streams adjacent to or downstream of approved development projects.

7.4.6.1 Targeted Studies

For the California red-legged frog, few data exist on the dispersal patterns and utilized habitats of the frogs, especially the young, and this information may be critical for evaluating the adequacy of terrestrial habitat that surrounds and connects the multiple breeding ponds required by the species.

More information is also needed concerning the most effective methods to eradicate introduced predators, particularly bullfrogs. Some initial questions that should be addressed include:

- Where should initial eradication efforts be concentrated?
- In which areas is it practical and feasible to remove bullfrogs?
- What combination of management techniques can and should be used at each site (i.e., what techniques are the most feasible and effective for each habitat type)?
- How will bullfrogs be prevented from recolonizing areas where they have already been eradicated from?
- How will the Plan deal with bullfrog movement from land that is inaccessible for bullfrog control?
- Can an incentive program be developed to get private landowners to implement bullfrog control/eradication and prevention?

7.4.7 Callippe Silverspot Butterfly

Callippe silverspot butterfly monitoring involves two components. The first component addresses mapping and monitoring the distribution and abundance of the larval host plant (Johnny jump-up). The second component addresses surveying and monitoring for adult butterflies. Both of these monitoring components will follow the general monitoring design detailed in Section 7.4.3 and in Table 7.2.

As part of the reserve approval processes under the Solano HCP, an assessment of the distribution of the larval host plant, Johnny jump-up, will be conducted. During these initial surveys, patches of Johnny jump-up will be identified and the locations will be recorded and mapped using a GPS unit. The upland areas will be surveyed for adults during the appropriate time of year and under the appropriate weather conditions. This initial assessment of each reserve prior to becoming established under the Solano HCP will provide the background data for Biological Effectiveness Monitoring.

Another component of the Callippe Silverspot Butterfly Conservation Strategy involves the restoration/enhancement of additional host plant (Johnny jump-up) and nectar plant habitat (Mitigation Measure CSB 2). The initial restoration activities and subsequent monitoring (for the first 5 years at a minimum) will be conducted by individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plans (see Section 7.3.5 and Section 10.5). Following this initial monitoring period, long-term monitoring of these habitat areas will be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA.

1. **Johnny Jump-up Monitoring.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Objectives CSB 1.1 and CSB 1.2 (see Chapter 5.0):

    a. **Monitoring Objective CSB 1.** What is the distribution and density of stands of the Johnny jump-up (*Viola pedunculata*) on reserves/preserves in the potential range of the callippe silverspot butterfly within the Plan Area?

        1) **Biological Effectiveness Monitoring.** Reserve areas within the Callippe Silverspot Butterfly Conservation Area with suitable habitat for Johnny jump-up that were identified during baseline surveys will be divided into appropriate monitoring groups (see Table 7.2). These areas will be surveyed for Johnny jump-up stands during the peak blooming period. The location and area of all stands, in each monitoring unit, will be measured and mapped using a GPS unit with minimum submeter accuracy. When a relatively large area supporting the target plant is located, a 1-square-meter quadrat will be used to facilitate the counting of individual plants. Density measures for relatively large areas will be estimated via transects bisecting the center of the sub-population, and all plants within 1 meter of the centerline, 2 meters, 3 meters, etc. will be counted in a predetermined stretch until no more plants are found. For smaller sub-populations, a 1-square-meter quadrat will be placed in such a manner as to encompass all the plants in the stand. Stands covering less than 1 square meter will be counted without the aid of the quadrat, and scattered individuals will not be counted. In this manner, a likely estimate of all the plants within a preserve/reserve area will be obtained. The distance between subpopulations will also be estimated using GIS. In addition to populations of the larval host plant, the location and distribution of the adult nectar plants and other dominant plant species will also be noted during these surveys. Populations will be monitored at least once during Phase 1, every year during Phase 2, and every 3 years for the life of the HCP.

        2) **Performance Criteria.** The relative area and density of Johnny jump-up stands shall show an increasing trend over time.

2. **Callippe Silverspot Butterfly Population Monitoring.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Objectives CSB 1.1 and CSB 1.4 (see Chapter 5.0):

    a. **Monitoring Objective CSB 2.** What proportion of habitat is occupied by callippe silverspot butterfly in the HCP reserve system?

        1) **Biological Effectiveness Monitoring.** Surveys will be conducted for the presence of callippe silverspot butterflies within potential habitat on the preserve/reserve. Areas containing all three habitat requirements for the callippe silverspot butterfly (i.e., larval host plant, adult nectar plants, and hilltops and ridgelines) that are identified during the

baseline surveys will be divided into potential sub-populations. The habitat area, identified as one potential sub-population will be considered one site. Surveys will be conducted by qualified biologists during the appropriate time of year, and will entail walking a route that encompasses the designated sub-population area on a preserve/reserve that supports the larval host plant and contains seasonal watercourses, areas supporting nectar plants, and hilltops and ridgelines. The location of each butterfly observation will be recorded using GPS and should include notes on the surrounding habitat (i.e., distance to nearest larval host plant populations, adult nectar plant, or hilltop or ridgeline), behavior observed, time of day, and weather variables. All sites will be surveyed for the presence/absence of butterflies in a rotating panel design. Populations will be monitored at least once during Phase 1, every year during Phase 2, and every 3 years for the life of the HCP.

To estimate detection probabilities, each site will be visited a maximum of two times during the survey year. A second visit will only be performed if butterflies are not observed during the first visit. A subset of sites will be treated as intensive sites and visited four times during the survey period, even if butterflies are detected during the first visit, in order to more accurately estimate detectability of butterflies by the protocol and improve accuracy of the calculations.

2) **Performance Criteria.** The proportion of sites occupied by callippe silverspot butterfly will either remain the same or show an increasing trend over time.

7.4.7.1 Targeted Studies

Specific research needs and targeted studies that would improve efforts to successfully manage and monitor this species were broken up into five categories corresponding to the data gaps and uncertainties section of the species account in Appendix B. These include:

- **Population Genetics.** In general, more research is needed on the phylogeography of this species complex. For example:
  - How are the 16 different subspecies in the *Speyeria callippe* species complex related? Do the morphological characters that distinguish subspecies correspond to distinct genetic lineages?
  - Is the *Speyeria callippe* that occurs in western Solano County the same as other populations of *S.c. callippe* in the Bay Area? In other words, are the silverspot butterflies resembling the callippe subspecies in Solano County more closely related to *callippe callippe* than to *callippe comstocki* or *callippe liliana*?
- **Rodent Control.** Rodents have a large effect on the turnover of grassland soils. This has implications for mineral cycling in grassland ecosystems. Rodents also create local areas of disturbance that could be colonized by a variety of plant species. What is the relationship between rodents and the larval and adult food plants of the callippe silverspot butterfly?
- **Fire.** The effects of fire on callippe silverspot butterfly populations are not well known. Experiments need to be conducted to determine whether controlled burning of limited areas of habitat at particular times of year would benefit butterfly populations.

- **Johnny Jump-up Reproduction and Establishment**
  - What are the pollination and seed dispersal mechanisms of Johnny jump-up (*Viola pedunculata*)?
  - Specifically, what role do ants play in the seed dispersal of Johnny jump-up?
  - What are the factors that affect the germination success of Johnny jump-up? What is the ability of seedlings to compete with other grassland species? These and other factors affecting the expansion of populations of Johnny jump-up should be examined.
  - What are the microhabitat requirements of Johnny jump-up? How do factors such as spring moisture, depth of soil, and associated plant species affect the distribution and density of Johnny jump-up stands?
  - What is the role of grazing in maintaining violet populations?
- **Buffers**
  - What are the dispersal capabilities of the callippe silverspot butterfly?
  - How tolerant is this species to disturbance, and how wide should buffers be in order to facilitate movement between sub-populations and to minimize disturbance to populations?

7.4.8 Riparian, Stream, and Freshwater Marsh

Biological Effectiveness Monitoring for the Riparian, Stream, and Freshwater Marsh Natural Community and associated Covered Species are described below. Monitoring for this Natural Community primarily includes water quality monitoring and an assessment of riparian habitat quality and invasive, exotic species.

7.4.8.1 Natural Community Monitoring

The primary goal of the Riparian, Stream, and Freshwater Marsh Natural Community is to maintain and enhance the natural hydrogeomorphic processes, essential ecological processes, functions, and values, species diversity, and habitat heterogeneity of Riparian, Stream, and Freshwater Marsh habitat in the Plan Area. The three main areas of focus for the Biological Effectiveness Monitoring include water quality, riparian habitat quality, and problematic invasive species. A large component of the Conservation Strategy involves restoring riparian habitat. The initial restoration activities and subsequent monitoring (for the first 5 years at a minimum) will be conducted by individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plans (see Section 7.3.6). Following this initial monitoring period, long-term monitoring of a subset of these restored areas will be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA.

1. **Hydrology and Water Quality.** Several of the Mitigation Measures in Chapter 6.0 (see Table 7.1) are designed to maintain hydrology and water quality within priority drainages and watershed. This monitoring, in combination with project-specific monitoring, will be conducted to ensure these mitigation measures are effectively achieving Goal RSM 1 and Objectives RSM 1.4 and RSM 1.5 (see Chapter 5.0).
   a. **Monitoring Objective RSM 1.** Are natural hydrological patterns or processes in key watersheds being maintained?

1) **Biological Effectiveness Monitoring.** Urban development that would likely increase impervious surfaces above levels that could be expected to alter hydrological patterns is planned within the watersheds of key natural drainages in the Laurel, Ledgewood, Laguna, Gibson Canyon, and Sweeney Creeks where at least portions of the creek channels remain in relatively natural conditions (e.g., the creek channels have not been fully reconstructed into trapezoidal channels). Plan Participants shall establish three to five monitoring sites per affected reach of the key drainages within the first 5 years of adopting the Plan in order to assess the effectiveness of mitigation measures designed to minimize changes in channel forming and peak flows. Baseline monitoring will be conducted annually during Phase 2 and then every 3 years thereafter in perpetuity. The following parameters shall be monitored:

   a) *Suspended Sediment Volumes.* Suspended sediments will be measured in streams using a single-stage sampler, or an equivalent apparatus, in coordination with stream flow measurements at suitable locations in the streams. At least one set of samples will be collected during two to three large storm events each season.

   b) *Bedload Sediment Deposition/Scour.* Bedload sediment deposition and/or scour shall be measured at fixed sites by measuring the depth of accumulated sediments or scour in representative stream habitats (e.g., pools, riffle, runs) at or near the monitoring stations.

   c) *Stream Cross-Sections.* Cross-section profiles shall be measured at permanent stations at each monitoring site. Cross-sections will be placed at representative transition points (typically three to five cross-sections) where erosion or sediment deposition is most likely to occur. The cross-sections will serve as a control for the map-based geomorphic interpretations and will also provide data to evaluate future stability or instability.

2) **Performance Criteria.** Stream segments should remain stable or should evolve over the monitoring period in the direction of stability:

   a) There should be no evidence of new significant downcutting, bank erosion, rill formations, or formation of new headcuts above baseline levels.

   b) Bedload sediment volumes should remain relatively stable; there should not be significant increases or decreases over time.

   c) Cross sections shall remain fairly stable and not show significant changes in channel depth, width, or profile (i.e., thalweg elevation).

   Significant changes in the above criteria will require more in-depth evaluation of the factors influencing channel morphology and potential alterations to the management of upstream hydrological controls associated with residential development.

2. **Riparian Habitat Quality.** The ecological and physical functions of streams and associated riparian habitats in Solano County have been severely impaired and continue to be threatened by a number of activities. The Science Advisors recommended that measures be developed to better assess riparian habitat quality and to establish parameters for future preservation, restoration, and management. The Riparian Bird Conservation Plan prepared by The California Partners in Flight and The Riparian Habitat Joint Venture (RHJV 2000) identifies a number of important parameters for assessing and monitoring the health and value of riparian systems in the Central Valley. These parameters include factors such as adjacent land use, riparian zone width, distance to higher quality habitats, and structural diversity. During the HCP planning

process, a riparian habitat assessment was conducted that identified key areas of restoration (LSA 2008a). The Riparian Habitat Quality Monitoring Program will continue using the approach used in this assessment to track the long-term success of restoration and enhancement activities as well as ongoing invasive species control activities. The initial monitoring of restored habitat areas and the success of avoidance and minimization measures will be conducted by individual projects as part of their Resource Management Plans and Restoration and Enhancement Plans (see Section 7.3.6). Following this initial monitoring period, these locations will be incorporated into the long-term monitoring conducted under the Biological Effectiveness Monitoring Program administered by SCWA. The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal RSM 1 and Objectives RSM 1.1, RSM 1.2, and RSM 1.3 (see Chapter 5.0):

a. **Monitoring Objective RSM 2.** What is the quality of riparian habitat on preserves throughout the Plan Area?

   1) **Biological Effectiveness Monitoring.** Riparian, Stream, and Freshwater Marsh habitat on preserves in the Plan Area will be evaluated by collecting data at discrete sample locations, with an emphasis on areas where restoration, enhancement, and invasive species control measures have been conducted. All Riparian, Stream, and Freshwater Marsh habitat in reserves shall be divided into five monitoring groups (i.e., one permanent monitoring group and four rotating monitoring groups) (Table 7.3). Each monitoring group will consist of a representative sample of each habitat type, representing significant drainages and physiographic regions encompassed in the reserve system. Discrete sample locations, encompassing a representative sample of each habitat type, in each monitoring group will be assessed using standard stream assessment methods (Delaware River Basin Commission et al. 1996; Koning 1999; Rosgen 1996; BLM 1993, 1994; Leonard et al. 1992; Smith and Prichard 1992). Information on a number of key attributes will be collected at each sample location and a GPS point will be taken. At each location, the following characteristics will be assessed:

      a) Adjacent land uses
      b) Upland buffer widths
      c) Stream width (including any floodplain features)
      d) Channel morphology
      e) Canopy width
      f) Canopy cover and species composition
      g) Shrub cover and species composition
      h) Herbaceous cover and species composition
      i) Habitat for Covered Species (e.g., elderberry shrubs)
      j) Wildlife habitat features (e.g., snags, down logs, pools)
      k) Invasive species
      l) Bank erosion
      m) Disturbance

Table 7.3: Monitoring Schedule for Riparian, Stream, and Freshwater Habitats

Monitoring Group	Monitoring Schedule									
	Phase 1 (years)	Phase 3 - Long-Term Monitoring (years)								
	1 through 5	6	9	12	15	18	21	24	27	30
Permanent	●	●	●	●	●	●	●	●	●	●
1		●				●				●
2			●				●			
3				●				●		
4					●				●	

This assessment will occur at least once during Phase 1 of the monitoring program (Table 7.3). Unlike the monitoring schedule for assessing populations, it is unlikely that riparian habitat features will change drastically from year to year. Monitoring of restored and enhanced areas will be conducted annually for at least 5 years on individual reserves; this monitoring is designed to complement the reserve's specific monitoring. The long-term monitoring cycle, which is in 3-year intervals, will begin in Year 6 (Table 7.3). The permanent monitoring group will be monitored every monitoring year and each additional group will be monitored on a rotating basis such that all areas will be monitored at least once in 15-year cycles (Table 7.3).

2) **Performance Criteria.** Specific performance criteria have yet to be developed. However, the initial performance criteria will be to see a net overall increase in the health of riparian habitat throughout the Plan Area over time. Long-term performance criteria developed as part of the Restoration and Enhancement Plans for individual sites will be incorporated into the overall performance criteria.

3. **Problematic Invasive Species.** The establishment and expansion of invasive plants may be the greatest long-term threat to the natural communities in the reserves established under the HCP as these aggressive, exotic plants have significant potential to displace Covered Species and impact natural habitats. That is why Objective RSM 1.2 is to control problematic invasive, exotic plant and animal species along a minimum of 30 miles (mi) of stream habitat in Solano County, particularly targeting Conservation Area RSM 2 stream reaches. The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal RSM 1 and Objective RSM 1.2 (see Chapter 5.0).

   a. **Monitoring Objective RSM 3.** What is the distribution and relative abundance of aggressive, exotic species in riparian areas in the Plan Area?

   b. **Monitoring Objective RSM 4.** Are control measures successfully decreasing the distribution and abundance of these aggressive, exotic species?

      1) **Biological Effectiveness Monitoring.** Monitoring for the distribution and abundance of aggressive, exotic species will be conducted in tandem with the overall monitoring of riparian habitat quality. Within the first 5 years of adoption of the HCP, Plan Participants are required to implement invasive species control measures as a regular part of the ongoing operations and maintenance activities associated with public facilities (e.g., flood control channels, parks, bike paths and linear parks). Within the first 5 years of the HCP, an assessment of aggressive, exotic species will be conducted in those areas to be targeted in these programs. This information will then be used to

guide the development of these programs and the prioritization of areas and species to be targeted.

The areas to be treated in this program will be divided into monitoring groups similar to those established for Riparian Habitat Quality Monitoring. Each monitoring group will consist of a representative sample of each habitat type, with an emphasis on habitat in Priority Drainages within Conservation Area RSM 2 (see Figure 4-11). Discrete sample locations in each monitoring group will be assessed for the abundance and distribution of aggressive, exotic species. Invasive Species Monitoring will be conducted on the same schedule as the Riparian Habitat Quality Monitoring (see Table 7.3).

2) **Performance Criteria.** Aggressive, exotic species (including those classified as immediate management concern [A1 Species] by the California Exotic Pest Plant Council and as Noxious Weeds by the CDFA) shall show a downward trend in abundance and distribution in all riparian areas in the Plan Area.

7.4.8.2 Covered Species Monitoring

Six Covered Species are associated with the Riparian, Stream, and Freshwater Marsh Natural Community. Specific Biological Effectiveness Monitoring and target studies for two of these species (i.e., California red-legged frog and giant garter snake) are addressed in Sections 7.4.6 and 7.4.9, respectively. The second goal of the Riparian, Stream, and Freshwater Marsh Conservation Strategy (Goal RSM 2) is to contribute to the recovery of Covered Species associated with the Natural Communities in the Plan Area through the preservation and expansion of existing populations and to allow for future population expansion and re-colonization into restored areas. The following section describes the Biological Effectiveness Monitoring for Covered Species associated with the Natural Communities. All habitat restoration activities and subsequent monitoring (for the first 5 years at a minimum) will be conducted by individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plans (see Section 7.3.6). Following this initial monitoring period, long-term monitoring of a subset of these restored areas will be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA.

1. **Salmonids.** SCWA has implemented studies to better assess steelhead distribution in the County. The current effort along with other existing data has essentially focused on confirming the presence of steelhead in a number of streams in Solano County. Such point-in-time data are valuable but may not adequately identify important steelhead streams. As identified in the Science Advisors report, local steelhead sub-populations may be occasionally extirpated as a result of natural environmental cycles or other environmental problems but may become reestablished by colonies from other sub-populations. Thus, the identification of suitable breeding/rearing through assessment of habitat parameters may be more crucial than presence or absence data.

   A salmonid habitat assessment for the Plan Area was conducted in 2008 to provide background information on the location of potentially suitable salmonid habitat as well as an initial assessment of fish passage barriers along key salmonid streams (LSA 2008b). This assessment concluded that Lynch Canyon, Jameson Canyon, Green Valley, Suisun Valley, and Laurel Creeks have extensive lengths of potentially suitable habitat based on gradient and temperature thresholds assessed using a suitability model. Eleven potential fish passage barriers were

identified in these streams. Objective RSM 2.1 states that the Plan Participants will remove all existing in-stream full or partial barriers, to the maximum extent practicable, within their rights-of-way along important steelhead streams within 10 years of the adoption of the HCP. Plan Participants will also prevent the creation of new in-stream barriers on private lands as new development occurs along Jameson Canyon, Lynch Canyon, Ledgewood, Suisun, and Green Valley Creeks and their tributaries that contain suitable breeding and rearing habitat for steelhead.

The RWQCBs established beneficial uses (i.e., "uses that benefit the people of the state") for major streams in their jurisdiction. Three beneficial uses relate to the ability of a stream to support salmonid habitat: cold freshwater habitat (COLD), fish migration (MIGR), and fish spawning (SPWN). These are the three aspects that will be monitored under the Solano HCP Biological Effectiveness Monitoring.

The following monitoring objectives and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal RSM 2 and Objectives RSM 2.1 and RSM 2.2 (see Chapter 5.0):

a. **Monitoring Objective RSM 5.** Is the pass-ability of potential salmonid streams increasing over time?

   1) **Biological Effectiveness Monitoring.** One of the recommendations from the Salmonid Habitat Assessment (LSA 2008b) was to analyze potential barriers to fish passage in Lynch Canyon Creek, Jameson Canyon Creek, Green Valley Creek, and Suisun Valley Creek using established/approved methods such as the National Inventory and Assessment Procedure for Identifying Barriers to Aquatic Organism Passage at Road-Stream Crossings (Clarkin et al. 2005) to determine the degree to which passage is actually restricted and the feasibility of restoring passage. More extensive field surveys or polling of property owners should be conducted to identify other potential passage barriers that may have been overlooked by the first assessment. This analysis will be conducted within the first 5 years of plan implementation (i.e., during Phase 1 of the monitoring program). SCWA will conduct a follow-up assessment in year 25 to ensure that Objectives RSM 2.1 and RSM 2.2 have been achieved.

   2) **Performance Criteria.** All partial and full in-stream barriers that were determined feasible to remove were removed.

b. **Monitoring Objective RSM 6.** Are the designated salmonid streams maintaining suitable temperature ranges for the species?

   1) **Biological Effectiveness Monitoring.** The following additional water quality data will be collected in salmonid streams, Lynch Canyon Creek, Jameson Canyon Creek, Green Valley Creek, Suisun Valley Creek, and Laurel Creek, concurrent with water quality monitoring:

      a) Water and air temperature data loggers will be installed to obtain annual and seasonal temperature data, capture diurnal variation in temperature, and obtain temperature data on a reach scale. These data will help to determine if shade cast by riparian vegetation keeps water temperatures sufficiently low for salmonids.

      b) Obtain stream flow and water level data, including an assessment of water withdrawal locations and amounts of water withdrawn seasonally. Flow measurements and stream gauging (installing permanent staff plates and water

level monitors at a stable location in the channel) are useful in assessing whether a stream is providing suitable habitat for salmonids.

2) **Performance Criteria.** Key salmonid drainages maintain suitable water temperature and flow levels to support salmonids.

c. **Monitoring Objective RSM 7.** What is the location and extent of potentially important salmonid breeding and rearing habitat in the Plan Area, and to what extent is it occupied?

1) **Biological Effectiveness Monitoring.** During Phase 1 a full habitat assessment will be conducted in suitable streams, identified in Salmonid Habitat Assessment (LSA 2008b), including a mapping of substrate/pool-riffles. During Phase 2 of the monitoring program, creeks and their tributaries that contain suitable breeding and rearing habitat for steelhead will be surveyed annually during the first 10 years of the monitoring program for the presence of salmonids. Since the status of salmonids in these streams is currently not well documented, if salmonids are not observed occupying streams after 5 years, survey frequency will decrease to every 3 years consistent with the Phase 3 long-term monitoring schedule. The purpose of periodically surveying these streams over several decades is to determine the temporal patterns of population variability of steelhead and rainbow trout as well as Chinook salmon and other native fishes. In addition to survey data, the most recent capture data for streams in Solano County will be obtained from the USFWS and CDFG to identify the streams in the County where spawning has been observed in the previous 5-year period.

2) **Performance Criteria.** There are two performance criteria for this monitoring:

a) The proportion of streams occupied by salmonids shall either remain the same or show an increasing trend from the proportion occupied during baseline surveys. This performance criterion is highly susceptible to natural environmental cycles or other environmental problems outside of the scope of the Solano HCP. Therefore, this performance criterion will be accompanied by measurements of habitat quality.

b) The quality and quantity of potential breeding/rearing habitat for salmonids will remain the same and potentially show a net increase throughout the Plan Area over time.

2. **Valley Elderberry Longhorn Beetle.** Objective RSM 2.3 states that the Solano HCP Conservation Strategy will provide for an increase in the available habitat for the valley elderberry longhorn beetle in the riparian areas of Alamo Creek, Ulatis Creek, Putah Creek, and other creeks in Solano County by replacing impacted elderberry plants at a minimum ratio of 2:1. The following monitoring objectives and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal RSM 2 and Objective RSM 2.3 (see Chapter 5.0):

a. **Monitoring Objective RSM 8.** What is the status and distribution of elderberry shrubs in riparian areas in the Plan Area and on established reserves?

b. **Monitoring Objective RSM 9.** What is the density of exit holes for valley elderberry longhorn beetle larvae on elderberry shrubs in riparian areas in the Plan Area and on established reserves?

1) **Biological Effectiveness Monitoring.** Monitoring for the distribution and abundance of elderberry shrubs will be conducted in tandem with the overall monitoring of riparian habitat quality. During the riparian habitat quality assessment, the distribution and density of elderberry shrubs will be assessed at each sample location. Each sample location will be mapped using a Trimble GPS. During surveys, all elderberry shrubs with stems measuring 1.0 inch or greater in diameter shall be inspected for exit holes of the valley elderberry longhorn beetle. Because the larvae are wood borers and adult beetles are rarely seen, survey efforts will focus on searching for the characteristic exit holes left in the bark once the larvae pupate and the adult beetle emerges. Surveys shall be timed to encompass the elderberry blooming season. Beetles are more likely to emerge (i.e., leaving visible exit holes) during this time to feed on flowers and leaves (Davis and Comstock 1924; Linsley and Chemsak 1972; USFWS 1984).

2) **Performance Criteria.** There are two performance criteria for this monitoring:

   a) The distribution and abundance of elderberry shrubs along drainages in the Plan Area shall show an increasing trend over time.

   b) The average density of exit holes on elderberry shrubs shall show an increasing trend over time.

3. **Tricolored Blackbirds.** Objective RSM 2.4 is to establish a minimum of 28 ac of new, suitable nesting habitat for tricolored blackbird in agricultural reserves established for Swainson's hawk foraging and nesting habitat mitigation. Objective RSM 2.5 is to preserve one known tricolored blackbird breeding site for each known breeding colony affected by development. To achieve Objective RSM 2.5, the SCWA, in consultation with the Resource Agencies (see Section 10.2.6), will implement interim measures to protect active and known colonies until such time as the HCP reserve system supports a number of breeding colonies equal to or greater than the number lost as a result of development activities. The establishment and subsequent monitoring of suitable nesting habitat will be conducted as part of the Restoration and Enhancement Plans of individual reserves. The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal RSM 2 and Objectives RSM 2.4 and RSM 2.5 (see Chapter 5.0):

   a. **Monitoring Objective RSM 10.** What is the status of the tricolored blackbird in the Plan Area?

      1) **Biological Effectiveness Monitoring.** Baseline inventory information will be collected concurrently with the Swainson's hawk inventory (see Section 7.4.11). Sampling blocks correspond with the 1-square-mile (sq mi) (640 ac) sections of the State township and range grid.

         For the Solano HCP, the primary agricultural monitoring area is defined as all sections north of the Township 06N/05N line within the Irrigated Agriculture Potential Reserve Area, where 50 sections will be randomly selected from the above sampling area in which to focus nest-searching efforts. Trained observers visit each section at least three times from March 20 through July 30, which is the tricolored blackbird breeding season. Each section should be surveyed as systematically as possible for tricolored blackbird activity and nesting colonies. GPS data shall be collected at each nest colony for entry in the central HCP's GIS database. Data to be collected includes land use information, dominant vegetation at the breeding colony, and population estimate.

In addition to the 50 sections in the primary agricultural monitoring area, an additional 25 sections south of the Township 06N/05N line within the Valley Grassland Potential Reserve Area will be selected to ascertain the status of this species in the non-agricultural portion of the County. Selected sections in this zone will include known nest sites from previous years and areas where suitable nesting habitat has been restored and preserved. This population assessment will be conducted at least once within the first 5 years of the HCP, every year during Phase 2, and every 3 years thereafter in perpetuity as part of the long-term monitoring program.

2) **Performance Criteria.** The number and size of breeding colonies will remain the same and will potentially show a net increase throughout the Plan Area over time.

7.4.8.3 Targeted Studies

Potential targeted studies needed for implementation of the Monitoring and Adaptive Management Program for Riparian, Stream, and Freshwater Marsh Natural Community include:

- Targeted studies and research focusing on methods to re-establish riparian vegetation and floodplains along drainages in Solano County where riparian vegetation or floodplains formerly occurred. This will require the cooperation of private landowners and public agencies to secure suitable sites and to alter their current land use activities to cooperate in the restoration of riparian woodland habitat. Cost-effective methods to eradicate and control invasive plants, plus propagation and cultivation techniques for plant taxa used for restoration, also need to be developed and tested.
- Studies on the biology and life history of the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*).
- Research needs regarding hydrology and sediment/water quality concerns as recommended by the Science Advisors include:
    - An assessment of historic flora and fauna of Suisun, Green Valley, Alamo, and Ulatis Creeks should be done to determine the true baseline. This information should then be used to help determine how, if at all, each of these creeks could be restored or maintained. This should rightfully include consultation with the public to determine what the community wants out of their watersheds.
- Assessments should be done to determine appropriate dry season environmental flows for Covered Species (particularly steelhead trout), especially in Suisun and Green Valley Creeks. This assessment should ideally utilize an assessment of historical flow regime and land use change to determine what is potentially feasible.
- If flora and fauna studies, flow regime studies, channel habitat assessments, and fish population assessments demonstrate that beneficial uses are impaired by water quality and/or quantity, or sediment quality, the following scientific assessment should be done:
    - A scientific study should be done to determine the relative magnitude sources of non-point contaminants so that appropriate management techniques can be selected.
- Studies should be undertaken to determine the relative sediment supply from various sediment sources (hill slopes, bank and bed erosion, farming, and urban runoff) so that appropriate management techniques can be applied.

7.4.9 Giant Garter Snake

The distribution of the giant garter snake in Solano County is poorly understood. There are only three known historic locations: one along lower Putah Creek and two near Liberty Island. These records are also somewhat dated, and more recent studies by Wylie and Martin of the USGS (Wylie and Martin 2004, 2005) failed to find any giant garter snakes in Solano County although potential habitat for the snake is also widespread in channels, sloughs, and some canals in agricultural areas (see Figure 4-19). Based on the paucity of giant garter snake records from Solano County and a lack of recent observations (i.e., USGS surveys), it appears that the giant garter snake is very rare in or may have been extirpated from Solano County; however, a sizeable population of giant garter snakes was recently discovered in the western edge of the Yolo Bypass near Putah Creek (E. Hansen, pers. comm.[1]), suggesting that populations could reestablish or expand into suitable habitat areas in the County in the future. That is why the primary goal for the species is to contribute to the recovery of the giant garter snake through protection, management, restoration, and enhancement of suitable habitat in the Yolo Basin-Liberty Farms population area. Objective GGS 1.1 is to improve habitat quality within the Giant Garter Snake Conservation Area and Yolo Basin-Liberty Farms population area through improvements in water quality discharged from urban and agricultural sources and control of invasive exotic plants and animals. Objective GGS 1.2 is to acquire, enhance, and manage 175 ac of aquatic habitat and 121 ac of associated upland habitat for the giant garter snake. Since a large part of the Conservation Strategy involves restoration of aquatic habitat, the initial restoration activities and subsequent monitoring (for the first 5 years at a minimum) will be conducted by individual mitigation banks and/or private project-specific mitigation lands as part of their Restoration and Enhancement Plan (see Sections 7.3.7 and 10.5.4). Following this initial monitoring period, long-term monitoring of these habitat areas will be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA.

1. **Habitat Monitoring.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal GGS 1 and Objectives GGS 1.1 and GGS 1.2 (see Chapter 5.0):

    a. **Monitoring Objective GGS 1.** What is the quality of habitat for giant garter snakes in the Solano HCP reserve system?

        1) **Biological Effectiveness Monitoring.** Habitat in reserves established for giant garter snakes and suitable habitat areas in Plan Participant facilities that are subject to short-term impacts shall be monitored to assess habitat quality for the species. This habitat assessment and monitoring will be conducted in conjunction with and on the same schedule as the Riparian Habitat Quality Monitoring (Table 7.3) and shall include an assessment of the following additional habitat parameters:

            a) Presence of abundant emergent, herbaceous wetland vegetation (e.g., cattails and bulrushes) for escape cover and foraging habitat during the active season

            b) Presence of adjacent upland habitat for basking, shelter, and retreat sites

            c) Presence of adjacent upland habitat (levees or banks) high enough to provide refuge from winter floodwaters

[1] E. Hansen, Consulting Environmental Biologist, personal communication with Steve Foreman, Principal/Wildlife Biologist, LSA Associates, Inc. (2010).

d) Presence of a suitable prey base (fish and/or frogs)

e) Presence of adequate water during the giant garter snake active period (i.e., April through October)

Because restored habitat for this species may not yet be established within the first 5 years of the Plan, initial surveys during Phase 1 of the monitoring program will be focused on: (1) establishing baseline conditions of suitable habitat areas in Plan Participant facilities prior to the short-term impacts; and (2) assess and identify potential restoration opportunities to assist in giant garter snake conservation. Following the restoration of the 85 ac of aquatic habitat specified under Mitigation Measure GGS 1, habitat monitoring will be conducted as part of the Restoration and Enhancement Plan of the reserve for the first 5 years after restoration or until habitat performance criteria have been met. Following the post-restoration and enhancement monitoring, monitoring will be conducted as part of the Biological Effectiveness Monitoring Program every 3 years in perpetuity, consistent with the Riparian, Stream, and Freshwater Marsh Habitat Quality Monitoring (Table 7.3).

2) **Performance Criteria.** The quality and quantity of suitable giant garter snake habitat shall increase over time.

2. **Population Monitoring.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal GGS 1 and Objectives GGS 1.1 and GGS 1.2 (see Chapter 5.0):

a. **Monitoring Objective GGS 2.** What is the status of giant garter snakes in the Solano HCP reserve system?

1) **Biological Effectiveness Monitoring.** No giant garter snakes were observed in Solano County during intensive trapping studies in 2004 and 2005. Long-term monitoring for this species will continue with surveys to document the status of the giant garter snake on reserves established under the HCP. The surveys by Wylie and Martin (2004, 2005) serve as the baseline for the long-term monitoring plan. Following successful restoration of the initial 85 ac of aquatic habitat on reserves, trapping surveys will be conducted in years 10, 15, and 20, and every 10 years thereafter in perpetuity. If, during any given survey year, weather conditions during the spring are unfavorable to giant garter snake activity, the survey period will be shifted to the late summer and early fall. In the event that a population of giant garter snakes is discovered on reserves, monitoring will be conducted every year for the first 5 years following rediscovery to establish an estimate of the population, then again in years 7 and 10 following rediscovery but prior to resuming long-term monitoring frequencies.

2) **Performance Criteria.** Because no giant garter snakes have been observed in Solano County, no performance criteria have been set for this species except to maintain and expand suitable habitat for this species in the Plan Area. If a population is discovered on a reserve, the population shall show a steady increase toward self-sustaining numbers prior to resuming long-term monitoring frequencies.

7.4.9.1 Targeted Studies

While considerable information has been developed in recent years regarding giant garter snake occurrence in agricultural areas that are primarily devoted to rice production, limited information is available for the species uses of ditches and other aquatic habitats in agricultural areas such as

Solano County, where rice is not grown or is of limited extent. Targeted studies should assess use of seasonal irrigation ditches and drains by giant garter snakes.

7.4.10 Coastal Marsh

The main conclusion from the conceptual models discussed in Appendix B is that Suisun Marsh is a dynamic system that is constantly changing. Several of these changes, particularly in food web dynamics, are driven by the introduction of exotic species. The presence and expansion of invasive plant and animal species probably poses the current greatest threat to the continued existence of these species. The presence and expansion of these invasive species results from a number of environmental factors and pressures, including contributions from changes in water quality associated with urban runoff and wastewater discharge. As such, the two main monitoring issues addressed in the Biological Effectiveness Monitoring Program for the Solano HCP are water quality monitoring and controlling aggressive invasive species.

7.4.10.1 Natural Community Monitoring

The primary conservation actions for the Coastal Marsh Natural Community include enhancing habitat quality (primarily through invasive species control) and improving water quality. Goal CM 1 is to contribute to enhancing the essential ecological processes, functions, and values; species diversity; and habitat heterogeneity of Coastal Marsh habitat in the Plan Area. Objective CM 1.1 is to provide a net increase in the quality of Coastal Marsh habitat in the Plan Area through implementation of programs to control invasive exotic plants and animals and improve water quality. Objective CM 1.2 states that Plan Participants shall prevent increases in dry season (May 1 through October 15) discharge from storm water sewer systems into tributaries draining into Suisun Marsh, Southampton Marsh, and the marshes bordering the Napa River and San Pablo Bay.

Impacts to Coastal Marsh habitat will primarily be avoided through setbacks and buffer areas. Monitoring for the success of these avoidance and minimization measures will be conducted by individual projects as part of their Resource Management Plans (see Sections 7.3.8 and 10.5.4). This chapter deals with the larger conservation commitments designed to mitigate indirect impacts to the Coastal Marsh Natural Community through increases in urban runoff, which are primarily water quality and controlling aggressive invasive species.

1. **Water Quality.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal CM 1 and Objective CM 1.2 (see Chapter 5.0):

    a. **Monitoring Objective CM 1.** Are water quality levels in compliance with NPDES permit requirements established by the applicable RWQCBs?

        1) **Biological Effectiveness Monitoring.** The Solano HCP will annually compile water quality monitoring data collected by the Environmental Monitoring Program (EMP), the Suisun Marsh Program (SMP), the Regional Monitoring Program (RMP), and the Fairfield-Suisun Sewer District (FSSD) to assess compliance with NPDES permit requirements established by the applicable RWQCBs. In addition to existing water quality monitoring data, additional monitoring stations will be established at several discharge points, and readings will be taken twice a month during the dry season to

determine if dry season flows are either decreasing or, at a minimum, not increasing as a result of new development.

2) **Performance Criteria.** Specific performance criteria for water quality are those outlined in the municipal Plan Participants' NPDES permit established by the RWQCBs, such as no increase in dry season flows in downstream receiving waters.

2. **Invasive Species Control and Water Quality Improvement Programs.** Objective CM 1.1 is to provide a net increase in the quality of Coastal Marsh habitat in the Plan Area through the implementation of programs to control invasive exotic plants and animals and improve water quality. Funding for the invasive species control program shall be sufficient to control invasive species on between 100 to 170 ac of Coastal Marsh habitat each year (or between 5,000 to 8,500 ac over the life of the HCP). This objective shall be achieved through the implementation of a grant program administered by SCWA. The following outlines the Biological Effectiveness Monitoring requirements for these programs. All Biological Effectiveness Monitoring of activities performed shall be the responsibility of the grant recipients. The following monitoring objectives and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal CM 1 and Objective CM 1.1 (see Chapter 5.0):

   a. **Monitoring Objective CM 2.** Are invasive species control programs successfully decreasing the distribution and abundance of problematic invasive species?

   b. **Monitoring Objective CM 3.** Are water quality improvement measures for urban and agricultural runoff successfully improving water quality in the marsh?

      1) **Biological Effectiveness Monitoring.** All grant applications submitted to SCWA to receive funds through this program to control invasive species and/or implement water quality improvement measures shall also submit a proposal detailing their Biological Effectiveness Monitoring associated with funded activities for a minimum duration of 5 years. Long-term vegetation monitoring of marsh habitat treated to control invasive species will be conducted concurrent with population monitoring for Suisun thistle and soft bird's-beak monitoring (Monitoring Objective CM 4).

      2) **Performance Criteria.** At the end of the 5-year monitoring period, the Biological Effectiveness Monitoring shall clearly demonstrate that the goals of the implemented control program and/or water quality improvement measures have been met.

7.4.10.2 Covered Species Monitoring

The second goal of the Coastal Marsh Conservation Strategy (Goal CM 2) is to maintain and, where possible through restoration, increase population levels and distribution of Coastal Marsh-associated species in order to contribute to their recovery. The following section describes the Biological Effectiveness Monitoring for Covered Species associated with the Coastal Marsh Natural Community. All habitat monitoring associated with restoration activities and/or monitoring to show the effectiveness of implemented avoidance and minimization measures (i.e., effectiveness of buffers; Chapter 5.0) will be conducted by individual projects as part of their Resource Management Plans or Restoration and Enhancement Plans (see Section 7.3.8).

1. **Suisun Thistle and Soft Bird's-Beak Monitoring.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting Objectives CM 2.1 and CM 2.3 (see Chapter 5.0):

a. **Monitoring Objective CM 4.** What is the distribution and status of populations/ occurrences of Suisun thistle and soft bird's-beak in the reserve system?

1) **Biological Effectiveness Monitoring.** The Solano HCP Conservation Strategy for Coastal Marsh primarily entails avoidance of sensitive marsh habitat. However, some impacts are anticipated, and approximately 80 ac of coastal brackish marsh habitats will be preserved, managed, and restored under the HCP (Objective CM 2.1). In addition, funding will be provided to control invasive species in existing marsh preserves. All suitable habitat areas preserved under the HCP and where invasive species control has occurred will be divided into six monitoring groups (i.e., one permanent monitoring group and five rotating monitoring groups) (Table 7.2). The permanent monitoring group will consist of habitat areas only on preserves established for the HCP. During Phase 1 of the Biological Effectiveness Monitoring Program, techniques will be developed to monitor populations for each plant species sufficient to quantitatively assess the overall health and status of each occurrence and of their overall population levels throughout the reserve system. At a minimum, the monitoring technique will collect presence/absence data or estimates of the PAO (MacKenzie et al. 2003).

2) **Performance Criteria.** Suisun thistle and soft bird's-beak shall occur in the same or greater percentage of habitat sampled during the monitoring year as during the baseline survey.

2. **California Black Rail and California Clapper Rail Monitoring.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting Objective CM 2.1 (see Chapter 5.0):

a. **Monitoring Objective CM 5.** What proportion of suitable habitat is occupied by California black rails and California clapper rails in the reserve system?

1) **Biological Effectiveness Monitoring.** The Solano HCP Conservation Strategy for Coastal Marsh primarily entails avoidance of sensitive marsh habitat. However, some impacts are anticipated, and approximately 80 ac of coastal brackish marsh habitats will be preserved, managed, and restored under the HCP (Objective CM 2.1). Preserves/reserves established under the HCP for the Coastal Marsh Natural Community shall be required to map suitable habitat for California clapper rail and California black rail. Passive listening stations adjacent to the most suitable rail habitat in the preserve will be established. Listening stations should be established no more than 150 m apart along transects in or adjacent to marsh areas. There will be enough passive listening stations so that the entire marsh preserve is covered by circular plots with radii ranging from 82 yards to 109 yards. Each station will be surveyed four times between March 1 and March 31 (surveys may be extended until April 15 if weather or other factors postpone a survey). This timing coincides with the breeding season, when calling rails are most easily detected. Surveys should be conducted at sunset or sunrise. Surveys conducted at sunrise should begin 45 minutes before sunrise and continue until 1-1/4 hours after sunrise. Surveys conducted at sunset should begin 1-1/4 hours before sunset and continue until 45 minutes after sunset. Surveyors will remain at each listening station for 30 minutes and then will move to the next station. All rail vocalizations should be recorded, noting the call type, location, and time on a detailed map of the marsh. At a minimum, this monitoring technique will allow for the collection of presence/absence data or estimates of the PAO (MacKenzie et al. 2003).

2) **Performance Criteria.** The proportion of habitat occupied by California black rail and California clapper rail shall either remain the same or show an increasing trend from the proportion of habitat occupied during baseline surveys.

3. **Salt Marsh Harvest Mouse Monitoring.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting Objective CM 2.1 (see Chapter 5.0):

   a. **Monitoring Objective CM 6.** Document the presence of salt marsh harvest mouse in the reserves/preserves.

      1) **Biological Effectiveness Monitoring.** Small mammal trapping will be conducted on Coastal Marsh preserves to document the presence/occupancy of habitat by salt marsh harvest mice. Trap lines and/or grids (50 traps per trap line or grid) will be established in the reserve area (targeting restoration sites). Trapping will be conducted for three consecutive nights for a total of 1,800 trap nights. Trapping will be conducted during a new moon cycle in the late summer.

         Traps shall be provisioned with fiber bedding for insulation and a mixture of rolled oats, wild bird seed, and walnut meats as bait. Trap lines will be checked beginning at sunrise each day. When harvest mice are found in the trap, they will be processed immediately in order to minimize time spent in the trap. Standardized harvest mouse identification methods established by Fisler (1965) and Shellhammer (1984) will be used to distinguish the southern subspecies of salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*) from the western harvest mouse (*Reithrodontomys megalotis*). All measurements and observations of captured harvest mice will be recorded on data sheets. All captured harvest mice will be marked with non-toxic markers on the tail in order to identify any recaptures. All other small mammals captured during the study will be identified by species prior to release. Traps will be closed following the sunrise inspection so that no animals can enter the traps during the day, but shall be open again in the evenings at sunset.

         Habitat information will also be obtained for each trap location and trap line. Data on pickleweed cover, vegetation maximum and mean height, mean soil salinity, and mean pickleweed salinity will be collected. Cover data will be collected at each trap site. Pickleweed and soil salinity can be collected at a subset of trap sites (10 to 25 locations per line).

      2) **Performance Criteria.** The proportion of habitat occupied by salt marsh harvest mice shall either remain the same or show an increasing trend from the proportion of habitat occupied during baseline surveys.

4. **Delta Smelt and Long-Fin Smelt Habitat Monitoring.** The following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting biological Goal CM 2 and Objectives CM 2.2 and CM 2.4 (see Chapter 5.0):

   a. **Monitoring Objective CM 7.** What is the quality of habitat for Delta smelt and long-fin smelt habitat in the reserve system?

      1) **Biological Effectiveness Monitoring.** Habitat in reserves established for delta smelt and long-fin smelt shall be monitored to assess habitat quality for the species. This habitat assessment and monitoring will be conducted in conjunction with the Riparian Habitat Quality Monitoring and Giant Garter Snake Habitat Monitoring. The

monitoring shall include an assessment of the suitability of restored areas to provide spawning habitat.

Because restored habitat for these species may not yet be established within the first 5 years of the Plan, initial surveys during Phase 1 of the monitoring program will be focused on assessing and identifying potential restoration opportunities to assist in delta smelt and long-fin smelt conservation. Following the restoration of the 85 ac of habitat, habitat monitoring will be conducted, as part of the Restoration and Enhancement Plan of the reserve, for the first 5 years after restoration or until habitat performance criteria have been met. Following the post-restoration and enhancement monitoring, monitoring will be conducted as part of the Biological Effectiveness Monitoring Program every 3 years, consistent with the Riparian, Stream, and Freshwater Marsh Habitat Quality Monitoring in perpetuity (Table 7.3).

2) **Performance Criteria.** The quality and quantity of suitable shallow water aquatic breeding and rearing habitat for Delta smelt and long-fin smelt shall increase over time.

7.4.10.3 Targeted Studies

The tidal marshes of Solano County are poorly understood in terms of modern and historic plant species composition, vegetation community dynamics, and the interactions between vegetation and geomorphic and hydrologic processes (Noss et al. 2002). There are substantial gaps in the scientific data and understanding of the ecosystems and individual species. Research needs for this Natural Community as recommended by the Science Advisors (Noss et al. 2002) that would support conservation planning for this ecosystem include:

- **Suisun Thistle:** Basic biological research on the life history characteristics, population dynamics, species interactions, and response to management (hydrology, water quality) regimes;
- **Endangered Plant-Invasive Plant Interactions and Control Methods:** *Lepidium latifolium* invasions threaten several endangered wetland plant and animal species, and will compromise wetland restoration efforts in Solano County. Applied research on the species and community consequences of potential control measures are needed;
- Research directed toward the restoration of biogeochemical function is paramount to the restoration of tidal marsh communities, as most tidal wetland restoration efforts have failed in this regard; and
- A complete classification and description of wetland types considering landscape position, hydrogeomorphology, biogeochemistry, and vegetation (see Ferren et al. 1996) is needed to understand and conserve Solano County wetland diversity.

Additional research needs as identified by workshop speakers during the Suisun Marsh Science Workshop and summarized in Brown (2004) include:

- **Biogeochemical and Morphological Processes.** There are significant data gaps concerning our knowledge of the biogeochemical and morphological processes in the marsh. Some potential studies include:

- Comparative land use studies of soils characteristics, biogeochemical cycling, and ecosystem functions;
- Accurate, fine-scale elevation data describing Suisun Marsh intertidal elevations and soil surface directional tendencies;
- Organic matter/carbon production and storage rates;
- Suisun-specific subsidence rates;
- Regional rates of ground surface movement;
- Local/regional groundwater characterization; and
- Sediment movement and deposition rates into and within Suisun Marsh.

- **Food Webs.** Some questions emerging from a model by Anke Mueller-Solger presented in Brown (2004) include:
  - Are more interior sloughs a "productivity refuge?"
  - Based on food resources in the channels, what are appropriate restoration targets?
  - What is the relative importance of new zooplankton and benthos in the channels?
  - All questions about the effects of introduced species on the system.
- **California Black Rail and California Clapper Rail.** Several information needs for rails in the Suisun Marsh were identified. These include:
  - Annual abundance surveys and baseline demographic information,
  - Science-based restoration designs,
  - Effects of native and introduced predators and effective methods of predator control,
  - Extent and suitability of existing habitat,
  - Enhancement opportunities for existing habitat, and
  - Identification and protection of source populations.

7.4.11 Swainson's Hawk

The main biological goals for Swainson's hawk are to: (1) maintain a population level of Swainson's hawk similar to current numbers (estimated to be between 120 and 130 pairs) in the Plan Area, and (2) provide sufficient nesting habitat in proximity to suitable foraging habitat to support the current Swainson's hawk population levels in the Plan Area. The primary focus of the Biological Effectiveness Monitoring Program for Swainson's hawk is estimating the number of breeding pairs in Solano County. The number of breeding pairs was selected as the primary monitoring variable because of its direct association with population size as well as its relative cost-effectiveness compared to other, more labor-intensive parameters (e.g., nesting success, number of young produced/nest). Furthermore, Swainson's hawk population estimates conducted statewide by the CDFG are also expressed as numbers of pairs. Most members of the Swainson's Hawk Technical Advisory Committee (SHTAC) agree that "tracking the number of nest sites over time is the best indicator of HCP success" (M. Bradbury, pers. comm.[1]). By monitoring Swainson's hawk breeding population size over the term of the HCP, the Plan Participants (or other monitoring entity) will be able to determine whether objectives aimed at the species (e.g., preservation of foraging habitat, planting of nest trees) are effective at maintaining the current population. In

[1] M. Bradbury, Swainson's Hawk Technical Advisory Committee, personal communication with Steve Foreman, Principal/Wildlife Biologist, LSA Associates, Inc. (2004).

addition to monitoring population numbers, monitoring of nest trees will also be conducted to determine that the reserve system contains a sufficient number of occupied nest trees.

The biological effectiveness monitoring for Swainson's hawk will follow the implementation schedule outlined in Table 7.2. A baseline assessment of the Swainson's hawk population in Solano County will be conducted at least once during Phase 1, after which the population will be monitored every year for 10 years during the Intense Monitoring Program (Phase 2). Finally, monitoring will be conducted every 3 years in perpetuity as part of the Long-Term Monitoring Program (Phase 3).

1. **Swainson's Hawk Population Monitoring.** One of the main goals of the Swainson's Hawk Conservation Strategy is to maintain a population level of Swainson's hawk similar to current numbers (estimated to be between 120 and 130 pairs) in the Plan Area. Several of the objectives under the Swainson's Hawk Conservation Strategy deal with the establishment and management of the reserve system. Monitoring to track compliance with these specific objectives is outlined in the monitoring section for individual reserves (Section 7.3.9) and under compliance monitoring in Section 10.6. The following monitoring objectives and Biological Effectiveness Monitoring are designed to demonstrate that all of the conservation actions outlined in the objectives and mitigation measures are effectively achieving Goal SH 1 and Objectives SH 1.1 through SH 1.4 (see Chapter 5.0):

    a. **Monitoring Objective SH 1.** What is the number of Swainson's hawk pairs breeding within the Irrigated Agriculture and Valley Floor Grassland Conservation Areas?

    b. **Monitoring Objective SH 2.** What is the long-term population trend of Swainson's hawk in Solano County?

        1) **Biological Effectiveness Monitoring.** To estimate the number of breeding pairs in the Plan Area, the Solano HCP is adopting the sampling design and approach developed for the 2005–2006 California Swainson's Hawk Inventory conducted by the CDFG (Anderson et al. 2007). In the statewide census, the current known Swainson's hawk range was divided by known breeding densities into three strata[1]: dense, moderately dense, or sparse. Within each stratum, random sampling blocks were selected. Sampling blocks corresponded to a 1 sq mi (640 ac) section of the State Township and Range grid.

            The Solano HCP Plan Area can also be divided up into dense, moderately dense, and sparse areas. The dense area is defined as all sections north of the Township 06N/05N line within the Irrigated Agriculture Conservation Area. This area contains the highest known nesting densities of Swainson's hawk in the County (Resseguie, unpubl. data). The moderately dense area consists of all sections south of the Township 06N/05N line within the Valley Floor Grassland Conservation Area.

            Similar to the statewide Census methods, sampling blocks will only be established in the dense and moderately dense areas. For the dense area, 50 sections will be initially randomly selected in which to focus nest-searching efforts. As Swainson's hawk reserves become established for the HCP, future sampling blocks will include these

[1] Dense = average density is ≥1 breeding pair per 10 sq mi; Moderately Dense = average density is ≥1 breeding pair per 11 to 75 sq mi; and Sparse = average density is ≥1 breeding pair per 76+ sq mi.

reserve areas. In the moderately dense area, 25 sections will be surveyed to ascertain the status of Swainson's hawk nesting in the nonagricultural portion of Solano County. Because of the current low density of Swainson's hawk nests in this area, selected sections will include known nest sites from previous years as well as random samples.

Trained observers with experience identifying and observing nesting Swainson's hawk will visit each section at least three times (twice from March 20 through April 20, and once from June 10 through July 30) during the Swainson's hawk breeding season. As per the SHTAC survey guidelines (SHTAC 2000), surveys should not be conducted between April 21 and June 10 since nests are extremely difficult to locate this time of year. Each section should be surveyed as systematically as possible for Swainson's hawk nests. Although confirmed nest sites (e.g., females sitting on nest, male delivering food to nest, parents delivering food to young) are preferable, observations of pairs in the vicinity of suitable nesting habitat will also be counted as evidence of a nesting pair. If possible, GPS data should be collected at each nest site for entry in the central HCP's GIS database. Data on other raptor nesting activity shall also be documented. Sections that cannot be completely surveyed shall be mapped to show the portion surveyed and only that area will be included when calculating the total amount of area surveyed.

Data gathered from the nesting surveys will be entered into a centralized database, maintained by the SCWA. Population estimates will be expressed in terms of number of pairs detected per square mile (section) surveyed. Trend analysis protocols will be adapted from the CDFG statewide survey protocol, which has not yet identified specific data analysis methods. Protocols will be subject to revision and refinement if new information indicates that surveys could be conducted more efficiently (e.g., addition of more observers to adequately survey sections) or the sampling design needs to be modified to more accurately track the number of breeding pairs.

2) Performance Criteria

a) The estimated number of breeding pairs shall not decrease significantly for 2 consecutive monitoring years or over a 3-year period, whichever is greater.

b) Average number of nests that fledge young in the field-surveyed blocks shall not decrease significantly for 2 consecutive monitoring years or over a 3-year period, whichever is greater.

2. **Swainson's Hawk Nest Tree Monitoring.** The second goal of the Swainson's Hawk Conservation Strategy is to provide sufficient nesting habitat in proximity to suitable foraging habitat to support the current Swainson's hawk population levels in the Plan Area. There are two programs in the Conservation Strategy that are designed to achieve this goal. The first consists of providing suitable nesting habitat on reserves (Objectives SH 2.1 and SH 2.3). The second consists of preserving and managing one active Swainson's hawk nest for each known nest affected by development (Objective SH 2.2). Monitoring of the suitability and occupancy of Swainson's hawk nesting habitat established on reserves will be conducted on individual mitigation banks and/or private project-specific mitigation lands as part of their Resource Management Plans (i.e., to demonstrate that biological Objectives SH 2.1 and SH 2.3 are being met; see Section 7.3.9). However, additional monitoring to determine whether these trees are being used by Swainson's hawk and whether other preserved known nest trees (such as those temporarily preserved under defined termed contracts) are still occupied will be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA. The

following monitoring objective and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting Goal SH 2 and biological Objective SH 2.2 (see Chapter 5.0):

a. **Monitoring Objective SH 3.** What is the use of known and potential nest trees established on reserves for Swainson's hawk in the Plan Area?

1) **Biological Effectiveness Monitoring.** Concurrent with the population surveys, known and potential nest trees established on Swainson's hawk reserves shall be monitored for the presence of nesting hawks. Potential nest trees on reserves shall be visited at least three times (twice from March 20 through April 20, once from June 10 through July 30) during the Swainson's hawk breeding season. These surveys will be conducted concurrently with the population monitoring described above. Trees on the reserves shall also be assessed for their suitability as nest trees. Occupied and potential nest trees established on Swainson's hawk reserves established under Objectives SH 2.1, SH 2.3, and the first component of Objective SH 2.2 shall follow the same monitoring schedule outlined for the population monitoring. Nest trees established under the interim nest protection program (Objective SH 2.2) shall be monitored annually until a sufficient number of known nest trees have become established on reserves such that defined term contracts or agreements are no longer necessary.

2) **Performance Criteria**

a) *Nesting Habitat Preserved Under Objectives SH 2.1 and SH 2.3.* The number of occupied Swainson's hawk nesting trees on reserves throughout the reserve system shall increase over time.

b) *Nesting Habitat Preserved under Defined Term Contracts (Objective SH 2.2).* Nesting habitat in reserves shall remain intact and occupied. If a preserved nest tree dies of natural causes or is unoccupied for 3 consecutive years, the contract shall be transferred to another known occupied nest tree.

7.4.11.1 Targeted Studies

Potential targeted studies needed for implementation of the Monitoring and Adaptive Management Program for Swainson's hawk include:

- What is the population status of Swainson's hawk inhabiting the Vernal Pool and Valley Floor Grassland Natural Community and Suisun Marsh? To what extent are grasslands used for foraging, is prey selection different from agricultural communities, and what is the foraging behavior in this portion of the County?
- What are the effects of herbicides on Swainson's hawk? Test and develop a set of BMPs to minimize pesticide effects.
- Is Swainson's hawk susceptible to significant potential mortality as a result of new diseases such as recent new strains of avian influenza (H5N1) and West Nile virus? Are there effective treatments/inoculations for these diseases, and how can treatments be applied to the wild population?

7.4.12 Burrowing Owl

The biological goals for burrowing owls are to: (1) maintain sufficient suitable foraging and nesting habitat to support a self-sustaining burrowing owl population throughout the Plan Area, and (2) preserve existing nesting areas and promote expansion of nesting habitat/burrows in the Plan Area. As with the Swainson's hawk monitoring program, the number of breeding pairs is the primary monitoring variable for the Biological Effectiveness Monitoring for burrowing owls. The number of breeding pairs is the most cost-effective yet accurate parameter for tracking the Solano County burrowing owl population. It is also the most commonly used parameter for reporting population size among most studies conducted in California (DeSante and Ruhlen 1995; Rosenberg and Haley 2004). By monitoring breeding population size, the HCP will be able to determine whether mitigation measures aimed at habitat protection for the species (e.g., preservation of foraging habitat, promoting expansion of nesting habitat) are effective at maintaining and expanding the current population. In addition, to monitoring population numbers, monitoring of nest burrows will also be conducted to determine that the reserve system contains a sufficient number of active/occupied burrowing owl nest sites, per biological Objective BO 2.1.

The Biological Effectiveness Monitoring for burrowing owl will follow the implementation schedule outlined in Table 7.2 and be conducted concurrently with Swainson's hawk monitoring. A baseline assessment of the burrowing owl population in Solano County will be conducted at least once during Phase 1. Then the population will be monitored every year for 10 years during the Intense Monitoring Phase (Phase 2). Finally, monitoring will be conducted every 3 years in perpetuity as part of the Long-Term Monitoring Program (Phase 3).

1. **Burrowing Owl Population Monitoring.** One of the main goals of the Burrowing Owl Conservation Strategy is to maintain a sufficient suitable foraging and nesting habitat to support a self-sustaining burrowing owl population throughout the Plan Area. Several of the objectives under the Burrowing Owl Conservation Strategy deal with the establishment and management of the reserve system. Monitoring to track compliance with these specific objectives is outlined in the monitoring section for individual reserves and under compliance monitoring in Section 10.6. The following monitoring objectives and Biological Effectiveness Monitoring are designed to demonstrate that all of the conservation actions outlined in the objectives and mitigation measures are effectively achieving Goal BO 1 and Objectives BO 1.1 and BO 1.2 (see Chapter 5.0):

    a. **Monitoring Objective BO 1.** What is the number of burrowing owl pairs breeding within the Irrigated Agriculture and Valley Floor Grassland Priority Conservation Areas?

    b. **Monitoring Objective BO 2.** What is the long-term population trend of burrowing owl in the County?

        1) **Biological Effectiveness Monitoring.** The burrowing owl population assessment will be conducted at the same time and in the same areas as the Swainson's hawk population assessment. To estimate the number of burrowing owl pairs in the County, randomly selected, 1 sq mi Township sections (the same ones selected for the Swainson's hawk monitoring program) will be surveyed for burrowing owl breeding activity. This method is similar to the statewide burrowing owl census conducted by the Institute for Bird Populations from 1991–1993 (DeSante et al. 1995). Similar to Swainson's hawk distribution, burrowing owl populations are more dense in the agricultural areas of the Plan Area than on the valley floor. Therefore, 50 sections will initially be randomly selected from within the Irrigated Agriculture Natural

Community and 25 sections will be initially sampled within the Valley Floor Grassland and Vernal Pool Natural Community (Figure 4-2). The dense area is defined as all sections north of the Township 06N/05N line within the Irrigated Agriculture Conservation Area. The moderately dense area consists of all sections south of the Township 06N/05N line within the Valley Floor Grassland Conservation Area. Additional sections may be added after the initial monitoring trials are complete or if populations expand substantially on the valley floor.

Trained observers with experience identifying and observing nesting burrowing owl and Swainson's hawk will visit each section at least three times (twice from March 20 through April 20, and once from June 10 through July 30). Each section should be surveyed as systematically as possible for burrowing owl activity. Although confirmed nest sites (e.g., owls at burrows, male delivering food to nest, parents delivering food to young) are preferable, observations of individual owls or pairs of owls will also be counted as evidence of a nesting pair. If possible, GPS data should be collected at each nest site for entry in the central HCP's GIS database.

Data gathered from the nesting surveys will be entered into a centralized database maintained by SCWA. Population estimates will be expressed in terms of number of pairs detected per square mile (section) surveyed. Sections that cannot be completely surveyed shall be mapped to show the portion surveyed, and only that area will be included when calculating the total amount of area surveyed. Trend analysis protocols will be adapted from the CDFG statewide survey protocol, which has not yet identified specific data analysis methods. Protocols will be subject to revision and refinement if new information indicates that surveys could be conducted more efficiently (e.g., addition of more observers to adequately survey sections) or the sampling design needs to be modified to more accurately track the number of breeding pairs.

A baseline inventory of the number of burrowing owl pairs in Solano County will be conducted within the first 5 years of the adoption of the HCP, during Phase 1 of the Biological Effectiveness Monitoring Program. Then the population will be monitored every year for 10 years during the Intense Monitoring Phase (Phase 2). Finally, monitoring will be conducted every 3 years in perpetuity as part of the Long-Term Monitoring Program (Phase 3). Using appropriate statistical analyses, resulting population estimates (with associated confidence intervals) can then be compared across years to determine if the number of pairs in the County is increasing, decreasing, or remaining stable.

2) **Performance Criteria.** The goal of the Conservation Strategy is to contribute to maintaining or increasing, where possible, the burrowing owl population in Solano County. The following performance criteria will be evaluated:

   a) The estimated number of breeding pairs shall not decrease significantly for 2 consecutive monitoring years or over a 3-year period, whichever is greater.

   b) Average number of nests that fledge young in the field-surveyed blocks shall not decrease significantly for 2 consecutive monitoring years or over a 3-year period, whichever is greater.

2. **Burrowing Owl Nest Monitoring.** The second goal in the Burrowing Owl Conservation Strategy is to preserve existing nesting areas and promote expansion of nesting habitat/burrows in the grassland and agricultural regions of the Plan Area. There are two programs in the Conservation Strategy that are designed to achieve this goal. The first consists of providing

suitable nest burrows on reserves, both natural and artificial (Objectives BO 2.2, BO 2.3, and BO 2.4). The second consists of protecting at least one known active burrowing owl nest site in the reserve system for each active nest site eliminated as a result of Covered Activities (Objective BO 2.1). Monitoring of burrow occupancy and densities of burrows on reserves will be conducted on individual mitigation banks and/or private project-specific mitigation lands as part of their Resource Management Plans (i.e., to demonstrate that biological Objectives BO 2.2, BO 2.3, and BO 2.4 are being met; see Section 7.3.10). Additional monitoring to determine if known occupied nest burrows (natural and artificial) established on reserves or protected under defined term contracts continue to be occupied will be conducted as part of the Biological Effectiveness Monitoring Program administered by SCWA. Therefore, the following monitoring objectives and Biological Effectiveness Monitoring are designed to demonstrate that the HCP is meeting Goal BO 2 and biological Objective BO 2.1 (see Chapter 5.0):

a. **Monitoring Objective BO 3.** What is the use of artificial burrows by burrowing owls on reserves established in the Plan Area?

b. **Monitoring Objective BO 4.** What is the status of known occupied burrowing owl nest sites on reserves and preserves in the Plan Area?

   1) **Biological Effectiveness Monitoring.** Concurrent with the population surveys, artificial burrows established on agricultural preserves and a representative sample of either artificial or natural burrows established on valley floor grassland reserves will be monitored for the presence of nesting owls. In addition, known occupied nest burrows protected by defined term contracts shall also be monitored to determine their continued status as being occupied. All monitored burrows shall be visited at least three times (twice from March 20 through April 20, and once from June 10 through July 30) during the breeding season. These surveys will be conducted concurrently with the population monitoring described above. Artificial burrows shall also be assessed for their suitability for nesting. Artificial burrows established on agricultural reserves shall follow the same monitoring schedule outlined for the population monitoring. Monitoring of known occupied nest burrows temporarily protected under a defined term contract (Objective BO 2.1) shall be monitored annually until a sufficient number of known nest burrows have become established on reserves.

   2) **Performance Criteria**

      a) *Artificial Burrows Established:* The number of artificial burrows or natural burrows established on burrowing owl reserves shall show an increased trend in occupancy over time.

      b) *Known Occupied Nest Burrows Preserved under Defined Term Contracts (Objective BO 2.1):* Known occupied nest sites protected under a defined term contract shall remain intact and occupied. If a nest burrow is destroyed by natural causes or is unoccupied for 3 consecutive years, the contract shall be transferred to another known occupied nest site.

7.4.12.1 Targeted Studies

Specific questions that may warrant additional monitoring or focused studies include the following:

- How effective are artificial burrows in attracting owls to preserves? Are there any differences in population levels between sites that contain artificial burrows and those that contain only natural burrows?
- What is the best way to re-establish ground squirrel populations on grassland preserves?
- What is the necessary home range size or how much foraging habitat is necessary to support a breeding pair?
- Are owls evicted from urban development sites able to find nearby burrows? How far will they travel to do so? Are they successful at raising young once they've moved?
- What is the feasibility of actively relocating owls from urban parcels to large grassland preserves? What is the optimum period for habituating owls to a new area?
- Do owls in agricultural habitats display greater tolerance for disturbance (e.g., levee maintenance activities) than those in grasslands?
- Where do wintering populations come from? Are they local birds that relocate to different areas or do they migrate from longer distances?

7.5 DATABASE DEVELOPMENT AND REPORTING

7.5.1 Database Development

Proper data management, analysis and reporting are critical to the success of the Monitoring and Adaptive Management Program. Therefore, Plan Participants will develop and maintain a comprehensive GIS-linked database to track the success of the Monitoring and Adaptive Management Program. This database will also be linked to all other aspects of plan implementation.

Just as the collection of sufficiently robust monitoring data is necessary to evaluate the efficacy of the conservation and adaptive management programs, it is essential that data be analyzed, evaluated, and stored in a manner that allows easy retrieval and understanding by all stakeholders. CDFG's Biogeographic Information and Observation System (BIOS) has established database standards, protocol, recommendations, table formats and relationships, and business rules for managing, visualizing, and analyzing biogeographic data. These standards were developed to allow data from disparate sources to be assembled and analyzed while recognizing that complete uniformity of all biological databases is unattainable and may not be desirable. The Plan Participants will utilize these standards to the extent that they assist the Plan Participants achieve their goals in implementing the HCP and in meeting their reporting requirements. Metadata will be maintained for all geographic datasets maintained through the GIS-linked database.

To assist in reporting and compliance tracking, the Solano HCP will be using the HabiTrak system, which is a GIS-based data management system (Section 10.6) that was developed cooperatively by CDFG, USFWS, local jurisdictions, special districts, and the San Diego Association of Governments (SANDAG) in response to the habitat tracking and reporting requirements of the large southern California regional conservation plans. The Plan Participants will either expand the existing database system or integrate additional information into the HabiTrak program to provide a comprehensive GIS-linked database to assist in implementing the Monitoring and Adaptive Management Program. The expanded database will incorporate data on compliance monitoring (see Section 10.6), Biological Effectiveness Monitoring, results of targeted studies, the status of

ongoing research and adaptive management, and all relevant reports and baseline studies/ assessments reports conducted in the Plan Area.

SCWA will manage the overall database and will be responsible for assuring applicable information is made available to all reserve managers, Plan Participants, resource agencies, and other stakeholders. SCWA will also be responsible for quality assurance and quality control of the data and the management of metadata.

In order to facilitate access and retrieval by all stakeholders, the GIS-linked database will be integrated into an ArcIMS® format. ArcIMS® is a software and hardware solution for delivering dynamic maps and GIS data and services via the Internet. It allows for centralization of data while offering access to this data by all stakeholders. The Internet-based system will also allow data to be made available to the general public. Because some information maintained by the database may be subject to access limitations, due to copyrights, proprietary data, confidential sources, or species protection, access restrictions will be incorporated through a password system for Internet-based information.

Similar to management of the reserve system, database management must also be developed in an adaptive context. Due to the longevity of the permit duration, the database system will need to be periodically updated as new technologies become available. A review of efficiency and updates to the database will be made once every 5 years during the life of the HCP.

7.5.2 Reporting

Annual reports will be submitted to the CDFG, USFWS, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA NMFS), Plan Participants, and Advisory Board within 5 months of the end of the reporting period (reports of the previous year's activities would be due by March 31). SCWA will be responsible for production of the report. The annual reports will summarize the previous year's monitoring and research results. The agencies, Plan Participants, and Advisory Board will use results presented in the monitoring reports and other available information to assess success of the HCP in meeting the biological goals and objectives and to formulate recommendations to the Plan Participants for HCP implementation in subsequent years.

The monitoring and research reports should include:

1. A description of all Covered Activities implemented during the reporting period;
2. A description of all HCP Natural Community protection/enhancement/creation/restoration actions implemented during the reporting period;
3. A year-to-date summary of the extent of protected/enhanced/created/restored Natural Communities;
4. A summary of impacts on covered Natural Community types and species associated with implementation of Covered Activities and mitigation measures;
5. A description of avoidance, minimization, and mitigation measures implemented to address impacts from Covered Activities;

6. A description of performance monitoring undertaken during the reporting period, an analysis of monitoring results, and a description of remedial actions if undertaken during the reporting period;
7. A description of all HCP research undertaken during the reporting period, an analysis of research results, and a description of integration with monitoring, assessment, and compliance elements;
8. An assessment of the efficacy of the monitoring and research program, and recommended changes to the program based on interpretation of the monitoring results and research findings;
9. An assessment of the efficacy of habitat enhancement/creation/restoration methods in achieving performance objectives, and recommended changes to improve the efficacy of the methods; and
10. An assessment of the appropriateness of performance indicators and objectives based on results of Biological Effectiveness Monitoring, and recommended changes to performance indicators and objectives.

7.5.3 Conservation Strategy Modification

The Solano HCP Conservation Strategies, Chapter 5.0, identify the conservation goals and objectives for Covered Species and Natural Communities. Typically, these objectives envision the conservation of Covered Species being achieved through one or more actions consisting of avoidance measures (habitat and individual animals), protection and stewardship management of habitats, restoration of former habitats, and/or specific management actions designed to enhance or improve habitat quality, and therefore the carrying capacity of the area, to support the species (e.g., control/eradication of invasive, exotic species and competitors).

Monitoring is required to evaluate long-term success of the mitigation measures by measuring appropriate biological conditions (e.g., population levels, reproductive success, habitat parameter conditions and trends). If the results of the Biological Effectiveness Monitoring determine that specified biological conditions are outside of specified performance criteria and that the objectives of the conservation strategy are not being achieved, adjustments in the conservation and mitigation strategies and/or management actions may be made. Similarly, if new outside research identifies alternative and more effective mitigation measures, adjustments in the mitigation measures may be implemented as agreed to by the Resource Agencies and permit holders pursuant to the restrictions and procedures identified in Section 10.9.

The types of adjustments that may be made include, but are not limited to:

- Shifts in priority areas for acquisition and management;
- Modifications to seasonal constraints and other take avoidance and minimization measures;
- Implementation of reintroduction programs for Covered Species;
- Modifications to monitoring survey protocols and procedures; and
- Elimination or modification of reserve management and habitat restoration techniques in favor of alternative measures and procedures.

It is also anticipated that the Resource Agencies will prepare new Recovery Plans during the life of the HCP and that these Recovery Plans may identify alternative and important mitigation measures such as:

- New information, procedures, or techniques that would increase the effectiveness of the HCP's conservation program;
- Measures that can be achieved in the Solano HCP Plan Area; and
- New measures that are consistent with the overall intent, framework, and financing plan of the HCP.

The Monitoring and Adaptive Management Program for the Solano HCP provides the ability to incorporate new recovery strategies and goals; however, the new procedures must be consistent with the HCP's original goals and objectives, take parameters, and other conditions specified in Section 10.7, the "No Surprises" assurances. Essentially, modified or additional measures may be implemented if the overall costs are roughly equivalent to the current strategies, the Plan Participants approve increases in agreed to funding levels for recovery efforts, or additional outside funding sources are found.

Figure 7-1: Adaptive Management Feedback Loop

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Figure 7-2: Overview of the Monitoring and Adaptive Management Structure for the Solano HCP Reserve System

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Figure 7-3: Individual Reserve Management and Monitoring Schedule

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Figure 7-4: Planning and Implementation Schedule for Biological Monitoring Program

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