Water Hyacinth Control Program

FINAL

Programmatic Environmental Impact Report

Volume I – Chapters 1 to 7

November 30, 2009

A program for effective control of Water Hyacinth in the Sacramento-San Joaquin Delta and its tributaries.

Copies of this Final Programmatic Environmental Impact Report in hard copy form, or on computer compact disc (CD), can be obtained from the California Department of Boating and Waterways.

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NewPoint Group, Inc., of the
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at Honker Bay.

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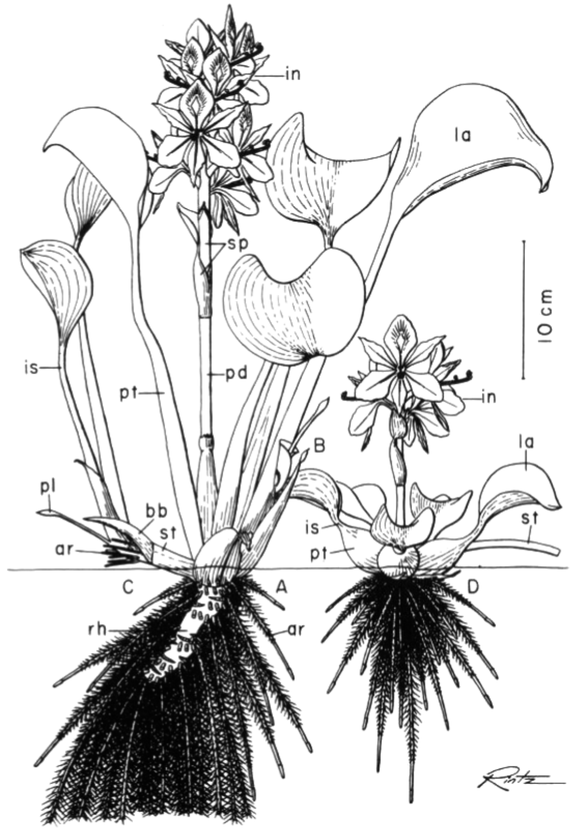

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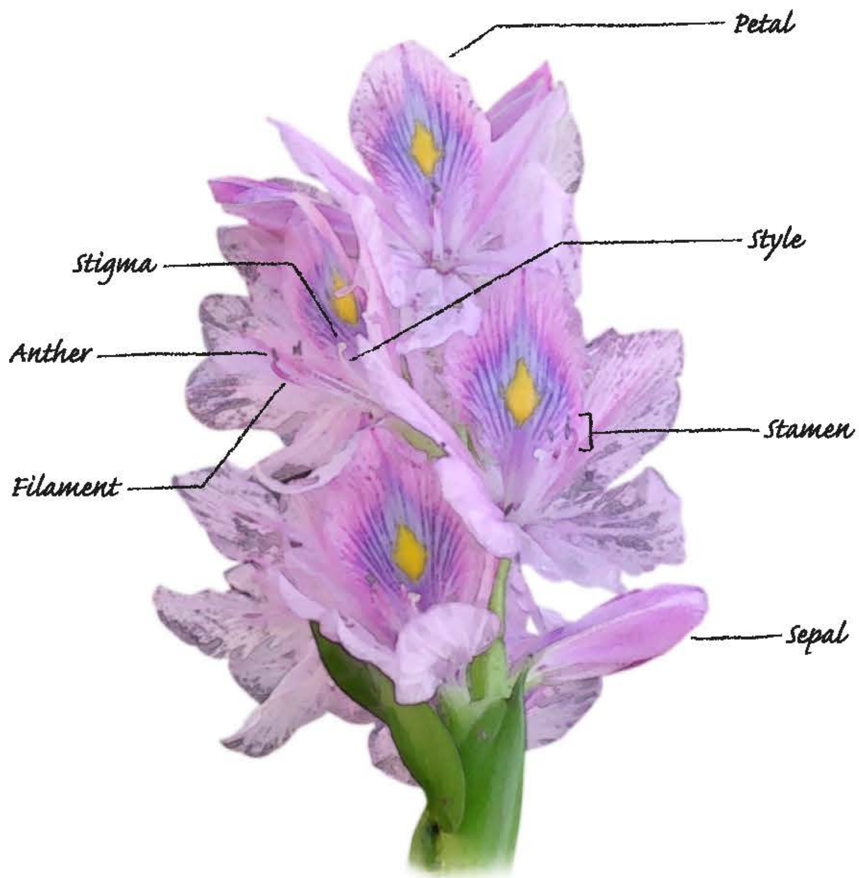
Water hyacinth *(Eichhornia crassipes)*



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Acronyms and Abbreviations

Acronyms and Abbreviations

1. **2,4-D** – 2,4-dichlorophenoxyacetic acid
2. **2,4,5-T** – 2,4,5-trichlorophenoxyacetic acid
3. **ADI** – Acceptable Daily Intake
4. **a.e.** – Active ingredient
5. **AGR** – Agricultural supply (Basin Plan beneficial use)
6. **AHS** – Agricultural Health Study
7. **ALS** – Amyotrophic lateral sclerosis
8. **AMPA** – Aminomethylphosphonic acid
9. **APMP** – Aquatic Pesticide Monitoring Program
10. **Bay-Delta Estuary** – San Francisco Bay and Sacramento-San Joaquin Delta
11. **BA** – Biological Assessment
12. **BDCP** – Bay Delta Conservation Plan
13. **BMP** – Best Management Practices
14. **BO** – Biological Opinion
15. **C** – Centigrade/Celsius
16. **CAC** – County Agricultural Commissioner
17. **CALFED** – California-Federal Bay Delta Program
18. **CCWD** – Contra Costa Water District
19. **CDFA** – California Department of Food and Agriculture
20. **CDFG** – California Department of Fish and Game
21. **CE** – California Endangered
22. **CEQA** – California Environmental Quality Act
23. **CESA** – California Endangered Species Act
24. **cfs** – Cubic feet per second
25. **CI** – Confidence Interval
26. **COA** – Coordinated Operations Agreement
27. **COMM** – Commercial sport fishing (Basin Plan beneficial use)
28. **COLD** – Cold freshwater habitat (Basin Plan beneficial use)
29. **CNDDB** – California Natural Diversity Database
30. **CNPS** – California Native Plant Society
31. **CR** – California Rare
32. **CSC** – California Species of Special Concern

Acronyms and Abbreviations *(continued)*

33. **CT** – California Threatened
34. **CVP** – Central Valley Project
35. **CVRWQB** – Central Valley Regional Water Quality Control Board
36. **CWA** – Clean Water Act
37. **dBA** – Decibels
38. **DBW** – California Department of Boating and Waterways
39. **DCC** – Delta Cross Channel
40. **Delta** – Sacramento-San Joaquin Delta
41. **DMA** – Dimethylamine salt
42. **DO** – Dissolved oxygen, measured in mg/l or ppm
43. **DOC** – California Department of Conservation
44. **DPR** – California Department of Pesticide Regulation
45. **DPS** – Distinct Population Segment
46. **DRERIP** – Delta Regional Ecosystem Restoration Implementation Plan
47. **DWSP** – Delta Water Supply Project
48. **DWR** – California Department of Water Resources
49. **EA** – Environmental Assessment
50. **EC50** – Effective concentration for 50 percent of target
51. **EDCP** – *Egeria densa* Control Program
52. **EFH** – Essential Fish Habitat
53. **EIR** – Environmental Impact Report
54. **EIS** – Environmental Impact Statement
55. **ERP** – Ecosystem Restoration Program
56. **ESA** – Endangered Species Act (federal)
57. **EST** – Estuarine habitat (Basin Plan beneficial use)
58. **ESU** – Evolutionary Significant Unit
59. **EWA** – Environmental Water Account
60. **FC** – Federal Candidate (for consideration of endangered or threatened status)
61. **FCH** – Federal Critical Habitat
62. **FCHP** – Federal critical habitat for this species proposed
63. **FE** – Federal Endangered
64. **FETAX** – Frog Embryo Teratogenesis Assay – *Xenopus*
65. **FIFRA** – Federal Insecticide, Fungicide, and Rodenticide Act
66. **FMWT** – Fall Midwater Trawl

Acronyms and Abbreviations *(continued)*

67. **FONSI** – Finding of No Significant Impact
68. **FT** – Federal Threatened
69. **GI** – Gastrointestinal
70. **GWR** – Groundwater recharge (Basin Plan beneficial use)
71. **HAPC** – Habitat Areas of Particular Concern
72. **HCP** – Habitat Conservation Plan
73. **HQ** – Hazard Quotient
74. **IARC** – International Agency for Registration of Carcinogens
75. **IEP** – Interagency Ecology Program
76. **IND** – Industrial service supply (Basin Plan beneficial use)
77. **IPM** – Integrated Pest Management
78. $\mathbf{K_{oc}}$ – Soil adsorption coefficient, normalized by organic matter
79. **LC5** – Lethal concentration for 5 percent of subjects
80. **LC10** – Lethal concentration for 10 percent of subjects
81. **LC50** – Lethal concentration for 50 percent of subjects
82. **LD50** – Lethal dose or lethal dietary dose for 50 percent of subjects
83. **LH** – Luteinizing hormone
84. **LOC** – Level of Concern
85. **LOD** – Limit of detection
86. **LOEC** – Lowest Observable Effect Concentration
87. **LOEL** – Lowest Observable Effect Level
88. **MAF** – Million acre feet
89. **MATC** – Maximum Acceptable Toxicant Concentration
90. **MCL** – Maximum Contaminant Level
91. **MCP** – Maintenance Control Practices
92. **MCPA** – 4-chloro-2-methylphenoxyacetic acid
93. **MIGR** – Migration of aquatic organisms (Basin Plan beneficial use)
94. **mM** – millimolar, a concentration of one thousandth of a mole per liter
95. **MOE** – Margin of Error or Margin of Safety
96. **MOU** – Memorandum of Understanding
97. **MRA** – Montane Riverine Aquatic
98. **MRDL** – Maximum Residual Disinfectant Level
99. **MSA** – Magnuson-Stevens Fishery Conservation and Management Act

Acronyms and Abbreviations *(continued)*

100. **MSDS** – Material Safety Data Sheet
101. **MUN** – Municipal and domestic supply
102. **NAV** – Navigation (Basin Plan beneficial use)
103. **NBA** – North Bay Aqueduct
104. **NCCP** – Natural Community Conservation Plan
105. **ND** – Non-detectable
106. **NFPE** – Nontidal Freshwater Permanent Emergent
107. **NHL** – Non-Hodgkin lymphoma
108. **NIH** – National Institute of Health
109. **NMFS** – National Marine Fisheries Service
110. **NOAA-Fisheries** – National Oceanic and Atmospheric Administration-Fisheries (also previously referred to as NMFS, National Marine Fisheries Service)
111. **NOEC** – Non-observable effect concentration
112. **NOEL** – Non-observable effect level
113. **NOI** – Notice of Intent
114. **NOP** – Notice of Preparation
115. **NPDES** – National Pollution Discharge Elimination System
116. **NPE** – Nonylphenol ethoxylates
117. **NRDC** – Natural Resources Defense Council
118. **NTU** – Nephelometric Turbidity Units
119. **OCAP** – Operations Criteria and Plan
120. **OMP** – Operations Management Plan
121. **OMR** – Old and Middle River
122. **OR** – Odds Ratio
123. **OSHA** – Occupational Safety and Health Administration
124. **PCA** – Pest Control Advisor
125. **PEIR** – Program Environmental Impact Report
126. **PFMC** – Pacific Fisheries Management Council
127. **PG&E** – Pacific Gas and Electric
128. **POD** – Pelagic Organism Decline
129. **POEA** – Polyethoxylated tallowamine
130. **ppb** – parts per billion (μg/l)
131. **ppm** – parts per million (mg/l or mg/kg)

Acronyms and Abbreviations *(continued)*

132. **ppt** – parts per thousand (g/l)
133. **PPE** – Personal Protective Equipment
134. **PRO** – Industrial process supply (Basin Plan beneficial use)
135. **PUR** – Pesticide Use Recommendations
136. **QAC** – Qualified Applicator Certificate
137. **QAPP** – Quality Assurance Project Plan
138. **RARE** – Rare, threatened, or endangered species (Basin Plan beneficial use)
139. **RCRA** – Resource Conservation and Recovery Act
140. **REC-1** – Water contact recreation (Basin Plan beneficial use)
141. **REC-2** – Non-water contact recreation (Basin Plan beneficial use)
142. **RfD** – Reference Dose
143. **ROD** – Record of Decision
144. **RPA** – Reasonable and Prudent Alternative
145. **RQ** – Risk Quotient
146. **RR** – Risk Ratio
147. **RUP** – Restricted Use Permit
148. **SDIP** – South Delta Improvement Program
149. **SFA** – Seasonally Flooded Agricultural
150. **SFEI** – San Francisco Estuary Institute
151. **SJRRP** – San Joaquin River Restoration Program
152. **SHELL** – Shellfish harvesting (Basin Plan beneficial use)
153. **SMR** – Standard Mortality Ratio
154. **SMUD** – Sacramento Municipal Utility District
155. **SOD** – Superoxide dismutase
156. **SPWN** – Spawning, reproduction, and/or early development (Basin Plan beneficial use)
157. **STS** – Soft tissue sarcoma
158. **SVWMA** – Sacramento Valley Water Management Agreement
159. **SWB** – State Water Board (Water Resources Control Board)
160. **SWP** – State Water Project
161. **SWRCB** – State Water Resources Control Board
162. **TDF** – Through-Delta Facility
163. **TFE** – Tidal Freshwater Emergent
164. **THM** – Trihalomethane

Acronyms and Abbreviations *(continued)*

165. **TPA** – Tidal Perennial Aquatic
166. **UC** – Upland Cropland
167. **USBR** – United States Bureau of Reclamation
168. **USDA-ARS** – United States Department of Agriculture – Agricultural Research Service
169. **USFS** – United States Forest Service
170. **USFWS** – United States Fish and Wildlife Service
171. **VAMP** – Vernalis Adaptive Management Plan
172. **VFR** – Valley/Foothill Riparian
173. **VRA** – Valley Riverine Aquatic
174. **WARM** – Warm freshwater habitat (Basin Plan beneficial use)
175. **WHCP** – Water Hyacinth Control Program
176. **WHO** – World Health Organization
177. **WILD** – Wildlife habitat (Basin Plan beneficial use)
178. **WOE** – Weight-of-evidence
179. **X2** – the line at which 2ppt (parts per thousand) saline occurs

Executive Summary

Executive Summary

A. Introduction to the PEIR

This document presents a final programmatic environmental impact report (PEIR) analyzing the potential environmental effects of the California Department of Boating and Waterways, Water Hyacinth Control Program (WHCP). This document was prepared in compliance with the California Environmental Quality Act of 1970 (CEQA) (Public Resource Code 21000 *et seq*.).

The basic purpose of CEQA is to (1) inform governmental decision-makers and the public about the potential, significant environmental effects of proposed activities; (2) identify ways that environmental damages can be avoided or significantly reduced; (3) prevent significant avoidable damages through alternatives and mitigation measures; and (4) disclose why a project is approved if significant environmental effects are involved. The Environmental Impact Report (EIR) is a State of California public document used by governmental agencies to analyze significant environmental effects of a proposed project, to identify project alternatives, and to disclose possible ways to reduce, or avoid, possible environmental damages.

A programmatic EIR is an EIR which may be prepared on a series of actions that can be characterized as one large project, such as this WHCP. The California Department of Boating and Waterways (DBW) is the Lead Agency for purposes of this PEIR.

Water hyacinth *(Eichhornia crassipes)* is a non-native, invasive, free-floating aquatic plant. Water hyacinth grows in wetlands, marshes, shallow water bodies, slow moving waterways, lakes, reservoirs, and rivers. Water hyacinth is often noted in the scientific literature as one of the world's fastest growing and most problematic weeds. Water hyacinth is native to the Amazon region of South America.

Water hyacinth was introduced to the United States in 1884 at New Orleans, Louisiana. California's first reported water hyacinth was at a Yolo County slough, in 1904. Water hyacinth spread into the Sacramento-San Joaquin Delta (Delta) by the 1940s and 1950s, and by 1981 it covered 1,000 acres of the Delta. Since 1981, estimated water hyacinth coverage in the Delta has ranged from approximately less than 500 acres, to over 2,500 acres.

Water hyacinth negatively influences biodiversity, recreation, and agriculture. It de-stabilizes dissolved oxygen (DO) cycles, shades out important shallow water fish habitat, prevents boat passage, and blocks agricultural water intakes. In response to concerns about water hyacinth, in 1982, Senate Bill 1344 amended the California Harbors and Navigation Code and designated the California Department of Boating and Waterways as the lead agency for controlling water hyacinth in the Delta, its tributaries, and Suisun Marsh.

The DBW initiated the WHCP in 1983. For the sixteen years, between 1983 and 1999, and for the nine years, from 2001 to to-date, the DBW has operated the WHCP. There were no water hyacinth treatments in 2000, as the program was the subject of legal and regulatory changes. Prior to resuming to-date the WHCP in 2001, the DBW obtained an individual National Pollution Discharge Elimination System (NPDES) permit for the WHCP, issued by the State Water Resources Control Board (SWRCB), and administered by the Central Valley Regional Water Quality Control Board (CVRWQCB).

The individual NPDES permit expired in 2006, and was replaced with a NPDES General Permit. The WHCP also operates under two biological opinions (BOs) from the United States Fish and Wildlife Service (USFWS), and the National Oceanic and Atmospheric Administration (NOAA-Fisheries).

The WHCP currently operates under the following three (3) Federal permits:

- NPDES Statewide General Permit (CAG990005)
- USFWS Biological Opinion (1-1-02-F-157 and 1-1-03-F-0114)
- NOAA Biological Opinion (151422SWR2005SA00681:JSS)

The goal of the WHCP is to keep waterways safe and navigable by controlling the growth and spread of water hyacinth in the Delta and its surrounding tributaries. Because of the persistence of water hyacinth in the Delta, the WHCP legislative mandate is for control, rather than eradication of water hyacinth.

The primary purpose of the WHCP is to control the growth and spread of water hyacinth in order to minimize negative impacts of the plant on navigation, recreation, and agricultural activities in Delta waterways. The DBW seeks to manage water hyacinth growth while (1) minimizing non-target plant and species impacts and (2) preventing environmental degradation in Delta waterways and tributaries.

B. Purpose of This PEIR

With preparation of this WHCP Final PEIR, the DBW is seeking to update its twenty-five (25) years of environmental documentation for the WHCP. The DBW also wants to provide parity with its other aquatic weed program, the *Egeria densa* Control Program (EDCP). For the EDCP, the DBW prepared an EIR in 2001, and in 2006, a Second Addendum to the EDCP EIR and Five-Year Program Review.

The WHCP has operated without an EIR since the program's inception. In 1985, the United States Army Corps of Engineers, acting as a Lead Agency for water hyacinth control in the Delta, prepared an Environmental Assessment and Finding of "No Significant Impact" (EA/FONSI) for the WHCP. This FONSI determined that there was no need at that time to complete further environmental documentation for the program. The DBW operated the program with no additional environmental documentation until 1999. Since 2001, the DBW has been following the new and extensive environmental monitoring and compliance measures specified in the NPDES permit and USFW and NOAA-Fisheries Biological Opinions for the program.

Much has changed in the Delta since the WHCP began in 1983. The list of threatened and endangered species has expanded, new (less toxic) aquatic herbicides and adjuvants have been added to the WHCP, and there are significant new water quality and environmental concerns in the Delta. This Final PEIR for the WHCP provides the DBW with the opportunity to carefully reevaluate the program within the current context of the Delta environment and the DBW's current treatment practices.

C. Project Alternatives Considered in this PEIR

CEQA requires that an EIR discuss a reasonable range of alternatives that could avoid, or substantially lessen, the significant environmental impacts of the proposed program, even if the alternatives might impede to some degree attainment of program objectives, or the alternatives would be more costly. An EIR must also evaluate the impacts of the "No Program Alternative" to allow decision makers to compare impacts of approving the proposed program with impacts of not approving the proposed program.

The DBW considered six program alternatives: (1) Integrated Management (the selected alternative); (2) Chemical Control Only; (3) Handpicking Only; (4) Biological Control Only; (5) Mechanical Harvesting Only; and (6) No Program Alternative. In over twenty-five years of operating the WHCP, the DBW has examined and tested a broad range of potential control methods. Reflecting an adaptive management approach, the WHCP has continuously evolved over more than two decades to incorporate new information and experience. The selected WHCP alternative reflects this program experience, and provides flexibility to continue to adapt the program over time.

D. WHCP Overview

The DBW utilizes treatment protocols that balance the need to control water hyacinth with the need to minimize resulting environmental impacts to Delta waterways. The selected program alternative consists of an integrated approach, emphasizing chemical treatment, with limited handpicking and herding, and continued assessment of biological controls.

Selected program herbicides are 2,4-D and glyphosate, with 2,4-D being used for the majority of treatments. The DBW applies both herbicides with an adjuvant to increase adhesion to water hyacinth leaves and to reduce drift.

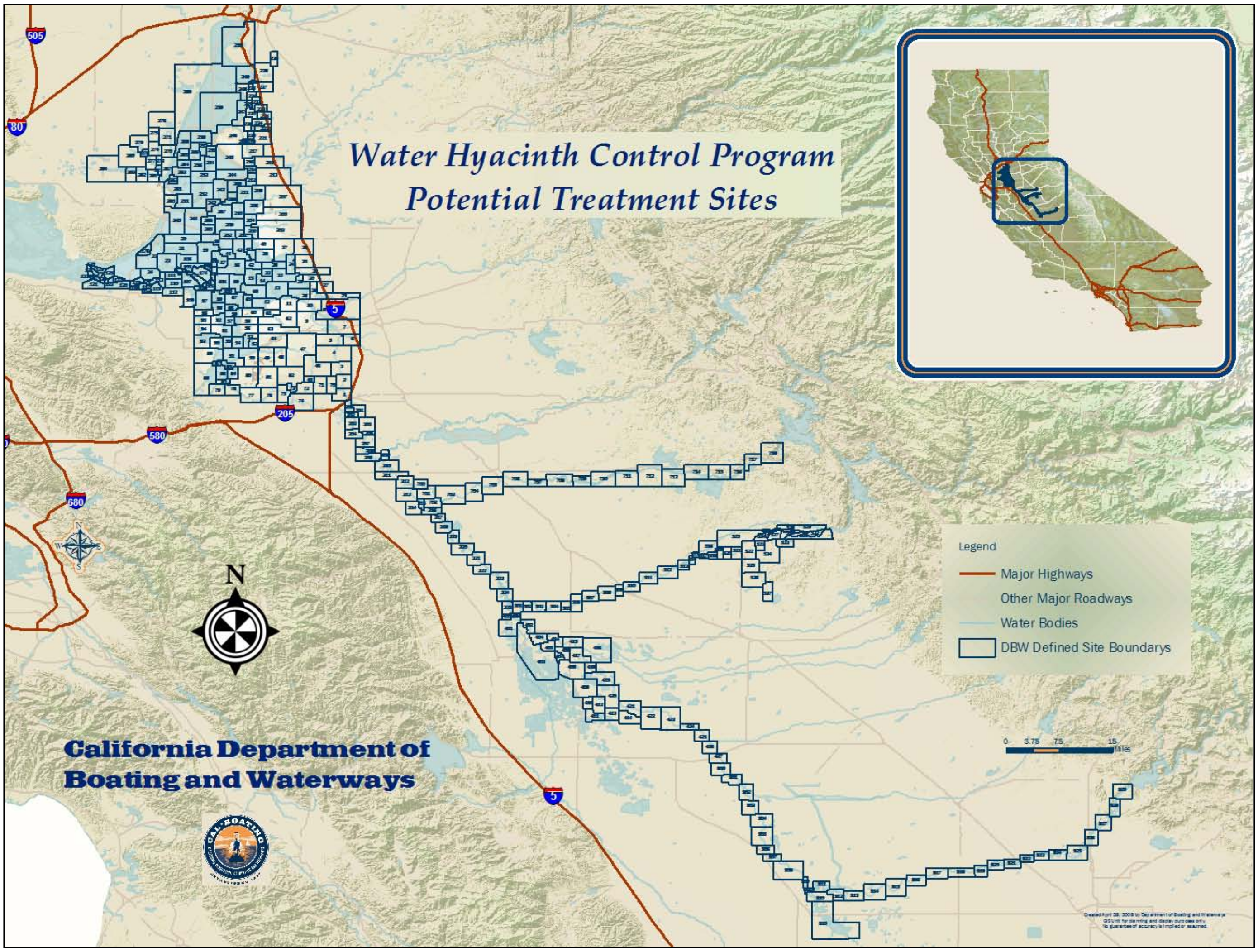
The DBW has six, two-person crews, conducting WHCP treatments (plus one Fresno County crew, and one Merced County crew). Chemical treatments begin April 1st, or April 15th in selected areas; however, the main region of the Delta can only be treated between July 1st and October 15th, to avoid potential impacts on fisheries.

The WHCP region is divided into 368 treatment sites that average between one and two miles in length. **Exhibit ES-1,** on the next page, provides a summary map of the WHCP project area and treatment sites. Sites may be treated multiple times during a treatment season. Treatment sites are prioritized so that nursery areas, and areas where water hyacinth causes negative public, agricultural, or industrial impacts are treated first. The WHCP also takes into account logistical factors such as prevailing wind, travel time, and weather, conditions when selecting treatment locations.

The WHCP follows an Operations Management Plan that specifies a pre-application planning protocol; an application/monitoring coordination protocol; "Best Maintenance Practices" for handling herbicides; spray equipment maintenance and calibration; and an herbicide spill contingency plan. The Operations Management Plan also specifies requirements related to avoiding threatened or endangered species; conducing habitat evaluation; dissolved oxygen measurement; fish passage protocols; and other monitoring requirements.

Based on NPDES permit requirements, the DBW follows the Annual Monitoring Protocol. This protocol fulfills monitoring requirements of the Regional Water Quality Control Board, NOAA Fisheries, and the USFWS. Each treatment season, the DBW is required to conduct monitoring at ten (10) percent of the sites it treats,

Exhibit ES-1
WHCP Project Area Map



for each chemical and type of waterway. At each monitoring site, WHCP environmental scientists take samples pre-application (adjacent to the water hyacinth mat), and post-application (upstream, adjacent to, and downstream of the treatment area). WHCP environmental scientists also take a sample one week following treatment.

E. WHCP Environmental Impacts and Mitigation Measures

Table ES-1, starting on page ES-6, provides the WHCP Environmental Checklist for the seventeen (17) (I to XVII) broad EIR impact categories. This table follows the general format provided in CEQA Guidelines, Appendix G. There are five (5) resource areas with avoidable, potentially avoidable, or unavoidable significant impacts. Table ES-1 also identifies eight (8) resource areas for which the WHCP has beneficial impacts. Finally, Table ES-1 identifies Mandatory Findings of Significance. In two areas, the WHCP has unavoidable, or potentially unavoidable significant impacts: (1) potential to degrade the environment, and (2) cumulative impacts.

Within this PEIR, the DBW has identified twenty-two (22) mitigation measures to reduce environmental impacts of the WHCP. Many of these mitigation measures apply to more than one impact. **Table ES-2,** on page ES-14, provides a brief summary of each mitigation measure, and identifies the specific mitigation measure numbers associated with each WHCP potential impact.

Table ES-3, starting on page ES-15, provides a summary of proposed WHCP impacts, significance levels before mitigation, associated mitigation measures, and significance levels after mitigation. Table ES-3 identifies two (2) specific agricultural resource impacts; eight (8) specific biological resource impacts; two (2) specific hazards and hazardous materials impacts; six (6) specific hydrology and water quality impacts; and one (1) specific utilities and service systems impact. The mitigation measures are numbered according to the order provided in Table ES-2.

The CEQA Guidelines, Section 15142, state that EIR's shall focus on the significant effects on the environment. Section 15128 states that the EIR shall briefly indicate reasons that various possible effects of a project were determined not to be significant.

Furthermore, Section 15150 discusses incorporation by reference from another public document in cases where descriptions and/or analyses are duplicative. The WHCP Final PEIR makes use of these guidelines to address eleven (11) environmental factor categories. These eleven resource categories are addressed in detail in the *Egeria densa* Control Program Final EIR, prepared by the DBW in 2001.

Table ES-1 summarizes sixteen (16) environmental factor areas, plus mandatory findings of significance. Table ES-3 summarizes potential impacts in the five (5) environmental factor areas with any significant impacts. **Table ES-4,** starting on page ES-20, summarizes eleven (11) environmental factor areas that DBW determined were not significantly affected by the WHCP. Table ES-4 also summarizes Growth Inducing Impacts, stating that the WHCP will not result in any of these impacts.

Table ES-1
WHCP Environmental Checklist

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED BY THE WHCP

The environmental factors checked below would be potentially affected by this project, involving at least one impact that is a "Significant Impact" (either "unavoidable", "potentially unavoidable", or "avoidable") as indicated by the checklist on the following pages.

[ ] Aesthetics I	[**X**] Agricultural Resources II	[ ] Air Quality III
[**X**] Biological Resources IV	[ ] Cultural Resources V	[ ] Geology/Soils VI
[**X**] Hazards & Hazardous Materials VII	[**X**] Hydrology/Water Quality VIII	[ ] Land Use/Planning IX
[ ] Mineral Resources X	[ ] Noise XI	[ ] Population/Housing XII
[ ] Public Services XIII	[ ] Recreation XIV	[ ] Transportation/Traffic XV
[**X**] Utilities/Service Systems XVI	[**X**] Mandatory Findings of Significance XVII	

Environmental Factors	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
I. AESTHETICS — Would the project:						
a) Have a substantial adverse effect on a scenic vista?		[ ]	[ ]	[ ]	[X]	[ ]
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?		[ ]	[ ]	[ ]	[X]	[ ]
c) Substantially degrade the existing visual character or quality of the site and its surroundings?		[ ]	[ ]	[ ]	[X]	[**X**]
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?		[ ]	[ ]	[ ]	[X]	[ ]
II. AGRICULTURAL RESOURCES — In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:						
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?		[ ]	[ ]	[ ]	[X]	[ ]
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?		[ ]	[ ]	[ ]	[X]	[ ]
c) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?		[ ]	[ ]	[ ]	[X]	[ ]
d) Adversely impact agricultural crops or agricultural operations, such as irrigation?						
Impact A1: Agricultural crops	3, 22	[ ]	[**X**]	[ ]	[ ]	[ ]
Impact A2: Irrigation pumps	13, 22	[ ]	[**X**]	[ ]	[ ]	[**X**]

Environmental Factors	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
III. AIR QUALITY — Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:						
a) Conflict with or obstruct implementation of the applicable air quality plan?		[ ]	[ ]	[ ]	[X]	[ ]
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?		[ ]	[ ]	[ ]	[X]	[ ]
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?		[ ]	[ ]	[ ]	[X]	[ ]
d) Expose sensitive receptors to substantial pollutant concentrations?		[ ]	[ ]	[X]	[ ]	[ ]
e) Create objectionable odors affecting a substantial number of people?		[ ]	[ ]	[X]	[ ]	[ ]
IV. BIOLOGICAL RESOURCES — Would the project:						
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?						
Impact B1: Herbicide overspray	1, 2, 3, 4	[**X**]				[**X**]
Impact B2: Herbicide toxicity	1, 3, 5, 6, 7, 8	[**X**]				
Impact B3: Herbicide bioaccumulation				[X]		
Impact B4: Food web effects	1, 6, 7	[**X**]				[**X**]
Impact B5: Dissolved oxygen levels	9, 10, 11, 12		[**X**]			[**X**]
Impact B6: Treatment disturbances	1, 4		[**X**]			
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFG or USFWS?						
Impact B1: Herbicide overspray	1, 2, 3, 4	[**X**]				[**X**]
Impact B5: Dissolved oxygen levels	9, 10, 11, 12		[**X**]			[**X**]
Impact B6: Treatment disturbances	1, 4		[**X**]			
Impact B7: Plant fragmentation	13, 14		[**X**]			
Impact B8: Disposal following handpicking	15, 16			[X]		
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?						
Impact B1: Herbicide toxicity	1, 2, 3, 4	[**X**]				[**X**]
Impact B5: Dissolved oxygen levels	9, 10, 11, 12		[**X**]			[**X**]
Impact B6: Treatment disturbances	1, 4		[**X**]			[**X**]
Impact B7: Plant fragmentation	13, 14		[**X**]			
Impact B8: Disposal following handpicking	15, 16			[X]		

Table ES-1
WHCP Environmental Checklist *(continued)*

Page 3 of 8

Environmental Factors	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
IV. BIOLOGICAL RESOURCES *(continued)* — Would the project:						
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?						
Impact B2: Herbicide toxicity	1, 3, 5, 6, 7,	[**X**]				
Impact B4: Food web effects	1, 6, 7	[**X**]				[**X**]
Impact B5: Dissolved oxygen levels	9, 10, 11, 12		[**X**]			[**X**]
Impact B6: Treatment disturbances	1, 4		[**X**]			
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?		[ ]	[ ]	[X]	[ ]	[**X**]
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?		[ ]	[ ]	[ ]	[X]	[**X**]
V. CULTURAL RESOURCES — Would the project:						
a) Cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?		[ ]	[ ]	[ ]	[X]	[ ]
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to §15064.5?		[ ]	[ ]	[ ]	[X]	[ ]
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?		[ ]	[ ]	[ ]	[X]	[ ]
d) Disturb any human remains, including those interred outside of formal cemeteries?		[ ]	[ ]	[ ]	[X]	[ ]
VI. GEOLOGY AND SOILS — Would the project:						
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:						
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.		[ ]	[ ]	[ ]	[X]	[ ]
ii) Strong seismic ground shaking?		[ ]	[ ]	[ ]	[X]	[ ]
iii) Seismic-related ground failure, including liquefaction?		[ ]	[ ]	[ ]	[X]	[ ]
iv) Landslides?		[ ]	[ ]	[ ]	[X]	[ ]
b) Result in substantial soil erosion or the loss of topsoil?		[ ]	[ ]	[ ]	[X]	[ ]
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?		[ ]	[ ]	[ ]	[X]	[ ]
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?		[ ]	[ ]	[ ]	[X]	[ ]
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?		[ ]	[ ]	[ ]	[X]	[ ]

Environmental Factors	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
VII. HAZARDS AND HAZARDOUS MATERIALS — Would the project:						
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?						
Impact H1: General public exposure	17			[X]		
Impact H2: Treatment crew exposure	3, 7, 18, 19, 20		[**X**]			
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?						
Impact H3: Accidental spills	19		[**X**]			
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?		[ ]	[ ]	[ ]	[X]	[ ]
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?		[ ]	[ ]	[ ]	[X]	[ ]
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?		[ ]	[ ]	[ ]	[X]	[ ]
f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?		[ ]	[ ]	[ ]	[X]	[ ]
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?		[ ]	[ ]	[ ]	[X]	[**X**]
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?		[ ]	[ ]	[ ]	[X]	[ ]
VIII. HYDROLOGY AND WATER QUALITY — Would the project:						
a) Violate any water quality standards or waste discharge requirements?						
Impact W1: Chemical constituents	3, 6, 7, 21	[**X**]				
Impact W2: Pesticides	1, 3, 4, 6, 7, 21	[**X**]				
Impact W3: Toxicity	1, 3, 4, 6, 7, 21	[**X**]				
Impact W4: Dissolved oxygen levels	9, 10, 11, 12	[**X**]				[**X**]
Impact W5: Floating material	13, 21, 22		[**X**]			[**X**]
Impact W6: Turbidity	4			[X]		

Table ES-1
WHCP Environmental Checklist *(continued)* *Page 5 of 8*

Environmental Factors	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
VIII. HYDROLOGY AND WATER QUALITY *(continued)* — Would the project:						
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?		[ ]	[ ]	[ ]	[X]	[ ]
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?		[ ]	[ ]	[ ]	[X]	[ ]
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?		[ ]	[ ]	[ ]	[X]	[ ]
e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?		[ ]	[ ]	[ ]	[X]	[ ]
f) Otherwise substantially degrade water quality?						
Impact W1: Chemical constituents	3, 6, 7, 21	[**X**]				
Impact W2: Pesticides	1, 3, 4, 6, 7, 21	[**X**]				
Impact W3: Toxicity	1, 3, 4, 6, 7, 21	[**X**]				
Impact W4: Dissolved oxygen levels	9, 10, 11, 12	[**X**]				[**X**]
Impact W5: Floating material	13, 21, 22		[**X**]			[**X**]
Impact W6: Turbidity	4			[X]		
g) Otherwise substantially degrade drinking water quality?						
Impact W1: Chemical constituents	3, 6, 7, 21	[**X**]				
Impact W2: Pesticides	1, 3, 4, 6, 7, 21	[**X**]				
Impact W3: Toxicity	1, 3, 4, 6, 7, 21	[**X**]				
h) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?		[ ]	[ ]	[ ]	[X]	[ ]
i) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?		[ ]	[ ]	[ ]	[X]	[ ]
j) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?		[ ]	[ ]	[ ]	[X]	[ ]
k) Inundation by seiche, tsunami, or mudflow?		[ ]	[ ]	[ ]	[X]	[ ]

Table ES-1
WHCP Environmental Checklist *(continued)*

Environmental Factors	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
IX. LAND USE AND PLANNING — Would the project:						
a) Physically divide an established community?		[ ]	[ ]	[ ]	[X]	[ ]
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?		[ ]	[ ]	[ ]	[X]	[ ]
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?		[ ]	[ ]	[ ]	[X]	[ ]
X. MINERAL RESOURCES — Would the project:						
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?		[ ]	[ ]	[ ]	[X]	[**X**]
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?		[ ]	[ ]	[ ]	[X]	[ ]
XI. NOISE — Would the project result in:						
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?		[ ]	[ ]	[ ]	[X]	[ ]
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?		[ ]	[ ]	[ ]	[X]	[ ]
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?		[ ]	[ ]	[ ]	[X]	[ ]
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?		[ ]	[ ]	[X]	[ ]	[ ]
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?		[ ]	[ ]	[ ]	[X]	[ ]
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?		[ ]	[ ]	[ ]	[X]	[ ]
XII. POPULATION AND HOUSING — Would the project:						
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?		[ ]	[ ]	[ ]	[X]	[ ]
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?		[ ]	[ ]	[ ]	[X]	[ ]
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?		[ ]	[ ]	[ ]	[X]	[ ]

Table ES-1
WHCP Environmental Checklist *(continued)*

Environmental Factors	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
XIII. PUBLIC SERVICES — Would the project:						
a) Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:						
Fire protection?		[ ]	[ ]	[ ]	[X]	[ ]
Police protection?		[ ]	[ ]	[ ]	[X]	[ ]
Schools?		[ ]	[ ]	[ ]	[X]	[ ]
Parks?		[ ]	[ ]	[ ]	[X]	[ ]
Other public facilities?		[ ]	[ ]	[ ]	[X]	[ ]
XIV. RECREATION — Would the project:						
a) Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?		[ ]	[ ]	[ ]	[X]	[**X**]
b) Include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?		[ ]	[ ]	[ ]	[X]	[ ]
c) Would the project adversely impact existing recreational opportunities?		[ ]	[ ]	[X]	[ ]	[**X**]
XV. TRANSPORTATION/TRAFFIC — Would the project:						
a) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?		[ ]	[ ]	[ ]	[X]	[ ]
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?		[ ]	[ ]	[ ]	[X]	[ ]
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?		[ ]	[ ]	[ ]	[X]	[ ]
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?		[ ]	[ ]	[ ]	[X]	[ ]
e) Result in inadequate emergency access?		[ ]	[ ]	[ ]	[X]	[ ]
f) Result in inadequate parking capacity?		[ ]	[ ]	[ ]	[X]	[ ]
g) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?		[ ]	[ ]	[ ]	[X]	[ ]

Table ES-1
WHCP Environmental Checklist *(continued)*

Environmental Factors	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
XVI. UTILITIES AND SERVICE SYSTEMS — Would the project:						
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?		[ ]	[ ]	[ ]	[X]	[ ]
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?		[ ]	[ ]	[ ]	[X]	[ ]
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?		[ ]	[ ]	[ ]	[X]	[ ]
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?		[ ]	[ ]	[ ]	[X]	[ ]
e) Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?		[ ]	[ ]	[ ]	[X]	[ ]
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?		[ ]	[ ]	[ ]	[X]	[ ]
g) Comply with federal, state, and local statutes and regulations related to solid waste?		[ ]	[ ]	[ ]	[X]	[ ]
h) Result in problems for local or regional water utility intake pumps?						
Impact U1: Water utility intake pumps	13, 23	[ ]	[**X**]	[ ]	[ ]	[**X**]
XVII. MANDATORY FINDINGS OF SIGNIFICANCE — Does the project:						
a) Have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	[**X**]	[ ]	[ ]	[ ]	[ ]
b) Have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22	[**X**]	[ ]	[ ]	[ ]	[ ]
c) Have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	3, 7, 17, 18, 19, 20	[ ]	[**X**]	[ ]	[ ]	[ ]

Table ES-2
WHCP Mitigation Measures Summary

	Mitigation Measures Summary[1]	Specific Mitigation Measures
1.	Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources	B1a; B2d; B4c; B6a; W2a; W3a
2.	Provide a 250 foot buffer between treatment sites and shoreline elderberry shrubs (*Sambucus* ssp.), host plant for the valley elderberry longhorn beetle *(Desmocerus californicus dimorphus)*	B1b
3.	Conduct herbicide treatments in order to minimize potential for drift	B1c; B2f; H2d ; W1d; W2e; W3e; A1b
4.	Operate program vessels in a manner that causes the least amount of disturbance to the habitat	B1d; B6b; W2f; W3f; W6a
5.	Implement temporal and spatial limitations and restrictions on herbicide treatments to minimize treatments during times, and at locations, where larval and/or migratory fish are likely to be present	B2a
6.	Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters	B2b; B4a; W1a; W2b; W3b
7.	Implement an adaptive management approach to minimize the use of herbicides	B2c; B4b; H2c; W1c; W2c; W3c
8.	Provide treatment crews with electronic mapping that identifies previously surveyed areas for giant garter snake habitat	B2e
9.	Monitor dissolved oxygen levels pre- and post-treatment for all WHCP treatments	B5a; W4a
10.	Treat no more than three contiguous acres at any treatment site	B5b; W4b
11.	Treat no more than one-half of the area at one time of completely infested dead-end sloughs to allow for fish passage	B5c; W4c
12.	Treat no more than one-half of completely infested moving waterways at one time to allow for fish passage	B5d; W4d
13.	Collect plant fragments during and immediately following treatment	B7a; W5c; U1b; A2b
14.	Conduct handpicking and herding only as required	B7b
15.	Identify and utilize disposal areas that have no and/or low habitat value for the federal and State listed giant garter snake *(Thamnophis gigas)*	B8a
16.	Identify and utilize disposal areas that are at least 100 feet away from elderberry shrubs (*Sambucus* ssp.)	B8b
17.	Minimize public exposure to herbicide treated water	H1a
18.	Require treatment crews to participate in training on herbicide and heat hazards	H2a
19.	Follow best management practices to minimize the risk of spill and to minimize the impact of a spill, should one occur	H2b ; H3a
20.	Implement safety precautions on hot days to prevent heat illness	H2e
21.	Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities	W1b; W2d; W3d; W5a; U1a
22.	Notify County Agricultural Commissioners about WHCP activities	W5b; A1a; A2a

[1] Please refer to the text in Chapters 3 through 6 for the complete mitigation measure description.

Table ES-3
Summary of Proposed WHCP Impacts, Mitigation Measures, and Significance Levels Before and After Mitigation

Page 1 of 5

Resource Areas	Potential Impacts	Significance Level Before Mitigation			Mitigation	Significance Level After Mitigation	
		Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact		Reduced, but still Potentially Unavoidable Significant Impact	Less than Significant Impact
II. Agricultural Resources	**A1 – Agricultural crops:** effects of WHCP herbicide treatments on agricultural crops		[X]		**3** – Conduct herbicide treatments in order to minimize drift **22** – Notify County Agricultural Commissioners about WHCP activities		[X]
	A2 – Irrigation pumps: effects of WHCP treatments on agricultural irrigation		[X]		**13** – Collect plant fragments during and immediately following treatment **22** – Notify County Agricultural Commissioners about WHCP activities		[X]
IV. Biological Resources	**B1 – Herbicide overspray:** effects of herbicide overspray on special status species, riparian or other sensitive habitats, and wetlands	[X]			**1** – Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources **2** – Provide a 250 foot buffer between treatment sites and shoreline elderberry shrubs, host plant for the valley elderberry longhorn beetle **3** – Conduct herbicide treatments in order to minimize potential for drift **4** – Operate program vessels in a manner that causes the least amount of disturbance to the habitat	[X]	
	B2 – Herbicide toxicity: toxic effects of herbicides on special status species, native resident fish, and migratory fish	[X]			**1** – Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources **3** – Conduct herbicide treatments in order to minimize potential for drift **5** – Implement temporal and spatial limitations and restrictions on herbicide treatments to minimize treatments during times, and at locations, where larval and/or migratory fish are likely to be present **6** – Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters **7** – Implement an adaptive management approach to minimize the use of herbicides **8** – Provide treatment crews with electronic mapping that identifies previously surveyed areas for giant garter snake habitat	[X]	
	B3 – Herbicide bioaccumulation: effects of herbicide bioaccumulation on special status species			[X]	NA		NA

Table ES-3
Summary of Proposed WHCP Impacts, Mitigation Measures, and Significance Levels Before and After Mitigation *(continued)*

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Resource Areas	Potential Impacts	Significance Level Before Mitigation: Unavoidable or Potentially Unavoidable Significant Impact	Significance Level Before Mitigation: Avoidable Significant Impact	Significance Level Before Mitigation: Less than Significant Impact	Mitigation	Significance Level After Mitigation: Reduced, but still Potentially Unavoidable Significant Impact	Significance Level After Mitigation: Less than Significant Impact
IV. Biological Resources *(continued)*	**B4 – Food web effects:** effect of treatment on food webs, and resulting impact on special status species, sensitive habitats, and migration of species	[X]			**1** – Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources **6** – Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters **7** – Implement an adaptive management approach to minimize the use of herbicides	[X]	
	B5 – Dissolved oxygen levels: effects of treatment on local dissolved oxygen (DO) levels, and resulting impact on special status species, resident native or migratory fish, sensitive habitat, and wetlands		[X]		**9** – Monitor dissolved oxygen levels pre- and post-treatment for all WHCP treatments **10** – Treat no more than three contiguous acres at any treatment site **11** – Treat no more than one-half of the area at one time of completely infested dead-end sloughs to allow for fish passage **12** – Treat no more than one-half of completely infested moving waterways at one time to allow for fish passage		[X]
	B6 – Treatment disturbances: effects of treatment disturbances on special status species, resident native or migratory fish, sensitive habitat, and wetlands		[X]		**1** – Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources **4** – Operate program vessels in a manner that causes the least amount of disturbance to the habitat		[X]
	B7 – Plant fragmentation: effects of plant fragmentation on sensitive habitat and wetlands		[X]		**13** – Collect plant fragments during and immediately following treatment **14** – Conduct handpicking and herding only as required		[X]
	B8 – Disposal following handpicking: effects of disposal following handpicking on sensitive habitat and wetlands			[X]	Not required, however, the following measures will be followed: **15** – Identify and utilize disposal areas that have no and/or low habitat value for federal and State listed giant garter snake **16** – Identify and utilize disposal areas that are at least 100 feet away from elderberry shrubs		[X]

Table ES-3
Summary of Proposed WHCP Impacts, Mitigation Measures, and Significance Levels Before and After Mitigation *(continued)*

Resource Areas	Potential Impacts	Significance Level Before Mitigation: Unavoidable or Potentially Unavoidable Significant Impact	Significance Level Before Mitigation: Avoidable Significant Impact	Significance Level Before Mitigation: Less than Significant Impact	Mitigation	Significance Level After Mitigation: Reduced, but still Potentially Unavoidable Significant Impact	Significance Level After Mitigation: Less than Significant Impact
VII. Hazards and Hazardous Materials	**H1 – General public exposure:** there is potential for the WHCP to create a significant hazard to the public through the routine transport, use, or disposal of WHCP herbicides			[X]	Not required; however, DWB will implement the following mitigation measure: **17** – Minimize public exposure to herbicide treated water		[X]
	H2 – Treatment crew exposure: there is potential for the WHCP to create a significant hazard to treatment crews through the routine transport, use, or disposal of WHCP herbicides; and/or through heat exposure		[X]		**3** – Conduct herbicide treatments in order to minimize potential for drift **7** – Implement an adaptive management approach to minimize the use of herbicides **18** – Require treatment crews to participate in training on herbicide and heat hazards **19** – Follow best management practices to minimize the risk of spill, and to minimize the impact of spill, should one occur **20** – Implement safety precautions on hot days to prevent heat illness		[X]
	H3 – Accidental spill: there is potential for the WHCP to create a significant hazard to the public or the environment through reasonably foreseeable upset and accidental conditions involving the release of hazardous materials into the environment		[X]		**19** – Follow best management practices to minimize the risk of spill, and to minimize the impact of spill, should one occur		[X]
VIII. Hydrology and Water Quality	**W1 – Chemical constituents:** following WHCP herbicide treatment, waters may potentially contain chemical constituents that adversely affect beneficial uses, violating water quality standards or otherwise substantially degrading water quality or drinking water quality	[X]			**3** – Conduct herbicide treatments in order to minimize potential for drift **6** – Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters **7** – Implement an adaptive management approach to minimize the use of herbicides **21** – Follow the Memorandum of Understanding (MOU) protocol for various herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities	[X]	

Table ES-3
Summary of Proposed WHCP Impacts, Mitigation Measures, and Significance Levels Before and After Mitigation *(continued)*

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Resource Areas	Potential Impacts	Significance Level Before Mitigation: Unavoidable or Potentially Unavoidable Significant Impact	Significance Level Before Mitigation: Avoidable Significant Impact	Significance Level Before Mitigation: Less than Significant Impact	Mitigation	Significance Level After Mitigation: Reduced, but still Potentially Unavoidable Significant Impact	Significance Level After Mitigation: Less than Significant Impact
VIII. Hydrology and Water Quality *(continued)*	**W2 – Pesticides:** following WHCP herbicide treatment pesticides may potentially be present in concentrations that adversely affect beneficial uses, violating water quality standards or otherwise substantially degrading water or drinking water quality	[X]			**1** – Avoid herbicide applications near special status species, and sensitive riparian and wetland habitat; and other biologically important resources **3** – Conduct herbicide treatments in order to minimize potential for drift **4** – Operate program vessels in a manner that causes the least amount of disturbance to the habitat **6** – Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters **7**– Implement an adaptive management approach to minimize the use of herbicides **21** – Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities	[X]	
	W3 – Toxicity: following WHCP herbicide treatment toxic substances may potentially be found in waters in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life, violating water quality standards or otherwise substantially degrading water or drinking water quality	[X]			**1** – Avoid herbicide applications near special status species, and sensitive riparian and wetland habitat; and other biologically important resources **3** – Conduct herbicide treatments in order to minimize potential for drift **4** – Operate program vessels in a manner that causes the least amount of disturbance to the habitat **6** – Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters **7** – Implement an adaptive management approach to minimize the use of herbicides **21** – Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities	[X]	

Table ES-3

Summary of Proposed WHCP Impacts, Mitigation Measures, and Significance Levels Before and After Mitigation *(continued)*

Resource Areas	Potential Impacts	Significance Level Before Mitigation			Mitigation	Significance Level After Mitigation	
		Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact		Reduced, but still Potentially Unavoidable Significant Impact	Less than Significant Impact
VIII. Hydrology and Water Quality *(continued)*	**W4 – Dissolved oxygen:** following WHCP herbicide treatment, dissolved oxygen may potentially be reduced below Basin Plan and Bay-Delta Plan objectives, violating water quality standards or otherwise substantially degrading water quality	[X]			**9** – Monitor dissolved oxygen (DO) levels pre- and post- treatment for all WHCP treatments **10** – Treat no more than three contiguous acres at any treatment site **11** – Treat no more than one-half of the area at one time of completely infested dead-end sloughs to allow for fish passage **12** – Treat no more than one-half of completely infested moving waterways at one time to allow for fish passage	[X]	
	W5 – Floating material: following WHCP treatments, waters may potentially contain floating water hyacinth fragments in amounts that cause nuisance or adversely affect beneficial uses, violating water quality standards or otherwise substantially degrading water quality		[X]		**13** – Collect plant fragments during and immediately following treatment **21** – Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities **22** – Notify County Agricultural Commissioners about WHCP activities		[X]
	W6 – Turbidity: WHCP treatment may potentially result in changes to turbidity that cause nuisance or adversely affect beneficial uses, violating water quality standards or otherwise substantially degrading water quality			[X]	Not required, however, the following measure will be followed: **4** – Operate program vessels in a manner that causes the least amount of disturbance to the habitat		[X]
XVI. Utilities and Service Systems	**U1 – Water utility intake pumps:** effects of WHCP treatments on water utility intake pumps		[X]		**13** – Collect plant fragments during and immediately following treatment **21** – Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities		[X]

Table ES-4
WHCP Environmental Factors with "Less Than Significant Impact" or "No Impact" *Page 1 of 5*

Environmental Factors	Impact Level		Discussion *The WHCP will not:*	Incorporation by Reference
	Less Than Significant	No Impact		
I. AESTHETICS — Would the project:				
a) Have a substantial adverse effect on a scenic vista?	[ ]	[X]	Impact scenic vistas. The WHCP will improve scenic vistas by controlling large monoculture expanses of water hyacinth.	*EDCP Final EIR* (2001), DBW, Pages 2-48 to 2-49; 3-99
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	[ ]	[X]	Damage scenic resources. The WHCP will improve scenic resources by controlling large monoculture expanses of water hyacinth.	
c) Substantially degrade the existing visual character or quality of the site and its surroundings?	[ ]	[X]	Degrade the existing visual character or quality of the Delta. The WHCP will improve the visual character of the Delta by controlling large monoculture expanses of water hyacinth.	
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	[ ]	[X]	Create a new source of light or glare.	
III. AIR QUALITY — Would the project:				
a) Conflict with or obstruct implementation of the applicable air quality plan?	[ ]	[X]	Conflict with or obstruct implementation of the applicable air quality plan.	*EDCP Final EIR* (2001), DBW, Pages 2-42; 3-84 to 3-85
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	[ ]	[X]	Violate any air quality standard or contribute to an existing or projected air quality violation.	
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?	[ ]	[X]	Result in net increases of any criteria pollutants for which the project region is under an applicable federal or state ambient air quality standard.	
d) Expose sensitive receptors to substantial pollutant concentrations?	[X]	[ ]	Result in significant exposure of sensitive receptors to substantial pollutant concentrations. There may be short-term less than significant impacts on sensitive receptors due to drift of WHCP herbicides during spraying operations.	
e) Create objectionable odors affecting a substantial number of people?	[X]	[ ]	Result in significant objectionable odors. There may be short-term, less than significant, objectionable odors in the immediate vicinity of treatments due to drift of WHCP herbicides during spraying operations.	
V. CULTURAL RESOURCES — Would the project:				
a) Cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?	[ ]	[X]	Cause a substantial adverse change in a historical resource.	*EDCP Final EIR* (2001), DBW, Pages 2-47; 3-98
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to §15064.5?	[ ]	[X]	Cause a substantial adverse change in an archeological resource.	
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	[ ]	[X]	Destroy a unique paleontological resource or site or a geologic feature.	
d) Disturb any human remains, including those interred outside of formal cemeteries?	[ ]	[X]	Disturb any human remains.	

Table ES-4

WHCP Environmental Factors with "Less Than Significant Impact" or "No Impact" *(continued)*

Environmental Factors	Impact Level		Discussion	Incorporation by Reference
	Less Than Significant	No Impact	*The WHCP will not:*	
VI. GEOLOGY AND SOILS — Would the project:				
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				*EDCP Final EIR* (2001), DBW, Pages 2-44; EC-4
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	[ ]	[**X**]	Expose people or structures to adverse effects due to a known earthquake fault.	
ii) Strong seismic ground shaking?	[ ]	[**X**]	Expose people or structures to adverse effects due to seismic ground shaking.	
iii) Seismic-related ground failure, including liquefaction?	[ ]	[**X**]	Expose people or structures to adverse effects due to seismic related ground failure, including liquefaction.	
iv) Landslides?	[ ]	[**X**]	Expose people or structures to adverse effects due to landslides.	
b) Result in substantial soil erosion or the loss of topsoil?	[ ]	[**X**]	Result in substantial erosion or loss of topsoil.	
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	[ ]	[**X**]	Be located on a geological unit or soil that is or could become unstable and result in landslide, lateral spreading, subsidence, liquefaction, or collapse.	
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	[ ]	[**X**]	Be located on expansive soil	
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?	[ ]	[**X**]	Have soils incapable of supporting septic tanks or alternative waste disposal systems.	
IX. LAND USE AND PLANNING — Would the project:				
a) Physically divide an established community?	[ ]	[**X**]	Physically divide a community.	*EDCP Final EIR* (2001), DBW, Pages 2-45 to 2-46; 3-95
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	[ ]	[**X**]	Conflict with applicable land use plans, policies, or regulations.	
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	[ ]	[**X**]	Conflict with any applicable habitat conservation plan or natural community conservation plan. WHCP has no known conflicts with various conservation plans, programs, or other initiatives in the Delta (see Chapter 7). WHCP's control of water hyacinth is consistent with, and supportive of, conservation planning efforts to reduce invasive species in the Delta.	

Table ES-4
WHCP Environmental Factors with "Less Than Significant Impact" or "No Impact" *(continued)* *Page 3 of 5*

Environmental Factors	Impact Level: Less Than Significant	Impact Level: No Impact	Discussion *The WHCP will not:*	Incorporation by Reference
X. MINERAL RESOURCES — Would the project:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	[ ]	[**X**]	Result in loss of availability of a known mineral resource.	*EDCP Final EIR* (2001), DBW, Pages 2-43; EC-7
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	[ ]	[**X**]	Result in loss of availability of a locally-important mineral resource recovery site.	
XI. NOISE — Would the project result in:				
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	[ ]	[**X**]	Result in exposure to, or generation of, noise levels in excess of standards.	*EDCP Final EIR* (2001), DBW, Pages 2-43; EC-7; 3-91
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	[ ]	[**X**]	Result in exposure of persons, or generation of, excessive groundborne vibration or groundborne noise levels.	
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	[ ]	[**X**]	Result in a permanent increase in ambient noise levels.	
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	[**X**]	[ ]	Result in a substantial temporary or period increase in ambient noise levels. There may be a less than significant increase in localized ambient noise levels due to operation of WHCP boats during treatment.	
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	[ ]	[**X**]	Be located within an airport land use plan, or within two miles of a public airport, or expose people within the area to excessive noise levels.	
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?	[ ]	[**X**]	Be located within the vicinity of a private airstrip, or expose people within the area to excessive noise levels.	
XII. POPULATION AND HOUSING — Would the project:				
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	[ ]	[**X**]	Induce population growth in the area.	*EDCP Final EIR* (2001), DBW, Pages 2-47; 3-97
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	[ ]	[**X**]	Displace existing housing.	
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	[ ]	[**X**]	Displace people.	

Table ES-4

WHCP Environmental Factors with "Less Than Significant Impact" or "No Impact" *(continued)*

Environmental Factors	Impact Level		Discussion *The WHCP will not:*	Incorporation by Reference
	Less Than Significant	No Impact		
XIII. PUBLIC SERVICES — Would the project:				
a) Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:				*EDCP Final EIR* (2001), DBW, Pages 2-47; 3-96
Fire protection?	[ ]	[**X**]	Impact fire protection.	
Police protection?	[ ]	[**X**]	Impact police protection.	
Schools?	[ ]	[**X**]	Impact schools.	
Parks?	[ ]	[**X**]	Impact parks.	
Other public facilities?	[ ]	[**X**]	Impact other public facilities.	
XIV. RECREATION — Would the project:				
a) Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	[ ]	[**X**]	Result in substantial physical deterioration of neighborhood or regional parks due to increased use.	*EDCP Final EIR* (2001), DBW, Pages 2-40 to 2-41; 3-82 to 3-83
b) Include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?	[ ]	[**X**]	Include or require expansion of recreational facilities that would have an adverse physical effect on the environment.	
c) Would the project adversely impact existing recreational opportunities?	[**X**]	[ ]	Adversely impact existing recreational opportunities. The WHCP would temporarily impact recreational boating at treatment sites, during treatment, however this impact would be less than significant. The WHCP would have a beneficial impact on recreational boating in the Delta by controlling the growth of water hyacinth.	

Table ES-4
WHCP Environmental Factors with "Less Than Significant Impact" or "No Impact" *(continued)* *Page 5 of 5*

Environmental Factors	Impact Level: Less Than Significant	Impact Level: No Impact	Discussion *The WHCP will not:*	Incorporation by Reference
XV. TRANSPORTATION/TRAFFIC — Would the project:				
a) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?	[ ]	[**X**]	Cause an increase in traffic.	*EDCP Final EIR* (2001), DBW, Pages 2-38 to 2-39; EC-9
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?	[ ]	[**X**]	Exceed a level of service standard for designated roads or highways.	
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	[ ]	[**X**]	Result in a change in air traffic patterns.	
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	[ ]	[**X**]	Substantially increase hazards due to a design feature or incompatible uses.	
e) Result in inadequate emergency access?	[ ]	[**X**]	Result in inadequate emergency access.	
f) Result in inadequate parking capacity?	[ ]	[**X**]	Result in inadequate parking capacity.	
g) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	[ ]	[**X**]	Conflict with adopted policies, plans, or programs supporting alternative transportation.	

GROWTH-INDUCING IMPACTS[a] — Would the project:				
a) Foster economic or population growth?	[ ]	[**X**]	Foster economic or population growth.	*EDCP Final EIR* (2001), DBW, Page 7-1
b) Foster construction of additional housing, either directly or indirectly, in the surrounding environment? (Including removing obstacles to population growth).	[ ]	[**X**]	Foster construction of housing, either directly or indirectly.	
c) Encourage or facilitate other activities that could significantly affect the environment, either individually or cumulatively?	[ ]	[**X**]	Encourage or facilitate other activities that could affect the environment.	

[a] Growth-inducing impacts are not included within the environmental factors checklist, however, CEQA Guidelines, Section 15126.2(d) require a discussion of the growth-inducing impacts of the proposed project or program. Because the WHCP will not result in growth-inducing impacts, the topic is included in this table of "Less Than Significant Impact" and "No Impact" factors.

Chapter 1
Introduction

1. Introduction

The California Department of Boating and Waterways (DBW) operates the Water Hyacinth Control Program (WHCP). A key goal of the WHCP is to keep waterways safe and navigable by controlling the growth and spread of water hyacinth in the Sacramento-San Joaquin Delta (Delta), and its surrounding tributaries. The WHCP is California's oldest, and largest, aquatic weed control program.

The WHCP was established over twenty-six years ago by the California Legislature in 1982 with the passage of Senate Bill 1344. The law has been amended since that time (with minor wording changes and with the *Egeria densa* Control Program added to the code in 1997) . Section 64 of the Harbors and Navigation Code currently reads as follows:

"(a) The Legislature hereby finds and declares that the growth of water hyacinth and *Egeria densa* in the Sacramento-San Joaquin Delta, its tributaries, and the Suisun Marsh has occurred at an unprecedented level and the resulting accumulations of water hyacinth and *Egeria densa* obstruct navigation, impair other recreational uses of waterways, have the potential for damaging manmade facilities, and may threaten the health and stability of fisheries and other ecosystems within the delta and marsh. Accordingly, it is necessary that the state, in cooperation with agencies of the United States, undertake an aggressive program for the effective control of water hyacinth and *Egeria densa* in the delta, its tributaries, and the marsh.

"(b) The department is designated as the lead agency of the state for the purpose of cooperating with agencies of the United States and other public agencies in controlling water hyacinth and *Egeria densa* in the delta, its tributaries, and the marsh."

Exhibit 1-1, on the next page, illustrates the location of the WHCP. The WHCP operates within the Delta, and three major tributaries: the San Joaquin, Merced, and Tuolumne Rivers. **Exhibit 1-2**, on page 1-3, provides an illustration of the legal boundaries of the Sacramento-San Joaquin Delta, as defined by Section 12220 of the California Water Code.[i]

This chapter of the Final Program Environmental Impact Report (PEIR) describes the approach of this Final PEIR document, describes the purpose of the Final PEIR, provides historical background on the WHCP. This chapter is organized as follows:

A. Organization of the WHCP Final PEIR
B. Purpose of the WHCP Final PEIR
C. History of the WHCP.

A. Organization of the WHCP Final PEIR

The DBW, as the lead agency under the California Environmental Quality Act (CEQA), has prepared this Final PEIR. This Final PEIR satisfies the procedural, analytical, and public

Exhibit 1-1
The Delta and its Tributaries

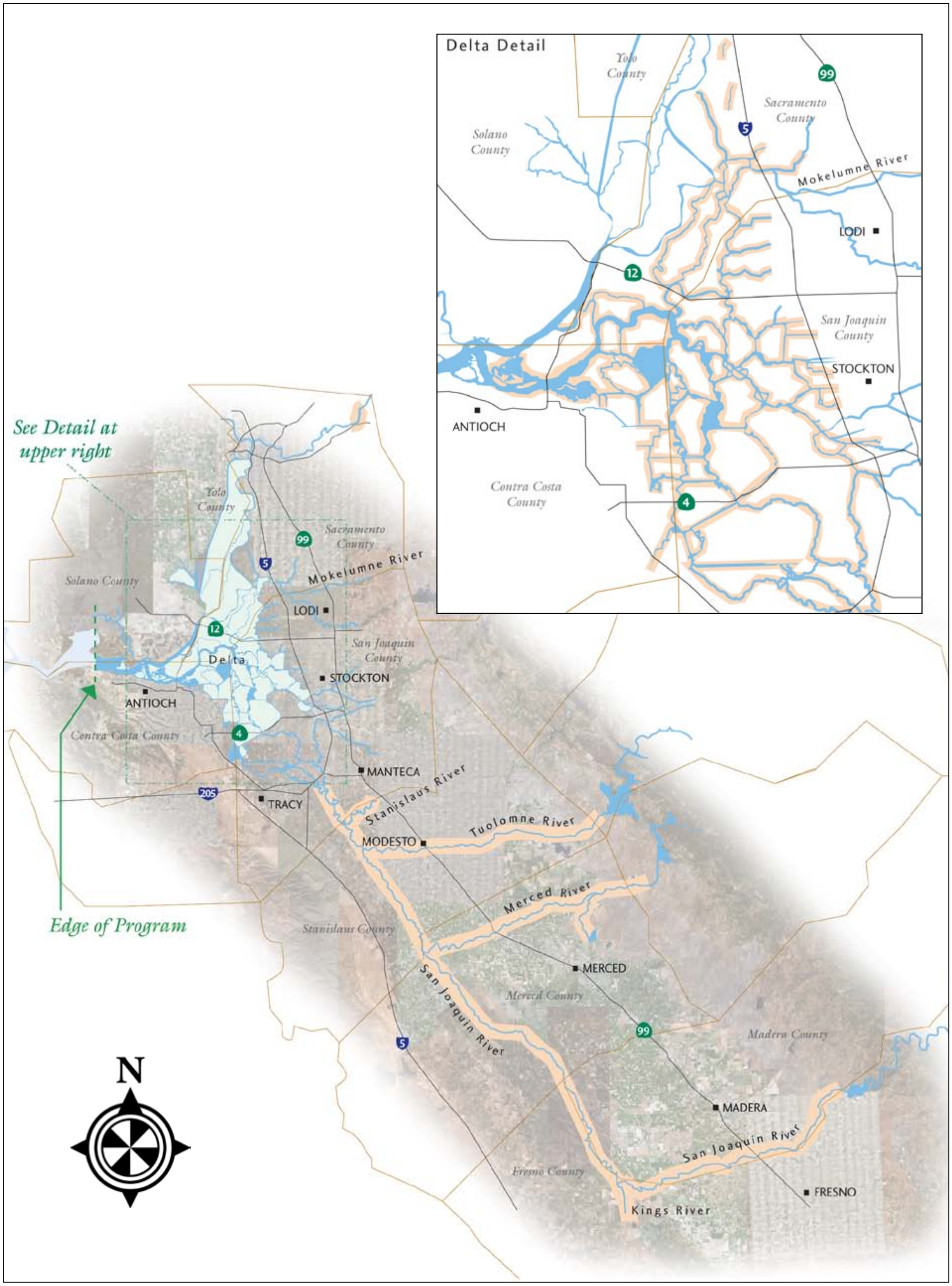
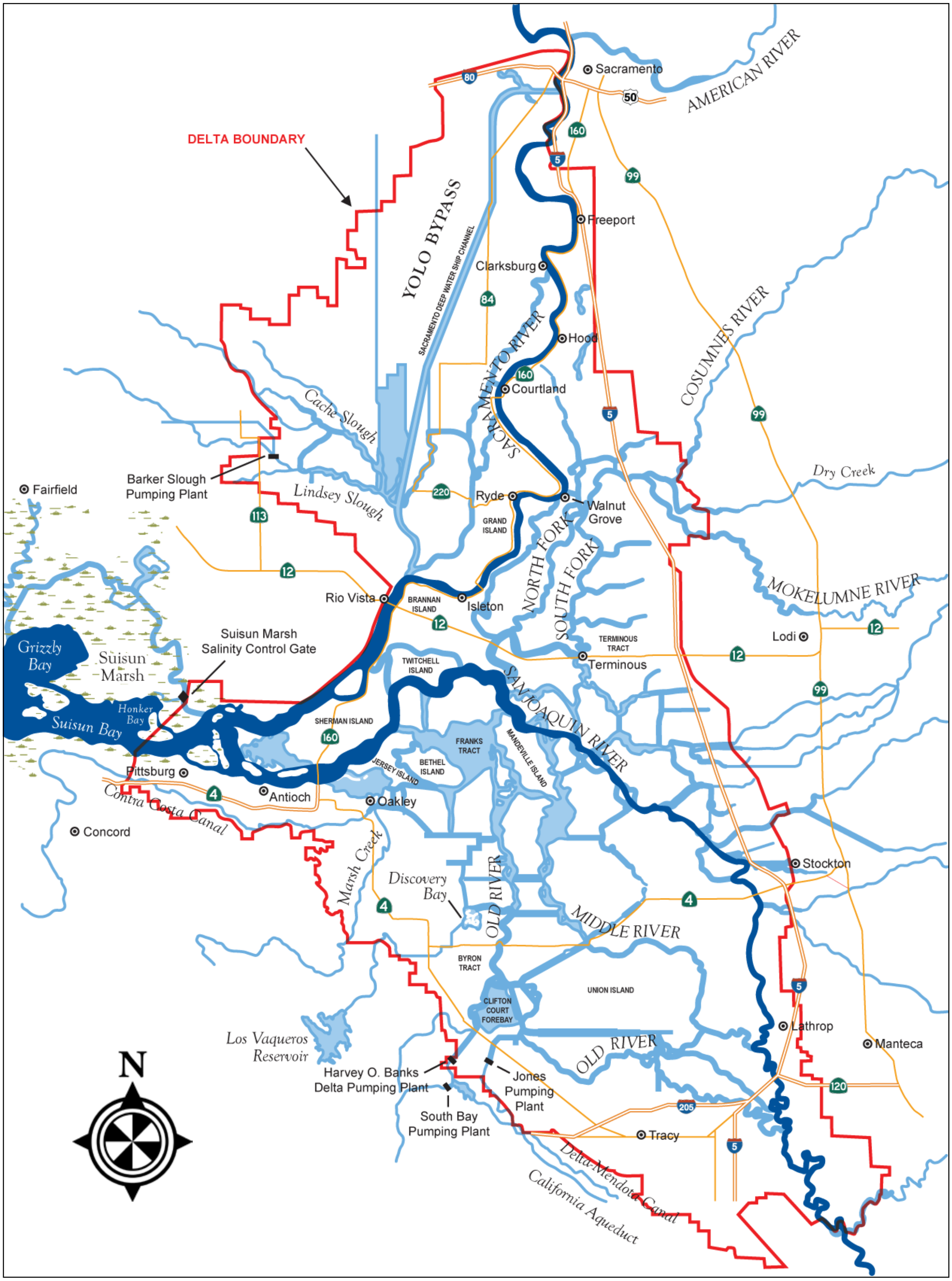


Exhibit 1-2

The Sacramento-San Joaquin Delta Legal Area



disclosure requirements of CEQA. The DBW has prepared this document pursuant to CEQA Guidelines (Title 14. California Code of Regulations, Section 15000 et. seq.). This Final PEIR is a programmatic EIR, as defined in CEQA Guidelines, Section 15168.

This Final PEIR is organized as follows:

Volume I – Chapters 1 to 7

- **Chapter 1: Introduction** – describes the organization and purpose of the Final PEIR. This chapter also provides a history of the WHCP. The chapter includes the environmental factors checklist, followed by a discussion of "less than significant" and "no impact" environmental resource categories.
- **Chapter 2: Program Description and Program Alternatives** – provides a description of the WHCP locations, operations, permits, compliance, and monitoring. This chapter also describes project alternatives, including those that are not considered for further analysis.
- **Chapter 3: Biological Resources Impacts Assessment** – provides descriptions of the environmental setting, potentially significant impacts, and mitigation measures related to WHCP potential impacts on biological resources. This chapter includes discussions of potentially impacted special status species and critical habitats.
- **Chapter 4: Hazards and Hazardous Materials Impacts Assessment** – provides descriptions of the environmental setting, potentially significant impacts, and mitigation measures related to WHCP potential impacts on worker safety and hazardous materials in the environment.
- **Chapter 5: Hydrology and Water Quality Impacts Assessment** – provides descriptions of the environmental setting, potentially significant impacts, and mitigation measures related to WHCP potential impacts on water quality.
- **Chapter 6: Utilities and Service Systems and Agricultural Resources Impacts Assessments** – provides descriptions of the environmental setting, potentially significant impacts, and mitigation measures related to WHCP potential impacts on water utility intake pumps, agricultural crops, and agricultural irrigation pumps.
- **Chapter 7: Cumulative Impacts Assessment** – discusses the potential cumulative impacts of the WHCP when considered in combination with other projects and programs in the Delta.
- **References** – contains references used in the preparation of the Final EIR.

Appendices – the following appendices provide additional information on the environmental review process, technical information that was used in the EIR analysis, and WHCP procedures.

Volume II – Appendices

- **Appendix A: WHCP Permits** – provides copies of the current WHCP National Pollutant Discharge Elimination System (NPDES) permit; and USFWS and NOAA-Fisheries Biological Opinions.
- **Appendix B: WHCP Herbicide Labels and Material Safety Data Sheets** – provides copies of labels and material safety data sheets for WHCP herbicides and adjuvants.
- **Appendix C: WHCP Operations Management Plan** – provides a detailed description of WHCP operations.
- **Appendix D: WHCP Fish Passage Protocol** – provides WHCP procedures to allow for fish passage during treatment.
- **Appendix E: WHCP Environmental Checklist** – provides a checklist reference that can be used by WHCP field workers to help implement the mitigation measures in this PEIR.

Volume III – Findings of Fact and Statement of Overriding Considerations

Volume III of the Final PEIR includes the CEQA requirements related to final approval of the EIR. Volume III is organized as follows:

A. Certification and Notice of Determination
B. Introduction
C. Project Description
D. Administrative Process
E. Findings Related to Significant Effects Reduced to Less than Significant Levels by Mitigation
F. Findings Related to Unavoidable Significant Effects of the WHCP
G. Findings Related to Project Alternatives
H. Statement of Overriding Considerations
I. Mitigation Monitoring and Reporting.

B. Purpose of the WHCP Final PEIR

With preparation of this WHCP Final PEIR, the DBW is updating environmental documentation for the WHCP. When the WHCP was initiated in the early 1980s, the federal and State agencies involved with the program determined that the WHCP did not require an EIR (or Environmental Impact Statement (EIS)).

The DBW's request, the U.S. Army Corps of Engineers provided the program's first formal environmental documentation in 1985. The Army Corps of Engineers prepared an "Environmental Assessment" and "Finding of No Significant Impact" (EA/FONSI) for the WHCP.

The DBW operated the WHCP with no additional environmental documentation until 1999. In 2000, DBW halted water hyacinth treatments in response to legal and regulatory changes.

Legal action from Delta Keepers claimed that the DBW needed a National Pollution Discharge Elimination System (NPDES) permit from the Central Valley Regional Water Quality Control Board (CVRWQB). The NPDES permit was required subsequent to the Talent decision (*Headwaters Inc. vs. Talent Irrigation District*, 2001), in which the 9th Circuit Court of Appeals ruled that aquatic herbicides and chemicals used by water agencies and other water body managers in ditches, canals, and other water bodies were not exempt from NPDES permitting requirements under the Clean Water Act.

Prior to restart of WHCP treatments in 2001, the DBW prepared a Biological Assessment of the WHCP, and obtained an NPDES permit and Section 7 Biological Opinions for the program. These permits required new environmental monitoring and compliance measures, which the DBW has been following since 2001. However, these permits are not as broad as an EIR, and do not provide the same environmental documentation that an EIR provides.

The WHCP has conducted extensive water quality monitoring, toxicity testing, and program evaluation over the last seven years. During this time, the DBW has not conducted a systematic effort to review and evaluate this new program data to analyze the environmental impacts of the WHCP. This Final PEIR provides DBW with the opportunity to conduct such a review.

This Final PEIR for the WHCP provides the DBW with the opportunity to carefully evaluate the program within the current context of the Delta environment and its current treatment practices. Much has changed in the Delta since the WHCP began in 1983. The list of threatened and endangered species has expanded, new (less toxic) aquatic herbicides and adjuvants have been added to the program, and there are significant new water quality and environmental concerns in the Delta.

Finally, this WHCP Final PEIR provides environmental documentation parity with other newer aquatic invasive weed programs. Over the last several years, agencies implementing new aquatic invasive weed control programs in California have prepared EIRs:

- In 2001, the DBW prepared an EIR for the *Egeria densa* Control Program (EDCP)
- In 2003, the State Coastal Commission and U.S. Fish and Wildlife Service prepared an EIR/EIS for the Spartina Control Program

- In 2005, Lake County prepared a PEIR for their Clear Lake Integrated Aquatic Plant Management Plan.

There are three important characteristics of the WHCP which make it somewhat different from many projects or programs that require EIRs. First, like the three aquatic invasive weed programs identified above, the WHCP has long-term beneficial impacts. These beneficial impacts are in contrast to potential short-term detrimental impacts resulting from water hyacinth control alternatives. Discussions of the overall environmental impact of the WHCP must take into account trade-offs between potential short-term negative impacts and long-term positive impacts.

Second, the WHCP is a legislatively mandated State of California program. The Harbors and Navigation Code, Section 64, specifies that it is "necessary that the state, in cooperation with agencies of the United States, undertake an aggressive program for the effective control of water hyacinth and *Egeria densa* in the Delta, its tributaries, and the marsh [Suisun Marsh]." Section 64 further designates the DBW as the lead agency in controlling water hyacinth and *Egeria densa*. The WHCP was implemented in order to address problems created by water hyacinth in the Delta.

Third, the WHCP has been in operation for almost twenty-five years. The program was initiated in 1983, and has successfully operated each year since then, with the exception of 2000. During twenty-four years of WHCP operation without an EIR, the DBW has evaluated the program's environmental impacts, and analyzed various treatment methods.

C. History of the WHCP

In order to provide a perspective on WHCP operations and environmental impacts, this subsection describes the natural history of water hyacinth, and history of the WHCP.

Photo: Water hyacinth.

1. Water Hyacinth in the Sacramento-San Joaquin Delta

Water Hyacinth Background

Water hyacinth (*Eichhornia crassipes*) is a non-native, invasive, free-floating aquatic macrophyte. Aquatic macrophytes are aquatic plants that are large enough to be apparent to the naked eye; in other words they are larger than most algae.

Water hyacinth is often noted in the literature as one of the world's most problematic weeds (Gopal 1987, Cohen and Carlton 1995, Batcher 2000, Lancar and Krake 2002). Native to the Amazon region of South America, it has spread to more than 50 countries on five continents. Water hyacinth creates significant problems in waterways and irrigation canals in Africa and Southeast Asia (Cohen and Carlton 1995, Lancar and Krake 2002).

Water hyacinth was introduced into the United States in 1884 at the Cotton States Exposition in New Orleans when display samples were distributed to visitors and extra plants were released into local waterways. By 1895, water hyacinth had spread across the Southeast and was growing in 40-km long mats that blocked navigation in the St. Johns River in Florida (Cohen and Carlton 1995).

The State of Florida was spending $6 million per year on invasive weed control, primarily water hyacinth, in the 1970s and 1980s (Rockwell 2003). In Fiscal Year 2006/2007, Florida's water hyacinth was in a maintenance control phase, requiring approximately $2 million per year to manage (Florida Department of Environmental Protection 2007).

The invasion of water hyacinth in California was slower than in the Southeast, probably due to water flow stabilization and the more temperate climate in the Delta (Toft 2000).Water hyacinth was first reported in California in 1904 in a Yolo County slough. It spread gradually for many decades, and was reported in Fresno and San Bernardino Counties in 1941 and in the Delta in the late 1940s and early 1950s. There were increased reports of water hyacinth in the Delta region during the 1970s, and by 1981, water hyacinth covered 1,000 acres of the Delta, and 150 of the 700 miles of waterways (U.S. Army Corps of Engineers 1985). Water hyacinth coverage estimates in the Delta since 1981 have ranged from approximately less than 500 acres up to approximately 2,500 acres. This wide range of annual water hyacinth acreage in the Delta is dependent on many factors including: acres treated, timing of treatments, winter air and water temperatures, summer air and water temperatures, water flow, and rainfall.

Water Hyacinth Natural History

Water hyacinth is characterized by showy lavender flowers and thick, highly glossy leaves up to ten inches across. These features have made water hyacinth a favorite in ornamental ponds and it can be readily purchased at aquatic nurseries. The plant grows from 1 ½ to 4 feet in height, and the floating portion of a single plant can grow to more than four feet in diameter. As much as 50 percent of a single water hyacinth's biomass can be roots, which extend to a depth of up to two feet in the water (Batcher 2000).

Water hyacinth grows in wetlands, marshes, shallow ponds, sluggish flowing waters, large lakes, reservoirs, and rivers (Batcher 2000). Water hyacinth often forms monospecific mats across sloughs and other waterways (Batcher 2000, Cohen and Carlton 1995). The mats are dispersed by winds and currents (Batcher 2000). In the Delta, water hyacinth is found in sloughs, connecting waterways, and tributary rivers. The growing season for water hyacinth in the Delta is typically from March to early December. Water hyacinth dies back or reduces growth during the cold winter months. However, the majority of plants do not die, and carry-over plants begin to grow in spring as the weather warms. Plants can tolerate extremes of water level fluctuation and seasonal variations in flow velocity, extremes of nutrient availability, pH, temperature, and toxic substances (Gopal 1987).

Water hyacinth requires freshwater. Water hyacinth will not survive in salinities greater than two parts per thousand (2ppt) (Wilson et al., 2001). Thus, water hyacinth infestations occur in those areas within the Delta with very low salinity. (Freshwater is defined as less than 3ppt, drinking water is less than 1ppt, brackish water is typically defined as between 3ppt and 35ppt, and seawater is 35ppt.) In the Delta, the line at which 2ppt salinity occurs, the X2, fluctuates with tidal levels and water outflow. The X2 line is typically located around Suisun Bay. As a result, water hyacinth generally does not grow in the western portions of the Delta, beyond this zone.

Over the long-term, water management practices in the Delta have reduced the natural variability in Delta salinity. Water exports and releases during the summer months reduce the inflow of San Francisco Bay waters, and maintain low levels of salinity suitable for drinking water and agriculture. This also improves growing conditions and habitat for water hyacinth and other invasive species.

Water hyacinth reproduces both vegetatively and sexually, although most reproduction is thought to be vegetative. In sexual reproduction, seeds may remain viable for up to twenty years, often sprouting along the muddy shorelines after a dry period, and dropping into the water with high tides (Batcher 2000). In vegetative reproduction, short runner stems (stolons) radiate from the base of the plant to form daughter plants (Batcher 2000).

Water hyacinth nursery areas include slow moving waterways, temporarily isolated oxbow lakes, tule stands along channel margins, and stagnant, dead-end sloughs. Small colonies of plants separate and form floating mats that drift downstream, infesting new areas. When water hyacinth extends into faster channels, or when higher flows occur, plants are torn away from their mats and moved by currents and wind until they encounter obstructions such as marinas, irrigation pumps, or backwater areas (U.S. Army Corps of Engineers 1985).

Water hyacinth spreads and grows rapidly under favorable temperature and nutrient conditions (warmer temperatures and higher nutrient levels). Water hyacinth mats weigh up to 200 tons per acre and its surface area may double in size from just six to fifteen days (Harley et al. 1996).

In a study comparing water hyacinth growth and temperature in the Sacramento San Joaquin Delta, Spencer and Ksander found that water hyacinth achieved maximum biomass in October (Spencer and Ksander 2005). This was later than expected, and later than in other regions of the country. Water hyacinth in the Delta increased in height from less than 10 cm in winter and early spring, to more than 80 cm in later summer (Spencer and Ksander 2005). New leaves began growing in March, and by August 7, leaves had reached 50 percent of their maximum leaf area (Spencer and Ksander 2005).

Concerns with Water Hyacinth

Water hyacinth displaces native aquatic plant and animal communities, causes substantial economic hardships, and interferes with water uses (Batcher 2000). Water hyacinth clogging Delta waterways and impeding navigation were an impetus for legislation in 1982 to establish the WHCP. Water hyacinth's negative impacts on ecosystems have only been understood more recently. Like other invasive species control programs, the WHCP must balance the cost of control, the impacts of control, and the benefits resulting from control. Below, we describe problems resulting from the spread of water hyacinth in the Delta.

Concerns Related to Boating and Recreation

In the 1970s and early 1980s, there were a growing number of complaints about water hyacinth by boaters and marina operators in the Delta (U.S. Army Corps of Engineers 1985). Delta marina operations lost an estimated $600,000 in 1981 due to unusable slips and launch ramps, reduced sales, increased rental boat repairs, and labor and equipment costs to deal with the water hyacinth problem according to the San Joaquin Delta Marina Association (U.S. Army Corps of Engineers 1985).

Water hyacinth clogs waterways and impedes navigation, presents a safety hazard to boating and water-skiing, and leads to hull damage when boats collide with obstructions hidden under water hyacinth (U.S. Army Corps of Engineers 1985). As water hyacinth spread in the Delta, many Delta boat harbors and marinas were forced to restrict operations because water hyacinth blocked facilities and damaged boats. Boats were unable to launch due to closed ramps and boat motors were damaged by overheating when water cooling systems become plugged with plant material. The houseboat rental industry and other marina businesses reported reductions in the use of their facilities due to water hyacinth (U.S. Army Corps of Engineers 1985).

Photo: Water hyacinth coverage.

After halting the control program in 2000 in response to the Delta Keepers lawsuit, the DBW received new complaints from marina operators that were unable to launch boats and were losing revenues due to water hyacinth. Even now, in a typical year, the DBW fields numerous complaints concerning water hyacinth. The complaints, received during the spring and summer, are from both marina operators and residents in the Delta.

Without a coordinated effort by the DBW to treat water hyacinth, the potential presently exists for private citizens and marina operators to utilize their own control methods. These *ad hoc* treatments can result in: (1) potentially inappropriate selection of control methods that may not be efficacious; (2) improper application rates for aquatic herbicides; and (3) associated significant adverse impacts to fish, wildlife, and water quality.

The Army Corps of Engineers report also noted that water hyacinth interferes with swimming, fishing from banks in infested areas, and the aesthetic enjoyment of waterways. In addition, real estate values in areas adjacent to water hyacinth covered waterways are reduced (U.S. Army Corps of Engineers 1985).

Concerns Related to Ecosystems

The Delta ecosystem is a critically important part of California's natural environment and the ecological hub of the Central Valley. In addition, it is probably the most invaded ecosystem worldwide, with over 200 invasive non-native species (Cohen and Carlton 1995). Cohen and Carlton found that non-native species accounted for 40 to 100 percent of common species at many sites (Cohen and Carlton 1995).

Water hyacinth is labeled as an invasive habitat modifier. It provides a structurally complex canopy, with roots in the water column and leaves above water providing habitat for both native and non-native species. The CALFED Ecosystem Restoration Program Plan states that "these weeds [water hyacinth] are extremely dangerous because of their ability to displace native plant species, harm fish and wildlife, reduce foodweb productivity, or interfere with water conveyance and flood control systems" (CALFED Vol. 1 2000, p. 462). Similarly, the U.S. Fish and Wildlife Service (USFWS) notes that excessive water hyacinth growth outcompetes native vegetation and clogs waterways, impeding and impairing aquatic life (USFWS 1995).

The dense water hyacinth mats block sunlight, inhibiting photosynthesis in algae and submersed vascular plants (CALFED Vol. 1 ERP 2000, USFWS 1995). Water hyacinth increases sedimentation and accretion of organic matter, inhibits gaseous interchange with the air, reduces water flow, and depletes oxygen, all of which harm other aquatic organisms (CALFED Vol. 1 ERP 2000). In addition, organic fallout can influence the benthic zone (Toft 2000) and alter ecosystem processes such as nutrient cycling, hydrologic conditions, and water chemistry (CALFED Vol. 1 ERP 2000).

In the Stone Lakes National Wildlife Refuge in Sacramento County, the USFWS found that fish and wildlife habitat would be "greatly degraded or lost completely on shorelines, shallow water, and deepwater areas" if water hyacinth was allowed to grow unchecked (USFWS 1995). Even smaller infestations of water hyacinth along shorelines can prevent ducks, turtles, snakes, and frogs from seeking shelter (USFWS 1995).

Toft found significant differences in insect densities in water hyacinth and pennywort (a native aquatic plant), with increased taxa richness and diversity of invertebrates in pennywort in the early summer. While there were a greater number of species present in water hyacinth later in the summer, there were fewer native species (Toft 2000, Toft 2003).

Water hyacinth increases mosquito habitat by providing larval breeding sites where mosquito predators cannot reach (CALFED Vol. 1 2000), creating microhabitats for the vectors of malaria, encephalitis, schistosomiasis (USFWS 1995), and West Nile virus. Water hyacinth also competes with native plants, including Mason's lilaeopsis, a special status species (CALFED Vol. 1 ERP 2000).

Toft and others have found lower levels of dissolved oxygen under water hyacinth canopies. Average spot measures were below 5 mg/L in water hyacinth (the minimum level for fish survival) and above 5 mg/L in pennywort (Toft 2000). These results were supported by a study in Texas which found lower dissolved oxygen in water hyacinth compared to other aquatic weeds, and a University of California Davis study which found dissolved oxygen levels of as low as 0 mg/L below a solid water hyacinth mat (Toft 2000). Toft hypothesizes that the lower dissolved oxygen levels explain the absence of epibenthic amphipods and isopods beneath the water hyacinth canopy at one test site (Toft 2000, Toft 2003).

Concerns Related to Agriculture

Water hyacinth has significant negative impacts on agriculture and water conveyance systems in the Delta. The plant blocks pumping facilities, including those at the Delta Mendota Canal, the Tracy Pumping Plant, and the California Aqueduct near Clifton Court Forebay (U.S. Army Corps of Engineers 1985). In the early years of the control program, the Bureau of Reclamation estimated that the WHCP saved the Bureau $400,000 a year in reduced operating and maintenance costs associated with removing water hyacinth from just the Tracy Pumping Plant (DBW 1991).

Water hyacinth also interferes with pumping at numerous smaller water diversion structures. There are approximately 1,800 irrigation intakes throughout the Delta with the potential for clogging by water hyacinth, resulting in inefficient pumping, increased pumping costs, and possible mechanical failure of pumps. In a letter to the U.S. Army Corps of Engineers in 1981, the San Joaquin Farm Bureau Federation stated that growers were facing increased costs from efforts to open clogged channels where water hyacinth was decreasing the flow of water to pumps and clogging screens. Water hyacinth also spreads into irrigation and drainage systems (U.S. Army Corps of Engineers 1985), and impairs the use of fish protective devices such as fish screens (CALFED Vol. 1 ERP 2000).

2. Water Hyacinth Control Program (1983 to 1999)

Legislation and Start-Up

In 1982, Senate Bill 1344 amended the California Harbors and Navigation Code to designate the California Department of Boating and Waterways as the lead agency for controlling water hyacinth in the Delta, its tributaries, and the Suisun Marsh. Senate Bill 1344 was passed by the legislature and signed by Governor Deukmejian in response to the growing concern over problems created by water hyacinth.

The DBW established an interagency water hyacinth Task Force early on in the WHCP to coordinate the control activities of federal, state, and local interests and to resolve problems and concerns associated with public health and safety, and environmental impacts. The Task Force's primary role was to review results of the previous year's treatment program and to develop and approve the water hyacinth treatment protocol each year. **Table 1-1,** right, identifies agencies represented on the original task force.

Role of Participating Agencies

The DBW has served as the lead agency for local and federal water hyacinth control efforts. In 1981, the DBW asked the U.S. Army Corps of Engineers to assist in controlling water hyacinth in the Delta. In 1985, the Army Corps developed a State Design Memorandum on the Water Hyacinth for the Sacramento-San Joaquin Delta (U.S. Army Corps of Engineers 1985). The report described an operational plan for water hyacinth control based on the prior three years of DBW experience. The DBW was designated as the responsible agency for all control operations under the plan. The Army Corps completed a "Finding of No Significant Impact" (FONSI) for the program and obtained U.S. Fish and Wildlife Service approval in June 1985.[1]

In 1996, the U.S. Fish and Wildlife Service began management of the Stone Lakes Basin Water Hyacinth Control Group. The USFWS obtained approval for Pesticide Use Proposals for aerial and ground applications of 2,4-D and diquat and received an Intraservice Section 7 Evaluation. They have continued to treat Stone Lakes Basin in coordination with the DBW and several local agencies.

The Merced County Agricultural Commissioners Office began a treatment program for water hyacinth on the Merced and San Joaquin Rivers in Merced

Table 1-1
WHCP Original Multi-Agency Task Force Participants (circa 1983 to 2004)

Task Force Participants
California State Agencies
California Department of Boating and Waterways
California Department of Fish and Game
California Central Valley Regional Water Quality Control Board
California State Water Resources Control Board
California Department of Health Services
California Department of Food and Agriculture
California Department of Water Resources
Federal Agencies
U.S. Department of Agriculture – Agricultural Research Service
U.S. Army Corps of Engineers, Army Engineer Waterways Experiment Station
U.S. Bureau of Reclamation
U.S. Fish and Wildlife Service
Local Agencies
Contra Costa County Agricultural Commissioners Office
San Joaquin County Agricultural Commissioners Office
Fresno County Agricultural Commissioners Office
Solano County Agricultural Commissioners Office
Madera County Agricultural Commissioners Office
Merced County Agricultural Commissioners Office
Sacramento County Agricultural Commissioners Office
Stanislaus County Agricultural Commissioners Office
San Luis-Delta-Mendota Water Authority
Marina Recreation Association
Contra Costa Water District
Marina Owners and Operators
Sacramento Regional County Sanitation District.

[1] The FONSI was completed before the listing of several endangered fish species in the Delta.

Photo: Water hyacinth monitoring.

County in 1986. The DBW entered into a formal contract allowing the County to operate the treatment program within Merced County boundaries. By the mid-1990s, the County was able to reduce the amount sprayed to a control level. The DBW provided funding, equipment, materials, and technical support.

In 1996, the Fresno County Agricultural Commissioners Office entered into a similar contract with the DBW to implement a treatment program on the San Joaquin River and Kings River within Fresno County. During 1996, the County conducted surveys of water hyacinth on the San Joaquin River, and in 1997, initiated a treatment program of spraying and limited hand pulling. These affiliated programs followed the DBW Water Hyacinth Control Program protocol and DBW provided monitoring support.

The multi-agency Water Hyacinth Task Force met each year before the treatment season. This group had a significant impact on the design of the WHCP, as the DBW shaped protocols and treatment locations to help meet needs of the various member agencies. The role of the Task Force was less relevant after 2001, when the NPDES permit and biological opinion permits guided the program, and as a result, the Task Force stopped meeting in 2004. The DBW continues to work closely with various State, local, and federal agencies in implementing the WHCP.

Operations and Monitoring

The DBW initiated the WHCP in 1983. The program operated between March and December of each year until December 1999. Using an adaptive management approach, the DBW has revised and improved the WHCP since the program was initiated. This section provides an overview of the treatment program through 1999, including program description, program success, and program monitoring.

After conducting testing in 1982, the DBW treated approximately 500 acres of water hyacinth, primarily in the Central Delta, in 1983. The primary treatment consisted of spraying the systemic herbicide 2,4-D from a small boat using hand-held spray nozzles. The DBW and their partners followed treatment and monitoring protocols developed and approved each year by the Water Hyacinth Task Force.

The first several years of the WHCP focused on bringing water hyacinth under control in the Central Delta and enclosed water bodies. As these areas were controlled, the program focused on waterways in the West, North, and Southern Delta as well as three tributary rivers with severe water hyacinth problems (the San Joaquin, Tuolumne, and Merced Rivers).

The primary treatment method was chemical. Almost 97 percent of the treatment used 2,4-Dichlorophenoxyacetic acid, dimethylamine salt (2,4-D), with limited amounts of diquat and glyphosate used in special circumstances. While the DBW conducted some aerial and ground spraying, treatment typically was conducted with hand-held sprayers applied from 19 to 21 foot aluminum air or outboard motor boats. The boats were equipped for direct metering of herbicides, adjuvants, and water with mechanical pump systems. The pumps forced a mixture of the three components through a chemical resistant hose to a handheld spray gun. Trained field crews sprayed the chemical mixture directly onto the plants.

For the seventeen years between 1983 and 1999, the DBW treated between 160 and 2,700 acres of water hyacinth a year with no known measurable water quality or environmental degradation. Treatment levels varied depending on the number of crews available and the extent of water hyacinth infestation. For the first several years of the WHCP, the DBW had only one or two boat crews treating water hyacinth. Thus, the acres treated in those years were limited by boat crew time, not the amount of water hyacinth.

In the mid-1990s, the DBW was able to increase the number of its treatment crews. By increasing the number of crews, the DBW was able to treat a larger acreage of water hyacinth, and by 1999 the WHCP had reached the program's highest level of control.

If treatment had occurred in 2000, DBW estimated they would have only needed to treat about 200 acres in subsequent years. As water hyacinth was controlled, fewer acres required treatment each year, resulting in reduced herbicide use. **Table 1-2,** right, provides a summary of the acres treated and number of applications between 1983 and 1999.

In the early years of the program, the DBW systematically increased the treatment acres, first bringing the Central Delta and enclosed water bodies under control and then expanding treatment to the North, West, and then South Delta. The

Table 1-2
Historical WHCP Treatment Acreage (1983 to 1999)

	Year	Total Acres	Number of Applications
1	1983	507	
2	1984	244	98
3	1985	166	88
4	1986	227	93
5	1987	384	113
6	1988	633	114
7	1989	849	162
8	1990	699	141
9	1991	350	104
10	1992	798	129
11	1993	1,506	217
12	1994	2,743	287
13	1995	1,826	383
14	1996	2,051	685
15	1997	1,907	657
16	1998	2,434	1,117
17	1999	521	473

1985 WHCP summary report states that the program achieved at least a 99 percent control rate for those waterways east of Antioch, north of Mossdale, and south of Highway 12, the targeted control areas between 1983 and 1985 (DBW 1985).

In 1991, the DBW treated 350 acres in the Delta waterways, only half as much as the previous year (in part due to favorable weather for treating water hyacinth). Treatment in the Central Delta dropped from 492 acres in 1990 to 35 acres in 1991. As the DBW controlled areas such as the Central Delta, they were able to focus efforts on problem areas such as the San Joaquin and Tuolumne Rivers (DBW 1991).

In 1998, five two-person DBW crews concentrated their efforts in the North, West, and Central Delta, obtaining complete coverage within 12 weeks, considered a key milestone in establishing good control early in the season, allowing for a low maintenance control program the remainder of the season (DBW 1998).

In 1999, after several years of intensive treatment with four to five two-person crews, most sites needed only a low maintenance control program, and only 521 acres required treatment, about 20 percent of the previous year's treatment level (DBW 1999).

The original WHCP monitoring program was developed in 1982 by the DBW and Water Hyacinth Task Force members. A subcommittee of the task force developed a protocol for sampling and analysis that was jointly accepted by all participating agencies. The protocol included the adoption of specified methodologies for collecting and analyzing samples, quality control, and the use of split samples. The United States Department of Agriculture – Agricultural Research Service (USDA-ARS) sampled and analyzed pre- and post-treatment water samples for the DBW. The protocol included:

- Replicated sampling for 2,4-D before, and after, pesticide applications were conducted at a minimum of three locations, upstream, within, and downstream of the application site
- Additional sampling conducted at water outtakes near pesticide application areas
- Use of dye tracers with pesticide application to monitor the flow of water from the application site, with sampling conducted where any dye plume reached a water diversion within a two-hour period and at all water diversions within one mile of treatment.

Results of the first eight years of the WHCP monitoring showed very little chemical residue resulting from the program. The sampling protocol was followed between 1983 and 1990. During this time, levels of 2,4-D did not approach or exceed the federal maximum allowable level of 100 parts per billion (ppb). While conducting almost daily sampling at the fixed station site, the Tracy pumping plant had no detectable levels of 2,4-D in all but a few samples.

In 1991, the DBW and the Water Hyacinth Task Force determined that "the ability to control water hyacinth with 2,4-D and without any associated significant 2,4-D residues in Delta water has been established" (DBW 1991). The DBW and their partners stopped intensive daily monitoring and developed a new protocol that would document compliance with allowable levels of 2,4-D.

This 1991 protocol was implemented through 1999. The USDA-ARS conducted the monitoring until 1997. In 1998 and 1999, the California Department of Food and Agriculture Laboratory for Analytical Chemistry provided water sample collecting and analysis. Results were provided to the DBW weekly, or immediately if levels of 2,4-D exceeded criteria. The protocol included:

- Monitoring at three fixed stations: Tracy Pumping Plant, Oakley (Highway 4 and Contra Costa Canal), and the Antioch Water Intake. Samples were taken in duplicate at these stations Monday, Wednesday, and Friday morning. Samples were only obtained at the Antioch Water Intake when water was being pumped for potable use. Only samples taken on Monday and Friday were analyzed. Samples were stored for 30 days in the event that future analysis was needed
- Spot-checks of pesticide levels (pre- and post-monitoring as per the 1985 protocol) were taken once during the first two weeks of spring operations, and at any time if more than 3 contiguous acres were sprayed
- For fixed samples, the action criteria stated that if any duplicate samples averaged over 20 ppb 2,4-D, operations would be suspended until shown that contamination was not the result of operational spraying

Photo: Water hyacinth spraying.

Photo: Water hyacinth control program water sample laboratory analysis..

- For spot samples, if any duplicate post-treatment samples averaged over 50 ppb, operations would be suspended until adjustments were made to reduce levels below 50 ppb.

Between 1991 and 1999, the WHCP resulted in low to no detectable levels of 2,4-D in almost all samples. The vast majority of all samples tested fell below the detectable level of 2,4-D, 0.70 ppb. The highest level found in seven years of recorded analyses was 11.55 ppb, still well below the federal limit of 100 ppb and the state level of 20 ppb.

3. Water Hyacinth Control Program Transition Period (2000)

The DBW, Merced County, and Fresno County halted their control programs in 2000 after a legal action from the Delta Keepers claimed that the DBW must obtain a National Pollutant Discharge Elimination System (NPDES) permit from the Central Valley Regional Water Quality Control Board (CVRWQCB) before discharging pesticides into Delta waterways.

The DBW applied for the NPDES permit in January 2000. The CVRWQCB developed proposed permit conditions for the WHCP; however, in October 2000, the CVRWQCB tabled the application, and the DBW petitioned the State Water Board for a judgment on NPDES appropriateness. In March 2001, the DBW received an individual NPDES permit for the program. Delta Keeper asked a Federal judge for summary judgment rather than take the dispute to trial, and in January 2001, the judge dismissed the case without prejudice.

During the 2000 WHCP hiatus, the DBW worked closely with State and federal agencies to prepare a Biological Assessment and obtain required permits for the program. These original permits (2000 and 2001), and updated versions subsequent, have guided much of the program's operations since the WHCP re-initiated treatments in 2001. We describe permit requirements and current program operations (i.e. 2001 to present) in Chapter 2: Program Description and Program Alternatives.

i The legal definition of the Sacramento-San Joaquin Delta is as follows. These boundaries are reflected in Exhibit 1-2. 12220. The Sacramento-San Joaquin Delta shall include all the lands within the area bounded as follows, and as shown on the attached map prepared by the Department of Water Resources titled "Sacramento-San Joaquin Delta," dated May 26, 1959:

Beginning at the Sacramento River at the I Street bridge proceeding westerly along the Southern Pacific Railroad to its intersection with the west levee of the Yolo By-Pass; southerly along the west levee to an intersection with Putah Creek, then westerly along the left bank of Putah Creek to an intersection with the north-south section line dividing sections 29 and 28, T8N, R6E; south along this section line to the northeast corner of section 5, T7N, R3E; west to the northwest corner of said section; south along west boundary of said section to intersection of Reclamation District No. 2068 boundary at northeast corner of SE 1/4 of section 7, T7N, R3E; southwesterly along Reclamation District No. 2068 boundary to southeast corner of SW 1/4 of section 8, T6N, R2E; west to intersection of Maine Prairie Water Association boundary at southeast corner of SW 1/4 of section 7, T6N, R2E; along the Maine Prairie Water Association boundary around the northern and western sides to an intersection with the southeast corner of section 6, T5N, R2E; west to the southwest corner of the SE 1/4 of said section; south to the southwest corner of the NE 1/4 of section 7, T5N, R2E; east to the southeast corner of the NE 1/4 of said section; south to the southeast corner of said section; west to the northeast corner of section 13, T5N, R1E; south to the southeast corner of said section; west to the northwest corner of the NE 1/4 of section 23, T5N, R1E; south to the southwest corner of the NE 1/4 of said section; west to the northwest corner of the SW 1/4 of said section; south to the southwest corner of the NW 1/4 of section 26, T5N, R1E; east to the northeast corner of the SE 1/4 of section 25, T5N, R1E; south to the southeast corner of said section; east to the northeast corner of section 31, T5N, R2E; south to the southeast corner of the NE 1/4 of said section; east to the northeast corner of the SE 1/4 of section 32, T5N, R2E; south to the northwest corner of section 4, T4N, R2E; east to the northeast corner of said section; south to the southwest corner of the NW 1/4 of section 3, T4N, R2E; east to the northeast corner of the SE1/4 of said section; south to the southwest corner of the NW 1/4 of the NW 1/4 of section 11, T4N, R2E; east to the southeast corner of the NE 1/4 of the NE 1/4 of said section; south along the east line of section 11, T4N, R2E to a road intersection approximately 1000 feet south of the southeast corner of said section; southeasterly along an unnamed road to its intersection with the right bank of the Sacramento River about 0.7 mile upstream from the Rio Vista bridge; southwesterly along the right bank of the Sacramento River to the northern boundary of section 28, T3N, R2E; westerly along the northern boundary of sections 28, 29, and 30, T3N, R2E and sections 25 and extended 26, T3N, R1E to the northwest corner of extended section 26, T3N, R1E; northerly along the west boundary of section 23, T3N, R1E to the northwest corner of said section; westerly along the northern boundary of sections 22 and 21, T3N, R1E to the Sacramento Northern Railroad; southerly along the Sacramento Northern Railroad; southerly along the Sacramento Northern Railroad to the ferry slip on Chipps Island; across the Sacramento River to the Mallard Slough pumping plant intake channel of the California Water Service Company; southward along the west bank of the intake channel and along an unnamed creek flowing from Lawler Ravine to the southern boundary of the Contra Costa County Water District; easterly along the southern boundary of the Contra Costa County Water District to the East Contra Costa Irrigation District boundary; southeasterly along the southwestern boundaries of the East Contra Costa Irrigation District, Byron-Bethany Irrigation District, West Side Irrigation District and Banta-Carbona Irrigation District to the northeast corner of the NW 1/4 of section 9, T3S, R6E; east along Linne Road to Kasson Road; southeasterly along Kasson Road to Durham Ferry Road; easterly along Durham Ferry Road to its intersection with the right bank of the San Joaquin River at Reclamation District No. 2064; southeasterly along Reclamation District No. 2064 boundary, around its eastern side to Reclamation District No. 2075 and along the eastern and northern sides of Reclamation District No. 2075 to its intersection with the Durham Ferry Road; north along the Durham Ferry Road to its intersection with Reclamation District No. 17; along the eastern side of Reclamation District No. 17 to French Camp Slough; northerly along French Camp Turnpike to Center Street; north along Center Street to Weber Avenue; east along Weber Avenue to El Dorado Street; north along El Dorado Street to Harding Way; west along Harding Way to Pacific Avenue; north along Pacific Avenue to the Calaveras River; easterly along the left bank of the Calaveras River to a point approximately 1,600 feet west of the intersection of the Western Pacific Railroad and the left bank of said river; across the Calaveras River and then north 18* 26' 36 west a distance of approximately 2,870 feet; south 72* 50' west a distance of approximately 4,500 feet to Pacific Avenue (Thornton Road); north along Pacific Avenue continuing onto Thornton Road to its intersection with the boundary line dividing Woodbridge Irrigation District and Reclamation District No. 348; east along this boundary line to its intersection with the Mokelumne River; continuing easterly along the right bank of the Mokelumne River to an intersection with the range line dividing R5E and R6E; north along this range line to the Sacramento-San Joaquin County line; west along the county line to an intersection with Reclamation District No. 1609; northerly along the eastern boundary of Reclamation District No. 1609 to the Cosumnes River, upstream along the right bank of the Cosumnes River to an intersection with the eastern boundary of extended section 23, T5N, R5E; north along the eastern boundary of said extended section to the southeast corner of the NE 1/4 of the NE 1/4 of said extended section; west to the southeast corner of the NE 1/4 of the NW 1/4 of extended section 14, T5N, R5E; west to an intersection with Desmond Road; north along Desmond Road to Wilder-Ferguson Road; west along Wilder-Ferguson Road to the Western Pacific Railroad; north along the Western Pacific Railroad to the boundary of the Elk Grove Irrigation District on the southerly boundary of the N 1/2 of section 4, T5N, R5E; northerly along the western boundary of the Elk Grove Irrigation District to Florin Road; west on Florin Road to the eastern boundary of Reclamation District No. 673; northerly around Reclamation District No. 673 to an intersection with the Sacramento River and then north along the left bank of the Sacramento River to I Street bridge. Section, range, and township locations are referenced to the Mount Diablo Base Line and Meridian. Road names and locations are as shown on the following United States Geological Survey Quadrangles, 7.5 minute series: Rio Vista, 1953; Clayton, 1953; Vernalis, 1952; Ripon, 1952; Bruceville, 1953; Florin, 1953; and Stockton West, 1952.

Chapter 2

Program Description and Program Alternatives

2. Program Description and Program Alternatives

This chapter of the Final PEIR describes WHCP objectives, program alternatives, and the selected control alternative. This chapter is organized as follows:

A. Program Overview and Objectives
B. Program Area
C. Program Alternatives
D. Selected Program Approach.

A. Program Overview and Objectives

The goal of the WHCP is to keep waterways safe and navigable by controlling the growth and spread of water hyacinth in the Delta and its surrounding tributaries. Because of the persistence of water hyacinth in the Delta, the WHCP legislative mandate is for control, rather than eradication of water hyacinth. The primary purpose of the WHCP is to control the growth and spread of water hyacinth in order to minimize negative impacts of the plant on navigation, recreation, and agricultural activities in Delta waterways. The DBW seeks to manage water hyacinth growth while (1) minimizing non-target plant and species impacts and (2) preventing environmental degradation in Delta waterways and tributaries.

Through the WHCP, the DBW clears water hyacinth and maintains adequate navigation channels for Delta users; and clear water hyacinth areas surrounding marinas, launch ramps, pumping facilities, and intake pipes. Another important WHCP objective is to improve habitat for native species by reducing the negative impacts of water hyacinth on surrounding ecosystems. This objective links directly to the CALFED Ecosystem Restoration Program (CALFED 2000).[1] By clearing Delta water hyacinth, DBW contributes to the creation of shallow-water habitat suitable for native species.

The DBW utilizes treatment protocols that balance the need to control water hyacinth with the need to minimize resulting environmental impacts to Delta waterways. **Table 2-1,** on the next page, identifies a total of ten specific objectives for the WHCP. Table 2-1 also identifies performance measures (i.e. expected outcomes) that the DBW uses to evaluate success of the WHCP in meeting these project objectives.

The WHCP currently operates under the following three permits:

- NPDES Statewide General Permit (CAG990005)

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[1] The CALFED Ecosystem Restoration Program Plan Objective 5 states: "Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed."

Table 2-1
WHCP Objectives and Performance Measures

Objectives	Performance Measures
1. Limit future growth and spread of water hyacinth in the Delta 2. Improve boat and vessel navigation in the Delta 3. Utilize the most efficacious treatment methods available with the least environmental impacts 4. Prioritize sites so that WHCP activities are focused on sites with a high degree of infestation, as well as navigational, agricultural, or recreational significance 5. Employ a combination of control methods to allow maximum program flexibility 6. Improve the WHCP as more information is available on appropriate control methods for the Delta 7. Monitor results of the WHCP to fully understand impacts of the WHCP on the environment 8. Improve shallow-water habitat for native species by controlling water hyacinth 9. Decrease WHCP control efforts, if sufficient efficacy of water hyacinth treatment is realized 10. Minimize use of control methods that could cause adverse environmental impacts.	■ Reduce total acres infested with water hyacinth ■ Reduce water hyacinth biomass at high priority navigation sites currently infested with water hyacinth ■ Reduce water hyacinth biomass at nursery sites ■ Prevent water hyacinth infestation of new sites ■ Produce fewer incidents of boat navigation, agricultural, and recreation problems related to water hyacinth ■ Prepare reports for regulatory agencies and the public summarizing WHCP monitoring results ■ Minimize WHCP environmental impacts, as measured by compliance with program permits ■ Increase efficacy of the WHCP, and of each control method over time ■ Increase the number of shallow-water sites suitable for native species ■ Limit the number of, and significance of, environmental impacts resulting from the WHCP ■ Limit the number of WHCP acres treated with methods that have the potential for adverse environmental impacts ■ Reduce the quantity of herbicides and adjuvants applied to the Delta over time.

- USFWS Biological Opinion (1-1-04-F-0149)
- National Oceanic and Atmospheric Administration-Fisheries (NOAA-Fisheries) Biological Opinion (151422SWR2005SA00681:JSS).

These permits substantially guide current program operations, and are described in Subsection D.

B. Program Area

The WHCP includes portions of eleven counties that encompass much of the Sacramento-San Joaquin Delta and its upland tributaries. The eleven counties include: Alameda, Contra Costa, Fresno, Madera, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Tuolumne, and Yolo. The general boundaries for the treatment area in the Delta and its tributaries are as follows:

- West up to and including Sherman Island, at the confluence of the Sacramento and San Joaquin Rivers;
- West up to the Sacramento Northern Railroad to include water bodies north of the southern confluence of the Sacramento River and Sacramento River Deep Water Ship Channel;
- North to the northern confluence of the Sacramento River and Sacramento River Deep Water Ship Channel, plus waters within Lake Natoma;
- South along the San Joaquin River to Mendota, just east of Fresno;
- East along the San Joaquin River to Friant Dam on Millerton Lake;
- East along the Tuolumne River to LaGrange Reservoir below Don Pedro Reservoir; and
- East along the Merced River to Merced Falls, below Lake McClure.

Within the WHCP project area, there are approximately 368 possible treatment sites that average between one and two miles in length. **Exhibit 2-1,** on the following pages, provides a map of the WHCP project area.

Exhibit 2-1a

WHCP Project Area Map – Northern Sites

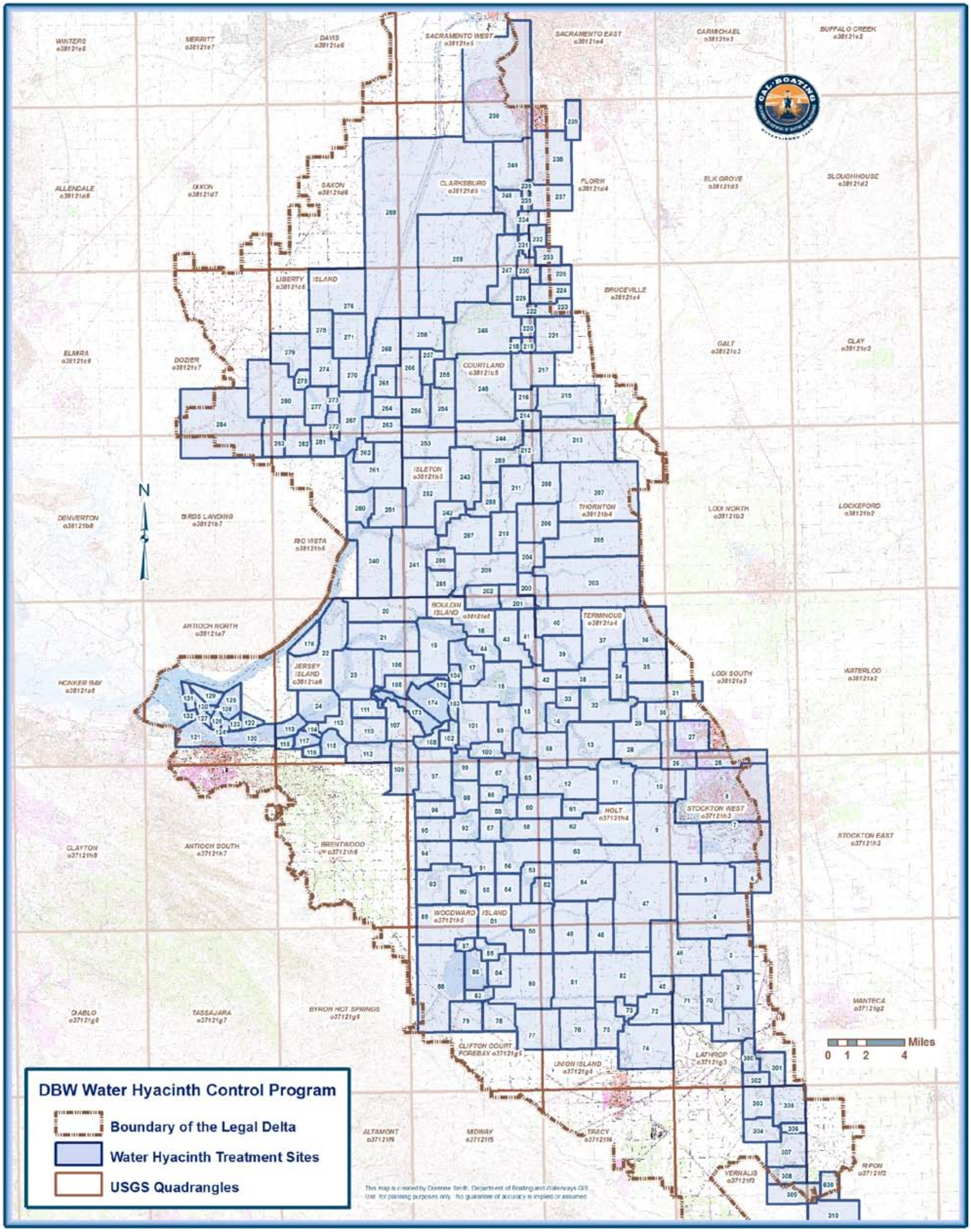

Exhibit 2-1b

WHCP Project Area Map – Southern Sites

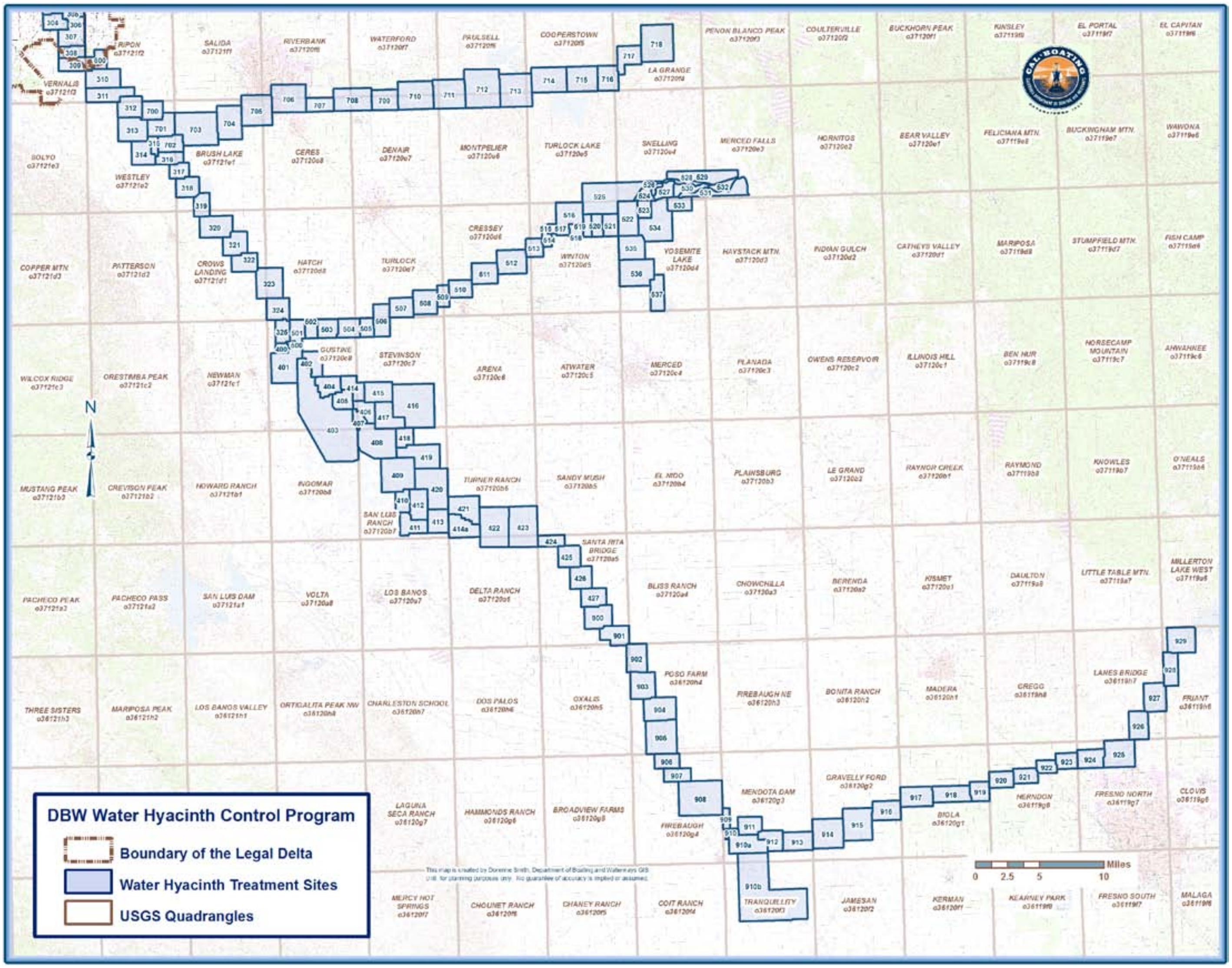

Table 2-2, starting on the next page, provides a listing of the approximately 369 WHCP treatment sites.

C. Program Alternatives

CEQA requires that an EIR discuss a reasonable range of alternatives that could avoid, or substantially lessen, the significant environmental impacts of the proposed program, even if the alternative might impede to some degree attainment of program objectives, or the alternative would be more costly. The discussion of each program alternative should provide sufficient information about each alternative to allow meaningful evaluation, analysis, and comparison with the proposed program. An EIR must also evaluate the impacts of the "No Program Alternative" to allow decision makers to compare the impacts of approving the proposed program with the impacts of not approving the proposed program.

This subsection identifies, discusses, and compares program alternatives for controlling water hyacinth in the Delta and surrounding tributaries, including the selected alternative and a No Program Alternative. This subsection also briefly discusses alternatives that the DBW considered, but rejected as infeasible. **Table 2-3,** on page 2-11, provides a summary of the expected impacts of program alternatives 2 through 6 on the five resource areas for which the WHCP has potentially significant impacts.

In over twenty-five years of operating the WHCP, the DBW has examined and tested a broad range of potential control methods. Reflecting an adaptive management approach, the WHCP has evolved during this time to incorporate new information and experience. The selected WHCP alternative reflects this experience, and provides flexibility to continue to adapt the program over time.

Program Alternative 1 (Selected Alternative) – Integrated Management

The selected program alternative consists of an integrated management approach, emphasizing chemical treatment, with limited handpicking and herding, and continued assessment of biological controls. Selected herbicides are 2,4-D and glyphosate, with 2,4-D to be used for the majority of treatments. Both herbicides are applied with an adjuvant, Agridex®. The DBW will continue to research and evaluate other less toxic herbicides and adjuvants, including the vegetable oil based adjuvant, Competitor®.

The DBW will conduct handpicking as required, particularly when chemical treatments are not allowed. The DBW is currently completing a three-year cost-benefit analysis of the handpicking program. The results of this study will be incorporated into the hand-picking program.

The DBW will conduct limited herding, typically during the winter, when chemical treatments are not allowed. Herding will generally be limited to locations in the west Delta, near Antioch, and only when weather and water conditions are appropriate.

The DBW is also working with the United States Department of Agriculture – Agricultural Research Service (USDA-ARS) and the California Department of Food and Agriculture (CDFA) to establish viable biological control methods for water hyacinth. These research efforts currently focus on identifying water hyacinth pathogens (e.g. fungi).

For each particular season and treatment site, DBW will evaluate characteristics of the site, and select the most appropriate treatment option(s).

The selected program alternative is guided by the general NDPES permit and USFWS and NOAA-Fisheries biological opinions issued for the program. Subsection D of this chapter describes the approach, permits, operations, and environmental monitoring for program alternative 1 in more detail.

Table 2-2
WHCP Treatment Sites

Site Number(s)	County	Location	Water Type(s)
1, 2, 3, 4, 5	San Joaquin	■ San Joaquin River	■ Tidal
6	San Joaquin	■ French Camp Slough ■ Walker Slough	■ Tidal ■ Tidal
7	San Joaquin	■ San Joaquin River	■ Tidal
8	San Joaquin	■ Mormon Slough ■ San Joaquin River- Stockton Deep Water Channel	■ Tidal ■ Tidal
9	San Joaquin	■ Burns Cutoff	■ Tidal
10	San Joaquin	■ Buckley Cove ■ San Joaquin River- Stockton Deep Water Channel	■ Tidal ■ Tidal
11	San Joaquin	■ Black Slough ■ Black Slough Landing ■ Fourteen Mile Slough ■ San Joaquin River	■ Tidal ■ Tidal ■ Tidal ■ Tidal
12	San Joaquin	■ Turner Cut	■ Tidal
13	San Joaquin	■ Heypress Reach ■ Hog Island Cut ■ San Joaquin River- Stockton Deep Water Channel ■ Twentyone Mile Cut	■ Tidal ■ Tidal ■ Tidal
14	San Joaquin	■ San Joaquin River	■ Tidal
15	San Joaquin	■ Empire Tract Slough	■ Tidal
16	San Joaquin	■ Mandeville Cut ■ Mandeville Reach ■ San Joaquin River- Stockton Deep Water Channel ■ Three River Reach ■ Venice Cut ■ Venice Reach	■ Tidal ■ Tidal ■ Tidal ■ Tidal ■ Tidal ■ Tidal
17	San Joaquin	■ Potato Slough	■ Tidal
18	San Joaquin	■ Mokelumne River	■ Tidal
19	Contra Costa	■ San Joaquin River	■ Tidal
20	Sacramento	■ San Joaquin River ■ Seven Mile Cut	■ Tidal ■ Tidal
21	Contra Costa Sacramento	■ San Joaquin River	■ Tidal
22	Sacramento	■ Sacramento River ■ Three Mile Slough	■ Tidal ■ Tidal
–	Sacramento	■ Lake Natoma	■ Slow-moving

Table 2-2
WHCP Treatment Sites *(continued)*

Site Number(s)	County	Location	Water Type(s)
23	Contra Costa Sacramento	■ False River ■ San Joaquin River	■ Tidal ■ Tidal
24	Contra Costa Sacramento	■ San Joaquin River	■ Tidal
25	San Joaquin	■ Fourteen Mile Slough	■ Tidal
26, 28, 29	San Joaquin	■ Fourteen Mile Slough	■ Tidal
27	San Joaquin	■ Five Mile Slough	■ Tidal
30	San Joaquin	■ Mosher Slough	■ Tidal
31	San Joaquin	■ Bear Creek ■ Disappointment Slough ■ Pixley Slough	■ Tidal ■ Tidal ■ Tidal
32, 33	San Joaquin	■ Disappointment Slough	■ Tidal
34	San Joaquin	■ Bishop Cut	■ Tidal
35	San Joaquin	■ Telephone Cut	■ Tidal
36, 37, 39	San Joaquin	■ White Slough	■ Tidal ■ Tidal
38	San Joaquin	■ Bishop Cut	■ Tidal
40, 41	San Joaquin	■ Little Potato Slough	■ Tidal
42	San Joaquin	■ Little Connection Slough	■ Tidal
43, 44	San Joaquin	■ Potato Slough	■ Tidal
45, 46, 47, 48, 49, 52, 53, 56, 58, 59, 66, 67, 68	San Joaquin	■ Middle River	■ Tidal
50, 51	San Joaquin	■ North Canal ■ Victoria Canal	■ Tidal
54, 55	San Joaquin	■ North Victoria Canal ■ Woodard Canal	■ Tidal ■ Tidal
57	San Joaquin	■ Railroad Cut	■ Tidal
60	San Joaquin	■ Empire Cut	■ Tidal
61, 62, 63	San Joaquin	■ Whiskey Slough	■ Tidal
64	San Joaquin	■ Trapper Slough	■ Tidal
65	San Joaquin	■ Latham Slough	■ Tidal
69	San Joaquin	■ Connection Slough ■ Middle River	■ Tidal
70, 71	San Joaquin	■ Old River	■ Tidal
72	San Joaquin	■ Old River ■ Paradise Cut	■ Tidal

Table 2-2
WHCP Treatment Sites *(continued)*

Page 3 of 5

Site Number(s)	County	Location	Water Type(s)
73	San Joaquin	■ Old River ■ Paradise Cut ■ Salmon Slough	■ Tidal ■ Tidal ■ Tidal
74	San Joaquin	■ Sugar Cut ■ Tom Paine Slough	■ Tidal ■ Tidal
75, 76, 77, 78, 79, 83, 84, 85, 87, 89, 90, 91, 92, 98, 99	San Joaquin	■ Old River	■ Tidal
80, 81, 82	San Joaquin	■ Fabian & Bell Canal ■ Grant Line Canal	■ Tidal
86	Contra Costa	■ Old River ■ West Canal	■ Tidal ■ Tidal
88	Contra Costa	■ Italian Slough	■ Tidal
93	Contra Costa	■ Indian Slough	■ Tidal
94, 95, 96	Contra Costa	■ Warner Dredger Cut	■ Tidal
97	Contra Costa	■ Rock Slough	■ Tidal
100	San Joaquin	■ Connection Slough ■ Old River	■ Tidal
101	San Joaquin	■ Old River	■ Tidal
102	Contra Costa	■ Sheep Slough	■ Tidal
103, 104	Contra Costa San Joaquin	■ Old River	■ Tidal
105	Contra Costa	■ False River	■ Tidal
106	Contra Costa	■ Fishermen's Cut	■ Tidal
107	Contra Costa	■ Piper Slough	■ Tidal
108	Contra Costa	■ Roosevelt Cut ■ Sand Mound Slough	■ Tidal
109	Contra Costa	■ Sand Mound Slough	■ Tidal
110, 111	Contra Costa	■ Taylor Slough	■ Tidal
112	Contra Costa	■ Dutch Slough ■ Emerson Slough	■ Tidal ■ Tidal
113, 114	Contra Costa	■ Dutch Slough	■ Tidal
115, 116, 117, 118	Contra Costa	■ Big Break	■ Tidal
119, 120, 121	Contra Costa Sacramento	■ San Joaquin River	■ Tidal
122, 123, 124, 125, 126, 127, 128, 129, 130, 131	Sacramento	■ Sherman Lake	■ Tidal
176	Solano	■ Sacramento River-Decker Island	■ Tidal
200, 201, 202, 204, 206, 208	San Joaquin	■ South Mokelumne River	■ Tidal

Table 2-2
WHCP Treatment Sites *(continued)*

Site Number(s)	County	Location	Water Type(s)
203	San Joaquin	■ Sycamore Slough	■ Tidal
205	San Joaquin	■ Hog Slough	■ Tidal
207	San Joaquin	■ Beaver Slough	■ Tidal
209, 210, 211, 213	Sacramento San Joaquin	■ North Mokelumne River	■ Tidal
214, 215, 216, 217, 218, 219	Sacramento	■ Snodgrass Slough	■ Tidal
220, 221, 222, 223, 224, 225, 226, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239	Sacramento	■ Stone Lakes	■ Tidal
300, 302, 303, 304, 305, 306, 307, 308, 309	San Joaquin	■ San Joaquin River	■ Fast or slow-moving
301	San Joaquin	■ Welthall Slough	■ Fast or slow-moving
310, 313, 314, 316, 318, 319, 320, 321, 322, 323	Stanislaus	■ San Joaquin River	■ Fast or slow-moving
316	Stanislaus	■ Brush Lake	■ Fast or slow-moving
311, 312	Stanislaus	■ Finnegan Cut ■ San Joaquin River	■ Fast or slow-moving
315	Stanislaus	■ Laird Slough	■ Fast or slow-moving
317	Stanislaus	■ Del Puerto Creek ■ San Joaquin River	■ Fast or slow-moving
320	Stanislaus	■ Lake Ramona	■ Fast or slow-moving
324, 325	Merced Stanislaus	■ San Joaquin River	■ Fast or slow-moving
401, 403, 414, 415, 417, 418, 419, 421, 422, 423, 424, 425, 426, 427	Merced	■ San Joaquin River	■ Fast or slow-moving
402	Merced	■ Snag Slough ■ San Joaquin River	■ Fast or slow-moving
404	Merced	■ San Joaquin River	■ Fast or slow-moving
405, 406, 407, 408, 409, 410, 412, 413	Merced	■ Salt Slough	■ Fast or slow-moving
414	Merced	■ Poso Slough ■ Salt Slough	■ Fast or slow-moving
411	Merced	■ Mud Slough	■ Fast or slow-moving
416	Merced	■ Bear Creek ■ Bravel Slough	■ Fast or slow-moving
500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 517, 518, 519, 520, 521, 522, 523, 524, 526, 527, 530, 532	Merced	■ Merced River	■ Fast or slow-moving
516	Merced	■ Ingalsbe Slough ■ Hope Town Slough	■ Fast or slow-moving
525	Merced	■ Ingalsbe Slough	■ Fast or slow-moving

Table 2-2
WHCP Treatment Sites *(continued)*

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Site Number(s)	County	Location	Water Type(s)
528, 529	Merced	■ Merced River ■ North Canal	■ Fast or slow-moving
531, 533, 537	Merced	■ Main Canal	■ Fast or slow-moving
534, 535	Merced	■ Main Canal ■ Canal Creek	■ Fast or slow-moving
536	Merced	■ Main Canal ■ Parkinson Creek	■ Fast or slow-moving
600	Stanislaus	■ Stanislaus	■ Fast or slow-moving
700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718	Stanislaus	■ Tuolumne River	■ Fast or slow-moving
900, 901, 902, 903, 904, 905, 909, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929	Fresno	■ San Joaquin River	■ Fast or slow-moving
910	Fresno	■ San Joaquin River ■ Mendota Pool	■ Fast or slow-moving
910A, 910B	Fresno	■ Fresno Slough ■ Kings River	■ Fast or slow-moving

Program Alternative 2 – Chemical Control Only

The chemical control only alternative would include only the chemical control aspects of the selected program alternative. The DBW would utilize 2,4-D and glyphosate to treat water hyacinth, following existing program operational requirements. This alternative would not include handpicking or the ongoing evaluation or use of biological control agents.

The chemical control only alternative would result in all of the alternative 1 potential impacts related to use of herbicides, without the additional flexibility that an integrated management approach would provide. This chemical only approach would not allow for adaptive adjustment of treatment methods to site-specific and season-specific needs and requirements. In addition, the chemical only approach would not provide any treatment alternatives during the majority of the year, when chemical treatments are limited or prohibited.

Program Alternative 3 – Handpicking Only

The handpicking only alternative would include expanded, year-round, handpicking of water hyacinth. The current handpicking program is generally conducted only from November through February. Two-person field crews utilize boats, 30-gallon barrels, and lawn-grooming rakes for handpicking. Each crew consists of one person driving the boat and one person handpicking water hyacinth. The crew member would use the lawn-groom rake to collect water hyacinth and place it in 30-gallon barrels.

Once the 30-gallon barrels are filled, field crews would locate a dispersal area. Dispersal areas are defined as levees or other previously surveyed areas with no- and low-habitat values to the federal and state listed threatened giant garter snake (*Thamnophis gigas*). Dispersal would also be located at least 100 feet away from elderberry

Table 2-3
Comparison of WHCP Alternatives

Resource	Program Alternative 2 Chemical Control Only	Program Alternative 3 Handpicking Only	Program Alternative 4 Biological Control Only	Program Alternative 5 Mechanical Harvesting Only	Program Alternative 6 No Program Alternative
1. Biological Resources	Under alternative 2, there would be the same potential impacts to biological resources due to herbicide use as discussed in Chapter 3, for the selected program alternative.	Under alternative 3 there would be no biological impacts due to herbicide use. Handpicking would not result in impacts to biological resources, however the increased growth in water hyacinth due to the inability of handpicking to effectively control the plant could result in direct and indirect negative impacts to biological resources.	Under alternative 4 there would be no biological impacts due to herbicide use. Biological control would not result in impacts to biological resources, however the increased growth in water hyacinth due to the inability of biological control to effectively manage the plant could result in direct and indirect negative impacts to biological resources.	Under alternative 5 there would be no biological impacts due to herbicide use, however there is the potential for harvesting to kill, injure, or disturb mammals, birds, reptiles, amphibians, fish, and insects, and to damage or kill plants. This would result in potentially significant impacts to biological resources.	Under the no program alternative, uncontrolled growth of water hyacinth would result in direct and indirect negative impacts to Delta ecosystems, fish habitat, and special status fish and plant species. To the extent that local landowners would conduct ad hoc chemical treatments, there would be additional potentially significant impacts to biological resources.
2. Hazards and Hazardous Materials	Under alternative 2, there would be the same potential impacts related to hazards and hazardous materials due to herbicide use as discussed in Chapter 4, for the selected program alternative.	Alternative 3 would result in no impacts related to hazards and hazardous materials.	Alternative 4 would result in no impacts related to hazards and hazardous materials.	Alternative 5 would result in no impacts related to hazards and hazardous materials.	Under the no program alternative, there would be no impacts related to hazards and hazardous materials.
3. Hydrology and Water Quality	Under alternative 2, there would be the same potential impacts to hydrology and water quality due to herbicide use as discussed in Chapter 5, for the selected program alternative.	Alternative 3 would result in no impacts to hydrology and water quality.	Alternative 4 would result in no impacts to hydrology and water quality.	Alternative 5 would not have a significant impact on Delta water quality or nutrient loading. There would be temporary impacts on turbidity, and potential localized temporary reductions in DO levels as cut plants decomposed.	Under the no program alternative, uncontrolled growth of water hyacinth could result in reduced DO levels under water hyacinth mats, however there would be no impacts to water quality due to herbicide treatments.

Table 2-3
Comparison of WHCP Alternatives *(continued)*

Page 2 of 2

Resource	Program Alternative 2 Chemical Control Only	Program Alternative 3 Handpicking Only	Program Alternative 4 Biological Control Only	Program Alternative 5 Mechanical Harvesting Only	Program Alternative 6 No Program Alternative
4. Utilities and Service Systems	Under alternative 2, there would be the same potential impacts to utilities and service systems due to herbicide use as discussed in Chapter 6, for the selected program alternative.	Under alternative 3, there would be less control of water hyacinth than under the selected program alternative. This would potentially result in significant impacts to utility pump systems due to clogging by water hyacinth plants.	Under alternative 4, there would be less control of water hyacinth than under the selected program alternative. This would potentially result in significant impacts to utility pump systems due to clogging by water hyacinth plants.	Alternative 5 would potentially negatively affect utility pump systems, due to increased concentrations of plant fragments following harvesting. If harvested water hyacinth was removed from the water, this alternative would increase solid waste generation, with potentially significant impacts.	Under the no program alternative, uncontrolled growth of water hyacinth would result in potentially significant impacts to utility pump systems due to clogging by water hyacinth plants.
5. Agricultural Resources	Under alternative 2, there would be the same potential impacts to agricultural resources due to herbicide use as discussed in Chapter 6 for the selected program alternative.	Under alternative 3, there would be less control of water hyacinth than under the selected program alternative. This would potentially result in significant impacts to agricultural irrigation systems due to clogging by water hyacinth plants. There would be no potential for negative impacts to crops due to herbicide treatments.	Under alternative 4, there would be less control of water hyacinth than under the selected program alternative. This would potentially result in significant impacts to agricultural irrigation systems due to clogging by water hyacinth plants. There would be no potential for negative impacts to crops due to herbicide treatments.	Alternative 5 would potentially negatively affect agricultural irrigation systems, due to increased concentrations of plant fragments following harvesting. There would be no potential for negative impacts to crops due to herbicide treatments.	Under the no program alternative, uncontrolled growth of water hyacinth would result in potentially significant impacts to agricultural irrigation systems due to clogging by water hyacinth plants. There would be no potential for negative impacts to crops due to herbicide treatments.

shrubs (*Sambucus* ssp.) that are potential habitat for the federally threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*).

The DBW would leave water hyacinth in these dispersal areas to desiccate naturally, and DBW would periodically monitor the dispersal areas to observe and record the fate of the water hyacinth and any effects of dispersal activities.

Handpicking avoids all impacts resulting from application of herbicides. Handpicking is likely to result in impacts to utilities and agricultural irrigation due to the release of small plants that are not captured by raking.

While handpicking only volumes would be relatively low, a handpicking only alternative would potentially result in solid waste impacts, as more water hyacinth would be deposited on shorelines.

Handpicking only would result in fewer recreational and ecosystem benefits, as compared to the selected program alternative, because significantly less water hyacinth would be controlled in any given year.

While handpicking provides a viable option to control water hyacinth during the winter months, and in areas when chemicals cannot be used, handpicking alone is not a feasible program alternative. Problems with this alternative include: high cost and labor requirements, potential solid waste impacts, and relatively low acres managed.

Program Alternative 4 – Biological Control Only

Biological control is the use of biological agents, typically insects or pathogens, to control undesirable plants. The biological control only alternative would consist of expanded introduction of the water hyacinth weevil, *Neochetina bruchi*, as well as other biological control agents (the moth, *Sameodes albiguttailis*, and/or new agents as they are developed and approved) into the Delta. As the history of biological control agents in the Delta illustrates, this alternative is not likely to result in substantial control of water hyacinth.

In 1982, the USDA-ARS first released the water hyacinth-eating weevil, *Neochetina bruchi*, in the Delta. Following the initial releases of *Neochetina bruchi*, USDA-ARS released other host-specific species (*Neochetina eichhorniae* and *Sameodes albiguttailis*).

Recent surveys have shown that *Neochetina bruchi* is the only species to have survived and spread throughout the Delta. However, the small size of *Neochetina bruchi* populations have failed to effectively control water hyacinth. Between 2003 and 2006, the DBW contracted with the California Department of Food and Agriculture to examine populations of *Neochetina bruchi* in an effort to understand the impacts and dynamics of *Neochetina bruchi* populations in the Delta.

A California Department of Food and Agriculture study demonstrated the challenge of biological control in the Delta (Akers and Pitcairn 2006). The study found that there is essentially a mismatch between the life cycle of the weevil, and the climate and growing cycle of water hyacinth in the Delta. Weevils have limited survival during the winter, because the 7°C average temperature in the Delta (Akers and Pitcairn 2006) is well below *Neochetina bruchi* optimum feeding and oviposition temperatures, at 30°C (Julien 2001).

In the spring, when water hyacinth starts to grow rapidly, weevil populations are too low to effectively damage the plant. In October, when the weevil population has increased to a level where it might provide some control, the plant is starting to decline. In addition, perhaps because of low humidity in the Delta, plant weevil populations that provide effective control in other regions (at least 5 weevils per plant), do not provide control in the Delta. Akers and Pitcairn summarize, “the weevils do not exert a level of damage consistent enough to bring the weed under control” (Akers and Pitcairn 2006).

These findings are consistent with evaluations of success and failure factors related to biological control of water hyacinth. Factors that may reduce the effectiveness of biological controls include: temperate climates, high nutrient status of the water, periodic flooding or drought conditions, and uptake of heavy metals by water hyacinth (Julien 2001). All of these factors are present in the Delta.

Implementation of the biological control only alternative would require a significant increase in deployment of biological controls in the Delta. The biological control only alternative would also require extensive monitoring to determine the impacts of this deployment.

When it is effective, biological control of water hyacinth is attractive because of low potential environmental impacts, long-term sustainability, and low cost. In the Delta, this alternative has been shown to have severely limited effectiveness.

In addition, researchers and waterway managers generally recommend that biological control alone is not a solution, and it should be part of an integrated management approach (Labrada 1995, Julien 2001, Center et al 1999). The DBW will continue to evaluate and incorporate biological control as part of the WHCP, but will not solely rely on biological agents to control water hyacinth in the Delta.

The biological control only alternative would result in fewer recreational and ecosystem benefits, as compared to the selected program alternative, because significantly less water hyacinth would be controlled in any given year.

Program Alternative 5 – Mechanical Harvesting Only

Mechanical harvesters utilize equipment which cuts (and in some cases collects) aquatic plants. There are several types of mechanical harvesters, ranging from simple hydraulic cutters attached to pontoon boats or airboats, to 10,000 pound capacity harvesters with conveyors to remove the cut plant material to the shore (Mossler and Langeland 2006). Mechanical harvesters have been used to control water hyacinth in Florida and other Southeastern states.

Because mechanical harvesting can be costly, it is often used only when immediate removal of weeds is required. In addition to the high cost, concerns with mechanical harvesting include disposal costs and permitting, rapid regrowth of plants following harvesting, nutrient loading due to cut plants in the water, potential release of mercury, and the impact of harvesting on non-target aquatic species.

During 2003 and 2004, the San Francisco Estuary Institute (SFEI) conducted a study of mechanical harvesting of water hyacinth in the Delta (Greenfield et al 2005). The study examined costs and permitting issues, regrowth potential, and impacts on nutrient loading in Delta waters. This study was part of a settlement between the State Water Board and Waterkeepers Northern California. The State Water Board funded the Aquatic Pesticide Monitoring Program (APMP) to assess pesticide alternatives, contracting with SFEI to conduct the research. SFEI tested three different mechanical harvesters in two different Delta locations, in both the spring and fall (Greenfield, Blankenship and McNabb 2006). The cut pieces of water hyacinth from all three harvesters remained in Delta waters.

Plant pieces were tested for regrowth in both laboratory and field conditions. Cut plants, including those that were cut twice, had very high survival rates (from 50 percent to 100 percent). Plants that had been cut once produced new leaves at a greater rate than uncut plants (Spencer et al 2006). Plants that had been cut produced new leaves within one week of cutting, and floating water hyacinth fragments remained in the cut areas six months after treatment.

The study concluded that, at least for the three mechanical harvesters tested, cutting water hyacinth in the Delta has limited effectiveness (Spencer et al 2005). Greenfield and McNabb identified the primary concern with mechanical harvesting: the shredding operation could actually worsen the infestation by increasing the spread and recruitment of plants (Greenfield and McNabb 2005).

Because of these issues, the DBW has determined not to further pursue mechanical harvesting as a program alternative, even within their integrated management approach. Mechanical harvesting would not achieve the goals of the WHCP, and would likely increase the amounts of water hyacinth in the Delta.

Mechanical control would result in fewer recreational and ecosystem benefits, as compared to the selected program alternative, because significantly less water hyacinth would be controlled in any given year.

Table 2-4
Potential WHCP Methods Rejected as Infeasible

Control Method	Description	Reason Rejected
1. Triploid Grass Carp	Sterilized, herbivorous fish that provide control by consuming aquatic weeds and other plants in waterways.	Water hyacinth is not a preferred food for triploid grass carp. In addition, the California Department of Fish and Game prohibits the use of triploid grass carp in non-enclosed water bodies.
2. Physical Barriers	Physical barriers (such as booms) to limit the ability of water hyacinth to spread.	Barriers are not effective in the winter high-flow period. Barriers require extensive maintenance, and are not effective in controlling water hyacinth.
3. Shade Barriers	Use of shade fabrics placed over aquatic weeds to limit the amount of photosynthetically available light.	Utilizing shade fabrics in the Delta would be technically challenging, difficult to maintain, and expensive.
4. Water Level Manipulation	Pumping or releasing water via a dam or weir to dewater an area.	Delta channels do not have structures available to control water levels. In addition, water hyacinth seeds can germinate after years of exposure to air.
5. Flow Rate Manipulation	Increasing or decreasing water flow through a channel for weed control	Flow rates in the Delta could not be artificially increased to create enough force to flush water hyacinth fully out of the Delta.

Program Alternative 6 – No Program Alternative

The No Program Alternative would be in conflict with existing state law. In 1982, Senate Bill 1344 amended the California Harbors and Navigation Code to designate the California Department of Boating and Waterways as the lead agency for controlling water hyacinth in the Delta. The Harbors and Navigation Code, Section 64, specifies that it is "necessary that the state, in cooperation with agencies of the United States, undertake an aggressive program for the effective control of water hyacinth and *Egeria densa* in the Delta, its tributaries, and the marsh [Suisun Marsh]." Thus, the DBW is mandated to conduct water hyacinth control efforts.

In addition, the uncontrolled growth of water hyacinth which would result from the No Program Alternative would lead to negative impacts to navigation, recreation, agriculture, and Delta ecosystems. While it would avoid potential impacts due to herbicides, the No Program Alternative would not achieve any goals of the WHCP.

Alternatives Rejected as Infeasible

In addition to the six program alternatives described in this chapter, the DBW considered a number of other alternatives for controlling water hyacinth in the Delta. The DBW determined that these alternatives were legally, technically, or operationally infeasible; would fail to meet most of the basic project objectives; or would result in significant environmental impacts. **Table 2-4,** above, briefly summarizes five alternatives that were not considered for further analysis.

D. Selected Program Alternative

The selected program alternative is based on Integrated Pest Management (IPM) and Maintenance Control Practices (MCP). The State defines IPM as: a pest management strategy that focuses on long-term prevention or suppression of pest problems through a combination of techniques such as monitoring for pest presence and establishing treatment threshold levels, using non-chemical practices to make the habitat less conducive to pest development, improving sanitation, and employing mechanical and physical controls. Pesticides that pose the least possible hazard and are effective in a manner that minimizes risks to people, property, and the environment, are used only after careful monitoring indicates they are needed according to pre-established guidelines and treatment thresholds.

IPM denotes the coordinated use of available control methods for a particular pest. MCP refers to practices that minimize plant biomass through regular, low-level, control treatments applied at times during a plant's life cycle when treatments are most effective. Ideally, under a maintenance control program, the acres of water hyacinth required to be treated are reduced each year until they reach a minimal level.

The WHCP has historically been following IPM and MCP, and will continue to do so. The DBW balances IPM and MCP in order to simultaneously reduce impacts and increase effectiveness. For example, in order to avoid impacts to migrating special status fish, treatments occur as early in the growing season as possible, but later in a plant's lifecycle than would be ideal.

To minimize potential environmental impacts, DBW selects the most appropriate control methods for a given site in the Delta based on the season and that site's conditions. The DBW conducts limited handpicking to supplement chemical treatment, when appropriate. The DBW also monitors results of the WHCP, and bases future control methods on these results. This selected alternative is chosen to provide the greatest reduction in water hyacinth biomass while avoiding or minimizing environmental impacts.

The WHCP follows an adaptive management approach in which DBW seeks to improve efficacy and reduce environmental impacts over time as new and better information is available about the program. Within their adaptive management approach, the DBW:

- Evaluates the need for control measures on a site-by-site basis
- Follows NPDES general permit pre- and post-treatment monitoring protocols and evaluates data to determine environmental impacts
- Supports ongoing research to explore the impacts of the WHCP and alternative control methodologies, including biological controls and herbicides and adjuvants with reduced environmental impacts
- Reports findings from monitoring evaluations and research to regulatory agencies and stakeholders
- Adjusts program actions, as necessary, in response to recommendations and evaluations by regulatory agencies and stakeholders.

1. WHCP Permits and Reporting

Since the WHCP was reinitiated in 2001, the NPDES permits and biological opinions have guided much of the program's operations and environmental monitoring. This subsection provides an overview of these permit requirements.

NPDES General Permit

The DBW obtained an individual National Pollutant Discharge Elimination System (NPDES) permit in 2001 (CA0084654) from the Central Valley Regional Water Quality Control Board (CVRWQCB). The individual NPDES permit expired in March 2006. In April 2006, the CVRWQCB replaced the individual NPDES permit with a general NPDES permit (CAG990005). The general NPDES permit has fewer monitoring requirements than the individual NPDES permit.

The NPDES permit includes specific receiving water limits for herbicide concentrations, dissolved oxygen (DO), pH, and turbidity. Key NPDES requirements for the WHCP are as follows:

- **Dissolved oxygen** – specific DO limits depend on the location and season, but range from 5.0 mg/l (ppm) to 9.0 mg/l (ppm). DO levels are not to drop below these levels as a result of WHCP treatments

- **Turbidity** – specific turbidity standards are not to increase above a specified number or percent of Nephelometric Turbidity Units (NTUs), depending on the initial level of natural turbidity. Generally, the WHCP shall not increase turbidity more than 10 to 20 percent
- **pH** – WHCP discharges shall not cause pH to fall below 6.5, or exceed 8.5, or change by more than 0.5 units
- **2,4-D residues** – maximum 2,4-D levels are based on EPA municipal drinking water standards, and shall not exceed 70 µg/l, or 70 ppb
- **Glyphosate residues** – maximum glyphosate levels are based on EPA municipal drinking water standards, and shall not exceed 700 µg/l, or 700 ppb
- **Adjuvant residues** – there are no specified limits for adjuvants; however, the DBW is required to monitor adjuvant levels
- **Monitoring** – requires a monitoring protocol. Monitoring is required at 10 percent of sites treated, for each chemical and waterbody type. Sampling stations are identified as : "A" (where treatment occurred), "B" (downstream of the treatment area), and "C" (control, typically upstream). Sampling times are identified as: "1" (pre-treatment), "2" (immediately post-treatment), and "3" (within seven days after treatment). Thus, sample 2B is taken immediately post-treatment, downstream of the treatment location
- **Reporting** – The DBW is required to submit an annual report by March 1st of each year
- **Initial individual NPDES requirements** – as part of the initial individual NPDES permit, The DBW was required to conduct toxicity studies on algae, water fleas, and minnows, develop a Quality Assurance Project Plan (QAPP),prepare a biological assessment, report on herbicide residues in sediment, and develop a fish passage protocol.

USFWS Biological Opinion

The United States Fish and Wildlife Service (USFWS) issued a biological opinion for the WHCP on June 1, 2001. This biological opinion was subsequently amended three times, and then reissued on May 21, 2004. The WHCP is currently operating under the May 21, 2004 USFWS biological opinion, 1-1-04-F-0149. This biological opinion includes an incidental take statement and reasonable and prudent measures to minimize impacts on delta smelt and its critical habitat, the valley elderberry longhorn beetle, and the giant garter snake.

Updates to the biological opinion reflect improved understanding of the impact of the WHCP on special status species. The original USFWS permit required toxicity testing on delta smelt, Sacramento splittail (since delisted), and garter snakes. USFWS removed the toxicity testing requirements after results showed no significant impacts.

Key requirements of the USFWS biological opinion are as follows:

- **Avoidance** – there are no longer avoidance measures in place for delta smelt. To avoid impacts to the valley elderberry longhorn beetle, the DBW is required to survey for *Sambucus ssp.* (elderberry shrub), and treat at low tide if any elderberry shrubs are within 100 feet of the water's edge. The DBW must also consider wind speed and direction, and if treatment cannot occur away from habitat, treat a maximum of one-half of the area. Avoidance measures for giant garter snake apply only to land based operations away from launch ramps and roads. There are currently no such operations, however the DBW implements additional avoidance measures for giant garter snakes. These measures include mapping of giant garter snake habitat, and training crews to minimize impacts when treatment occurs in potential giant garter snake habitat

- **Environmental training** – personnel involved with the WHCP are required to receive USFWS approved environmental awareness training related to valley elderberry longhorn beetles, and giant garter snakes. The DBW also provides training related to delta smelt
- **Monitoring** – requires that the NPDES permit monitoring sites include sites with valley elderberry longhorn beetle, giant garter snake, and delta smelt habitats
- **Reporting** – requires the DBW to report results and impacts (including take) by January 31st of each year
- **Requirements of earlier USFWS biological opinions** – the DBW was required to conduct laboratory research trials on the impacts of WHCP herbicides and adjuvants on smelt and splittail eggs and larvae, and on a representative species of the giant garter snake. Early BOs also required avoidance measures and environmental training for delta smelt.

NOAA-Fisheries Biological Opinion

National Oceanic and Atmospheric Administration-Fisheries (NOAA-Fisheries) issued a biological opinion for the WHCP on June 8, 2001, with subsequent biological opinions issued on June 11, 2002, and August 11, 2003. The WHCP is currently operating under the April 4, 2006 biological opinion, 151422SWR2005SA00681:JSS.

The NOAA-Fisheries biological opinion includes an incidental take statement and reasonable and prudent measures to minimize impacts on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and critical habitats for each of these species. The April 4, 2006 biological opinion also includes an incidental take statement and measures to minimize impacts on the southern district population segment of North American green sturgeon, which was designated as threatened by NOAA-Fisheries, effective June 6, 2006. Key metrics for the most recent NOAA-Fisheries biological opinion are as follows:

- **Avoidance** – measures restrict treatments in order to avoid periods when juvenile steelhead and salmon may be present. Treatments are unrestricted between July 1st, and October 15th. Treatments in sites that are not considered salmon habitat are allowed starting April 1st, or April 15th. If Interagency Ecology Program (IEP) monitoring shows that the salmon pulse has migrated through the system by June 1st, and DBW receives written verification, treatments in the remainder of the Delta may start on June 1st
- **Environmental training** – there are no longer any formal training requirements; however, the DBW provides training on the life history, importance of migratory routes, and terms and conditions of the biological opinion for Chinook salmon, steelhead, and green sturgeon
- **Dissolved oxygen** – DO levels of above 5.0 ppm and below 3.0 ppm are required for treatment (in addition to the NPDES DO requirements). The DBW may treat if DO is below 3.0 ppm
- **Monitoring** – there are no specific monitoring requirements
- **Fish passage** – requires the DBW to follow a fish passage protocol to ensure fish are not impacted by WHCP operations
- **Reporting** – requires the DBW to report results and impacts (including take) by January 31st of each year.

Each year, the DBW prepares a WHCP Annual Report that fulfills reporting requirements of the NPDES, USFWS, and NOAA-Fisheries permits. The annual report describes the treatment program, herbicide use, permit requirements, monitoring protocols, monitoring results, and compliance with permit requirements. WHCP Annual Reports are available at the DBW offices.

Photo: Water hyacinth spraying

Since 2001, the DBW has commissioned or conducted a number of special studies to better understand the impacts and efficacy of the WHCP. These studies include the following:

- *Acute Oral and Dermal Toxicity of Aquatic Herbicides and a Surfactant to Garter Snakes*, Robert C. Hosea, California Department of Fish and Game (2004)
- *Chronic Toxicities of Herbicides Used to Control Water Hyacinth and Brazilian Elodea on Neonate Cladoceran and Larval Fathead Minnow,* Frank Riley and Sandra Finlayson, California Department of Fish and Game (2004)
- *Acute Toxicities of Herbicides Used to Control Water Hyacinth and Brazilian Elodea on Larval Delta Smelt and Sacramento Splittail,* Frank Riley and Sandra Finlayson, California Department of Fish and Game (2004)
- *Ceriodaphnia dubia (water flea) Static Definitive Chronic Toxicity Test Data (7-day) for Exposure to Various Aquatic Herbicides,* California Department of Fish and Game, Aquatic Toxicology Laboratory (2003)
- *Pogonichthys macrolepitdotus (Sacramento Splittail) Static Definitive Acute Toxicity Test Data (96-hour) for Exposure to Various Aquatic Herbicides*, California Department of Fish and Game, Aquatic Toxicology Laboratory (2003)
- *Biological Control of Water Hyacinth in the Sacramento-San Joaquin Delta,* Lars W.J. Anderson, Ph.D, and Jason Brennan, USDA-ARS Exotic and Invasive Weed Research (2003)
- *Biological Control of Water Hyacinth: Second Year Progress Report,* Lars W.J. Anderson and Jason Brennan, USDA-ARS Exotic and Invasive Weed Research (2005)
- *Biological Control of Water Hyacinth in the Sacramento-San Joaquin Delta: Year 3 – Final Report*, R. Patrick Akers and Michael J. Pitcairn, California Department of Food and Agriculture (2006)
- *Mapping Invasive Plant Species in the Sacramento-San Joaquin Delta Region Using Hyperspectral Imagery,* Susan L. Ustin, Ph.D., et al, Center for Spatial Technologies and Remote Sensing (CSTARS), California Space Institute Center of Excellence (CalSpace), UC Davis (2004)
- *Monitoring Valley Longhorn Elderberry Beetle Elderberry Shrub Habitat,* Paul Ryan, et al., California Department of Boating and Waterways (multiple years).

2. WHCP Methods

Environmental Training

Prior to the start of each treatment season, the DBW conducts environmental awareness training for all field crew members. The training includes: species identification and impact avoidance guidelines; protocol for identification and protection of elderberry shrubs; protocol for identification and protection of delta smelt, Chinook salmon, steelhead, green sturgeon, and associated protected habitats; and protocol for take of protected species. In addition, field crew members also are trained on use and calibration of equipment and the WHCP Operations Management Plan.

Chemical Control

Since 2001, the DBW has had between three and six full-time treatment crews of two persons each conducting treatments during the WHCP season. Most of this time, at least one crewmember has possessed a Qualified Applicators Certificate, category "F" (aquatics), from the California Department of Pesticide Regulation (DPR). The DBW assigns each crew to one of four large regions: west, north, central, or south.

Treatment crews visually survey all sites in their applicable regions prior to starting treatment. In developing each season's treatment plan, the DBW prioritizes herbicide applications. Nursery areas and areas that are critical to public, agricultural, and industrial uses are treated first.

Factors that DBW considers in selecting sites include impacts to navigation, threats to agricultural pumping facilities, and high levels of infestation. The DBW considers logistical factors, such as tides and travel times, and factors daily weather conditions such as wind speed into daily site selection. The DBW may update, revise, or reprioritize the treatment site list over the course of the treatment year based upon new information about the treatment sites.

Each week, the DBW submits Notices of Intent (NOIs) to the appropriate County Agricultural Commissioner. NOIs detail the sites, dates, and herbicides and adjuvants to be used for the following week. This list typically includes back-up sites, in case wind and weather conditions preclude spraying in designated areas.

The DBW may begin chemical treatments as early as April 1st in sites that are not considered salmon habitat, including some sites on the San Joaquin River and eastern Delta. The DBW may begin treatments in the remainder of the Delta after June 1st, as long as (1) Interagency Ecology Program (IEP) Real-Time Monitoring shows the salmon pulse has migrated through the system, (2) water temperatures have increased, and (3) NOAA- Fisheries issues written verification. There are no restrictions on treatment locations within the WHCP project area between July 1st and October 15th.

Crews typically conduct treatment with hand-held sprayers applied from 19 to 21 foot aluminum airboats or outboard motor boats. The boats are equipped with direct metering of herbicides, adjuvants, and water pump systems. The crews spray the chemical mixture directly onto the plants. Treatment crews follow specific requirements to account for wind, dissolved oxygen, drinking water intakes, agricultural intakes, and total acres treated. Treatment crews also implement a fish passage protocol to ensure that migratory fish are not impacted by the WHCP.

Aquatic Herbicide Use

The amount of herbicide used and number of acres treated in a given year can reflect the magnitude of infestation. However, there are several other factors that affect the amount of treatment that DBW conducts (regulatory limits, local water conditions, weather, staff levels, etc.). For example, in winter 2006/2007, there was an early freeze in the Delta, which likely contributed to the significant decline in acres requiring water hyacinth treatment between 2006 and 2007. In 2008, water hyacinth levels were low, perhaps due to weather and water conditions, and/or the cumulative effects of annual treatments.

Table 2-5, on the next page, provides the acres treated, and gallons of herbicides and adjuvant used by the WHCP from 2001 to 2008. The two herbicides are 2,4-D (Weedar® 64) and glyphosate (AquaMaster™). The WHCP also utilizes Agridex®, an adjuvant. The DBW is also considering another adjuvant, Competitor®. Labels and Material Safety Data Sheets (MSDSs) for all four chemicals are provided in Appendix B.

Table 2-5
WHCP Herbicide and Adjuvant Use and Acres Treated (2001 to 2008)

Year	Gallons 2,4 D	Gallons Glyphosate	Total Gallons Herbicide	Gallons Adjuvant*	Total Acres Treated
2001	948	16	964	82	1,013
2002	1,762	67	1,829	540	1,854
2003	1,719	367	2,086	519	2,222
2004	2,062	517	2,579	751	2,770
2005	1,903	219	2,122	736	2,208
2006	2,176	208	2,384	918	2,446
2007	938	149	1,087	441	1,137
2008	336	64	400	163	420

* In 2001, the DBW utilized the adjuvant Placement, in 2002 and 2003, the DBW utilized the adjuvant R-11. Both of these adjuvants were found to be potentially more toxic than the adjuvant Agridex, which the DBW began using in 2005.

Herbicide use in future years will be heavily dependent on weather conditions. One possible reason for the low acreage of water hyacinth in the Delta in 2008 was the extremely low rainfall during winter 2007/2008. Another low rainfall season in 2008/2009 would likely result in even lower quantities of water hyacinth in the 2009 season.

A high rainfall winter could potentially result in significant increases in water hyacinth in the following season. This is because riverbeds and shorelines exposed by drought conditions act as nursery areas. When nursery areas become inundated again after heavy rains, water hyacinth seeds germinate, and the new plants move downriver into the Delta.

Handpicking

Primarily during the period from October 15th to April 1st, when chemical treatment is restricted, treatment crews survey for water hyacinth, and conduct handpicking in selected areas. The goals of the handpicking program are to aid in the control of water hyacinth and reduce impacts of chemical application by clearing areas that are not accessible to chemical treatment, subject to high infestation, and within emergent vegetation.

Crews follow specific handpicking protocols to ensure the protection of water quality and special status species. The DBW is currently conducting a three-year cost benefit analysis of the handpicking program. During the 2007/2008 off-season (October 15 to April 1), treatment crews collected over 4,000 30-gallon barrels of water hyacinth. Once collected, water hyacinth is left on the levee banks, at selected dispersal sites, to decompose.

Herding

Herding is conducted by field crews using spray boats fitted with a rebar and wire U-shaped "cage" mounted to the front of the boat. The boats approach water hyacinth and push the mat or section of mat toward a main channel. Once in a main channel, the water hyacinth flows out of the Delta, into saline waters and dies. Water hyacinth cannot survive in waters of greater than 2ppt saline water (brackish water).

Herding is generally limited to selected periods during November to February. Field supervisors take into account tides, storm events, and dam releases to select appropriate days and times for herding to take place. Herding typically occurs in the western portion of the Delta, near Antioch, to ensure that water hyacinth mats will be pushed out of the Delta. Crews do not herd in areas where physical damage to emergent, native vegetation is likely to occur such as among stands of cattails (*Typha* spp.), *Phragmites* spp., bulrushes (*Scirpus* spp.), or native cordgrass (*Spartina foliosa*). In addition, the total amount of water hyacinth herded in one area is limited to avoid impeding navigation. Due to timing and logistical limitations of herding activities, this method is not used as frequently as handpicking.

Biological Control

While successful implementation of biological control for water hyacinth is challenging in the Delta, DBW and their partners continue to evaluate and consider new alternatives. The DBW is currently funding research at UC Davis to identify plant pathogens in the Delta with potential for controlling water hyacinth. Plant pathogens, in combination with other mechanisms, may be a promising future alternative for water hyacinth control (Charudattan 2001). Because the biological control component of the WHCP consists of research only, we do not analyze biological control methods further within this PEIR.

3. WHCP Environmental Monitoring

The DBW conducts extensive monitoring for the WHCP. The DBW is responsible for collecting water quality monitoring data, as well as collecting water samples for chemical residue testing.

Based on NPDES permit requirements, DBW follows a monitoring protocol. This protocol fulfills requirements of the Regional Water Quality Control Board, NOAA Fisheries, and USFWS. **Exhibit 2-2,** on the next page, illustrates the field and laboratory components of WHCP monitoring. At each monitoring site, DBW's environmental scientists take samples immediately pre-application (adjacent to the water hyacinth mat), and post-application (upstream, adjacent to, and downstream of the treatment area). WHCP environmental scientists also take a sample one week following treatment.

The DBW selects monitoring sites that reflect a mix of water types (tidal, riverine, tidal dead-end), both herbicides, sites with the greatest amount of herbicide use, and different habitat types. The DBW typically conducts monitoring at approximately 20 sites during a treatment season. Each treatment season, DBW is required to conduct monitoring at 10 percent of the sites it treats and 10 percent of each type of waterway.

At each monitoring site, environmental scientists monitor dissolved oxygen, turbidity, pH, and several other water quality measures. The DBW environmental scientists collect water samples in amber bottles, packed in ice, and submit them to a Certified Analytical Laboratory to measure chemical residue levels. Between 2001 and 2005, the DBW also submitted water samples to the California Department of Fish and Game (CDFG) Toxicology Laboratory to conduct a series of toxicity tests. The DBW has not been required to conduct toxicity tests since 2005.

Treatment crews conduct daily monitoring, in addition to the extensive monitoring conducted by DBW environmental scientists. Treatment crews monitor and report pre- and post-treatment dissolved oxygen and turbidity, wind speed, temperature, acres treated, quantity of herbicide and adjuvant, presence of elderberry shrubs or other species of concern, and coordinates of treatment location. **Table 2-6,** on the next page, lists monitoring requirements for WHCP environmental scientists and WHCP treatment crews.

We discuss results of WHCP monitoring in detail in Chapters 3 and 4. In summary, over eight years of monitoring results (2001 to 2008) have indicated no degradation of Delta water quality following water hyacinth treatments. Concentrations of chemicals following treatments were minimal, with most non-detectable, or far below labeled rates, application concentrations, and guiding standards.

Exhibit 2-2
WHCP Water Quality Data and Water Sample Collection

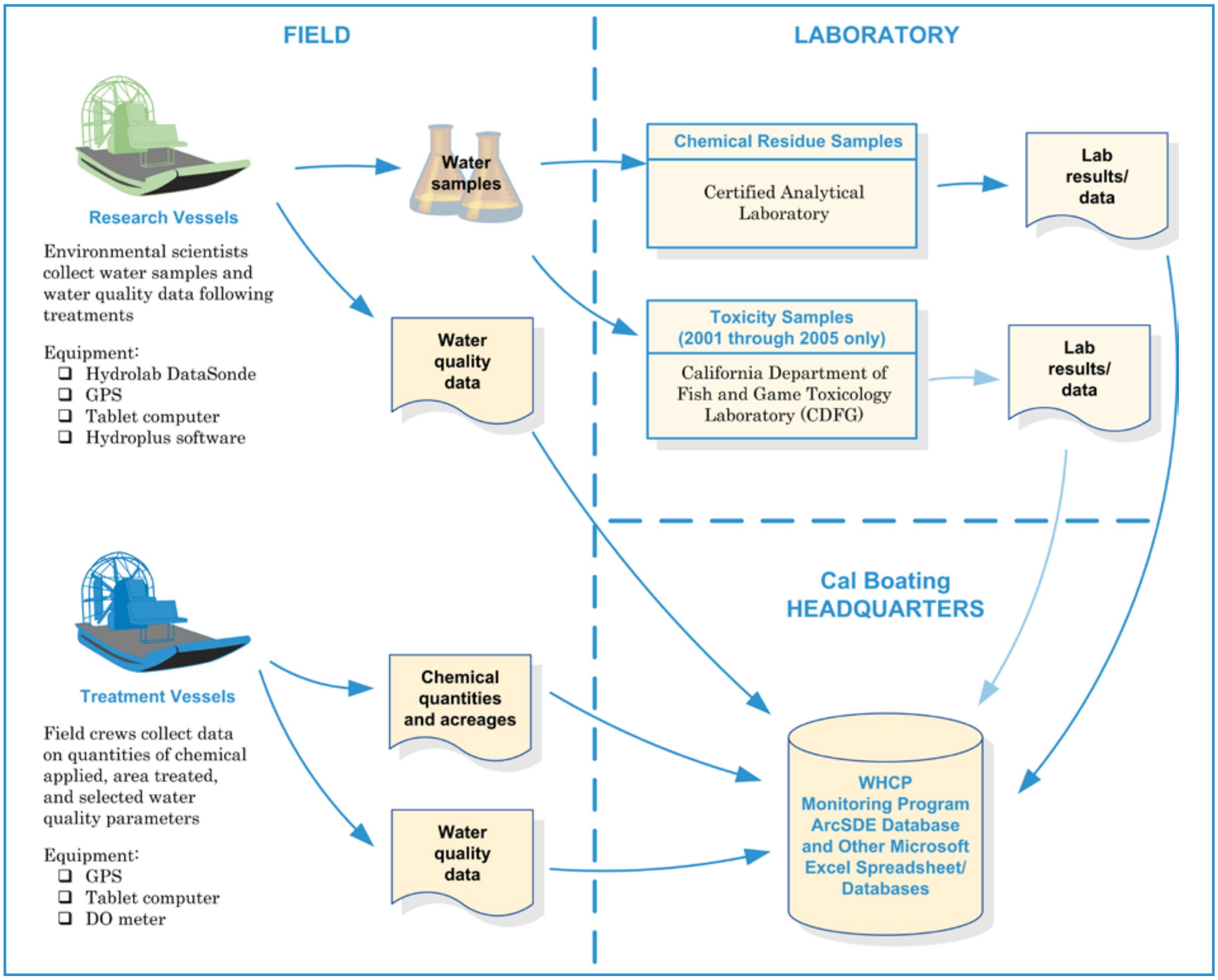


Table 2-6
WHCP Environmental Monitoring Requirements

Treatment Crews (for each site treated)	Environmental Scientists (for each sample event)
1. Water temperature (ºC)	1. Water temperature (ºC)
2. Dissolved oxygen (DO, mg/L or parts per million (ppm))	2. Dissolved oxygen (DO, mg/L or ppm)
3. Turbidity (NTU, Nephelometric Turbidity Unit)	3. Turbidity (NTU)
4. Wind speed (mph)	4. pH
5. Coordinates of treatment location	5. Salinity (ppt)
6. Presence of elderberry shrubs	6. Specific conductance (mS/cm)
7. Presence of species of concern	7. Water depth (feet)
8. Acres treated	8. Tide cycle
9. Quantity of herbicide and adjuvant	9. Water samples (pre-treatment, post-treatment, control; submitted to a Certified Analytical Laboratory)

In 2007 and 2008, the highest level of 2,4-D, at 27 ppb, was found immediately post-treatment. All other post-treatment 2,4-D levels were either non-detectable, or below 9.5 ppb. The maximum allowable residue level of 2,4-D is 70 ppb. All except one WHCP post-treatment glyphosate residue samples in 2007 and 2008 were at non-detectable levels.

The toxicology testing conducted by CDFG Toxicology Laboratory between 2001 and 2005 found less than significant toxicity impacts due to WHCP herbicides. The DBW eliminated the use of the herbicide diquat, and the adjuvants Placement® and R-11®, when toxicity tests showed potentially negative impacts. Diquat was used for only a small portion of WHCP treatments, and was replaced with 2,4-D and glyphosate. The DBW replaced Placement® and R-11® with a less toxic alternative, Agridex®.

In the field, the DBW has not identified any WHCP impacts on special status species' habitat resulting from the WHCP. In addition, the DBW has found no known "take" of threatened or endangered species as a result of the WHCP.

Chapter 3

Biological Resources Impacts Assessment

3. Biological Resources Impacts Assessment

This chapter analyzes effects of the WHCP on biological resources. The chapter is organized as follows:

A. Environmental Setting

B. Impact Analysis and Mitigation Measures.

The environmental setting describes the biological status of the Sacramento-San Joaquin Delta. This discussion includes identification of habitat types, and special status plants, invertebrates, fish, amphibians, reptiles, birds, and mammals. This chapter does not provide a detailed discussion of the regulatory context in the Delta. Such a discussion is included in Chapter 7 – Cumulative Impacts Assessment, in which we provide a description of relevant regulations, programs, projects, and planning efforts that shape the current Delta.

The impact analysis provides an assessment of the specific environmental impacts potentially resulting from program operations. The discussion of impacts utilizes findings from WHCP environmental monitoring and research projects, technical information from scientific literature, government reports, and relevant information on public policies. The impact assessment is based on technical and scientific information.

The mitigation measures are specific actions that the DBW will undertake to avoid, or minimize, potential environmental impacts. The DBW has undergone, and will continue to undergo, consultation with various State and federal agencies, including USFWS, CDFG, NOAA-Fisheries, and CVRWQCB regarding impacts and mitigation measures. Many of the mitigation measures result from the biological consultation process with USFWS and NOAA-Fisheries. Proposed mitigation measures may be revised, and/or additional mitigation measures incorporated, as a result of this ongoing consultation process with environmental regulatory agencies.

A. Environmental Setting

Exhibit 2-1 illustrates the WHCP program area. The WHCP occurs primarily in the Delta, with additional treatments occurring on lower stretches of the San Joaquin, Tuolumne, and Merced Rivers.

The Delta is arguably the most environmentally sensitive region in California today. The Delta also has been described as "heavily modified" (Sommer et al. 2007). Starting in the mid-1800's, the Delta has been subject to hydraulic gold mining, channelization and wetland reclamation, fish and other non-native species introductions, dams controlling water inflows, and water exports (Sommer et al. 2007).

Concerns about the Delta environment gained momentum in the early 1990s. In establishing the Delta Protection Commission in 1992, the California legislature recognized that the Delta is "a natural resource of statewide, national, and international significance, containing irreplaceable resources." In the seventeen years since the Delta Protection Commission was established, and particularly over the last few years, concerns about water quality, water quantity, increasing land subsidence, flooding, climate change, increased salinity, invasive species, risk of catastrophic earthquake, and declining fish populations have only increased.

In 2006, Governor Schwarzenegger established the Delta Vision Blue Ribbon Task Force to identify a sustainable strategy for managing the Delta. The Governor's Executive Order recognized that "failure to act to address identified Delta challenges and threats will result in potentially devastating environmental and economic consequences of statewide and national significance" (Executive Order S-17-06).

The Delta Vision Blue Ribbon Task Force established a strategic plan to meet twelve objectives, the first objective being: "The Delta ecosystem and a reliable water supply for California are the primary co-equal goals of a sustainable Delta" (Delta Vision Blue Ribbon Task Force 2008).

In early 2008, Governor Schwarzenegger initiated another major collaborative planning effort, the Bay Delta Conservation Plan (BDCP). This initiative is led by the California Department of Water Resources, California Department of Fish and Game, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and NOAA-Fisheries. The "purpose of the BDCP is to help recover endangered and sensitive species and their habitats in the Delta in a way that will also provide for sufficient and reliable water supplies" (DWR 2008). The BDCP will examine four water conveyance and physical habitat restoration alternatives for the Delta, including a peripheral aqueduct from the Sacramento River to south Delta.

The Delta Vision and Bay Delta Conservation Plan are just two of dozens of initiatives in the Delta directed toward improving water quality, managing water diversion, controlling floods, restoring ecosystems, reducing fish decline, and reducing invasive species. Many of these initiatives are described in Chapter 7.

The WHCP is a minor element of this complex dynamic Delta environment. The WHCP seeks to control only one of the hundreds of invasive species in the Delta. The WHCP operates within the context of an environment that has been managed and manipulated since the mid-1800s.

The challenge in today's Delta is to support gradual restoration of natural Delta ecosystems, where possible, while preventing further environmental deterioration. The specific challenge of the WHCP is to control the growth of water hyacinth within this highly modified Delta environment. Water hyacinth, left to grow unchecked, has significant negative environmental impacts. At the same time, the WHCP also must minimize potential negative impacts of water hyacinth treatment.

1. Regulatory Settings

There are several Federal and State laws relevant to biological resources that are applicable in the WHCP project area. Below, we describe five such regulatory programs.

Endangered Species Act

The Endangered Species Act (ESA) was signed into law in 1973 to conserve and protect species that are endangered or threatened, and the ecosystems on which they depend (NOAA-Fisheries 2008). The law is implemented by USFWS and NOAA-Fisheries. Major activities within the law include identification of listed species, identification of critical habitat, development of recovery plans, cooperation with states, interagency consultation (Section 7), international cooperation, enforcement, permits, and habitat conservation plans. When a federal project may result in "take" of an endangered or threatened species, the federal agency must obtain a biological opinion and Section 7 Incidental Take permit. The WHCP has obtained ESA Section 7 Biological Opinions from USFWS and NOAA-Fisheries through the consultation process. The federal nexus for this process is USDA-ARS. The biological opinions specify requirements that the DBW must follow to minimize the potential for take of endangered of threatened species.

California Endangered Species Act

The California Endangered Species Act (CESA) is administered by CDFG Habitat Conservation Planning Branch. The California Endangered Species Act protects wildlife and plants listed as threatened or endangered by the California Fish and Game Commission (CDFG 2008). This law restricts "take" of listed species, and agencies must apply for an incidental take permit under CESA, similar to the process under ESA. CESA includes additional species that are not covered by the federal ESA, however implementation of CESA and ESA is typically closely coordinated between USFWS, NOAA-Fisheries, and CDFG.

Magnuson-Stevens Fishery Conservation and Management Act (MSA) – Essential Fish Habitat (EFH)

The Magnuson-Stevens Fishery Conservation and Management Act was originally passed in 1976, and amended most recently in 2006. The MSA governs marine fisheries in the United States (Pacific Fisheries Management Council 2008). The MSA regulates fishing to waters 200 nautical miles off the U.S. coast, established fishery management councils, and includes provision to create fishery management plans, conserve and manage fishery resources, and prevent overfishing. The Pacific Fishery Management Council implements the MSA for Washington, Oregon, and California. The MSA defines essential fish habitat as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The MSA requires fishery management councils to describe EFH within fishery management plans, and to minimize impacts on EFH. A habitat area of particular concern (HAPC) is a subset of EFH, and consists of sensitive areas that are particularly important in the fish life cycle. Estuaries, such as the Delta, are classified as HAPCs. The WHCP could potentially impact EFH for salmon, as well as EFH for certain groundfish species that are regulated under the MSA.

Natural Community Conservation Plans (NCCP) and Habitat Conservation Plans (HCP)

The NCCP is a California planning program, while the HCP is a federal planning program (DFG 2008; USFWS 2005). Both programs are related to their respective endangered species laws. Within California, most entities prepare a joint NCCP/HCP. Both laws focus on broader ecosystem planning and protection of special status species, within the context of development of a particular project or region. The NCCP is intended to "conserve natural communities at the ecosystem scale while accommodating compatible land use." The HCP provides planning and conservation measures, including mitigation, when a project or development could result in incidental take of a threatened or endangered species. The HCP process has evolved into a broad-based planning effort to incorporate conservation into development efforts. There are several NCCP/HCP planning efforts within the Sacramento/San Joaquin Delta, including those summarized below. To the extent that WHCP activities are mitigated, and will result in long-term benefits to ecosystems, they are compatible with these planning efforts.

Migratory Bird Treaty Act

The Migratory Bird Treaty Act authorizes the U.S. Secretary of the Interior to protect and regulate migratory birds (USFWS 2008). The law is implemented by the USFWS, and protects migratory birds, occupied nests, and eggs. The Migratory Bird Treaty Act was first passed in 1918, and has been amended several times since. The act implements conventions between the United States and Canada, Mexico, Japan, and the former Soviet Union to protect migratory birds. There are 836 bird species protected by the Act.

2. The Delta

The Sacramento-San Joaquin Delta includes approximately 1,100 square miles and was originally a tidal marsh and an overland area of the Sacramento and San Joaquin Rivers. The area was developed primarily for agriculture beginning in the mid-1800s and has approximately 60 major land tracts and islands protected from flooding by 1,100 miles of levees.

There are approximately 700 miles of rivers, sloughs, and connecting channels with a surface area of approximately 50,000 acres of water. Delta river depths typically range between five and ten feet, with inland navigation channels for the ports of Sacramento and Stockton dredged to 30 feet.

Over 40 percent of the State's runoff drains into the Delta. The Sacramento River contributes approximately 80 percent of Delta inflow, the San Joaquin River contributes approximately 15 percent, with the remaining five percent of flows contributed from the Cosumnes, Mokelumne, and Calaveras Rivers. Most of the Delta is subject to tidal action with mean fluctuations of approximately two to three feet.

The Delta climate is hot and dry in summer, and cool and moist in winter. Temperatures in the summer may reach over 100°F, and drop to below freezing in the winter. Annual rainfall varies from approximately 10 to 18 inches and prevailing winds are from the west. Winds frequently range up to approximately 25 miles per hour.

The primary land use in the Delta is agricultural, with only about five percent urban use. The Delta supports a wide variety of field crops, vegetables, fruits, nuts, livestock, and poultry.

Delta waterways also support a large variety of recreational uses. There are many public and private recreational areas including marinas and camping, primarily along waterfronts. Fishing and boating account for 70 percent of Delta recreation use.

The California State Water Project (SWP) and federal Central Valley Project (CVP) export approximately five million acre-feet of water annually from the Delta for agricultural, municipal, and industrial purposes in central and southern California. An almost equal amount of water is withdrawn from the Sacramento and San Joaquin Rivers for agricultural and municipal uses before it reaches the Delta. Approximately 25 percent of California's drinking water comes from the Delta, and two-thirds of California households receive some drinking water from the Delta (URS Corporation 2007).

The remainder of this Environmental Setting subsection describes habitat types within the Delta, and identifies special status species potentially impacted by the WHCP.

3. Natural Community Conservation Plan (NCCP) Habitats

The Delta consists of a wide variety of different habitat types. In order to provide a background framework from which to discuss the biological resource impacts of the WHCP, we first describe the habitat types within the WHCP area. The CALFED Multispecies Conservation Strategy (MSCS) developed a classification system for eighteen habitats and two ecologically-based fish groups (CALFED July 2000). These categories include several habitat or vegetation types found in frequently used classification systems, such as the CDFG's California Wildlife Habitat Relationships System.

CALFED's NCCP categories are more specific to the Delta region, and have been utilized in a number of recent Delta environmental documents. Those twelve NCCP habitats that are within the WHCP area are described below, including two fish groups. The fish groups were developed because typical habitat classifications, based on vegetation, land-use, and geography, do not adequately address these groups, which move between habitats. Fish species included within the two fish groups were defined as those that are most affected by CALFED water projects, depend on the Bay-Delta ecosystem, and are subject to established USFWS, NOAA-Fisheries, and CDFG recovery goals (USBR 2003, 5-20).

Tidal Perennial Aquatic

Tidal perennial aquatic (TPA) habitat is defined as deep water aquatic (greater than three meters deep from mean low tide), shallow aquatic (less than or equal to three meters from mean low tide), and un-vegetated intertidal (i.e., tidalflats) zones of estuarine bays, river channels, and sloughs (CALFED July 2000). This habitat can be found throughout the Delta, including sloughs, channels, and flooded islands. Water hyacinth is typically found in this habitat.

Additional TPA habitat aquatic plant species include water primrose, *Egeria densa*, hornwort, parrot's feather, and western milfoil. Colonies of these aquatic plants are generally infrequent, but mats of noxious weeds, such as water hyacinth or *Egeria densa*, can clog waterways, shade habitat for native aquatic vegetation, and smother low-growing intertidal vegetation when washed onto channel banks (DWR 2006, 6.2-6). There are no special status plants associated with tidal perennial aquatic habitats (CALFED July 2000, C-2-1 to C-2-12). However, many animal species rely on tidal perennial aquatic habitat during some portion of their life cycle.

There has been a substantial loss of historic shallow tidal waters, mainly as a result of reclamation and channel dredging and scouring. Many leveed lands in the Delta have subsided and are too low to support shallow tidal perennial aquatic habitat. Mid-channel islands and shoals have been shrinking or disappearing from progressive erosion of the remaining habitat.

Major factors contributing to the loss of mid-channel islands and shoals are gradual erosion from channels conveying water across the Delta to South Delta pumping plants, boat wakes, and dredging within the Delta or adjacent waters. CALFED has an NCCP goal to restore 9,000 acres of tidal perennial aquatic habitat and minimize effects on tidal perennial aquatic habitat (USBR 2003, 5-4).

Tidal Freshwater Emergent

Tidal freshwater emergent (TFE) habitat includes portions of the intertidal zones of the Delta that support emergent wetland plant species that are not tolerant of saline or brackish conditions (CALFED July 2000). Tidal freshwater emergent habitat occurs within the Delta along island levees, channel islands, and shorelines (USBR 2003, 5-11), including many sites with water hyacinth.

The dominant vegetation for tidal emergent wetland habitat includes bulrush, tules, cattails, and common reed. Several special status plant species potentially affected by the WHCP are found within this habitat, including Suisun Marsh aster, wooly rose-mallow, Delta tule pea, Mason's lilaeopsis, and Delta mudwort (CALFED July 2000, C-2-1 to C-2-12). Freshwater emergent wetlands are among the most productive wildlife habitats in California, providing food, cover, and water for more than 160 species of birds, as well as many mammals, reptiles, and amphibians (USBR 2003, 5-10).

Historically, freshwater marshes were widespread throughout the Delta and backwaters of the upper Sacramento River. Many types of wetlands and their inhabitants have disappeared. Between 30 and 50 percent of the original wetlands of the United States have been lost, mostly to urban development, water diversions, conversion of land to agriculture, or contamination. Until the 1950s the rate of wetland loss in the United States was more than 800,000 acres per year, dropping to less than 80,000 acres per year in the 1980s and early 1990s (Heimlich 1998). The Clean Water Act has a policy of "no net loss of wetland" that has reduced wetland loss in the United States, estimated to be less than 60,000 acres per year in the late 1990s.

In California, 90 percent of the original five million acres of wetlands has been lost, much of it within the Delta. Levees and other land uses led to loss of fresh emergent wetland in the Delta, reducing habitat for wetland wildlife species as well. Fresh emergent wetland losses have also substantially reduced the area available for biological conversion of nutrients in the Delta. The Delta now contains insufficient wetland area to provide adequate levels of nutrient transformation, which results in lower water quality in San Francisco Bay (USBR 2003, 5-10).

Nontidal Freshwater Permanent Emergent

Nontidal freshwater permanent emergent (NFPE) habitat includes permanent (natural and managed) wetlands, including meadows, dominated by wetland plant species that are not tolerant of saline or brackish conditions (CALFED July 2000). NFPE habitat occurs throughout the Delta in areas where soils are inundated or saturated for all or most of the growing season, such as landward sides of levees, constructed waterways, ponds, and on Delta islands in low-lying areas among crop and pasture land (USBR 2003, 5-12). Portions of the WHCP treatment area are within this classification.

Vegetation and wildlife for nontidal freshwater permanent emergent habitats are similar to tidal freshwater emergent habitats (USBR 2003, 5-11). Special status plant species potentially affected by the project and within this habitat include: wooly rose-mallow, Sanford's arrowhead, marsh skullcap, and side-flowering skullcap. The decline of nontidal freshwater permanent emergent habitats is similar to that described for tidal freshwater emergent habitats

Valley Riverine Aquatic

Valley riverine aquatic habitat (VRA) includes the water column of flowing streams and rivers in low-gradient channel reaches below an elevation of approximately 300 feet that are not tidally influenced. Additionally, VRA includes associated shaded riverine aquatic pool, riffle, run, and unvegetated channel substrate habitat features, and sloughs, backwaters, overflow channels, and flood bypasses hydrologically connected to stream and river channels (CALFED July 2000). Delta waterways that are classified as VRA include the Sacramento, San Joaquin, Cosumnes, Mokelumne, and Calaveras rivers and other sloughs, streams, and ephemeral creeks (USBR 2003, 5-6), including many sites with water hyacinth.

Dominant vegetation of VRA habitat includes plankton, water moss, algae, and duckweed. One special status plant species potentially affected by the WHCP, eel-grass pondweed, is associated with this habitat (CALFED July 2000, C-2-1 to C-2-12). Aquatic species include riffle insects, pool insects, mollusks, crustaceans, diving beetles, and water boatmen. Avian species include waterfowl, wading birds, shorebirds, and raptors. Mammal species include river otter, muskrat, and beaver.

Valley riverine aquatic habitat in the Central Valley has declined from over 900,000 acres, historically, to about 100,000 acres today. Much of the existing habitat is in a highly degraded condition. Degradation has occurred due to channel straightening; channel incising; channel dredging and clearing; instream gravel mining; riparian zone grazing; flow modifications; removal and fragmentation of shoreline riparian vegetation; and loss of sediment, bedload, and woody debris from watershed sources upstream of dams (USBR 2003, 5-5).

Natural Seasonal Wetland

Natural seasonal wetland habitat includes vernal pools and other nonmanaged seasonal wetlands with natural hydrologic conditions that are dominated by herbaceous vegetation. These habitats also annually pond surface water or maintain saturated soils at the ground surface for enough of the year to support a variety of wetland plant species. Alkaline and saline seasonal wetlands that were not historically part of a tidal regime are included in natural seasonal wetlands (CALFED July 2000). Vernal pools, including those recently protected in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (USFWS 2005a) are found within the broader WHCP control area, but are not adjacent to waterways, and thus will not be impacted by the program. The three vernal pool regions that are within the Delta are the Solano-Colusa region, Southeastern Sacramento Valley region, and San Joaquin region (USFWS 2005a).

Managed Seasonal Wetland

Managed seasonal wetland habitat includes wetlands dominated by native or non-native herbaceous plants, excluding croplands farmed for profit (e.g., rice), that land managers flood and drain during specific periods to enhance habitat values for specific wildlife species. Ditches and drains associated with managed seasonal wetlands are included in this habitat type (CALFED July 2000). Managed seasonal wetlands occur throughout the Delta, and are within the WHCP project area, including private lands managed primarily for waterfowl or state and federal wildlife areas/refuges (USBR 2003, 5-14). WHCP treatment sites may occur adjacent to managed seasonal wetland habitat.

Vegetation and wildlife species associated with managed seasonal wetland habitats are similar to those associated with natural seasonal wetland habitats, with the exception of vernal pool species (USBR 2003, 5-14). There are no plant species of concern potentially affected by the project within this habitat classification.

The extent and quality of managed seasonal wetlands vary, based on the practices that create and maintain this type of habitat. There are ongoing efforts to convert agricultural lands to managed seasonal wetlands in the Delta, and CALFED has a goal of restoring almost 30,000 acres of MSW (USBR 2003, 5-15).

Valley/Foothill Riparian

Valley/foothill riparian (VFR) habitat includes all successional stages of woody vegetation, within active and historical floodplains of low-gradient reaches of streams and rivers generally below an elevation of 300 feet (CALFED July 2000). VFR habitat encompasses the approximately 0.1 to 1 mile width of woody vegetation along riverine habitats, including Delta waterways such as the Sacramento, San Joaquin, Cosumnes, Mokelumne, and Calaveras rivers and other sloughs, streams, and ephemeral creeks (USBR 2003, 5-16). Water hyacinth may occur adjacent to, but not within, VFR.

Valley/foothill riparian habitat is dominated by cottonwood, sycamore, alder, ash, and valley oak tree overstory; and a blackberry, poison oak, and wild grape understory (USBR 2003, 5-15). None of the special status plants impacted by the WHCP fall within this habitat. However, valley elderberry shrub, protected for the valley elderberry longhorn beetle, exist in this habitat. Over 225 species of birds, mammals, reptiles, and amphibians depend on riparian habitats and cottonwood-willow riparian areas support more breeding avian species than any other broad California habitat type (USBR 2003, 5-15).

The condition of riverine aquatic and nearshore habitats in the Delta has not been well documented, however, these habitats have been degraded by channel straightening; channel incising; channel dredging and clearing; instream gravel mining; riparian zone grazing; flow modifications; removal and fragmentation of shoreline riparian vegetation; and the loss of sediment, bedload, and woody debris from upstream watershed sources (USBR 2003, 5-15).

Montane Riverine Aquatic

Montane riverine aquatic (MRA) habitat includes the water column of flowing streams and rivers above an elevation of approximately 300 feet (USBR 2003). MRA includes associated pools, riffles, runs, unvegetated channels, sloughs, backwaters, and overflow channels connected to stream and river channels. Within the WHCP, this habitat exists on the Merced, San Joaquin, and Tuolumne Rivers. Dominant vegetation and wildlife are similar to VRA habitat species. Special status species in this habitat that may be impacted by the WHCP include western pond turtle, California red-legged frog, and eel-grass pondweed.

Upland Cropland

Upland cropland (UC) habitat includes agricultural lands farmed for grain, field, truck, and other crops for profit that are not seasonally flooded (USBR 2003, 5-15). The predominant land use category in the Delta is agricultural, including upland cropland, and seasonally flooded agriculture, described below. There are over 370,000 acres of harvested or grazed irrigated crops in the Delta (Rich 2006).

Upland cropland vegetation is dominated by cereal rye, barley, wheat, corn, dry beans, safflower, alfalfa, cotton, tomatoes, lettuce, Bermuda grass, ryegrass, tall fescue, almonds, walnuts, peaches, plums, pears, and grapes. Wildlife use of these areas varies throughout the growing season depending on crop type, level of disturbance, and available cover (USBR 2003, 5-17). Water hyacinth may be situated in waterways adjacent to upland cropland habitat.

Seasonally Flooded Agricultural Lands

Seasonally flooded agricultural lands (SFA) habitat includes agricultural lands farmed for grain, rice, field, truck, and other crops for profit that require seasonal flooding for at least one week at a time as a management practice, or are purposely flooded seasonally to enhance habitat values for specific wildlife species (e.g., ducks for duck clubs). Agricultural ditches and drains associated with maintaining seasonally flooded agricultural lands are included in this habitat type (CALFED July 2000). Agricultural lands throughout the Delta fall into this habitat category, and may be adjacent to waterways with water hyacinth.

Rice fields, a large component of this habitat category, provide important habitat cover for a variety of species. Many species forage on post-harvest grain waste, as well as duckweed, fish, and crayfish found in rice fields. Rice can provide resting and nesting habitat similar to natural wetlands, particularly for migrating waterfowl. Species dependent on rice fields for all or part of their lifecycle include the giant garter snake, various rodents, and various raptors. Irrigation ditches can contain wetland vegetation such as cattails, and provide habitat for rails, egrets, herons, bitterns, marsh wrens, sparrows, and common yellowthroats (USBR 2003, 5-19).

Anadromous Fish Group

The anadromous fish group includes tidal perennial aquatic, valley riverine aquatic, montane river aquatic, saline emergent, and tidal freshwater emergent aquatic habitats. Fish species of concern associated with these habitats include Sacramento river winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead evolutionary significant units (ESUs), and green sturgeon (USBR 2003, 5-22). All of these species are potentially impacted by the WHCP, and are discussed in this chapter.

Estuarine Fish Group

The estuarine fish group includes tidal perennial aquatic, valley riverine aquatic, saline emergent, and tidal freshwater aquatic habitats. Fish species of concern associated with these habitats include tidewater goby, delta smelt, longfin smelt, Sacramento splittail, and Sacramento perch (USBR 2003, 5-22). Three of these species, delta smelt, longfin smelt, and Sacramento splittail, may potentially be impacted by the WHCP, and are discussed in this chapter.

4. Special Status Species

The WHCP occurs on waterways within portions of 11 counties: Alameda, Contra Costa, Fresno, Madera, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Tuolumne, and Yolo. The DBW obtained lists of State and federal special status species occurring within these 11 counties from the USFWS, and the California Natural Diversity Database (CNDDB). Federal endangered and threatened species are regulated by USFWS and NOAA-Fisheries, through the Endangered Species Act (ESA). California threatened and endangered species are regulated by CDFG, through the California Endangered Species Act (CESA).

The 26 special status species that may occur in, or utilize, habitats potentially impacted by the WHCP are identified in **Table 3-1,** on the next page. There are eleven special status plants, one invertebrate, eight fish, one amphibian, two reptiles, three birds, and five critical habitats potentially impacted by WHCP activities.

Under the ESA, the federal government may identify critical habitats for specific listed species. Critical habitats are defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation. The five species that are potentially impacted by the WHCP, and for which critical habitat has been designated, are: (1) delta smelt, (2) Central Valley steelhead, (3) Central Valley spring-run Chinook salmon, (4) winter run Chinook salmon, Sacramento River, and (5) California red-legged frog. Parts of the critical habitat for the first four of these species occur within the WHCP, however none of the designated critical habitat for the California red-legged frog occurs within the WHCP area.

We describe the current status of each of these species below, and potential impacts of the WHCP on these species in the impacts analysis section.

The majority of the special status species identified for these 11 relevant counties do not occur in, or utilize, waterways, channels, and channel banks of the Delta or its tributaries. For example, many of the identified species occur in mountainous or coastal habitats within the 11 counties, not within the Delta region. Other species may occur within the Delta, but are not at all likely to be impacted by WHCP activities. This programmatic EIR does not consider these majority special status species.

Table 3-1
Special Status Species Potentially Impacted by the WHCP *Page 1 of 2*

Invertebrates		
Scientific Name	**Common Name**	**Status***
1. *Desmocerus californicus dimorphus*	valley elderberry longhorn beetle	FT
Fish		
Scientific Name	**Common Name**	**Status**
1. *Acipenser medirostris*	green sturgeon	FT, FCHP, CSC
2. *Hypomesus transpacificus*	delta smelt	FT (considering FE)[1], **FCH,** CE
3. *Lampetra ayresi*	river lamprey	CSC
4. *Oncorhynchus mykiss*	Central Valley steelhead	FT, **FCH**
5. *Oncorhynchus tshawytscha*	Central Valley spring-run Chinook salmon	FT, **FCH,** CT
6. *Oncorhynchus tshawytscha*	winter-run Chinook salmon, Sacramento River	FE, **FCH,** CE
7. *Pogonichthys macrolepidotus*	Sacramento splittail	CSC
8. *Spirinchus thaleichthys*	longfin smelt	CT, under consideration for federal listing
Amphibians		
Scientific Name	**Common Name**	**Status**
1. *Rana aurora draytonii*	California red-legged frog	FT, **FCH,** CSC
Reptiles		
Scientific Name	**Common Name**	**Status**
1. *Clemmys marmorata*	western pond turtle	CSC
2. *Thamnophis gigas*	giant garter snake	FT, CT
Birds		
Scientific Name	**Common Name**	**Status**
1. *Agelaius tricolor*	tricolored blackbird	CSC
2. *Laterallus jamaicensis coturniculus*	California black rail	CT
3. *Xanthocephalus xanthocephalus*	yellow-headed blackbird	CSC

[1] USFWS initiated a five-year review to assess endangered species classification on March 25, 2009.

Table 3-1
Special Status Species Potentially Impacted by the WHCP

Plants		
Scientific Name	**Common Name**	**Status***
1. *Carex comosa*	bristly sedge	CNPS 2.1
2. *Hibiscus lasiocarpus*	**wooly rose-mallow**	CNPS 2.2
3. *Lathyrus jepsonii var. jepsonii*	**Delta tule pea**	CNPS 1B.2
4. *Lilaeopsis masonii*	**Mason's lilaeopsis**	CR, CNPS 1B.1
5. *Limonsella subulata*	**Delta mudwort**	CNPS 2.1
6. *Potamogeton zosteriformis*	Eel-grass pondweed	CNPS 2.2
7. *Sagittaria sanfordii*	Sanford's arrowhead	CNPS 1B.2
8. *Scutellaria galericulata*	marsh skullcap	CNPS 2.2
9. *Scutellaria lateriflora*	side-flowering skullcap	CNPS 2.2
10. *Symphyotrichum lentum*	**Suisun Marsh aster**	CNPS 1B.2
11. *Trichocoronis wrightii var. wrightii*	Wright's trichocoronis	CNPS 2.1

* Status Key

- FE – federal endangered
- FT – federal threatened
- FCH – federal critical habitat specified for this species (of the five critical habitats identified in Table 3-1, four include areas within the WHCP, and could potentially be impacted by the WHCP. Critical habitat for the California red-legged frog does not occur within the WHCP area.)
- FC – federal candidate for consideration of endangered or threatened
- FCHP – federal critical habitat for this species is proposed
- CE – California endangered
- CT – California threatened
- CR – California rare
- CSC – California species of special concern
- CNPS – California Native Plant Society listings:
  - 1B.1: plants rare, threatened, or endangered in California and elsewhere; seriously threatened in California
  - 1B.2: plants rare, threatened, or endangered in California and elsewhere; fairly threatened in California
  - 2.1: plants rare, threatened, or endangered in California, but more common elsewhere; seriously threatened in California
  - 2.2: plants rare, threatened, or endangered in California, but more common elsewhere; fairly threatened in California

Bolds above indicate plant has been found in the DBW surveys.

Table 3-15, located on page 3-77 at the end of Chapter 3, identifies more than 250 species that we do not expect to be impacted by the WHCP, but that may occur within the 11 WHCP counties. Less than ten percent of all the special status species identified for the 11 WHCP counties could be potentially impacted by the WHCP.

No new primary data surveys were conducted specifically for this final PEIR. However, data from previous DBW and prior relevant plant or wildlife surveys were included in this PEIR. The DBW has monitored and reviewed environmental impacts of the WHCP each year since 1983.

5. Invertebrates

Only one special status invertebrate, valley elderberry longhorn beetle, could potentially be affected by WHCP operations. It is described below.

Source: www.fws.gov.

Photo: Valley Elderberry Longhorn Beetle.

Valley Elderberry Longhorn Beetle

Valley elderberry longhorn beetle is classified as federally threatened. Valley elderberry longhorn beetle is a dimorphic species strictly tied to its host plant, the elderberry *(Sambucus* ssp.) during its entire life cycle. Adults emerge from pupation inside the wood of the elderberry in the spring as the trees begin to flower. The exit holes made by the emerging adults are distinctive small oval openings. Often these holes are the only clue that beetles occur in an area. Adults eat elderberry foliage until approximately June when they mate. Females lay eggs in crevices in the bark. Upon hatching, larvae begin to tunnel into the shrub, where they will spend one to two years eating interior wood, which is their sole food source.

Valley elderberry longhorn beetle historically occurred throughout the Sacramento and San Joaquin valleys and into the foothills of the Coast Ranges and the Sierra Nevada to 2,200-foot in elevation. Elderberry shrub is a common component of riparian forests and savannah areas (USFWS 2004). Recent surveys have found beetles in only scattered localities along the Sacramento, American, San Joaquin, Kings, Kaweah, and Tuolumne rivers and their tributaries. Valley elderberry shrubs with evidence of beetles have been spotted in WHCP treatment sites along the Sacramento and Cosumnes Rivers (CNDDB 2006).

Over the last 150 years, agricultural and urban development has destroyed 90 percent of Central Valley riparian vegetation, which included the elderberry host plant, resulting in extreme fragmentation of the beetle's habitat.

The valley elderberry longhorn beetle is threatened by habitat loss and fragmentation, invasion by Argentine ants, agricultural conversion, levee construction, removal of riparian vegetation, riprapping of shoreline, and possibly other factors such as pesticide drift, exotic plant invasion, and grazing (USFWS 2004).

6. Fish

Fish dependent on the Delta as a migration corridor, nursery, or permanent residence include striped bass, American shad, sturgeon, Chinook salmon, steelhead, catfish, largemouth bass, and numerous less known marine and freshwater species. Since 1993, 87 species of fish have been identified in the Delta during the CDFG/ Interagency Ecology Program (IEP) fall midwater trawl (FMWT) survey, and salvage at the SWP pumping plant. In these two surveys, introduced species accounted for over 40 percent of the total number reported (Sommer et al. 2007).

Table 3-2, on the next page, identifies 13 native and 28 non-native fish species identified in sampling surveys during 1992 to 1999, and 2001 and 2003 (Feyrer and Healey 2003; Nobriga et al. 2005). Non-native fish species dominated surveys in both time periods, with non-native fish accounting for 96 percent of the total fish captured.

The most commonly captured fish in the 1992 to 1999 time period were bluegill, redear sunfish, white catfish, largemouth bass, and golden shiner. The most commonly captured fish in the 2001 and 2003 surveys were inland silverside, threadfin shad, striped bass, and yellowfin goby. In the later survey, inland silversides, thought to prey on and compete with delta smelt (Bennett 2005), accounted for over 50 percent of the fish captured.

Of more than 80 fish species in the Delta, important game fish include American shad, Chinook salmon, steelhead, and striped bass. Although all these fish spend most of their adult lives in the lower bays or in the ocean, the Delta is an important habitat for most of them.

Two Natural Community Conservation Plan (NCCP) habitat types for fish are present in the Delta: the Anadromous Fish Group, and the Estuarine Fish Group. Special status fish from each of these groups are potentially impacted by the WHCP, and are described below. Delta fish habitat types include estuary, fresh water, and marine water. Transition from one zone to the next is gradual, and the zones move up or downstream depending on the amount of fresh water entering the estuary, outflow regime and water year hydrology.

Delta aquatic habitat varies from dead-end sloughs to deep, open-water areas of the lower Sacramento and San Joaquin rivers and Suisun Bay. A scattering of flooded islands also offer submerged vegetative shelter. Channel banks are varied and include riprap, tules, emergent marshes, and native riparian habitat. The dominant channel banks are those that have been modified for flood control or navigation. There have also been substantial increases in the invasive aquatic weed, *Egeria densa*, over the past twenty years, further modifying natural waterways (Feyrer et al. 2007). Water temperatures generally reflect ambient air temperatures, but riverine shading may moderate summer temperatures in some areas.

Food supplies for Delta fish communities consist of phytoplankton, zooplankton, benthic invertebrates (living in the sediment), insects, and fish. General productivity is in constant flux. Monitoring of productivity is ongoing, including an evaluation of the interrelationships of the food web by the IEP for the Delta and Suisun Marsh. Recent evaluations of zooplankton in the Delta have found that all native zooplanktons have decreased in abundance since they were first monitored in the 1970s. At the same time, many introduced species are now more abundant (Mecum 2005). Monitoring data for zooplankton, phytoplankton, and benthic organisms indicate that overall productivity at lower food chain levels has decreased during the past 30 years.

The entrapment zone (at the X2 salinity line) concentrates sediments, nutrients, phytoplankton, some fish larvae, and fish food organisms. Biological standing crop (biomass) of phytoplankton and zooplankton in the estuary was historically highest in this zone. However, phytoplankton levels no longer show a peak in the entrapment zone, since introduced clams began cropping production in 1987. Keeping the entrapment zone in the upper reaches of Suisun Bay creates more desirable habitat for some species than could be maintained in narrower channels upstream in the Delta.

Flows caused, provided, or controlled by the CVP and SWP affect fish in numerous ways. Flows toward project pumps can draw both fish and fish food organisms into export facilities. Most large fish are screened out, and many do not survive screening and subsequent handling. Most fish less than about an inch long, and fish food, pass through the screens. In addition, the draw of the pumps may cause water in some channels

Table 3-2
Numbers and Species of Fish Collected in Two Delta Fish Survey Studies (1992 to 1999, and 2001/2003)

#	Common Name	Scientific Name	Status*	1992 to 1999 Count	1992 to 1999 Percent	2001 and 2003 Count	2001 and 2003 Percent	Total Count
1	Inland silverside	*Menidia beryllina*	I	4,262	6%	42,994	53%	47,256
2	Threadfin shad	*Dorosoma petenense*	I	3,589	5%	18,267	23%	21,856
3	Bluegill	*Leposmis macrochirus*	I	19,820	28%	999	1%	20,819
4	Striped bass	*Morone saxatilis*	I	5,043	7%	5,886	7%	10,929
5	Redear sunfish	*Lepomis microlophus*	I	9,521	13%	1,294	2%	10,815
6	White catfish	*Ameiurus catus*	I	9,088	13%	501	1%	9,589
7	Largemouth bass	*Micropterus salmoides*	I	7,950	11%	1,248	2%	9,198
8	Golden shiner	*Notemigonus crysoleucas*	I	5,393	8%	352	0.4%	5,745
9	Yellowfin goby	*Acanthogobius flavimanus*	I	497	1%	2,366	3%	2,863
10	Common carp	*Cyprinus carpio*	I	1,726	2%	8	0.01%	1,734
11	American shad	*Alosa sapidissima*	I	63	0.1%	1,236	2%	1,299
12	Channel catfish	*Ictalurus punctatus*	I	712	1%	100	0.1%	812
13	Bigscale logperch	*Percina macrolepida*	I	180	0.3%	318	0.4%	498
14	Warmouth	*Lepomis gulosus*	I	313	0.4%	14	0.02%	327
15	Shimofuri goby	*Tridentiger bifasciatus*	I	192	0.3%	132	0.2%	324
16	Black crappie	*Pomoxis nigromaculatus*	I	226	0.3%	53	0.1%	279
17	Goldfish	*Carassius auratus*	I	256	0.4%	1	0.001%	257
18	Mosquitofish	*Gambusia affinis*	I	67	0.1%	153	0.2%	220
19	Brown bullhead	*Ameiurus nebulosus*	I	186	0.3%	7	0.01%	193
20	Green sunfish	*Lepomis cyanellus*	I	138	0.2%	–	–	138
21	Smallmouth bass	*Micropterus dolomieui*	I	138	0.2%	–	–	138
22	Rainwater killifish	*Lucania parva*	I	–	–	72	0.1%	72
23	Black bullhead	*Ameiurus melas*	I	43	0.1%	1	0.001%	44
24	Fathead minnow	*Ptychocheleius grandis*	I	18	0.03%	1	0.001%	19
25	Red shiner	*Cyprinella lutrensis*	I	13	0.02%	4	0.005%	17
26	White crappie	*Pomoxis annularis*	I	4	0.01%	–	–	4
27	Spotted bass	*Micropterus puntulatus*	I	–	–	2	0.002%	2
28	Shokihaze goby	*Tridentiger barbosus*	I	–	–	2	0.002%	2
1	Splittail	*Pogonichthys macrolepidotus*	N	94	0.1%	1,471	2%	1,565
2	Chinook salmon	*Oncorhynchus tshawytscha*	N	390	1%	825	1%	1,215
3	Tule perch	*Hysterocarpus traski*	N	384	1%	656	1%	1,040
4	Sacramento pikeminnow	*Ptychocheleius grandis*	N	55	0.1%	581	1%	636
5	Delta smelt	*Hypomesus transpacificus*	N	–	–	553	1%	553
6	Sacramento sucker	*Catostomus occidentalis*	N	278	0.4%	55	0.1%	333
7	Sacramento blackfish	*Orthodon microlepidotus*	N	238	0.3%	8	0.01%	246
8	Hitch	*Lavinia exilicauda*	N	–	–	174	0.2%	174
9	Prickly sculpin	*Cottus asper*	N	60	0.1%	104	0.1%	164
10	Starry flounder	*Platyichthys stellatus*	N	–	–	78	0.1%	78
11	Staghorn sculpin	*Leptocottus armatus*	N	–	–	64	0.1%	64
12	Three-spine stickleback	*Gasterosteus acculeatus*	N	–	–	9	0.0%	9
13	Steelhead	*Oncorhynchus mykiss*	N	2	0.003%	1	0.001%	3
	Total, All Species			70,939	–	80,590	–	151,529

Sources: Nobriga et al., 2005 (for 2001 and 2003 data), and Feyrer and Healey 2003 (for 1992-1999 data).
* I identifies invasive or non-native species, N identifies native species.

to flow too fast for optimal fish food production, and reverse flows in some channels may confuse migrating fish. Delta flows may act as cues for anadromous fish outmigrating to the ocean.

Factors beside CVP and SWP operations that affect fish include water diversions within the Delta; upstream spawning conditions and diversions; municipal, industrial, and agricultural water pollution; habitat reduction; legal and illegal harvesting; competition from introduced species; natural predator/prey interactions; reduced food abundance; and drought. Cumulative effects of these and other factors have contributed to declining populations of many Delta fish.

Abundance of four important Delta fish species, native longfin smelt and delta smelt, and introduced striped bass and threadfin shad, have declined sharply since 2002. The decline was unexpected, given moderate winter-spring flows in the immediately preceding years. The Interagency Ecological Program (IEP) initiated a Pelagic Organism Decline (POD) working group in 2005 to evaluate causes of the decline.

The POD working group initially evaluated three general factors that appeared to be individually, or in concert, lowering pelagic productivity: invasive species (including the Asian clam, which consumes plankton); toxins; and water project operations (Armor et al. 2005). Increased water flows from the Delta through CVP and SWP operations have been targeted by many as a major cause of fish decline (Contra Costa Times 2006).

Analyses conducted in parallel with the POD working group examined other potential causes of pelagic organism decline. Engineers at the Contra Costa Water District hypothesized that salinity may be a threat to dwindling delta smelt (Traugher 2006). The engineers hypothesized that shifting the timing of State water project deliveries may have led to saltier water in the fall, and for same reason, may be leading to fewer delta smelt.

A presentation made by DWR environmental scientists at the 4th Biennial CALFED Science Conference on October 24, 2006 found declines in indices for habitat quality associated with salinity and turbidity variables. The scientists opined that turbidity indicators can be closely associated with submerged aquatic vegetation (including the invasive *Egeria densa*) (Feyrer et al. 2006). DWR scientists are also studying the effects of toxic algae in the Delta to determine whether it poses a serious threat to human health, and to determine if it plays a role in the Delta's ongoing ecosystem concerns (Taugher 2005). The algae, Microsystis aeruginosa (Microcystis toxins) was first discovered in the Delta circa 1999.

More recently, a San Francisco State University study is considering the impact of ammonia in wastewater released from the Sacramento Regional County Sanitation District facility in Freeport (Weiser 2008). Ammonia may disrupt the Delta food chain by reducing the availability of phytoplankton. This in turn reduces the amount of zooplankton available for fish species such as the delta smelt. Because the Sacramento region has grown significantly, the volume of wastewater has increased. In early 2009, a CalFed panel reported that ammonia is a likely contributor to environmental shifts in the Delta. The panel recommended further research (Weiser 2009).

By early 2008, the POD working group refined their analysis, developing two conceptual modeling approaches for identifying causes of pelagic organism decline. The first model included four major components: (1) previous abundance levels; (2) habitat; (3) top-down effects; and (4) bottom-up effects (Baxter et al. 2008a). Previous abundance levels consider stock-recruitment levels and survival among different life stages. Habitat considers analyses of water clarity, salinity, temperature, and contaminants. Top-down effects evaluate predator relationships, including how invasive species such as *Egeria densa* improve habitats for invasive prey species (e.g. largemouth bass). Bottom-up effects consider the importance of food resources, particularly for delta smelt. The change in species composition of Delta zooplankton, with dominance of invasive plankton species, is of particular interest. The second conceptual model approach will examine specific models for individual species.

The POD working group continues to refine the conceptual models in order to further evaluate causes of POD. The 2008 workplan identifies three types of work: (1) continuation of expanded monitoring, (2) 31 ongoing studies, and (3) 19 new studies (Baxter et al. 2008b). As the POD working group obtains new information, State and federal agencies are adapting Delta management practices, seeking to alleviate potential sources of decline (Broddrick 2007).

In other related actions, a federal court decision dated December 14, 2007, required the Bureau of Reclamation and CDWR to restrict water exports to specified levels in order to protect delta smelt larvae and juveniles. The decision also required the agencies to obtain a new biological opinion from the USFWS for the Operation Criteria and Plan for the SWP and CVP.

The USFWS issued a new biological opinion in December 2008. This new BO incorporated more restrictive water exports, as specified in the 2007 federal court decision. The San Luis and Delta-Mendota Water Authority and Westlands Water District moved for a preliminary injunction of the export restrictions. In a May 2009 decision, the federal court required USFWS to “explain why alternative, less restrictive flows would not adequately protect the delta smelt,” but did not preclude the restrictive flows (U.S. District Court 2009).

Salmon abundance has not followed the same pattern as pelagic species. Until 2007, salmon abundance appeared to be low, but relatively stable. However, low salmon abundance figures for 2007 were followed by even lower abundance estimates in the winter of 2008, particularly for the dominant fall-run. As a result, the Pacific Fishery Management Council (PFMC) and NOAA-Fisheries closed the commercial and recreational ocean salmon fisheries from Cape Falcon (in northern Oregon), south into California. The PFMC closed this fishery again in 2009.

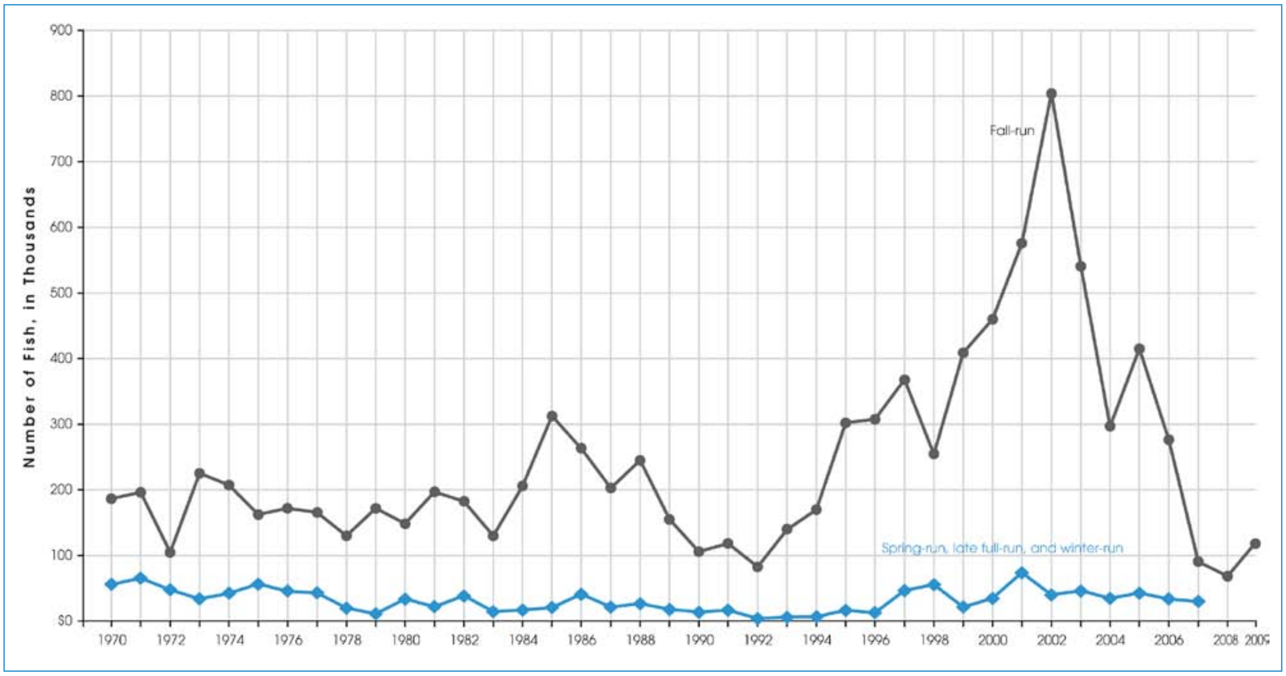
The causes of this unprecedented decline are unknown, but likely factors include ocean temperature changes, in-stream water withdrawals, habitat alternations, dam operations, construction, pollution, and changes in hatchery operations (PFMC 2008). A multi-agency task force will review 46 possible causes of the decline.

Responding to these low salmon counts, CDFG closed Central Valley recreational salmon fishing for State waters in July 2008. This closure includes the Sacramento River and tributaries, and the ocean, out three miles. CDFG will still allow catch-and-release salmon fishing, and limited (one salmon catch) fishing on the Sacramento River between the Red Bluff Diversion Dam and Knights Landing from November 1st to December 31st, 2008. CDFG implemented similar closures in 2009.

The low abundance figures are for Sacramento River fall-run Chinook salmon, an ESU that is not listed as a threatened or endangered species. **Exhibit 3-1,** on the next page, illustrates hatchery and natural escapement (i.e. fish that return to spawn) of Central Valley salmon (PFMC February 2008). Spring- and winter-run Chinook are endangered and threatened, respectively.

In November 2008, California Trout released two reports on the status of salmon, steelhead, and trout in California (Moyle et al. 2008a; Moyle et al. 2008b). The reports evaluated 31 living salmonid taxa, and identified 20 that are in danger of extinction in the next 100 years. While Moyle et al. (2008a, 2008b) identified significant threats to California salmonids, they also offered a number of recommendations to maintain these fisheries in the State.

Exhibit 3-1
Central Valley Salmon Abundance, Hatchery, and Natural Escapements of Central Valley Adults (1970 to 2009)



Source: PFMC, February 2008, February 2009.

Photo: Green Sturgeon.

Green Sturgeon

Green sturgeon *(Acipenser medirostris)* southern population (south of the Eel River), found in San Francisco Bay and the Delta, was designated as a federal threatened species by NOAA-Fisheries in July 2006. This is a Distinct Population Segment (DPS), separate from green sturgeon found at the Eel River and north to British Columbia (NOAA-Fisheries February 2005). The green sturgeon is also listed as a California species of special concern by CDFG. In September 2008, NOAA-Fisheries proposed critical habitat for green sturgeon, including San Francisco Bay, the Delta, and the Sacramento River. In May 2009, NOAA-Fisheries issued proposed rules to establish take prohibitions for the southern green sturgeon population.

Green sturgeon is a large, olive green, bony-plated, prehistoric looking fish, with a shovel-like snout and vacuum cleaner-like mouth used to siphon food from the mud. Green sturgeon can reach over seven feet in length, weigh up to 350 pounds, and may live to be 60 to 70 years of age (CBD 2006). The Sacramento River contains the only known spawning population of southern DPS green sturgeon.

IEP fish monitoring in the San Francisco Bay, Delta, and river systems captured only 34 green sturgeons between April 2001 and September

2006, out of more than 100,000 fish sampled (IEP 2006a). Most captured sturgeon (17) were found at fish salvage facilities in the South Delta, indicating that they are found throughout the Delta. Another 14 sturgeon, most small, at less than 100mm, were found along the Sacramento River between Red Bluff and Colusa, and three were found during Chipps Island midwater trawls, west of WHCP sites, near Suisun Marsh. Sturgeon captured at Chipps Island were generally larger, between 400 and 550mm in length, but still in juvenile stages. There is a significant need for additional information on abundance, distribution, population dynamics, mortality rates, and threats to green sturgeon. The CDFG Central Valley Bay-Delta Branch is conducting studies of both white and green sturgeon to increase understanding of these issues (CDFG 2006c).

The following information on green sturgeon is quoted from Moyle et al., (1995):

> "In California, green sturgeon have been collected in small numbers in marine waters from the Mexican border to the Oregon border. They have been noted in a number of rivers, but spawning populations are known only in the Sacramento and Klamath Rivers… The San Francisco Bay system, consisting of San Francisco Bay, San Pablo Bay, Suisun Bay and the Delta, is home to the southernmost reproducing population of green sturgeon...
>
> "The habitat requirements of green sturgeon are poorly known, but spawning and larval ecology probably are similar to that of white sturgeon. However, the comparatively large egg size, thin chorionic layer on the egg, and other characteristics indicate that green sturgeon probably require colder, cleaner water for spawning than white sturgeon (S. Doroshov, pers. comm.). In the Sacramento River, adult sturgeon are in the river, presumably spawning, when temperatures range between 8°C to 14°C. Preferred spawning substrate likely is large cobble, but can range from clean sand to bedrock. Eggs are broadcast-spawned and externally fertilized in relatively high water velocities and probably at depths >3 in (Emmett et al., 1991). The importance of water quality is uncertain, but silt is known to prevent the eggs from adhering to each other (C. Tracy, minutes to USFWS meeting)…
>
> "The ecology and life history of green sturgeon have received comparatively little study evidently because of their generally low abundance in most estuaries and their low commercial and sportfishing value in the past. Adults are more marine than white sturgeon, spending limited time in estuaries or fresh water…
>
> "Juveniles and adults are benthic feeders, and may also take small fish. Juveniles in the Sacramento-San Joaquin Delta feed on opossum shrimp (*Neomysis mercedis)* and amphipods *(Corophium sp.)* (Radtke 1966). Adult sturgeon caught in Washington had been feeding mainly on sand lances *(Ammodyies hexapterus)* and callianassid shrimp (P. Foley, unpublished). In the Columbia River estuary, green sturgeon are known to feed on anchovies, and they perhaps also feed on clams (C. Tracy, minutes to USFWS meeting)."

There has been substantial habitat loss in the Sacramento River above Keswick and Shasta dams (NOAA-Fisheries February 2005, 15). Threats to green sturgeon include concentration of spawning, small population size, lack of population data, potentially growth-limiting and lethal temperatures, harvest concerns, loss of spawning habitat, entrainment by water projects, influence of toxic material, and exotic species (NOAA-Fisheries February 2005, 13-14).

Photo: Delta Smelt.

Delta Smelt

The delta smelt *(Hypomesus transpacificus)* is State listed as endangered, and federally listed as threatened. The federal threatened status was maintained following the 5-Year Review (USFWS March 2004), however several groups recently petitioned the USFWS for emergency listing of the delta smelt as endangered (CBD 2006). In July 2008, the USFWS initiated a 60-day comment period to consider changing the listing of delta smelt from "threatened" to "endangered". In March 2009, the USFWS initiated a five-year review to assess the endangered status of delta smelt. A change in designation will not impact WHCP operations or biological opinions, as the species already is subject to an incidental take permit.

Critical habitat for this species includes Suisun Bay (including contiguous Grizzly and Honker bays); the length of Goodyear, Suisun, Cutoff, First Mallard, and Montezuma sloughs; and existing continuous waters within the Sacramento-San Joaquin Delta. Delta smelt is native to the Sacramento-San Joaquin estuary. It is found primarily in the lower Sacramento and San Joaquin Rivers, in the Delta above their confluence, in Suisun Marsh water channels and in Suisun Bay. Delta smelt is endemic to low-salinity and freshwater habitats of the Delta (Bennett 2005).

Delta smelt spawn in fresh water from February to June, with peak spawning in April and May. Spawning has been reported to occur at about 45°F to 59°F in tidally influenced rivers and sloughs, including dead-end sloughs and shallow edgewaters of the upper Delta. Longer spawning seasons, based on this temperature range, are thought to result in more cohorts in a given season (Bennett 2005, 34). The spawning microhabitat for delta smelt is not known, and eggs have not been found in the field. Smelt are thought to spawn at night, broadcasting eggs just above the substratum, where the demersal (deposited near the bottom) and adhesive eggs mostly likely attach to submerged vegetation, rocks, or tree roots (Bennett 2005, 17).

Newly hatched larvae are planktonic and drift downstream near the surface in nearshore and channel areas to the freshwater/saltwater interface. Mager (1996) found that larvae hatched in 10 to 14 days under laboratory conditions and started feeding on phytoplankton at day four and on zooplankton at day six. Growth is rapid through summer, and juveniles reach 40 to 50 millimeters (fork length) by early August. Growth slows in fall and winter, presumably to allow for gonadal development. Adults range from 55 to 120 millimeters, but most do not grow larger than 80 millimeters.

The FWMT survey index, one measure of delta smelt abundance, declined in the mid-1980s, then generally increased through the late 1980s and early 1990s. In 1993, the FMWT index was the sixth highest of the 25 years of record. In 1990, the CDFG reviewed the status of delta smelt but could not determine factors causing the decline. In 1994, the index dropped to a 28-year low, but it rebounded again in 1995, only to drop again in 1996. Both the FMWT index and the summer tow net survey, conducted by CDFG, have shown extremely low levels of delta smelt starting in 2002, and continuing through 2008.

The 2008 FMWT index for delta smelt was the lowest on record, continuing a series of declining abundance indices (Smelt Working Group June 16, 2009). The total number of delta smelt caught in the CDFG's 2008 spring kodiak trawl survey was also low, as compared to previous years (Smelt Working Group June 16, 2008). There is significant concern regarding low fish counts over the last several years for delta smelt, as well as other species (see discussion of the POD working group, above). Delta smelt is of great concern, as the species is considered an indicator species of Delta health. There are a number of ongoing research efforts aimed at better understanding specific causes of the drastic decline in delta smelt (Baxter et al. 2008b; Sommer et al. 2007).

Because delta smelt has only a one-year life-cycle, they are particularly sensitive to threats. In addition, delta smelt have a limited diet, produce low number of eggs, are poor swimmers, are easily stressed, and reside primarily in the moving interface between saltwater and freshwater. There are many potential reasons for delta smelt decline, including: high or low Delta water outflow, reduction in preferred food prey organisms, toxic substances, disease, competition, predation, and loss of genetic integrity (CDFG 2005, 73). In addition, delta smelt larvae, juveniles, and adults are entrained in diversions of the CVP and SWP. Although some species of fish can be salvaged at fish screening facilities, delta smelt suffer 100 percent mortality (USFWS March 2004, 11). In the USFWS 5-Year Review, fisheries biologist Peter Moyle indicated that Delta smelt will never be out of danger of extinction unless there are permanent and reliable changes made to the flow and temperature regimes that favor the smelt (USFWS March 2004, 27).

Relatively little is known about delta smelt compared to most other fish in the Delta, and even after a thorough review of delta smelt, three critical questions remain: (1) should the species continue to be listed as threatened, and what is the probability of extinction?, (2) What is the impact of human activities, particularly water export operations, on population abundance?, (3) Are there potential avenues for restoration and recovery (Bennett 2005)?

Bennett (2005) concluded that there is a 55 percent chance that the delta smelt population would become "quasi-extinct" (less than 8,000 fish) within 20 years. New analyses of threats to delta smelt are considering factors such as water quality and water flows on a regional, rather than a Delta-wide scale (Nobriga et al. 2008). Nobriga et al., (2008) found that at a regional level water clarity, salinity, and temperature were indicators of delta smelt habitat suitability.

Source: www.hoatzin.de.

Photo: River Lamprey.

River Lamprey

River lamprey *(Lampetra ayresi)* is a California species of special concern on the "watch list." River lamprey has no federal listing. The USFWS evaluated Pacific lamprey, western brook lamprey, and river lamprey in 2004, and found no basis for listing these species (USFWS 2004c). No critical habitat has been designated for this species.

River lamprey are more widely distributed in British Columbia. Relatively little is known of the river lamprey's distribution, abundance, life history, and habitat requirements in California (USFWS 2004c). The following is quoted from Moyle and others (1995):

“The habitat requirements of spawning adults and ammocoetes [larvae] have not been studied in California. Presumably, the adults need clean, gravelly riffles in permanent streams for spawning, while the ammocoetes require sandy backwaters or stream edges in which to bury themselves, where water quality is continuously high and temperatures do not exceed 25°C.

“River lampreys have been collected from large coastal streams from fifteen miles north of Juneau, Alaska, down to San Francisco Bay. In California, they have been recorded only from the lower Sacramento and San Joaquin rivers and from the Russian River (Lee and others 1980), but they have not really been looked for elsewhere. Wang (1980) indicates that a landlocked population may exist in upper Sonoma Creek (Sonoma County), a tributary to San Francisco Bay…

“Trends in the populations of river lamprey are unknown in California, but it is likely that they have declined, along with the degradation of suitable spawning and rearing habitat in rivers and tributaries. River lamprey are abundant in British Columbia, the center of their range, but there are relatively few records from California, the southern end of their range.

“The river lamprey has become uncommon in California, and it is likely that the populations are declining because the Sacramento, San Joaquin, and Russian Rivers and their tributaries have been severely altered by dams, diversions, pollution, and other factors. Two tributary streams where spawning has been recorded in the past (Sonoma and Cache creeks) are both severely altered by channelization, urbanization, and other problems.”

Source: www.fs.fed.us.

Photo: Central Valley Steelhead.

Central Valley Steelhead

Central Valley steelhead *(Oncorhynchus mykiss),* which are the anadromous form of rainbow trout, are federally listed threatened, a status that was confirmed in 2005 (NOAA-Fisheries 2005). NOAA-Fisheries is developing a recovery plan for Central Valley steelhead. Central Valley steelhead migrate to the ocean as juveniles and return to fresh water to spawn when they are 2 to 4 years old. Spawning migration (through the Delta) can be anytime from August through March.

Steelhead usually do not die after spawning. Survivors return to the ocean between April and June, and some make several more spawning migrations. Juvenile steelhead usually remain in fresh water for the first year, then migrate to the ocean between November and May. Steelhead are found in the Delta predominantly during migration.

Steelhead are primarily threatened by loss of the vast majority of historical spawning habitats above impassable dams, and mixing with hatchery fish (NOAA-Fisheries 2005, 290). California began implementing measures to protect steelhead in 1998, including 100 percent marking of all hatchery steelhead, zero bag limits for unmarked steelhead, gear restrictions, closures, and designation of size limits to protect smolts (NOAA-Fisheries 2007).

Source: www.fws.gov.

Photo: Chinook Salmon.

Chinook Salmon

There are four distinct runs of Chinook salmon *(Oncorhynchus tshawytscha)*, distinguished by their timing of upstream migration and spawning season. The runs are named for the season during which the adults enter fresh water. Two of these runs are special status species and will be discussed below: winter-run, and spring-run. NOAA-Fisheries is developing recovery plans for both species.

In 1989, the Sacramento River winter-run Chinook salmon was listed as threatened under the federal ESA by NOAA-Fisheries (54 FR 32085). NOAA-Fisheries reclassified the winter-run as endangered in 1994 (59 FR 440), and reaffirmed this classification in 2005 (NOAA-Fisheries 2005). Winter-run Chinook salmon were classified by the State as endangered in 1989. In 1993, NOAA-Fisheries designated critical habitat for the winter-run Chinook from Keswick Dam (Sacramento river mile 302) to the Golden Gate Bridge (58 FR 33212) (Federal Register 2004).

Central Valley spring-run salmon was listed as threatened by both the State and federal governments in 1999, and reaffirmed as threatened by the federal government in 2005. Critical habitat for Central Valley spring-run Chinook salmon was designated in September 2005. Critical habitat within the Delta includes portions of three hydrologic units: Sacramento Delta, Valley Putah-Cache, and Valley-American. Unlike winter-run Chinook, which utilize only the Sacramento River, spring-run Chinook utilize primarily the Feather and Yuba Rivers, with smaller populations likely in the Sacramento River and Big Chico Creek (NOAA-Fisheries 2005).

Central Valley fall-run and late fall-run Chinook salmon runs do not have any special State or federal status. All four runs of Chinook salmon are found in the Delta only during migration to and from the Pacific Ocean. They do not spawn or rear in the Delta.

The life span of Chinook salmon ranges from two to seven years. Although Chinook salmon can spend 1½ to 5 years in the ocean before returning to natal streams to spawn, most return to fresh water 2½ years after entering the ocean.

Chinook salmon eggs are laid in nests (called "redds") excavated by the female in loose gravel. Juvenile salmon may migrate downstream to the estuary immediately after emerging from the redd, or they may spend a year or more in fresh water. The length of juvenile residence time in fresh water and estuaries varies between salmon runs and depends on a variety of factors, including season of emergence, streamflow, turbidity, water temperature, and interaction with other species.

There are two general types of Chinook salmon life history strategies, stream type and ocean type. Stream-type juveniles remain in the river for a year or more before migrating to the ocean. Ocean-type juveniles typically move to the ocean during their first few months. Although California races typically follow the ocean pattern, some juveniles of the fall, late-fall, and spring runs may emigrate as age-one smolts. Apparently all winter-run salmon migrate during the first few months after emergence.

Adult winter-run salmon immigrants enter the Sacramento River from December through June, peaking in March and April. Adults remain in the

Sacramento River until spawning in May through August (CDFG 2005, 64). Juveniles spend five to nine months in the river and Delta before entering the ocean. Juveniles begin to move out of the upper river no earlier than fall, when water temperatures in lower reaches are suitable for migration (NOAA-Fisheries 2005, 145).

The entire historical spawning habitat of the Sacramento River winter-run Chinook salmon was blocked by construction of Shasta Dam. All spawning now occurs in the Sacramento River, below Keswick Dam (NOAA-Fisheries 2005, 145). The population size of winter-run Chinook salmon may have been as high as 200,000, dropped to 100,000 in the 1960s, and fell well below 5,000 between 1982 and 2001. Population estimates have increased to just under 10,000 since 2001 (NOAA-Fisheries 2005, 147).

Spring-run Chinook salmon traditionally spawned in upper reaches of Central Valley rivers and their tributaries, which are now blocked by dams. The spring run in the Sacramento River system generally enters fresh water between February and June, moving upstream and entering tributary rivers from February through July, peaking in May and June (CDFG 2005, 66). Fish migrate into headwaters and hold in pools through the summer, spawning from mid-August through mid-October. This is a distinguishing feature of this run, as adults hold over during the summer in colder pools in the upper river areas and do not spawn until fall, sometime between late August and October. Some juveniles emerge in early November, continuing through April, emigrating from the tributaries as fry from mid-November through June (CDFG 2005, 66). "Yearlings" remain in the stream until the following October, and emigrate starting in October through the following March (CDFG 2005, 66).

There are three independent populations of spring-run Chinook salmon, which utilize tributaries of the Sacramento River: Mill Creek, Deer Creek, and Butte Creek (NOAA-Fisheries 2007). There are also four dependent populations of spring-run Chinook salmon, utilizing Kings River, and Big Chico, Antelope, Clear, Thomes, Cottonwood, Beegum, and Stony Creeks (NOAA-Fisheries 2007).

Delta operations of the CVP and SWP affect adult and juvenile Chinook salmon as they pass through the Delta on their way to and from spawning and nursery areas in the Sacramento and San Joaquin River systems. Flow direction and velocity in Delta channels, operation of the Delta Cross Channel, and exposure of fish to the export pumps are major water project-related factors affecting salmon survival.

Adult salmon require presence of homestream water to guide them to their spawning grounds. Salmon from the Sacramento River system outmigrating through the Delta as juveniles in spring and early summer may be affected by altered flow patterns in the lower San Joaquin River. Some are also diverted to the interior Delta through Georgiana Slough and the Delta Cross Channel, where survival is lower than if they continued downstream in the Sacramento River. Exposure to water project fish screens results in losses due to predation by larger fish in front of screens, screen inefficiency, and attrition in the process of handling and hauling salvaged fish.

Other factors leading to declines in Chinook salmon include loss of most historical spawning habitat; degradation of remaining habitat, genetic threats from hatchery fish or other runs, predation by non-native species, and excessively high water temperatures (NOAA-Fisheries 2005, 153-155).

Source: www.fws.gov.

Photo: Sacramento Splittail.

Sacramento Splittail

Sacramento splittail *(Pogonichthys macrolepidotus)* was proposed threatened by the USFWS in January 1994, and officially listed as threatened in February 1999. Following a court challenge and mandated reevaluation in 2000, the USFWS delisted Sacramento splittail in 2003 (USFWS 2006). In August 2007, the Center for Biological Diversity submitted a notice of intent to sue the USFWS to require reconsideration of the splittail listing, and also to sue for political interference with the decision to delist the splittail (CBD 2008). Sacramento splittail is listed as a California species of special concern. No critical habitat is currently designated for this species.

Sacramento splittail is a large minnow endemic to the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Estuary). Once found throughout low elevation lakes and rivers of the Central Valley from Redding to Fresno, this native species is now confined to lower reaches of the Sacramento and San Joaquin rivers, the Delta, Suisun and Napa marshes, and tributaries of north San Pablo Bay (CDFG 1994). Although Sacramento splittail is considered a freshwater species, adults and sub-adults have an unusually high tolerance for saline waters, up to 10-18 ppt (Meng 1993), for a member of the minnow family (CDFG 1994). Therefore, Sacramento splittail is often considered an estuarine species. When splittail were more abundant, they were commonly found in Suisun Bay and Suisun Marsh. Salt tolerance of splittail larvae is unknown (CDFG 1992).

Juveniles and adults use shallow edgewater areas lined by emergent aquatic vegetation. Submerged vegetation provides food sources and escape cover. Shallow, seasonally flooded vegetation is also apparently a preferred splittail spawning habitat. Year class strength appears to be primarily controlled by inundation of floodplain areas (high rainfall years), which provides spawning, rearing and foraging habitat. The splittail's life history pattern, featuring high fecundity, relatively long life span, and ability to migrate to spawning areas, shows an ability to adapt to a variable environment (Moyle et al. 2004).

Sacramento splittail is a relatively long-lived minnow, reaching ages of five and possibly up to seven years. Both males and females usually reach sexual maturity in their second year. Like most cyprinids, splittail has high fecundity, ranging from 5,000 to 100,000 eggs per female.

Timing and location of splittail reproduction have varied during separate investigations. From 1978 to 1983, samples of larvae indicate that splittail spawned in tidal freshwater and oligohaline (brackish, 0.5 to 5ppt saline) habitats such as Montezuma and Suisun sloughs and San Pablo Bay, from late January or early February through July. However, most spawning activity appears to occur in the Sacramento and San Joaquin Rivers and their tributaries. Splittail in the Delta are most abundant in the north and west portions when populations are low, but are more evenly distributed in years with higher reproductive success (Moyle et al. 2004).

Splittail eggs are adhesive or become adhesive soon after contacting water. Eggs appear to be demersal, are believed to be laid in clumps, and attach to vegetation or other submerged substrates. Larvae become free swimming five to seven days after hatching; feeding begins after five days post-hatch.

Young splittail appear to seek out shallow, vegetated areas protected from strong currents near spawning grounds and move downstream as they grow. They apparently move or are carried with higher spring flows downstream into the estuary and bays, where they are captured regularly by midwater trawl sampling in Suisun Bay near Montezuma Slough, in the vicinity of Pittsburgh Power Plant near New York Slough, near Antioch, and sometimes as far downstream as Carquinez Strait and San Pablo Bay.

Splittail recruitment decreased during 1987 to 1990 and apparently improved in 1991 and 1993. Juvenile splittail abundance is often highest in wet years. In 1994, the midwater trawl index once again showed a decline in young-of-the-year abundance, but the 1995 year class was exceptionally strong. In most surveys, the number of adult splittail has been variable since 1979, without a discernible trend, but Suisun Marsh surveys showed a major decline after 1981, with little or no resurgence since then. Again, 1995 abundance indices were the highest on record for CVP and SWP salvages, the San Francisco Bay Study otter trawl, and the (San Francisco) Bay Study midwater trawl (Sommer et al. 1997).

There are several different monitoring programs that measure splittail abundance, although none are focused on splittail. These surveys show that splittail have high natural variability (due to their life history), some successful reproduction takes place every year, and most successful reproduction years occur with relatively high outflow (Moyle et al. 2004, 13).

A major factor in species decline appears to be habitat constriction associated with the reduction of water flows and changed hydraulics in the Delta. There is a strong positive correlation between splittail year class success and outflows, with reduced survival during years of low outflow and high diversion (CDFG 2006a). A number of other factors may also influence splittail abundance, including loss of prey, effects of drought and climate change on habitat, non-native competitors and predators, and possible threats of disease and environmental contaminants (CDFG 2006a).

Source: swr.nmfs.noaa.gov.

Photo: Longfin Smelt.

Longfin Smelt

Longfin smelt *(Spirinchus thaleichthys)* is designated as a California threatened species. The USFWS initiated a status assessment of the longfin smelt in April 2009. No critical habitat has been granted to this species.

The longfin smelt is a small, planktivorous fish that is found in several Pacific coast estuaries from San Francisco Bay to Prince William Sound, Alaska. Within California, longfin smelt have been reported from Humboldt Bay and the mouth of the Eel River. However, data are infrequently collected from Humboldt Bay, and there are no recent records from the Eel River (SFEP 1992a). In California, the largest longfin smelt reproductive population inhabits the Bay-Delta Estuary (CDFG 1992). This four to five inch long (adult), pelagic anadromous species spawns in fresh waters of the Delta and lower rivers, rears throughout the Estuary, and matures in brackish and marine waters (SFEP 1997).

Longfin smelt can tolerate salinities ranging from fresh water to sea water. Spawning occurs in fresh to brackish water or fresh water, over sandy-gravel substrates, rocks, or aquatic vegetation (Meng 1993; CUWA 1994).

In the Bay-Delta Estuary, the longfin smelt life cycle begins with spawning in the lower Sacramento and San Joaquin Rivers, the Delta, and freshwater portions of Suisun Bay (SFEP 1992a). Spawning may take place as early as November and extend into June, with peak spawning occurring from February to April (Meng 1993). Eggs are adhesive and, after hatching, larvae are carried downstream by freshwater outflow to nursery areas in the lower Delta and Suisun and San Pablo Bays (SFEP 1992a). The principal nursery habitat for larvae is productive waters of Suisun and San Pablo Bays. Adult longfin smelt are found mainly in Suisun, San Pablo, and San Francisco Bays, although their distribution is shifted upstream in years of low outflow (Meng 1993).

With the exceptions that both longfin smelt and Delta smelt spawn adhesive eggs in river channels of the eastern Estuary and have larvae that are carried to nursery areas by freshwater outflow, the two species differ substantially. Consistently, a measurable portion of the longfin smelt population survives into a second year (SFEP 1992a). During the second year of life, they inhabit San Francisco Bay and, occasionally, the Gulf of the Farallones; thus, longfin smelt are often considered anadromous. Longfin smelt are also more broadly distributed throughout the Estuary, and are found at higher salinities, than Delta smelt (Sommer et al. 2002).

Because longfin smelt seldom occur in fresh water except to spawn, but are widely dispersed in brackish waters of the Bay, it seems likely that their range formerly extended as far up into the Delta as salt water intruded. The easternmost catch of longfin smelt in the fall midwater trawl was at Medford Island in the Central Delta. They have been caught at all stations of the Bay Study. A pronounced difference between the two species in their region of overlap in Suisun Bay is by depth; longfin smelt are caught more abundantly at deep stations (10 meters), whereas Delta smelt are more abundant at shallow stations (<3 meters) (SFEP 1992a).

A strong relationship exists between freshwater outflow during spawning and larval periods and subsequent abundance of longfin smelt (SFEP 1997). Outflow disperses buoyant larvae, increasing likelihood that some will find food. By reducing salinities in Suisun and San Pablo Bays, outflow may also provide habitat with few marine or freshwater competitors and predators (marine species often do not tolerate lower salinities, and freshwater species have mechanisms to avoid being washed downstream (SFEP 1997)).

The factor most strongly associated with recent declines in abundance of longfin smelt has been the increase in water diverted by the SWP and the CVP during winter and spring months when longfin smelt are spawning (NHI 1992a; DWR 1992). Pumping changes the hydrology of the Delta and increases exposure of larval, juvenile, and adult longfin smelt to predation and entrainment (NHI 1992b). Salvage data indicate that longfin smelt have been more vulnerable to pumping operations since 1984. This increase in vulnerability may be due to concentration of longfin smelt populations in the upper Estuary, within the zone of influence of the pumps, as a result of reduced Delta outflow. Also, decreases in outflow fail to disperse larvae downstream to Suisun Bay nursery areas, away from effects of Delta pumping (Meng 1993).

Longfin smelt have declined significantly from historic levels. Prior to the drought years 1987 through 1994, the FMWT Survey recorded longfin smelt averages of approximately 17,000 fish (USFWS May 6, 2008). This figure dropped to less than 600 during the drought, and then increased to approximately 4,000 from 1995 to 2000. Since 2001, FMWT surveys have averaged less than 600 longfin smelt per year, although there have not been drought conditions. A study of FWMT, San Francisco Bay Study, and Suisun Marsh Survey data, found significant declines in longfin smelt abundance (Rosenfield and Baxter 2007).

7. Amphibians

Source: www.fws.gov.

Photo: California Red-Legged Frog.

California Red-Legged Frog

The California red-legged frog (*Rana aurora draytonii*) is listed as federal threatened, and a California species of special concern. The California red-legged frog is the largest frog native to California. Habitat of the California red-legged frog is characterized by dense, shrubby vegetation associated with deep, still, or slow-moving water. They are infrequent inhabitants where introduced aquatic predators (e.g., bullfrogs) are present. Red-legged frogs rely on dense cover to protect them while breeding and foraging. They were found historically throughout the Central Valley, along the Pacific Coast, and in the San Francisco Bay area. Today the frog occupies only about 30 percent of its original range and is found primarily along the coast between San Francisco and Ventura. The USFWS finalized critical habitat designation for the California red-legged frog in May 2006. There are thirty critical habitat units covering 4.1 million acres in 28 counties. None of the designated habitat overlaps with WHCP treatment sites.

California red-legged frogs breed from late November to April. At breeding sites, males typically call in small mobile groups (three to seven individuals) to attract females. Females attach eggs to emergent vegetation where embryos hatch six to 14 days after fertilization. Larvae require four to five months to attain metamorphosis. Juvenile frogs seem to favor open, shallow aquatic habitats with dense submergent vegetation. They frequently are active during the day, spending daylight hours basking in the warm surface water layer associated with floating and submergent vegetation. Adult frogs are wary and highly nocturnal. Introduced predators (particularly bullfrogs), habitat modification and destruction, and drought have all contributed to the decline of the species.

8. Reptiles

Source: www.californiaherps.com.

Photo: Giant Garter Snake.

Giant Garter Snake

The giant garter snake *(Thamnophis gigas)* is listed as State and federal threatened. Giant garter snakes are the largest garter snake in North America and are endemic to the valley floor wetlands in the Sacramento and San Joaquin Valleys. They inhabit sloughs, ponds, small lakes, and other low-gradient waterways, including irrigation canals where water is present throughout the summer. Giant garter snakes are rarely found away from water, forage in the water for food, and will retreat to water to escape predators and disturbance (USFWS May 2004). These snakes typically avoid larger waterways with predatory fish, and woodland streams with excessive cover.

Giant garter snakes may exceed five feet in length, are dull brown with a checkered pattern of black spots on the dorsal side, and have a dull yellow, mid-dorsal stripe. The head is elongated with a pointed snout (CDFG 2005, 128).

Giant garter snake diet consists of small fishes, tadpoles, and frogs. Components of essential giant garter snake habitat include: adequate water during the active season (early-spring through mid-fall) to provide food and cover; emergent, herbaceous wetland vegetation, such as cattails and bulrushes, for escape cover and foraging habitat during the active season; upland habitat with grassy banks and openings in waterside vegetation for basking; and higher elevation uplands for cover and refuge from flood waters during the snake's dormant season in the winter (CDFG 2005, 17).

Giant garter snakes are currently found in only a small number of populations. Loss of wetlands, development, levee construction, grazing, and agriculture have all fragmented and reduced giant garter snake habitat (CDFG 2005, 18).

Source: www.fws.gov.

Photo: Western Pond Turtle.

Western Pond Turtle

The western pond turtle *(Clemmys marmorata)* includes two subspecies, the northwestern pond turtle *(Clemmys marmorata marmorata)* and the southwestern pond turtle *(Clemmys marmorata palida).* Both subspecies are designated as California species of special concern by CDFG. No critical habitat has been designated for this species.

Western pond turtles occur in suitable aquatic habitats throughout California west of the Sierra-Cascade crest and in parts of Oregon and Washington (Stebbins 1985). The northwestern subspecies is found generally north of San Francisco Bay, while the southwestern subspecies is found south of San Francisco Bay. The two subspecies may intergrade throughout the Delta and San Joaquin Valley (Stebbins 1985), or intergrades may be restricted to the Delta region with San Joaquin Valley populations represented by the southwestern pond turtle (USFWS 1992).

Western pond turtles are omnivorous. In addition to aquatic vegetation, turtles feed on larval dragonflies, mayflies, stoneflies, caddisflies, beetles, and other aquatic invertebrates (DBW 2001). Carrion is reported to be a common food item. Western pond turtles are a common prey item for river otters, raccoons, minks, coyotes, and bears.

Western pond turtles are found in association with a wide variety of wetlands, including ponds, marshes, lakes, streams, and irrigation ditches (Stebbins 1985). Suitable habitat is typically well-vegetated and contains exposed logs, rocks, or other basking sites from which turtles can easily escape into the water when disturbed (Stebbins 1985). Egg-laying may occur along sandy wetland margins or at upland locations as far as 1,300 feet from water (DBW 2001). Hatchlings and juveniles apparently require a more specialized aquatic habitat than do adults (USFWS 1992). Western pond turtles may move overland for short distances: females to lay eggs; entire local populations to reach new water and escape drying bodies of water (Zeiner et al. 1988).

Historic populations of western pond turtles in California have declined extensively (possibly as much as 90 to 99 percent in the Central Valley since 1850) as riparian corridors have been stripped of vegetation, flood plains diminished, and natural waterways channelized, leveed, and riprapped. Young turtles are vulnerable to a wide variety of predators including many introduced species such as bullfrogs and game fish (DBW

2001). Pond turtles may be victims of bioaccumulation of heavy metals and other toxins, which have increased dramatically in California's waterways since the industrialization of the state (DBW 2001). In the San Joaquin Valley, western pond turtles declined between 1880 and 1990 from an estimated 10 million or more, to less than 5,000 (DBW 2001).

Commercial collecting, wetland and upland habitat loss, and introduced predators have all been implicated in the decline of western pond turtles (USFWS 1992). Less than 10 percent of wetlands historically found throughout the species' range in California persist today (USFWS 1992).

9. Birds

Source: www.birdphotography.com.

Photo: California Black Rail.

California Black Rail

The California black rail *(Laterallus jamaicensis coturniculus)* is listed as a threatened species in California. There is no critical habitat for this species.

The California black rail is believed to have occurred historically from Tomales Bay in Marin County, south along the coast into northern Baja California, and in inland marshes of San Francisco Bay, the Delta, the San Bernardino-Riverside area, and along the lower Colorado River and the Salton Sea (Steinhart 1990). Throughout its range, the species is known to inhabit tidal salt, brackish, and freshwater marshes.

Highest densities of breeding black rails occur in larger undiked tidal marshes associated with the Petaluma and Napa Rivers, and in some bayshore marshes of San Pablo Bay. Elsewhere in San Pablo Bay, Suisun Bay, Suisun Marsh, and the Delta, distribution of the species is patchy due to habitat loss and fragmentation.

California black rail is the most secretive of rails, moving through and hiding under dense marsh vegetation. Black rails utilize undiked tidal marshes that include a high marsh elevational zone. They are critically dependent on the narrow upper peripheral halophyte zone above the area of extreme and frequent tidal action where insect abundance is greatest. Marsh elevation, freshwater inflow, and tidal regime may be variables that control occurrence of black rails in wetlands (DWR 1994).

The population of California black rail subspecies has been reduced to just a few thousand, the bulk of which are now limited to the northern San Francisco Bay area. Suitable California black rail habitat is limited in the Delta. The few areas of marsh vegetation that form suitable habitat are either shrinking from inundated substrates or are dominated by willows.

Loss, conversion, and fragmentation of natural tidal marshes have reduced historic habitat of California black rails. Domestic animals such as cats and introduced exotics such as red fox continue to threaten the species' existence. Black rail mortality has been reported from collisions with power lines, transmission towers, and automobiles (Zeiner et al. 1990).

California black rails are rarely found in the project area (Herbold and Moyle 1989). The only documented locations of black rails in the Delta are on instream berm islands, and these islands are slowly disappearing (DWR 1996).

Source: www.fws.gov.

Photo: Yellow-Headed Blackbird.

Yellow-Headed Blackbird

The yellow-headed blackbird *(Xanthocephalus xanthocephalus)* is a California species of special concern, priority 3. There is no critical habitat designated for this species.

Yellow-headed blackbirds are primarily migrant and summer residents of California, with current ranges in the Central Valley, northeastern California, and southern deserts (information on this species from: Jaramillo 2008). Yellow-headed blackbirds are present from April to early October, breeding from mid-April to late July.

Yellow-headed blackbirds breed in marshes with tall emergent vegetation, such as tules or cattails. They generally prefer open areas and edges over relatively deep water, and nest in low vegetation. Most nests are attached to cattails, tules, or willows. Males choose territories with open water, and females choose waterway edges with moderately dense vegetation and extensive channels. The diet of yellow-headed blackbirds consists of seed, and to a minor extent, insects.

Yellow-headed blackbirds are threatened by habitat loss, specifically wetland drainage for irrigation, flood control, or water diversion. They are sensitive to water depth, and lowering water levels may adversely affect breeding. Loss of historic wetlands has reduced the number of breeding yellow-headed blackbirds in the Delta, however they have been identified in the Delta in Sacramento, Yolo, San Joaquin, and Contra Costa counties. The species may also be present along rivers in the San Joaquin Valley.

Source: www.fws.gov.

Photo: Tricolored Blackbird.

Tricolored Blackbird

The tricolored blackbird *(Agelaius tricolor)* is a California species of special concern, priority 1. There is no critical habitat designated for this species.

Tricolored blackbirds are most numerous in the Central Valley and vicinity, and are largely endemic to California (CNDDB 1997). Most breeding occurs in California's Central Valley from mid-March through early August (Beedy 2008). A first breeding effort occurs primarily from the San Joaquin Valley south to Kern County, and separately in southern Sacramento County (DBW 2001). An itinerant breeding effort following this occurs in other portions of the Sacramento Valley, including north of the Delta in Glenn and Colusa counties. A large portion of the population is believed to overwinter in the Delta. Large numbers observed there indicate that the region may be especially important for overwintering adults and juveniles.

Tricolored blackbirds are highly colonial birds. These birds breed near fresh water, preferably in emergent wetlands with tall, dense cattails and tules, but also in thickets of willow, blackberry, wild rose, and tall herbs (Zeiner et al. 1990). Tricolored blackbirds create dense colonies of nests in cattail marshes, typically from a few centimeters to 1.5 meters above water or ground in freshwater marshes (Beedy 2008). They may also nest slightly higher, in willows and other riparian trees (Beedy 2008). Nesting sites are adjacent to open accessible water, provide protected nesting substrate, and suitable nearby foraging space with adequate insect prey (Beedy 2008).

The tricolored blackbird population has been declining, at least since the 1930s. Habitat loss is thought to be the primary reason for this decline. Recent conversion of pastures and grasslands to vineyards in Sacramento County has resulted in loss of several large colonies (Beedy 2008).

10. Plants

We identified eleven special status plant species potentially affected by the WHCP as those that are located, or potentially located, in those habitat types that will be directly impacted by water hyacinth treatments. Species on channel banks immediately adjacent to treatment sites may potentially be affected by herbicide drift, although DBW takes steps to minimize drift, as described in mitigation measures. The eleven plant species that are potentially impacted by the WHCP are identified in Table 3-1, and are described below.

In botanical surveys conducted by DBW in 2002 and 2003 at WHCP treatment sites, two emergent or submergent special status plants, and two additional special status plants were identified: Suisun Marsh aster (common on Sherman Island),wooly rose-mallow (common on Old River and Middle River), Delta tule pea (on Delta island interiors and the lower Sacramento River), and elderberry, protected for the valley elderberry longhorn beetle. **Table 3-3,** on the next page, identifies submergent and emergent plants found in DBW's botanical surveys.

Source: calphotos.berkeley.edu.

Photo: Bristly sedge.

Bristly Sedge

Bristly sedge *(Carex comosa)* has no federal or State status. It is included on California Native Plant Society (CNPS) List 2.1: plants are rare, threatened, or endangered in California, but more common elsewhere, and seriously threatened in California. No critical habitat has been designated for this species.

Bristly sedge is recognized by male and female flowers on separate spikes. It is a monocot perennial herb with slender rhizomes, the stem is erect and smooth, growing up to five feet tall (USGS 2006).

Bristly sedge is found in marshes and swamps, as well as coastal prairies, and valley and foothill grasslands. It has been found in three topographic quadrants that include WHCP treatment sites: Holt, Bouldin Island, and Courtland (CNPS 2008). Bristly sedge is more common in wetlands in the Midwest and East. Bristly sedge is threatened by marsh drainage (CNPS 2008). Bristly sedge is associated with the nontidal freshwater permanent emergent habitat classification within the Delta (CALFED July 2000, C-2-3).

Table 3-3
Common Submergent and Emergent Plants Identified in DBW Botanical Surveys (2002 and 2003)

Submergent

Common Name	Scientific Name	Native/Nonnative *(if specified)*
1. Coontail	*Ceratophyllum demersum*	Native
2. Brazilian elodea	*Egeria densa*	Nonnative
3. Eurasion water milfoil	*Myriophyllum spicatum*	Nonnative
4. curly leaf pondweed	*Potamogeton crispus*	Native
5. fanwort	*Cabomba carolina*	Native
6. long-leaved pondweed	*Potamogeton nodus*	Native
7. southern naid	*Najas guadalupensis*	Native
8. sago pondweed	*Stuckenia pectinatus*	Native

Emergent

Common Name	Scientific Name	Native/Nonnative *(if specified)*
1. pennywort	*Hydrocotyl ranuculoides*	Native
2. common tule	*Scirpus acutus*	Native
3. California bullrush	*Scirpus californicus*	Native
4. smartweed	*Polygonum*	Native
5. water hyacinth	*Eichhornia crassipes*	Nonnative
6. yellow water primrose	*Ludwigia peploides*	*
7. common reed	*Phragmites australis*	Native
8. cattail	*Typha latifolia*	Native
9. flatsedge	*Cyperus odoratus*	Native
10. rush	*Juncus*	Native
11. spike rush	*Eleocharis*	Native
12. bur marigold	*Bidens cernua*	Native

* There are both native and non-native species of *Ludwigia peploides* in the Delta.

Source: www.dbw.ca.gov.

Photo: Wooly Rose-Mallow.

Wooly Rose-Mallow

Wooly rose-mallow *(Hibiscus lasiocarpus)* is on the CNPS List 2.2: plants are rare, threatened, or endangered in California, but more common elsewhere, and fairly threatened in California. The plant has no State or federal status. No critical habitat has been designated for this species.

Wooly rose-mallow occurs along the Sacramento River and adjoining sloughs from Butte County to the Delta. Wooly rose-mallow has been found throughout the Delta, and has been identified in several topographic quads covering WHCP treatment sites, including: Stockton West, Holt, Woodward Island, Clifton Court Forebay, Thornton, Terminous, Isleton, Rio Vista, Jersey Island, Bouldin Island, and Courtland (CNPS 2008). Outside of California, the species is widespread, but threatened. Wooly rose-mallow is primarily found in western North America, but occurs as far east as Missouri (CNDDB 1992).

Wooly rose-mallow is a rhizomatous perennial emergent herb. It grows three to seven feet, and has two to four-inch white and rose flowers (Jepson Flora Project 1993). Within the Delta, wooly rose-mallow is found in tidal freshwater emergent and nontidal freshwater permanent emergent habitats (CALFED July 2000, C-2-7). It is associated with tules, willows, buttonwillow, and other marsh and riparian species on heavy silt, clay, or peat soils (CNDDB 1992).

Wooly rose-mallow is seriously threatened by development, agriculture, recreation, and channelization of the Sacramento River and its tributaries (CNPS 2006). Preferred habitat has been altered or destroyed by levee construction and maintenance, agricultural development, and marsh reclamation (CALFED July 2000, 303).

Source: www.dbw.ca.gov.

Photo: Delta Tule Pea.

Delta Tule Pea

Delta tule pea *(Lathyrus jepsonii Greene ssp. Jepsonii)* is on CNPS List 1B.2: plants are rare, threatened, or endangered in California and elsewhere, and fairly threatened in California. It has no State or federal status. No critical habitat has been designated for this species.

Delta tule pea occurs on the Delta islands of the lower Sacramento and San Joaquin Rivers and westward through Suisun Bay to the lower Napa River. The plant also has been reported in western Alameda and Santa Clara counties (Calflora 2006).

Delta tule pea has been identified in a number of topographic quads covering WHCP treatment sites, including: Stockton West, Holt, Woodward Island, Thornton, Terminous, Isleton, Rio Vista, Jersey Island, Bouldin Island, Antioch North, and Courtland (CNPS 2008). Delta tule pea is associated with saline emergent and tidal freshwater emergent habitats within the Delta (CALFED July 2000, C-2-7).

Delta tule pea is a sprawling perennial vine found in coastal and Valley freshwater marshes. It has been observed in association with a broad spectrum of other plants ranging from common tule to Valley oak to arrowgrass. It prefers sites above tidal influence, which are still within the area of soil saturation (CNDDB 1992). It is threatened by agriculture, water diversions, salinity, and erosion (CNPS 2006).

Source: calphotos.berkeley.edu.

Photo: Mason's Lilaeopsis.

Mason's Lilaeopsis

Mason's lilaeopsis *(Lilaeopsis masonii)* is State listed rare and is included on the CNPS List 1B.1: plants are rare, threatened, or endangered in California and elsewhere, and seriously threatened in California. It has no federal status. No critical habitat has been designated for this species.

Mason's lilaeopsis is found in the Delta from the margins of the Napa River in Napa County, east to the channels and sloughs of the Delta (CDFG 2005, 444). Mason's lilaeopsis is found in topographic quads throughout WHCP treatment sites, including: Holt, Union Island, Woodward Island, Clifton Court Forebay, Thornton, Terminous, Lodi South, Isleton, Rio Vista, Jersey Island, Bouldin Island, and Antioch North (CNPS 2008). Mason's lilaeopsis is found in tidal freshwater emergent habitats within the Delta (CALFED July 2000, C-2-8). The DBW botanical surveys in 2002 and 2003 found Mason's lilaeopsis to be common at the tidal edge clay.

Mason's lilaeopsis is a minute, turf-forming, perennial herb in the carrot family. It is found in tidal zones, on mud-banks and flats along sloughs and rivers, in freshwater marshes, brackish marshes, and in riparian scrub, that are in some way, influenced by saline water. Mason's lilaeopsis is semi-aquatic, growing on saturated clay soils that are regularly inundated by water. It is often found with other rare plants such as Delta mudwort, Suisun Marsh aster, and Delta tule pea (CDFG 2005, 444).

This species is threatened by development, bank and channel-stabilization, flood control projects, widening of Delta channels for water transport, dredging and dumping of spoils, boat wake overwash, recreation (fishing trails), levee maintenance, erosion, agriculture, and in some areas, by water hyacinth (CDFG 2005, 444).

Source: calphotos.berkeley.edu.

Photo: Delta Mudwort.

Delta Mudwort

Delta mudwort *(Limosela subulata Ives.)* has no federal or State status. It is included on CNPS List 2.1: plants are rare, threatened, or endangered in California, but more common elsewhere, and seriously threatened in California. No critical habitat has been designated for this species. Delta mudwort is not native to California, it was introduced and naturalized in the wild (Calflora 2006).

Delta mudwort is found in the Delta, along the Sacramento River near Bradford and Twitchell

Islands, near Holland Tract, Victoria Island, and Mandeville Island (Calflora 2006). The plant also has been located in Marin County at Drakes Bay, and in Oregon, Washington, and on the Atlantic coast (CNPS 2006). Delta mudwort has been found in ten topographic quads that include WHCP treatment sites, including: Stockton West, Holt, Woodward Island, Clifton Court Forebay, Thornton, Terminous, Rio Vista, Jersey Island, Bouldin Island, and Antioch North (CNPS 2008). The DBW botanical surveys in 2002 and 2003 found Delta mudwort to be common at the tidal edge clay.

Delta mudwort is a low-growing stoloniferous herb with white to lavender flowers (Jepson Flora Project 1993). Delta mudwort occurs in intertidal fresh- and brackish-water marshes. In the Delta, it is associated with the tidal freshwater emergent habitat classification (CALFED 2000, C-2-8). It grows on exposed mud often associated with Mason's lilaeopsis, aquatic pigmy-weed, or dwarf spike-rush (CNDDB 1992).

The intertidal habitats available to Delta mudwort are limited. Levee construction and maintenance, recreational boating, and trampling from fishing access are possible threats to Delta mudwort populations (CNDDB 1992).

Source: www.elacuarista.com.

Photo: Eel-Grass Pondweed.

Eel-Grass Pondweed

Eel-grass pondweed *(Potamogeton zosteriformis)* is included on CNPS List 2.2: plants are rare, threatened, or endangered in California, but more common elsewhere, and fairly threatened in California. It has no State or federal status. No critical habitat has been designated for this species.

Eel-grass pondweed is found in the Delta in two topographic quads, Jersey Island and Bouldin Island. It is also found in Lake County, northeastern California, Idaho, Oregon, Utah, and Washington (CNPS 2008).

Eel-grass pondweed is an annual aquatic herb of the pondweed family. It is a monocot, and generally found in fresh to alkaline water, and grows less than 60 centimeters tall. Eel-grass pondweed blooms in June and July. It is found in various freshwater marsh and swamp habitats including lake beds, ponds, and streams (CALFED 1999, 376). Eel-grass pondweed is associated with the valley riverine aquatic habitat classification category in the Delta (CALFED July 2000, C-2-10).

Eel-grass pondweed has very small populations and occupies only a small area, making it vulnerable to decline and extinction from genetic problems and events such as floods, insect attacks, disease, or extended droughts (CALFED 1999, 376).

Source: calphotos.berkeley.edu.

Photo: Sanford's Arrowhead.

Sanford's Arrowhead

Sanford's arrowhead (*Sagittaria sanfordii*) is on CNPS List 1B.2: plants are rare, threatened, or endangered in California and elsewhere, and fairly threatened in California. The plant has no State or federal status. No critical habitat has been designated for Sanford's arrowhead.

Sanford's arrowhead is distributed throughout the northern part of the north coast, Central Valley, and northern south coast of California (CALFED July 2000, 382). It has been recently observed at several locations within Sacramento County (Calflora 2006), and observed historically in seven topographic quads included in WHCP treatment sites: Stockton West, Lathrop, Isleton, Fresno North, Turner Ranch, Mendota Dam, and Stevinson (CNPS 2008). Sanford's arrowhead is found within nontidal freshwater permanent emergent habitats within the Delta (CALFED July 2000, C-2-10).

Sanford's arrowhead is a rhizomatous perennial emergent herb. It is a monocot with blades 14 to 25 cm in length and small white flowers that bloom from May through October (Jepson Flora Project 1993). It grows in freshwater marshes, ponds, ditches, and various other freshwater habitats (CALFED 1999, 382).

Sanford's arrowhead is threatened by grazing, development, dumping, road maintenance, pond maintenance, herbicide spraying, clearing of channel vegetation, non-native plants, and channel alteration (CALFED 1999, 382).

Source: cricket.biol.sc.edu.

Photo: Marsh Skullcap.

Marsh Skullcap

Marsh skullcap (*Scutellaria galericulata*) is included on CNPS List 2.2: plants are rare, threatened, or endangered in California, but more common elsewhere, and fairly threatened in California. It has no State or federal status. No critical habitat has been designated for this species.

Marsh skullcap has been found in San Joaquin and Contra Costa Counties, within the Woodward Island and Bouldin Island topographic quadrants, although it is noted that these occurrences need further study. It is more commonly found in northeastern California, Oregon, and elsewhere (CNPS 2008). Marsh skullcap is typically found at elevations above 1,000 meters (Jepson Flora Project 1993).

Marsh skullcap is a shrub-like annual perennial herb in the mint family. It grows 20 cm to 80 cm in height, and has violet-blue flowers that bloom from June through September (Jepson Flora Project 1993). Marsh skullcap is found in meadows and seeps, marshes and swamps, and lower montane coniferous forests (CNPS 2006). It is found in the nontidal freshwater permanent emergent habitat classification within the Delta (CALFED July 2000, C-2-11). Known populations of marsh skullcap are threatened by erosion (CALFED 1999, 386).

Source: www.globalherbalsupplies.com.

Photo: Side-Flowering Skullcap.

Side-Flowering Skullcap

Side-flowering skullcap (*Scutellaria lateriflora*) has no federal or State status. It is included on CNPS List 2.2: plants are rare, threatened, or endangered in California, but more common elsewhere, and fairly threatened in California. No critical habitat has been designated for this species.

Side-flowering skullcap is found in Sacramento and San Joaquin counties on the Sacramento River near Locke (Calflora 2006). Within the WHCP area, side-flowering skullcap has been found in the Bouldin Island topographic quadrant (CNPS 2008). It has also been found in Inyo county. Side-flowering skullcap is associated with non-tidal freshwater permanent emergent and natural seasonal wetlands within the Delta (CALFED July 2000).

Side-flowering skullcap is a rhizomatous perennial herb with blue flowers and loosely branching stems, 20 to 60 cm in height (Jepson Flora Project 1993). It blooms from July to September. This skullcap occurs in marshes and swamps, and meadows and seeps. Threats to the plant include altered water regimes (CALFED 1999).

Source: calphotos.berkeley.edu.

Photo: Suisun Marsh Aster.

Suisun Marsh Aster

Suisun Marsh aster *(Symphyotrichum lentum)* is on CNPS List 1B.2: plants are rare, threatened, or endangered in California and elsewhere. The plant has no State or federal status. No critical habitat has been designated for Suisun Marsh aster.

Suisun Marsh aster has a historical range that includes Suisun Bay and the Delta (CALFED 1999, 190). It has been observed in many topographic quads covered by WHCP sites, including: Vernalis, Union Island, Lathrop, Woodward Island, Thornton, Terminous, Isleton, Rio Vista, Jersey Island, Bouldin Island, and Antioch North (CNPS 2008). Suisun Marsh aster is found within saline emergent and tidal freshwater emergent habitat classifications in the Delta (CALFED July 2000, C-2-2).

Suisun Marsh aster is a slightly succulent perennial rhizomatous herb of the sunflower family that grows over three feet tall (CALFED 1999, 190). It is a dicot, and has small violet flowers that bloom from May to November (Jepson Flora Project 1993). Suisun Marsh aster grows in brackish and freshwater marshes. It occurs along brackish sloughs, riverbanks, and levees affected by tidal fluctuations, usually around the mid- to high-tide mark (CALFED 1999, 190). Associated species include marsh plants such as bulrush, cattail, common reed, willow, and rose mallow. The plants are often found at, or near, the water's edge.

Factors leading to decline of this species include marsh alteration, trampling by livestock, recreational use, riprap, levee repair and maintenance, competition from non-native plants, and habitat loss (CALFED 1999, 190).

Source: www.nativeplantproject.com.

Photo: Wright's Trichocoronis.

Wright's Trichocoronis

Wright's trichocoronis *(Trichocoronis wrightii var. wrightii)* is on the CNPS List 2.1: plants are rare, threatened, or endangered in California, but more common elsewhere, and seriously threatened in California. The plant has no State or federal status. No critical habitat has been designated for this species.

Wright's trichocoronis is found in meadows and seeps, marshes and swamps, riparian forests, and vernal pools (CNPS 2008). It is found in the northern Central Valley (Colusa County), as well as Merced and San Joaquin Counties. Wright's trichocoronis has been found in two topographic quadrants covering WHCP treatment sites: Turner Ranch and Lathrop (CNPS 2008). There are also plant populations in Riverside County, and Texas. There is confusion related to the origin of the plant. It may be native to California, or may have been introduced to California and naturalized into the wild (CNPS 2008; Calflora 2008).

Wright's trichocoronis is an annual herb. It grows to two feet in height, with white or bluish flowers. The plant grows in moist locations, and usually occurs in wetlands. Wright's trichocoronis is nearly extirpated in the Central Valley, due to habitat lost to agriculture and urbanization (CNPS 2008).

11. Essential Fish Habitat

Recognizing the importance of habitat to the viability of fish species, in 1996 Congress added new habitat provisions to the Magnuson-Stevens Fishery Conservation and Management Act (MSA). The MSA is the federal law that regulates marine fisheries management in the United States (PFMC 2005). The MSA is implemented through the activities of eight management councils. The Pacific Fisheries Management Council (PFMC) has jurisdiction over California, Oregon, and Washington.

Each management council is required to develop fishery management plans, which among other requirements, describe essential fish habitat (EFH) (PFMC 2006). Councils are to minimize impacts on EFH from fishery and other activities, and to coordinate and consult with NOAA-Fisheries and other federal agencies that undertake activities that could impact EFH. Because EFH and Endangered Species Act (ESA) consultations often overlap, agencies are encouraged to coordinate regulatory activities to the extent possible (NOAA-Fisheries 2004).

The primary focus of EFH is promoting long-term health of ocean fisheries through fishery management activities such as catch-limits. The intended purpose of the EFH guidance process is to avoid or minimize adverse impacts of activities on EFH by forward, informed planning (PFMC 1999, A-74).

Essential fish habitat includes habitats necessary to ensure healthy fisheries now, and in the future, and is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (PFMC 2006). EFH consists of both the water column and underlying surface (seafloor, vegetation, etc.) of a particular area. The PFMC has developed documents for four EFH: Coastal Pelagic Species, Groundfish, Salmon, and Highly Migratory Species. Two of these EFH are within the WHCP area, Salmon and Groundfish. In addition, as a subset of EFH, the PFMC defines "habitat areas of particular concern" (HAPC). There are currently five HAPC types identified in the Fisheries Management Plan for groundfish, one of which (estuaries) potentially overlaps with WHCP treatment locations. The other HAPC types are: canopy kelp, seagrass, rocky reefs, and specific "areas of interest" (PFMC 2006).

Chinook Salmon

Amendment 14 to the Pacific Coast Salmon Plan, *Identification and Description of Essential Fish Habitat, Adverse Impacts, and Recommended Conservation Measures for Salmon*, describes habitat and potential impacts for three salmon species: Chinook salmon, Coho salmon, and Puget Sound pink salmon. Only one of these species, Chinook salmon, is found within WHCP treatment sites. EFH for Chinook salmon includes freshwater and marine habitat, encompassing "all currently viable waters and most of the habitat historically accessible to salmon…" (PFMC 1999, A-2). EFH is inclusive, and encompasses USGS hydrologic units (watersheds) from Washington to Central California, including the Sacramento-San Joaquin Delta unit. Critical habitat for winter-run and spring-run Chinook salmon also overlap with EFH, and WHCP treatment sites, in the Delta.

Amendment 14 describes habitat requirements and habitat concerns for six life stages of salmon: (1) adult migration pathways, (2) spawning and incubation, (3) stream rearing habitat, (4) smolt migration pathways, (5) estuarine habitat, and (6)marine habitat. Three of these life stages move through, or temporarily reside in the Delta, potentially within or near WHCP treatment locations: adult migration pathways, smolt migration pathways, and estuarine habitat. Characteristics of Chinook salmon, including migration patterns in the Delta, are described earlier in this Chapter.

Groundfish

The *Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery* provides a chapter addressing EFH for groundfish (PFMC September 2006). As with pacific salmon, the PFMC took an inclusive approach in identifying groundfish EFH for 80-plus species of groundfish included in the management plan. The groundfish fish management plan covers over 60 species of rockfish, 12 species of flatfish, six species of roundfish, as well as sharks, skates, and several other species. All of these species are managed for fishery values. Groundfish EFH is defined as:

- "Depths less than or equal to 3,500 m (1,914 fathoms) to mean higher water level (MHHW) or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5ppt [i.e. freshwater] during the period of average annual low flow.
- Seamounts in depths greater than 3,500 m as mapped in the EFH assessment GIS.
- Areas designated as HAPCs not already identified by the above criteria" (PFMC September 2006).

Groundfish EFH includes areas within the WHCP, as the Delta could fall within the first definition above, as well as the estuary HAPC. There are two groundfish species identified by NOAA-Fisheries as potentially impacted by the WHCP: starry flounder (*Platichthys stellatus*) and English sole (*Parophrys vetulus*). We provide a description of these two species, and their habitats, below.

Source: www.afsc.noaa.gov.

Photo: Starry Flounder.

Starry Flounder

Starry flounder (*Platichythys stellatus*) is a flatfish found throughout the rim of the north Pacific Ocean. It is commonly found in nearshore waters and estuaries off the west coast of the United States (Ralston 2005). Starry flounder usually grows to 12 to 14 inches, and has distinctive light-dark bars on both the dorsal and anal fins. Starry flounder is tolerant to a wide range of salinities, and has been observed in the Sacramento and San Joaquin Rivers in freshwater, at salinities of 0.02 to 0.06ppt (Ralston 2005).

Adults move inshore in late winter or early spring to spawn (from November to February in California), and move offshore to deeper waters in summer and fall (Ralston 2005; PFMC November 2005). Eggs and larvae float at the surface (epipelagic), while juveniles and adults are demersal (bottom fish). Eggs are found in polyhaline (18 to 30ppt saline) and euhaline (30 to 40ppt saline, i.e. seawater), while juveniles are found in mesohaline (5 to 18ppt saline) to freshwater (<0.5ppt saline). Both adults and larvae are found in euhaline to freshwater. Larvae are thought to move into estuarine waters with the tide, with metamorphosis to juveniles occurring at 10 to 12mm in length. Juveniles remain in estuarine waters until age two, when most migrate into the ocean. Larvae are planktivorous, while juveniles and adults are carnivorous, feeding on a wide number of copepods, amphipods, annelid worms, mollusks, and crabs.

IEP fish monitoring in the Delta and San Francisco Bay captured 275 starry flounder (out of about 33,000 fish) between April, 2004 and September, 2006 (IEP 2006b). Given the size of the starry flounder captured (mostly from 50 to 200mm), the fish were predominantly juveniles between two-plus months and two-years of age. Most captured fish were either at Chipps Island and Suisun Slough, both west of the WHCP project area, or salvaged at the Skinner or Tracy fish facilities in the South Delta, indicating that starry flounder are found throughout the Delta.

Source: hmsc.oregonstate.edu.

Photo: English Sole.

English Sole

English sole *(Parophrys vetulus)* is also a flatfish, found from the southeast Bering Sea to Baja California. English sole is an important commercial fish, particularly off the coasts of Washington, Oregon, and Northern and Central California (PFMC November 2005). English sole primarily inhabit estuaries and near-shore areas. English sole is a right-eyed flatfish, typically brown to olive brown in color, sometimes with white speckles. Adult females are over 35cm long, while males are somewhat smaller.

In California, English sole spawn in January and February in deeper water (PFMC November 2005; Stewart 2005). Larvae are thought to move to near-shore areas or estuaries with the tide. Larvae metamorphose into juveniles in spring and early summer. Near shore areas and estuaries are considered nurseries for this species, where juveniles rear until fall/winter, when most emigrate to somewhat deeper waters. Juveniles spend one or two years in coastal estuaries and/or the open coast, in part determined by water temperature (the upper lethal limit for English sole is 26.1C). Eggs are found in polyhaline waters, optimally at 25 ppt to 28ppt, while adults are found in euhaline waters. Juveniles and larvae occur in polyhaline and euhaline waters. Juvenile English sole are also temperature sensitive, with 18C appearing to be the upper tolerance. Optimal conditions for larval survival were temperatures of 8 to 9C and 25 to 28ppt salinity – indicating that larval English sole are not likely to be found within the WHCP. Like starry flounder, English sole larvae are planktivorous, while juveniles and adults are carnivorous.

IEP fish monitoring in the Delta and San Francisco Bay between April, 2001 and September, 2006 captured only thirteen English sole (IEP 2006c). All fish were in the juvenile size range (45mm to 89mm in length), and all were found within San Pablo or San Francisco Bays. Lower salinity levels and somewhat higher temperatures found within the Delta (and WHCP treatment areas) are not consistent with English sole habitat, as described in the literature.

12. Wildlife

The complex interface between land and water in the Delta provides rich and varied habitat for wildlife, especially birds. Wildlife habitats include agricultural land, riparian forest, riparian scrub-shrub, emergent freshwater marsh, heavily shaded riverine aquatic, and grassland/rangeland.

Although much of the Delta is used for agriculture, the land also provides habitat for wildlife. Many agricultural fields are flooded in winter, providing foraging and roosting sites for migratory waterfowl. Aside from these seasonally used areas, tens of thousands of acres are managed specifically for wildlife. Major State, federal, and private wildlife areas in Delta areas are shown in **Table 3-4,** on the next page. There has been a significant increase in protected habitat acreage in the Delta over the last ten years, including conversion of agricultural land to natural habitat (Arambura 2005).

The Delta is particularly important to waterfowl migrating via the Pacific Flyway. The principal attraction for waterfowl is winter-flooded fields, mainly cereal crops, which provide food and extensive seasonal wetlands. The Delta and other Central Valley wetlands provide winter habitat for 60 percent of waterfowl on the Pacific Flyway and 91 percent of waterfowl that winter in California. More than a million waterfowl are frequently in the Delta at one time, although this occurs during winter months when there are no WHCP treatments. While there are a number of special status bird species that inhabit the eleven county WHCP region (see Table 3-15), only three of these species may be potentially impacted by the WHCP.

Small mammals find suitable habitat in the Delta and upland areas. Vegetated levees, remnants of riparian forest, and undeveloped islands provide some of the best mammalian habitat in the region. Species include muskrat, mink, river otter, beaver, raccoon, gray fox, and skunks.

While there are a number of special status mammal species in the eleven county WHCP region (see Table 3-15), none of these species is likely to be impacted by the WHCP. None of these mammal special status species are expected to frequent specific treatment locations during the treatment season. In the extremely unlikely event that a special status mammal species did occur within a treatment site, herbicide levels for the WHCP are well below those likely to impact mammals (DBW 2001).

B. Impact Analysis and Mitigation Measures

This biological resources impact analysis provides an assessment of the specific environmental impacts potentially resulting from program operations. The discussion of impacts utilizes findings from WHCP research projects, technical information from scientific literature, and relevant information on public policies. Impact assessments are based on technical and scientific information.

In determining significance, where possible, we quantify the extent of the impacts (e.g. persistence of herbicides in the water column over time and herbicide toxicity levels compared to herbicide treatment levels). However, in many instances it was not possible to quantify the extent of a particular impact accurately. In such cases, the analysis is primarily qualitative.

For purposes of this analysis, we considered a Biological Resource impact (designated with the letter 'B') to be significant and require mitigation if it would result in any of the following:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS
- Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the CDFG or USFWS

Table 3-4
Major Wildlife and Habitat Areas in the Sacramento-San Joaquin Delta

Name	County	Owner/Manager	Acreage
1. Yolo Bypass Wildlife Area	Yolo County	CDFG	16,610
2. Lower Sherman Island Wildlife Area	Sacramento County	CDFG/Sacramento County	3,115
3. White Slough Wildlife Area	San Joaquin County	CDFG/DWR/San Joaquin County	800
4. Rhode Island Wildlife Area	Contra Costa County	CDFG/Contra Costa County	67
5. Miner Slough and Decker Island Wildlife Areas	Solano County	Solano County	50
6. Woodbridge Ecological Reserve	San Joaquin	CDFG	360
7. Antioch Dunes National Wildlife Refuge	Contra Costa	USFWS	67
8. Stone Lakes National Wildlife Refuge	Sacramento	USFWS, Sacramento County, others	17,640
9. Jepson Prairie Reserve	Solano	Solano Land Trust	1,566
10. Cosumnes Preserve	Sacramento and San Joaquin Counties	The Nature Conservancy	11,085
11. Liberty Island	Solano and Yolo Counties	Trust for Public Land	4,760
12. Conservation easements	All Delta counties	Various	12,656
Total			68,776

- Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means
- Interfere substantially with the movement of any native resident or migratory fish, or wildlife species, or with established native resident or migratory wildlife corridors, or impede use of native wildlife nursery sites
- Conflict with any local policies or ordinances protecting biological resources, such as tree preservation policies or ordinances
- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

Following each Biological Resource impact, we identify associated mitigation measures (also designated with the letter 'B'). These include specific actions that DBW will undertake to avoid or minimize potential impacts. The DBW continues to undergo consultation with various State and federal agencies, including USFWS, CDFG, NOAA-Fisheries, and CVRWQCB regarding impacts and mitigation measures. Many of the discussed mitigation measures are specific conditions that result from the biological consultation process with USFWS and NOAA-Fisheries. Proposed mitigation measures may be revised and/or additional mitigation measures incorporated as a result of this ongoing consultation process with regulatory agencies.

Table 3-5, on the next page, provides a summary of potential WHCP impacts for each of the significance criteria areas. The remainder of this chapter analyzes eight specific impacts and associated mitigation measures.

Table 3-5
Crosswalk of Biological Resources Significance Criteria, Impacts, and Benefits of the WHCP *Page 1 of 2*

	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?						Removal of water hyacinth could improve habitat for sensitive species (through opening up shallow water habitat, regrowth of native plant species, improving navigation channels, and increased DO levels)
Impact B1: Herbicide overspray	1, 2, 3, 4	**X**				X
Impact B2: Herbicide toxicity	1, 3, 5, 6, 7, 8	**X**				
Impact B3: Herbicide bioaccumulation				X		
Impact B4: Food web effects	1, 6, 7	**X**				X
Impact B5: Dissolved oxygen levels	9, 10, 11, 12		**X**			X
Impact B6: Treatment disturbances	1, 4		**X**			
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFG or USFWS?						Removal of water hyacinth could improve riparian and sensitive habitat
Impact B1: Herbicide overspray	1, 2, 3, 4	**X**				X
Impact B5: Dissolved oxygen levels	9, 10, 11, 12		**X**			X
Impact B6: Treatment disturbances	1, 4		**X**			
Impact B7: Plant fragmentation	13, 14		**X**			
Impact B8: Disposal following handpicking	15, 16			X		
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?						Removal of water hyacinth could improve wetland habitat
Impact B1: Herbicide overspray	1, 2, 3, 4	**X**				X
Impact B5: Dissolved oxygen levels	9, 10, 11, 12		**X**			X
Impact B6: Treatment disturbances	1, 4		**X**			
Impact B7: Plant fragmentation	13, 14		**X**			
Impact B8: Disposal following handpicking	15, 16			X		

Table 3-5
Crosswalk of Biological Resources Significance Criteria, Impacts, and Benefits of the WHCP *(continued)* *Page 2 of 2*

	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?						Removal of water hyacinth could improve navigation channels for migrating species and movement of resident species
Impact B2: Herbicide toxicity	1, 3, 5, 6, 7	**X**				
Impact B4: Food web effects	1, 6, 7	**X**				X
Impact B5: Dissolved oxygen levels	9, 10, 11, 12		**X**			X
Impact B6: Treatment disturbances	1, 4		**X**			
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?				WHCP has no known significant conflicts with local policies or ordinances protecting biological resources		Removal of water hyacinth could improve local habitat
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?					WHCP has no known conflicts with various conservation plans, programs, or other initiatives in the Delta. WHCP's reduction in an invasive species is supportive of these conservation efforts	Removal of water hyacinth is consistent with conservation planning efforts to reduce invasive species in the Delta

For each of the eight potential WHCP impacts, we provide a description of the impact, analyze the impact, classify the impact level, and when appropriate, identify mitigation measures to reduce the impact level. The impact levels are as follows:

1. **Unavoidable or potentially unavoidable significant impact** – an impact that may result in significant adverse effects, and cannot be mitigated with certainty. We identify mitigation measures for these impacts
2. **Avoidable significant impact** – an impact that may result in significant adverse effects that can be mitigated to a less than significant level. We identify mitigation measure for these impacts
3. **Less than significant impact** – an impact that is likely to result in less than significant adverse effects, without mitigation. We may not identify mitigation measures for less than significant impacts
4. **No impact** – no adverse effects resulting from the proposed action.

Impact B1 – Herbicide overspray: effects of herbicide overspray on special status species, riparian or other sensitive habitats, and wetlands

The primary treatment of the WHCP is chemical. The program utilizes two herbicides, 2,4-D and glyphosate.

Weedar® 64 (2,4-Dichlorophenoxyacetic acid, dimethylamine (DMA) salt, or 2,4-D) is a systemic herbicide specific to broadleaf plants and is most effective in plants with a large enough leaf area to absorb sufficient quantities. 2,4-D is water soluble and chemically stable. The herbicide mimics the plant hormone auxin, causing rapid cell division and abnormal growth. 2,4-D can be absorbed by both foliage and roots.

Plant death from 2,4-D typically occurs within three to five weeks after treatment, although during periods of warm weather, water hyacinth shows signs of dying within hours of spraying. Any broadleaf vegetation subject to overspray will be vulnerable to 2,4-D activity. Most of the special status plants and several other native plants are broadleaf species. Sensitive riparian habitats and wetlands near WHCP treatment sites also include other potentially impacted broadleaf plants.

AquaMaster™ (glyphosate) is a broad spectrum, non-selective, systemic herbicide. (DBW has also used Rodeo®, a similar glyphosate herbicide). Glyphosate is water soluble, and is absorbed across the plant surface and translocated throughout the plant. Glyphosate inhibits activity of the shikimic acid pathway enzymes, found only in plants and microorganisms. Glyphosate is not metabolized by plants (Schuette 1998).

Plants begin to show symptoms of glyphosate treatment (gradual wilting and yellowing) within two to seven days. Exposure of any non-target plants to glyphosate, including those in sensitive riparian and wetland habitats, could result in loss of plant species and habitat impacts.

The DBW also utilizes adjuvants to increase absorption and translocation of the herbicide. Currently, DBW utilizes the paraffin-based non-ionic surfactant, Agridex®. The DBW continues to evaluate other adjuvants, such as the modified vegetable oil, Competitor®. Relatively little is known about impacts of adjuvants on plants. However, use of these chemicals in concentrations specified on the labels is not expected to negatively impact special status species, sensitive habitats, or wetlands.

The potential for impacts resulting from herbicide overspray depend on the amount of exposure, concentration of herbicide, and proximity of sensitive habitats, wetlands, and special status plants. One study found that only three to four percent of 2,4-D droplets drift beyond the target zone, and no significant amount of material is collected as drift (HSDB 2001). Blankenship and Associates (2004) found that using conservative application rates, detectable adverse effects could result from less than one percent spray drift of glyphosate or 2,4-D.

The concentration of active ingredient (2,4-D or glyphosate) leaving the spray nozzle is high enough (ranging from 600 ppm to 4,800 ppm) to cause adverse effects. Thus, there is the potential that uncontrolled herbicide overspray could affect nearby nontarget vegetation.

Treatment of water hyacinth could result in loss of native submerged aquatic vegetation growing in and around treatment areas. Such vegetation may be utilized by special status fish for rearing, coverage, and forage. In particular, shallow vegetated habitat is believed to be important to spawning success of splittail and delta smelt.

Loss of cover, rearing, and forage area of special status species could constitute a significant impact under certain conditions. However, dense canopies of water hyacinth reduce light levels for submerged plant photosynthesis and thus can effectively shade out native vegetation. The benefit to native submerged aquatic vegetation from removal of water hyacinth is expected to outweigh losses due to herbicide toxicity overspray.

While there is a potential risk to sensitive habitats, wetlands, and special status plants due to herbicide overspray, the likelihood of such effects occurring is low. Herbicide application will be focused directly on target plants to decrease the possibility that concentrated herbicides would come in contact with sensitive plants, or result in impacts to sensitive habitats or wetlands.

The DBW will follow herbicide label instructions that reduce herbicide drift. These steps include using the largest size spray droplets, and lowest spray pressure, that will provide sufficient coverage and control. Furthermore, DBW will not treat at a particular site if the wind is greater than 10 mph (or 7 mph in Contra Costa County).

Should any herbicide damage to special status plants, or sensitive riparian or wetland habitats occur, it would represent a significant impact. This impact would be an **unavoidable or potentially unavoidable significant impact.** This impact would potentially be reduced by implementing the following four mitigation measures.

- **Mitigation Measure B1a** – Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources.

  Each year, prior to start of the treatment season, the DBW will conduct field crew environmental awareness training. Under this training, crews will be informed about the presence and life histories of special status species; habitats associated with species; sensitive habitats and wetlands; the terms and conditions of the program's biological opinions; incidental take procedures; and that unlawful take of an animal or destruction of its habitat is a violation of the Endangered Species Act.

  The DBW also will provide crews with a field guide (Species Identification Deck) for easy identification of special status species on-site. Prior to treating a site, crews will conduct a visual survey to determine whether special status plants, animals, or sensitive habitats are present. Crews will complete an Environmental Observations Checklist for each site to document the presence or absence of special status species. If any special status species or sensitive habits are present at the site, the field crew will not perform any treatment.

- **Mitigation Measure B1b** – Provide a 250 foot buffer between treatment sites and shoreline elderberry shrubs (*Sambucus* ssp.), host plant for the valley elderberry longhorn beetle *(Desmocerus californicus dimorphus)*.

  The DBW will conduct a survey of treatment sites to prepare a map that identifies locations of elderberry shrubs, and provide this map to field crews. **Exhibit 3-2,** on the next page, provides a map identifying locations of elderberry shrubs and giant garter snake sitings within the WHCP treatment area.

  DBW crews will maintain the 250 buffer zone when elderberry shrubs are present. Crews will also conduct treatments downwind of elderberry shrubs.

  In addition, DBW's Environmental Scientists will survey a sample of elderberry shrubs which could be potentially impacted by WHCP application activities at the beginning of the treatment season, and at the end of the treatment season. The Environmental Scientists will compare the health of elderberry shrubs at control sites (i.e. not adjacent to treatments) with elderberry shrubs located adjacent to treated sites. If elderberry shrubs located near treated sites show signs of adverse effects from treatment, DBW will develop additional mitigation measures to protect elderberry shrubs (for example, increasing the size of the buffer zone).

- **Mitigation Measure B1c** – Conduct herbicide treatments in order to minimize potential for drift.

  In addition to complying with the label application requirements, DBW will, to the degree possible, schedule herbicide applications to occur at high tide, or at a point in the tidal cycle determined by the field supervisor to provide the least non-target impact at a particular site. In general, treatment at high tide will allow for better spray accuracy and access, and will provide for greater dilution volume of herbicides. DBW crews will change nozzle type and spray pressures whenever conditions warrant, limiting the amount of herbicide which may inadvertently contact non-target species or enter the water.

Exhibit 3-2a

Valley Elderberry Shrub Locations and Giant Garter Snake Habitat Valuation – Northern Sites

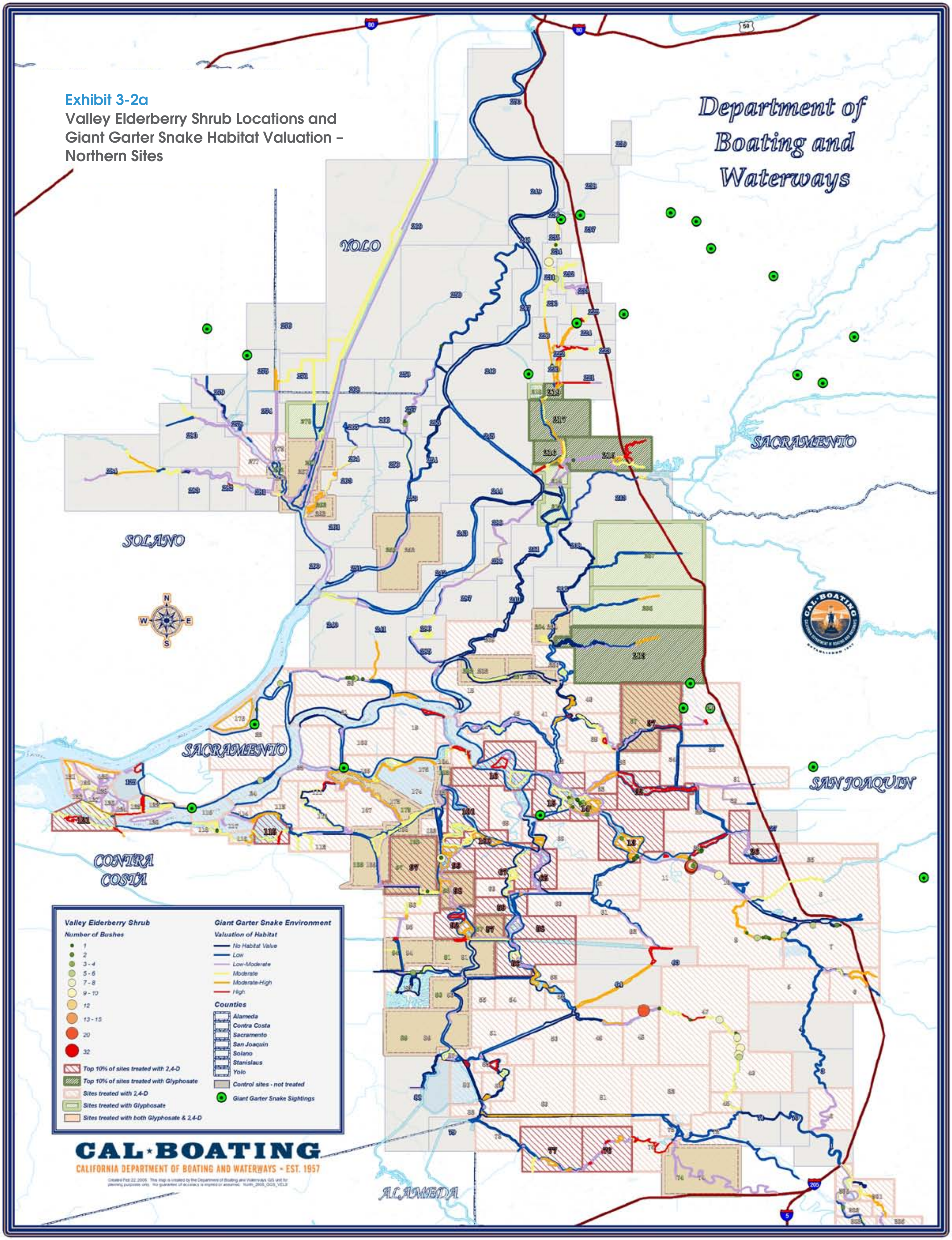
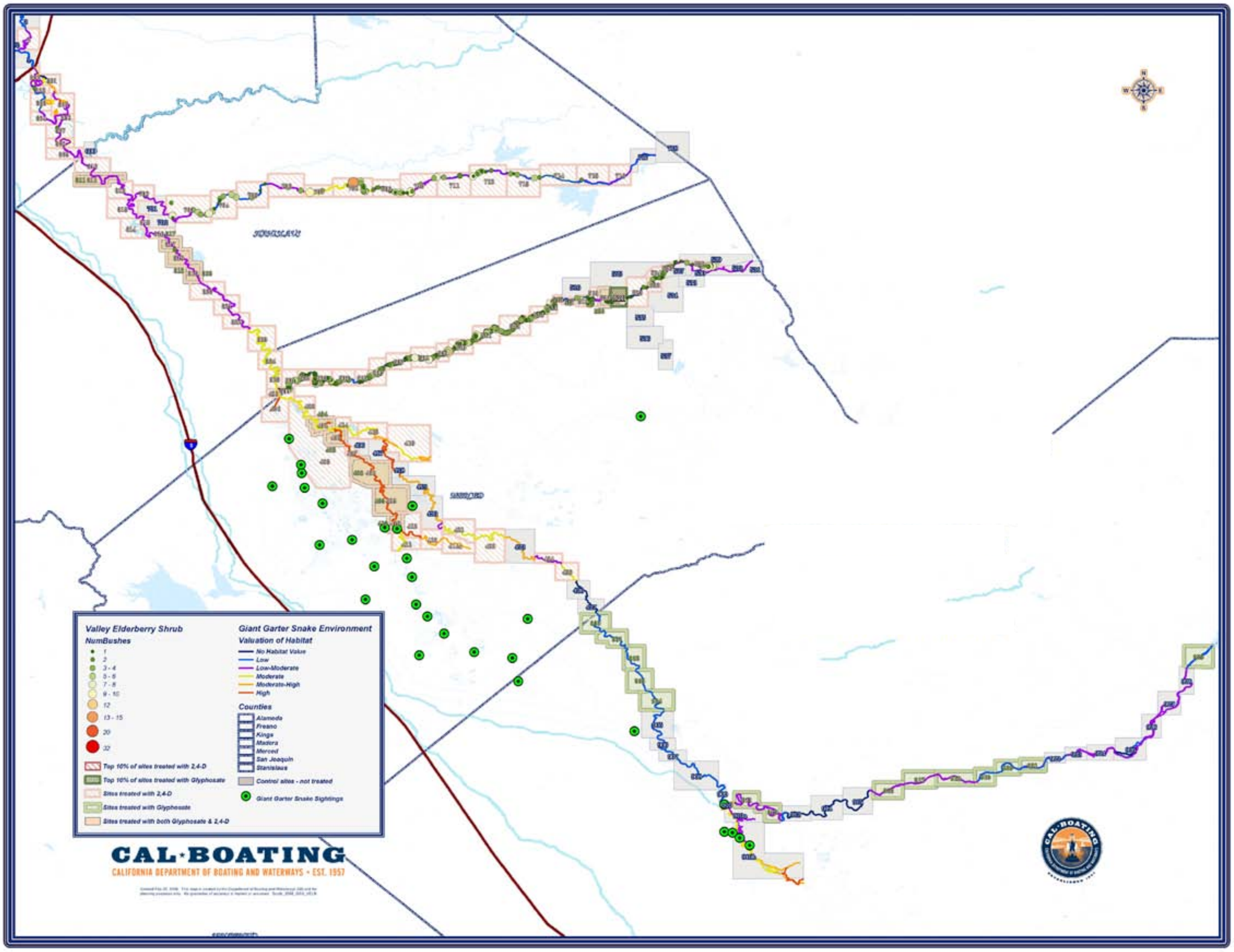


Exhibit 3-2b

Valley Elderberry Shrub Locations and Giant Garter Snake Habitat Valuation – Southern Sites



- **Mitigation Measure B1d** – <u>Operate program vessels in a manner that causes the least amount of disturbance to the habitat</u>.

  Operational procedures for DBW vessels will minimize boat wakes and propeller wash. These procedures will be particularly important in shallow water, or other sensitive habitats.

* * * * *

There also are potential positive impacts to special status plants, sensitive habitats, and wetlands from the WHCP. Water hyacinth clogs waterways and reduces overall habitat for native plants (CALFED 2000). Dense patches of water hyacinth shade out habitat and outcompete native aquatic vegetation, including Mason's lilaeopsis (CALFED 2000).

Control of water hyacinth in Delta waterways expands habitat suitable for native species. Thus, long-term impacts of water hyacinth control on special status plant species and sensitive habitats are likely to be beneficial.

There is uncertainty as to how habitats will respond to removal of water hyacinth. During 2008, some areas which had previously been heavily infested with water hyacinth, became heavily infested with native pennywort.

It may be that existing imbalances in Delta ecosystem functions may promote some monospecific growth, even of native species. While removing invasive species is a positive first step, there is need for additional research on Delta ecosystem restoration following removal of non-native species.

Impact B2 – Herbicide toxicity: toxic effects of herbicides on special status species, native resident fish, and migratory fish

There is the potential for direct toxic effects on special status or common fish, amphibian, reptile, and bird species, and resident native and migratory fish, due to the use of WHCP herbicides and adjuvants. Toxic effects may be acute, chronic, or sublethal.

Acute toxic effects are typically measured in LC50 levels over 48 or 96 hours, the concentration at which there is 50 percent mortality (lethal concentration) among test organisms. Chronic effects are typically measured in 7-day, or longer, LC50 levels. Toxicity tests may also measure a no observed effect level (NOEL). LC50 values are usually expressed in parts per million (ppm or mg/l) or parts per billion (ppb or µg/l). Length of test time is also typically indicated. Sublethal effects are more difficult to measure, as they may be reflected in subtle responses such as reduced ability to avoid predators, or more identifiable effects such as reduced enzyme activity, lesions, or tissue damage.

There have been hundreds of toxicity tests of 2,4-D and glyphosate on various animal species over the last 30 years. In addition, the WHCP has conducted a number of toxicity tests using surrogate species and water samples obtained from WHCP treatment sites.

For this herbicide toxicity impact, we first discuss some general issues related to potential toxic effects, and then discuss toxic effects separately for fish; amphibians and reptiles; and birds. We discuss the toxicity of WHCP herbicides to invertebrates under Impact B4 – Food web effects.

Herbicide Concentrations in Delta Waters Immediately Following WHCP Treatments

Toxic effects result from the combination of exposure and toxicity. Exposure refers to the degree of contact of an organism with a chemical. Exposure consists of a concentration component, and a temporal component. The concentration component of exposure depends on an initial concentration of the herbicide treatment, and dilution factors. The temporal component of exposure depends on dissipation of the herbicide, as well as water flow and movement of the organism. Toxicity depends on the specific interactions between the herbicide and organism in question.

Table 3-6
Calculated Maximum Concentrations of 2,4-D, Glyphosate, and Agridex® Immediately Following WHCP Treatment

Concentration of:	2,4 D *(active ingredient)*	Glyphosate *(active ingredient)*	Agridex® *(total adjuvant)*
1. Chemical directly out of spray nozzle	2,500 ppm	4,000 ppm	5,000 ppm
2. Chemical in 1 acre-ft, @ 100% water contact	3.1 ppm	2.3 ppm	1.5 ppm
3. Chemical in 10 acre-ft, @ 100% water contact	0.31 ppm	0.23 ppm	0.15 ppm
4. Chemical in 1 acre-ft, @ 10 to 20% water contact	0.31 ppm to 0.62 ppm	0.23 ppm to 0.46 ppm	0.15 ppm to 0.30 ppm
5. Chemical in 10 acre-ft, @ 10 to 20% water contact	0.031 ppm to 0.062 ppm	0.023 ppm to 0.046 ppm	0.015 ppm to 0.030 ppm

The WHCP utilizes pump-driven hand-held spray nozzles to treat water hyacinth. The pump mixes calibrated amounts of herbicide (either 2,4-D or glyphosate), adjuvant, and water. The DBW applies the chemicals at the herbicide label-specified rates.

Table 3-6, above, summarizes expected instantaneous concentrations of active ingredients at the spray nozzle, and in the water. Table 3-6 provides conservative estimates assuming that 100 percent of the herbicide reaches the water, and a more realistic estimate assuming 10 to 20 percent of the herbicide reaches the water. The latter range was determined in early WHCP tests by Anderson (1982), finding that only 10 to 20 percent of 2,4-D moved through the water hyacinth mat and into the water.

The calculated maximum concentrations in Table 3-6 reflect potential chemical concentrations immediately after (or during) spraying. However, herbicides dissipate over time, as most of the Delta is subject to tidal action and/or water flow. Thus, the concentration of chemicals will be further diluted as water moves within the Delta.

In 1982, prior to the start of the WHCP, USDA-ARS (Anderson 1982) conducted field tests of 2,4-D levels following herbicide applications at Coney Island, in the Delta. Anderson applied the herbicide at a rate that was 25 percent higher than the labeled maximum. Anderson collected samples in float samplers (open-top vessels containing 500 mls Delta water), inside the spray plot, upstream of the spray plot, and downstream of the spray plot, at 15 to 30 minute intervals post- treatment. **Table 3-7,** on the next page, provides the range and average for test measurements.

WHCP environmental monitoring results provide additional data on actual herbicide residue levels following treatments. Between 2001 and 2005, DBW obtained chemical residue tests on 110 water samples collected after treatment, inside the treatment areas. Samples were obtained from 48 different sites, and throughout the treatment season (for both chemicals at some sites). The average concentration at each of the 37 2,4-D sites ranged from non-detectable (ND), to 390 ppb. The average concentration at each of the 14 glyphosate sites ranged from non-detectable to 158 ppb. **Exhibit 3-3,** on page 3-52, summarizes herbicide concentrations of the in-treatment-site samples for 2001 to 2005.

Table 3-7
Results of Delta Coney Island Field Test, Concentrations of 2,4-D Following Treatment

Time and Location of Samples (number of samples)	Range	Average
1. Float samplers in spray plot (5)	51 ppb to 3,150 ppb	1,047 ppb
2. Water samples in spray plot @ 15 minutes post (6)	107 ppb to 8,420 ppb	2,262 ppb
3. Water samples in spray plot @ 60 minutes post (3)	593 ppb to 1,398 ppb	895 ppb
4. Water samples in spray plot @ 90 minutes post (3)	100 ppb to 157 ppb	119 ppb
5. Water samples upstream of spray plot @ 15 minutes post (3)	17 ppb to 59 ppb	32 ppb
6. Water samples downstream of spray plot @ 30 minutes post (3)	3 ppb to 5 ppb	4 ppb
7. Water samples downstream of spray plot @ 60 minutes post (3)	0 ppb to 50 ppb	17 ppb
8. Water samples downstream of spray plot @ 90 minutes post (3)	3 ppb to 23 ppb	10 ppb

Over three years of environmental monitoring (2006 to 2008), DBW has monitored receiving waters directly downstream of the treatment sites, immediately after treatment. As in previous years, environmental scientists also returned to each site two to seven days later to sample upstream, within, and downstream of the treatment site. Over the three year period, DBW conducted 36 sampling events for 2,4-D, and 21 sampling events for glyphosate. DBW also monitored Agridex® at all the 57 sampling events. In every case, Agridex® concentrations were non-detectable.

Exhibit 3-4, on page 3-52, illustrates the 2006 to 2008 sampling results from immediately downstream of treatment sites, in WHCP receiving waters. This is a slightly different location than the 2001 to 2005 results illustrated in Exhibit 3-3. While both sets of samples were taken immediately post-treatment, we would expect the downstream location to have lower chemical concentrations than the in-treatment-site location, due to dilution as herbicide flows out of the treatment site.

Seven of the 2006 to 2008 post-treatment receiving water 2,4-D samples (12 percent), were at non-detectable levels. In a few cases, 2,4-D levels were slightly higher in follow-up sampling (a maximum of 16.3 ppb at one site), although generally 2,4-D levels declined to even lower levels in the follow-up visit.

Glyphosate was tested fewer times, because the herbicide was used less frequently during the 2006 to 2008 treatment seasons. Of the 21 glyphosate receiving water sample events during 2006 to 2008, 15 resulted in non-detectable levels. All but one of the remaining glyphosate samples were at extremely low levels, ranging from 0.3 ppb to 1.9 ppb with one 2008 sample at 21 ppb. Glyphosate levels decreased in the follow-up visits, however there were a few cases in which glyphosate levels were higher in the pre-treatment samples (up to 21 ppb), indicating the herbicide was present in Delta waters from other sources.

The calculated, test plot, and actual WHCP herbicide levels indicate that 2,4-D, glyphosate, and adjuvant levels in the Delta following herbicide treatment are low. Maximum 2,4-D levels immediately after spraying within a treatment site may reach levels as high as 400 ppb (0.4 ppm), although this was uncommon. Maximum 2,4-D levels immediately downstream of the site are likely to be less than 10 ppb. Maximum glyphosate levels within a treatment site, immediately after spraying, may reach as high as 158 ppb (0.158 ppm), but are likely to be less than 30 ppb. Maximum glyphosate levels immediately downstream are likely to be less than 2 ppb. Herbicides may remain at these maximum levels for a relatively short period of time (for example, the downstream sampling typically occurs within one hour of treatment).

Exhibit 3-3a

Number of Sites at Various 2,4-D Concentrations (IN Treatment Site) (2001 to 2005)

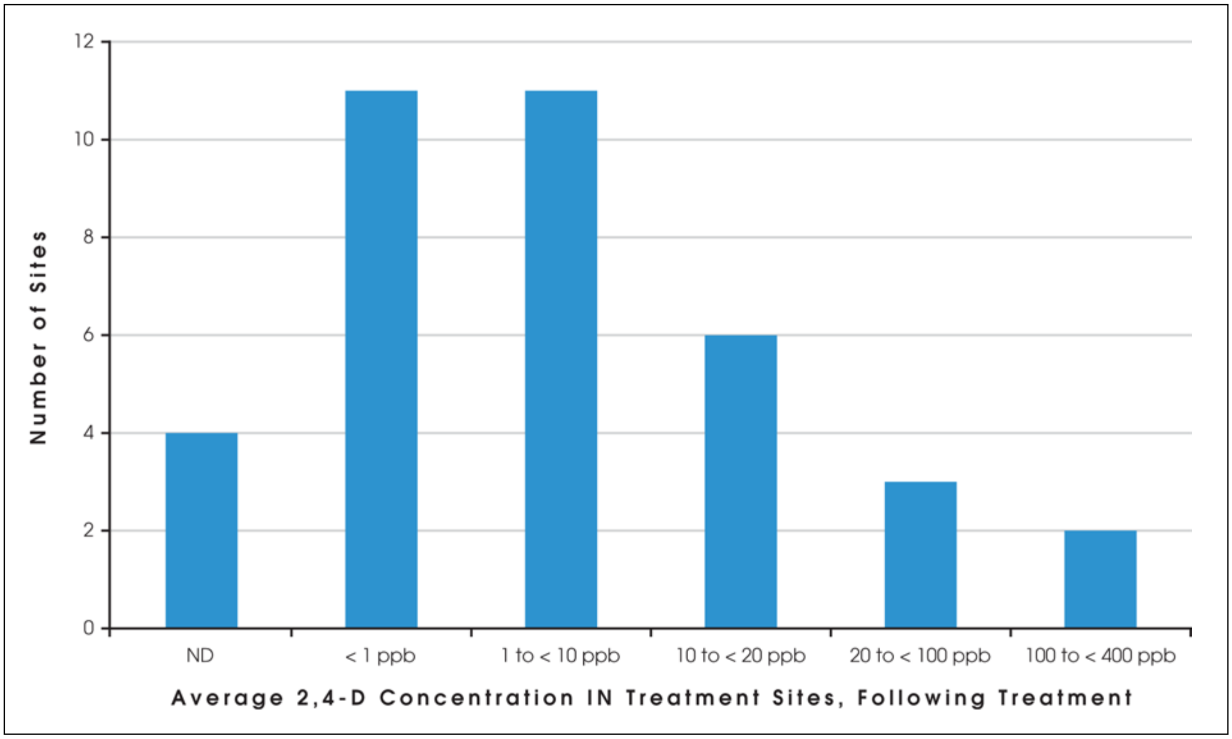


Exhibit 3-3b

Number of Sites at Various Glyphosate Concentrations (IN Treatment Site) (2001 to 2005)

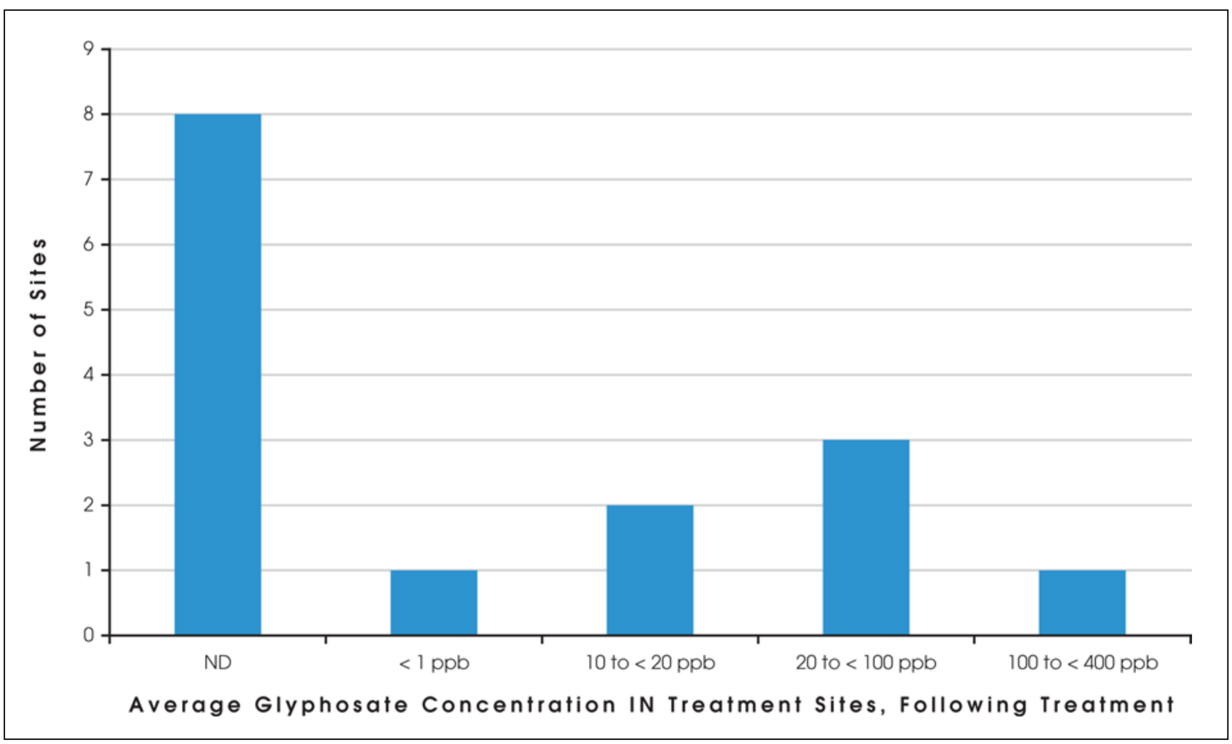


Exhibit 3-4a
Number of Sites at Various 2,4-D Concentrations (Downstream, IN Receiving Waters) (2006 to 2008)

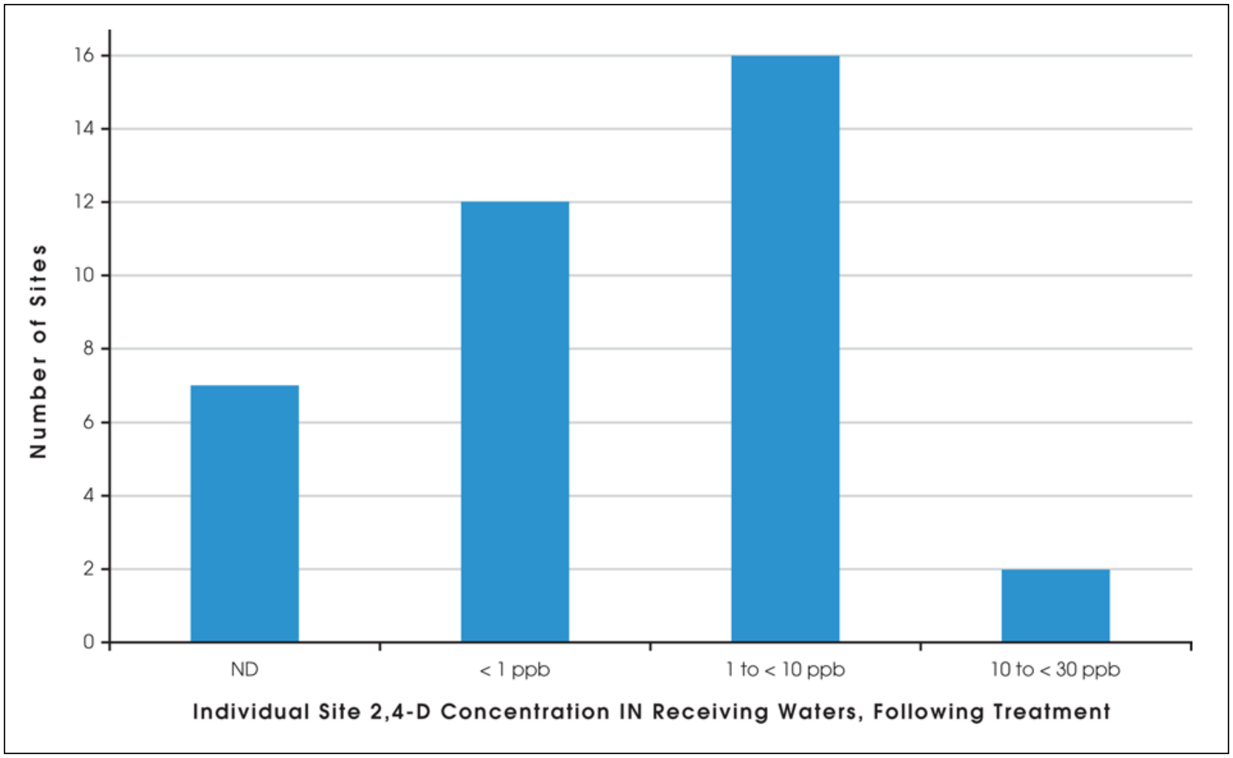
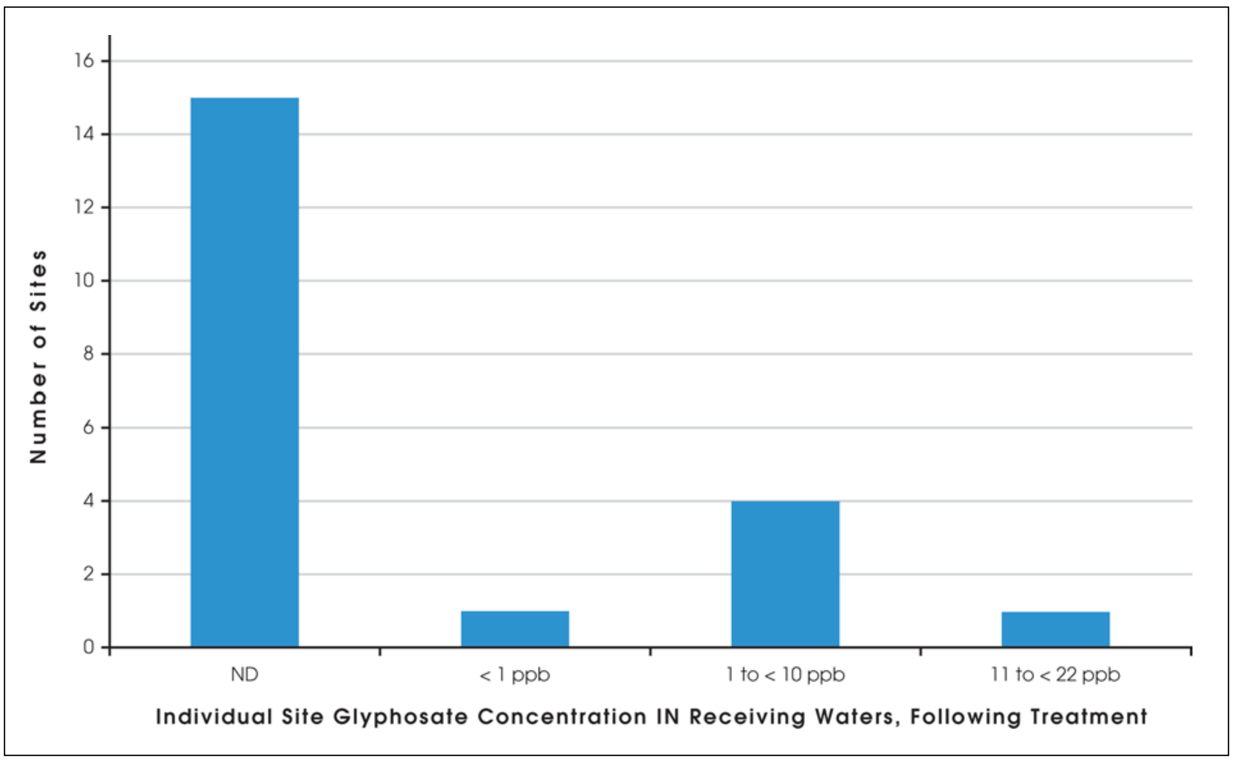


Exhibit 3-4b
Number of Sites at Various Glyphosate Concentrations (Downstream, IN Receiving Waters) (2006 to 2008)



Fate of WHCP Herbicides in Water

The second aspect of exposure relates to time – how long is a target (or non-target) species exposed to a certain chemical concentration? The time component is dependent on decomposition of the herbicide, and movement of Delta waters at the treatment site.

The WHCP occurs within a highly dynamic, and vast, Delta. There are approximately 50,000 surface acres of waterways in the Delta. Annual treatment acreage ranges from 200 to 2,500 acres, thus each year the WHCP treats between 0.002 percent and five percent of the Delta waters. As most WHCP treatment locations are classified either tidal, or fast- or slow-moving riverine (see Table 2-2), herbicide concentrations will not remain at their immediate post-treatment levels. Thus, any potential impacts resulting from WHCP treatments will be highly localized and temporary.

Decomposition of herbicides in water depends on a number of characteristics, including: water quality, sediments in the water, temperature, and chemical properties of the herbicide. A review of 34 research papers concerning the persistence of 2,4-D in water under both laboratory and field conditions concluded that (1) under laboratory conditions, 2,4-D in water decomposed in periods of hours to days; and (2) under some warm water field conditions, 2,4-D has consistently been shown to be reduced to non-detectable levels in closed water bodies in approximately one month; and (3) persistence of 2,4-D at extremely low levels may be encouraged by water movements in lakes, reservoirs, and streams (Gren 1983).

The chemical 2,4-D may also break down due to photodecomposition or by algal or bacterial decomposition (ESA/Madrone 1984). Westerdahl et al., (1983) found that the disappearance of 2,4-D in aquaria containing both plants and hydrosoil, and only hydrosoil, suggested that macrophytes, algae, fungi, and organic debris were the most likely sinks for 2,4-D. The aqueous half-life of 2,4-D (time in which one-half of the material is degraded) in a set of pools was 10 to 11 days. In a study with natural waters, 2,4-D half-life ranged from 0.5 to 6.6 days (HSDB 2001). Walters (1999) reported an aqueous photolysis half-life for 2,4-D, at 25C, of 13.0 days, and an aqueous aerobic half-life of 15.0 days. Results of WHCP follow-up monitoring typically show declining 2,4-D concentrations (often to non-detectable levels) between two and seven days after treatment.

Glyphosate does not appear to be persistent in the water column. Glyphosate binds tightly to sediment, removing the active ingredient from water. The half-life of glyphosate in pond water ranges from 12 days to 10 weeks (EXTONET 1996). At two Delta test plots, researchers applied 100 gallons of 6 pounds per acre glyphosate solution, somewhat higher than the labeled rate. The highest concentration of glyphosate was found after 4 hours (60 ppb), in a test spray area not subject to tidal flow (Corcoran et al. 1984). At a test site with tidal flow, the highest concentration of glyphosate (40ppb) was found one-half hour after treatment (Corcoran et al. 1984). When glyphosate was sprayed aerially at a rate of 5 pints per acre (also higher than the labeled rate), glyphosate was at its maximum concentration one-half day after treatment (0.28 ppm to 0.60 ppm). After six to eight days, glyphosate levels ranged from undetectable (<0.001 ppm) to 0.49 ppm (Henry et al. 1994). In turbid water, glyphosate is degraded by microorganisms (Siepmann 1995). Studies in Canada suggest that sediment adsorption and microbial degradation are responsible for glyphosate's loss from water (Schuette 1998).

Potential for Toxic Effects of WHCP Herbicides on Fish

The levels of herbicide and adjuvant utilized by the WHCP are unlikely to result in acute toxic effects to special status or other fish, including impacting movement of native resident or migratory fish. **Table 3-8**, on the next page, provides LC50 values for WHCP chemicals for a variety of fish species. These levels are significantly higher than the maximum concentrations of 2,4-D, glyphosate, or adjuvants in or immediately downstream of treatment sites.

There has been relatively little research on the toxic effects of adjuvants. Nonylphenol ethoxylate (NPE) surfactants are more toxic to aquatic species that most aquatic pesticides, and may also cause endocrine disruption. NPE adjuvants such as R-11® have been eliminated from the WHCP as a result.

The non-ionic adjuvant Agridex®, which replaced R-11®, has significantly lower toxicity, with LC50 levels greater than 1,000 mg/l (ppm). The DBW may consider use of another adjuvant, Competitor®. This adjuvant, which has not been utilized by the WHCP to-date, appears to have higher acute toxicity than Agridex®, but it is still far above WHCP exposure levels (see Table 3-6). Competitor® would be used at the same concentration as Agridex®.

Between 2001 and 2005, DBW commissioned toxicity testing of three fish species. The testing included water samples obtained following treatments. In addition, as part of their NPDES permit requirement, DBW sponsored several toxicity analyses using WHCP chemicals. These studies are indicative of actual environmental impacts, as they reflect Delta conditions, and/or laboratory results specifically related to the WHCP. Below, we summarize results of these studies, as they relate to toxic impacts on fish species:

- Riley and Finlayson (2003) conducted 96 hour acute toxicity screening for 2,4-D and glyphosate on larval delta smelt, larval Sacramento splittail, and larval fathead minnows. The results of these studies are provided in **Table 3-9,** on page 3-57. The study concluded that 2,4-D and glyphosate toxicity values for the three larval fish species were several orders of magnitude higher than detected concentrations in the environment (Riley and Finlayson 2003)
- Riley and Finlayson (2004) conducted 96 hour and seven day toxicity screening of WHCP chemicals on larval fathead minnows to determine chronic toxicity levels. For 2,4-D, the 96 hour LC50 value was 116 ppm, the seven day LC50 was 96.6 ppm, and the seven day maximum acceptable toxicant concentrations (MATC) was less than 40.5 ppm. These concentrations were orders of magnitude higher than concentrations resulting from the WHCP
- Riley and Finlayson's (2004) testing of glyphosate on larval fathead minnows found a 96 hour LC50 value of 608 ppm, a seven day LC50 of 586 ppm, and a seven day MATC of less than 104 ppm. Again, these concentrations were orders of magnitude higher than concentrations resulting from the WHCP. Riley and Finlayson concluded that there were minimal impacts to fish and wildlife from the WHCP
- The DBW conducted an analysis of water quality and toxicity using monitoring data gathered from 2001 to 2005. DBW collected several hundred pre-treatment and post-treatment water samples and delivered these to California Department of Fish and Game laboratories to conduct five different toxicology tests. Based on an examination of toxicology test results from post-treatment water samples, it appears that the WHCP did not have a significant or consistent adverse affect on test organisms used by the laboratories (including fathead minnow)
- In the DBW analysis, there were 20 samples which exceeded previous NPDES permit levels (20 ppb) for 2,4-D (NPDES permit levels are now 70 ppb 2,4-D). These 20 samples were tested for fathead minnow survival and growth. None of these 20 samples had an adverse effect on survival, however five samples had an adverse effect on fathead minnow growth. While none of the glyphosate samples exceeded NPDES permit criteria (700 ppb), the CDFG

Table 3-8
Response of Various Fish Species to WHCP Chemicals, at LC50 Values

Species	Chemical	LC50	Time Period	Reference
Fathead minnow	2,4-D dimethylamine salt (DMA)	344 ppm	96 hr	Alexander et al., 1985
Fathead minnow	2,4-D DMA	335 ppm	96 hr	Johnson and Finley 1980
Fathead minnow	2,4-D DMA	318 ppm	96 hr	USEPA 2000
Fathead minnow fingerlings, swim-up fry	2,4-D DMA	320 ppm to 630 ppm	96 hr	Johnson and Finley 1980
Fathead minnow egg stage	2,4-D DMA	1,400 ppm	96 hr	Johnson and Finley 1980
Bluegill	2,4-D DMA	168 ppm	96 hr	Johnson and Finley 1980
Bluegill	2,4-D DMA	524 ppm	96 hr	Alexander et al., 1985
Bluegill	2,4-D DMA	166 ppm to 458 ppm	48 hr	HSDB 2001
Bluegill	2,4-D DMA	108 ppm to 524 ppm	96 hr	USEPA 2000
Rainbow trout	2,4-D DMA	>100 ppm	96 hr	Johnson and Finley 1980
Rainbow trout	2,4-D DMA	250 ppm	96 hr	Alexander et al., 1985
Rainbow trout, Donaldson trout	2,4-D DMA	250 ppm	96 hr	USEPA 2000
Rainbow trout, Donaldson trout	2,4-D DMA	100 ppm to 1,360 ppm	96 hr	ECOTOX 2001
Cutthroat trout	2,4-D granular	64 ppm	96 hr	Johnson and Finley 1980
Lake trout	2,4-D granular	45 ppm	96 hr	Johnson and Finley 1980
Chinook salmon	2,4-D DMA	>100 ppm	96 hr	Johnson and Finley 1980
Coho salmon yearling	2,4-D DMA	>200 ppm	96 hr	HSDB 2001
Nile tilapia larvae	2,4-D DMA	28 ppm	48 hr	Sarikaya and Selvi 2005
Nile tilapia adults	2,4-D DMA	87 ppm	48 hr	Sarikaya and Selvi 2005
Channel catfish	2,4-D DMA	155 ppm	96 hr	Johnson and Finley 1980
Smallmouth bass	2,4-D DMA	236 ppm	96 hr	Johnson and Finley 1980
Largemouth bass	2,4-D DMA	350 ppm to 375 ppm	48 hr	HSDB 2001
Fathead minnow	Glyphosate	97 ppm	96 hr	Folmar et al., 1979
Fathead minnow	Glyphosate	9.4 ppm to 97 ppm	96 hr	USEPA 2000
Bluegill	Glyphosate	140 ppm	96 hr	Folmar et al., 1979
Bluegill	Glyphosate	120 ppm	96 hr	Corcoran et al., 1984
Bluegill	Glyphosate, isopropylamine salt	>1,000 ppm	96 hr	Corcoran et al., 1984
Rainbow trout	Glyphosate	140 ppm	96 hr	Folmar et al., 1979
Rainbow trout, Donaldson trout	Glyphosate	8.2 ppm to 240 ppm	96 hr	USEPA 2000
Trout	Glyphosate, isopropylamine salt	>1,000 ppm	96 hr	Corcoran et al., 1984
Trout	Glyphosate	86 ppm	96 hr	Corcoran et al., 1984
Chinook salmon	Glyphosate	9.1 ppm to 1,440 ppm	96 hr	ECOTOX 2001
Pink salmon	Glyphosate	17 ppm to 48 ppm	96 hr	ECOTOX 2001
Chum salmon	Glyphosate	11 ppm to 58 ppm	72 hr	ECOTOX 2001
Coho salmon, silver salmon	Glyphosate	5.7 ppm to 55 ppm	96 hr	ECOTOX 2001
Sockeye salmon	Glyphosate	28 ppm	96 hr	ECOTOX 2001
Harlequin fish	Glyphosate	168 ppm	96 hr	Corcoran et al., 1984
Carp	Glyphosate	115 ppm	96 hr	Corcoran et al., 1984
Carp	Glyphosate, isopropylamine salt	>10,000 ppm	96 hr	Corcoran et al., 1984
Channel catfish	Glyphosate	130 ppm	96 hr	Folmar et al., 1979
Rainbow trout	Agridex®	>1,000 ppm	96 hr	WSDA 2005
Rainbow trout	Competitor®	95 ppm	96 hr	WSDA 2005

Table 3-9
CDFG Study Results, Acute Toxicities of 2,4-D and Glyphosate on Three Larval Fish Species, 96 Hour LC50 Values (in ppm)

Fish Species	2,4 D LC50	Glyphosate LC50
Larval delta smelt	149 ppm	270 ppm
Larval Sacramento splittail	446 ppm	1,132 ppm
Larval flathead minnow	216 ppm	1,154 ppm

Table 3-10
Aquatic Animal and Plant Levels of Concern

Risk Presumption	Risk Quotient	Level of Concern
Acute High Risk	EC/LC50 or EC50	0.5
Acute Restricted Use	EC/LC50 or EC50	0.1
Acute Endangered Species	EC/LC50 or EC50	0.05
Chronic Risk	EC/MATC or NOEC	1

Sources: Siemering et al. February 2005; Siemering et al. 2008

laboratory conducted toxicity testing using the 18 samples with detectable levels of glyphosate. None of these 18 glyphosate samples had an adverse effect on fathead minnow survival, however three of the 18 had an adverse effect on fathead minnow growth. (It is worth noting that three of 52 samples without any detectable glyphosate also had an adverse effect on fathead minnow growth).

This series of studies provide no indication of acute toxic impacts on fish species as a result of WHCP treatments. All toxicity tests were conducted on the more sensitive larval stages of fish, providing further confidence in the results. While data are limited, there may be some impact of WHCP treatments (and/or simply from ambient Delta waters) on larval fish growth.

In an independent study of aquatic pesticide toxicity within the Delta, the San Francisco Estuary Institute (SFEI) conducted the Aquatic Pesticide Monitoring Program (APMP) (Siemering et al. 2008). The APMP, funded by the SWB, was part of the settlement of the 2001 *Headwaters, Inc. v. Talent Irrigation District* decision regarding the requirement to obtain an NPDES permit for aquatic pesticide use. The purpose of the APMP was to evaluate water quality impacts associated with the use of aquatic pesticides, and to evaluate non-chemical alternatives.

SFEI prioritized aquatic pesticides for further study, analyzed three years of monitoring data, and conducted several special studies of high priority pesticides. Both 2,4-D and glyphosate were among the herbicides evaluated by SFEI. Using an U.S. EPA methodology, SFEI calculated risk quotients (RQ) for each pesticide. The RQ was equal to the water chemical concentration divided by an acute or chronic toxicity value: RQ = Exposure/Toxicity. SFEI utilized the lowest available toxicity values in the scientific literature in order to ensure that RQ values were conservative.

SFEI compared the RQ values to a Level of Concern (LOC). LOC's are unit-less values determined by the U.S. EPA Office of Pesticide Programs. When the RQ is higher than the specified LOC, it is an indication of the need for further investigation of that particular chemical application. **Table 3-10**, above, provides the USEPA's LOCs.

Siemering et al., (February 2005) also provide USEPA's interpretations of the LOC risks:

- Acute high risk: potential for acute risk is high; regulatory action may be warranted in addition to restricted use classification
- Acute restricted use: the potential for acute risk is high, but this may be mitigated through restricted use classification
- Acute endangered species: the potential for acute risk to endangered species is high, but this may be mitigated through restricted use classification
- Chronic risk: the potential for chronic risk is high; regulatory action may be warranted.

For 2,4-D, the RQ values for Chinook salmon LC50, *Pimephales promelas* (fathead minnow) LC50, and delta smelt NOEC were all well below the LOC values. SFEI stated "this data indicates that there is no evidence of pesticide induced degradation at either of the sampling locations. In addition, no LOCs were exceeded by the maximum 2,4-D concentration measured" (Siemering et al. February 2005). In similar analyses for glyphosate, there were also no LOC exceedances. Of the eight aquatic pesticides evaluated, SFEI ranked glyphosate as the lowest risk (Siemering et al. 2008).

SFEI did identify LOC exceedances for the surfactant R-11®. As a result of these concerns, DBW eliminated R-11® from the WHCP at the end of the 2003 treatment season.

In another study, SFEI analyzed DBW WHCP monitoring results, calculating RQ values and the number of LOC exceedances for monitoring data from 2003 to 2005. For the 1,799 2,4-D RQs that SFEI calculated for the three year period, there were no LOC exceedances. For the 835 RQs that SFEI calculated for glyphosate, there were four LOC exceedances (one for delta smelt and three for Sacramento splittail). SFEI hypothesized that the small number of exceedances could result from overapplication, poor mixing and dispersion in the water column, or additional terrestrial sources of glyphosate (Siemering 2006). Siemering (2006) also noted that "only four exceedances in three years indicates that DBW glyphosate applications are not likely to pose a risk to the aquatic environment." For 472 RQ values calculated for Agridex® in 2004 and 2005, SFEI also found no LOC exceedances.

While the risk of acute toxicity to special status or other fish resulting from the WHCP is extremely low, there is concern about chronic/sublethal toxicity impacts from both 2,4-D and glyphosate. Studies have identified two potential areas of concern related to sublethal exposure to 2,4-D: endocrine disruption (in the form of estrogenic activity) and oxidative stress.

Xie et al., (2005) identified dose-related increases of vitellogenin in juvenile rainbow trout exposed to 2,4-D. Vitellogenin is an egg yolk precursor protein used as an indicator of estrogenic activity in both females and males. Juvenile trout were exposed to either 0.00164, 0.0164, 0.164, or 1.64 mg/l 2,4-D (ppm) for seven days. The trout exposed at the 1.64 mg/l level had vitellogenin levels 93 times higher than the controls. The lowest observed effect concentration (LOEC) was 0.164 mg/l (or 164 ppb). There was no observed effect at the lowest two exposure concentrations.

Sarikaya et al., (2005) examined 48 hour LC50 values for 2,4-D in larvae and adult Nile tilapia (*Oreochromis niloticus*). They observed changes among larvae and adults at various herbicide levels, and concluded that the toxicity of 2,4-D is related to oxidative stress. Behavioral and other changes included abnormal swimming behavior (hitting the walls of the tank), increased mucous secretion, faded coloring, sudden jerks, and anxiety.

Oruc and others (2000, 2002, 2004) examined antioxidant enzymes in carp and tilapia following exposure to 2,4-D. Oxidative stress results in the formation of free radicals, which cause cellular damage. Formation of free radicals also results in increased production of antioxidant enzymes, which can be measured in the laboratory. Carp and tilapia exposed to 87 ppm 2,4-D for 96 hours showed an increase in the antioxidant enzyme superoxide dismutase (SOD) in gills (but not kidney or brain). Oruc concluded that fish exposed to 2,4-D developed tissue-specific adaptive responses to protect cells against oxidative stress.

While glyphosate did not result in estrogenic activity (Xie et al. 2005), other studies have found indications of reduced liver activity and immune suppression resulting from sublethal exposure to glyphosate. Li and Kole (2004) found an inhibitory effect on liver esterase as compared to controls with exposure to 1.0, 5.0, and 25 mg/l glyphosate for 65 days. Li and Kole cited other studies that noted behavioral changes to rainbow trout after one month of exposure to 46 ppb glyphosate, Li and Kole (2004) also noted increased enzyme activity, and interruption of immune response and protein biosynthesis in carp exposed to 2.5 to 10 mg/l glyphosate.

These studies raise potential concerns about sublethal toxicity, however the exposure levels of 2,4-D that resulted in estrogenic activity or oxidative stress in fish are higher than those likely to result from the WHCP. Similarly, WHCP exposure levels of glyphosate are significantly lower than the long-term exposure levels tested by Li and Kole.

In addition, special status and native fish species may not commonly be present near water hyacinth, further reducing risk of exposure to WHCP chemicals. Toft et al., (2003) sampled fish adjacent to water hyacinth, and found that most of the fish were juveniles, and non-indigenous to the Delta. Three native species, Sacramento splittail, tule perch, and prickly sculpin accounted for only 8.2 percent of the fish captured at one Delta site (Toft 2003).

Potential for Toxic Effects of WHCP Herbicides on Amphibians and Reptiles

As compared to fish, there is significantly less information related to the toxic effects of WHCP herbicides and adjuvants to amphibians and reptiles. However, the limited information that is available indicates that toxic impacts to amphibians and reptiles resulting from the WHCP are highly unlikely.

Generally, amphibians are thought to be more sensitive to chemical exposure than reptiles, because of their thinner skin and the fact that they inhabit both water and land. As a result, amphibian toxicity studies are often used to infer toxicity effects on reptiles, when specific reptile studies are not available.

Because of the scarcity of reptile studies, one of the conditions of the WHCP's initial USFWS Biological Opinion was to conduct snake toxicity testing of WHCP herbicides. The DBW provided funding to the CDFG to conduct acute oral and dermal toxicity studies on garter snakes (Hosea et al. 2004). CDFG utilized two surrogate species of garter snakes, common garter snake, *Thamnophis sirtalis*, and western terrestrial garter snake, *Thamnophis elegans*. These garter snake species are closely related to the threatened giant garter snake, *Thamnophis gigas*.

Snakes were exposed both orally and dermally to a solution of herbicide, herbicide-surfactant, or control (distilled water). The surfactant studied was R-11®, which has since been removed from the WHCP due to its relative high toxicity to aquatic species. Both herbicides and surfactant were at concentrations equivalent to the mixing tanks (i.e. the concentration from the spray nozzle).

Table 3-11
Concentrations of Test Solutions and Calculated Exposure Ranges for Herbicides, Surfactants, and Mixtures from CDFG Garter Snake Acute Toxicity Study

Herbicide and/or Surfactant	Concentrations of Test Solutions (mg/l or ppm)	Experimental Oral Exposure Range (mg/kg)	Experimental Dermal Exposure Range (mg/kg)
2,4-D (Weedar® 64)	3,000	28.791 to 32.895	28.791 to 32.895
Glyphosate (Rodeo®*)	3,900	37.055 to 39.494	37.055 to 39.494
Nonylphenol ethoxylates (NPE)(R-11®)	2,360	22.056 to 30.256	22.056 to 30.256
2,4-D (Weedar® 64) and NPE (R-11®)	2,800	24.207 to 30.769	24.207 to 30.769
	1,160	10.029 to 12.747	10.029 to 12.747
Glyphosate (Rodeo®) and NPE (R-11®)	3,620	32.321 to 39.635	32.321 to 39.635
	2,200	19.643 to 24.088	19.643 to 24.088

Table 3-11, above, provides the concentrations of test solutions and actual exposure range (in mg/kg body weight). CDFG observed the snakes for seven days following treatment. There were no acute lethal or sublethal effects. Snakes did not exhibit significant alterations in behavior following treatment, and did not develop skin lesions or other physical abnormalities. There was no significant difference in post exposure weight change between test groups. CDFG reported that "if snakes were inadvertently sprayed directly or were to consume any of the undiluted spray solution, there should be no acute toxicity" (Hosea et al. 2004).

Much of the amphibian toxicity data in the literature for glyphosate was based on the herbicide Roundup®, and is not relevant for the WHCP. Roundup® is not approved for aquatic use because it includes a surfactant, polyethoxylated tallowamine (POEA), which is highly toxic to aquatic species. Because Roundup® includes this surfactant, the herbicide is toxic to aquatic species, including amphibians (and not approved for aquatic use). There were some studies in the literature, discussed below, that utilized technical grade glyphosate or Rodeo®. Rodeo® was previously utilized by the WHCP, and is essentially the same formulation as AquaMaster™, the current WHCP glyphosate herbicide.

Studies of 2,4-D acute toxicity to three frog species, tusked frog, brown striped marsh frog, and western chorus frog, found 96 hour LC50 values from 100 ppm to 340 ppm (ECOTOX 2001). Another study found no effects on tadpoles in up to 50 ppm 2,4-D for 48 hours, and no effects on frog abundance as a result of partial treatment of Long Pond, New York, with granular 2,4-D (Halter 1980).

Howe et al., (2004) examined the toxicity of four North American frog species to several glyphosate formulations (most with surfactant), as well as technical glyphosate. They found no significant acute toxicity with technical grade glyphosate. Edginton et al., (2004) conducted amphibian toxicity testing and compared two different study designs using *Xenopus* and several glyphosate herbicides. Rodeo® was the least toxic of the herbicide formulations tested, with LC levels dependent on pH. At pH 6.5, the Xenopus 96 hour LC10 (lethal concentration for 10 percent) ranged from 1,722 ppm to 3,024 ppm, and the LC50 ranged from 4,341 ppm to 6,419 ppm. Toxicity was greater at pH 8, but still far below WHCP exposure levels. The 96 hour LC10 at pH 8 was 240 ppm to 395 ppm, and the LC50 was 604 ppm to 645 ppm (Edginton et al. 2004).

Perkins et al., (2000) examined the effect of various glyphosate herbicides, including Rodeo®, on *Xenopus laevis*, using the Frog Embryo Teratogenesis Assay – *Xenopus* (FETAX). Rodeo® was found to be the least toxic, with a LC5 (lethal concentration for 5 percent) of 3,799 mg/l (ppm) and a LC50 of 5,407 mg/l. Roundup® was 700 times more toxic than Rodeo®, due to the surfactant POEA.

Sparling et al., (2006) examined the toxicity of a glyphosate herbicide (Glypro®) and the acid/buffer adjuvant LI700® on turtle embryos and early hatchlings. They exposed eggs of red-eared sliders (*Trachemys scripta elegens*) to between 0 to 11,206 ppm herbicide and between 0 and 678 ppm adjuvant. There were dose related impacts on hatching success, hatchling weight, and somatic indices, primarily at the highest levels. The study concluded that "because of the high concentrations needed to produce effects… glyphosate with LI700® poses low levels of risk to red-eared slider embryos under normal field operations with regards to endpoints measured in the present study" (Sparling et al. 2006).

In early WHCP documentation, the USFWS considered the potential impact of WHCP treatments on special status reptiles:

> *"The concentration of Weedar® or Rodeo® [equivalent to AquaMaster™] used on water hyacinth is not known to be toxic to reptiles (Van Way 1995), and direct exposure of giant garter snakes to these herbicides is unlikely. Giant garter snakes bask on grassy banks and on branches over the water's edge where herbicide applications will not occur. The giant garter snake is extremely shy and snakes in the water or on top of water hyacinth mats would probably move out of the area as the boat crews approach in motor driven boats. Emergent vegetation is used by adults for escape cover and for foraging habitat, and young use dense emergent vegetation for cover while absorbing their yolk sacks. Water hyacinth herbicides are applied only to water hyacinth and will not affect emergent vegetation or snakes utilizing emergent vegetation. The small potential adverse effect herbicide application could have on any giant garter snakes present is likely to be greatly outweighed by the benefit of water hyacinth removal on the species' habitat. Open water surface is a habitat requisite for this species (USFWS 1993). Water hyacinth infestations inhibit giant garter snakes from foraging and are reducing the numbers of prey species.*
>
> *It is unlikely that northwestern pond turtles would be directly exposed to the herbicides applied on the water hyacinth. Pond turtles are wary, and will quickly leave basking sites when approached. Water hyacinth control would benefit northwestern pond turtles on the Refuge by increasing food availability. Removal of water hyacinth mats would lead to an increase in the abundance and diversity of macroinvertebrates, tadpoles, small fish, and both submergent and floating native plant species"* (USFWS 1995, 5-6).

Potential for Toxic Effects of WHCP Herbicides on Birds

Birds could be adversely affected by exposure to herbicide-treated water, or by exposure to herbicide spray drift. While these exposure mechanisms are highly unlikely, there is potential for such exposure to occur.

The active ingredient of Weedar 64, 2,4-D, is practically non-toxic to birds. Studies of several bird species have found lethal dietary concentrations (LD50) values of over 5,000 ppm, and oral dose LD50 values of over 272 mg/kg of body weight. Thus, toxic impacts to bird species are highly unlikely. **Table 3-12,** on the next page, summarizes the toxicity data for birds. These concentrations are significantly higher than potential exposures to 2,4-D from the WHCP, either indirectly through contaminated food, or directly through spray from herbicide drift or contact with water.

Table 3-12
Response of Various Bird Species to WHCP Chemicals, as LC50 or LD50 Values

Species	Chemical	LC50 or LD50	Time Period	Reference
Northern bobwhite	2,4-D dimethylamine salt (DMA)	500 mg/kg dietary	14 days	Hammond 1996, USEPA 2000
Northern bobwhite	2,4-D DMA	>5,620 ppm	8-day dietary	Hammond 1996, USEPA 2000
Bobwhite quail	2,4-D DMA	>5,000 ppm	8-day dietary	ECOTOX 2001
Japanese quail	2,4-D DMA	>5,000 ppm	8-day dietary	ECOTOX 2001
Quails and pigeons	2,4-D DMA	668 mg/kg	Dietary	EXTONET 1996
Mallard duck	2,4-D DMA	>5,000 ppm	8-day dietary	ECOTOX 2001
Mallard duck	2,4-D DMA	>5,620 ppm	8-day dietary	Hammond 1996, USEPA 2000
Mallard duck	2,4-D DMA	1,000 mg/kg	dietary	EXTONET 1996
Pheasant	2,4-D DMA	272 mg/kg	Dietary	EXTONET 1996
Ring-necked pheasant	2,4-D DMA	>5,000 ppm	8-day dietary	HSDB 2001
Bobwhite quail	Glyphosate	>4,500 ppm	Dietary	ECOTOX 2001
Mallard duck	Glyphosate	>4,500 ppm	Dietary	ECOTOX 2001
Mallard duck	Glyphosate	178 lb/acre	1 time dose, 18 day study period	ECOTOX 2001
Mallard duck	Glyphosate	>33 lb/acre	1 time dose, 18 day study period	ECOTOX 2001
Broiler chickens	Glyphosate	60.8 ppm to 608 ppm	NOEL, diet for 21 days	HSDB 2001
Broiler chickens	Glyphosate	6,080 ppm	Not lethal, 50% decrease in body weight	HSDB 2001

Glyphosate is practically nontoxic to birds. Toxicity studies for glyphosate are also summarized in Table 3-12. Dietary LD50 values for glyphosate are over 4,500 ppm glyphosate in the diet. The concentrations are significantly higher than potential exposures to glyphosate from the WHCP, either indirectly through contaminated food sources or directly through spray from herbicide drift or contact with water. Thus, toxic impacts to bird species from the WHCP are highly unlikely.

Oliveira et al., (2006) examined the effects of Roundup® (glyphosate plus a POEA surfactant) on androgen and estrogen synthesis in mallard ducks (*Anas platyrhynchos*). Their study found effects were mostly dose dependent, "indicating that this herbicide may cause disorder in the morphophysiology of the male genital system of animals" (Oliveira et al. 2006). However, the LOEL and NOEL levels for tissue and enzyme impacts in their study were for 15 days exposure to between 5 mg/kg body weight and 100 mg/kg body weight (ECOTOX 2008), far higher than any potential WHCP exposures. In addition, it is not clear whether impacts resulted from glyphosate or POEA exposure.

There are no known toxic effects of adjuvants on birds at the exposures proposed in the WHCP. The potential for special status or other birds to be exposed to WHCP herbicides are minimal.

WHCP activities in any given treatment area are likely to be relatively brief (one to two days). While birds appear to tolerate a relatively high degree of human activity adjacent to their nests (DBW 2001), they are unlikely to place themselves immediately in treatment zones at the time of spraying.

A study in Florida found that bird species that forage in water hyacinth most often obtained prey that were located near the perimeter of the mats, and rarely hunted in the interior of the mats (Bartodziej and Weymouth 1995). Waterfowl tend to prefer native aquatic species for foraging, and in fact may avoid monospecific species. In an evaluation of waterfowl preferences, over 73 percent of the almost 4,000 bird observations occurred in native vegetation (Dick et al., 2004). The survey took place over a six-month period, and compared bird preferences in mixed native vegetation, hydrilla, and watermilfoil.

* * * * *

It is extremely unlikely that there would be acute toxic impacts from WHCP herbicide or adjuvants to special status fish, amphibians, reptiles, or birds, or that WHCP herbicides would result in toxic effects that would impact native resident or migratory fish species. In addition, given the low levels of herbicides utilized, and the limited treatment acreage, the potential for sublethal toxic impacts to special status fish, amphibians, reptiles, or birds, or native resident and migratory fish is likewise low. However, should such sublethal toxic impacts result, they would constitute an **unavoidable or potentially unavoidable significant impact**. These impacts would potentially be reduced by implementing the following six mitigation measures.

- **Mitigation Measure B2a** – Implement temporal and spatial limitations and restrictions on herbicide treatments to minimize treatments during times, and at locations, where larval and/or migratory fish are likely to be present.

  The specific locations and times are specified in the WHCP NOAA-Fisheries Biological Opinion (NOAA-Fisheries 2006), pages 9 and 10, and in maps provided to WHCP treatment crews. The Biological Opinion is provided in Appendix B of this Final PEIR.

  Between July 1st and October 15th, there are no restrictions for areas to be sprayed within the project area. No earlier than April 1st, and prior to July 1st, only certain areas where migratory fish are not likely to be present may be treated. Certain sites, including the San Joaquin River upstream of the confluence of the Merced River, may be treated as late as November 30th. No sites may be treated between November 30th and April 1st.

  These treatment time restrictions minimize potential exposure of migratory salmonids and sensitive juvenile fish to WHCP herbicides. **Exhibit 3-5,** on the next page, illustrates spawning and migration times for several special status fish, in relation to WHCP treatment times.

- **Mitigation Measure B2b** – Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters.

  The DBW will conduct comprehensive monitoring. This monitoring is in compliance with the general NPDES permit, and NOAA-Fisheries and USFWS Biological Opinions. The DBW will collect samples prior to treatment, immediately after treatment, and post-treatment within one week of spraying. The DBW will conduct water quality monitoring for visual parameters, physical parameters, and chemical parameters at ten (10) percent of the sites it treats for each pesticide, per water body type. Water samples will be submitted to a certified analytical laboratory to measure 2,4-D, glyphosate, and adjuvant levels. Should these levels exceed allowable limits, DBW will take immediate measures to reduce chemical levels at future treatment sites.

Exhibit 3-5

Proposed Period of WHCP Treatments; Periods of Spawning in the Delta; and Migration and Emigration of Special Status Fish Species through the Sacramento-San Joaquin River System

<table>
<tr><th>Jan.</th><th>Feb.</th><th>Mar.</th><th>Apr.</th><th>May</th><th>June</th><th>July</th><th>Aug.</th><th>Sep.</th><th>Oct.</th><th>Nov.</th><th>Dec.</th></tr>
<tr><td></td><td></td><td></td><td colspan="3">Treatment at selected sites</td><td colspan="4">Proposed WHCP treatment period</td><td></td><td></td></tr>
<tr><td colspan="7">Delta smelt spawning</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">Sacramento splittail spawning</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Longfin smelt spawning</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Adult winter-run salmon migration</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Juvenile winter-run salmon emigration</td><td></td><td></td><td></td><td></td><td colspan="4"></td></tr>
<tr><td></td><td></td><td colspan="5">Adult spring-run salmon migration</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Juvenile spring-run salmon emigration</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="5">Central Valley steelhead migration</td><td></td><td colspan="6"></td></tr>
</table>

Source: DBW 2001.

- **Mitigation Measure B2c** – Implement an adaptive management approach to minimize the use of herbicides.

  Under an adaptive management approach, DBW will seek to improve efficacy and reduce environmental impacts over time as new and better information is available. Specifically, DBW will evaluate the need for control measures on a site by site, month-to-month, basis; select appropriate indicators for pre-treatment monitoring; monitor indicators following treatment and evaluate data to determine program efficacy and environmental impacts; support ongoing research to explore impacts of the WHCP and alternative control methodologies; report findings to regulatory agencies; and adjust program actions, as necessary, in response to recommendations and evaluations by DBW staff, regulatory agencies and stakeholders.

  In addition to this adaptive management approach, DBW will follow maintenance control practices that from a program standpoint seek to reduce the number of acres of water hyacinth to be treated each year, until treatment acreage reaches a minimal level. This will reduce the volume of herbicide utilized by the WHCP.

- **Mitigation Measure B2d (same as Mitigation Measure B1a)** – Avoid herbicide application near special status species and sensitive riparian and wetland habitat; and other biologically important resources.

  Each year, prior to start of the treatment season, DBW will conduct field crew training on special status species and sensitive habitats. Under this training, crews will be informed about the presence and life histories of special status species; habitats associated with species; sensitive habitats and wetlands; the terms and conditions of the program's biological opinions; incidental take procedures; and that unlawful take of an animal or destruction of its habitat is a violation of the Endangered Species Act.

  The DBW also will provide crews with a field guide (Species Identification Deck) for easy identification of special status species on-site. Prior to treating a site, crews will conduct a visual survey to determine whether special status fish, amphibians, reptiles, or birds are present. Crews will complete an Environmental Observations Checklist for each site to document the presence or absence of special status species. If any special status species are present at the site, the field crew will not perform any treatment.

- **Mitigation Measure B2e** – Provide treatment crews with electronic mapping that identifies previously surveyed areas for giant garter snake habitat (see hard copy example in Exhibit 3-2).

  Application crews will use this map as a tool for performing pre-application visual inspections for the presence of giant garter snakes. If giant garter snakes are present, treatment crews will not treat at that location.

- **Mitigation Measure B2f (same as Mitigation Measure B1c)** – Conduct herbicide treatments in order to minimize potential for drift.

  In addition to complying with application label requirements, DBW will, to the degree possible, schedule herbicide applications to occur at high tide, or at a point in the tidal cycle determined by the field supervisor to provide the least non-target impact at a particular site. In general, treatment at high tide will allow for better spray accuracy and access, and will provide for greater dilution volume of herbicides. The DBW crews will change nozzle type and spray pressures whenever conditions warrant, limiting the amount of herbicide which may inadvertently contact non-target species.

Impact B3 – Herbicide bioaccumulation: effects of herbicide bioaccumulation on special status species

The WHCP is not likely to result in significant adverse effects due to bioaccumulation of herbicides. Bioaccumulation is an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in organisms whenever they are taken up and stored faster than they are broken down (metabolized) or excreted. Bioaccumulation of chemicals in herbicides can occur in plant or animal tissues due to direct uptake or exposure, or in animal tissues by consumption and ingestion of other plant or animal species that have bioaccumulated these chemicals.

According to most sources, 2,4-D does not bioaccumulate in plants, and there is no evidence that 2,4-D accumulates to a significant level in mammals or other organisms (EXTONET 1996). The half-life of 2,4-D in living organisms is between 10 and 20 hours, and most 2,4-D is excreted in the urine (EXTONET 1996; NPTN 2008). The National Library of Medicine Hazardous Substance Data Bank states that 2,4-D is metabolized in fish and that bioconcentration is not expected to be appreciable (HSDB 2001). In a study exposing channel catfish and bluegill to 2 ppm 2,4-D by intraperitoneal injection, the fish excreted 90 percent of the herbicide within six hours (HSDB 2001). The researchers concluded there was no evidence for bioaccumulation in channel catfish and bluegills (Sikka et al. 1977).

Carp exposed to 0.05 ppm glyphosate had a bioaccumulation factor (concentration in fish/ concentration in water) of 42 percent after seven days, decreasing to 25 percent after 14 days (Wang et al. 2004). The same 0.05 ppm exposure in Nile tilapia resulted in a 65 percent bioaccumulation factor after five days, decreasing to 13 percent after 14 days (Wang et al. 2004). Wang et al., (2004) also evaluated bioaccumulation factors of 2,4-D, exposing carp and Nile tilapia to 0.5ppm 2,4-D. The 2,4-D bioaccumulation factor in carp dropped from 45 percent after seven days to 22 percent after 14 days. For Nile tilapia, the bioaccumulation factor dropped from 33 percent after five days to 17 percent after 14 days. This study indicates that neither glyphosate or 2,4-D bioaccumulates in fish.

Tu et al., (2001) reported on studies in Russia that found residues of 2,4-D in eggs, milk, and meat, however the type of 2,4-D was not reported. Tu et al., (2001) also reported on an Oregon study that found that 2,4-D risk to browsing wildlife is low. In aquatic species, the highest concentrations of 2,4-D were typically reached shortly after application, and dissipated within three weeks following exposure (Tu et al. 2001). After animals were removed from contaminated waters, they tended to excrete 2,4-D residues.

There is some evidence that fish take up 2,4-D, but seemingly at low levels that do not adversely affect fish or other species ingesting them. Folmar (1980) found fish present within a spray plot take up enough 2,4-D, or breakdown enough phenols, to impart an objectionable taste for the flesh for several days after spraying. Water column concentrations of 500 ppb imparted an "inferior" taste, while 100 ppb imparted an "acceptable" taste. These levels are significantly higher than those found even immediately after WHCP treatments.

Glyphosate has virtually no tendency to bioconcentrate (Siepmann 1995). Glyphosate is poorly absorbed from the digestive tract, and is largely excreted unchanged by mammals. It has no significant potential to accumulate in animal tissue, and a very low potential for glyphosate to build up in the tissues of aquatic invertebrates or other aquatic organisms (EXTONET 1996). Glyphosate is also not expected to bioaccumulate in plants (County of Lake 2005).

In an AquaMaster™ fact sheet, Monsanto (2002) states that "in laboratory studies conducted with glyphosate, biocentration factors were less than 1.0, indicating that glyphosate does not accumulate in fish. The low bioaccumulation factor is a result of glyphosate being readily soluble in water, and therefore subject to rapid elimination from organisms in water. Other animal species studied include marine mollusks and crustaceans, also showed low potential for bioaccumulation."

There is limited information on bioaccumulation of adjuvants. The Material Safety Data Sheet (MSDS) for Agridex® states that bioaccumulation of the adjuvant is unlikely due to the low water solubility of the product (Bayer Crop Science 2004).

Based on existing evidence, neither 2,4-D, glyphosate, or the adjuvant Agridex® are likely to result in adverse effects on biological resources due to bioaccumulation of herbicide. **The impact of bioaccumulation on special status species is expected to be less-than-significant.** No mitigation measures are required.

Impact B4 – Food web effects: effect of treatment on food webs, and resulting impact on special status species, sensitive habitats, and migration of species

Special status fish species, or native resident or migratory fish, could be indirectly impacted if the WHCP decreases the abundance of invertebrates, such as zooplankton, upon which these fish feed. While there is potential for toxic impacts to invertebrates due to the WHCP, such food web effects are unlikely.

In order to better understand the impact of non-native species on the food web, Toft et al., (2003) compared habitat structure, invertebrate assemblages, and diets of fish associated with water hyacinth and the native floating aquatic plant, pennywort. Toft's results are particularly relevant, as the study took place at three different locations in the Delta. While water hyacinth is similar in appearance to pennywort, the study found that pennywort is functionally superior to water hyacinth, in terms of habitat.

The study compared populations of epiphytic invertebrates (present in the plant roots), epibenthic invertebrates (present just above the sediment), benthic invertebrates (present in the sediment), and insects in the canopy, in water hyacinth and pennywort. The study also surveyed fish present in both plants, and analyzed fish stomach contents to determine diets. Generally, Toft et al., (2003) found that "invertebrates associated with hyacinth occur less in the diets of adjacent fish than do invertebrates associated with pennywort." One finding was that the non-indigenous amphipod, *Crangonyx floridanus*, was more abundant in water hyacinth than pennywort. While the amphipod was prevalent, *Crangonyx* was not found in fish diets. By comparison, *Hyalella azteca*, commonly found in fish diets, was typically more prevalent in pennywort.

There were significant differences between water hyacinth and pennywort in terms of epibenthic and benthic invertebrates. There was greater diversity among invertebrate species in pennywort than in water hyacinth. At one of the three sites, there were no amphipods or isopods under water hyacinth, possibly due to low dissolved oxygen levels. Similarly, there were more insects in pennywort canopies than in water hyacinth, again with greater taxa diversity. Generally, Toft et al., found the two plants to be not functionally equivalent, with the native pennywort providing better habitat and food sources for native invertebrates and fish species. This would indicate that if there was loss of invertebrates due to WHCP treatments, the impact on the food web would likely not be significant.

Earlier studies have shown that several of the invertebrates commonly found in water hyacinth, in particular amphipods, chironomid larvae, and *Gammarus,* are consumed by special status fish species such as Sacramento splittail, juvenile Chinook salmon, and delta smelt (Moyle 1976, Wang 1986, and Herbold 1987). Typical prey items of special status fish are listed below. Loss of a significant quantity of any of these invertebrates could adversely impact certain special status fish species.

- Juvenile Chinook salmon feed on various aquatic and terrestrial insects, crustaceans, chironomid larvae and pupae, caddisflies (in fresh water), and *Neomysis, Cammarus*, and *Crangon* in more saline water (Wang 1986).
- Steelhead feed on terrestrial and aquatic insects, amphipods, crustaceans and small fish (Wang 1986).
- Juvenile delta smelt primarily eat copepods, planktonic crustaceans, small insect larvae, and mysid shrimp, while older fish feed almost exclusively on copepods (Moyle 1976). Over recent years, there have been significant declines in delta smelt's preferred food resources due to invasive species such as the overbite clam (Bennett 2005).
- Sacramento splittail are opportunistic benthic foragers that consume copepods, dipterans, detritus, algae, clams, and amphipods (DBW 2001).
- Longfin smelt feed primarily on *Neomysis mercedis*, although copepods and other crustaceans are important at times, especially to small fish (Moyle 1995, 1976).
- Juvenile green sturgeon feed on *Neomysis mercedis* and amphipods (Corophium) (Radtke 1966). Adults may feed on sand lances, clams, and shrimp (Moyle 1995).
- Ammocoetes of the river lamprey feed on microscopic plants and animals (Wang 1986). As adults, river lamprey prey on a variety of fishes in the 10 to 30 cm size range, but the most common prey seems to be herring and salmon (Moyle 1995).

When Weedar® 64 is applied at labeled rates, the herbicide is not likely to have toxic effects on aquatic invertebrates. In a study of invertebrate communities in artificial ponds, benthic macroinvertebrate communities showed no primary effects due to treatment (Stephenson and Mackie 1986). The LC50 in this study for various crustaceans and insects was over 100 ppm 2,4-D DMA. There were some subtle secondary effects, with lower benthic diversity in treated ponds almost one year after the initial treatment, however this response is not applicable to the tidal waters of the Delta. Washington State reported a NOEL for *Daphnia magna* exposed to 2,4-D of 27.5 ppm (Siemering 2006). Green and Abdelghani (2004) reported that high doses of 2,4-D in red swamp crawfish altered enzyme activity and gill structure, and disrupted liver function.

Toxicity levels for 2,4-D for a range of zooplankton are also higher than levels expected in the WHCP. LC50 values for most zooplankton were over 100 ppm 2,4-D, while two species had LC50 values ranging from 1 to 10 ppm 2,4-D (Halter 1980). LC50 values for 2,4-D for benthic invertebrates were found to be generally over 1,000 ppm and over 10 ppm in life-cycle invertebrate tests using eggs and early life stages (Halter 1980). **Table 3-13**, on the next page, summarizes toxicity data for invertebrate species at various life stages for 2,4-D, glyphosate, and two adjuvants.

When glyphosate is applied at labeled rates, the herbicide is not likely to have a negative impact on aquatic invertebrates. Invertebrates appear to be less sensitive to technical grade glyphosate than are fish (Siepmann 1995). Henry et al., (1994) concluded that Rodeo® (with X-77® and Chem-Trol® adjuvants) does not pose an acute hazard to native aquatic invertebrates because the concentrations of these chemicals found to be acutely toxic to invertebrates were much higher than their expected or measured concentrations in water from wetlands treated with the herbicide mix. In addition, in field studies conducted by Henry et al., (1994), resident invertebrates in all study wetlands were observed to be abundant during the study period. Kreutzweiser et al., (1989) found that application of glyphosate on or adjacent to small tributaries of a creek did not result in disturbance of stream invertebrates.

Chronic toxicity tests using WHCP chemicals also found impact levels several orders of magnitude greater than likely exposure levels. The California Department of Fish and Game, Aquatic Toxicology Laboratory, conducted seven day chronic toxicity tests on the water flea neonates, *Ceriodaphnia dubia* (CDFG 2003). The seven day LC50 for Weedar® 64 was 97 ppm. The seven day LOEC for Weedar® was 40.5 ppm. CDFG used the glyphosate herbicide Rodeo® for toxicity testing. The seven day LOEC for Rodeo® was 104 ppm.

The DBW conducted an analysis of water quality and toxicity using monitoring data gathered from 2001 to 2005. The DBW collected several hundred pre-treatment and post-treatment water samples and delivered these to CDFG laboratories to conduct five different toxicology tests. Based on examination of toxicology test results from post-treatment water samples, it appears that the WHCP did not have a significant or consistent adverse affect on the test organisms used by the laboratories (including the water flea, *Ceriodaphnia dubia*).

In the DBW analysis, there were 20 samples which exceeded NPDES permit levels (20 ppb) for 2,4-D, which were tested for water flea survival and growth. None of these samples adversely affected water flea survival. Two of the 20 samples adversely affected water flea reproduction.

While none of the glyphosate samples exceeded NPDES permit criteria (700 ppb), the CDFG laboratory conducted toxicity testing using the 18 samples with detectable levels of glyphosate. One of the 18 glyphosate samples had an impact on water flea survival. The glyphosate concentration of this sample was 84 ppb. Three of the 18 samples tested had glyphosate concentrations higher than 84 ppb, but had no impact on water flea survival or reproduction.

Because there were adverse effects on water flea survival and progeny on samples that did not have detectable levels of 2,4-D or glyphosate, it is not possible to attribute the small number of cases with adverse effects on exposure to 2,4-D or glyphosate.

The US EPA presumes that a pesticide poses a risk to nontarget aquatic biota when the ratio of the acute LC50 to the environmental concentration is less than or equal to 10 (Henry 1994). When glyphosate or 2,4-D are applied at labeled rates, assuming that 10 to 20 percent of the chemical reaches the water, the concentration of herbicide active ingredient in one acre-foot of water is between 0.2 ppm to 0.6 ppm. Thus, LC50 values of 2 ppm to 6 ppm, much lower than most of the values in Table 3-13, might be expected to pose risk to aquatic invertebrates.

Table 3-13
Response of Various Invertebrate Species to WHCP Chemicals, at LC50 Values

Species	Chemical	LC50	Time Period	Reference
Daphnia magna	2,4-D dimethylamine salt (DMA)	184 ppm	48 hr	Alexander et al., 1985
Daphnia magna	2,4-D DMA	176 ppm	96 hr	WSDE 2001
Ceriodaphnia dubia	Weedar® 64	116 ppm	96 hr	CDFG 2003
Cypridopsis, seed shrimp	2,4-D DMA	8 ppm	48 hr	Johnson and Finley 1980
Common shrimp	2,4-D DMA	>10 ppm	48 hr	ECOTOX 2001
Grass shrimp	2,4-D DMA	>100 ppm	48hr	ECOTOX 2001
Brown shrimp	2,4-D DMA	2 ppm	48 hr	PAN 2001
Gammarus fasciatus	2,4-D DMA	>100 ppm	96 hr	Johnson and Finley 1980
Aquatic sowbug	2,4-D DMA	>100 ppm	48 hr	PAN 2001
Crayfish	2,4-D DMA	>100 ppm	48 hr	PAN 2001
Red swamp crayfish, juvenile	2,4-D DMA	1,174 ppm to 1,681 ppm	96 hr	PAN 2001
Red swamp crayfish	2,4-D DMA	185 ppm	96 hr	Green and Abdelghani 2004
Daphnia magna	Rodeo®	218 ppm	48 hr	Henry et al., 1994
Daphnia magna	Rodeo®, X-77®, and Chemtrol®	130 ppm	48 hr	Henry et al., 1994
Daphnia	Glyphosate	780 ppm	96 hr	DBW 2001
Hyalella azteca	Rodeo®	720 ppm	96 hr	Henry et al., 1994
Ceriodaphnia dubia	Rodeo®	225 ppm to 415 ppm	48 hr	Tsui and Chu 2004
Ceriodaphnia dubia	Rodeo®	608 ppm	96 hr	CDFG 2003
Hyalella azteca	Rodeo®, X-77®, and Chemtrol®	218 ppm	96 hr	
Hyalella azteca	Rodeo®	225 ppm to 415 ppm	48 hr	Tsui and Chu 2004
Chironomus riparius (midge)	Rodeo®	1,216 ppm	48 hr	Henry et al., 1994
Chironomus riparius	Rodeo®, X-77®, and Chemtrol®	300 ppm	48 hr	Henry et al., 1994
Nephelopsis obscura (leech)	Rodeo®	1,177	96hr	Henry et al., 1994
Nephelopsis obscura	Rodeo®, X-77®, and Chemtrol®	116 ppm	96 hr	Henry et al., 1994
Stagnicola elodes (pond snail)	Rodeo®, X-77®, and Chemtrol®	234 ppm	96 hr	Henry et al., 1994
Midge	Glyphosate	55 ppm	96 hr	HSDB 2001
Atlantic oyster	Glyphosate	>10 ppm	48 hr	DBW 2001
Shrimp	Glyphosate	281 ppm	96 hr	DBW 2001
Fiddler crab	Glyphosate	934 ppm	96 hr	DBW 2001
Daphnia	Agridex®	>1,000 ppm	48 hr	WSDA 2005
Daphnia	Competitor®	>100 ppm	48 hr	WSDA 2005

It is unlikely that there would be significant adverse effects to special status, resident native, or migratory fish from WHCP impacts on the Delta food web. Given the low levels of herbicides utilized, and the limited treatment acreage, the potential for food web effects to impact special status fish, resident native or migratory fish, is likewise low. However, should such food web effects result, they would constitute an **unavoidable or potentially unavoidable significant impact**. These impacts would potentially be avoided or reduced by implementing the following three mitigation measures.

- **Mitigation Measure B4a (same as Mitigation Measure B2b) –** Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters.

  The DBW will conduct comprehensive monitoring. This monitoring is in compliance with the general NPDES permit, and NOAA-Fisheries and USFWS Biological Opinions. The DBW will collect samples prior to treatment, immediately after treatment, and post-treatment within one week of spraying. The DBW will conduct water quality monitoring for visual parameters, physical parameters, and chemical parameters at ten (10) percent of the sites it treats for each pesticide, per water body type. Water samples will be submitted to a certified analytical laboratory to measure 2,4-D, glyphosate, and adjuvant levels. Should these levels exceed allowable limits, DBW will take immediate measures to reduce chemical levels at future treatment sites.

- **Mitigation Measure B4b (same as Mitigation Measure B2c) –** Implement an adaptive management approach to minimize the use of herbicides.

  Under an adaptive management approach, DBW will seek to improve efficacy and reduce environmental impacts over time as new and better information is available. Specifically, DBW will evaluate the need for control measures on a site by site, month-to-month, basis; select appropriate indicators for pre-treatment monitoring; monitor indicators following treatment and evaluate data to determine program efficacy and environmental impacts; support ongoing research to explore impacts of the WHCP and alternative control methodologies; report findings to regulatory agencies; and adjust program actions, as necessary, in response to recommendations and evaluations by DBW, regulatory agencies and stakeholders.

  In addition to this adaptive management approach, DBW will follow maintenance control practices that from a program standpoint seek to reduce the number of acres of water hyacinth to be treated each year, until treatment acreage reaches a minimal level. This will reduce the volume of herbicide utilized by the WHCP.

- **Mitigation Measure B4c (same as Mitigation Measure B1a and B2d) –** Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources.

  Each year, prior to the start of the treatment season, DBW will conduct field crew training on special status species and sensitive habitats. Under this training, crews will be informed about the presence and life histories of special status species; habitats associated with species; sensitive habitats and wetlands; the terms and conditions of the program's biological opinions; incidental take procedures; and that unlawful take of an animal or destruction of its habitat is a violation of the Endangered Species Act.

  The DBW also will provide crews with a field guide (Species Identification Deck) for easy identification of special status species on-site. Prior to treating a site, crews will conduct a visual survey to determine whether special status species are present. Crews will complete an Environmental Observations Checklist for each site to document the presence or absence of special status species. If any special status species are present at the site, the field crew will not perform any treatment.

* * * * *

There also are potential positive impacts to the Delta food web resulting from the WHCP. Rapid growth and invasion of water hyacinth reduces open water habitat and impairs wetlands and sensitive riparian habitats, altering the natural food web. Toft et al. (2003) found that removal of water hyacinth also resulted in loss of the non-native amphipod *Crangonyx floridanus*, a species which was not prevalent in fish diets. Toft suggested that once an invasive species such as water hyacinth is removed from the system, "aspects of the community can return to a more natural pre-invasion state" (Toft et al. 2003).

Impact B5 – Dissolved oxygen levels: effects of treatment on local dissolved oxygen (DO) levels, and resulting impact on special status species, resident native or migratory fish, sensitive habitat, and wetlands

The WHCP could result in adverse indirect effects to special status fish, resident and migratory fish, and sensitive riparian and wetland habitats due to the rapid decay of water hyacinth, other aquatic macrophytes, and algae following herbicide application. Decomposition of vegetative material may create an organic carbon slug, which could in turn reduce dissolved oxygen concentrations. Low DO can result in fish kills, impede migration of salmonids, and kill aquatic invertebrates. These effects in turn may, at least temporarily, impair sensitive riparian and wetland habitats. However, DWR and the U.S. Bureau of Reclamation (1994) noted that in the Delta in general, constituents such as dissolved oxygen have not changed on a large enough scale to affect mobile organisms, specifically delta smelt and splittail.

Dissolved oxygen is the content of oxygen found in water. DO is determined by temperature, weather, water flow, nutrient levels, algae, and aquatic plants. Generally, a higher level of DO is beneficial.

Fish begin to experience oxygen stress or exhibit avoidance at levels below 5 mg/liter (5 ppm). DO levels drop in warmer temperatures, and increase with precipitation, wind, and water flow. Running water, such as tidal water in the Delta, dissolves more oxygen than still water. High levels of nutrients in water reduce DO levels, while algae and aquatic plants can increase DO through photosynthesis, but decrease DO through respiration and decomposition. DO levels fluctuate throughout the day, and are typically lowest in the morning and peak in the afternoon. In deep, still waters, DO levels are lower in the hypolimnion (bottom layer of water) because there is little opportunity for oxygen replenishment from the atmosphere.

There is the potential that following herbicide treatment, the biomass of decaying water hyacinth will create a large biological oxygen demand, resulting in decreases in dissolved oxygen. These decreases in dissolved oxygen could adversely affect fish species and aquatic invertebrates present at the treatment location, and generally impair sensitive riparian or wetland habitats.

The label for Weedar 64® (2,4-D) notes that decaying weeds use up oxygen, and recommends treating only one-half of a lake or pond to avoid fish kill. In larger bodies of weed infested waters, the label recommends leaving 100-foot wide buffer strips untreated, and delaying treatment of these strips for four to five weeks, until the treated dead vegetation has decomposed. The label for AquaMaster™ (glyphosate) recommends treating an area in strips when there is full coverage of the weed in impounded areas to avoid oxygen depletion. The DBW follows these label recommendations in their operations, to avoid reductions in DO.

Dissolved oxygen levels under water hyacinth are already low. Toft (2000) and others have found lower levels of dissolved oxygen under hyacinth canopies. Average spot measures were below 5 ppm in hyacinth, and above 5 ppm in pennywort (Toft 2000). These results were supported by a study in Texas which found lower dissolved oxygen in hyacinth compared to other aquatic weeds, and a University of California, Davis study which found dissolved oxygen levels as low as 0 ppm below a solid water hyacinth mat (Toft 2000). Toft hypothesized that lower dissolved oxygen levels explained the absence of epibenthic amphipods and isopods beneath the hyacinth canopy at one of the test sites (Toft 2000). Thus, it is likely that fish and other mobile aquatic invertebrates will avoid areas under water hyacinth mats with low dissolved oxygen, even prior to treatment (NOAA-Fisheries 2006).

Even short-term, localized impacts on dissolved oxygen could result in adverse effects on special status fish, resident native, or migratory fish, or impair sensitive riparian or wetland habitats in WHCP treatment sites. Such reductions in dissolved oxygen would represent avoidable significant impacts. **These avoidable significant impacts would be reduced to a less-than-significant level** by implementing the following four mitigation measures. These mitigation measures are also included within DBW's Fish Passage Protocol for the WHCP.

- **Mitigation Measure B5a** – Monitor dissolved oxygen levels pre- and post-treatment for all WHCP treatments.

  Based on the pre-treatment DO levels, the application crew will determine whether to conduct treatment at that site. No treatment will be performed when dissolved oxygen levels are between 3 ppm (the level below which DO is considered to be detrimental to fish species) and the basin plan limits established by the CVRWQCB. The basin plan limits depend on location and time of year, and range from 5 ppm to 8 ppm. The DBW will maintain written and map summaries of specific DO numeric limits. When pre-treatment levels are below 3 ppm, fish species are not likely to be present due to the extremely low oxygen levels. When pre-treatment levels are above the basin plan limit, WHCP treatments, following label guidelines and mitigation measures, are not expected to adversely affect special status fish, resident native or migratory fish, or sensitive riparian or wetland habitats.

- **Mitigation Measure B5b** – Treat no more than three contiguous acres at any treatment site.

  Crews will create a buffer zone around all treatment sites to ensure that impacts will be spread out and not segregated to one larger area. Buffer zones will be at least equal in size to the previously treated site. After treating three maximum acres, crews will then skip at least one adjacent site before treating another site. The DBW crews will not treat skipped sites until two tidal changes have occurred or, in nontidal areas, until 24 hours after treatment.

- **Mitigation Measure B5c** – Treat no more than one-half of the area at one time of completely infested dead-end sloughs to allow for fish passage.

  The DBW will return to treat the remaining half according to label instructions and permit conditions. The remaining area may be treated after four to five weeks, or when the dead vegetation has decomposed.

- **Mitigation Measure B5d** – Treat no more than one-half of completely infested moving waterways at one time to allow for fish passage.

  The DBW will not treat the remaining area until the treated water hyacinth is decomposed or until a passage has opened up in the waterway.

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There also are positive impacts related to dissolved oxygen that will result from the WHCP. Dissolved oxygen levels at treatment sites will increase, improving fish habitat, once dead water hyacinth have decayed or floated away. Removing large patches of water hyacinth will allow DO levels to increase, thus enhancing the ability of fish to move unimpeded in Delta waters. It could be argued that such a benefit outweighs the impact of short-term localized decreases in dissolved oxygen.

Impact B6 – Treatment disturbances: effects of treatment disturbances on special status species, resident native or migratory fish, sensitive habitat, and wetlands

Operational activities associated with WHCP herbicide treatments, handpicking, or herding, primarily using motorized watercraft, may result in operational-related disturbances on special status species, or resident native or migratory fish species located nearby. These disturbances may also temporarily result in impacts to sensitive riparian or wetland habitats. The following discussion of potential adverse effects is adopted from the *Clear Lake Integrated Aquatic Plant Management Plan Draft Program EIR* (County of Lake 2005, p 7-34 to 7-35).

Boat noise has been identified as inducing the startle and alarm responses in fish (Scholik and Yan 2002). These responses cause fish to flee an area (Boussard 1981). Boat noise has also been shown to temporarily reduce auditory sensitivity of some fish species (Scholik and Yan 2002). However, the Delta is already heavily used by motorboats, and the current level of water hyacinth and other vegetation management activities using boats have been conducted for over 25 years. Thus, fish are likely habituated to a substantial degree of boat-related noise. The WHCP is not expected to result in significant additional boat disturbance to fish.

The flush response in birds is defined as the instinct to abandon a current location in response to an external stimulus. While loud noise may stimulate the flush response of nesting, foraging, and resting waterfowl of any species, research suggests that rapid visual disturbance from approaching watercraft is a more influential factor in flushing waterfowl than noise (Rogers 1998, 2000). This appears to be particularly true for watercraft that displace a large amount of water into the air because of hull shape, motor behavior, velocity, and/or method of steering. However, because faster-moving boats produce more noise, flushing may be a combined effect of approach, velocity, and noise (Burger 1998). Direction of approach seems to make little difference.

In addition, loud noises (approximately 120dBA), usually generated by propane cannons, are successfully used to flush resting birds from the ponds of agricultural areas, open pit mines, and other locations where bird presence is undesirable. Thus, it can be concluded that very loud noise can elicit a flush response in birds. It should be noted that different species exhibit different levels of skittishness to external stimuli, and that nesting birds are more reluctant to flush than non-nesting birds of the same species. Some bird species have also shown an ability to develop tolerance to external stimuli.

Airboat noise and related disturbances during WHCP treatment are unlikely to result in significant impacts to special status fish; amphibians or reptiles; resident native or migratory fish; or sensitive riparian or wetland habitats. Airboat noise during WHCP treatment has the potential to result in noise-related disturbances to waterfowl. Two special status bird species, yellow-headed blackbird *(Xanthocephalus xanthocephalus)* and tricolored blackbird *(Agelaius tricolor)*, could nest adjacent to WHCP treatment locations during summer treatment months. There is the potential that these species would be disturbed by WHCP vessels. This disturbance would be temporary, and would occur at most one to two times per treated site. However, this disturbance would represent **an avoidable significant impact that would be reduced to a less-than-significant level** by implementation of the following two mitigation measures.

- **Mitigation Measure B6a (same as Mitigation Measure B1a, B2d, and B4c)** – Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources.

  In particular, avoid treatments near special status bird species nesting sites. Each year, prior to start of the treatment season, DBW will conduct field crew training on special status species. Under this training, crews will be informed about the presence and life histories of special status species; habitats associated with species; sensitive habitats and wetlands; the terms and conditions of the program's biological opinions; incidental take procedures; and that unlawful take of an animal or destruction of its habitat is a violation of the Endangered Species Act. This training will also include discussion of tricolored blackbird and yellow-headed blackbird nesting patterns and site identification.

  The DBW also will examine CNDDB records to determine if special status bird species have been sited within WHCP treatment locations, and prepare a map for field crews identifying such sites. Prior to treating a site, crews will conduct a visual survey to determine whether special status plants, animals, or sensitive habitats are present, including bird nesting sites. Crews will complete an Environmental Observations Checklist for each site to document the presence or absence of bird nesting sites. If any nesting sites for yellow-headed blackbird or tricolored blackbird are present at the site, the field crew will not perform any treatment.

- **Mitigation Measure B6b (same as Mitigation Measure B1d)** – Operate program vessels in a manner that causes the least amount of disturbance to the habitat.

  Operational procedures for DBW vessels will minimize boat wakes and propeller wash. These procedures will be particularly important in shallow water, or other sensitive habitats.

Impact B7 – Plant fragmentation: effects of plant fragmentation on sensitive habitat and wetlands

There is the potential for plant fragmentation resulting from WHCP activities to impact sensitive habitats and wetlands. Handpicking water hyacinth in nursery and sensitive areas will occur from November through February. Two-person field crews will utilize boats, 30-gallon barrels, and lawn-grooming rakes for handpicking. Each crew consists of one person driving the boat, and one person handpicking water hyacinth. The crew member will use the lawn-groom rake to collect water hyacinth and place it in 30-gallon barrels.

Herding in the western portion of the Delta near Antioch may occur from November through February. Herding will be planned based on tides, storm events, and dam releases. Herding will be conducted by field crews using spray boats fitted with a rebar and wire U-shaped "cage" mounted to the front of the boats. The boats will approach the water hyacinth and push the mat or a section of the mat toward the main channel, where it will be pushed out of the Delta into saline waters. Water hyacinth cannot survive in waters greater than 2 ppt saline. This method is not anticipated to be used as frequently as handpicking.

With handpicking, there is a possibility that some fragments of water hyacinth will float away from the boat before the crew can rake-up the plants. With herding, there is a possibility that some plants will escape the "cage", and not be pushed out of the Delta. The likelihood of either of these events occurring is low, as both handpicking and herding will take place under slow and deliberate conditions.

Water hyacinth has been shown to successfully propagate from fragments (Spencer et al. 2006). Thus, to the extent that plants or fragments “escape” the handpicking or herding processes, they may propagate into new water hyacinth plants, and establish new water hyacinth colonies. This would potentially impair sensitive habitats and wetlands in the Delta.

Further spread of water hyacinth due to fragmentation would represent **an avoidable significant impact to sensitive habitats and wetlands, but would be reduced to a less-than-significant level** by implementation of the following two mitigation measures.

- **Mitigation Measure B7a** – <u>Collect plant fragments during and immediately following treatments</u>.

  To maximize containment of plant fragments, crews will collect water hyacinth fragments. Crews will also be trained on the importance of minimizing fragment escape.

- **Mitigation Measure B7b** – <u>Conduct handpicking and herding only as required</u>.

  The DBW will limit handpicking and herding activities, primarily to winter months, when water hyacinth is dormant. In the unlikely event that water hyacinth fragments escape the raking and/or nets, the dormant plants are more likely to be washed out of the Delta, and less likely to become established, than if they had escaped during the growing season.

Impact B8 – Disposal following handpicking: effects of disposal following handpicking on sensitive habitat and wetlands

Disposal of handpicked water hyacinth, if not properly managed, could impair sensitive habitats and wetlands. To prevent such impacts, disposal of handpicked water hyacinth will occur on levees or other previously surveyed areas with low habitat value. Crews will leave water hyacinth in these dispersal areas to desiccate naturally, and will periodically monitor the areas to observe and record the fate of the water hyacinth and any effects of dispersal activities. Due to high cost and labor requirements of handpicking, the amount of handpicked water hyacinth disposed in this way will be minimal. The **less-than-significant level impact** that would occur to sensitive habitats and wetlands from plant disposal will be further minimized by the following two mitigation measures.

- **Mitigation Measure B8a** – <u>Identify and utilize disposal areas that have no and/or low habitat value for the federal and State listed giant garter snake</u> (*Thamnophis gigas*).

  The DBW will provide crews electronic mapping that identifies previously surveyed areas for giant garter snake habitat. Crews also will conduct surveys to ensure that there are no other special status plant or animal species located within 100 feet of disposal sites.

- **Mitigation Measure B8b** – <u>Identify and utilize disposal areas that are at least 100 feet away from elderberry shrubs</u> (*Sambucus* ssp.).

  Elderberry shrubs are potential habitat for the federally threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*).

* * * * *

This section identified 23 mitigation measures (of which 16 are unique measures) to address the eight (8) potential impacts to biological resources. Several mitigation measures are duplicative, as they apply to more than one impact. For example, Mitigation Measure B1c and Mitigation Measure B2f are identical, addressing the need to conduct herbicide treatments in order to minimize potential for drift. **Table 3-14**, on the next page, combines and summarizes these biological resource mitigation measures.

Table 3-14
Summary of Potential Biological Resource Impacts and Mitigation Measures

	Mitigation Measure Summary[1]	Mitigation Measure Number	Impacts Applied To
1.	Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources	Mitigation Measure B1a Mitigation Measure B2d Mitigation Measure B4c Mitigation Measure B6a[2]	Impact B1: Herbicide overspray Impact B2: Herbicide toxicity Impact B4: Food web effects Impact B6: Treatment disturbances
2.	Provide a 250 foot buffer between treatment sites and shoreline elderberry shrubs *(Sambucus* ssp.), host plant for the Valley elderberry longhorn beetle *(Desmocerus californicus dimorphus)*	Mitigation Measure B1b	Impact B1: Herbicide overspray
3.	Conduct herbicide treatments in order to minimize potential for drift	Mitigation Measure B1c Mitigation Measure B2f	Impact B1: Herbicide overspray Impact B2: Herbicide toxicity
4.	Operate program vessels in a manner that causes the least amount of disturbance to the habitat	Mitigation Measure B1d Mitigation Measure B6b	Impact B1: Herbicide overspray Impact B6: Treatment disturbances
5.	Implement temporal and spatial limitations and restrictions on herbicide treatments to minimize treatments during times and at locations where larval and/or migratory fish are likely to be present	Mitigation Measure B2a	Impact B2: Herbicide toxicity
6.	Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters	Mitigation Measure B2b Mitigation Measure B4a	Impact B2: Herbicide toxicity Impact B4: Food web effects
7.	Implement an adaptive management approach to minimize the use of herbicides	Mitigation Measure B2c Mitigation Measure B4b	Impact B2: Herbicide toxicity Impact B4: Food web effects
8.	Provide treatment crews with electronic mapping that identifies previously surveyed areas for giant garter snake habitat	Mitigation Measure B2e	Impact B2: Herbicide toxicity
9.	Monitor dissolved oxygen levels pre- and post-treatment for all WHCP treatments	Mitigation Measure B5a	Impact B5: Dissolved oxygen levels
10.	Treat no more than three contiguous acres at any treatment site	Mitigation Measure B5b	Impact B5: Dissolved oxygen levels
11.	Treat no more than one-half of the area at one time of completely infested dead-end sloughs to allow for fish passage	Mitigation Measure B5c	Impact B5: Dissolved oxygen levels
12.	Treat no more than one-half of completely infested moving waterways at one time to allow for fish passage	Mitigation Measure B5d	Impact B5: Dissolved oxygen levels
13.	Collect plant fragments during and immediately following treatments	Mitigation Measure B7a	Impact B7: Plant fragmentation
14.	Conduct handpicking and herding only as required	Mitigation Measure B7b	Impact B7: Plant fragmentation
15.	Identify and utilize disposal areas that have no and/or low habitat value for the federal and State listed giant garter snake *(Thamnophis gigas)*	Mitigation Measure B8a	Impact B8: Disposal following handpicking
16.	Identify and utilize disposal areas that are at least 100 feet away from elderberry shrubs *(Sambucus* ssp.)	Mitigation Measure B8b	Impact B8: Disposal following handpicking

[1] Please refer to the text for the complete mitigation measure description.

[2] Mitigation Measure 6a includes additional provisions specific to special status nesting birds.

Table 3-15

Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *Page 1 of 11*

Scientific Name	Common Name	Status*
Invertebrates		
1. *Apodemia mormo langei*	Lange's metalmark butterfly	FE
2. *Branchinecta conservatio*	Conservancy fairy shrimp	FE
3. *Branchinecta longiantenna*	longhorn fairy shrimp	FE, FCH
4. *Branchinecta lynchi*	vernal pool fairy shrimp	FT, FCH
5. *Elaphrus viridis*	delta green ground beetle	FT
6. *Euphydryas editha bayensis*	bay checkerspot butterfly	FT
7. *Lepidurus packardi*	vernal pool tadpole shrimp	FE, FCH
8. *Speyeria callippe callippe*	callippe silverspot butterfly	FE
Fish		
Scientific Name	**Common Name**	**Status***
1. *Archoplites interruptus*	Sacramento perch	CSC
2. *Eucyclogobius newberryi*	tidewater goby	FE, CSC
3. *Lampetra hubbsi*	Kern brook lamprey	CSC
4. *Lavinia symmetricus ssp. 1*	San Joaquin roach	CSC
5. *Lavinia symmetricus ssp. 3*	Red Hills roach	CSC
6. *Mylopharodon conocephalus*	hardhead	CSC
7. *Oncorhynchus (=Salmo) clarki henshawi*	Lahontan cutthroat trout	FT
8. *Oncorhynchus (=Salmo) clarki seleniris*	Paiute cutthroat trout	FT
9. *Oncorhynchus kisutch*	coho salmon central CA coast	FE, SE
10. *Oncorhynchus mykiss*	Central California Coastal steelhead	FT, FCH
Amphibians		
Scientific Name	**Common Name**	**Status***
1. *Ambystoma californiense*	California tiger salamander, central population	FT, FCH, CSC
2. *Bufo canorus*	Yosemite toad	CSC, FC
3. *Hydromantes platycephalus*	Mount Lyell salamander	CSC
4. *Rana boylii*	Foothill yellow-legged frog	CSC
5. *Rana muscosa*	mountain yellow-legged frog	FC, CSC
6. *Spea hammondii*	western spadefoot	CSC
Reptiles		
Scientific Name	**Common Name**	**Status***
1. *Anniella pulchra pulchra*	silvery legless lizard	CSC
2. *Gambelia (=Crotaphytus) sila*	blunt-nosed leopard lizard	FE, CE
3. *Masticophis flagellum ruddocki*	San Joaquin whipsnake	CSC
4. *Masticophis lateralis euryxanthus*	Alameda whipsnake	FT, FCH, CT
5. *Phrynosoma coronatum (frontale population)*	coast (California) horned lizard	CSC
6. *Thamnophis hammondii*	two-striped garter snake	CSC

Table 3-15
Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *(continued) Page 2 of 11*

Birds		
Scientific Name	**Common Name**	**Status***
1. *Ammodramus savannarum*	grasshopper sparrow	CSC
2. *Accipiter gentilis*	northern goshawk	CSC
3. *Asio flammeus*	short-eared owl	CSC
4. *Asio otus*	long-eared owl	CSC
5. *Athene cunicularia*	burrowing owl	CSC
6. *Buteo swainsoni*	Swainson's hawk	CT
7. *Charadrius alexandrinus nivosus*	western snowy plover	FT, CSC
8. *Charadrius montanus*	mountain plover	CSC
9. *Circus cyaneus*	northern harrier	CSC
10. *Coccyzus americanus occidentalis*	western yellow-billed cuckoo	FC, CE
11. *Coturnicops noveboracensis*	yellow rail	CSC
12. *Dendroica petechia brewsteri*	yellow warbler	CSC
13. *Empidonax traillii*	willow flycatcher	CE
14. *Falco peregrinus anatum*	American peregrine falcon	CE
15. *Geothlypis trichas sinuosa*	saltmarsh common yellowthroat	CSC
16. *Grus Canadensis Canadensis*	lesser sandhill crane	CSC
17. *Gymnogyps californianus*	California condor	FE
18. *Haliaeetus leucocephalus*	bald eagle	CE
19. *Icteria virens*	yellow-breasted chat	CSC
20. *Lanius ludovicianus*	loggerhead shrike	CSC
21. *Melospiza melodia maxillaris*	Suisun song sparrow	CSC
22. *Melospiza melodia pusillula*	Alameda song sparrow	CSC
23. *Melospiza melodia samuelis*	San Pablo song sparrow	CSC
24. *Pelecanus occidentalis californicus*	California brown pelican	FE
25. *Progne subis*	purple martin	CSC
26. *Rallus longirostris obsoletus*	California clapper rail	FE, CE
27. *Riparia riparia*	bank swallow	CT
28. *Rynchops niger*	black skimmer	CSC
29. *Sternula antillarum (=Sterna, =albifrons) browni*	California least tern	FE, CE
30. *Strix nebulosa*	great grey owl	CE
31. *Strix occidentalis caurina*	northern spotted owl	FT
32. *Toxostoma lecontei*	Le Conte's thrasher	CSC

Table 3-15
Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *(continued)* *Page 3 of 11*

Mammals		
Scientific Name	**Common Name**	**Status***
1. *Ammospermophilus nelson*	Nelson's (=San Joaquin) antelope squirrel	CT
2. *Antrozous pallidus*	pallid bat	CSC
3. *Aplodontia rufia californica*	Sierra Nevada mountain beaver	CSC
4. *Corynorhinus townsendii*	Townsend's big-eared bat	CSC
5. *Dipodomys ingens*	giant kangaroo rat	FE, CE
6. *Dipodomys nitratoides brevinasus*	short-nosed kangaroo rat	CSC
7. *Dipodomys nitratoides exilis*	Fresno kangaroo rat	FE, FCH, CE
8. *Dipodomys nitratoides nitratoides*	Tipton kangaroo rat	FE
9. *Euderma maculatum*	spotted bat	CSC
10. *Eumops perotis californicus*	western mastiff bat	CSC
11. *Gulo gulo*	California wolverine	CT
12. *Lasiurus blossevillii*	western red bat	CSC
13. *Lepus americanus tahoensis*	Sierra Nevada snowshoe hare	CSC
14. *Martes pennanti*	fisher	FC, CSC
15. *Microtus californicus sanpabloensis*	San Pablo vole	CSC
16. *Neotoma fuscipes annectens*	San Francisco dusky-footed woodrat	CSC
17. *Neotoma fuscipes riparia*	riparian (San Joaquin Valley) woodrat	FE, CSC
18. *Nyctinomops macrotis*	big free-tailed bat	CSC
19. *Onychomys torridus tularensis*	Tulare grasshopper mouse	CSC
20. *Ovis canadensis californiana*	Sierra Nevada (=California) bighorn sheep	FE, CE
21. *Reithrodontomys raviventris*	salt marsh harvest mouse	FE, CE
22. *Scapanus latimanus parvus*	Alameda Island mole	CSC
23. *Sorex lyelli*	Mount Lyell shrew	CSC
24. *Sorex ornatus sinuosus*	Suisun shrew	CSC
25. *Sorex vagrans halicoetes*	salt-marsh wandering shrew	CSC
26. *Sylvilagus bachmani riparius*	riparian brush rabbit	FE, CE
27. *Taxidea taxus*	American badger	CSC
28. *Vulpes macrotis mutica*	San Joaquin kit fox	FE, CT
29. *Vulpes vulpes necator*	Sierra Nevada red fox	CT

Table 3-15
Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *(continued) Page 4 of 11*

Plants		
Scientific Name	**Common Name**	**Status***
1. *Agrosti hendersonii*	Henderson's bent grass	CNPS 3.2
2. *Agrosti humilis*	mountain bent grass	CNPS 2.3
3. *Allium jepsonii*	Jepson's onion	CNPS 1B.2
4. *Allium sharsmithiae*	Sharsmith's onion	CNPS 1B.3
5. *Allium tribracteatum*	three-bracted onion	CNPS 1B.2
6. *Allium tuolumnense*	Rawhide Hill onion	CNPS 1B.2
7. *Allium yosemitense*	Yosemite onion	CNPS 1B.3
8. *Amsinckia grandiflora*	large-flowered fiddleneck	FE, CE, CNPS 1B.1
9. *Amsinckia lunaris*	bent-flowered fiddleneck	CNPS 1B.2
10. *Anomobryum julaceum*	slender silver moss	CNPS 2.2
11. *Arabis bodiensis*	Bodie Hills rock-cress	CNPS 1B.3
12. *Arctostaphylos auriculata*	Mt. Diablo manzanita	CNPS 1B.3
13. *Arctostaphylos manzanita ssp. laevigata*	Contra Costa manzanita	CNPS 1B.2
14. *Arctostaphylos nissenana*	Nissenan manzanita	CNPS 1B.2
15. *Arctostaphylos pallida*	pallid Manzanita (=Alameda or Oakland Hills manzanita)	FT, CE, CNPS 1B.1
16. *Astragalus rattanii var. jepsonianus*	Jepson's milk-vetch	CNPS 1B.2
17. *Astragalus ravenii*	Raven's milk-vetch	CNPS 1B
18. *Astragalus tener var. ferrisiae*	Ferris' milk-vetch	CNPS 1B.1
19. *Astragalus tener var. tener*	alkali milk-vetch	CNPS 1B.2
20. *Atriplex cordulata*	heartscale	CNPS 1B.2
21. *Atriplex depressa*	brittlescale	CNPS 1B.2
22. *Atriplex joaquiniana*	San Joaquin spearscale	CNPS 1B.2
23. *Atriplex minuscula*	lesser saltscale	CNPS 1B.1
24. *Atriplex persistens*	vernal pool smallscale	CNPS 1B.2
25. *Atriplex subtilis*	subtle orache	CNPS 1B.2
26. *Atriplex vallicola*	Lost Hills crownscale	CNPS 1B.2
27. *Balsamorhiza macrolepis var. macrolepis*	big-scale balsamroot	CNPS 1B.2
28. *Blepharizonia plumosa*	big tarplant	CNPS 1B.1
29. *Botrychium lineare*	slender moonwort	CNPS 1B.3
30. *Botrychium lunaria*	common moonwort	CNPS 2.3
31. *Botrychium minganense*	mingan moonwort	CNPS 2.2
32. *Botrychium montanum*	western goblin	CNPS 2.1
33. *Brodiaea pallida*	Chinese Camp brodiaea	FT, CE, CNPS 1B.1
34. *Bruchia bolanderi*	Bolander's bruchia	CNPS 2.2

Table 3-15

Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *(continued)* *Page 5 of 11*

Plants *(continued)*		
Scientific Name	**Common Name**	**Status***
35. *California macrophylla*	round-leaved filaree	CNPS 1B.1
36. *Calochortus pulchellus*	Mt. Diablo fairy-lantern	CNPS 1B.2
37. *Calycadenia hooveri*	Hoover's calycadenia	CNPS 1B.3
38. *Calyptridium pulchellum*	Mariposa pussy-paws	FT, CNPS 1B.1
39. *Calystegia atriplicifolia ssp. buttensis*	Butte County morning-glory	CNPS 1B.2
40. *Calystegia purpurata ssp. saxicola*	coastal bluff morning-glory	CNPS 1B.2
41. *Camissonia benitensis*	San Benito evening-primrose	FT, CNPS 1B.1
42. *Camissonia sierra ssp. alticola*	Mono Hot Springs evening-primrose	CNPS 1B.2
43. *Campanula exigua*	chaparral harebell	CNPS 1B.2
44. *Campanula sharsmithiae*	Sharsmith's harebell	CNPS 1B.2
45. *Carex limosa*	mud sedge	CNPS 2.2
46. *Carex praticola*	northern meadow sedge	CNPS 2.2
47. *Carex tompkinsii*	Tompkin's sedge	CNPS 4.3
48. *Carex virdula var. viridula*	green yellow sedge	CNPS 2.3
49. *Carex vulpinoidea*	brown fox sedge	CNPS 2.2
50. *Carlquistia muirii*	Muir's tarplant	CNPS 1B.3
51. *Carpenteria californica*	tree-anemone	CNPS 1B.2
52. *Castilleja campestris ssp. succulenta*	succulent (=fleshy) owl's-clover	FT, FCH, CE, CNPS 1B.2
53. *Castilleja rubicundula ssp. rubicundula*	pink creamsacs	CNPS 1B.2
54. *Caulanthus californicus*	California jewelflower	FE, CE, CNPS 1B.1
55. *Caulanthus coulteri var. lemmonii*	Lemmon's jewelflower	CNPS 1B.2
56. *Ceanothus purpureus*	holly-leaved ceanothus	CNPS 1B.2
57. *Centromadia parryi ssp. congdonii*	Congdon's tarplant	CNPS 1B.2
58. *Centromadia parryi ssp. parryi*	pappose tarplant	CNPS 1B.2
59. *Chaenactis douglasii var. alpina*	alpine dusty maidens	CNPS 2.3
60. *Chamaesyce hooveri*	Hoover's spurge	FT, FCH, CNPS 1B.2
61. *Chlorogalum grandiflorum*	Red Hills soaproot	CNPS 1B.2
62. *Chorizanthe biloba var. immemora*	Hernandez spineflower	CNPS 1B.2
63. *Chorizanthe cuspidata var. cuspidata*	San Francisco Bay spineflower	CNPS 1B.2
64. *Chorizanthe robusta var. robusta*	robust spineflower	FE, CNPS 1B.1
65. *Cirsium andrewsii*	Franciscan thistle	CNPS 1B.2
66. *Cirsium crassicaule*	slough thistle	CNPS 1B.1
67. *Cirsium fontinale var. campylon*	Mt. Hamilton fountain thistle	CNPS 1B.2
68. *Cirsium hydrophilum var. hydrophilum*	Suisun thistle	FE, FCHP, CNPS 1B.1

Table 3-15
Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *(continued) Page 6 of 11*

Plants *(continued)*		
Scientific Name	**Common Name**	**Status***
69. *Clarkia australis*	Small's southern clarkia	CNPS 1B.2
70. *Clarkia biloba ssp. brandegeeae*	Brandegee's clarkia	CNPS 1B.2
71. *Clarkia concinna ssp. automixa*	Santa Clara red ribbons	CNPS 4.3
72. *Clarkia franciscana*	Presidio clarkia	FE, CE, CNPS 1B.1
73. *Clarkia rostrata*	beaked clarkia	CNPS 1B.3
74. *Claytonia megarhiza*	fell-fields claytonia	CNPS 2.3
75. *Collomia rawsoniana*	Rawson's flaming trumpet	CNPS 1B.2
76. *Cordylanthus maritimus ssp. palustris*	Point Reye's bird's-beak	CNPS 1B.2
77. *Cordylanthus mollis ssp. hispidus*	Hispid bird's-beak	CNPS 1B.1
78. *Cordylanthus mollis ssp. mollis*	soft bird's-beak	FE, FCHP, CR, CNPS 1B.2
79. *Cordylanthus nidularius*	Mt. Diablo bird's-beak	CNPS 1B.1
80. *Cordylanthus palmatus*	palmate-bracted bird's beak	FE, CE, CNPS 1B.1
81. *Coreopsis hamiltonii*	Mt. Hamilton coreopsis	CNPS 1B.2
82. *Cryptantha crymophilia*	subalpine cryptantha	CNPS 1B.3
83. *Cryptantha hooveri*	Hoover's cryptantha	CNPS 1A
84. *Cryptantha mariposae*	Mariposa cryptantha	CNPS 1B.3
85. *Deinandra bacigalupii*	Livermore tarplant	CNPS 1B.2
86. *Deinandra halliana*	Hall's tarplant	CNPS 1B.1
87. *Delphinium californicum ssp. interius*	Hospital Canyon larkspur	CNPS 1B.2
88. *Delphinium inopinum*	unexpected larkspur	CNPS 4.3
89. *Delphinium recurvatum*	recurved larkspur	CNPS 1B.2
90. *Didymodon norrisii*	Norris' beard moss	CNPS 2.2
91. *Dirca occidentalis*	western leatherwood	CNPS 1B.2
92. *Downingia pusilla*	dwarf downingia	CNPS 2.2
93. *Draba asterophora var. asterophora*	Tahoe draba	CNPS 1B.3
94. *Draba incrassata*	Sweetwater Mountains draba	CNPS 1B.3
95. *Draba praealta*	tall draba	CNPS 2.3
96. *Draba sierrae*	Sierra draba	CNPS 1B.3
97. *Elymus scribneri*	Scribner's wheat grass	CNPS 2.3
98. *Epilobium howellii*	subalpine fireweed	CNPS 1B.3
99. *Eriastrum brandegeeae*	Brandegee's eriastrum	CNPS 1B.2
100. *Eriastrum hooveri*	Hoover's eriastrum	CNPS 4.2
101. *Erigeron aequifolius*	Hall's daisy	CNPS 1B.3
102. *Erigeron inornatus var. keilii*	keil's daisy	CNPS 1B.3

Table 3-15

Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *(continued) Page 7 of 11*

Plants *(continued)*		
Scientific Name	**Common Name**	**Status***
103. *Eriogonum apricum var. apricum*	Ione buckwheat	FE, CE, CNPS 1B.1
104. *Eriogonum eastwoodianum*	Eastwood's buckwheat	CNPS 1B.3
105. *Eriogonum luteolum var. caninum*	Tiburon buckwheat	CNPS 1B.2
106. *Eriogonum nervulosum*	Snow Mountain buckwheat	CNPS 1B.2
107. *Eriogonum nudum var. regirivum*	Kings River buckwheat	CNPS 1B.2
108. *Eriogonum ovalifolium var. monarchense*	Monarch buckwheat	CNPS 1B.3
109. *Eriogonum temblorense*	Temblor buckwheat	CNPS 1B.2
110. *Eriogonum truncatum*	Mt. Diablo buckwheat	CNPS 1B.1
111. *Eriophyllum nubigenum*	Yosemite woolly sunflower	CNPS 1B.3
112. *Eryngium aristulatum var. hooveri*	Hoover's button-celery	CNPS 1B.1
113. *Eryngium pinnatisectum*	Tuolumne button-celery	CNPS 1B.2
114. *Eryngium racemosum*	Delta button-celery	CE, CNPS 1B.1
115. *Eryngium spinosepalum*	spiny-sepaled button-celery	CNPS 1B.2
116. *Erysimum capitatum ssp. angustatum*	Contra Costa wallflower	FE, FCH, CE, CNPS 1B.1
117. *Erythronium pluriflorum*	Shuteye Peak fawn lily	CNPS 1B.3
118. *Erythronium taylorii*	Pilot Ridge fawn lily	CNPS 1B.2
119. *Erythronium tuolumnense*	Tuolumne fawn lily	CNPS 1B.2
120. *Eschscholzia rhombipetala*	diamond-petaled California poppy	CNPS 1B.1
121. *Festuca minutiflora*	small-flowered fescue	CNPS 2.3
122. *Fissidens aphelotaxifolius*	brook pocket moss	CNPS 2.2
123. *Fritillaria falcata*	talus fritillary	CNPS 1B.2
124. *Fritillaria liliacea*	fragrant fritillary	CNPS 1B.2
125. *Fritillaria pluriflora*	adobe-lily	CNPS 1B.2
126. *Fritillaria viridea*	San Benito fritillary	CNPS 1B.2
127. *Gilia yorkii*	Monarch gilia	CNPS 1B.2
128. *Glyceria grandis*	American manna grass	CNPS 2.3
129. *Gratiola heterosepala*	Bogg's Lake hedge-hyssop	CE, CNPS 1B.2
130. *Hackelia sharsmithii*	Sharsmith's stickseed	CNPS 2.3
131. *Harmonia hallii*	Hall's harmonia	CNPS 1B.2
132. *Helianthella castanea*	Diablo helianthella	CNPS 1B.2
133. *Helodium blandowii*	Blandow's bog moss	CNPS 2.3
134. *Hesperolinon breweri*	Brewer's western flax	CNPS 1B.2
135. *Hesperolinon drymarioides*	drymaria-like western flax	CNPS 1B.2
136. *Hesperolinon sp. nov. "serpentinum"*	Napa western flax	CNPS 1B.1

Table 3-15
Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *(continued) Page 8 of 11*

Plants *(continued)*		
Scientific Name	**Common Name**	**Status***
137. *Heterotheca monarchensis*	Monarch golden-aster	CNPS 1B.3
138. *Hoita strobilina*	Loma Prieta hoita	CNPS 1B.1
139. *Holocarpha macradenia*	Santa Cruz tarplant	FT, FCH, CE, CNPS 1B.1
140. *Horkelia cuneata ssp. sericea*	Kellogg's horkelia	CNPS 1B.1
141. *Hulsea brevifolia*	short-leaved hulsea	CNPS 1B.2
142. *Imperata brevifolia*	California satintail	CNPS 2.1
143. *Iris hartwegii ssp. columbiana*	Tuolumne iris	CNPS 1B.2
144. *Isocoma arguta*	Carquinez goldenbush	CNPS 1B.1
145. *Ivesia campestris*	field ivesia	CNPS 1B.2
146. *Ivesia unguiculata*	Yosemite ivesia	CNPS 4.2
147. *Juglans hindsii*	Northern California black walnut	CNPS 1B.1
148. *Juncus leiospermus var. ahartii*	Ahart's dwarf rush	CNPS 1B.2
149. *Juncus nodosus*	knotted rush	CNPS 2.3
150. *Lasthenia conjugens*	Contra Costa goldfields	FE, FCH, CNPS 1B.1
151. *Layia discoidea*	rayless layia	CNPS 1B.1
152. *Layia heterotricha*	pale-yellow layia	CNPS 1B.1
153. *Layia munzii*	Munz's tidy-tips	CNPS 1B.2
154. *Layia septentrionalis*	Colusa layia	CNPS 1B.2
155. *Legenere limosa*	legenere	CNPS 1B.1
156. *Lepidium jaredii ssp. album*	Panoche pepper-grass	CNPS 1B.2
157. *Lepidium latipes var. heckardii*	Heckard's pepper-grass	CNPS 1B.2
158. *Leptosiphon serrulatus*	Madera leptosiphon	CNPS 1B.2
159. *Lewisia congdonii*	Congdon's lewisia	CNPS 1B.3
160. *Lewisia disepala*	Yosemite lewisia	CNPS 1B.2
161. *Lomatium congdonii*	Congdon's lomatium	CNPS 1B.2
162. *Lomatium observatorium*	Mt. Hamilton lomatium	CNPS 1B.2
163. *Lomatium stebbinsii*	Stebbin's lomatium	CNPS 1B.1
164. *Lotus rubriflorus*	red-flowered bird's-foot-trefoil	CNPS 1B.1
165. *Lupinus citrinus var. citrinus*	orange lupine	CNPS 1B.2
166. *Lupinus gracilentus*	slender lupine	CNPS 1B.3
167. *Lupinus spectabilis*	shaggyhair lupine	CNPS 1B.2
168. *Madia radiata*	showy golden madia	CNPS 1B.1
169. *Malacothamnus aboriginum*	Indian Valley bush-mallow	CNPS 1B.2
170. *Malacothamnus arcuatus*	arcuate bush-mallow	CNPS 1B.2

Table 3-15

Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *(continued) Page 9 of 11*

Plants *(continued)*		
Scientific Name	**Common Name**	**Status***
171. *Malacothamnus hallii*	Hall's bush-mallow	CNPS 1B.2
172. *Meconella oregana*	Oregon meconella	CNPS 1B.1
173. *Meesia triquetra*	three-ranked hump moss	CNPS 4.2
174. *Meesia uliginosa*	broad-nerved hump moss	CNPS 2.2
175. *Mielichhoferia elongata*	elongate copper moss	CNPS 2.2
176. *Mimulus filicaulis*	slender-stemmed monkeyflower	CNPS 1B.2
177. *Mimulus gracilipes*	slender-stalked monkeyflower	CNPS 1B.2
178. *Mimulus norrisii*	Kaweah monkeyflower	CNPS 1B.3
179. *Mimulus pulchellus*	yellow-lip pansy monkeyflower	CNPS 1B.2
180. *Monardella douglasii ssp. venosa*	veiny monardella	CNPS 1B.1
181. *Monardella leucocephala*	Merced monardella	CNPS 1A
182. *Monardella villosa ssp. globosa*	robust monardella	CNPS 1B.2
183. *Monolopia congdonii (=Lembertia congdonii)*	San Joaquin wooly-threads	FE, CNPS 1B.2
184. *Myurella julacea*	small mousetail moss	CNPS 2.3
185. *Navarretia leucocephala ssp. bakeri*	Baker's navarretia	CNPS 1B.1
186. *Navarretia myersii ssp. myersii*	pincushion navarretia	CNPS 1B.1
187. *Navarretia nigelliformis ssp. radians*	shining navarretia	CNPS 1B.2
188. *Navarretia prostrata*	prostrate vernal pool navarretia	CNPS 1B.1
189. *Neostapfia colusana*	Colusa grass	FT, FCH, CE, CNPS 1B.1
190. *Oenothera deltoides ssp. howellii*	Antioch Dunes evening-primrose	FE, FCH, CE, CNPS 1B.1
191. *Orcuttia inaequalis*	San Joaquin Valley Orcutt grass	FT, FCH, CE, CNPS 1B.1
192. *Orcuttia pilosa*	hairy Orcutt grass	FE, FCH, CE, CNPS 1B.1
193. *Orcuttia tenuis*	slender Orcutt grass	FT, FCH, CE, CNPS 1B.1
194. *Orcuttia viscida*	Sacramento Orcutt grass	FE, FCH, CE, CNPS 1B.1
195. *Petrophyton caespitosum ssp. acuminatum*	marble rockmat	CNPS 1B.3
196. *Phacelia ciliate var. opaca*	Merced phacelia	CNPS 1B.3
197. *Phacelia phacelioides*	Mt. Diablo phacelia	CNPS 1B.2
198. *Plagiobothrys chorisianus var.*	Choris' popcorn-flower	CNPS 1B.2
199. *Plagiobothrys diffusus*	San Francisco popcorn-flower	CE, CNPS 1B.1
200. *Plagiobothrys glaber*	hairless popcorn-flower	CNPS 1A
201. *Plagiobothrys hystriculus*	bearded popcorn-flower	CNPS 1B.1
202. *Plagiobothrys uncinatus*	hooked popcorn-flower	CNPS 1B.2
203. *Poa lettermanii*	Letterman's blue grass	CNPS 2.3
204. *Pohlia tundrae*	tundra thread moss	CNPS 2.3

Table 3-15
Special Status Species in the Eleven (11) Counties within WHCP Area, Not Likely to be Impacted by the WHCP *(continued)Page 10 of 11*

Plants *(continued)*		
Scientific Name	**Common Name**	**Status***
205. *Polygonum marinense*	Marin knotweed	CNPS 3.1
206. *Potamogeton filiformis*	slender-leaved pondweed	CNPS 2.2
207. *Potamogeton robbinsii*	Robbins' pondweed	CNPS 2.3
208. *Pseudobahia bahiifolia*	Hartweg's golden sunburst	FE, CE, CNPS 1B.1
209. *Pseudobahia peirsonii*	San Joaquin adobe sunburst	FT, CE, CNPS 1B.1
210. *Ribes menziesii var. ixoderme*	aromatic canyon gooseberry	CNPS 1B.2
211. *Salix nivalis*	snow willow	CNPS 2.3
212. *Sanicula maritima*	adobe sanicle	CNPS 1B.1
213. *Sanicula saxatilis*	rock sanicle	CNPS 1B.2
214. *Schizymenium shevockii*	Shevock's copper moss	CNPS 1B.2
215. *Senecio aphanactis*	chaparral ragwort	CNPS 2.2
216. *Senecio clevelandii var. heterophyllus*	Red Hills ragwort	CNPS 1B.2
217. *Senecio (=Packera) layneae*	Layne's butterweed (=ragwort)	FT, CR, CNPS 1B.2
218. *Sidalcea keckii*	Keck's checker-mallow (=checkerbloom)	FE, FCH, CNPS 1B.1
219. *Sphagnum strictum*	pale peat moss	CNPS 2.3
220. *Sphenopholis obtusata*	prairie wedge grass	CNPS 2.2
221. *Streptanthus albidus ssp. peramoenus*	most beautiful jewel-flower	CNPS 1B.2
222. *Streptanthus fenestratus*	Tehipite Valley jewel-flower	CNPS 1B.3
223. *Streptanthus gracilis*	alpine jewel-flower	CNPS 1B.3
224. *Streptanthus hispidus*	Mt. Diablo jewel-flower	CNPS 1B.3
225. *Streptanthus insignis ssp. lyonii*	Arburua Ranch jewel-flower	CNPS 1B.2
226. *Streptanthus oliganthus*	Masonic Mountain jewel-flower	CNPS 1B.2
227. *Suaeda californica*	California seablite	FE, CNPS 1B.1
228. *Trifolium amoenum*	two-fork clover	FE, CNPS 1B.1
229. *Trifolium bolanderi*	Bolander's clover	CNPS 1B.2
230. *Trifolium depauperatum var. hydrophilum*	saline clover	CNPS 1B.2
231. *Triquetrella californica*	coastal triquetrella	CNPS 1B.2
232. *Tropidocarpum capparideum*	caper-fruited tropidocarpum	CNPS 1B.1
233. *Tuctoria greenei*	Greene's tuctoria (=Orcutt grass)	FE, FCH, CR, CNPS 1B.1
234. *Tuctoria mucronata*	Solano grass (=Crampton's tuctoria)	FE, CE, CNPS 1B.1
235. *Utricularia intermedia*	flat-leaved bladderwort	CNPS 2.2
236. *Verbena californica*	Red Hills (=California) vervain	FT, CT, CNPS 1B.1
237. *Viburnum ellipticum*	oval-leaved viburnum	CNPS 2.3
238. *Viola pinetorum ssp. grisea*	grey-leaved violet	CNPS 1B.3

* Status Key

- FE – federal endangered
- FT – federal threatened
- FCH – federal critical habitat specified for this species
- FC – federal candidate for consideration of endangered or threatened
- FCHP – federal critical habitat for this species is proposed
- CE – California endangered
- CT – California threatened
- CR – California rare
- CSC – California species of special concern
- CNPS – California Native Plant Society listings:
  - 1A: plants presumed extinct in California
  - 1B.1: plants rare, threatened, or endangered in California and elsewhere; seriously threatened in California
  - 1B.2: plants rare, threatened, or endangered in California and elsewhere; fairly threatened in California
  - 1B.3: plants rare, threatened, or endangered in California and elsewhere; not very threatened in California
  - 2.1: plants rare, threatened, or endangered in California, but more common elsewhere; seriously threatened in California
  - 2.2: plants rare, threatened, or endangered in California, but more common elsewhere; fairly threatened in California
  - 2.3: plants rare, threatened, or endangered in California, but more common elsewhere; not very threatened in California
  - 3.2: plants about which we need more information; fairly threatened in California
  - 4.2: plants of limited distribution; fairly threatened in California
  - 4.3: plants of limited distribution; not very threatened in California

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Chapter 4

Hazards and Hazardous Materials Impacts Assessment

4. Hazards and Hazardous Materials Impacts Assessment

This chapter analyzes the effects of the WHCP related to hazards and hazardous materials. The chapter is organized as follows:

A. Environmental Setting

B. Impact Analysis and Mitigation Measures.

The environmental setting describes existing conditions related to hazards and hazardous materials in the Delta. The impact analysis provides an assessment of the specific environmental impacts due to hazards and hazardous materials potentially resulting from program operations. The discussion utilizes findings from WHCP environmental monitoring and research projects, technical information from scientific literature, government reports, relevant information on public policies, and program experience. The impact assessment is based on technical and scientific information.

For each of the potential WHCP impacts related to hazards and hazardous materials we provide a description of the impact, analyze the impact, classify the impact level, and identify mitigation measures to reduce the impact level. For Impact H2: Treatment crew exposure, we provide a lengthy assessment of potential hazards and impacts related to worker exposure to 2,4-D and glyphosate. Because of the many uncertainties inherent in long-term human exposure to chemicals, this discussion is more detailed than many of the other impacts assessments.

The mitigation measures are specific actions that DBW will undertake to avoid, or minimize, potential environmental impacts. DBW has undergone, and will continue to undergo, consultation with various local, State, and federal agencies regarding impacts and mitigation measures. Proposed mitigation measures may be revised, and/or additional mitigation measures incorporated, as a result of this ongoing consultation with regulatory agencies.

A. Environmental Setting

There are numerous laws and regulations at the federal, State, and local levels that address hazardous materials. The most relevant federal law relating to the WHCP is the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). FIFRA establishes jurisdiction over the distribution, sale, and use of pesticides. At the State level, the California Department of Pesticide Regulation (DPR) implements one of the most rigorous pesticide oversight programs in the country. DPR oversight includes product evaluation and registration, environmental monitoring, residue testing of fresh produce, and local use enforcement through the County Agricultural Commissioners.

There are two major State laws related to hazardous materials. The first law is the Hazardous Materials Release Response Plans and Inventory Act of 1985. This law requires businesses using hazardous materials to prepare a hazardous materials business plan. The second law is the Hazardous Waste Control Act, which creates the State's hazardous waste management program. The California program is more stringent than the federal Resource Conservation and Recovery Act (RCRA) that regulates hazardous waste.

1. Health Hazards

The Delta is a drinking water source for approximately 23 million Californians. If Delta projects compromise the quality of drinking water, more extensive treatment may be required. We discuss drinking water in Chapter 5, and water utility intake pumps in Chapter 6.

2. Hazardous Materials and Waste

Hazardous material and wastes are those substances that, because of their physical, chemical, or other characteristics, may pose a risk of endangering human health or safety or of endangering the environment (California Health and Safety Code Section 25260). In the Delta, hazardous waste sites associated with agricultural production activities include storage facilities and agricultural ponds or pits contaminated with fertilizers, herbicides, or insecticides.

Petroleum products and other materials may be present in the soil and groundwater near leaking underground storage tanks used to store these materials. Leaking or abandoned pesticide storage containers also may be present on farmland. Water from agricultural fields on which fertilizers and pesticides are applied may drain into ponds, and rinse water from crop duster tanks and other application equipment routinely is dumped into pits. Evaporation can increase chemical concentrations in pond water and cause chemicals to be deposited in underlying soil. Surface water percolation can pollute groundwater and expand the area of soil contamination.

Spills and leaking tanks or pipelines from industrial and commercial sites also can be sources of contaminants, such as petroleum hydrocarbons and polychlorinated biphenyls from old electrical transformers.

B. Impact Analysis and Mitigation Measures

For purposes of this analysis, we considered an impact related to hazards and hazardous materials to be significant and require mitigation if it would result in any of the following:

- Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials
- Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment
- Emit hazardous emissions or handle acutely hazardous materials, substances, or wastes within one-quarter mile of an existing or proposed school
- Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5
- For a project located within an airport land use plan, or where such a plan has not been adopted, within two miles of a public airport or public use airport, result in a safety hazard for people residing or working in the project area
- For a project within the vicinity of a private airstrip, result in a safety hazard for people residing or working in the project area

- Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan
- Expose people or structures to a significant risk, injury, or death involving wildland fires.

Table 4-1, on the next page, provides a summary of the potential WHCP impacts for hazards and hazardous materials significance areas which could potentially be affected. Table 4-1 also explains those hazards and hazardous materials significance areas in which there will be no impacts or beneficial impacts.

Impact H1 – General public exposure: there is potential for the WHCP to create a significant hazard to the public through the routine transport, use, or disposal of WHCP herbicides

The general public could be exposed to WHCP herbicides through: consumption of drinking water contaminated with herbicides, consumption of fish or other aquatic organisms that have bioaccumulated WHCP herbicide residues, or swimming or water skiing in areas recently treated with WHCP herbicides.

We discuss the potential for drinking water contamination by WHCP herbicides in Chapter 5. The potential for WHCP herbicides to be present in concentrations in excess of USEPA Maximum Contaminant Levels (MCLs) of 70 ppb for 2,4-D, and 700 ppb for glyphosate, is extremely low. In addition, DBW will implement mitigation measures (including Mitigation Measure W1b, directed specifically at drinking water quality) to further reduce the potential for drinking water contamination by the WHCP.

We discuss the potential for WHCP herbicides to bioaccumulate in fish or other aquatic organisms in Chapter 3. Neither WHCP herbicide is expected to bioaccumulate in fish or aquatic species.

Potential exposure of the general public to WHCP chemicals through water recreation is unlikely. We discuss the toxicity of WHCP herbicides to humans under Impact H2, below. Herbicide exposure levels for the general public following WHCP treatments are orders of magnitude lower than potentially toxic herbicide levels.

WHCP treatments generally take place in heavily infested waterways, which are unsuitable for water recreation. It is unlikely that recreationists or nearby inhabitants would be close enough to WHCP treatments to come in contact with herbicides. Inhalation exposure basically applies to just applicators, not the general public (WDOE 2001). In addition, inhalation exposure for both glyphosate and 2,4-D are low. The vapor pressure of glyphosate is very low, and inhalation of spray droplets was found to be a minor route of glyphosate exposure (Acquavella et al. 2004). Exposure to glyphosate appeared to be very limited for those not in the immediate area of mixing, loading, or application activities (Acquavella et al. 2004 and 2005). Ibrahim et al. (1991) reported that studies of applicators showed that only 2 percent of the 2,4-D body burden was through respiratory exposures.

The Weedar® 64 label does not specify a waiting period for water recreation following aquatic weed control. Treated water should not be used for drinking water for three weeks, or until the 2,4-D level is no more than 0.1 ppm (100 ppb). WHCP monitoring results show 2,4-D levels significantly lower than 0.1 ppm, even one hour after treatment. The Aquamaster™ label states that there are no restrictions on the use of treated water for irrigation, recreation, or domestic purposes.

Table 4-1
Crosswalk of Hazards and Hazardous Materials Significance Criteria, Impacts, and Benefits of the WHCP

Significance Criteria and Impacts	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?						
Impact H1: General public exposure	17			X		
Impact H2: Treatment crew exposure	3, 7, 18, 19, 20		X			
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?						
Impact H3: Accidental spills	19		X			
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?					WHCP will not emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school	
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?					WHCP will not be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5	
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?					WHCP will not be located within an airport land use plan, or within two miles of a public airport or public use airport	
f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?					WHCP will not be located within the vicinity of a private airstrip or result in a safety hazard for people residing in or working in the project area	
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?					WHCP will not impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan	Removal of water hyacinth could improve access to waterways used by emergency boats
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?					WHCP will not expose people or structures to wildland fires	

Based on existing research evidence, program operations, and monitoring results, WHCP herbicide treatments are not likely to result in adverse effects on the general public due to drinking water exposure, consumption of aquatic species that have bioaccumulated WHCP herbicides, or exposure to herbicides during recreation. **The potential for the WHCP to create a significant hazard to the public through routine transport, use, or disposal is expected to be less-than-significant.** No mitigation measures are required, however several of the mitigation measures that reduce the potential for herbicide exposure identified in Chapters 3 and 5 will further minimize the already low risk of hazard to the general public. In addition, DBW will implement the following Mitigation Measure to further reduce potential for public exposure to WHCP herbicides.

- **Mitigation Measure H1a** – Minimize public exposure to herbicide treated water.

  Prior to treatments, DBW will notify marina and dock owners regarding timing of treatments. WHCP treatments generally take place in heavily infested waterways, which are usually unsuitable for water recreation. If recreationists are present when treatment occurs, treatments crews will inform recreationists about the treatment, asking them to move to a different location, or move treatments to a different location.

Impact H2 – Treatment crew exposure: there is potential for the WCHP to create a significant hazard to treatment crews through the routine transport, use, or disposal of WHCP herbicides; and/or through heat exposure

The potential for the WHCP to create a significant hazard to treatment crews through the routine transport, use, or disposal of WHCP herbicides depends on the same two factors discussed for Biological Resources toxicity impacts: exposure and toxicity. However, in relation to humans, there are even greater uncertainties regarding exposure levels and short- and long-term toxicity of WHCP herbicides.

Pesticide workers, such as WHCP treatment crews, are exposed to higher levels of herbicides, and over longer time horizons, than the general public (Burns 2005). Some WHCP crew members have been with the program for over fifteen years. Each year, treatments take place as many as four days a week, over a six month period. This small group of individuals is uniquely exposed to WHCP herbicides over relatively long periods of time.

While animal toxicity studies can be used to assess the potential for human toxicity, particularly acute toxicity, it is much more difficult to determine whether there are long-term human impacts resulting from exposure to herbicides. Alavanja et al. (2004) noted that there are questions as to whether laboratory short-term toxicity studies of a single chemical are adequate to determine human exposure to a mix of chemicals over a lifetime, stating "neither animal testing alone or its interpretation in setting policy is sufficient to protect public health."

In reviewing the use of herbicides, the USEPA, World Health Organization (WHO), United States Forest Service (USFS), and other agencies evaluate the extensive scientific literature on each chemical, and identify exposure levels intended to ensure worker and public safety. These agencies reevaluate herbicide safety every few years as new studies are released. In the discussions below, we draw on recent agency analyses, as well as scientific literature on potential exposure levels and impacts of WHCP herbicides on humans.

In addition to potential hazards from herbicide exposure, WHCP treatment crews are potentially at risk due to heat exposure. Below, we assess the potential for herbicide exposure, short-term toxic impacts of herbicides, long-term chronic effects of herbicides to treatment crews, and heat exposure.

Scientific Terminology Related to Animal and Human Health Studies

Case-control epidemiological study – a study in human populations in which individuals with a specific diagnosis (e.g. non-Hodgkin lymphoma (NHL)) are identified and compared to similar controls in the population without the diagnosis. Typically these studies use questionnaires or telephone interviews to identify exposure and other characteristics of each group. Results are typically adjusted for other non-exposure factors related to the disease (e.g. smoking, age). The most commonly cited problem with case-control studies is recall bias on exposure information.

Cohort epidemiological study – a study of a group of people, a cohort, usually with a common characteristic, such as occupation. Subjects are evaluated over an extended period of time, comparing diseases among the cohort to diseases among the general population or subgroups within the cohort. Cohort studies also use questionnaires to determine exposure, but may also employ biomonitoring to measure exposure. Cohort studies may examine disease and exposure in the past (retrospective), or future (prospective). To prove linkages, cohort studies require a large number of participants, particularly if the disease being studied is rare.

Odds ratio (OR) – is a comparison of the odds of a condition existing among the exposure group, as compared to the odds of a condition existing among the control group. In pesticide epidemiological studies, it is often used to compare exposure to a pesticide among the case group (with the disease), to exposure to a pesticide among the control group (without the disease). The OR equation is:

$$OR = \frac{p_1/q_1}{p_2/q_2}$$

An OR of 1 means that there are equal odds of the exposure occurring among both groups. An OR of greater than one means that the group with the disease (the case group) had a greater chance of having been exposed than the control group. An OR of below one means that the case group had less chance of exposure than the control group. An OR of 2 means that the case group was twice as likely to be exposed to the pesticide as the control group. All figures are typically expressed with a 95 percent confidence interval (CI): for example, OR 1.3 (95 percent CI of 0.7 to 3.4). An OR is not considered statistically significant unless the lower bound CI is greater than one (although an OR with a lower bound of less than one may still be indicative of a need for further study or a potential risk). The following is an example OR: in one case-control study, 32 of 170 NHL patients (cases) treated seeds with fungicides, as compared to 105 of 948 controls. The example showed an elevated risk (almost double) of NHL among those that used fungicides, with an OR of 1.9 (Hoar 1986):

$$\text{Cases: } \frac{32}{170} = 0.19 \qquad \text{Controls: } \frac{105}{948} = 0.11$$

$$OR = \frac{p_1/q_1}{p_2/q_2} = \frac{\frac{0.19}{0.81}}{\frac{0.11}{0.89}} = 1.91$$

Risk ratio (RR) – or relative risk ratio, is a comparison of the disease rates among exposed and non-exposed groups over a specific time period. RR is typically used in cohort studies to compare the risk of a particular cancer or disease in the cohort, to the risk in a non-exposed population (often further adjusted for age, sex, etc.). Similar to the OR, a RR of one means that there is equal risk among the exposed and non-exposed groups, while a RR of greater than one means that there is a greater risk among the exposed group, and a RR of less than one means that there is less risk among the exposed group. RRs are also typically reported with a 95 percent confidence interval. For example, in a cohort study, 63 of 40,376 farmers exposed to glyphosate developed melanoma (0.16 percent), while 12 of 13,280 farmers not exposed to glyphosate developed melanoma (0.09 percent). The RR is equal to 0.16/0.09, or 1.8. This means there was an 80 percent increased risk of melanoma associated with glyphosate use (De Roos et al., 2005).

Standard Mortality Ratio (SMR) – is the ratio of observed deaths to expected deaths, for a particular disease. If there were one out of 2,500 (0.04 percent) melanoma deaths in the cohort being studied, and the expected deaths from melanoma was two per 100,000 (0.002 percent), the SMR would be equal to 0.04/0.002, or 20.

In vitro – experiments conducted in a controlled environment, outside of a living organism. In vitro experiments typically use cellular material, cell cultures, or tissue cultures.

In vivo – experiments conducted using whole living organisms. In vivo experiments include animal testing and clinical trials.

Reference Dose (RfD) – is the dose to humans, as determined by USEPA, at which there is a reasonable certainty of no harm. It is usually calculated by taking the lowest animal NOEL, and dividing by a safety factor of at least 100. The safety factor is determined by multiplying by 10 for each point of uncertainty. For example, a safety factor of 100 is based on a factor of 10 for sensitivity between species (assuming humans are more sensitive than animals), and a factor of 10 for sensitivity among species (for sensitive populations such as children). For 2,4-D, the safety factor is 1,000, as there is an third factor of 10 due to uncertainty in the database of studies. RfDs may be calculated for acute and chronic exposure. For chronic exposure, since the NOEL is based on lifetime exposure, the RfD represents the tolerable daily dose over a lifetime.

Hazard Quotient (HQ) – is calculated by dividing the exposure level by the RfD. An HQ of 1 or greater indicates a level for which there is concern related to long-term exposure. The higher the HQ, the greater the level of concern for the development of adverse health outcomes. An HQ of below 1 indicates that adverse health outcomes would not be expected.

Weight-of-evidence review (WOE) – is generally a qualitative review in which an individual or panel rates and assesses the scientific literature addressing a particular hypothesis, typically the relationship between a compound and a disease outcome (Krimsky 2005). A WOE considers all varieties of evidence and types of studies (in vivo, in vitro, epidemiological studies). Reviewers may give greater weight to certain types of studies or to studies based on statistical significance of results. Krimksy notes that WOEs often "use a process methodology that is low on transparency and high on subjectivity." However, it is often not possible or ethical to conduct human testing on toxic or potentially toxic agents. Thus, the WOE is an important tool particularly in cases of environmental exposure to chemicals, when no single study resolves issues related to exposure and causation.

Chlorphenoxy, Phenoxy, or Phenoxyacetic Acid Herbicides

The WHCP herbicide 2,4-D (2,4-dichlorophenoxyacetic acid), is one of a family of herbicides known as chlorphenoxy, phenoxy, or phenoxyacetic acid herbicides. Many of the studies discussed in this section included phenoxy herbicides as a group, not specifically 2,4-D. Phenoxy herbicides were developed in the 1940s, and have been used extensively worldwide since that time. The family name is based on the presence of chlorine, and phenoxyacetic acid. Two other herbicides in this group are MCPA (4-chloro-2-methylphenoxyacetic acid), and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid). The 50:50 combination of 2,4-D and 2,4,5-T, known as Agent Orange, was used in Vietnam as a defoliant. 2,4,5-T contains dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin) as an impurity. Dioxin is highly toxic to humans, and as a result 2,4,5-T was banned in the United States, and in most other countries, by 1985. There has been some concern about impurities in 2,4-D, although typically it is thought not to contain dioxins (USFS 2006). In addition, most studies used in 2,4-D risk assessments use technical grade 2,4-D, which would include any impurities that do exist in the herbicide (USFS 2006). There are multiple forms of 2,4-D, including acid, dimethylamine salt (the form used in the WHCP), and esters. Generally, these types of 2,4-D are thought to have similar toxicity in mammals.

Exposure to WHCP Herbicides

It is extremely difficult to measure exposure levels to pesticides in humans – either in pesticide applicators, their family members, or the general public. An estimated 25 million agricultural workers worldwide experienced unintentional pesticide exposure each year during the 1990s (Alavanja et al. 2004).

In many exposure studies, pesticide worker exposures are based on answers to written or telephone questionnaires about their historical use of various chemicals, and/or about current chemical use. When subjects are deceased, researchers must rely on family members to answer detailed questions about past chemical exposure. Recall bias can result in both overestimating and underestimating chemical exposure. In some cases, researchers adjust reported exposure levels using exposure algorithms (e.g. increasing exposure factors if the worker does not wear personal protective equipment (PPE)). Even if there was perfect recollection of chemicals used and worker safety practices, these studies cannot measure actual amounts of chemical absorbed or inhaled.

Researchers also conduct biomonitoring to identify actual body loads of chemicals in exposed workers. Barr et al. (2006) note that biomonitoring can provide a “rough estimate of internal dose”, given assumptions about factors such as chemical uptake, metabolism, and steady-state excretion. Exposure to chemicals is usually in mg per kg body weight per day (mg/kg/day), or simply mg/kg body weight (mg/kg).

Biomonitoring includes measures of skin absorption, inhalation, and internal metrics. The amount of chemical absorbed by skin can be measured with patches, washing and wiping, and fluorescent tracers (Fenske 2005; Dosemeci et al. 2002). Inhalation is measured through personal air or air sampling (Fenske 2005). Internal chemical concentrations can be measured in urine, saliva, sweat, semen, and blood (Fenske 2005; Dosemeci et al. 2002).

Urine samples are another tool for measuring actual body load of chemicals that are excreted in urine. Urine samples must be adjusted for volume, depending on whether they are 24 hour samples, first void samples, or spot samples (Barr et al. 2006). A single spot urine sample measurement can provide information on whether exposure occurred, and some information on the magnitude of the exposure, but cannot provide information on total body load of the chemical. There are methods of extrapolating from single urine samples to total urine volume (and thus to determine total body load), for example using urine creatinine concentrations. The creatinine method introduces some uncertainty into the measurement, but is valuable in cases when it is not practical to obtain 24 hour urine samples.

We can estimate WHCP treatment crew exposure based on results of other studies that have evaluated pesticide applicator exposures in an agricultural or forestry setting. Exposure depends on characteristics of the chemical, conditions during application, and worker safety factors.

Numerous studies (Alavanja 2007; Hoar et al. 1986; Zahm and Blair 1992; Acquavella et al. 2004 and 2005; Mandel et al. 2005; Lavy et al. 1982) have shown that pesticide applicators that use PPE have lower risk and lower pesticide levels in blood or urine. In a talk to the North American Pesticide Applicator Certification and Safety Education Workshop in 2007, Dr. Michael Alavanja of the Agricultural Health Study, noted that proper glove use was the most influential item of PPE to mitigate chronic pesticide exposure (Alavanja 2007). Factors that increased exposure levels included fixing equipment during treatments, and more frequent mixing and loading of chemicals (Acquavella et al. 2004). In studies of urinary 2,4-D levels in applicators, predictors of herbicide levels included pesticide formulation, protective clothing and gear (especially gloves), handling practices, application equipment, personal hygiene, and type of spray nozzle used (Fenske 2005). Attitudes toward risk (as determined by questionnaires) played an important role in chronic exposure, as well (Alavanja 2007).

Exposure levels can also be influenced by outside factors and conditions. For example, USFS (2006) reported that several studies have found that sunscreen enhanced dermal absorption of 2,4-D. In addition, individuals that are pregnant, immune-compromised, malnourished, or have sickle-cell anemia, may be more sensitive to herbicides such as 2,4-D (USFS 2006).

WHCP treatment crews follow herbicide label requirements for PPE. This includes use of coveralls, chemical resistant gloves, safety goggles, and waterproof shoes. The DBW uses a laundry service to clean coveralls after a single day use. Herbicides are mixed using a feeder tube to draw chemical into the mixing tank, so that direct contact with the chemicals is not required. Potential exposure routes include dermal exposure when rinsing, or in the event that a feeder tube is broken. More likely exposure may occur through inhalation of drift in the event that the wind shifts during treatment. None of these exposure routes is likely, although they may occur.

2,4-D

Approximately 90 percent of WHCP treatments utilize 2,4-D. Thus, 2,4-D is of most concern as it relates to WHCP treatment crew exposure. Because it has been widely used, there are a number of studies in the literature on pesticide applicator exposure to 2,4-D. Chlorphenoxy herbicides are absorbed well from the gastrointestinal (GI) tract, less well from the lungs, and minimally from skin (Reigart and Roberts 1999).

Dermal exposure studies have found low dermal penetration of 2,4-D (WDOE 2001). One study found that approximately six percent of a dose was absorbed through the skin over a five day period. Other studies have found somewhat higher dermal absorption, ranging from seven percent to 14 percent (WDOE 2001).

Inhalation uptake of 2,4-D in humans has not been well studied, but rat studies found that 2,4-D was rapidly absorbed in lungs (Ibrahim et al. 1991). However, data from studies of applicators showed that respiratory sources only contributed two percent of total 2,4-D body burden (Ibrahim et al. 1991). In USEPA's 2005 review of 2,4-D, USEPA considered 2,4-D to be of low toxicity via acute inhalation exposure. USEPA also recommended that more inhalation studies be conducted to determine how rapidly the herbicide is absorbed via inhalation (USFS 2006). The half-life of 2,4-D in humans is 12 to 33 hours, thus most 2,4-D is excreted in urine within a few days.

Below, we summarize the results of several 2,4-D exposure studies. All studies focused on pesticide applicators, including farmers, forestry workers, or manufacturing workers.

- As part of the Farm Family Exposure Study, Mandel et al. (2005) examined 2,4-D levels in the urine of 34 farmers. Chemical levels were measured the day before treatment, the day of treatment, and for each of three days following treatment with 2,4-D. The geometric mean concentration of urinary 2,4-D was 64 ppb on the day of treatment, with a wide range of 2 ppb to 1,856 ppb. Skin contact and repairing equipment during treatment were associated with increased exposure. A relatively high 71 percent of applicators had detectable 2,4-D in their urine even before treatment, with a pre-treatment geometric mean of 4 ppb. This Farm Family Exposure Study also evaluated levels of glyphosate and chlorpyrifos after treatment with those herbicides. The study found higher urinary 2,4-D levels for farmers using 2,4-D, than corresponding urinary herbicide levels for farmers using glyphosate or chlorpyrifos
- Garry et al. (2001) evaluated 2,4-D urinary levels in forest pesticide applicators, by application method. Garry found that the highest 2,4-D levels were in forest pesticide applicators using back pack sprayers, closely followed by boom sprayers, then aerial application, skidders, and non-exposed controls, in that order. Garry found a ten-fold difference between the average urinary 2,4-D concentrations in back pack and boom sprayers (380.1 ppb) and the average urinary 2,4-D concentrations in aerial and skidder closed-cab applicators (33.2 ppb)
- Garry et al. (2001) also reported on a previous study that found workers employed in chlorophenoxy herbicide manufacture could have urinary 2,4-D levels over 1,000 ppb. This was significantly higher than most applicator studies, which typically found urinary 2,4-D levels in the range of 45 to 326 ppb
- Lavy et al. (1982) measured exposure to 2,4-D during aerial application, using respiratory exposure, skin patches, and urine levels. Workers applied herbicide at the rate of 4 lbs acid equivalent per acre, the same rate as the WHCP. Lavy tested 2,4-D levels in 18 forestry workers, including pilots, mechanics, mixers, supervisors, and flagmen. Using respiratory monitoring, only one worker (a mixer) had measurable 2,4-D levels, at 0.03 μg/kg. Using skin patches, most workers had non-detectable levels, and those with detectable levels ranged from 0.0005 mg/kg to 0.0409 mg/kg. Thirteen workers had detectable 2,4-D in urine, with 2,4-D levels in urine ranging from 0.00044 mg/kg to 0.0337 mg/kg (0.44 ppb to 33.7 ppb). Urine was measured over eight days total
- A Canadian study of 2,4-D acid residues in semen of 97 Ontario farmers that had recently used the herbicide found that 50 percent of samples had detectable 2,4-D residues of greater than 5ppb (Arbuckle et al. 1999)
- Studies of occupational exposure to 2,4-D reported in Ibrahim et al. (1991) found the highest daily exposure dose of 3.4 to 4.9 mg/day (equivalent to 0.05 to 0.07 mg/kg/day for a 70 kg person) for individuals using back pack sprayers on right-of-ways. The next highest exposures were found in farmers driving tractors (0.48 mg/day), and hand and tank commercial lawn sprayers (0.29 mg/day). There was a wide range of 2,4-D exposures in helicopter and airplane applicators, from 0.005 to 1.04 mg/day

Table 4-2
Pesticide Applicator Exposure Estimates for 2,4-D

Type of Application	Exposure in mg/kg/lb a.e.	Exposure in mg/kg/day	Exposure in mg/day	Source
1. Back pack sprayer		0.05 to 0.07*	3.4 to 4.9	Ibrahim et al. 1991
2. Boom spray from tractor		0.007*	0.48	Ibrahim et al. 1991
3. Broadcast ground spray	0.0002 (0.00001 to 0.0009)	0.02 (0.0007 to 0.15)	1.4* (0.05 to 10.5)	USFS 2006
4. Airboat handgun	0.0009 (0.0004 to 0.002)			USFS 2006
5. Calculated WHCP Crew (July to September 2007)	0.0009 (0.0004 to 0.002) based on USFS 2006	0.008 (0.003 to 0.017)	0.56* (0.21 to 1.19)	Calculated using 8.6 lb a.e. per crew

* Calculated based on 70 kg person (154 pounds).

- USFS (2006) exposure assessments for workers for 2,4-D were approximately 0.02 mg/kg/day for broadcast ground spray workers. The upper exposure range for broadcast ground spray workers was 0.15 mg/kg/day, with a lower exposure range of 0.0007 mg/kg/day. Among the USFS worker categories, broadcast ground spray worker exposures are most similar to WHCP treatment crews, in terms of likely exposure. However, USFS assumptions include treatment of a significantly higher acreage than the WCHP boat treatments, at 66 acres to 168 acres per day. This difference means that USFS total daily work exposure estimates are much higher than for WHCP treatment areas that treat approximately two to three acres per day.

Table 4-2, above, summarizes worker exposure studies most similar to WHCP treatment exposures. USFS (2006) developed a model to determine worker exposure levels based on Forest Service practices and treatment methods (boom spray or broadcast ground spray application, direct foliar application, and aerial application).

USFS (2006) estimated average 2,4-D exposure for a boom spray worker was 0.0002 mg/kg per lb of active ingredient (a.e.) handled per day, with a range of 0.00001 to 0.0009 mg/kg/lb a.e.

USFS (2006) also reported on a study of four workers applying liquid formulation 2,4-D by airboat handguns. For airboat applicators, USFS found exposure rates estimated at 0.0009 mg/kg/lb a.e. handled, with a range of 0.0004 to 0.002 mg/kg/lb a.e.. Airboat exposures were slightly higher than the ground-based boom spray, which might take place from an enclosed cab. Although only four workers were monitored, we utilized this study to estimate exposure for WHCP treatment crews.

We estimated WHCP treatment crew exposure using USFS exposure metrics. The highest potential WHCP treatment exposure to 2,4-D occurs during the months of July through September. During these three months in 2007, the six WHCP treatment crews each applied, on average, approximately 8.6 pounds a.e. 2,4-D per day, four days per week. Using the USFS airboat exposure estimates, WHCP treatment crews were exposed to 0.008 mg/kg/day (with a range of 0.003 to 0.017 mg/kg/day). Assuming an average 70 kg weight (154 pounds), the exposure per crew member was approximately 0.56 mg/day (with a range of 0.21 to 1.19 mg/day).

Glyphosate

In 2007, the WHCP utilized glyphosate on only 14 percent of the total acres treated for water hyacinth. Thus, exposure to glyphosate is significantly lower than exposure to 2,4-D.

Glyphosate is poorly absorbed through the skin (USFS 2003). Lavy et al. (1992) found that even though forestry sprayers had significant dermal exposure to glyphosate, biomonitoring results indicated no absorption of glyphosate. Dermal studies have shown absorption of less than 2 percent glyphosate (Acquavella et al., 2004). In addition, the vapor pressure of glyphosate is very low, and inhalation of spray droplets was found to be a minor route of glyphosate exposure (Acquavella et al., 2004).

While glyphosate exposure has not been as heavily studied as 2,4-D, there are still a large number of studies evaluating potential exposure to glyphosate among pesticide applicators.

- In the Farm Family Exposure Study, Acquavella et al. (2004 and 2005) examined urinary glyphosate levels in 48 farmers just prior to glyphosate treatment, the day of treatment, and three days following. The geometric mean concentration of glyphosate in farmers was 3 ppb, with a maximum of 233 ppb, and a minimum below the limit of detection (LOD) of 1ppb. Farmers that didn't use rubber gloves had a higher geometric mean (10 ppb for those without gloves, versus 2 ppb for those with gloves). Only 50 percent of farmers that did wear gloves had urinary glyphosate values above the LOD, while 86 percent of those that didn't wear gloves had levels above the LOD. Based on urinary levels, Acquavella calculated the maximum systemic dose was 0.004 mg/kg, and the geometric mean systemic dose was 0.001 mg/kg. Generally, glyphosate exposure was low, as 40 percent of farmers didn't have detectable urinary levels on the day of application. In this Family Farm Exposure Study, urinary glyphosate levels were lower than the other two herbicides monitored, 2,4-D and chlorpyrifos
- Acquavella et al. (2004) reported that a study of forest workers found the highest urinary levels at 14 ppb glyphosate. This same forest worker study estimated a maximum systemic dose of 0.006 mg/kg
- USFS (2003) worker exposure estimates are 0.026 mg/kg/day glyphosate, with a range of 0.0009 to 0.16 mg/kg/day for direct ground spray. Broadcast ground spray, with a boom, has slightly higher exposure estimates, of 0.045 mg/kg/day, with a range of 0.001 to 0.3 mg/kg/day. Similar to the USFS estimates for 2,4-D, the broadcast ground spray figures are likely closest to the potential exposure for WHCP treatment crews. However, these USFS estimates are similar to the USFS estimates for 2,4-D (USFS 2006), in that they assume that crews treat approximately 100 acres per day
- Solomon et al. (2005) reported on other studies with glyphosate worker exposure estimates, with a peak estimated glyphosate exposure at 0.056 mg/kg, and chronic exposure of 0.0085 mg/kg/day based on an 8 hour day and 5 day work week. Among farmers, the greatest estimated systemic dose was 0.004 mg/kg.

Table 4-3, on the next page, summarizes estimates of glyphosate exposure levels among pesticide applicators. USFS (2003) developed a model to determine worker exposure levels based on Forest Service practices and treatment methods (boom spray or broadcast ground spray application, direct foliar application, and aerial application).

USFS glyphosate estimates for broadcast ground spray with a boom were based on a figure of 0.0002 mg/kg/lb a.e. applied, with a range of 0.00001 to 0.0009 mg/kg/lb a.e. (USFS 2003). To estimate potential WHCP treatment crew exposure to glyphosate, we use an estimate of 12 pounds a.e. per day for ten days of glyphosate treatment in the first two weeks of October 2007. This was the highest

Table 4-3
Pesticide Applicator Exposure Estimates for Glyphosate

Type of Application	Exposure in mg/kg/lb a.e.	Exposure in mg/kg/day	Exposure in mg/day	Source
1. Tractor with boom spray		0.001 (max 0.004)	0.07* (max 0.28)	Acquavella et al. 2004
2. Forestry workers (method not specified)		0.006	0.42*	Acquavella et al. 2004
3. Direct ground spray		0.026 (0.0009 to 0.16)	1.82* (0.063 to 11.2)	USFS 2003
4. Broadcast ground spray (boom)	0.0002 (0.00001 to 0.0009)	0.045 (0.001 to 0.3)	3.15* (0.07 to 21)	USFS 2003
5. Agricultural workers		0.0085 to 0.056	0.6* to 3.92	Solomon et al. 2005
6. Calculated WHCP Crew (October 2007)	0.0002 (0.00001 to 0.0009) based on USFS 2003	0.0024 (0.0012 to 0.0108)	0.168* (0.084 to 0.756)	Calculated using 12 lb a.e. per crew

* Calculated based on 70 kg person (154 pounds).

application period for glyphosate during the 2007 treatment period. Even during October 2007, only three crews were using glyphosate. Based on USFS estimates, glyphosate exposure to treatment crews during this time period was 0.0024 mg/kg/day, with a range of 0.0012 to 0.0108 mg/kg/day. For a 70 kg person, this is equivalent to glyphosate exposure of 0.168 mg/day, with a range of 0.084 to 0.756 mg/day.

Short-Term or Acute Toxicity of WHCP Herbicides to Humans

Acute toxicity of pesticides in humans is generally extrapolated from several different types of sources: acute toxicity studies in laboratory mammals, biomonitoring of exposed workers, and intentional or accidental human poisoning cases. It is highly unlikely that WHCP activities would result in acute toxicity to WHCP treatment crews. The levels of either herbicide required to induce acute toxicity are several orders of magnitude higher than any potential exposure, even in the unlikely event of an accident. The discussion on short-term toxicity of these herbicides is provided below for background.

2,4-D Short-Term and Acute Toxicity

2,4-D is considered moderately toxic (Ibrahim 1991). The MSDS warns that 2,4-D is corrosive, and causes irreversible eye damage (Nufarm 2006). Existing respiratory and skin problems may also be aggravated by exposure (Nufarm 2006). In 1996, phenoxy herbicides were listed ninth among pesticides causing symptomatic illnesses (acute toxicity), with 453 total cases (63 children less than six years, and 387 cases age six and older), based on data from National Poison Control Centers (Reigart and Roberts 1999).

The reference, *Recognition and Management of Pesticide Poisonings* (Reigart and Roberts 1999) states that phenoxy herbicides are moderately irritating to skin, eyes, respiratory, and GI linings. In humans, ingestion of large amounts (accidental or suicidal) results in metabolic acidosis, electrocardiographic changes, myotonia (stiffness and in-coordination of muscles, including the inability to relax contracted muscle), muscle weakness, and myoglobinurea (presence of myoglobin, an oxygen-carrying muscle protein, in the urine). Several of these symptoms reflect injury to striated muscle. Clinical poisoning cases also often result in hyperthermia (elevated body temperature).

Most fatal outcomes of phenoxy herbicide poisoning involve renal failure, acidosis, electrolyte imbalance, and resultant multiple organ failure. In patients with phenoxy herbicide poisoning, clinicians may see vomiting, diarrhea, headache, confusion, and bizarre or aggressive behavior, peculiar odor on breath, hyperventilation, muscle weakness, tachycardia, and hypotension. These changes are indicative of liver cell injury. Levels of 2,4-D exposure required to achieve these symptoms are high. Herbicide applicators with blood 2,4-D levels at, or below, one mg/l (ppm) to two mg/l may have no symptoms. Cases of 2,4-D poisoning in which the patient was unconscious reported blood levels from 80 mg/l to 1,000 mg/l 2,4-D (Reigart and Roberts 1999).

In large doses to experimental animals, phenoxy herbicides caused vomiting, diarrhea, anorexia, weight loss, ulcers of mouth and pharynx, myotonia, and toxic injury to liver, kidneys, and the central nervous system (Reigart and Roberts 1999). Mammal 2,4-D LD50 values ranged from 100 mg/kg for dogs to 1,000 mg/kg for guinea pigs (Ibrahim et al. 1991). The 2,4-D salt form had LD 50s ranging from 375 mg/kg for mice to 2,000 mg/kg for rats. Most LD 50s, except dogs, range from 300 to 1,000 mg/kg (Ibrahim et al. 1991).

The Washington State Department of Ecology (WDOE 2001) reviewed a range of 2,4-D toxicity studies. The WDOE review found that neurotoxicity studies of 2,4-D were negative, and recent studies did not provide evidence that 2,4-D was immunotoxic. These studies did conclude that when 2,4-D was administered to test animals in high doses, there were histopathological changes in many organ systems, but primarily the kidney and liver. Researchers believe that once kidney function is compromised, mammals cannot excrete 2,4-D effectively. This, in turn, increases the amount of chemical in the animal's system, causing more harmful impacts. In a study examining the thymus and spleen of rats following exposure to 2,4-D at a dose of one-half the LD50 (228 mg/kg), Kaioumova et al. (2001) concluded that 2,4-D appeared to be causing hemolytic activity, destroying the vascular integrity of thymus and causing cell depletion in white pulp of spleen.

In a study of forest pesticide applicators following one-time application of 2,4-D, Garry et al. (2001) examined chromosome aberrations, reproductive hormone levels, and polymerase chain reaction-based rearrangements (indicative of altered genomic stability) . The study compared these biomarkers to urinary 2,4-D levels in 24 applicators and 15 controls. Applicators using hand-held backpack sprayers had the highest 2,4-D urinary levels, averaging 453.6 ppb. Among applicators, researchers found serum luteinizing hormone(LH) levels increased, correlated with urinary 2,4-D levels. They did not see similar changes in follicle stimulating hormone or testosterone. Chronically increased LH can lead to significant increases in testosterone, but the increases seen in this study were not of immediate clinical concern, and Garry was not sure what impact these reproductive hormone disruptions might have on male reproductive potential. Applicators with higher 2,4-D exposure levels (measured by urine 2,4-D) had rearrangements of DNA, but follow-up ten months later suggested that these DNA changes were reversible and temporary. The 2,4-D levels were not correlated with chromosome aberration frequencies. Garry et al.'s previous laboratory work had suggested that most phenoxy herbicides were not genotoxic at the chromosome level, and that these herbicides (or their adjuvants) may have had some endocrine disrupting activity. Garry et al. determined that "acute, high-level exposure to 2,4-D as measured by urinary concentration with or without adjuvant use, is not associated with detectable chromosome damage in G-banded lymphocytes."

Glyphosate Short-Term and Acute Toxicity

Glyphosate is not hazardous according to the federal Occupational Safety and Health Administration (OSHA) Hazard Communications Standard (Monsanto 2005). In humans, glyphosate can be irritating to eyes, skin, and upper respiratory tract (Reigart and Roberts 1999).

Among California occupational illnesses likely due to pesticides between 1991 and 1995, glyphosate was listed seventh, with nine systemic cases and 94 topical cases (skin, eye, or respiratory), for 103 total glyphosate illnesses reported (Reigart and Roberts 1999).

USFS (2003) reported on toxic impacts of glyphosate exposure to humans, creating a dose-response scale. Many of these exposures resulted from intentional ingestion of glyphosate. At calculated doses of 184 mg/kg in humans, there were "no apparent effects" from glyphosate. At the higher dose of 427 mg/kg, there was "mild poisoning," including transient signs and symptoms in oral mucosa or GI tract. More than double this dose (1,044 mg/kg) resulted in "moderate poisoning," with GI irritation, transient hepatic or renal damage, decreased blood pressure, and pulmonary dysfunction. Finally, "severe poisoning," which was fatal, occurred in patients that had consumed about 1,282 mg/kg. The lowest dose of 184 mg/kg would require drinking just under one ounce of Aquamaster™, while the highest dose of 1,282 mg/kg would require drinking just over ¾ of a cup of Aquamaster™. Neither of these scenarios is realistic within the framework of the WHCP.

Acute toxicity levels for glyphosate in animal studies were similarly high, with LD50 values ranging from 2,000 to 6,000 mg/kg in a number of test animals (USFS 2003). Toxic effects of glyphosate are thought to be related to uncoupling of oxidative phosphorylation (the process that converts energy from nutrients to storage in high-energy phosphate bonds). This uncoupling results in loss of energy and eventual death, and inhibition of hepatic mixed function oxidases (enzymes that are involved in metabolism of a wide range of endogenous compounds and xenobiotics) (USFS 2003).

Chronic Effects of WHCP Herbicides to Humans

Long-term or chronic toxicity effects include cancer, reproductive toxicity, teratogenicity, endocrine disruption, immunotoxicity, genotoxicty, mutagenicity, mental and emotional functioning, and damage to specific tissues or organs. Long-term toxicity can be evaluated through in vivo and in vitro studies, as well as epidemiological studies. Many epidemiological studies focus on farmers and pesticide applicators, as they tend to be exposed to pesticides over a long time period. WHCP treatment crew exposure may be similar to both of these groups.

Very little is understood about the health effects of low doses of pesticide exposure over a long time period. For every published study indicating that a particular pesticide or group of pesticides causes cancer, there is another published study indicating that the same pesticide does not cause cancer. It is extremely difficult to prove causation, and to sort out confounding factors such as exposure to multiple chemicals. In this section, we will first discuss general findings and issues related to the effects of long-term pesticide exposure, followed by discussion of studies specific to 2,4-D[1] and glyphosate.

General long-term effects

There have been hundreds of studies examining the effects of chronic pesticide exposure over the last several decades. Many of these studies have

[1] Many of the studies of long-term impacts of 2,4-D are for phenoxy herbicides more generally, or for each of several phenoxy herbicides.

shown a wide range of impacts including solid tumors, haematological cancers, genotoxic effects, mental and emotional functioning, and reproductive effects (Cohen 2007). For cancers, one of the key factors to consider is the link between exposure and biological plausibility. Is there a mechanism by which the pesticide in question could have induced the resulting cancer?

There is controversy as to whether chronic exposure to pesticides (as a broad category) is neurotoxic, and epidemiological studies linking pesticides and human cancers are inconsistent (Alavanja et al. 2004).

Generally, insecticide exposure is thought to be linked to neurotoxic effects, with less linkage for herbicides (Kamel et al. 2005). One study found that increased neurological symptoms were linked to increased cumulative lifetime days of exposure, particularly for organophosphate and organochlorine insecticides (although all classes of insecticides showed increases). Hong et al. (2006) examined neurobehavioral performance in organic farmers and pesticide using farmers in Korea. Hong found, based on a variety of tests, no apparent effect on either the peripheral or central nervous system in the pesticide users.

In one study, that did not identify specific herbicides and adjuvants, Burroughs et al. (1999) examined hormone levels in the bloodstream of agricultural workers in four groups: (1) controls; (2) herbicide only applicators; (3) herbicide and adjuvant applicators; and (4) applicators using herbicides, fumigants, and insecticides. Only the herbicide only applicator group showed a significant difference in hormone levels from controls. The herbicides evaluated included, but were not limited to, phenoxy herbicides. Burroughs also looked at in vitro impacts on genotoxicity, and found that all four adjuvants had a dose-response curve showing genotoxicity, but only one (unspecified) herbicide showed genotoxicity.

López et al. (2007) examined antioxidant enzymes in 81 pesticide applicators during the spraying season. López saw decreased enzyme activity during the spraying season, but was not sure if this decreased enzyme activity was related to adverse health effects. This study did not look at specific pesticides.

Blair and Zahm (1995) reviewed studies of agricultural exposure and cancer in the literature. Farmers were generally healthier than the overall population, but they appeared to have increased risks of some cancers, including: leukemia, NHL, multiple myeloma, soft-tissue sarcoma (STS), and cancers of the skin, lip, stomach, brain, and prostate. Blair and Zahm noted that the number of excess cancers were not large, but were noticeable because farmers were otherwise healthier than normal, and because the tumors were not smoking related. The study did not identify any established etiological factors for the cancers, but stated that some were associated with immune system deficiencies (Blair and Zahm 1995). The study also noted the need to evaluate exposures to materials other than pesticides, such as fuels, oils, engine exhausts, organic solvents, dusts, and microbes.

One of the largest efforts aimed at identifying long-term health impacts related to pesticides is the Agricultural Health Study (AHS). AHS is a prospective cohort study of over 89,000 farmers, pesticide applicators and spouses in Iowa and North Carolina. The study is sponsored by the National Institute of Health (NIH) and USEPA. The goal of the AHS is to "investigate the effects of environmental, occupational, dietary, and genetic factors on the health of the agricultural population."

Through the AHS, government scientists and collaborating academics and others have conducted a number of studies using the entire AHS cohort, as well as specific sub-groups. Data gathering has been ongoing. When they entered the program between 1993 and 1997, farmers and spouses completed questionnaires, and many completed a second, more detailed, take-home questionnaire. A Phase 2 follow-up took place between 1999 and 2003 (this included buccal (mouth) cell collection, a computer assisted telephone interview, and a mailed dietary questionnaire). A Phase 3 follow up began in 2005 (this included a third interview, DNA analysis, and questionnaire validation).

Overall, farmers and spouses in the AHS have a lower than expected risk of cancer than the general public in North Carolina and Iowa. However, for some specific cancers, such as prostate cancer, AHS participants have higher risks. While some cancers among AHS participants may be related to specific pesticides, there is not enough data yet to make any such conclusions (Alavanja et al. 2005). The AHS has shown that individuals that applied pesticides more than 400 days in their lifetimes had a higher risk of Parkinson's disease (as self-reported), compared with those that applied pesticides for fewer days. Again, there was not enough data to link the occurrence of Parkinson's to certain pesticides, although it is still being studied (Kamel 2006).

In the AHS examination of prostate cancer among male pesticide applicators, researchers evaluated over 55,000 applicators and 45 pesticides. They also controlled for known and suspected risk factors. While the overall risk of prostate cancer among AHS participants was higher, there were no elevated risks for prostate cancer among farmers exposed to glyphosate-family and phenoxy herbicides (Alavanja et al. 2003).

A more recent study of AHS pesticide applicators (Belseler et al. 2008) found a link between depression and pesticide exposure, suggesting that both acute high-intensity and cumulative pesticide exposure may contribute to depression in pesticide applicators. Three percent of the study population of almost 18,000 applicators reported depression symptoms. The highest level of lifetime days of exposure (over 752 days) showed a statistically significant relationship to depression. When researchers examined depression by exposure to major pesticide groups, use of herbicides showed a strong association with diagnosed depression, with an odds ratio (OR) of 2.0. The 95 percent confidence interval (CI) was not statistically significant, ranging from 0.76 to 5.54. For insecticides, the OR was 1.96, with a statistically significant 95 percent CI of 1.29 to 3.27. Belseler et al., (2008) concluded that "results suggest that pesticide exposure may contribute to depression in farmer applicators and the importance of minimizing pesticide exposures. Future work on neurological effects of pesticide exposure should include measures of affective disorders, including depression and anxiety."

These examples illustrate the significant uncertainty as it relates to pesticide exposure and long-term health impacts in humans. The uncertainties are even greater when one considers specific pesticides, such as 2,4-D and glyphosate. While researchers attempt to adjust their results for exposure to multiple chemicals and other risk factors such as age and smoking, it is extremely difficult to draw specific conclusions about the long-term impacts of these herbicides.

2,4-D long-term effects

Worldwide, 2,4-D is one of the most widely used herbicides. The chemical has been extensively studied, and while there are many conflicting studies, regulatory agencies at all levels consistently state that when used as specified, 2,4-D does not pose human health risks.

The Industry Task Force II on 2,4-D Research Data (Task Force), an industry funded research organization, provided a news release in 2006 summarizing several assessments on 2,4-D. The

Task Force cited a 2004 USEPA review that concluded “there is no additional evidence that would implicate 2,4-D as a cause of cancer.” USEPA stated that none of the recently reviewed epidemiological studies “definitely linked human cancer causes to 2,4-D.” The release also cited assessments by WHO, and Health Canada’s Pest Management Regulatory Agency that did not identify health risks from 2,4-D. The Task Force identified 23 separate regulatory decisions or expert panel reviews, dating from 1987 to 2005, that have concluded that 2,4-D does not present an unacceptable risk when used according to product instructions (Industry Task Force II 2006).

Despite these assessments on the safety of 2,4-D, there continues to be conflicting results and studies on various potential long-term impacts of 2,4-D. This uncertainty is evident in the California Department of Pesticide Regulation (DPR) assessment of 2,4-D. In the DPR Summary of Toxicology Data for 2,4-D (which was last updated in August 2006), there were five impact categories for 2,4-D that were identified as having a “possible adverse effect” – chronic toxicity rat, chronic toxicity dog, oncogenicity mouse, reproduction rat, and DNA damage.

One of the most controversial issues surrounding the use of 2,4-D is the potential link between 2,4-D and NHL. We discuss studies on NHL separately, following discussions of other potential long-term impacts of 2,4-D and glyphosate.

Another set of controversy surrounds the potential genotoxicity, mutagenicity, neurotoxicity, immunotoxicity, endocrine disruption, and/or reproductive effects of 2,4-D. There have been numerous published studies, at all levels, with both positive and negative effects. There are two primary potential reasons cited for the differing results: 1) the use of different grades of 2,4-D (reagent versus commercial), and 2) the differing endpoints of these various studies, in terms of media and timing (Tuschl and Schwab 2003; Madrigal-Bujaidar et al. 2001).

These studies demonstrate significant conflicting evidence surrounding the long-term effects of 2,4-D. Many studies that show negative effects of 2,4-D utilize relatively high doses, and/or cellular culture systems that do not include normal in vivo protective mechanisms. However, given the difficulty in measuring impacts of any chemical or combination of chemical and environmental factors, particularly over the long-term, it seems prudent to minimize worker exposure to 2,4-D to the greatest extent possible.

Further reflecting the controversy surrounding potential impacts of 2,4-D, in December 2008, the USEPA published an announcement seeking comments on a National Resources Defense Council (NRDC) petition to revoke all tolerances and cancel all registrations for 2,4-D (Federal Register 2008). One of the comments surrounding the USEPA evaluation of pesticides, including 2,4-D, is that the USEPA relied on studies submitted by industry for the registration process, and not on the open scientific literature. The comment period for the NRDC petition ended February 23, 2009; however, there was no published time frame for further USEPA action on 2,4-D. As of June 2009, the USEPA had received over 500 comments on the petition. In May 2009, the NRDC asked the USEPA to first address residential uses of 2,4-D, rather than agricultural uses.

Researchers have used a wide range of methodologies to examine long-term impacts of herbicides such as 2,4-D. The studies summarized below include in vitro, in vivo, and epidemiological studies, and several weight-of-evidence reviews. While a comprehensive summary of all studies on 2,4-D is beyond the scope of this Final PEIR, we include a sampling of summaries of these studies to illustrate the issues related to potential impacts of long-term exposure to 2,4-D.

In vitro analyses of 2,4-D include a wide variety of tests using various forms of 2,4-D in cellular cultures. Media evaluated include yeast, salmonella (Ames test), human erythrocytes, hamster ovary cells, germ cells, and others. There are published studies that illustrate various cytotoxic, genotoxic, mutagenic, or other effects, and studies that do not. As noted above, the use of different grades of 2,4-D, and different media and endpoints, may explain some of the variability. Several of these studies illustrate mechanisms of action for 2,4-D, some of which may be negated by in vivo protective mechanisms. For example, oxidation resulting from 2,4-D may be reduced by natural anti-oxidant systems in the cell. Most in vitro studies involve exposing the cellular medium to varying concentrations of 2,4-D for a set time period, then evaluating various end points. Most exposure levels are well above those likely to result from WHCP treatments, typically in the ppm, rather than ppb, range.

- Morelmans et al. (1984) found no mutagenic activity in four Salmonella strains tested with 2,4-D and other phenoxy herbicides at 2,4-D levels of 10 and 100 µg/test plate
- Mustonen et al. (1986) found that pure 2,4-D did not increase chromosome aberrations in human peripheral lymphocyte cultures, but a commercial 2,4-D formulation did increase chromosome breaks and aberrations at concentrations ranging from 54 to 217 ppm
- Holland et al. (2002) found increased effects with commercial as compared to pure 2,4-D; however genotoxic and cell cycle effects were relatively minimal for both. At 1 ppm commercial 2,4-D, they found a marginally significant increase in replicative index, a metric that indicates changes in cell cycle kinetics. There was also an increase in micronucleus formation at higher concentrations (217 ppm). Micronucleus formation is a marker of genotoxicity
- Gollapudi et al. (1999) and Charles et al. (1999) found no evidence of genotoxicity in cultures of rat lymphocytes and Chinese hamster ovary cells exposed to 2,4-D
- Venkov et al. (2000) found increases in gene conversions, reverse mutations, and moderate cytotoxic effects that were time and dose related in yeast cells exposed to 1,736 ppm 2,4-D
- Maire et al. (2007) found that 2.5 and 5 ppm 2,4-D induced cell transformation, but not apoptosis (cell death) in Syrian hamster cells
- Lin and Garry (2000) examined commercial and reagent grade 2,4-D in MCF-7, a breast cancer cell line. They found that higher doses of the commercial grade induced cell proliferation at the higher doses. As there were no impacts with the reagent grade, they hypothesized that additives in the commercial product were responsible for the estrogen-like receptor mediated proliferation. They also noted that because internal cell mechanisms would likely dampen the estrogen-like effects, one would not necessarily see these results in a clinical trial
- Tuschl and Schwab (2003) examined changes in cell cycle progression in the human hepatoma cell line (HepG2 cells) following exposure to 868 ppm, 1,736 ppm, or 3,472 ppm 2,4-D. The highest dose resulted in apoptosis due to reduced mitochondrial membrane potential. The lower two doses resulted in changes in cell cycle progression
- Bukowska et al. (2008) demonstrated that 2,4-D induced oxidation in human erythrocytes through the formation of free radicals. Effects, seen at doses ranging from 9.8 ppm to 542 ppm, ranged from changes in mitochondria potential, capase (an enzyme) dependent reactions, and apoptosis. 2,4-D induced oxidation in a time and dose dependent manner, although it did not result in denaturation of haemoglobin

- Gonzalez et al. (2005) found that 2,4-D at 6 ppm and 10 ppm increased sister chromatid exchange (sister chromatid exchange is an indicator of genotoxicity), reduced mitotic index (a measure of cell proliferation), and increased DNA damage in Chinese hamster ovary cells
- Bharadwaj et al. (2005) found indications of cell proliferation, changes in gene expression, and cytotoxicity at 22 ppm, 217 ppm, and 868 ppm 2,4-D in human hepatoma HepG2 cells
- Teixeira et al. (2004) evaluated the level of free radicals in yeast cells exposed to 2,4-D, and found that 2,4-D induced the formation of free radicals and stimulated the activity of anti-oxidant enzymes in a dose and time dependent fashion. Concentrations of 2,4-D ranged from 98 ppm to 141 ppm
- Moliner et al. (2002) exposed cerebellar granule cells to 217 ppm and 434 ppm 2,4-D. They found reduced cell viability, increases in apoptotic cells, increased capase 3 activation, and reduced cytochrome c. They concluded that 2,4-D induced apoptosis by direct effect on mitochondria
- Zeljezic et al. (2004) examined the genotoxic effect of 2,4-D on human lymphocytes at relatively low levels (86 ppb and 868 ppb). Both concentrations resulted in an increase in chromatid and chromosome breaks, increased number of micronuclei, and increased number of nuclear buds, all signs of genotoxicity
- Soloneski et al. (2007) examined the genotoxic effects of 10 ppm to 100 ppm 2,4-D on human lymphocytes with, and without, erythrocytes present. They found the highest dose to be cytotoxic, with delays in cell cycle progression and reduced mitotic index at the lower doses. They also noted that with erythrocytes present, none of the concentrations induced sister chromatid exchange, indicating that erythrocytes in the culture system modulated the DNA and cellular damage inflicted by 2,4-D
- Bukowska (2003) identified changes in anti-oxidant enzyme systems in human erythrocytes exposed to 250 ppm and 500 ppm, indicative of the oxidative effect of 2,4-D. In a later study, Bokowska et al. (2006) examined acetylcholinesterase activity in human erythrocytes, showing reduced enzyme activity at 500 ppm and 1,000 ppm 2,4-D, again indicative of oxidative activity of 2,4-D
- Bongiovanni et al. (2007) evaluated the oxidative stress produced by 2,4-D in rat cerebellar granule cells. They measured oxidation properties in cells exposed to 217 ppm 2,4-D, with and without the presence of melatonin, a known anti-oxidant. Melatonin countered most of the oxidative changes induced by 2,4-D, supporting the efficacy of melatonin as a neuroprotector
- Mi et al. (2007) examined the oxidative impacts of 2,4-D with, and without, another anti-oxidant, quercetin. Without quercetin, 50 ppm 2,4-D resulted in a number of oxidative impacts on chicken embryo spermatogonial cells, including: condensed nuclei, vacuolated cytoplasm, reduced cell viability, increased lactate dehydrodgenase, increased malondialdehyde, reduced glutathione, and reduced superoxide dismutase. Exposure to 2,4-D with quercetin reduced impacts to the same levels as controls, indicating that dietary quercetin may attenuate the negative effects of environmental toxicants.

In vivo analyses of 2,4-D exposure in laboratory animals typically involve feeding animal subjects 2,4-D at various doses, specified as mg/kg/day. Most laboratory study doses are well above potential worker exposure levels.

- Ibrahim et al., (1991) note that the dog subchronic NOEL is 10 mg/kg/day and rat chronic NOEL is 30 mg/kg/day. There was a NOEL for reproductive effects in rats of 10 mg/kg/day. This study found decreased birth weight in offspring even without apparent maternal toxicity

- de la Rosa et al. (2004) examined the impact of the herbicides propanil and 2,4-D in combination, and separately, on thymus weight (i.e. immune system impacts) in an in vivo experiment in mice. While the combination of the two herbicides did reduce thymus weight, propanil and 2,4-D alone did not
- USFS (2006) reported that a LOEL in canines of only 3 to 3.75 mg/kg/day (dogs are more sensitive to 2,4-D because they cannot excrete organic acids), and a LOEL in rodents of 75 to 100 mg/kg/day. At these doses, impacts included decreased body weight and food consumption, and adverse effects in the liver and kidney
- Charles and others conducted a number of studies for the 2,4-D Industry Task Force on chronic and subchronic effects of 2,4-D. Charles et al. (1996a) found reduced weight gain and other effects at up to 7.5 mg/kg/day in subchronic and chronic tests in dogs, but did not identify any immunotoxic or oncogenic impacts. In another 1996 study (Charles et al. 1996b) of 2,4-D chronic toxicity in rats and mice, the researchers identified impacts such as reduced weight gain, opthamalic impacts, and hematological impacts at higher doses, but no oncogenicity. Mattsson et al. (1997) identified mild, transient locomotor effects from high-level (250 mg/kg) acute exposure to 2,4-D, and retinal degeneration from high-level chronic exposure in female rats. They identified a NOEL for acute neurotoxicity of 15 mg/kg/day, and for chronic neurotoxicity of 75 mg/kg/day. In 2001, Charles et al. conducted developmental toxicity studies of 2,4-D in rats and rabbits, and concluded that no adverse fetal effects were noted at dose levels that did not also produce evidence of maternal toxicity, or exceed renal clearance of 2,4-D
- A group of scientists at the School of Biochemical and Pharmaceutical Sciences at the National University of Rosario in Argentina has investigated the impacts of 2,4-D since the mid-1990s. Many studies involved feeding pregnant and/or nursing rats doses of approximately 70/mg/kg/day (below the NOEL) to 100 mg/kg/day, and evaluating effects on both rat pups and mothers. In numerous published articles, the group has identified: reversible and irreversible behavioral alternations in pups (Bortolozzi et al. 1999); reduced body weight and central nervous system myelin deficits in rat pups (Duffard et al. 1996); neuron cell changes in rat pups (Brusco et al. 1997); transfer of 2,4-D from exposed dams to neonates (Stürz et al. 2000); changes in neurotransmitter receptors and brain weight in rat pups (Bortolozzi et al. 2004; Garcia et al. 2004); increases in 2,4-D milk residues as compared to maternal doses, reduced milk lipid content, changes in milk proteins and fatty acids, and impaired rat pup nutrition (Stürtz 2005); evidence of oxidative stress in brains of neonates exposed to 2,4-D in milk (Ferri et al. 2007); and disruptions in material behavior and neurotransmitter levels in exposed dams (Stürtz et al. 2008)
- Rawlings et al. (1998) found reductions in thryoxine levels, as compared to controls, in ewes receiving 10 mg/kg 2,4-D three times per week for 36 days. There were no overt signs of toxicity, including no effect on body weight. There were no reductions in other measured hormones, including leutenizing hormone (LH), insulin, estradiol, or cortisol
- Linnainmaa (1984) examined sister chromatid exchange frequency in the blood lymphocytes of rats and hamsters exposed one time to 100 mg/kg 2,4-D, and found no differences between treated and controlled rodents
- Mustonen et al. (1986) found no changes in cell cycle kinetics or chromosomal aberrations in the lymphocytes of workers exposed to 2,4-D. All workers did have measurable levels of 2,4-D in urine
- Lee et al. (2001) evaluated immune function in offspring of rats fed 8.5 mg/kg, 37 mg/kg, or 370 mg/kg 2,4-D during gestation. They found "subtle immune alterations" in offspring of the highest treatment group

- Chernoff et al. (1990) fed pregnant rats 2,4-D at the LD50 level, and four lower doses. They identified a number of effects, including reduced maternal weight, increased supernumary ribs in pups, and reduced thymus weight in pups
- After 12 and 24 hours, Venkov et al. (2000) found increases in chromosome aberrations and reduced mitotic index in mice intraperitoneally administered 3 to 5 mg/kg 2,4-D. They hypothesized that the cytotoxicity and mutagenicity were induced by the presence of chlorine atoms at positions 2 and/or 4 in the benzene ring of 2,4-D
- Madrigal-Bujaidar et al. (2001) found that 2,4-D induced moderate increases in sister chromatid exchange in both somatic and germ cells of mice exposed to a 50 to 200 mg/kg oral dose of 2,4-D
- Several studies suggested that 2,4-D adversely affects reproductive organs, particularly testes. Rats had lower testicular and ovarian weights at a dose of 75 mg/kg/day. Dogs had similar impacts at doses of 3 mg/kg/day. Impacts in both rats and dogs included lower testicular weights, inactive prostates, and deficient sperm production (USFS 2006).

Epidemiological studies of pesticide applicators and workers exposed to 2,4-D have examined a number of potential impacts (additional studies examining linkages between 2,4-D and NHL are described further below). Many of these studies identify areas of potential concern related to 2,4-D exposure, however it is nearly impossible to link chronic exposure to 2,4-D, with certainty, to any diseases.

- Swan et al. (2003) examined semen quality in relation to pesticide levels in blood for healthy men in Missouri and Minnesota to test whether reduced semen quality found in Missouri was linked to higher exposure to pesticides. Swan found strong odds ratios linking lower sperm quality to exposure to the pesticides alachlor, atrazine, and diazinon. They found "borderline with small and somewhat inconsistent associations" for 2,4-D and metolachlor. A small study in Argentina showed decreased sperm concentration and morphology related to high urinary levels of 2,4-D
- Faustini et al. (1996) examined blood levels of various immunological factors in ten farmers prior to exposure, within one to 12 days of exposure, and 50 to 70 days after exposure to 2,4-D and MCPA . They found immunosuppressive effects during the one to 12 days of exposure period, however most of the effects were short-term, and were no longer in evidence by 50 to 70 days after exposure
- Figgs et al. (2000) compared urinary and blood levels of 2,4-D in exposed workers, replicative index, micronuclei, and lymphocyte immunophenotypes in exposed workers. They found increased replicative index scores, indicative of stimulated cell growth, but no changes in lymphocyte immunophenotypes or micronuclei. Figgs et al concluded that there was no evidence of human chromosome damage at urinary levels of 12 to 1,285 ppb 2,4-D, and no support for genotoxicity of 2,4-D
- Holland et al. (2002) found that the lymphocyte replicative index, but not the mitotic index, was affected in applicators exposed solely to 2,4-D during a three-month period
- In a very general article, Buranatrevedh and Roy (2001) identified 2,4-D as endocrine disrupting, citing a 1988 study by Bond of chemical workers
- Burns (2005) (of Dow Chemical) reviewed several studies of pesticide applicators and manufacturers and cancer. Burns noted that while there are hundreds of such studies, few have focused on a single pesticide or class of pesticide, and that "limitations in sample size, exposure assessment, and the small number of studies make causal inference difficult." Burns noted that several studies of phenoxy herbicides, including 2,4-D, have found no increased risk of cancer. Other studies have shown an association between some of the lymphopoietic cancers and the use of

phenoxy herbicides. Some, but not all, case-control studies have shown an association between 2,4-D and NHL. Some studies examining exposure to herbicides in general have identified higher risk of NHL (for small farms), and for multiple myeloma. One meta-analysis of studies of farmers identified increased risk of NHL, but provided no details on exposures

- There is some indication that there is a potential link between 2,4-D exposure (in DOW workers) and ALS (amyotrophic lateral sclerosis) (Burns et al. 2001). There were only three cohort members in the study with ALS, which makes it difficult to draw conclusions. At least one researcher Freedman (2001) noted that this potential linkage warrants serious attention in future studies.

There have been a number of comprehensive weight-of-evidence reviews of 2,4-D conducted by scientists. In addition, regulatory agencies have conducted risk assessments that considered potential impacts of 2,4-D on workers. These evaluations identified several relevant conclusions.

- In 1992, Munro et al. conducted a comprehensive integrated review and evaluation of the scientific evidence relating to the safety of 2,4-D. All authors were from private research groups in Canada and Washington DC. Munro integrated data from worker exposure studies, whole animal studies, metabolic studies, and epidemiological studies
- Munro (1992) summarized that case-control studies linking 2,4-D with cancers were inconclusive, and that epidemiological studies, "provide, at best, only weak evidence of an association between 2,4-D and the risk of cancer"
- Munro (1992) also identified one of the most commonly cited criticisms of the potential link between 2,4-D and cancer, that the chemical structure of the herbicide, and animal studies, do not support that 2,4-D would be a carcinogen
- Munro (1992) further cited a large body of negative studies on genotoxicity of 2,4-D. These negative genotoxicity studies, together with the negative metabolic studies "clearly indicates that 2,4-D is highly unlikely to be a genotoxicity carcinogen." Munro also reviewed and found no evidence for adverse effects on immune system, endocrine system, neurotoxic effects, and reproductive effects (except at high acute toxic doses). Finally, Munro noted that historical exposure to 2,4-D was higher than current exposures, due to label changes and increased safety precautions that have been implemented
- In a weight-of-evidence analysis conducted by 12 scientists (and funded by the Industry Task Force II on 2,4-D), Ibrahim et al. (1991) evaluated the research (through 1989) on 2,4-D impacts. The panel reviewed published data, considered all evidence, and made weight-of-evidence judgments. The diverse panelists were not expected to all agree, and tried to capture their differences in the article. On mutagenicity, they found that: "although it has been one of the most rigorously tested compounds, the available evidence on the mutagenicity of 2,4-D and its related products is equivocal to negative. Evidence indicates it does not exhibit the gene-damaging potential of a classic mutagen." In vitro tests have shown both positive and negative mutagenicity results
- Ibrahim et al.'s (1991) analysis of carcinogen bioassays only considered those conducted after 1986, when procedures were refined. They summarized two two-year studies conducted in 1986 and 1987. One study on rats found a significant increase in brain tumors at the highest dose of 45 mg/kg/day 2,4-D, and two tumors in the second highest dose, 15 mg/kg/day. A similar study repeated on mice, did not find effects. The panel concluded, "considered together, these two animal studies do not provide impressive evidence that exposure to 2,4-D causes cancer in animals. Based on results from the rat study, the workshop participants

concluded that there was weak evidence supporting an excess of brain cancer occurrence in the male Fischer 344 rats receiving the highest dose"

- Ibrahim et al. (1991) also examined the cohort studies of 2,4-D and concluded, "in summary, the cohort studies provide little evidence to suggest that 2,4-D exposure increases the risk for more common types of cancers in humans." They only evaluated three of the six cohort studies that had been completed at the time, because the other three studies had small cohorts or low statistical power
- In Ibrahim (1991), the workshop participants did not find strong evidence between the exposure of 2,4-D and any other type of cancer, besides NHL, and were also not convinced that there was a cause-effect relationship between 2,4-D and cancer. Eleven of 13 participants said that it was "possible" that 2,4-D could cause cancer in humans, with one thinking the possibility was pretty strong, and five thinking that it was pretty weak. Two participants thought that it was unlikely that 2,4-D causes cancer in humans. Several panelist said that there was barely enough evidence to support any conclusions regarding carcinogenicity of 2,4-D
- WDOE (2001) summarize that 2,4-D is not considered to be a teratogen or reproductive hazard if administered below maternally toxic doses. This evaluation noted that there have been conflicting results on mutagenicity studies, but that an USEPA panel concluded, "2,4-D does not pose a mutagenic hazard and there is no concern for mutagenicity at this time." Animal carcinogenicity studies have not been positive. WDOE noted that epidemiological studies of 2,4-D exposed workers have been "controversial", and that studies haven't definitively demonstrated an association between 2,4-D and NHL or other cancer
- In 2002, Garabrant and Philbert conducted a review of human toxicity and cancer risks related to 2,4-D. This review, conducted for the Industry Task Force II on 2,4-D Research, focused on studies conducted between 1995 and 2001. Garabrant and Philbert focused their review on animal and epidemiological studies. They noted that "it is clear from the large amount of data available that 2,4-D, its salts, and esters are not teratogenic in mice, rats, or rabbits unless the ability of the dam to excrete the chemical is exceeded" (p.236). They also noted that it is unlikely that 2,4-D has any neurotoxic potential at doses below those that result in systemic toxicity. While Garabrant and Philbert discussed results of some in vitro studies, none of the three studies that they identified had positive results. The review concludes that despite several in vitro and in vivo studies, there is no experimental evidence that under physiologic conditions, 2,4-D causes DNA damage or is immunotoxic
- Garabrant and Philbert (2002) also summarized a large number of epidemiological studies. They noted many of the study weaknesses that had been previously identified, such as limited exposure data. The review did not find any compelling evidence among the case-control and cohort studies that 2,4-D was linked to soft tissue sarcoma, non-Hodgkin lymphoma, or Hodgkin lymphoma
- As part of the 2005 pesticide reregistration process, USEPA made a number of conclusions about 2,4-D, including that it had: low acute toxicity based on dermal, oral, and inhalation exposures; was a severe eye irritant; a Group D, non-classifiable carcinogen, based on the fact that it was not mutagenic, but that there were cytogenic effects (USEPA 2005). In the USEPA's reregistration approval of 2,4-D, they requested that a number of additional studies be completed to address areas of uncertainty related to 2,4-D's impacts. These included: a subchronic (28 day) inhalation study, a repeat two-generation reproduction study to address concerns related to endocrine disruption, and a developmental neurotoxicity study. USEPA noted that the endocrine disruption study should address concerns related to thyroid effects, immunotoxicity, and a more thorough assessment of the gonads and reproductive/developmental endpoints (USEPA 2005)

Table 4-4
Toxicity and Exposure Standards for 2,4-D and Glyphosate, Compared to Potential WHCP Exposure

Exposure Standard	2,4 D	Glyphosate
1. USEPA Chronic NOEL	5 mg/kg/day	175 mg/kg/day
2. USEPA Safety Factor	1,000	100
3. USEPA Chronic RfD	0.005 mg/kg/day	2 mg/kg/day
4. USEPA Acute NOEL	25 mg/kg/day (females) 67 mg/kg/day (general pop.)	175 mg/kg/day
5. USEPA Acute RfD	0.025 mg/kg/day (females) 0.067 mg/kg/day (general pop.)	2 mg/kg/day
6. WHO ADI	0 to 0.01 mg/kg/day	0.3 mg/kg/day
7. USFS HQ	16 to 30	0.2
8. WHCP Estimated Exposure	0.008 mg/kg/day (0.003 to 0.017)	0.0024 mg/kg/day (0.0012 to 0.0108)
9. WHCP Estimated HQ	1.6 (0.6 to 3.4)	0.0012 (0.0006 to 0.0054)

- In their risk analysis, USFS (2006) noted that 2,4-D is toxic to the immune system in recent studies, especially in combination with other herbicides. The toxicity mechanism is through cell membrane disruption and cellular metabolic processes. The herbicide was found to result in genetically programmed cellular death (apoptosis). Toxic effects started at the cellular membrane. In disrupting cellular metabolism, researchers hypothesized that because 2,4-D is similar to acetic acid, it forms analogues of the enzyme acetyl-Co-A, which is involved in glucose metabolism, and production of cholesterol, steroid hormones, and acetylcholine. By forming these analogues, 2,4-D disrupts these processes. 2,4-D may also cause apoptosis by directly damaging mitochondria, which initiates apoptosis in human lymphocytes.

The USEPA and other agencies determine pesticide levels that are considered safe for both long-term and short-term exposure. These agencies also make determinations about the carcinogenicity of various chemicals. Below (for 2,4-D), and in **Table 4-4,** above, we summarize current metrics for 2,4-D, and relevant figures for the WHCP, based on the exposure estimates in Table 4-2.

- USEPA maintains that 2,4-D is a Class D carcinogen, which is "not classified as to human carcinogenicity". The International Agency for Registration of Carcinogens (IARC) classifies 2,4-D as 2B, "possible carcinogen to humans". The World Health Organization (WHO) does not regard 2,4-D as genotoxic or carcinogenic (USFS 2006)
- USEPA uses a chronic NOEL of 5 mg/kg/day in rats, and a safety factor of 1,000 to calculate the chronic exposure RfD for 2,4-D of 0.005 mg/kg/day. The safety factor of 1,000 is based on safety factors of 10 each for sensitivity between species, sensitivity within species, and uncertainty in the database of study results. That is, the RfD is 1,000 times lower than the chronic NOEL, providing three orders of magnitude protection compared to the animal study NOEL. This RfD means that USEPA considers a daily lifetime exposure of 0.005 mg/kg/day to be safe (0.35 mg/day for a 70 kg person). This chronic RfD value is relevant for determining the potential risk of 2,4-D exposure to WHCP treatment crews
- USEPA uses two different acute NOEL values to determine acute RfDs. The lower acute NOEL of 25 mg/kg/day is for

females of reproductive age, while the higher 67 mg/kg/day is for the general population. These NOELs are based on animal acute toxicity studies. The acute RfD values are 1,000 times lower, at 0.025 mg/kg/day, and 0.067 mg/kg/day, for reproductive age females and the general population, respectively

- WHO identified an acceptable daily intake (ADI) for 2,4-D of between 0 and 0.01 mg/kg/day, based on a NOEL of 1 mg/kg/day
- USFS calculated a hazard quotient of 16 for backpack and aerial spray, and 30 for ground spray. These HQ values are based on the expected forest worker exposure, divided by the chronic RfD. An HQ greater than one indicates potential hazard. As a result, USFS (2006) noted that "based on upper bound hazard quotients, adverse health outcomes are possible for workers who could be exposed repeatedly over a longer-term period of exposure." The USFS exposure values, as summarized in Table 4-2, utilize significantly higher acreage per day treatment than the WHCP
- In Table 4-4, we calculate HQ values for estimated WHCP exposure, based on the exposure estimates for WHCP crews in Table 4-2, and the RfD of 0.005 mg/kg/day. Because WHCP crews are exposed to 2,4-D for only part of the year, these HQ values of over 1 may not be as potentially hazardous as it appears. The estimated WHCP HQ for 2,4-D is 1.6, with a range of 0.6 to 3.4. Thus, there is potential hazard to WHCP treatment crews from long-term exposure to 2,4-D.

Glyphosate long-term effects

Like 2,4-D, glyphosate is also a widely utilized and extensively studied herbicide. Similarly, glyphosate is generally considered safe for humans when used as specified. Another commonality is the conflicting results and ongoing controversy regarding the potential impacts of long-term exposure to glyphosate. In the DPR Summary of Toxicology Data for glyphosate (last updated November 1992), there were two impact categories identified as having a "possible adverse effect" – oncogenicity in mouse, and oncogenecity in rat. Monroy et al. (2005) stated that while glyphosate is considered to be of low health risk to humans, the occurrence of possible harmful side effects of glyphosate are not well documented and are controversial. Monroy notes that there have been studies that suggested glyphosate could alter various cellular processes in animals.

Below, we provide a summary of research on glyphosate to reflect the range of concerns that have been expressed. A full review of all such studies is beyond the scope of this Final PEIR.

In recent years there have been a number of in vitro studies that have raised concerns related to glyphosate. Generally, in vitro studies provide a first-level assessment of potential toxicity and mechanisms, and can indicate a need for further analyses.

- Monroy et al. (2005) examined the toxicity and genotoxicity of glyphosate to normal human cells and human fibrosarcoma cells. Monroy noted a dose-dependent effect, with cytotoxic and genotoxic effects at concentrations of 4.0 to 6.5 millimolar (mM) (equivalent to 676 to 1,098 ppb). They concluded that the mechanism of action of glyphosate was not limited to plant cells
- Hokanson et al. (2007) noted that the general chronic toxicity of glyphosate has not been determined, but that it is considered to be an endocrine disrupter. Hokanson examined the possibility that glyphosate interrupts estrogen-related gene expression in an in vitro DNA microarray analysis. The study found that 680 of 1,550 genes were dysregulated by in vitro exposure to commercial glyphosate, but that many of the changes were minor. Hokanson concluded that "there remains an unclear pattern of very complex events following exposure of human cells to low

levels of glyphosate." They noted that exposure was complicated and potentially damaging to adult and fetal cells

- Glyphosate has generally been considered as harmless in normal usage, but Marc et al. (2004a) noted conflicting evidence. In a study of five glyphosate formulations (all with surfactant) on sea urchin embryos[2], Marc et al. identified a dose-dependent effect, proportional to the amount of glyphosate. Some of the five glyphosate products produced impacts at 1mM (169 ppb), while others required levels of 8 to 12 mM (1,352 to 2,028 ppb). Marc saw dysfunction and a delay in morphological changes in the cell cycle at 10 times higher doses, but saw no aberrant chromosome morphology. Marc concluded that the effect appeared to be common to a group of glyphosate products, but did not establish a direct link with development of cancer
- In a follow-up study of sea urchin embryo development using Roundup®, Marc et al. (2004b) found that glyphosate at 10mM (1,690 ppb) delayed occurrence of the first cell cycle by 30 minutes. The delay was caused by glyphosate interfering with DNA replication. Marc determined that the effect was due to glyphosate acting in synergy with surfactants. Glyphosate concentrations in soil or water are expected to be in the nanomolar range, and there is no indication that they would result in genotoxic effects at those lower levels, but formulated glyphosate is sprayed at a concentration of 40mM (6,760 ppb) – so applicators could potential inhale micro-droplets at these levels shown to be toxic to sea urchins.

In vivo animal studies have historically shown glyphosate chronic toxicity only at high levels. However, some recent studies indicate that there may be cellular responses to glyphosate at lower concentrations. Exposure levels, even in the chronic toxicity studies, are still several orders of magnitude higher than potential exposures to WHCP crews.

- Daruich et al. (2001) studied the activity of several enzymes in pregnant rats and fetuses exposed to glyphosate, and found a variety of functional abnormalities in enzyme activity
- Benedetti et al. (2004) examined glyphosate in rats, examining hepatic effects at three dose levels for 75 days. The doses were 4.87 mg/kg, 48.7 mg/kg, and 487 mg/kg. At even the lowest concentrations of glyphosate, Benedetti found leakage of hepatic intracellular enzymes, suggesting irreversible damage in hepatocytes
- Dallegrave et al. (2003) examined the teratogenic potential of Roundup in rats, at relatively high doses of 500 mg/kg, 750mg/kg, and 1,000 mg/kg. At the highest dose, there was 50 percent mortality of dams. Dallegrave found 33 percent of fetuses at the lowest 500 mg/kg dose had skeletal alternations.

There are fewer epidemiological studies of exposure to glyphosate than of 2,4-D. These studies generally show little, to no, chronic health concerns related to glyphosate.

- In introducing their study of cancer incidence among glyphosate-exposed pesticide applicators in the AHS, De Roos et al. (2005) noted that there have been conflicting results of genotoxicity studies related to glyphosate. Some studies have found no genotoxic activities of glyphosate, while others have found genotoxic effects. In the early 1990s, USEPA and WHO concluded that glyphosate was non-mutagenic, but some more recent case-control studies have suggested associations between glyphosate and NHL. This study by De Roos et al. examined risk of cancers among the AHS participants with exposure to glyphosate, adjusting for five other pesticides highly associated with glyphosate use. De Roos also adjusted for age, demographic, and lifestyle factors. Unlike many cohort studies, this study had large

2 Sea urchin embryos have been found to be a good indicator of cell development in all species.

cohorts. There were 13,280 participants that had never been exposed to glyphosate, 15,911 participants with low exposure to glyphosate, and 24,465 participants with high exposure to glyphosate (as measured by questionnaires). The total number of cancers among all participants was 2,088. The researchers found no association between glyphosate exposure and increase in all cancers combined. Among specific cancers, they found an association between glyphosate exposure and melanoma, with a risk ratio of 1.8 (and a 95 percent CI of 1 to 3.4) when adjusted for age only. When adjusted for age and other lifestyle factors, the RR decreased to 1.6 (and a 95 percent CI of .8 to 1.6). The study did not observe any association between glyphosate and NHL. De Roos noted that the association between glyphosate and melanoma was based on a small number of cases. The association could result from spurious associations or chance, however some details were internally consistent indicating it was more than chance. The researchers were not sure of a causal pathway

- As reported by USFS (2003), the Ontario Farm Health Study, a retrospective cohort study of almost 2,000 farm couples, did not find linkages between glyphosate exposure and miscarriage, spontaneous abortion, or fecundity
- As part of their risk assessment in Columbia, Solomon et al. (2005) reported on a study evaluating whether glyphosate exposure was associated with adverse reproductive effects. They conducted a retrospective cohort study of 600 women of reproductive age in each of five regions in Columbia, comparing reproductive health to known pesticide use. They found no associations between fecundity and glyphosate spraying.

While not as extensively analyzed as 2,4-D, there have been a number of regulatory agency and third-party reviews of glyphosate.

- Williams et al. (2000) conducted a "current and comprehensive safety evaluation and risk assessment of glyphosate and Roundup®" (including POEA) for humans. They evaluated regulatory studies and published research reports. The review found low oral and dermal absorption of glyphosate, no bioaccumulation, and no significant glyphosate toxicity in acute, subchronic, and chronic studies. Williams did find that direct contact with glyphosate could result in ocular irritation, but noted that the potential for worker exposure was low
- Williams et al. (2000) applied a weight-of-evidence approach and standard evaluation criteria for genotoxicity data, and determined there was no convincing evidence for DNA damage in vitro or in vivo. They also did not find evidence of tumorigenic potential from multiple lifetime feeding studies in animals, and no effects indicative of reproductive, teratogenic, or endocrine disruption
- In their risk assessment of glyphosate, USFS (2003) reported that there were no neurotoxic, immune, or endocrine effects for glyphosate. USFS noted that there was potential for endocrine effects, because such effects have not been extensively evaluated
- USFS (2003) reported that a consistent sign of subchronic or chronic glyphosate toxicity is loss of body weight. Glyphosate likely acts as an uncoupler of oxidative phosphorylation, and may cause liver and kidney toxicity.
- Solomon et al. (2005) report that "overall, there is little epidemiological evidence to link glyphosate to any specific disease in humans." Their risk assessment of spraying coca and poppy with glyphosate in Columbia concluded that the risks to humans and human health were negligible.

USEPA and other agencies have determined glyphosate levels that are considered safe for both long-term and short-term exposure. These agencies also make determinations about the carcinogenicity of various chemicals. Below (for glyphosate), and in Table 4-4, we summarize current metrics for glyphosate exposure, and relevant figures for the WHCP, based on the exposure estimates in Table 4-3.

- USEPA assigned glyphosate as Class E, "evidence of non-carcinogenicity in humans (no evidence in at least two adequate animal tests in different species or in both epidemiological and animal studies)". WHO has assigned a similar carcinogenicity classification for glyphosate
- USEPA utilizes a NOEL for both acute and chronic exposure to glyphosate of 175 mg/kg/day, based on a teratogenicity study in rabbits. The safety factor for glyphosate is 100, based on factors of 10 each for sensitivity between species and sensitivity within species. The acute and chronic RfD for glyphosate is 2 mg/kg/day, calculated by dividing 175 mg/kg/day by 100, and rounding up to 2
- Based on a regression analyses of human and animal toxicity data, the RfD is conservative, and appears to be very protective for both short- and long-term exposures (USFS 2003)
- WHO determined an ADI of 0.3 mg/kg/day, based on a NOEL of 31.5 mg/kg, and an uncertainty factor of 100. These values are lower than the corresponding USEPA figures, and are based on a life-time feeding study in rats
- USFS (2003) noted that for glyphosate, the highest calculated HQ for workers, 0.2, was still well below one, the level at which there is concern
- The estimated HQ for glyphosate exposure of WHCP treatment crews, even using conservative exposure assumptions, is only 0.0012. This HQ is three orders of magnitude below one, the level at which there is potential for concern. Thus, long-term exposure of WHCP treatment crews following program operational procedures, is considered safe.

Non-Hodgkin Lymphoma

Some of the most studied linkages between pesticides and cancer are those of non-Hodgkin lymphoma and 2,4-D, phenoxy herbicides, and/or pesticides in general. Much of this research followed a study by the Swedish researcher Hardell in 1981 that showed a link between phenoxy herbicides and NHL. As many of these studies described below illustrate, the evidence, in both directions, is conflicting. Below, we summarize several of the epidemiological studies on NHL and pesticides, including both 2,4-D and glyphosate.

- Hardell and Ericksson were among the first to report potential linkages between NHL and phenoxy herbicides. They have continued to evaluate linkages between NHL and pesticides since the early 1980s. Over the years, their studies have been both criticized and confirmed
- In one of several such studies, Hardell and Eriksson (1999) examined the risk of NHL among subjects exposed to herbicides in Sweden. This was a case-control study, with 400 cases and 700 controls. The team used questionnaires to estimate exposure. If the subject was deceased, a living relative answered the questionnaire (which was one of the (many) criticisms of their work). Hardell and Ericksson found an increased risk of NHL for herbicide exposure in general, with an OR of 1.6 (95 percent CI 1.0 to 2.5). For fungicide exposure the OR was 3.7 (95 percent CI 1.1 to 13), for phenoxyacetic acid exposure the OR was 1.5 (95 percent CI 0.9 to 2.4), and for MCPA exposure the OR was 2.7 (95 percent CI 1.0 to 6.9). This study did not consider 2,4-D exposure alone. Hardell and Ericksson also noted an increased risk of NHL with glyphosate exposure, with an OR of 2.3 (95 percent CI 0.4 to 13). The glyphosate risk was based on only four cases and three controls with exposure, and was not statistically significant. After conducting multivariate analyses, the odds ratios were somewhat reduced, and the researchers

determined that they could not make conclusions about linkages between NHL and specific chemicals

- The fact that Hardell and Ericksson raised concerns about glyphosate and NHL caused several individuals to criticize Hardell's 1999 study. Researchers from Monsanto, Harvard, and Yale commented that Hardell and Eriksson did not address the other evidence that glyphosate was not carcinogenic, that there were problems with the questionnaire approach to gathering exposure information, and that the conclusions were based on only a small number of cases (Acquavella and Farmer 1999; Cullen 1999; Adamie and Trichopoulos (no date)).
- In a recent study, Eriksson et al. (2008) again examined pesticides as a risk factor for NHL in Sweden, with 910 cases and 1,106 controls. Exposure was also based on questionnaires. General herbicide exposure resulted in an OR of 1.72 (95 percent CI 1.18 to 2.51), MCPA exposure resulted in an OR of 2.81 (95 percent CI 1.27 to 6.22), and glyphosate exposure had an OR of 2.02 (95 percent CI 1.16 to 4.40). Eriksson concluded that this study confirmed an association between phenoxyacetic acids and NHL, and strengthened understanding of association with glyphosate
- In their first of several studies, Hoar et al. (1986) examined agricultural herbicide use and risk of lymphoma and soft tissue sarcoma (STS) in a population based case-control study of Kansas residents. The researchers chose Kansas due to high use of 2,4-D. This study looked at NHL, Hodgkin's disease, and STS cases from 1976 to 1982. There were just fewer than 1,000 controls, matched to between 120 and 170 cases for each of the three cancers. The researchers conducted interviews of cases and controls to answer exposure and lifestyle questions. For the 130 farming subjects, Hoar also confirmed exposure by examining pesticide supplier records. Hoar analyzed the data using a variety of approaches. They found a six-fold increased risk of NHL among high intensity 2,4-D users, which was cause for concern. Among all 2,4-D users, there was an OR of 2.2 (95 percent CI 1.2 to 4.1). There was also higher risk of NHL if the subject didn't use protective equipment when applying pesticides. This study confirmed Hardell's work in Sweden, however Hoar noted that there were no carcinogenicity studies in animals, or evidence of immunosuppression by 2,4-D[3]
- In a follow up study Zahm (formerly Hoar) and Blair (1992) reviewed the possible role of pesticides in increases in NHL. They noted a link between NHL and 2,4-D in studies in Sweden, Kansas, Nebraska, and Canada. In addition, canine malignant lymphoma was associated with dog owner use of 2,4-D and commercial pesticide treatments. Zahm and Blair commented that several other chemicals were found to have possible links to NHL, including triazine herbicides, organophosphate insecticides, fumigants, and fungicides. Zahm and Blair reviewed 21 cohort studies of farmers that provided data on NHL and farming. These studies had risk ratios ranging from 0.6 to 2.6. Eleven of the studies reported higher risks of NHL with exposure to chemicals, but only three studies were statistically significant. Zahm and Blair commented that, "both the descriptive and analytical data tend to show excesses [of NHL], but are not impressive overall"
- De Roos et al. (2003) noted that "an increased rate of non-Hodgkin lymphoma (NHL) has been repeatedly observed among farmers, but identification of specific exposures that explain this observation has proven difficult." De Roos examined case-control data from the 1980s, with a total sample sized of over 3,500. The studies, based in the Midwest, looked at 47 pesticides simultaneously, and controlled

[3] Immunosuppression is linked to NHL.

for confounding factors. They found associations with several pesticides, including glyphosate, but not 2,4-D. De Roos noted that these types of studies need to consider multiple exposures

- Wigle et al. (1990) looked at records of 70,000 male farmers in Saskatchewan to compare mortality records with Census of Agriculture records for pesticide use. They did not find an excess of mortalities among any specific causes of death, but did find dose-dependent increases in NHL risk for acres sprayed in 1970 with herbicides, and dollars spent on fuel and oil
- Pearce and McLean (2005) noted that, "farmers have an increased risk of non-Hodgkin lymphoma (NHL), several studies have found increased risks of NHL among producers or sprayers of pesticides. The findings are markedly inconsistent across countries and studies, but overall there is evidence of an increased risk among production workers and professional pesticide sprayers with heavy exposure." Pearce and McLean summarized 15 studies (and 22 endpoints) of phenoxy herbicides and risk of NHL. They found risk ratios ranging from 0.9 to 4.9, with only five of the endpoints with significant 95 percent confidence intervals lower bounds of over 1.0. The range of CIs among the studies was between 0.4 and 27.0. Pearce and McLean concluded that an increased risk of NHL due to phenoxy exposure was uncertain. They also noted that exposure to arsenic, solvents, organophosphate insecticides, organochlorine insecticides, and zoonotic viruses may explain increased risk of NHL among farmers
- Alavanja (2004) reviewed 29 studies examining pesticides and NHL. Alavanja noted that while there is growing evidence for a link, there is no consistent pattern. He evaluated studies of NHL and exposure to phenoxy acetic acids (2,4-D), organochlorine, and organophosphate pesticides. Eighteen of 29 studies had a higher OR for NHL, with an average of 1.3, and a 95 percent CI of 1.17 to 1.55
- Burns et al. (2001) provided a follow-up report on Dow Chemical Company employees that manufactured 2,4-D between 1945 and 1994. The study looked at mortality among these 2,4-D workers compared to other company employees. Burns found no significant risk for NHL, using a standardized mortality ratio (SMR). The SMR for 2,4-D workers was 1.0 compared to the United States population, and 2.63 (95 percent CI 0.85 to 8.33) compared to other Dow employees
- Kogevinas et al. (1995) examined an international cohort of workers exposed to 2,4-D, 2,4,5-T, and dioxins using data from the IARC. For 2,4-D exposure and STS, with 9 cases and 24 controls, they calculated an OR of 5.72 (95 percent CI of 1.14 to 28.65). The OR for NHL was lower, based on 12 cases and 56 controls, for an OR of 1.11 (95 percent CI of 0.46 to 2.65, i.e. not significant). However, there was a dose-response relationship, with number of NHL cases (and the OR) increasing with increased exposure to 2,4-D
- Bond et al. (1989) report that "the weight-of-evidence currently available does not support a conclusion that the phenoxy herbicides present a carcinogenic hazard to humans." They noted that others have not been able to replicate Hardell's studies, and that there have been inconsistent results in various studies. Bond evaluated eight studies, with ORs ranging from 0.8 to 6.8 for soft tissue sarcoma or NHL. Bond noted that uncontrolled confounding could cause the large ORs in Hardell's studies
- McDuffie et al. (2001) conducted a cross-Canada study of pesticides and health and noted that there was elevated risk of NHL with exposure to multiple pesticides. For phenoxy herbicides, the OR was 1.38 (95 percent CI 1.06 to 1.81). For 2,4-D specifically, the OR was 1.32 (95 percent CI 1.01 to 1.73 CI), based on 517 cases and 1,506 controls
- In their weight-of-evidence review, Ibrahim et al. (1991) evaluated case-control studies of 2,4-D, summarizing a number of studies

with varying results (many mentioned above). One of their concerns was that many of the earlier studies were on phenoxy herbicides in general, not just 2,4-D. These studies included 2,4,5-T, which has been banned in most countries. Ibrahim summarizes, "the case-control findings for NHL, taken as a whole, suggest an association with use of phenoxy herbicides, although the evidence is not entirely consistent. Less clear but still suggestive is the evidence for an association between NHL and exposure to 2,4-D." They also noted, "one cannot dismiss the possibility that 2,4-D has been falsely implicated or that the ORs for 2,4-D are suppressed inappropriately when the adjustments are made for use of other herbicides."

While Ibrahim made these observations in 1991, studies in the seventeen years since do not seem to have clarified the potential linkages between 2,4-D, glyphosate, or pesticides in general, and NHL.

Exposure to Heat

WHCP treatment crews work outdoors during the hottest summer months. Without proper precautions, there is potential for workers to suffer from heat illness. Heat illness is defined as a serious medical condition resulting from the body's inability to cope with a particular heat load, and includes heat cramps, heat exhaustion, heat syncope, and heat stroke (CCR Title 8, Section 3395). In response to a high number of heat-related deaths among outdoor workers in 2005, the State of California implemented Heat Illness Prevention Standards. These regulations outline preventative measures for employers to take to reduce the risk of heat illness among their employees.

CalOSHA, the State's job safety agency, further reviewed heat-related illness in early 2009. This additional review occurred in response to seven deaths and 60 worker injuries during 2008, despite the implementation of the Heat Illness Prevention Standards (Ferriss 2008).

Heat illness covers a range of types and symptoms, ranging from headaches and nausea to death. Heat illness is preventable, but it is important to treat the first signs of heat illness seriously. Symptoms of several types of heat illness, as provided by CalOSHA, are listed below (CalOSHA 2008a):

- **Heat rash** – also called prickly heat, may occur in hot, humid environments where sweat is not easily removed from skin by evaporation. Heat rash can become serious if extensive, or infected
- **Fainting** – also called heat syncope, is a stage of heat stroke. Fainting may occur when a worker not acclimated to heat simply stands still in the heat
- **Heat cramps** – muscle spasms that occur when workers are hydrated, but have not replaced electrolytes lost in sweat
- **Heat exhaustion** – occurs when workers become dehydrated and/or have lost electrolytes. Workers will sweat, but may experience extreme weakness, fatigue, giddiness, nausea, or headache. Skin may become clammy and moist, complexion pale or flushed, and body temperate may be slightly higher than normal
- **Heat stroke** – is the most serious form of heat illness, and can result in death. Heat stroke is caused by the failure of the body's internal mechanism to regulate its core temperature. Sweating stops and the body can no longer rid itself of excess heat. Symptoms include: mental confusion, delirium, loss of consciousness, convulsions, coma, and high body temperature (106 degrees Farenheit or more). Skin of heat stroke patients may be hot, dry, red, mottled, or bluish.

California's Heat Illness Prevention Standard includes four steps to preventing heat illness: training, water, shade, and planning. The regulations require employers to provide training on heat illness prevention; provide enough fresh water so that each employee can drink at least one quart per hour (and encourage them to do so); provide access to at least five minutes of rest in the shade when needed for preventative recovery; and develop and implement written procedures for complying with the heat illness prevention standard. The DBW follows CalOSHA's heat illness prevention guidelines, including the "85 degree" rule to ensure that shade is available and accessible.

CalOSHA encourages employers to proactively address heat illness by monitoring weather conditions, providing additional training on hot days, adjusting work shifts to avoid the heat, and promoting a "buddy system" so that workers can monitor each other (CalOSHA 2008a). CalOSHA also recently published a guide for employees to carry out tailgate training for workers (CalOSHA 2008b).

WHCP treatment crews may be outside during hot weather for extended periods of time. In addition, use of coveralls and other PPE make workers more susceptible to heat illness. Workers may also be more susceptible to heat illness if they have not acclimated to warm temperatures. There is potential for WHCP treatment crews to suffer adverse impacts to their health as a result of exposure to heat during normal WHCP operations.

* * * * *

To minimize exposure to herbicide, WHCP treatment crews are required to <u>utilize personal protective equipment (PPE) as specified on the herbicide labels, and described in the WHCP Operations Management Plan</u>.

WHCP treatment crews are required to follow the PPE requirements specified on the Weedar® 64 label. These requirements are more stringent than those of Aquamaster™. PPE requirements include: coveralls, chemical-resistant gloves, chemical resistant footwear, chemical-resistant headgear for overhead exposure, and protective eye wear. In addition, a chemical-resistant apron should also be worn when cleaning equipment, mixing, or loading. Masks will also be available to treatment crews, if they prefer additional facial protection. Proper use of PPE has been proven to reduce herbicide exposure.

It is extremely unlikely that there would be acute health impacts to WHCP treatment crews as a result of exposure to herbicides. It is also unlikely that there would be chronic health impacts to WHCP treatment crews as a result of exposure to herbicides. However, given the uncertainties related to the long-term human health impacts of low level exposure to 2,4-D and glyphosate, it is important that the DBW minimize the potential for adverse health outcomes as a result of long-term, low-level, exposure of WHCP treatment crews to 2,4-D, and to a much lesser extent, glyphosate. There is also potential for acute health impacts to WHCP treatment crews as a result of heat exposure during WHCP treatments. **These potential impacts to WHCP treatment crew health would be avoidable significant impacts.** These impacts would potentially be avoided, or reduced to a less-than-significant, level by implementing the following five mitigation measures.

- **Mitigation Measure H2a** – <u>Require treatment crews to participate in training on herbicide and heat hazards</u>.

  The DBW will provide training to ensure that treatment crews have the knowledge and tools necessary to conduct the program in a safe manner. Training will include reading, understanding, and following herbicide label requirements; purpose and proper use of PPE; symptoms of herbicide poisoning and minimization of exposure; avoidance, symptoms, and treatment of heat exposure; and emergency medical procedures.

- **Mitigation Measure H2b** – <u>Follow best management practices to minimize the risk of spill, and to minimize the impact of a spill, should one occur</u>.

  The best management practices includes several provisions to reduce the potential for spill, such as: fastening herbicide containers securely in boats in original, watertight containers; carrying a marker buoy and anchor line to mark any spills in water; reporting spills immediately to appropriate State and local agencies; immediately stopping movement of land spills using absorbing materials; marking and monitoring spills in water for herbicide residues and environmental impacts, if appropriate. Treatment crews will include at least one person with a Qualified Applicators Certificate (QAC), and all crew members will participate in annual training on herbicide handling procedures.

- **Mitigation Measure H2c (same as Mitigation Measures B2c; B4b; W1c, W2c; and W3c)** – Implement an adaptive management approach to minimize the use of herbicides.

  Under an adaptive management approach, DBW will seek to improve efficacy and reduce environmental impacts over time as new and better information is available. Specifically, DBW will evaluate the need for control measures on a site by site basis; select appropriate indicators for pre-treatment monitoring; monitor indicators following treatment and evaluate data to determine program efficacy and environmental impacts; support ongoing research to explore the impacts of the WHCP and alternative control methodologies; report findings to regulatory agencies; and adjust program actions, as necessary, in response to recommendations and evaluations by regulatory agencies and stakeholders. In addition to this adaptive management approach, DBW will follow maintenance control practices that seek to reduce the number of acres of water hyacinth to be treated each year, until treatment acreage reaches a minimal level. This will reduce the volume of herbicide utilized by the WHCP.

- **Mitigation Measure H2d (same as Mitigation Measures B1c; B2d; W1d; W2e; W3e; and A1b)** – Conduct herbicide treatments in order to minimize potential for drift.

  In addition to following the label requirements, DBW will, to the degree possible, schedule herbicide applications to occur at high tide, or at a point in the tidal cycle determined by the field supervisor to provide the least non-target impact at a particular site. In general, treatment at high tide will allow for better spray accuracy and access and will provide for greater dilution volume of herbicides. DBW crews will change nozzle type and spray pressures whenever conditions warrant, limiting the amount of herbicide which may inadvertently contact non-target species.

- **Mitigation Measure H2e** – Implement safety precautions on hot days to prevent heat illness.

  In addition to annual training on heat illness prevention, and compliance with CalOSHA's California Heat Illness Prevention Standard, DBW Field Supervisors will conduct special training sessions on days when weather is expected to be hot. This training will cover the symptoms of heat illness, and immediate actions to take should any symptoms occur. Field Supervisors will cancel treatments if the weather is exceptionally hot. The DBW will also provide bimini tops (shade covers) for WHCP treatment boats.

Impact H3 – Accidental spill: there is potential for the WHCP to create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment

A catastrophic spill of either 2,4-D or glyphosate could result in adverse impacts to human health due to exposure of concentrated herbicides. In concentrated form, WHCP herbicides could have acute toxic or corrosive effects if inhaled, ingested, or upon direct contact with skin. Such a spill could also result in adverse impacts to aquatic wetland and intertidal habitat and associated flora and fauna, including special status plants, fish, and wildlife. Impacts could occur to public water supplies, and agricultural production and operations following a spill. The degree of harm would depend on the amount and type of chemical spilled, environmental conditions (flow, tidal action, weather), and emergency response time.

The DBW's *WHCP Operations and Management Plan* (DBW 2008) identifies best management practices (BMP), including a Spill Contingency Plan (BMP #3). The BMP provides procedures for spill prevention, cleanup, and notification. The DBW follows these procedures to minimize the risk of spill, and to minimize the impact of a spill, should one occur. In 25 years of operation, there have not been any accidental spills of herbicide during WHCP operations.

Should an accidental spill of WHCP herbicides occur, it would represent a significant impact. The potential for the WHCP to result in an accidental spill is **an avoidable significant impact, reduced to a less-than-significant level by implementing the following mitigation measure.**

- **Mitigation Measure H3a (same as Mitigation Measure H2b)** – Follow best management practices to minimize the risk of spill, and to minimize the impact of a spill, should one occur.

  The best management practice includes several provisions to reduce the potential for spill, such as: fastening herbicide containers securely to boats in original, watertight containers; carrying a marker buoy and anchor line to mark any spills in water; reporting spills immediately to appropriate State and local agencies; immediately stopping movement of land spills using absorbing materials; marking and monitoring spills in water for herbicide residues and environmental impacts, if appropriate. Treatment crews will include at least one person with a Qualified Applicators Certificate (QAC), and all crew members will participate in annual training on herbicide handling procedures.

This section identified six mitigation measures to address three potential impacts related to hazards and hazardous materials. One mitigation measure is duplicative, as it applies to two impacts. Two of the mitigation measures, numbers 3 and 7, were also identified in Chapter 3. The remaining four mitigation measures apply specifically to hazards and hazardous materials. **Table 4-5,** below, combines and summarizes the hazards and hazardous materials mitigation measures.

Table 4-5
Summary of Potential Hazards and Hazardous Materials Impacts and Mitigation Measures

	Mitigation Measure Summary[1]	Mitigation Measure Number	Impacts Applied To	Same As Prior Mitigation Numbers
3.	Conduct herbicide treatment in order to minimize potential for drift	Mitigation Measure H2d	Impact H2: Treatment crew exposure	B1c; B2f
7.	Implement an adaptive management approach to minimize the use of herbicides	Mitigation Measure H2c	Impact H2: Treatment crew exposure	B2c; B4b
17.	Minimize public exposure to herbicide treated water	Mitigation Measure H1a	Impact H1: General public exposure	**New**
18.	Require treatment crews to participate in training on herbicide and heat hazards	Mitigation Measure H2a	Impact H2: Treatment crew exposure	**New**
19.	Follow best management practices to minimize the risk of spill, and to minimize the impact of a spill, should one occur	Mitigation Measure H2b Mitigation Measure H3a	Impact H2: Treatment crew exposure Impact H3: Accidental spill	**New**
20.	Implement safety precautions on hot days to prevent heat illness	Mitigation Measure H2e	Impact H2: Treatment crew exposure	**New**

[1] Please refer to the text for the complete mitigation measure description.

Chapter 5

Hydrology and Water Quality Impacts Assessment

5. Hydrology and Water Quality Impacts Assessment

This chapter analyzes the effects of the WHCP on hydrology and water quality. The chapter is organized as follows:

A. Environmental Setting

B. Impact Analysis and Mitigation Measures.

The environmental setting describes the hydrology and water quality status of the Delta. This discussion covers water quality requirements, surface water quality, surface water hydrology, Delta exports, and groundwater.

The impact analysis provides an assessment of the specific environmental impacts to hydrology and water quality potentially resulting from program operations. The discussion utilizes findings from WHCP environmental monitoring and research projects, technical information from scientific literature, government reports, relevant information on public policies, and program experience. The impact assessment is based on technical and scientific information.

For each of the potential WHCP impacts to hydrology and water quality we provide a description of the impact, analyze the impact, classify the impact level, and identify mitigation measures to reduce the impact level. The mitigation measures are specific actions that the DBW will undertake to avoid, or minimize, potential environmental impacts. The DBW has undergone, and will continue to undergo, consultation with various local, State, and federal agencies, including the Central Valley Regional Water Quality Control Board (CVRWQCB) regarding impacts and mitigation measures. Proposed mitigation measures may be revised, and/or additional mitigation measures incorporated, as a result of this ongoing consultation with regulatory agencies and water providers.

A. Environmental Setting

1. Water Quality Regulatory Setting

The State Water Resources Control Board (SWB) regulates water quality in California, through the federal Clean Water Act (CWA), and the Porter-Cologne Water Quality Control Act. The State Water Code gives Regional Water Boards primary responsibility for formulating and adopting water quality control plans in each of the State's nine regions.

There are two plans that jointly specify water quality controls for the Delta, the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan), and the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins. The Bay- Delta Plan, developed by the SWB, is

Table 5-1
Beneficial Uses in Delta Waters

Beneficial Use	Abbreviation
Municipal and domestic supply	MUN
Industrial service supply	IND
Industrial process supply	PRO
Agricultural supply	AGR
Groundwater recharge	GWR
Navigation	NAV
Water contact recreation	REC-1
Non-contact water recreation	REC-2
Shellfish harvesting	SHELL
Commercial and sport fishing	COMM
Warm freshwater habitat	WARM
Cold freshwater habitat	COLD
Migration of aquatic organisms	MIGR
Spawning, reproduction, and/or early development	SPWN
Estuarine habitat	EST
Wildlife habitat	WILD
Rare, threatened, or endangered species	RARE

complementary to the Basin Plan developed by the CVRWQCB. Water quality plans must also be approved by the USEPA.

Both plans consist of beneficial uses to be protected, water quality objectives, and a program for implementation of the water quality objectives. A primary goal of the water quality planning process is to identify and protect beneficial uses for surface and groundwater in a given region. **Table 5-1,** above, summarizes several of the beneficial uses for Delta waters.

Water quality objectives are "the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area" (Water Code Section 13050(h), in CVRWQCB 2007). In establishing water quality objectives, the Regional Water Boards must consider the following:

- Past, present, and probable future beneficial uses;
- Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto;
- Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area;
- Economic considerations;
- The need for developing housing within the region;
- The need to develop and use recycled water (Water Code Section 13241).

The SWB and Regional Water Boards refine their respective plans over time to take into account new water quality issues. The most recent Bay-Delta Plan was published in December 2006, and the most recent Basin Plan was published in October 2007. These plans specify surface water quality objectives for a range of categories, including: bacteria, biostimulatory substances, chemical constituents, color, dissolved oxygen, floating material, methylmercury, oil and grease, pH, pesticides, radioactivity, salinity, sediment, settleable material, suspended material, tastes and odors, temperature, toxicity, and turbidity. The Bay-Delta Plan identifies additional requirements for chloride, salinity, dissolved oxygen, delta outflow, river flows, and export limits. These Bay-Delta Plan water quality objectives are intended to protect municipal, industrial, agricultural, and fish and wildlife beneficial uses. The Bay-Delta Plan requirements supersede those of the Basin Plan.

One mechanism that the CVRWQCB uses to implement the Bay-Delta and Basin Plans is a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits are issued to entities that discharge to waterways, known as point source dischargers. In the 2001 Headwaters, Inc. v. Talent Irrigation case, the Ninth Circuit Court of Appeals held that discharges of pollutants from the use of aquatic pesticides to waters of the United States required coverage under a NPDES permit (CVRWQCB 2006). The DBW obtained an individual NPDES permit in March 2001, and operated under this permit until April 2006. In April 2006, the DBW applied to operate under the General NPDES Permit for the Discharge of Aquatic Pesticides for Aquatic Weed Control in Waters of the United States – General Permit No. CAG990005 (General Permit).

Since the Talent decision, there has been some confusion regarding the need to obtain an NPDES permit for aquatic pesticide use. In November 2006, the USEPA issued a regulation stating that application of a pesticide in compliance with relevant requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) does not require a NPDES permit when the application is made directly in waters to control pests in the water, or when the application of the pesticide is made to control pests that are over (or near) waters (Federal Register 2006). The rulemaking was based on the USEPA's interpretation of the term "pollutant" under the Clean Water Act.

In theory, this regulation eliminated the need for a NPDES permit for the WHCP. However, there were at least two legal challenges to this regulation, and SWB legal counsel recommended that the SWB not rescind their general NPDES permits related to aquatic pesticides (SWB 2007). The USEPA ruling did mean that agencies operating under the General Permit had the option to terminate their coverage by the General Permit. The DBW elected to maintain coverage under the General Permit until legal challenges to the ruling were resolved. In January 2009, an appeals court vacated the USEPA rule that had allowed pesticides to be applied to U.S. waters without a NPDES permit. This ruling does not change WHCP operations because DBW maintained permit coverage.

Key NPDES requirements for the WHCP are as follows:

- **Dissolved oxygen** – specific DO limits depend on the location and season, but range from 5.0 mg/l (ppm) to 8.0 mg/l (ppm). DO levels are not to drop below these levels as a result of WHCP treatments
- **Turbidity** – specific turbidity standards are not to increase above a specified number or percent of Nephelometric Turbidity Units (NTUs), depending on the initial level of natural turbidity. Generally, the WHCP shall not increase turbidity more than 10 to 20 percent
- **pH** – WHCP discharges shall not cause pH to fall below 6.5, or exceed 8.5, or change by more than 0.5 units
- **2,4-D residues** – maximum 2,4-D levels are based on EPA municipal drinking water standards, and shall not exceed 70 µg/l, or 70 ppb
- **Glyphosate residues** – maximum glyphosate levels are based on EPA municipal drinking water standards, and shall not exceed 700 µg/l, or 700 ppb
- **Adjuvant residues** – there are no specified limits for adjuvants; however, DBW is required to monitor adjuvant levels
- **Monitoring** – requires a monitoring protocol. Monitoring is required at 10 percent of sites treated, for each chemical and waterbody type. Sampling stations are identified as : "A" (where treatment occurred), "B" (downstream of the treatment area), and "C" (control, typically upstream). Sampling times are identified as: "1" (pre-treatment), "2" (immediately post-treatment), and "3" (within seven days after treatment). Thus, sample 2B is taken immediately post-treatment, downstream of the treatment location
- **Reporting** – the DBW is required to submit an annual report by March 1st of each year.

2. Surface Water Quality

The Bay-Delta Plan notes that "the Bay-Delta Estuary itself is one of the largest ecosystems for fish and wildlife habitat and production in the United States. Historical and current human activities (e.g. water development, land use, wastewater discharges, introduced species, and harvesting), exacerbated by variations in natural conditions, have degraded the beneficial uses of the Bay-Delta Estuary, as evidenced by the declines in populations of many biological resources of the Estuary" (SWB 2006).

Pollutants in Delta waterways include: pesticides (chlorpyrifos, DDT, diazinon, furan compounds, and Group A pesticides[1]), exotic species, mercury, salinity, dissolved oxygen, pathogens, and PCBs (CVRWQCB 2006). Potential sources of these pollutants include: agriculture, municipal point sources, urban runoff, storm sewers, resource extraction, and hydromodification. More recently, concerns have been raised about ammonia levels in the Delta. The CVRWQCB is working with researchers at San Francisco State University and the University of California, Davis, to evaluate the impact of ammonia in the Delta (CVRWQCB 2008).

While evidence of gross pollution in the Delta has been largely eliminated, the recent rapid growth in population and industrial activity in tributary areas has left some problems unsolved and has created new ones. Existing water quality problems may be categorized as 1) eutrophication and associated dissolved oxygen fluctuations, 2) suspended sediments and turbidity, 3) salinity, 4) toxic material, and 5) bacteria.

Pesticides are found in the water and bottom sediments throughout the Delta. The more persistent chlorinated hydrocarbon pesticides are consistently found at higher levels than the less persistent organophosphate compounds. Sediments in the western Delta have the highest pesticide content. Pesticides have concentrated in aquatic life, but long-term effects and the effects of intermittent exposure are not known. There are now concerns about the aquatic toxicity of pyrethroid-based pesticides, which are replacing organophosphorus pesticides such as diazinon and chlorpyrifos.

Bacteriological quality, as measured by the presence of coliform bacteria, varies depending on the proximity to waste discharges and significant runoff. The highest concentration of coliform organisms is generally in the western Delta and near major municipal waste discharges.

The most serious enrichment in the Delta is due to a high influx of nutrients. Enrichment problems in the Delta occur along the lower San Joaquin River and in certain areas receiving waste discharges but having little or no net freshwater flow. These problems occur mainly in the late summer and coincide with low streamflow, high temperature, and the harvest season when fruit and vegetable canneries are in full operation. Deepening channels for navigation has further depressed dissolved oxygen levels to the point that at times levels are insufficient to support aquatic life. In the fall, these circumstances, combined with reverse flows due to export pumping, have created conditions unsuitable for salmon passage through the Delta to spawning areas in the San Joaquin Valley.

Warm, shallow, dead-end sloughs of the eastern Delta support populations of potentially toxic planktonic blue-green algae during the summer. Floating, semi-attached and attached aquatic plants such as water primrose *(Ludwigia peploides),* water hyacinth *(Eichhornia crassipes),* hornwort or coontail *(Ceratophyllum demersum),* eurasian milfoil *(Myriophylum spicatum), an*d *Egeria densa* frequently clog Delta waterways during summer. Extensive growth of these plants interferes with small boat traffic and contributes to the total organic load as these plants break loose and move downstream in the fall and winter.

1 Group A pesticides include: aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane, endosulfan, and toxaphene.

Most Delta waters are turbid as a result of suspended silt, clay, and organic matter. Most of these sediments enter the Delta system with flow from major tributaries. Some enriched areas are turbid as a result of planktonic algal populations, but inorganic turbidity tends to suppress nuisance algal populations in much of the Delta. Continuous dredging to maintain deep channels for shipping also has contributed to turbidity and has been a significant factor in the temporary destruction of bottom organisms through displacement and suffocation.

Salinity control is necessary in the Delta because it is contiguous with the ocean and its channels are at, or below, sea level. Unless repelled by continuous seaward flow of fresh water, ocean water will advance up the estuary and degrade water quality. During winter and early spring, flows through the Delta are usually above the minimum required to control salinity (described as “excess water conditions”). At least for a few months in summer and during the fall of most years, however, salinity must be carefully monitored and controlled for “balanced water conditions”. The Central Valley Project and State Water Project monitor and control salinity, and salinity levels are regulated by the State Water Resources Control Board under its water right authority (through the Bay-Delta and Basin Plans). There are concerns that Delta salinity is increasing as more water is diverted through the SWP and CVP.

Salinity intrusion is a problem mainly during years of below-normal runoff, although in recent years with higher export levels, salinity has also been a concern. The degree of seawater intrusion into the Delta, and thus one source of salinity, is a result of daily tidal fluctuations, freshwater inflow to the Delta from the Sacramento and San Joaquin Rivers, the rate of export at the SWP and CVP intake pumps, and the operation of various control structures such as the Delta Cross-Channel Gates and Suisun Marsh Salinity Control System (USBR 2003).

In the eastern Delta salinity is largely associated with agricultural drainage and the high concentration of salts carried by the San Joaquin River. The Banks and Jones pumping plant operations draw high quality Sacramento River water across the Delta and restrict the low quality area to the southeastern corner. In areas such as dead-end sloughs, irrigation returns cause localized problems. In the western Delta, incursion of saline water from San Francisco Bay is one of the main water quality problems.

Another concern is that Delta water contains trihalomethane (THM) precursors. THMs are suspected carcinogens produced when chlorine used for disinfection reacts with natural substances during the water treatment process. Dissolved organic compounds that originate from decayed vegetation act as precursors by providing a source of carbon in THM formation reactions. During periods of reverse Delta flow, bromides from the ocean mix with Delta water at the western edge of Sherman Island. When bromides occur in water along with organic THM precursors, THMs are formed that contain bromine as well as chlorine. Drinking water supplies taken from the Delta are treated to meet THM standards, set at 0.080 mg/l, MRDL (maximum residual disinfectant level (USBR 2003). Contra Costa Water District (CCWD) reports that bromide in the Delta is 6.5 times above the national average (Taugher 2005). To reduce THM formation, CCWD has reduced the amount of chlorine used in their treatment process.

3. Surface Water Hydrology

Prior to the mid-1800s, the Delta was a floodplain consisting of marshes and tidal channels. Beginning around the 1850s, European settlers constructed levees to reclaim marshes and floodplains for farming. There are approximately 1,100 miles of levees in the Delta.

Table 5-2
Delta Water Balance in Million Acre Feet (MAF) (1998, 2000, 2001)

	Inflows to Delta					Outflows from Delta			
Type Year	Precipitation	Sacramento River	San Joaquin River	Other	Total	In-Delta Consumption	Exports	Outflow to SF Bay	Total
Wet – 1998	1.42	37.94	8.44	2.09	49.89	1.69	4.78	43.42	49.89
Average – 2000	0.95	21.28	2.84	1.08	26.15	1.69	6.32	18.14	26.15
Dry – 2001	0.76	10.87	1.73	.37	13.73	1.69	5.08	6.96	13.73

Source: URS Corporation 2007, p.18

The Sacramento and San Joaquin Rivers unite at the western end of the Delta at Suisun Bay. Over 40 percent of the State's runoff drains into the Delta. The Sacramento River contributes roughly 80 percent of the Delta inflow in most years, the San Joaquin River contributes 15 percent, with the remaining 5 percent of flows contributed from the Mokelumne, Cosumnes, and Calaveras rivers. From Suisun Bay, water flows through Carquinez Strait into San Pablo Bay (the northern half of San Francisco Bay) and then through the Golden Gate to the Pacific Ocean.

Most of the Delta is subject to tidal action with mean fluctuations of approximately two to three feet. This tidal influence is important throughout the Delta. Historically, when mountain runoff dwindled during the summer, ocean water intruded upstream as far as Sacramento. During winter and spring, fresh water from heavy rains pushed the salt water back, sometimes past the mouth of San Francisco Bay.

With the addition of Shasta, Folsom, and Oroville dams, salt water intrusion during summer has been controlled by reservoir releases. Peaks in winter and spring flows have been dampened, and summer and fall flows have been increased. The result is relatively consistent salinity levels in the Delta throughout the year. However, in very wet years reservoirs are unable to control runoff, so during the winter and spring the upper bays become fresh and even the upper several feet of water at the Golden Gate can be fresh.

On average, about 26 million acre-feet of water reaches the Delta annually, but actual inflow varies widely from year-to-year and within the year (DWR 2005). **Table 5-2,** above, provides the Delta water balance for wet, average, and dry years. There is even greater variation between extreme water years. For example, in 1977, a year of extraordinary drought, Delta inflow totaled only 5.9 million acre-feet. Inflow for 1983, an exceptionally wet year, was about 70 million acre-feet. On a seasonal basis, average natural flow to the Delta varies by a factor of more than 10 between the highest month in winter or spring and the lowest month in fall. Because of the large tidal flows compared to inflows, outflow must be calculated rather than measured. Calculated outflows are reasonably accurate on time scales longer than a few weeks but not at all accurate for shorter periods.

Delta hydraulics are complex. The influence of the tide is combined with freshwater outflow, resulting in flow patterns that vary daily. Inflow varies seasonally and is affected by upstream diversions. Hydraulics are further complicated by a multitude of agricultural, industrial, and municipal diversions for use in the Delta itself and by exports for the CVP and SWP. The primary factors currently influencing Delta hydrodynamic conditions are: river inflow from the Sacramento and San Joaquin Rivers;

daily tidal inflow and outflow through the San Francisco Bay, and export pumping from the south Delta through the Harvey O. Banks Pumping Plant and the C.W. "Bill" Jones Pumping Plant (USBR 2003). Delta hydraulics are likely to be further modified in the future due to climate change, sea level rise, and risk of levee failure.

4. Delta Exports

The CVP, operated by the U.S. Bureau of Reclamation, and the SWP, operated by the Department of Water Resources, coordinate operations to manage the flow of water into, and out of, the Delta. Both agencies monitor and manage releases from upstream reservoirs and export pumping at the SWP Banks and CVP Jones pumping plants (DWR 2005).

To minimize water level fluctuation caused by the SWP intake along Old River, Clifton Court Forebay is operated so water is drawn through the gates at high tides and the gates are closed at low tides. This operation provides a more constant head for the pumps and allows the Department of Water Resources to maintain optimum velocities in the channel and across the fish screens. The CVP draws water directly from the channels over the entire tidal cycle, resulting in a continuous flow toward the Jones Pumping Plant whenever it is operating.

Operational changes of the SWP and CVP can affect flow in the lower San Joaquin River along Sherman Island. When outflow is low, increases in export and internal use results in a net reverse flow in this portion of the river, so that net movement of water is upstream toward the pumps. Although they are small in relation to tidal flows, there is concern that net reverse flows may harm fish, including salmon, steelhead, delta smelt, and planktonic eggs and larvae of striped bass.

The CVP can pump a maximum of 4,600 cubic feet per (cfs) second into the Delta-Mendota Canal. This is equivalent to a maximum annual export volume of 3.33 million acre-feet, however, CVP export has historically averaged approximately 2.5 million acre-feet per year (DWR 2006). Adding the Contra Costa Canal brings the CVP export capacity to 4,900 cfs. The SWP can pump 10,300 cfs at Banks Pumping Plant (up to 4.2maf annually, but an agreement with the U.S. Army Corps of Engineers limits pumping to 6,680 cfs).

The SWP typically exports approximately 3 million acre-feet per year. Pumping at both facilities was curtailed to levels thought to be more protective of Delta fish in December 2007 under an order by federal Judge Oliver Wanger. Judge Wanger also required the USBR and DWR to obtain a new biological opinion from the USFWS for the Operation and Criteria Plan for the SWP and CVP. Although significant changes to export mechanisms in the Delta are unlikely for many years, there are several initiatives to evaluate around-Delta export mechanisms (see Chapter 7 for additional discussion).

5. Groundwater

The groundwater hydrology of the Sacramento-San Joaquin Delta, as with the geology, is contiguous with that of the Sacramento River Basin. Large amounts of water are stored in thick sedimentary deposits in the Sacramento Valley groundwater basin. Groundwater is used intensively in some areas but only slightly in areas where surface water supplies are abundant.

Groundwater occurs in various degrees of confinement in the Sacramento Valley basin. Groundwater is generally unconfined in the relatively shallow alluvial fan, flood plain, and stream channel deposits and partially confined in and under the flood basin deposits. In the older Pleistocene and Pliocene formations, especially at deeper levels, water is confined beneath impervious thick clay and mudflow strata.

Groundwater levels fluctuate according to supply and demand on daily, seasonal, annual, and even longer bases. Short-term and long-term water level changes have been recorded for wells since the first documented measurements in 1929. In the low-lying central portion of the Sacramento Valley Basin, from the Delta north to Glenn and Butte counties, depth to water in wells is 10 feet or less.

Groundwater is replenished through deep percolation of streamflow, precipitation, and applied irrigation water. Recharge by subsurface inflow is negligible compared to other sources. Groundwater quality is generally excellent throughout the area and is suitable for most uses, although at shallow depths within the Delta the water is often saline.

B. Impact Analysis and Mitigation Measures

For purposes of this analysis, we considered an impact to hydrology and water quality to be significant and require mitigation if it would result in any of the following:

- Violate any water quality standards or waste discharge requirements
- Substantially alter the existing drainage pattern of the site or area in a manner which would result in substantial erosion or siltation on- or off-site
- Substantially alter the existing drainage pattern of the site or area in a manner which would result in flooding on- or off-site
- Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff
- Otherwise substantially degrade water quality
- Otherwise substantially degrade drinking water quality
- Place housing within a 100-year flood hazard area
- Place structures which would impede or redirect flood flows within a 100-year flood hazard area
- Expose people or structures to a significant risk of loss, injury, or death involving flooding
- Inundation by seiche, tsunami, or mudflow.

Table 5-3, on the next page, provides a summary of the potential WHCP impacts for hydrology and water quality significance areas which could potentially be affected. Table 5-3 also explains potential benefits, and those hydrology and water quality significance areas in which there will be no impacts. We discuss potential impacts of the WHCP on water intake pump systems in Chapter 6.

The first three potential impacts, Impact W1: Chemical constituents; Impact W2: Pesticides; and Impact W3: Toxicity; are closely related. We discuss each of these potential impacts and their mitigation measures separately. However, to minimize duplication, within one particular impact, we may reference discussions within either of the other two related impacts. In addition, we reference more detailed discussions of Biological Resource impacts related to herbicide toxicity in Chapter 3.

Impact W1 – Chemical constituents: following WHCP herbicide treatment, waters may potentially contain chemical constituents that adversely affect beneficial uses, violating water quality standards or otherwise substantially degrading water quality or drinking water quality

WHCP herbicide treatments involve spraying chemical constituents onto water hyacinth plants growing in the Delta and its tributaries. Anderson (1982) determined that 10 to 20 percent of herbicide reaches the water following water hyacinth treatment, either moving through the water hyacinth mat, or as a result of drift. This herbicide is considered a chemical constituent in the water.

Table 5-3
Crosswalk of Hydrology and Water Quality Significance Criteria, Impacts, and Benefits of the WHCP

Page 1 of 2

	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
a) Violate any water quality standards or waste discharge requirements?						Removal of water hyacinth through WHCP efforts could improve Delta water quality so that measurements are more closely aligned with standards (e.g. increased dissolved oxygen, and reduced fragments)
Impact W1: Chemical constituents	3, 6, 7, 21	**[X]**				
Impact W2: Pesticides	1, 3, 4, 6, 7, 21	**[X]**				
Impact W3: Toxicity	1, 3, 4, 6, 7, 21	**[X]**				
Impact W4: Dissolved oxygen levels	9, 10, 11, 12	**[X]**				[X]
Impact W5: Floating material	13, 21, 22		**[X]**			[X]
Impact W6: Turbidity	4			[X]		
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?					WHCP will not deplete groundwater supplies or interfere substantially with groundwater recharge	
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?					WHCP will not alter the existing drainage pattern of the site or area in a manner which would result in erosion or siltation on- or off-site	
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?					WHCP will not alter the existing drainage pattern of the site or area, or increase the rate of runoff, in a manner which would result in flooding on- or off-site	
e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?					WHCP will not create or contribute runoff water or provide additional sources of polluted runoff	

Table 5-3
Crosswalk of Hydrology and Water Quality Significance Criteria, Impacts, and Benefits of the WHCP *(continued)*

Page 2 of 2

	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
f) Otherwise substantially degrade water quality?						Removal of water hyacinth through WHCP efforts could improve Delta water quality so that measurements are more closely aligned with standards (e.g. increased dissolved oxygen, and reduced fragments). The WHCP will also improve several beneficial uses of Delta waterways
Impact W1: Chemical constituents	3, 6, 7, 21	**[X]**				
Impact W2: Pesticides	1, 3, 4, 6, 7, 21	**[X]**				
Impact W3: Toxicity	1, 3, 4, 6, 7, 21	**[X]**				
Impact W4: Dissolved oxygen levels	9, 10, 11, 12	**[X]**				[X]
Impact W5: Floating material	13, 21, 22		**[X]**			[X]
Impact W6: Turbidity	4			[X]		
g) Otherwise substantially degrade drinking water quality?						
Impact W1: Chemical constituents	3, 6, 7, 21	**[X]**				
Impact W2: Pesticides	1, 3, 4, 6, 7, 21	**[X]**				
Impact W3: Toxicity	1, 3, 4, 6, 7, 21	**[X]**				
h) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?					WHCP will not place housing within a 100-year flood hazard area	
i) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?					WHCP will not place structures within a 100-year flood hazard area	
j) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?					WHCP will not expose people or structures to risk of loss, injury, or death involving flooding	
k) Inundation by seiche, tsunami, or mudflow?					WHCP will not result in inundation by seiche, tsunami, or mudflow	

Table 5-4
Post-Treatment Water Samples Collected for Residue Analysis from Inside Treatment Area and Downstream from Treatment Area (2001 to 2005)

Chemical	Number of Samples		Percent of Samples		Minimum Detected Residue (ppb)	Maximum Detected Residue (ppb)	Mean Residue (ppb)[a]	Median Residue (ppb)[a]	Number of Samples Exceeding MCL
	Tested	Non-Detectable (ND)	ND	Detected					
2,4-D	149	27	18.1%	81.9%	0.10	867.0	20.18	1.40	6
Glyphosate	70	52	74.3	25.7	9.80	246.0	15.88	0.50	0
Total	219	79	36.1%	63.9%					6

[a] Non-detected samples were given a value of 0.50ppb, one half of difference between 0 ppb and the 1.0 ppb limit of detection.

The Basin Plan water quality objectives related to chemical constituents are as follows: *"Waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses… At a minimum, water designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs) specified in the following provisions of Title 22 of the California Code of Regulations…"* (CVRWQCB 2007). The relevant MCL levels for the WHCP are:

- 70 ppb or µg/l for 2,4-D
- 700 ppb or µg/l for glyphosate.

For purposes of compliance with these MCLs, the relevant chemical concentrations are in receiving waters, e.g., waters downstream of the treatment site. We briefly discuss the potential for the WHCP to result in chemical constituents, below. Refer to Chapter 3, Impact B2, for a more detailed description of calculated and actual maximum herbicide and adjuvant levels immediately following WHCP treatments. Chapter 3, Impact B2, also includes a discussion of the fate of WHCP herbicides in water.

WHCP monitoring results provide data on actual herbicide residue levels following treatments. Between 2001 and 2005, DBW obtained chemical residue tests on 219 post-treatment water samples, collected inside, and downstream of, treatment areas. Samples were obtained from 48 different sites, and throughout the treatment season (for both chemicals at some sites). **Table 5-4,** above, summarizes these results. Over the five year period, only six of the 149 2,4-D samples (4 percent) were above the MCL of 70 ppb. None of the 70 glyphosate samples were above the MCL of 700 ppb.

Over the last three years of environmental monitoring (2006 to 2008), DBW monitored receiving waters directly downstream of the treatment site, immediately after treatment. As in previous years, environmental scientists also returned to each site two to seven days later to sample upstream, within, and downstream of the treatment site. Over the three year period, DBW conducted 36 sampling events for 2,4-D, and 21 sampling events for glyphosate. All 57 samples of the adjuvant Agridex® were at non-detectable levels.

None of the 2,4-D samples were above the MCL of 70 ppb, and the highest 2,4-D sample was significantly lower than 70 ppb, at 16.3 ppb. None of the glyphosate samples were above the MCL of 700 ppb, and the highest glyphosate sample was also significantly lower than 700 ppb, at 21 ppb. In both cases, given the time and location of sampling, it was unlikely that these highest sample readings were even a result of WHCP treatments, but rather were due to ambient herbicide levels in Delta waters.

The calculated, test plot, and actual WHCP herbicide levels indicate that 2,4-D, glyphosate, and adjuvant levels in the Delta following herbicide treatment are low. Maximum 2,4-D levels immediately following spraying within a treatment site may reach levels as high as 800 ppb, although this was extremely rare. Maximum 2,4-D levels immediately downstream of the site are likely to be less than 10 ppb. Maximum glyphosate levels within a treatment site, immediately after spraying, may reach as high as 158 ppb, but are likely to be less than 30 ppb. Maximum glyphosate levels immediately downstream are likely to be less than 2 ppb. Herbicides may remain at these maximum levels for a relatively short period of time (for example, the downstream sampling typically occurs within one hour of treatment).

The potential for WHCP herbicide treatments to be present in water at concentrations that would adversely affect beneficial uses, or result in violations of MCL levels is low. However, should WHCP herbicide levels occur at such concentrations, it would constitute an **unavoidable or potentially unavoidable significant impact.** This impact would potentially be reduced by implementing the following four mitigation measures.

- **Mitigation Measure W1a (same as Mitigation Measures B2b; B4a; and W1a)** – Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters.

  The DBW will conduct comprehensive monitoring. This monitoring is in compliance with the general NPDES permit, and NOAA-Fisheries and USFWS Biological Opinions. The DBW will collect samples prior to treatment, immediately after treatment, and post-treatment within one week of spraying. The DBW will conduct water quality monitoring for visual parameters, physical parameters, and chemical parameters at ten (10) percent of the sites it treats for each pesticide, per water body type. Water samples will be submitted to a certified analytical laboratory to measure 2,4-D, glyphosate, and adjuvant levels. Should these levels exceed allowable limits, DBW will take immediate measures to reduce chemical levels at future treatment sites.

- **Mitigation Measure W1b** – Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities.

  The MOU is an agreement between CCWD and DBW. Generally, no applications shall occur within Rock Slough, or within one mile of the confluence of Rock Slough and Old River, or within one mile of CCWD's Old River or Mallard Slough intake pumps without consensual agreement between CCWD and DBW. Herbicide applications within one mile of CCWD's water intakes may only occur with prior consent of CCWD. In order to treat within one mile of an intake, DBW must notify CCWD at least two weeks in advance, and make every reasonable attempt to schedule applications during periods when CCWD's intakes are shut down for environmental or maintenance reasons, allowing at least two complete tidal cycles between application and restart. This measure is primarily aimed at reducing the potential for drinking water contamination from the WHCP.

- **Mitigation Measure W1c (same as Mitigation Measures B2c; B4b; and H2c)** – Implement an adaptive management approach to minimize the use of herbicides.

  Under an adaptive management approach, DBW will seek to improve efficacy and reduce environmental impacts over time as new and better information is available. Specifically, DBW will evaluate the need for control measures on a site by site month to month basis; select appropriate indicators for pre-treatment monitoring; monitor indicators following treatment and evaluate data to determine program efficacy and environmental impacts; support ongoing research to explore impacts of the WHCP and alternative control methodologies; report findings to regulatory agencies; and adjust program actions, as necessary, in response to recommendations and evaluations by regulatory agencies and stakeholders.

In addition to this adaptive management approach, DBW will follow maintenance control practices that seek to reduce the number of acres of water hyacinth to be treated each year, until treatment acreage reaches a minimal level. This will reduce the volume of herbicide utilized by the WHCP.

- **Mitigation Measure W1d (same as Mitigation Measures B1c; B2f; and H2d) –** Conduct herbicide treatments in order to minimize potential for drift.

  In addition to following the label requirements, DBW will, to the degree possible, schedule herbicide applications to occur at high tide, or at a point in the tidal cycle determined by the field supervisor to provide the least non-target impact at a particular site. In general, treatment at high tide will allow for better spray accuracy and access and will provide for greater dilution volume of herbicides. DBW crews will change nozzle type and spray pressures whenever conditions warrant, limiting the amount of herbicide which may inadvertently contact non-target species or enter the water.

Impact W2 – Pesticides: following WHCP herbicide treatment pesticides may potentially be present in concentrations that adversely affect beneficial uses, violating water quality standards or otherwise substantially degrading water or drinking water quality

WHCP herbicide treatments entail spraying of 2,4-D, glyphosate, and adjuvants on water hyacinth plants located in Delta and tributary waterways. These treatments have the potential to adversely affect beneficial uses, violating water quality standards or otherwise substantially degrading water or drinking water quality. The following water quality objectives for pesticides are potentially relevant to the WHCP:

- *"No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses.*
- *Discharges shall not result in pesticide concentrations in bottom sediments or aquatic life that adversely affect beneficial uses.*
- *Pesticide concentrations shall not exceed those allowable by applicable antidegradation policies (see State Water Resources Control Board Resolution No. 68-16 and 40 C.F.R. Section 131.12).*
- *Pesticide concentrations shall not exceed the lowest levels technically and economically achievable.*
- *Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of pesticides in excess of the Maximum Contaminant Levels set forth in California Code of Regulations, Title 22, Division 4, Chapter 15" (CVRWQCB 2007).*

Below, we discuss these five water quality objectives and the potential for WHCP herbicide treatments to adversely affect beneficial uses related to these objectives. Several of these potential impacts are discussed in Chapter 3, and for Impacts W1 and W3.

Presence of WHCP Herbicides in Concentrations that Adversely Affect Beneficial Uses

The beneficial uses that are most likely to be affected by WHCP herbicide treatments are MUN, AGR, WARM, COLD, WILD, BIOL, RARE, MIGR, and SPWN. As noted above under Impact W1, the potential for WHCP herbicides to be present in concentrations that would affect MUN beneficial uses (e.g. to exceed the MCLs) is low. As noted in Chapter 6, the potential for WHCP herbicides to be present in concentrations that would affect AGR beneficial uses are avoidable, and can be mitigated to a less-than significant level.

The potential for WHCP herbicide treatments to impact the biological resource beneficial uses, WARM, COLD, WILD, RARE, MIGR, and SPWN are discussed in Chapter 3. These impacts represent unavoidable or potentially unavoidable impacts that could adversely affect beneficial uses. Below, and in Chapter 3, we identify a number of mitigation measures that can reduce these potential impacts to biological resource beneficial uses.

Presence of WHCP Herbicides in Bottom Sediments or Aquatic Life

WHCP herbicides are not considered to bioaccumulate in aquatic plant or animal life forms. Both herbicides are excreted and/or metabolized following exposure. We discuss the potential for WHCP herbicide bioaccumulation in Chapter 3, Impact B3. In Chapter 3, we determined that the impact of bioaccumulation of WHCP herbicides on special status species is expected to be less than significant. Similarly, the potential for WHCP herbicides to be present in any other aquatic life forms in concentrations that would adversely affect beneficial uses is less than significant.

Herbicide characteristics related to sediment are not necessarily the same as herbicide characteristics related to bioaccumulation. Glyphosate and 2,4-D exhibit very different characteristics in sediment, however neither herbicide is likely to accumulate in sediment, or to result in toxic effects to species present in sediment. The potential for WHCP herbicide treatments to result in concentrations that would adversely affect beneficial uses is less than significant.

The soil adsorption coefficient, K_{OC}, for 2,4-D is relatively low, at 48 μg/g (University of California 2005).This means that 2,4-D does not persist in soil or sediments. The half life of 2,4-D in soil is also relatively short, at 10 days (University of California 2005). The major method of 2,4-D breakdown in soil is microbial degradation (Walters 1999).

Glyphosate binds strongly to soil and sediment and becomes biologically unavailable (Monsanto 2002; Monsanto 2005). The soil adsorption coefficient for glyphosate , K_{OC}, is 24,000 μg/g (University of California 2005). This is one of the highest K_{OC} values among pesticides, and indicates extremely strong binding to sediments. The half life of glyphosate in soil is 47 days (University of California 2005). Once bound to sediments, glyphosate does not move back into the water, but is degraded by soil microbes and fungi to aminomethylphosphonic acid (AMPA), and then carbon dioxide and phosphate. AMPA also strongly adsorbs to soil (NPTN 2000), and is characterized as having little toxicity to non-target organisms (Monsanto 2005).

Presence of WHCP Herbicides in Concentrations that Exceed Applicable Antidegradation Policies

In 1968, the SWB passed Resolution 68-16, *Statement of Policy with Respect to Maintaining High Quality Water in California* (SWB 1968, CVRWQCB 2007). This resolution addresses the USEPA Clean Water Act requirement to adopt an “antidegradation” policy. The goal of the policy is to maintain high quality waters. This policy generally restricts Regional Water Boards and dischargers from reducing the water quality of surface or groundwaters even though such a reduction in water quality might still allow the protection of beneficial uses associated with the water (CVRWQCB 2007).

The waters of the Delta and its tributaries within the WHCP project area are not high quality waters. Significant portions of the Delta and its tributaries are considered impaired due to pesticides, dissolved oxygen, salinity, mercury, exotic species, pathogens, and other discharges. If antidegradation policies did apply in the Delta, the relatively small volumes of WHCP herbicides, applied annually to 200 to 2,500 of the Delta's 50,000 water acres, would be extremely unlikely to exceed any such antidegradation policies.

Presence of pesticides at levels that shall not exceed the lowest levels technically and economically achievable

Through their adaptive management approach and maintenance control (see Mitigation Measure W2c), DBW seeks to minimize the amount of herbicide utilized in the WHCP. Thus, the WHCP will not result in pesticide levels in the Delta and tributaries that exceed the lowest levels technically and economically achievable.

Presence of WHCP Herbicides in Concentrations in Excess of MCLs

The potential for WHCP herbicide treatments to exceed MCLs is discussed extensively under Impact W1, above, and in Chapter 3, Impact B2. The potential for WHCP herbicides to be present in concentrations in excess of MCLs of 70 ppb for 2,4-D, and 700 ppb for glyphosate, is low.

Pesticides present in Delta waters following WHCP herbicide treatments are unlikely to bioaccumulate in species or accumulate in sediment, are unlikely to affect antidegradation policies, and are unlikely to be present in concentrations that exceed MCLs. The DBW will not apply WHCP herbicides at levels that exceed the lowest levels technically and economically achievable.

It is also unlikely that pesticide concentrations resulting from WHCP herbicide treatments will adversely affect beneficial uses, violate water quality standards, or otherwise substantially degrade water or drinking water quality. However, should such concentrations result, it would represent **an unavoidable or potentially unavoidable significant impact.** This impact would be reduced by implementing the following six mitigation measures.

- **Mitigation Measure W2a (same as Mitigation Measures B1a; B2d; B4c; and B6a)** – Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources.

  Each year, prior to the start of the treatment season, DBW will conduct field crew environmental awareness training. Under this training, crews will be informed about the presence and life histories of special status species, habitats associated with species, sensitive habitats and wetlands, the terms and conditions of the program's biological opinions, incidental take procedures, and that unlawful take of an animal or destruction of its habitat is a violation of the Endangered Species Act. The DBW will provide crews with a field guide (Species Identification Deck) for easy identification of special status species on site. Prior to treating a site, crews will conduct a visual survey to determine whether special status plants, animals, or sensitive habitats are present. Crews will complete an Environmental Observations Checklist for each site to document the presence or absence of special status species. If any special status species or sensitive habits are present at the site, the field crew will not perform the treatment.

- **Mitigation Measure W2b (same as Mitigation Measures B3b; B4a; and W1a) -** Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters.

The DBW will conduct comprehensive monitoring. This monitoring is in compliance with the general NPDES permit, and NOAA-Fisheries and USFWS Biological Opinions. The DBW will collect samples prior to treatment, immediately after treatment, and post-treatment within one week of spraying. The DBW will conduct water quality monitoring for visual parameters, physical parameters, and chemical parameters at 10 percent of the sites it treats for each pesticide, per water body type. Water samples will be submitted to a certified analytical laboratory to measure 2,4-D, glyphosate, and adjuvant levels. Should these levels exceed allowable limits, DBW will take immediate measures to reduce chemical levels at future treatment sites.

- **Mitigation Measure W2c (same as Mitigation Measures B2c; B4b; H2c; and W1c)** - Implement an adaptive management approach to minimize the use of herbicides.

  Under an adaptive management approach, DBW will seek to improve efficacy and reduce environmental impacts over time as new and better information is available. Specifically, DBW will evaluate the need for control measures on a site by site basis; select appropriate indicators for pre-treatment monitoring; monitor indicators following treatment and evaluate data to determine program efficacy and environmental impacts; support ongoing research to explore the impacts of the WHCP and alternative control methodologies; report findings to regulatory agencies; and adjust program actions, as necessary, in response to recommendations and evaluations by regulatory agencies and stakeholders. In addition to this adaptive management approach, DBW will follow maintenance control practices that seek to reduce the number of acres of water hyacinth to be treated each year, until treatment acreage reaches a minimal level. This will reduce the volume of herbicide utilized by the WHCP.

- **Mitigation Measure W2d (same as Mitigation Measure W1b)** - Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities.

  The MOU is an agreement between CCWD and DBW. Generally, no applications shall occur within Rock Slough, or within one mile of the confluence of Rock Slough and Old River, or within one mile of CCWD's Old River or Mallard Slough intake pumps without consensual agreement between CCWD and DBW. Herbicide applications within one mile of CCWD's water intakes may only occur with prior consent of CCWD. In order to treat within one mile of an intake, DBW must notify CCWD at least two weeks in advance, and make every reasonable attempt to schedule applications during periods when CWD's intakes are shut down for environmental or maintenance reasons, allowing at least two complete tidal cycles between application and restart. This measure is primarily aimed at reducing the potential for drinking water contamination from WHCP herbicide treatments.

- **Mitigation Measure W2e (same as Mitigation Measures B1c; B2d; H2d; and W1d)** – Conduct herbicide treatments in order to minimize potential for drift.

  In addition to the label requirements noted above, DBW will, to the degree possible, schedule herbicide applications to occur at high tide, or at a point in the tidal cycle determined by the field supervisor to provide the least non-target impact at a particular site. In general, treatment at high tide will allow for better spray accuracy and access and will provide for greater dilution volume of herbicides. DBW crews will change nozzle type and spray pressures whenever conditions warrant, limiting the amount of herbicide which may inadvertently contact non-target species.

- **Mitigation Measure W2f (same as Mitigation Measures B1d and B6b)** – <u>Operate program vessels in a manner that causes the least amount of disturbance to the habitat</u>.

  Operational procedures for DBW vessels will minimize boat wakes and propeller wash. These procedures will be particularly important in shallow water, or other sensitive habitats.

* * * * *

Pesticide applications in the Delta and its tributaries, through the WHCP, are intended to result in improvements to a number of beneficial uses. One of the causes of impaired use in the Delta and its tributaries is exotic species, including water hyacinth. The goal of the WHCP is to keep waterways safe and navigable by controlling the growth and spread of water hyacinth.

By reducing the amount of water hyacinth clogging pumps and intake pipes, the WHCP will improve municipal and domestic supply (MUN), industrial service supply (IND), and agricultural supply (AGR) beneficial uses. These benefits are discussed in Chapter 6, and below under Impact W5.

By reducing the amount of water hyacinth clogging Delta and tributary waterways, the WHCP will improve navigation (NAV), and recreation beneficial uses (REC-1 and REC-2). By removing monospecific mats of water hyacinth from Delta and tributary waterways, the WHCP will result in increased DO levels, and improved native habitats for aquatic species. Control of water hyacinth in Delta waterways expands habitat suitable for native species. These benefits, discussed in more detail under Impact W4, and in Chapter 3, will result in improvements to warm freshwater habitat (WARM), cold freshwater habitat (COLD), migration of aquatic organisms (MIGR), spawning, reproduction, and/or early development (SPWN), and estuarine habitat (EST) beneficial uses.

Impact W3 – Toxicity: following WHCP herbicide treatment toxic substances may potentially be found in waters in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life, violating water quality standards or otherwise substantially degrading water or drinking water quality

Application of WHCP herbicides to Delta waters and tributaries could result in concentrations of chemicals that produce toxic responses. The water quality objectives for toxicity are as follows:

> *"All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. The objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances. Compliance with this objective will be determined by analyses of indicator organisms, species diversity, population density, growth anomalies, and biotoxicity tests of appropriate duration or other methods as specified by the Regional Water Board" (CVRWQCB 2007).*

In response to the SWB's initial interim NPDES permit for aquatic pesticides, prepared in 2001 (Order 2001-12-DWQ), Waterkeepers Northern California filed a lawsuit against the SWB. As part of the settlement with Waterkeepers Northern California, the SWB agreed to fund a comprehensive aquatic pesticide monitoring program to assess toxicity of pesticides in receiving water following aquatic pesticide treatments. The SWB contracted with the San Francisco Estuary Institute (SFEI) to conduct the study. In their 2004 study, SFEI found no toxicity for the two WHCP herbicides, 2,4-D and glyphosate.

DBW monitoring, and a review of scientific literature, as discussed in Chapter 3, Impact B2, also found no evidence of acute toxicity at herbicide levels likely to be present following WHCP treatments. As discussed in Chapter 3, there is some evidence of potential sublethal effects on aquatic species, although data are not conclusive.

At the concentrations at which they will be applied, WHCP herbicides are known to be toxic to plants and algae. The method of action of 2,4-D and glyphosate on plants is discussed in Chapter 3, Impact B1. Any broadleaf vegetation subject to overspray is vulnerable to 2,4-D activity. Exposure of any non-target plant to glyphosate could result in loss of plant species.

The potential for impacts resulting from herbicide overspray depend on the amount of exposure, concentration of herbicide, and proximity of sensitive habitats, wetlands, and plants. One study found that only three to four percent of 2,4-D droplets drift beyond the target zone, and no significant amount of material is collected as drift (HSDB 2001). Blankenship and Associates (2004) found that using conservative application rates, detectable adverse effects could result from less than one percent spray drift of glyphosate or 2,4-D.

The concentration of active ingredient (2,4-D or glyphosate) leaving the spray nozzle is high enough (ranging from 600 ppm to 4,800 ppm) to cause adverse effects. Thus, there is the potential that uncontrolled herbicide overspray could affect nearby non-target vegetation.

Treatment of water hyacinth could result in loss of native submerged aquatic vegetation growing in and around treatment areas. While loss of non-target plant species could constitute a significant impact under certain conditions, it is expected to be less than significant for the WHCP. Dense canopies of water hyacinth reduce light levels for submerged plant photosynthesis and thus can effectively shade out native vegetation. The benefit to native submerged aquatic vegetation from removal of water hyacinth is expected to outweigh any losses due to herbicide toxicity.

While there is a potential toxic risk to plants due to herbicide overspray, the likelihood of such effects occurring is low. Herbicide application will be focused directly on target plants to decrease the possibility that concentrated herbicides will come in contact with non-target plants. The DBW will follow herbicide label application instructions that reduce herbicide drift. These steps include using the largest size spray droplets, and lowest spray pressure, that will provide sufficient coverage and control. Furthermore, DBW will not treat at a particular site if the wind is greater than 10 mph (or 7 mph in Contra Costa County).

Should any acute or sublethal toxic effects to non-target plants or aquatic species occur, it would represent a significant impact. These impacts would be **unavoidable or potentially unavoidable significant impacts.** These impacts could be reduced by implementing the following mitigation measures. The six mitigation measures for this impact are identical to the six mitigation measures for Impact W2. Both sets of mitigation measures are directed toward reducing the potential for pesticide toxicity impacts following WHCP treatments.

- **Mitigation Measure W3a (same as Mitigation Measures B1a; B2d; B4e; B6a; and W2a)** – Avoid herbicide application near special status species, and sensitive riparian and wetland habitat; and other biologically important resources.

  Each year, prior to the start of the treatment season, DBW will conduct field crew environmental awareness training. Under this training, crews will be informed about the presence and life histories of special status species, habitats associated with species, sensitive habitats and wetlands, the terms and conditions of the program's biological opinions, incidental take procedures, and that unlawful take of an animal or destruction of its habitat is a violation of the Endangered Species Act. The DBW will provide crews with a field guide (Species Identification Deck) for easy identification of special status species on site. Prior to treating a site, crews will conduct a visual survey to determine whether special status plants, animals, or sensitive habitats are present. Crews will complete an Environmental Observations Checklist for each site to document the presence or absence of special status species. If any special status species or sensitive habits are present at the site, the field crew will not perform the treatment.

- **Mitigation Measure W3b (same as Mitigation Measures B2b; B4a; W1a; and W2b) -** Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters.

  The DBW will conduct comprehensive monitoring. This monitoring is in compliance with the general NPDES permit, and NOAA-Fisheries and USFWS Biological Opinions. The DBW will collect samples prior to treatment, immediately after treatment, and post-treatment within one week of spraying. The DBW will conduct water quality monitoring for visual parameters, physical parameters, and chemical parameters at 10 percent of the sites it treats for each pesticide, per water body type. Water samples will be submitted to a certified analytical laboratory to measure 2,4-D, glyphosate, and adjuvant levels. Should these levels exceed allowable limits, DBW will take immediate measures to reduce chemical levels at future treatment sites.

- **Mitigation Measure W3c (same as Mitigation Measures B2c; B4b; H2c; W1c; and W2c)** – Implement an adaptive management approach to minimize the use of herbicides.

  Under an adaptive management approach, DBW will seek to improve efficacy and reduce environmental impacts over time as new and better information is available. Specifically, DBW will evaluate the need for control measures on a site by site basis; select appropriate indicators for pre-treatment monitoring; monitor indicators following treatment and evaluate data to determine program efficacy and environmental impacts; support ongoing research to explore the impacts of the WHCP and alternative control methodologies; report findings to regulatory agencies; and adjust program actions, as necessary, in response to recommendations and evaluations by regulatory agencies and stakeholders. In addition to this adaptive management approach, DBW will follow maintenance control practices that seek to reduce the number of acres of water hyacinth to be treated each year, until treatment acreage reaches a minimal level. This will reduce the volume of herbicide utilized by the WHCP.

- **Mitigation Measure W3d (same as Mitigation Measures W1b)** - Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities.

  The MOU is an agreement between CCWD and DBW. Generally, no applications shall occur within Rock Slough, or within one mile of the confluence of Rock Slough and Old River, or within one mile of CCWD's Old River or Mallard Slough intake pumps without consensual agreement between CCWD and DBW. Herbicide applications within one mile of CCWD's water intakes may only occur with prior consent of CCWD. In order to treat within one mile of an intake, DBW must notify CCWD at least two weeks in advance, and make every reasonable attempt to schedule applications during periods when CCWD's intakes are shut down for environmental or maintenance reasons, allowing at least two complete tidal cycles between application and restart. This measure is primarily aimed at reducing the potential for drinking water contamination from WHCP herbicide treatments.

- **Mitigation Measure W3e (same as Mitigation Measures B1c; B2f; H2d; W1d; and W2e)** – Conduct herbicide treatments in order to minimize potential for drift.

In addition to the label requirements noted above, DBW will, to the degree possible, schedule herbicide applications to occur at high tide, or at a point in the tidal cycle determined by the field supervisor to provide the least non-target impact at a particular site. In general, treatment at high tide will allow for better spray accuracy and access and will provide for greater dilution volume of herbicides. DBW crews will change nozzle type and spray pressures whenever conditions warrant, limiting the amount of herbicide which may inadvertently contact non-target species.

- **Mitigation Measure W3f (same as Mitigation Measures B1d; B6b; and W2f)** – Operate program vessels in a manner that causes the least amount of disturbance to the habitat.

  Operational procedures for DBW vessels will minimize boat wakes and propeller wash. These procedures will be particularly important in shallow water, or other sensitive habitats.

Impact W4 – Dissolved oxygen: following WHCP herbicide treatment, dissolved oxygen may potentially be reduced below Basin Plan and Bay-Delta Plan objectives, violating water quality standards or otherwise substantially degrading water quality

Dissolved oxygen levels may potentially be reduced below Basin Plan and Bay-Delta Plan objectives following WHCP herbicide treatments, and the resulting rapid decay of water hyacinth, other aquatic macrophytes, and algae. Decomposition of vegetative material may create an organic carbon slug, which could in turn reduce dissolved oxygen concentrations.

The Basin Plan water quality objectives for dissolved oxygen in the WHCP project area are as follows:

"Within the legal boundaries of the Delta, the dissolved oxygen concentration shall not be reduced below:

7.0 mg/l in the Sacramento River (below the I Street Bridge) and in all Delta waters west of the Antioch Bridge; 6.0 mg/l in the San Joaquin River (between Turner Cut and Stockton, 1 September through 30 November); and 5.0 mg/l in all other Delta waters except for those bodies of water which are constructed for special purposes and from which fish have been excluded or where the fishery is not important as a beneficial use.

For surface water bodies outside the legal boundaries of the Delta, the monthly median of the mean daily dissolved oxygen (DO) concentration shall not fall below 85 percent of saturation in the main water mass, and the 95 percentile concentration shall not fall below 75 percent saturation. The dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time:

- *Waters designated WARM 5.0 mg/l*
- *Waters designated COLD 7.0 mg/l*
- *Waters designated SPWN 7.0 mg/l"* (CVRWQCB 2007).

In addition, there are more stringent requirements for the Merced River from Cressy to New Exchequer Dam, of 8.0 mg/l (all year), and for the Tuolumne River from Waterford to La Grange, of 8.0 mg/l from October 15th to June 15th.

Dissolved oxygen is the content of oxygen found in water. DO is determined by temperature, weather, water flow, nutrient levels, algae, and aquatic plants. Generally, a higher level of DO is beneficial. Fish begin to experience oxygen stress or exhibit avoidance at levels below 5 mg/l (5 ppm).

DO levels drop in warmer temperatures, and increase with precipitation, wind, and water flow. Running water, such as tidal water in the Delta, dissolves more oxygen than still water. High levels of nutrients in water reduce DO levels, while algae and aquatic plants can increase DO through photosynthesis, but decrease DO through respiration and decomposition. DO levels fluctuate throughout the day, and are typically lowest in the morning and peak in the afternoon. In deep, still waters, DO levels are lower in the hypolimnion (bottom layer of water) because there is little opportunity for oxygen replenishment from the atmosphere.

There is the potential that following herbicide treatment, the biomass of decaying water hyacinth will create a large biological oxygen demand, resulting in decreases in dissolved oxygen. The label for Weedar 64® (2,4-D) notes that decaying weeds use up oxygen, and recommends treating only one-half of a lake or pond to avoid fish kill. In larger bodies of weed infested waters, the label recommends leaving 100-foot wide buffer strips untreated, and delaying treatment of these strips for four to five weeks, until the treated dead vegetation has decomposed. The label for AquaMaster™ (glyphosate) recommends treating an area in strips when there is full coverage of the weed in impounded areas to avoid oxygen depletion. The DBW follows these label recommendations in their operations, to avoid reductions in DO.

Dissolved oxygen levels under water hyacinth are already low, and may be in violation of water quality standards. In the Delta, Toft (2000) and others have found lower levels of dissolved oxygen under hyacinth canopies. Average spot measures were below 5 ppm in hyacinth (Toft 2000). These results were supported by a study in Texas which found lower dissolved oxygen in hyacinth compared to other aquatic weeds, and a University of California, Davis study which also found dissolved oxygen levels as low as 0 ppm below a solid water hyacinth mat in the Delta (Toft 2000).

The DBW analyzed monitoring results from 2001 to 2005 to determine whether there were statistical differences between water quality parameters before, and after, treatment. In general, there was no statistical evidence that water quality degraded significantly as a result of aquatic herbicide treatments. When there was a demonstrated change in dissolved oxygen, it appears that DO increased after treatment. The average post-treatment increase in DO at 110 first-visit follow-up monitoring visits was 0.66 mg/l. When the DBW conducted additional (second to fifth) follow-up monitoring visits, DO levels remained higher than the pre-treatment levels. This increase in DO following treatment supports the findings of Toft and others that water hyacinth depresses DO levels.

The DBW did find some exceptions in post-treatment DO levels. Between 2001 and 2005, in 16 of 110 sampling events, the post-treatment DO dropped below 5 mg/l from a pre-treatment level that was greater than 5 mg/l. These follow-up DO levels ranged from a low of 1.5 mg/l to a high of 4.95 mg/l. Many of these 16 sample event locations were already characterized as low DO sites with ambient DO levels that often fluctuated well below 5.0 mg/l (e.g. Snodgrass Slough and Lost Slough), particularly during the warmer times of the year (July through September) and depending on the time of day. The DBW concluded that these cases were not the result of changes to the DO caused by decaying plant material from WHCP spraying.

The DBW permit requirements allow treatments to proceed only when DO is below 3.0 mg/l, or above the Basin Plan limit for that location. The DBW treatment crews monitor DO levels prior to treatment to determine whether treatment can occur. However, between 2001 and 2005, there were ten instances in which treatment occurred when DO levels were greater than 3.0 mg/l, but below the Basin Plan limit. In most cases, DO levels were fractionally below the limit. The DBW believes that there were no significant impacts from these occurrences; however, they have worked to improve field communication to prevent treatments when DO is not within specified limits.

In 2006, DO basin limits for receiving waters were exceeded on two occasions. One occurred at site 011, two days following treatment. The Basin Plan limit for this site is 5.0 mg/l, and the measured DO was 4.99 mg/l. This measures was within the range of accuracy of DO measurement, 0.01 mg/l. The second exceedence occurred at site 028, also on August 3, at follow-up sampling two days after treatment. In this case, the DO level was 4.76 mg/l. Although the limits were exceeded on this date, spray crew measurements taken after this date showed that DO levels were back above basin limits. DO was well above the 3.0 mg/l required for fish survival, the reduced DO was shown to be temporary, and all fish passage protocol were followed. Thus it is unlikely that there was any serious impact to water quality.

In 2007, DO limits for receiving waters were exceeded on one occasion. This occurred post-treatment at site 065 on August 24. The basin plan limit for this site is 5.0 mg/l, and the DO measurement was 4.93 mg/l. The field crew also noted that algae were present in this area, in addition to the first stages of water hyacinth mortality, both potential contributors to reduced DO. It is believed in this case, there was not any serious impact to water quality.

Reductions in DO levels below Basin Plan limits occur only infrequently as a result of WHCP treatments, and if they do occur, are likely to be short-lived. However, should WHCP treatments result in violations of the Bay-Delta Plan or Basin Plan water quality objectives for dissolved oxygen, it would constitute an **unavoidable or potentially unavoidable significant impact.** These impacts would potentially be reduced by implementing the following four mitigation measures.

- **Mitigation Measure W4a (same as Mitigation Measure B5a)** – <u>Monitor dissolved oxygen (DO) levels pre- and post-treatment for all WHCP treatments</u>.

  Based on the pre-treatment DO levels, the application crew will determine whether to conduct treatment at that site. No treatment will be performed when dissolved oxygen levels are between 3 ppm (the level below which DO is considered to be detrimental to fish species) and the basin plan limits established by the CVRWQCB. The basin plan limits depend on location and time of year, and range from 5 ppm to 8 ppm. The DBW will maintain written and map summaries of specific DO numeric limits. The current dissolved oxygen map summaries are shown in **Exhibits 5-1a** and **5-1b,** on the following pages. When pre-treatment levels are below 3 ppm, fish species are not likely to be present due to the extremely low oxygen levels. When pre-treatment levels are above the basin plan limit, WHCP treatment, following label guidelines and mitigation measures, are not expected to adversely affect dissolved oxygen levels.

- **Mitigation Measure W4b (same as Mitigation Measure B5b)** – <u>Treat no more than three contiguous acres at any treatment site</u>.

  Crews will create a buffer zone around all treatment sites to ensure that impacts will be spread out and not segregated to one larger area. Buffer zones will be at least equal in size to the previously treated site. After treating three maximum acres, crews will then skip at least one adjacent site before treating another site. The DBW crews will not treat skipped sites until two tidal changes have occurred or, in nontidal areas, until 24 hours after treatment.

- **Mitigation Measure W4c (same as Mitigation Measure B5c)** – <u>Treat no more than one-half of the area at one time of completely infested dead-end sloughs, to allow for fish passage</u>.

  The DBW will return to treat the remaining half according to label instructions and permit conditions. The remaining area may be treated after four to five weeks, or when the dead vegetation has decomposed.

- **Mitigation Measure W4d (same as Mitigation Measure B5d)** – <u>Treat no more than one-half of completely infested moving waterways, at one time, to allow for fish passage</u>. The DBW will not treat the remaining area until the treated water hyacinth is decomposed or until a passage has opened up in the waterway.

Exhibit 5-1a

WHCP Dissolved Oxygen Limits – Northern Sites

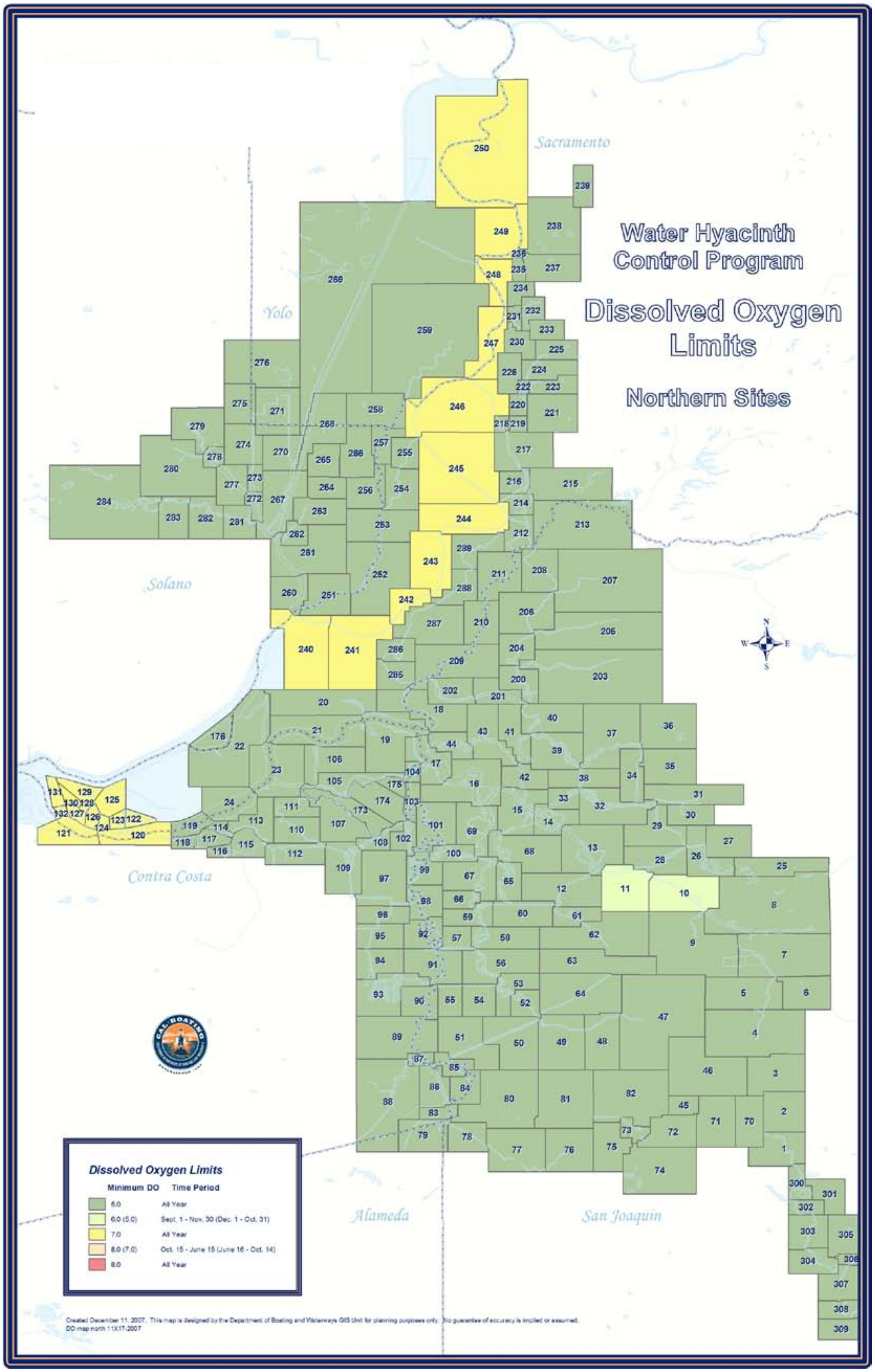
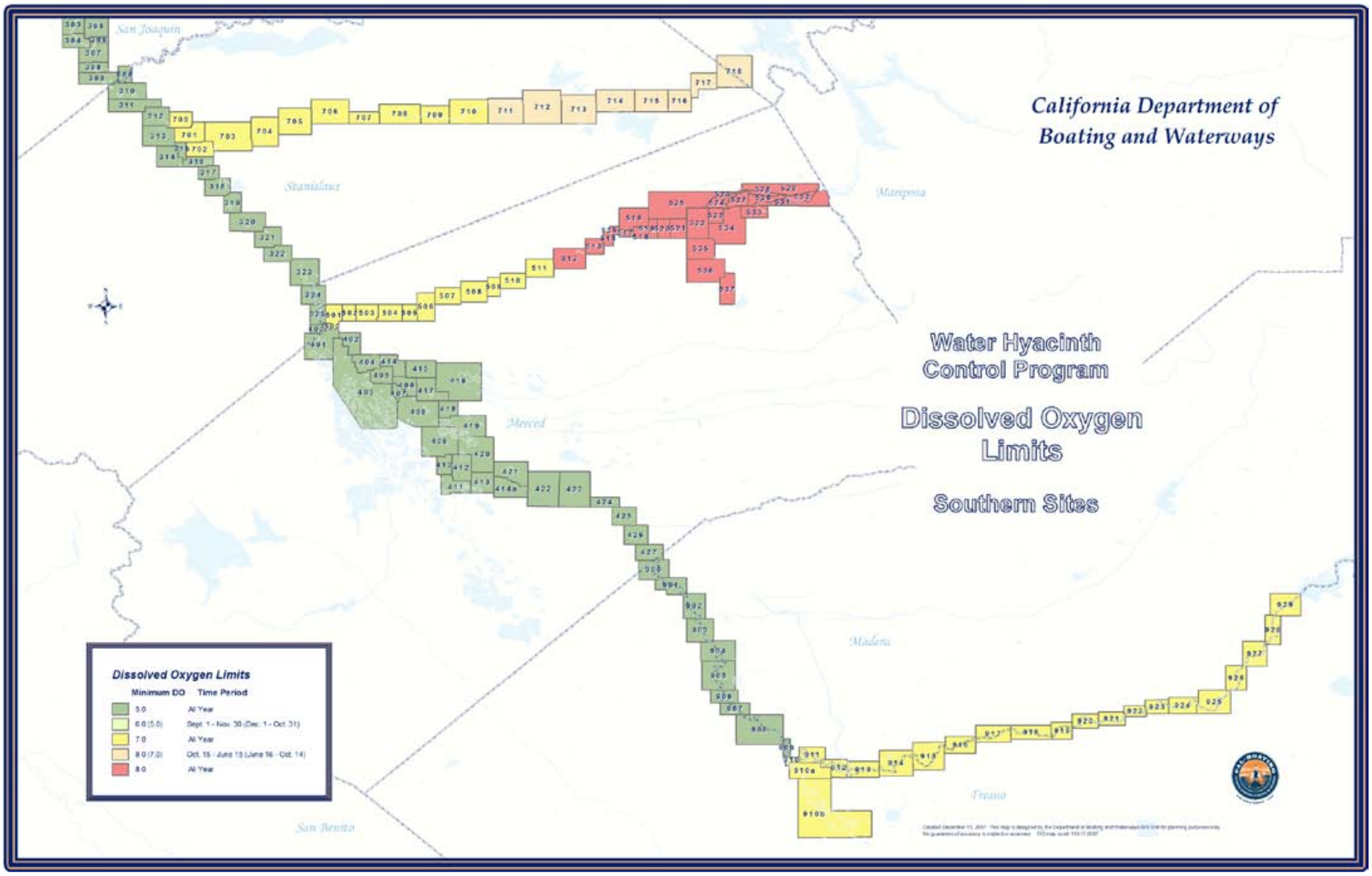


Exhibit 5-1b
WHCP Dissolved Oxygen Limits – Southern Sites



*   *   *   *   *

There are also positive impacts related to dissolved oxygen that will result from the WHCP. Dissolved oxygen levels at treatment sites will increase, improving compliance with water quality standards, once dead water hyacinth have decayed or floated away. Removing large patches of water hyacinth will allow DO levels to increase, thus enhancing the beneficial uses of Delta waters. It can be argued that such a benefit can outweigh the impact of short-term localized decreases in dissolved oxygen.

Impact W5 – Floating material: following WHCP treatment, waters may potentially contain floating water hyacinth fragments in amounts that cause nuisance or adversely affect beneficial uses, violating water quality standards or otherwise substantially degrading water quality

Herbicide treatments, handpicking, and herding may break fragments of water hyacinth loose in Delta waterways. These water hyacinth fragments could result in nuisance or adversely affect beneficial uses. The Basin Plan specifies that *"water shall not contain floating material in amounts that cause nuisance or adversely affect beneficial uses"* (CVRWQCB 2007).

As discussed in Chapter 6, potential negative impacts from floating debris include increasing debris loading at water utility intake facilities and agricultural irrigation intakes. Municipal and domestic supply, industrial service supply, and agricultural supply, are designated beneficial uses of Delta waters.

The potential for water hyacinth fragments resulting from WHCP treatments to result in violations of water quality standards or otherwise substantially degrade water quality is low. However, should water hyacinth debris resulting from the WHCP cause nuisance or adversely affect beneficial uses, it would represent a significant impact. This impact would be an **avoidable significant impact, reduced to a less-than-significant level by implementing the following three mitigation measures:**

- **Mitigation Measure W5a (same as Mitigation Measures W1b; W2d; and W3d)** – Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities.

  The MOU is an agreement between CCWD and DBW. Generally, no applications shall occur within Rock Slough, or within one mile of the confluence of Rock Slough and Old River, or within one mile of CCWD's Old River or Mallard Slough intake pumps without consensual agreement between CCWD and DBW. Herbicide applications within one mile of CCWD's water intakes may only occur with prior consent of CCWD. In order to treat within one mile of an intake, DBW must notify CCWD at least two weeks in advance, and make every reasonable attempt to schedule applications during periods when CCWD's intakes are shut down for environmental or maintenance reasons, allowing at least two complete tidal cycles between application and restart. This measure is primarily aimed at reducing the potential for drinking water contamination from the WHCP, however, it would also serve to minimize the potential for water hyacinth fragments to occur near water intake pumps.

- **Mitigation Measure W5b** – Notify County Agricultural Commissioners about WHCP activities.

  Before an application may occur, DBW shall file Pesticide Use Recommendations (PUR) and a Notice of Intent (NOI) with the appropriate County Agricultural Commissioner (CAC) office. Each NOI will include the site number, spray dates, locations, and herbicides and adjuvants to be used. NOIs will be submitted by no later than

2 pm on the Wednesday before the upcoming treatment week. Based on information in the NOIs, CAC's could inform land owners of particular periods of time during which irrigation should not occur. If necessary, DBW shall also obtain a Restricted Use Permit (RUP) from all appropriate CACs.

- **Mitigation Measure W5c (same as Mitigation Measure B7a)** – Collect plant fragments during and immediately following treatments.

  To maximize containment of plant fragments, crews will collect water hyacinth fragments. Crews will also be trained on the importance of minimizing fragment escape.

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The potential increase in floating material resulting from the WHCP is likely to be outweighed by the benefits to water utility and agricultural intake pump systems that result from removing water hyacinth from Delta waterways. One concern resulting from water hyacinth's invasion in the Delta in the 1980s was untreated plants blocking CVP and SWP pumps (U.S. Army Corps of Engineers 1985). In fact, the Bureau of Reclamation estimated that the WHCP saved the Bureau $400,000 per year in reduced operating and maintenance costs associated with removing water hyacinth from just the C.W. "Bill" Jones Pumping Plant (DBW 2001).

Similarly, clogging of agricultural pumps by untreated water hyacinth can result in inefficient pumping, increased pumping costs, and possible mechanical failure of pumps. Prior to the start of the WHCP, in a letter to the U.S. Army Corps of Engineers, the San Joaquin Farm Bureau Federation stated that growers were facing increased costs from efforts to open clogged channels where water hyacinth was decreasing the flow of water to pumps and clogging screens (U.S. Army Corps of Engineers 1985).

Impact W6 – Turbidity: WHCP treatment may potentially result in changes to turbidity that cause nuisance or adversely affect beneficial uses, violating water quality standards or otherwise substantially degrading water quality

Operation of WHCP vessels for treatment and monitoring may potentially result in changes in turbidity that violate water quality standards or otherwise substantially degrade water quality. Such turbidity increases could result in nuisance or adversely affect beneficial uses.

The WHCP operates under the General NPDES permit CAG990005, and the Basin Plan objectives for turbidity. The Basin Plan turbidity objectives are as follows:

"Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits:

- *Where natural turbidity is between 0 and 5 Nephelometric Turbidity Units (NTUs), increases shall not exceed 1 NTU.*
- *Where natural turbidity is between 5 and 50 NTUs, increases shall not exceed 20 percent.*
- *Where natural turbidity is between 50 and 100 NTUs, increases shall not exceed 10 NTUs.*
- *Where natural turbidity is greater than 100 NTUs, increases shall not exceed 10 percent.*

In Delta waters, the general objectives for turbidity apply subject to the following: except for periods of storm runoff, the turbidity of Delta waters shall not exceed 50 NTUs in the waters of the Central Delta and 150 NTUs in other Delta waters. Exceptions to the Delta specific objectives will be considered when dredging operations can cause an increase in turbidity. In this case, an allowable zone of dilution within which turbidity in excess of limits can be tolerated will be defined for the operation and prescribed in a discharge permit" (CVRWQB 2007).

DBW analyzed monitoring results from 2001 to 2005 to determine whether there were statistical differences between water quality parameters before, and after, treatment. In general, there was no statistical evidence that water quality degraded significantly as a result of aquatic herbicide treatments.

DBW measured compliance with turbidity requirements by comparing pre-treatment turbidity levels with post-treatment turbidity levels measured at follow-up visits. For the 2001 to 2005 time period, DBW compared pre- and post-treatment turbidity for 352 pairs of samples. In all cases, the WHCP was in compliance with Basin Plan limits for changes in turbidity.

In 2006, 2007, and 2008, there were a total of 20 occasions and 10 sites for which turbidity levels exceeded basin plan limits. In all but three instances in each year, the exceedences were due to the sampling boat entering areas where it was very shallow, many submerged aquatic plants, agricultural discharges, inputs from more turbid tributaries, wading livestock, or instrument error. In the three other instances each year, there was no recorded explanation for the exceedence in the measured turbidity levels. In most cases, the exceedences occurred on the treatment day, and when the turbidity was measured on the follow-up sampling day, they were again within basin limits. In a few cases, the follow-up turbidity levels were still high. Therefore, if the WHCP was responsible for the turbidity violations, the effects were only temporary and most likely did not have any adverse affects on beneficial uses.

While exceedences in Basin Plan limits may occur within the Delta, it is difficult to determine whether these exceedences are a result of WHCP activities. In addition, any exceedences that are a result of WHCP activities are likely to be short-term. The WHCP is not likely to result in increases in turbidity that create nuisance or adversely affect beneficial uses. As a result, **the impact of the WHCP on turbidity is expected to be less than significant.** While no mitigation measures are required, DBW will implement the following mitigation measure to further reduce any potential impact level.

- **Mitigation Measure W6a (same as Mitigation Measures B1d; B6b; W2f; and W3f)** – <u>Operate program vessels in a manner that causes the least amount of disturbance to the habitat</u>.

  Operational procedures for DBW vessels will minimize boat wakes and propeller wash. These procedures will be particularly important in shallow water, or in other sensitive habitats.

This section identified twenty-four (24) mitigation measures to address six (6) potential impacts to hydrology and water quality. Many of these mitigation measures are duplicative, as they each apply to multiple impacts. **Table 5-5,** on the next page, combines and summarizes the hydrology and water quality mitigation measures.

Table 5-5
Summary of Potential Hydrology and Water Quality Impacts and Mitigation Measures

	Mitigation Measure Summary[1]	Mitigation Measure Number	Impacts Applied To	Same As Prior Mitigation Numbers
1.	Avoid herbicide applications near special status species, and sensitive riparian and wetland habitat; and other biologically important resources	Mitigation Measure W2a Mitigation Measure W3a	Impact W2: Pesticides Impact W3: Toxicity	B1a; B2d; B4c; B6a
3.	Conduct herbicide treatment in order to minimize potential for drift	Mitigation Measure W1d Mitigation Measure W2e Mitigation Measure W3e	Impact W1: Chemical constituents Impact W2: Pesticides Impact W3: Toxicity	B1c; B2f
4.	Operate program vessels in a manner that causes the least amount of disturbance to the habitat	Mitigation Measure W2f Mitigation Measure W3f Mitigation Measure W6a	Impact W2: Pesticides Impact W3: Toxicity Impact W6: Turbidity	B1d; B6a
6.	Monitor herbicide and adjuvant levels to ensure that the WHCP does not result in potentially toxic concentrations of chemicals in Delta waters	Mitigation Measure W1a Mitigation Measure W2b Mitigation Measure W3b	Impact W1: Chemical constituents Impact W2: Pesticides Impact W3: Toxicity	B2b; B4a
7.	Implement an adaptive management approach to minimize the use of herbicides	Mitigation Measure W1c Mitigation Measure W2c Mitigation Measure W3c	Impact W1: Chemical constituents Impact W2: Pesticides Impact W3: Toxicity	B2c; B4b; H2c
9.	Monitor dissolved oxygen (DO) levels pre- and post-treatment for all for all WHCP treatments	Mitigation Measures W4a	Impact W4: Dissolved oxygen	B5a
10.	Treat no more than three contiguous acres at any treatment site	Mitigation Measure W4b	Impact W4: Dissolved oxygen	B5b
11.	Treat no more than one-half of the area of completely infested dead-end sloughs to allow for fish passage	Mitigation Measure W4c	Impact W4: Dissolved oxygen	B5c
12.	Treat no more than one-half of completely infested moving waterways to allow for fish passage	Mitigation Measure W4d	Impact W4: Dissolved oxygen	B5d
13.	Collect plant fragments during and immediately following treatments	Mitigation Measure W5c	Impact W5: Floating material	B7a
21.	Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities	Mitigation Measure W1b Mitigation Measure W2d Mitigation Measure W3d Mitigation Measure W5a	Impact W1: Chemical constituents Impact W2: Pesticides Impact W3: Toxicity Impact W5: Floating Material	**New**
22.	Notify County Agricultural Commissioners about WHCP activity	Mitigation Measure W5c	Impact W5: Floating material	**New**

[1] Please refer to the text for the complete mitigation measure description.

Chapter 6

Utilities and Service Systems and Agricultural Resources Impacts Assessments

6. Utilities and Service Systems and Agricultural Resources Impacts Assessment

This chapter analyzes effects of the WHCP on utility and service systems, and agricultural resources. WHCP effects on both of these resource areas are likely to be minimal. The chapter is organized as follows:

A. Utility and Service Systems Impacts Assessment
B. Agricultural Resources Impacts Assessment.

For each resource area, we first describe the environmental setting, and then provide an impact analysis and mitigation measures. The environmental setting sections describe the current status of utility and service systems, and agricultural resources, in the Delta. The discussions focus on water utility pumps and agricultural crops, which are areas of potential impact.

The impact analyses sections provide assessments of the specific environmental impacts potentially resulting from program operations. The discussions of impacts utilizes findings from WHCP research projects, technical information from government reports, and program experience. The impact assessments are based on technical information.

For each of the potential WHCP impacts to utility and service systems and agricultural resources, we provide a description of the impact, analyze the impact, classify the impact level, and identify mitigation measures to reduce the impact level.

The mitigation measures are specific actions that the DBW will undertake to avoid, or minimize, potential environmental impacts. The DBW has developed these actions based on twenty-five (25) years of program experience and discussions with local governments, water agencies, and County Agricultural Commissioners. The DBW maintains regular contact with these entities regarding potential impacts to pump systems and crops, and will respond to concerns expressed by these agencies to revise and/or add new mitigation measures, as necessary.

A. Utilities and Service Systems Impacts Assessment

1. Environmental Setting

Water-Related Infrastructure

Water conveyance infrastructure consists of many agricultural, industrial, and municipal diversions for supplying water to the Delta itself and for export by the SWP

Table 6-1
Delta Drinking Water Intakes

No.	Intake Name	Jurisdiction	Waterbody
1	Barker Slough Intake	Department of Water Resources	Sacramento River and Deep Water Channel
2	Harvey O. Banks Pumping Plant	Department of Water Resources	Clifton Court Forebay
3	C.W. "Bill" Jones Pumping Plant	U.S. Bureau of Reclamation (USBR)	Delta-Mendota Canal
4	Rock Slough Intake	Contra Costa Water District	Rock Slough and Contra Costa Canal
5	Old River Intake[1]	Contra Costa Water District	Old River
6	Mallard Slough Intake Pump Station	Contra Costa Water District and USBR	Mallard Slough and Suisun Bay

[1] CCWD is moving forward on a project to develop a new intake pump at Victoria Canal that will be used when the water quality at Old River Intake is reduced. This new pump, located at "7" in Exhibit 6-1, will not be completed until 2010.

and CVP. Diversions and conveyance require canals, waterways, levees, siphons, pumps, radial gates, and other miscellaneous infrastructure. We discuss agricultural diversions in Section B of this chapter.

Most water conveyance facilities in the Delta have been developed under the authority of the federal government's Central Valley Project (CVP) and California's State Water Project (SWP). As part of CVP development, exportation of water from the Delta began in 1940 with the completion of the Contra Costa Canal. Other major federal units were completed during the early 1950s, including the Delta-Mendota Canal and the Delta Cross Channel (DCC). The DCC transfers water across the Delta from the Sacramento River to the C.W. "Bill" Jones Pumping Plant (formerly the Tracy Pumping Plant), which serves the Delta-Mendota Canal. Numerous SWP facilities have been developed in the Delta, including the Harvey O. Banks Delta Pumping Plant, the California Aqueduct, and the North Bay Aqueduct (NBA). Combined, the CVP and SWP typically export approximately five (5) million acre feet of water annually for agricultural and urban use in Central and Southern California.

The Contra Costa Water District (CCWD) provides water to approximately 550,000 customers in central and eastern Contra Costa County. CCWD operates three pumps that divert drinking water from the Delta. There are power plants in the western Delta, at Antioch and Pittsburg, which utilize Delta waters for cooling. The East Bay Municipal Utility District operates the Mokelumne Aqueduct, providing water to 1.3 million people. Mokelumne Aqueduct pipelines cross through the southern portion of the Delta, but do not pump Delta waters.

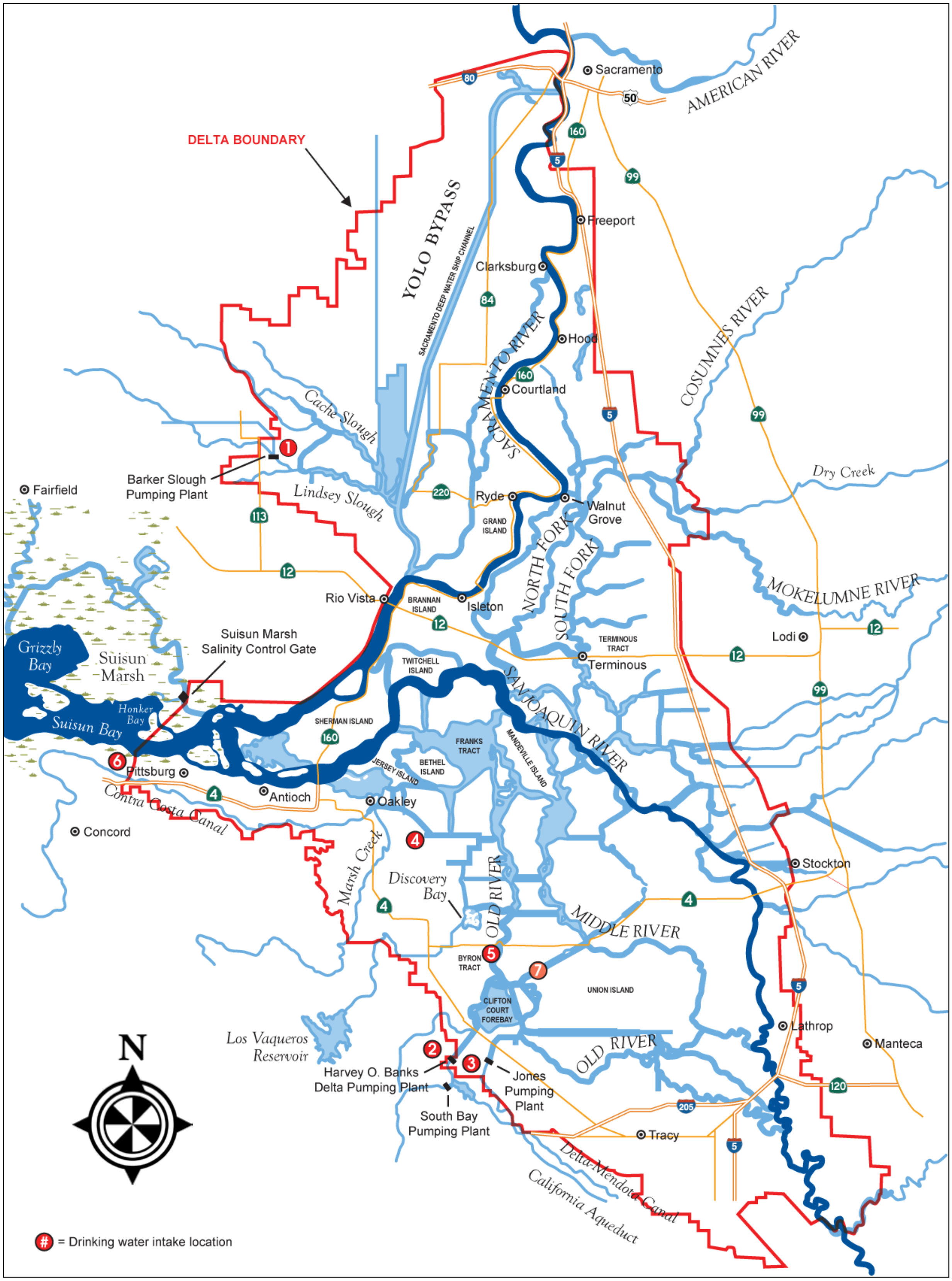
Exhibit 6-1, on the next page, and **Table 6-1,** above, identify six major drinking water intake pumps in and near the WHCP project area. The numbers in Table 6-1 refer to the locations on Exhibit 6-1.

Natural Gas Infrastructure

Natural gas was discovered in the Delta region in 1935 and has since been developed into a significant source and depot for underground storage. Gas fields, pipelines, underground storage areas, and related infrastructure are located in the Delta. Infrastructure consists mainly of pipelines and storage facilities owned by oil and gas companies, public utilities, and various independent leaseholders.

In 2004, there were approximately 240 operating natural gas wells in the Delta and Suisun Marsh (URS Corporation 2007). There

Exhibit 6-1
Drinking Water Intakes in the Sacramento-San Joaquin Delta



are more than twenty-five (25) underground natural gas storage areas located throughout the Delta and surrounding vicinity. Pacific Gas and Electric (PG&E) maintains a storage area under McDonald Island in the Central Delta that provides approximately 33 percent of the peak natural gas supply for the PG&E service area (URS Corporation 2007). In addition, fuel pipelines carry gasoline and aviation fuel from the Bay Area to the Central Valley through the Delta.

Public Services

Police protection is provided by various departments within the cities and counties of the Delta region. For example, the San Joaquin Sheriff's Department marine patrol division provides water patrol services to approximately 600 square miles of waterways in the Delta area. The Contra Costa County Sheriff's Department provides law enforcement services in the area. Fire protection service is provided by various departments in the Delta area, including the San Joaquin County Delta Fire Protection District and the Contra Costa Fire Protection District. Volunteer firefighters also respond to fire emergencies as needed. Fire suppression in areas not under the jurisdiction of a fire protection district is the responsibility of the landowners. Cities and counties in the region provide emergency services.

Solid Waste and Wastewater Treatment Services

There are over thirty (30) solid waste facilities located in or adjacent to the Delta and Suisun Marsh (URS Corporation 2007). Most facilities are located at the periphery of the Delta. There are thirteen (13) sewage treatment plants located in the Delta region, all located in the periphery, near developed areas (URS Corporation 2007).

Source: DBW, 2001.

Electric Utilities and Communication Infrastructure

Power transmission facilities have developed with the population growth of various communities surrounding the Delta. PG&E, Sacramento Municipal Utility District (SMUD), and the Western Area Power Administration have developed and oversee power transmission lines across the Delta islands and waterways. There are more than 500 miles of transmission lines and 60 substations within the Delta boundaries (URS Corporation 2007). Many of the transmission corridors are within the periphery of the Delta upland areas, including several natural gas-fired plants. Communication infrastructure in the region includes underground cable and fiber optic lines, and communication/transmission towers.

2. Impact Analysis and Mitigation Measures

For purposes of this analysis, we considered an impact to utilities and service systems to be significant and require mitigation if it would result in any of the following:

- Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board
- Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities

- Require or result in the construction of new storm water drainage facilities or expansion of existing facilities
- Require new or expanded entitlements for water supply
- Result in a determination by the wastewater treatment provider that it does not have adequate capacity to serve the project
- Exceed permitted landfill capacity
- Result in noncompliance with federal, state, or local statutes and regulations related to solid waste
- Result in problems for local or regional water utility intake pumps.

Table 6-2, on the next page, provides a summary of the potential WHCP impact for the one utility and service systems significance area which could potentially be affected. Table 6-2 also explains those utility and service systems significance areas in which there will be no impacts. We discuss potential impacts of the WHCP on water quality in Chapter 5.

Impact U1 – Water utility intake pumps: effects of WHCP treatments on water utility intake pumps

Herbicide treatments, handpicking, and herding may break fragments of water hyacinth loose into Delta waterways. These water hyacinth fragments would increase debris loading at intake facilities. Fragments have the potential to clog water utility intake pumps, requiring additional pump maintenance for affected water agencies.

The potential for water hyacinth fragments resulting from WHCP treatments to cause adverse effects on water utility intake pumps is low. However, should water hyacinth debris resulting from the WHCP clog or damage water utility intake pumps, it would represent a significant impact. This impact would be an **avoidable significant impact, reduced to a less-than-significant level by implementing the following two mitigation measures.**

- **Mitigation Measure U1a (same as Mitigation Measures W1b; W2d; W3d; and W5a)** – <u>Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities</u>.

  The MOU is an agreement between CCWD and DBW. Generally, no applications shall occur within Rock Slough, or within one mile of the confluence of Rock Slough and Old River, or within one mile of CCWD's Old River or Mallard Slough intake pumps without consensual agreement between CCWD and DBW. Herbicide applications within one mile of CCWD's water intakes may only occur with prior consent of CCWD. In order to treat within one mile of an intake, DBW must notify CCWD at least two weeks in advance, and make every reasonable attempt to schedule applications during periods when CCWD's intakes are shut down for environmental or maintenance reasons, allowing at least two complete tidal cycles between application and restart. This measure is primarily aimed at reducing the potential for drinking water contamination from theWHCP, however, it would also serve to minimize the potential for water hyacinth fragments to occur near water intake pumps.

- **Mitigation Measure U1b (same as Mitigation Measures B7a and W5c)** – <u>Collect plant fragments during and immediately following handpicking, herding, or herbicide treatments</u>.

  To maximize containment of plant fragments, crews will collect water hyacinth fragments. Crews will also be trained on the importance of minimizing fragment escape.

* * * * *

Table 6-2
Crosswalk of Utility and Service Systems Significance Criteria, Impacts, and Benefits of the WHCP

	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?					WHCP will have no wastewater treatment impacts	
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?					WHCP will not require construction or expansion of water or wastewater treatment facilities	
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?					WHCP will not require construction or expansion of storm water drainage facilities	
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?					WHCP will have no impact on water supplies	
e) Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?					The WHCP will have no impact on wastewater treatment capacity.	
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?					WHCP will have no impact on landfill capacity. A small amount of handpicked water hyacinth will be placed on levee banks and allowed to naturally desiccate and disperse	
g) Comply with federal, state, and local statutes and regulations related to solid waste?					WHCP will comply with federal, state, and local statues and regulations related to solid waste	
h) Result in problems for local or regional water utility intake pumps?						Removal of water hyacinth from Delta waterways could reduce clogging of water utility intake pumps
Impact U1: Water utility intake pumps	13, 21		**X**			X

The potential impact to water intake systems is likely to be outweighed by the benefits to water intake pump systems that result from removing water hyacinth from Delta waterways. One concern resulting from water hyacinth's invasion in the Delta in the 1980s was plants blocking CVP and SWP pumps (U.S. Army Corps of Engineers 1985). In fact, the Bureau of Reclamation estimated that the WHCP saved the Bureau $400,000 per year in reduced operating and maintenance costs associated with removing water hyacinth from just the C.W. "Bill" Jones Pumping Plant (DBW 2001).

B. Agricultural Resources Impacts Assessment

1. Environmental Setting

The Delta is an important agricultural area. Farming in the Delta region began in the 1850s, following passage of the Swamp and Overflow Act, and Reclamation District Act, which provided for the sale of swamp and overflow lands for reclamation (DPC January 2001). Early farmers built a system of levees and irrigation ditches, and began growing a variety of vegetables, fruits, and grains. Over time, most farms have shifted from growing diverse crops, to growing a few crops, which are rotated (DPC January 2001). Crops that have been important at various times in the Delta include potatoes, asparagus, pears, and sugar beets. Characteristics that make the Delta well-suited to agriculture include: rich soil, ample water, a long growing season, mild climate, and proximity to end markets (DPC May 2001).

California is the fifth largest agricultural economy in the world, producing over 350 plant and animal commodities worth nearly $32 billion in 2006 (CDFA 2007). There were over 28 million acres of agricultural land (including grazing land) in California in 2004 (DOC 2006). In 2001, based on reported conversions of agricultural land (primarily for habitat conservation) the Delta region had about 360,000 acres in agriculture (DPC May 2001), just over 1 percent of the total agricultural acreage statewide, and approximately 74 percent of Delta land and water acreage. Estimated agricultural acreage, including harvested or grazed irrigated crop acres between 1998 and 2004 was 405,899 (Rich 2007). The average annual gross value of the agricultural output of the California's Delta during the 1998 to 2004 time period was approximately 2 percent of the statewide agricultural output.

The six counties with land area in the legal Delta (Alameda, Contra Costa, Sacramento, San Joaquin, Solano, and Yolo) produced over $2.6 billion in agricultural products in 2004 (USDA 2005) and $2.7 billion in 2006 (CDFA 2007). The value of Delta agricultural output represented over 20 percent of the total agricultural output in those six counties in 2004.

The additional WHCP counties (Fresno, Stanislaus, Madera, Tuolumne, Merced) produced a combined $10.3 billion in agricultural output. The WHCP project area in these counties is limited to the treatment sites on the San Joaquin, Merced, and Tuolumne Rivers.

Among the six counties with land area in the legal Delta, San Joaquin County has the greatest agricultural output. San Joaquin County produced the seventh highest value of agricultural products statewide, at $1.7 billion in 2006, with approximately 25 percent of that revenue generated in the Delta. In 2004, 63 percent of San Joaquin County's 912,602 acres were in agriculture, with almost 40 percent of those acres in the Delta.

Yolo County had almost 50 percent of its 653,452 acres in agricultural production, with approximately 40,000 of those acres in the Delta. Sacramento County had approximately 24 percent of land in agriculture in 2004, with over 50 percent of agricultural land located within the Delta. Solano County had approximately 30 percent of land in agriculture in 2004, with 20 percent of

Table 6-3
Total and Agricultural Acres* in Delta Counties

County	Total Acres	Delta Acres	2004 Agricultural Acres	1998 to 2004 Delta Agricultural Acres
San Joaquin	912,602	190,000	579,267	222,597
Yolo	653,452	75,000	324,228	39,661
Sacramento	636,083	95,000	150,798	79,558
Solano	582,373	86,000	181,313	34,579
Contra Costa	514,019	47,000	35,552	27,775
Alameda	525,338	10,000	9,362	1,730
Total	3,823,867	503,000	1,280,520	405,900

* Harvested, bearing acres, excluding dry rangeland/unirrigated pasture, and livestock areas. Sources: DOC, http://www.consrv.ca.gov; Delta Protection Commission (DPC), Inventory of Recreational Facilities (Sacramento, CA: DPC, November 1997); Jim Rich, "The Value of the Agricultural Output of the California Delta, A Revised Draft DWR Paper" (Sacramento, CA: DWR, February 22, 2007).

Table 6-4
Top Ten Delta Agricultural Products, Based on 1998 to 2004 Average Output

Agricultural Product	Annual Gross Value (in millions of dollars)
1. Wine grapes	$113.5
2. Livestock and poultry products	71.7
3. Asparagus	58.8
4. Processing tomatoes	55.9
5. Alfalfa hay	5.9
6. Nursery products	43.0
7. Pears	29.0
8. Corn, grain	27.3
9. Fresh tomatoes	26.9
10. Corn, silage	23.4

Source: Jim Rich, "The Value of the Agricultural Output of the California Delta, A Revised Draft DWR Paper" (Sacramento, CA: DWR, February 22, 2007).

Table 6-5
Top Ten Delta Agricultural Products, Based on 1998 to 2004 Irrigated Acreage

Agricultural Product	Delta Irrigated Acres
1. Alfalfa hay	70,405
2. Corn, grain	57,143
3. Wheat	39,967
4. Corn, silage	37,366
5. Irrigated pasture	27,346
6. Wine grapes	27,262
7. Processing tomatoes	26,604
8. Asparagus	22,927
9. Safflower	17,342
10. Misc. field crops	8,882

Source: Jim Rich, "The Value of the Agricultural Output of the California Delta, A Revised Draft DWR Paper" (Sacramento, CA: DWR, February 22, 2007).

agricultural land located within the Delta. Contra Costa County had only 5 percent of its 514,019 acres in agriculture in 2004, with the majority of agricultural acres in the Delta. Less than 2 percent of Alameda County falls within the Delta, and 20 percent of that land is agricultural. **Table 6-3,** above, summarizes total and Delta agricultural land use in the six Delta counties.

Tables 6-4 and **6-5,** above, identify the top ten Delta agricultural products between 1998 and 2004, based on annual average gross value, and acreage. These tables illustrate the diversity of agriculture in the Delta, with no single product dominating either acreage or economic output.

Table 6-6

Crosswalk of Agricultural Resources Significance Criteria, Impacts, and Benefits of the WHCP

	Mitigation Measures	Unavoidable or Potentially Unavoidable Significant Impact	Avoidable Significant Impact	Less than Significant Impact	No Impact	Beneficial Impact
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?					WHCP will not convert prime farmland, unique farmland, or farmland of statewide importance to non-agricultural use	
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?					WHCP will not conflict with existing zoning from agricultural use, or a Williamson Act contract	
c) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?					WHCP will not involve other changes in the existing environment which would result in conversion of farmland to non-agricultural uses	
d) Adversely impact agricultural crops or agricultural operations, such as irrigation?						Removal of water hyacinth from Delta waterways could reduce clogging of agricultural pumps
Impact A1: Agricultural crops	3, 22		**X**			
Impact A2: Irrigation pumps	13, 22		**X**			X

2. Impact Analysis and Mitigation Measures

For purposes of this analysis, we considered an impact to agricultural resources to be significant and require mitigation if it would result in any of the following:

- Conflict with existing zoning for agricultural use, or a Williamson Act contract
- Involve other changes in the existing environment which, due to their location or nature, could result in conversion of farmland to non-agricultural use
- Adversely impact agricultural crops or agricultural operations.

Table 6-6, above, provides a summary of the potential WHCP impacts for the one agricultural resources significance area which could potentially be affected. Table 6-6 also explains those agricultural resource significance areas in which there will be no impacts.

Impact A1 – Agricultural crops: effects of WHCP herbicide treatments on agricultural crops

There are approximately 1,800 agricultural diversions in the Delta. During the peak summer irrigation season, diversions from these facilities collectively exceed 5,000 cubic feet per second (URS Corporation May 2007). The WHCP could adversely impact agricultural crops, since treatments would occur during the irrigation season.

WCHP herbicide treatments occurring adjacent to agricultural diversions could result in adverse impacts to nearby agricultural crops, since irrigation with herbicide-treated water may injure irrigated vegetation. Both 2,4-D and glyphosate could reduce growth or possibly kill crops they contact.

WHCP herbicide treatments occurring adjacent to agricultural crops could also result in adverse impacts due to herbicide drift. As discussed in Chapter 3 (Impact 1), 2,4-D is a systemic herbicide specific to broadleaf plants. Exposure of broadleaf crops to 2,4-D could result in damage to crops. Glyphosate is a broad spectrum, non-selective, systemic herbicide. Exposure of any non-target crops to glyphosate could result in damage to crops.

The Weedar® 64 label specifies that the herbicide not be used adjacent to sensitive broadleaf crops, in particular grapes, tomatoes, and cotton. Grapes and tomatoes are grown throughout the Delta. The DBW will utilize glyphosate, rather than 2,4-D, when treating sites adjacent to sensitive broadleaf crops. The Weedar® 64 label also requires a delay in the use of treated waters for irrigation for three weeks after treatment, unless an approved assay shows that water does not contain more than 0.1 ppm 2,4-D. As discussed in Chapter 3, typical post-treatment 2,4-D levels are far below this threshold, even immediately post-treatment. The AquaMaster™ label does not specify any restrictions for use of treated water for irrigation.

While there is a potential risk to agricultural crops due to herbicide overspray, the likelihood of such effects is low. Herbicide application will be focused directly on target plants to decrease the possibility that concentrated herbicides would come in contact with agricultural crops. The DBW will follow herbicide label instructions that reduce herbicide drift. These steps include using the largest spray droplets, and lowest spray pressure, that will provide sufficient coverage and control. Furthermore, DBW will not treat at a particular site if the wind is greater than 10 mph (or 7 mph in Contra Costa County).

While there is also a potential risk to agricultural crops due to irrigating with water following WHCP herbicide treatments, the likelihood of such effects is similarly low. WHCP environmental monitoring has shown consistently low herbicide levels immediately following WHCP treatments. Tidal movement and water flow in the Delta promote dilution of WHCP herbicides.

Should agricultural crops adjacent to WHCP treatment sites be adversely affected by herbicide drift or irrigation waters containing WHCP herbicides, it would represent a significant impact. This impact would be an **avoidable significant impact, reduced to a less-than-significant level by implementing the following two mitigation measures.**

- **Mitigation Measure A1a (same as Mitigation Measures W5b)** – <u>Notify County Agricultural Commissioners about WHCP activities</u>.

  Before an application may occur, DBW shall file Pesticide Use Recommendations (PUR) and a Notice of Intent (NOI) with the appropriate County Agricultural Commissioner (CAC) office. Each NOI will include the site number, spray dates, locations, and herbicides and adjuvants to be used. NOIs will be submitted by no later than 2pm on the Wednesday before the upcoming treatment week. Based on information in the NOIs, CAC’s could inform land owners of particular periods of time during which irrigation should not occur. If necessary, DBWg shall also obtain a Restricted Use Permit (RUP) from all appropriate CACs.

- **Mitigation Measure A1b (same as Mitigation Measures B1c; B2f; H2d; W1d; W2e; and W3e)** – <u>Conduct herbicide treatments in order to minimize potential for drift</u>.

  In addition to the label requirements noted above, DBW will, to the degree possible, schedule herbicide applications to occur at high tide, or at a point in the tidal cycle determined by the field supervisor to provide the least non-target impact at a particular site. In general, treatment at high tide will allow for better spray accuracy and access and will provide for greater dilution volume of herbicides. DBW crews will change nozzle type and spray pressures whenever conditions warrant, limiting the amount of herbicide which may inadvertently contact agricultural crops.

Impact A2 – Irrigation pumps: effects of WHCP treatments on agricultural irrigation

Herbicide treatments, handpicking, and herding may break fragments of water hyacinth lose into Delta waterways. These water hyacinth fragments would increase debris loading at the 1,800 agricultural irrigation intakes located throughout the Delta. Fragments have the potential to clog water agricultural irrigation intakes, requiring additional intake maintenance for affected farmers.

The potential for fragments of water hyacinth from herbicide treatment, handpicking, or herding to cause adverse effects to agricultural irrigation intakes is low. However, should water hyacinth fragments resulting from the WHCP clog or damage agricultural irrigation intakes, it would represent a significant impact. This impact would be an **avoidable significant impact, reduced to a less-than-significant level by implementing the following two mitigation measures.**

- **Mitigation Measure A2a (same as Mitigation Measures W5b and A1a)** – Notify County Agricultural Commissioners about WHCP activities.

  Before an application may occur, DBW shall file Pesticide Use Recommendations (PUR) and a Notice of Intent (NOI) with the appropriate County Agricultural Commissioner (CAC) office. Each NOI will include the site number, spray dates, locations, and herbicides and adjuvants to be used. NOIs will be submitted by no later than 2pm on the Wednesday before the upcoming treatment week. Based on information in the NOIs, CAC's could inform land owners of particular periods of time during which irrigation should not occur. If necessary, DBW shall also obtain a Restricted Use Permit (RUP) from all appropriate CACs.

- **Mitigation Measure A2b (same as Mitigation Measures B7a and W5c)** – Collect plant fragments during and immediately following treatments.

  To maximize containment of plant fragments, crews will collect water hyacinth fragments. Crews will also be trained on the importance of minimizing fragment escape.

* * * * *

There are also potential benefits to agricultural resources resulting from the WHCP. Left untreated, water hyacinth can potentially interfere with pumping at the 1,800 agricultural irrigation intakes throughout the Delta. Clogging by water hyacinth may result in inefficient pumping, increasing pumping costs, and possible mechanical failure of pumps. Prior to the start of the WHCP, in a letter to the U.S. Army Corps of Engineers, the San Joaquin Farm Bureau Federation stated that growers were facing increased costs from efforts to open clogged channels where water hyacinth was decreasing the flow of water to pumps and clogging screens (U.S. Army Corps of Engineers 1985).

This section identified six mitigation measures to address three potential impacts to utility and service systems and agricultural resources. Two mitigation measures are duplicative, as they each apply to two impacts. **Table 6-7**, on the next page, combines and summarizes the utility and service systems and agricultural resources mitigation measures.

Table 6-7
Summary of Potential Utility and Service Systems and Agricultural Resources Impacts and Mitigation Measures

	Mitigation Measure Summary[1]	Mitigation Measure Number	Impacts Applied To	Same As Prior Mitigation Numbers
3.	Conduct herbicide treatment in order to minimize potential for drift	Mitigation Measure A1b	Impact A1: Agricultural crops	B1c; B2f; H2d; W1d; W2e; W3e
13.	Collect plant fragments during and immediately following treatments	Mitigation Measure U1b Mitigation Measure A2b	Impact U1: Water utility intake pumps Impact A2: Irrigation pumps	B7a; W5c
21.	Follow the Memorandum of Understanding (MOU) protocol for herbicide applications within one (1) mile of Contra Costa Water District (CCWD) drinking water intake facilities	Mitigation Measure U1a	Impact U1: Water utility intake pumps	W1b; W2d; W3d; W5a
22.	Notify County Agricultural Commissioners about WHCP activity	Mitigation Measure A1a Mitigation Measure A2a	Impact A1: Agricultural crops Impact A2: Irrigation pumps	W5c

[1] Please refer to the text for the complete mitigation measure description.

Chapter 7

Cumulative Impacts Assessment

7. Cumulative Impacts Assessment

This chapter of the Final PEIR provides an assessment of the WHCP's potential to contribute to cumulative impacts in the Delta region. Section 15130 of the CEQA guidelines require that an EIR discuss the cumulative impacts of a project when the project's incremental effect is cumulatively considerable.

Section 15355 of the CEQA guidelines defines cumulative impacts as follows: "Cumulative impacts refer to two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts. The individual effects may be changes resulting from a single project or number of separate projects. The cumulative impact from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time."

There are two possible approaches to discussing significant cumulative impacts. The first approach, utilized in this Final PEIR, is to use a list of past, present, and probable future projects producing related or cumulative impacts. The second approach is to utilize projections in an adopted general plan or planning document. Within the first approach, factors to consider when determining whether or not to assess a related project include: the nature of each environmental resource being examined, location of the project, and type of project.

This chapter identifies related projects, and provides a discussion of potential cumulative impacts. The chapter is organized as follows:

A. Related Project Summaries
B. Assessment of Cumulative Impacts.

A. Related Project Summaries

There are numerous large and small-scale projects in the Delta related to resource conservation, endangered species, restoration, water conveyance, water quality, and water use. Many of these projects have been in operation for several years, while others are in the early stages of planning and environmental permitting. In developing this summary of past, current, and future projects, we primarily utilized the July 2009, Delta-Mendota Canal/California Aqueduct Interie EIS, and the August 2008, Biological Assessment on the Continued Long-Term Operations of the Central Valley Project and the State Water Project, as well as other environmental documentation and project summaries.

Most Delta-wide projects are of far greater scope than the WHCP. For example, several of the projects described in this chapter involve significant Delta-wide operations that will influence Delta hydraulics and fisheries. None of the prior Delta EIRs or EISs reviewed for this PEIR (with the exception of the EDCP EIR) even considered the WHCP or EDCP in their cumulative impacts assessment. This suggests to the DBW that as compared to other Delta projects, the environmental impacts of the WHCP are immaterial.

Below, we describe 33 past, present, and possible future projects (not including the WHCP) with which the WHCP may potentially contribute to cumulative impacts. We categorize these projects based on their implementation time period: (1) Existing Delta Projects, (2) Near Future Delta Projects, (3) Longer-Term Future Delta Projects, and (4) Terminated Delta Projects. Near future Delta projects are in construction or planning phases, with significant probable action expected in the next few years. Longer-term future Delta projects are earlier in the planning phases. Terminated Delta projects include projects that were past projects, and projects that were planned, but at this point in time are no longer likely to be implemented.

1. Existing Delta Projects

Egeria densa Control Program (EDCP) (1)

The DBW operates the *Egeria densa* Control Program, as well as the WHCP. *Egeria densa* (Brazilian Waterweed) is a fast growing submerged invasive aquatic plant that has a significant impact on shallow-water habitat in the Delta. In the past 45 years since *Egeria densa* was introduced into the Delta, it has infested approximately 10,000 of the 55,000 surface acres of the Delta. *Egeria densa* crowds out native plants, slows water flows, entraps sediments, obstructs waterways, impedes anadromous fish migration patterns, and clogs water intakes.

In 1997, AB 2193 amended the California Harbors and Navigation Code (Chapter 2, Article 2, Section 64) to designate the DBW as lead agency for control of *Egeria densa* in the Delta, its tributaries, and Suisun Marsh. The DBW prepared an EIR for the EDCP in 2001, and has operated the EDCP since the 2001 treatment season. The EDCP operates under the same NPDES General Permit for Aquatic Pesticides Use (CAG 990005) as does the WHCP. In addition, the EDCP operates under USFWS and NOAA-Fisheries biological opinions with similar requirements as the WHCP biological opinions.

The EDCP essentially operates in parallel to the WHCP, with the same time periods, monitoring, and permit requirements. In 2008, the EDCP utilized only one herbicide, fluridone, although DBW used three different formulations of this chemical. After several years of limited efficacy, the DBW implemented a new approach in 2007 and 2008, with extensive treatments in one nursery area, Franks Tract. In 2008, the DBW treated 2,571 acres within Franks Tract between April 7th and May 31st. The treatment protocol was designed to maintain between 1 and 10 ppb of fluridone in the water column during the treatment period.

DBW conducted Fastest (immune-assay) testing and residue sampling for fluridone levels. All but five receiving water residue samples had non-detectable levels of fluridone, and the five samples with detectable levels were orders of magnitude below the maximum receiving water residue limit of 560 ppb (all five samples were less than 2 ppb). In addition, Fastest samples were taken within and adjacent to Franks Tract to ensure that residue levels did not exceed the target concentration levels, or levels established by NOAA-Fisheries in the biological opinion. The maximum Fastest sample was 17.5 ppb, and most samples were less than 5 ppb.

The EDCP nursery area treatment approach was effective in reducing *Egeria densa* bio-cover, and bio-volume in Franks Tract. As a result, the DBW is continuing this focused treatment-area approach for the EDCP, expanding to a new nursery area in the eastern Delta in 2009. This focused approach means that, rather than treat numerous sites spread throughout the Delta, material EDCP herbicide treatments occur in only one, or perhaps two, locations during a treatment season.

The DBW's December 2006, *Second Addendum to 2001 Environmental Impact Report with Five-Year Program Review and Future Operations Plan* identified potentially affected environmental factors for the EDCP. Many of the potentially affected environmental factors are the same potentially affected environmental factors as described for the WHCP. The environmental resource areas with potentially significant impacts resulting from the EDCP include:

- **Agricultural Resources** – avoidable significant impacts to agricultural crops or agricultural operations, such as irrigation.
- **Biological Resources** – unavoidable or potentially unavoidable significant impacts to special status species, wetlands, and movement of native species; avoidable significant impacts to riparian or sensitive natural communities.
- **Hazards and Hazardous Materials** – avoidable significant impacts due to routine transport, use, or disposal; or accidental spill, of hazardous materials.
- **Hydrology and Water Quality** – unavoidable or potentially unavoidable significant impacts due to violation of water quality standards, waste discharge requirements, or otherwise degrading water quality; avoidable significant impacts due to potentially degrading drinking water quality.
- **Utilities and Service Systems** – avoidable significant impacts due to plant fragments blocking water utility intake pumps.

Central Valley Project (CVP) and State Water Project (SWP) (2)

All activities within the Delta occur within the context of the CVP and SWP. The CVP and SWP are two major inter-basin water storage and delivery systems that divert and re-divert water from the southern portion of the Delta. Both the CVP and SWP include major reservoirs upstream of the Delta, and transport water via natural watercourses and canal systems to areas south and west of the Delta.

The USBR and DWR operate the CVP and SWP to divert, store, and convey water consistent with applicable law and contractual obligations. The Coordinated Operations Agreement (COA) defines the project facilities and their water supplies, sets forth procedures for coordination of operations, identifies formulas for sharing joint responsibilities for meeting Delta standards, identifies how unstored flow will be shared, sets up a framework for exchange of water and services, and provides for periodic review of the agreement (USBR August 2008). The Operations Criteria and Plan (OCAP) defines the ongoing operations of the CVP and SWP. The USBR prepared a biological assessment for the OCAP in August 2008.

Environmental Water Account (3)

The Environmental Water Account (EWA) is a two-part cooperative management program to assist in protecting and restoring native fish species, and to increase water supply reliability for CVP and SWP water deliveries (USBR 2003; USBR 2008). Agencies involved in implementing the EWA are: the Department of Water Resources, the Department of Fish and Game, the Bureau of Reclamation, the USFWS, and NOAA-Fisheries. The EWA curtails pumping at CVP and SWP facilities to protect fish, and then purchases water from willing sellers to replace contract water supplies. The EWA was proposed in the CALFED 2000 Record of Decision (ROD), and an EIR/EIS was completed in 2004. The program was originally scheduled to run through 2007.

The Bureau of Reclamation, USFWS, and NOAA-Fisheries received congressional authorization to participate in the EWA through September 30, 2010, including an emphasis to support the Vernalis Adaptive Management Plan (VAMP). Federal authorization would be required to continue the EWA beyond September 30, 2010. EWA agencies are currently conducting environmental reviews to determine the future of the EWA (USBR August 2008).

South Delta Temporary Barriers Project (4)

The DWR has installed temporary barriers in the South Delta in the spring and/or fall for most years since 1991 (DWR 2008). After the 1991 test project proved successful, the DWR extended the project until 2001, and then until 2010. The project consists of four rock barriers across South Delta channels. The barriers serve as "fish barriers", to benefit migrating salmon, or "agricultural barriers", to increase water levels, water quality, and circulation patterns for agricultural users. The DWR monitors impacts of the barriers on water quality and fisheries. In response to the NOAA-Fisheries 2008 biological opinion on the temporary barriers, the DWR is conducting additional monitoring on the potential for predation at the barriers. This analysis will supplement the South Delta Improvement Program environmental documentation (NOAA-Fisheries June 2009).

USFWS BO – Reasonable and Prudent Alternative (5)

The USFWS determined in December 2008 that a Reasonable and Prudent Alternative (RPA) is necessary for the protection of delta smelt (USBR July 2009). The RPA includes measures to: (1) prevent/reduce entrainment of delta smelt at Jones and Banks Pumping Plants; (2) provide adequate habitat conditions that will allow the adult delta smelt to successfully migrate and spawn in the Bay-Delta; (3) provide adequate habitat conditions that will allow larvae and juvenile delta smelt to rear in the Bay-Delta; (4) provide suitable habitat conditions that will allow successful recruitment of juvenile delta smelt to adulthood; and (5) monitor delta smelt abundance and distribution by continued sampling programs through the IEP. The RPA is comprised of the following actions:

- **Action 1:** To protect pre-spawning adults, exports would be limited starting as early as December 1st (depending on monitoring triggers) so that the average daily Old and Middle River (OMR) flows is no more negative than -2,000 cfs for a total duration of 14 days.
- **Action 2:** To further protect pre-spawning adults, the range of net daily OMR flows will be no more negative than -1,250 to -5,000 cfs (as recommended by smelt working group) beginning immediately after Action 1 is needed.
- **Action 3:** To protect larvae and small juveniles, the net daily OMR flows will be no more negative than -1,250 to -5,000 cfs (as recommended by smelt working group) for a period that depends on monitoring triggers (generally March through June 30th).
- **Action 4:** To protect fall habitat conditions, sufficient Delta outflow will be provided to maintain an average X2 for September and October no greater (more eastward) than 74 km (Chipps Island) in the fall following wet years and 81 km (Collinsville) in the fall following above normal years.
- **Action 5:** The head of Old River barrier will not be installed if delta smelt entrainment is a concern. If installation of the head of Old River barrier is not allowed, the agricultural barriers would be installed as described in the Project Description (of the OCAP BA).

- **Action 6:** A program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh will be implemented within 10 years. A monitoring program will be developed to focus on the effectiveness of the restoration program (USBR July 2009, 6-4).

NOAA-Fisheries BO – Reasonable and Prudent Alternative (6)

NOAA-Fisheries (also known as National Marine Fisheries Service, NMFS) determined (June 2009) that an RPA was necessary for the protection of salmon, steelhead, and green sturgeon (USBR July 2009). The RPA includes measures to improve habitat, reduce entrainment, and improve salvage, through both operational and physical changes in the system. Additionally, the RPA includes development of new monitoring and reporting groups to assist in water operations through the CVP and SWP systems and a requirement to study passage and other migratory conditions. The more substantial actions of the RPA include:

- Providing fish passage at Shasta, Nimbus, and Folsom Dams
- Providing adequate rearing habitat on the lower Sacramento River and Yolo Bypass through alternation of operations, weirs, and restoration projects
- Engineering projects to further reduce hydrologic effects and indirect loss of juveniles in the interior Delta
- Technological modifications to improve temperature management in Folsom Reservoir.

Overall the RPA is intended to avoid jeopardizing listed species or adversely modifying their critical habitat, but not necessarily achieve recovery. Nonetheless, the RPA would result in benefits to salmon, steelhead, green sturgeon and other fish and species that use the same habitats (USBR July 2009, 6-5).

Old River and Rock Slough Water Quality Improvement Project (7)

CCWD completed the Old River and Rock Slough Water Quality Improvement Project in 2006 (USBR July 2009). This project was designed to minimize salinity and other constituents of concern in drinking water by relocating or reducing agricultural drainage in the south Delta. CCWD intake facilities are located on Rock Slough and Old River, which also receive agricultural drainage water discharged from adjacent agricultural lands. Agricultural drainage water can adversely affect water quality entering the CCWD system (USBR July 2009, 6-11).

CalFed Levees Program (8)

The goal of the CALFED Levees Program is to uniformly improve Delta levees by modifying cross sections, raising levee height, widening levee crown, flattening levee slopes, or constructing stability berms (USBR July 2009). Estimates predict that there are 520 miles of levees in need of improvement and maintenance to meet the standard for Delta levees. The levees program continues to implement levee improvements throughout the Delta, including the south Delta area (USBR July 2009, 6-14).

CalFed – Ecosystem Restoration Program Conservation Strategy/ Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) (9)

As controversies over the Delta and water grew in the early 1990's, Governor Pete Wilson and State and federal agencies established the Delta Accord. The Accord established interim water quality standards, and created CalFed. CalFed was tasked to: (1) develop long-term water quality standards for the Delta, (2) coordinate operations of the CVP and SWP, and (3) develop long-term solutions for the Delta. After several years of preparation, CalFed was formally established in 2000, with the signing of the Record of Decision (ROD). The State-Federal partnership was tasked to: expand water supplies and ensure efficient water use, improve water quality, improve the health of the Bay-Delta ecosystem, and improve Bay-Delta levees. The partnership has been slow to meet these objectives, and is now operating under a new 10-Year Action Plan, including establishing a strategic planning function and developing program performance measures.

CalFed is developing an Ecosystem Restoration Program (ERP) Conservation Strategy to identify restoration opportunities in the Delta and Suisun Marsh. The strategy will serve as a guidance document for ecosystem restoration, and will incorporate new information on the ecosystem as it is better understood. The first ERP Conservation Strategy will focus on the Delta and Suisun Marsh, and is titled: Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) (CDFG 2008; URS Corporation 2007). The DRERIP will refine and develop new Delta specific ecosystem restoration projects, and will incorporate performance evaluation and adaptive management feedback. The plan is being developed during 2009.

CalFed has developed a DRERIP Scientific Evaluation Process to evaluate draft conservation measures, including those outlined in the Bay Delta Conservation Plan (BDCP). The evaluation process includes criteria for scoring the magnitude of ecological outcomes, and the certainty of ecological outcomes (The Essex Partnership, May 2009).

As stated in the South Delta Improvement Program (SDIP) Draft EIS/EIR, "The CalFed ERP [Ecosystem Restoration Program] actions, when considered with other cumulative Delta projects and actions are intended to improve, in part, Delta habitat and conditions for fish and wildlife. Although implementing ERP actions in the Delta may result in some temporary disturbance of Delta waterways and habitat, it is unlikely that these effects would substantially affect local or export water supplies. Improvements to Delta aquatic and terrestrial habitats could result in improved water quality and habitat conditions that ultimately would be beneficial to improving local and export water supply reliability" (DWR October 2005, 10-24).

Stockton East Water District Efficiency Enhancement Project) (10)

The Stockton East Water District began a $12 million Efficiency Enhancement Project in 2005 to increase the amount of drinking water available for the Stockton urban area (Stockton East Water District 2009). The enhancements include pretreatment system efficiency improvements, a new sedimentation basin and chemical feed system, and retrofits for an existing pump system.

2. Near Future Delta Projects

Contra Costa Water District (CCWD) Alternative Intake Project (11)

The CCWD will construct a new intake pump at Victoria Canal. Construction began in 2009 (CCWD May 2006; CCWD 2006; CCWD 2009). The project will enable CCWD to relocate some of its existing diversions to Victoria Canal, a Delta location with higher-quality source water than is currently available at its Old River and Rock Slough intakes. The new pump location at Victoria Canal will provide improved drinking water quality to CCWD customers. The new intake pump will not increase total diversions, and will include fish screens, improving long-term benefits to Delta fisheries.

The new intake could result in potentially significant impacts to Delta fisheries and aquatic resources during construction as a result of underwater sound pressure from cofferdam installation, potential chemical spills, and potential fish and macroinvertebrate stranding during dewatering of the cofferdam (CCWD May 2006).

The new intake could result in less than significant impacts during construction due to increased sedimentation, turbidity, and contaminants. The new intake could result in less than significant impacts to Delta water resources due to long-term changes in Delta water supplies, potential violations of Delta water quality standards, and potential long-term changes that result in water quality degradation that would affect beneficial uses. The CCWD will implement mitigation measures to reduce these significant impacts.

City of Sacramento Water Facilities Expansion Project (12)

The City of Sacramento is in the process of expanding and replacing facilities at the E.A. Fairbairn Water Treatment Plant, and the Sacramento River Water Treatment Plant. The City is also considering the eventual construction of a new treatment plant north of the Sacramento International Airport. The City obtained an EIR for a first round of treatment plant expansion in 2000, and made a number of improvements, including a new intake facility on the Sacramento River. In 2009, the City is considering a range of capital improvement projects that will increase the sustainable capacity of the Sacramento plant from the current level of 93 million gallons per day, to 150 million gallons per day. The City also evaluated three expansion alternatives to provide an additional 150 million gallons per day of capacity (City of Sacramento March 2009).

Sacramento River and Stockton Deep Water Ship Channels (13)

The Sacramento River Deep Water Ship Channel provides a deep-draft channel from Suisun Bay to an inland harbor at Washington Lake, west of the Sacramento River in the City of West Sacramento. The Stockton Deep Water Ship Channel extends from Suisun Bay into the San Joaquin River and ends at the turning basin in the City of Stockton, a distance of 43 miles. The John F. Baldwin Ship Channel extends from the Golden Gate to Chipps Island (in Suisun Bay). The U.S. Army Corps of Engineers is planning to solicit bids for annual maintenance dredging in the Sacramento River and Stockton Deep Water Ship Channels. The U.S. Army Corps of Engineers is also preparing a feasibility study and EIS/EIR for a San Francisco Bay to Stockton Improvement Study that would evaluate effective, affordable, and environmentally sustainable approaches to improving the navigation efficiency of this transportation artery (U.S. Army Corps of Engineers 2008).

Delta Wetlands Project (14)

The Delta Wetlands Project, is a private water development project that would divert and store up to 210,000 acre-feet on two islands in the Delta and dedicate two other islands for wetland and wildlife habitat improvements (USBR July 2009). The Delta Wetlands Project was analyzed in environmental documents and permits were issued for the private project in 2001, and an update to those analyses is currently being prepared. As part of the Delta Wetlands Project, Webb Tract and Bacon Island would be converted to reservoirs, and Bouldin Island and Holland Tract would be used as wetland and wildlife habitat per DFG habitat management plans (USBR July 2009, 6-7). The Semitropic Water Storage District is assuming the role of CEQA lead agency for the Delta Wetlands Project EIR. Semitropic published a Notice of Preparation in November 2008 (Delta Wetlands Project 2009).

San Joaquin River Agreement and Vernalis Adaptive Management Plan (VAMP) (15)

The VAMP is a twelve year experimental management program intended to protect juvenile Chinook salmon in the San Joaquin River, while determining how salmon survival rates change based on alterations in San Joaquin River flows and SWP/CVP exports (CDFG 2008; San Joaquin River Group Authority 2008). The program was initiated in 2000 as part of the San Joaquin River Agreement, and will run until 2012. VAMP consists of implementing a pulse flow in the San Joaquin river for a 31-day period in April/May, and reduced CVP/SWP pumping, to facilitate migration and attraction of anadromous fish. Lead agencies include USFWS, NOAA-Fisheries, and CDFG. The program evaluates salmon survival rates and flows, and determines flow levels based on hydrological conditions in the San Joaquin River watershed. The original agreement was intended to implement the SWRCB 1995 Water Quality Control Plan for the San Joaquin River and San Francisco Bay-Delta Estuary. In 2007, VAMP activities were modified slightly to account for low salmon production at the Merced River Hatchery, and concern over delta smelt abundance.

San Joaquin River Restoration Program (SJRRP) (16)

The SJRRP will implement the San Joaquin River litigation settlement involving the Natural Resources Defense Council (NRDC), Friant Water Users Authority, the Department of Interior, and NOAA-Fisheries (SJRRP 2007). The program is being implemented by the Bureau of Reclamation, USFWS, NOAA-Fisheries, DWR, and DFG. The goals of the program are to restore and maintain fish populations in "good condition" on the main stem of the San Joaquin River below Friant Dam, and to the confluence of the Merced River, and to reduce or avoid adverse water supply impacts to Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the settlement.

Federal legislation to fund the SJRRP was signed in March 2009. The program will prepare a Draft EIR/EIS by August 2009, to analyze specific impacts of the settlement. The settlement requires specified releases from Friant Dam to support migration and emigration of spring and fall run Chinook salmon. Interim flows are to begin in fall 2009, and the project will also include structural and channel improvements. Construction is likely to result in significant environmental impacts to biological resources and hydrology and water quality. Total costs are expected to range from $250 million to $800 million. The project area falls within WHCP treatment sites currently managed by Merced and Fresno Counties.

Bay Delta Conservation Plan (17)

This major collaborative planning effort is led by the California Department of Water Resources, California Department of Fish and Game, State Water Resources Control Board, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Services, and NOAA-Fisheries (DWR 2008; Resources Agency 2008). Several water agencies, environmental organizations, and other organizations are also involved. The "purpose of the BDCP is to help recover endangered and sensitive species and their habitats in the Delta in a way that also will provide for sufficient and reliable water supplies."

The effort was initiated by Governor Schwarzenegger when he requested that the DWR evaluate at least four alternative Delta conveyance strategies in coordination with BDCP efforts to better protect at-risk fish species. The BDCP effort will meet ESA and Natural Community Conservation Planning requirements, and will also include development of an EIR/EIS.

As outlined in the Notice of Preparation, the BCDP is ultimately intended to "secure authorizations that would allow the conservation of covered species, the restoration and protection of water supply reliability, protection of certain drinking water quality parameters, and the restoration of ecosystem health to proceed within a stable regulatory framework." Activities under the BDCP will include habitat development, water supply and power generation, facility maintenance, and improvements. The entire BDCP and EIR/EIS process will be completed in late 2010, with draft documents completed in early 2010 (California Natural Resources Agency March 2009).

One of the goals of the project is to reexamine the conveyance alternatives that were analyzed in the CALFED August 2000 documents, based on recent declines in pelagic organisms, particularly delta smelt, increased concern about higher risks from Delta levees due to earthquakes, and potential impacts of climate change. The BDCP stems in part from the Delta Vision's recommendation that the State should consider different approaches to conveying water through the Delta than the current through-Delta alternative that was approved by the CALFED Record of Decision. The four alternatives that the BDCP Steering Committee is currently considering are:

- Existing through Delta conveyance with physical habitat restoration
- Improved through Delta conveyance with physical habitat restoration
- Dual conveyance, including improved through Delta conveyance and isolated conveyance from the Sacramento River to the south Delta, with physical habitat restoration
- Isolated conveyance from the Sacramento River to south Delta, with physical habitat restoration.

Franks Tract Project) (18)

The DWR and Bureau of Reclamation propose to implement the Franks Tract Project to improve water quality and fisheries conditions in the Delta (USBR July 2009). DWR and Reclamation are evaluating installing operable gates to control the flow of water at key locations (Threemile Slough and/or West False River) to reduce sea water intrusion, and to positively influence movement of fish species of concern to areas that provide favorable habitat conditions. By protecting fish resources, this project also would improve operational reliability of the SWP and CVP because curtailments in water exports (pumping restrictions) are likely to be less frequent. The overall purpose of the Franks Tract Project is to modify hydrodynamic conditions to protect and improve water quality in the central and south Delta, protect and enhance conditions for fish species of concern in the western and central Delta, and achieve greater operational flexibility for pump operations in the south Delta (USBR July 2009, 6-12).

Two-Gate Project (19)

As part of the interim remedy order of December 14, 2007, U.S. District Court Judge Wanger imposed restrictions on reverse flows in the south Delta to protect delta smelt from entrainment at the SWP and CVP export facilities (USBR July 2009). In response, the Two-Gate Project has been proposed by Delta exporters in coordination with the DWR as a physical and operational measure to help reduce potential entrainment under certain conditions and to reduce the water costs associated with such protection. Although the proposed project and associated operations are still being developed, an initial project description is provided below. This description will be revised when further information becomes available.

The Two-Gate Project would involve the installation and operation of two gate systems in the central Delta: one on the Old River between Holland Tract and Bacon Island, and one on Connection Slough near Middle River between Bacon Island and Mandeville Island.

The project would be implemented in two phases. Phase 1 (a 5-year pilot period) would involve the installation and operation of temporary gates constructed from barge modules with top-mounted butterfly gates. This barge-gate system and temporary sheetpile walls connecting them to the river channel levees would be set in place seasonally from mid-December through June, and then removed until the following December. If operation of these gates proves successful during the pilot phase, Phase 2 would involve the installation and operation of an inflatable bladder gate system or equivalent system.

Both the Phase 1 and Phase 2 gate installations would be operated under protocols developed to protect delta smelt; this would include real-time monitoring elements to determine when to operate the gates, and an evaluation process to assess operational success. In effect, the Old River and Connection Slough gates would provide hydraulic separation of the Franks Tract area from the effects of reverse flows of Old River and Middle River and would be operated in a manner to allow vessel passage.

Compatibility between the Franks Tract Project and the Two-Gate Project will be considered as part of the Franks Tract federal planning process as both projects are further developed (USBR July 2009, 6-12).

Suisun Management Plan (20)

The Bureau of Reclamation, USFWS, and DFG are currently NEPA and CEQA lead agencies in the development of a management plan to restore 5,000 to 7,000 acres of tidal wetlands and enhance existing seasonal wetlands in Suisun Marsh (USBR July 2009). The plan would be implemented over 30 years and is expected to contribute to the recovery of many terrestrial and aquatic species. The EIS/EIR for the plan is expected to be complete in 2009 (USBR July 2009, 6-14).

Delta Water Supply Project (DWSP) (21)

The City of Stockton Municipal Utility Department is constructing a new pipeline and treatment facility. The DWSP will develop a new supplemental water supply for the Stockton Metropolitan Area by taking in water from the Delta and pumping that water through miles of pipeline running along Eight Mile Road. From there, the water will be pumped to a state-of-the-art surface water treatment plant where it will be treated to drinking water standards. The water treatment plant will be located just north of Eight Mile Road on Lower Sacramento Road (City of Stockton, 2009). The Final EIR for the $200 million project was completed in October 2005, construction began in 2009, and the expected completion date is 2011.

3. Longer-Term Future Delta Projects

South Delta Improvement Program (SDIP) Stage 1 (22)

The SDIP is divided into Stages 1 and 2. Stage 1 includes the construction and operation of permanent operable gates (to replace the temporary barriers), dredging in portions of the south Delta, and extension of some agricultural diversion structures by 2012 (USBR July 2009). The operation of the gates is included in the OCAP analysis.

The head of Old River gate would be operated between April 15th and May 15th and in the fall. The remaining three agricultural gates would be operated April 15th through the agricultural season. The gates would maintain south Delta water levels above 0.0 mean sea level for channels upstream of the operable gates (USBR July 2009, 6-2).

The NOAA-Fisheries OCAP Biological Opinion specified that the DWR shall not implement Stage 1 of the SDIP because of concerns that microhabitats created at the permanent barriers would increase fish predation. The DWR is exploring different barrier designs and conducting monitoring on predation impacts at their South Delta Temporary Barriers. The DWR is likely to reinitiate consultation on the SDIP Stage 1 once that monitoring is completed (NOAA-Fisheries June 2009). The DWR will continue to pursue this project, although it is not likely to be implemented until 2016.

Upper San Joaquin River Basin Storage Investigation (23)

The Upper San Joaquin River Basin Storage Investigation is a feasibility study by the U.S. Bureau of Reclamation and DWR (USBR July 2009). The purpose of the investigation is to determine the type and extent of federal, State, and regional interests in a potential project in the upper San Joaquin River watershed to expand water storage capacity; improve water supply reliability and flexibility of the water management system for agricultural, urban, and environmental uses; and enhance San Joaquin River water temperature and flow conditions to support anadromous fish restoration efforts.

Progress and results of the investigation are being documented in a series of interim reports that will culminate in a Feasibility Report and an EIS/EIR. The first of a series of reports analyzing alternatives was completed in 2003, with a second report, an "Initial Alternatives Information Report," completed in spring 2005, and a Plan Formulation Report completed in October 2008. A final feasibility report and environmental review are expected to be complete in 2011 (USBR July 2009, 6-8).

Tracy Fish Test Facility (24)

The Tracy Fish Test Facility, to be constructed near Byron, California, will develop and implement new fish collection, holding, transport, and release technology to significantly improve fish protection at the major water diversions in the south Delta (USBR July 2009). The DWR and USBR will use results of the Tracy Fish Test Facility to design the potential Clifton Court Forebay Fish Facility, and improve fish protection at the Jones Pumping Plant facility.

The test facility, unlike conventional fish screening facilities, will require fish screening, fish holding, and fish transport and stocking capabilities. The facility would be designed to screen about 500 cfs of water at an approach velocity of 0.2 feet per second and meet other appropriate fish agency criteria. The facility would have the structural and operational flexibility to optimize screening operations for multiple species in the south Delta.

Construction of the facility has been delayed by shortfalls in funding. The South Delta Fish Facilities Forum, a CALFED workgroup, is evaluating the cost effectiveness and cost sustainability of the fish facilities strategy. If eventually constructed, the Tracy Fish Test Facility would not affect current CVP and SWP operations (USBR July 2009, 6-9).

Delta Cross Channel (DCC) Re-operation and Through-Delta Facility (25)

As part of the CALFED ROD, changes in the operation of the DCC and the potential for a Through-Delta Facility (TDF) are being evaluated (USBR July 2009). Studies are being conducted to determine how changing the operations of the DCC could benefit fish and water quality. This evaluation will help determine whether a screened through-Delta facility is needed to improve fisheries and avoid water quality disruptions. In conjunction with the DCC operations studies, feasibility studies are being conducted to determine the effectiveness of a TDF. The TDF would include a screened diversion on the Sacramento River of up to 4,000 cfs and conveyance of that water into the Delta. Both a DCC re-operation and a TDF would change the flow patterns and water quality in the Delta, affecting fisheries, ecosystems, and water supply reliability. Further consideration of related actions will take place only after completion of several assessments (USBR July 2009, 6-10).

Bay Area Water Quality and Reliability Program (26)

The Bay Area Water Quality and Reliability Program would encourage participating Bay Area partners, including Alameda County Water District, Alameda County Flood Control & Water Conservation District, Bay Area Water Users Association, Contra Costa Water District, East Bay Municipal Utility District, San Francisco, and the Santa Clara Valley Water District, to develop and coordinate regional exchange projects to improve water quality and supply reliability (USBR July 2009). This project would include the cooperation of these agencies in operating their water supplies for the benefit of the entire Bay Area region as well as the potential construction of interconnects between existing water supplies. This program is in the preliminary planning stages. No specific projects have been proposed and evaluated in detail (USBR July 2009, 6-11).

North Bay Aqueduct Intake Project (27)

The North Bay Aqueduct Intake Project would construct a new intake for the North Bay Aqueduct to increase the flow in the aqueduct (USBR July 2009). It will involve the construction of pipeline corridors and connection points to the existing North Bay Aqueduct. Possible intake points are the Deep Water Ship Channel, Sutter/Elk Slough, Steamboat Slough, Miner Slough, and Main Stem Sacramento River. Environmental analysis is expected to begin in 2009 (USBR July 2009, 6-11).

Sacramento Valley Water Management Agreement (Phase 8) (28)

The State Water Board has held proceedings regarding the responsibility for meeting the flow-related water quality standards in the Delta established by the Delta Water Quality Control Plan (D-1641) (USBR July 2009). The State Water Board hearings have focused on which users should provide this water, and Phase 8 focuses on the Sacramento Valley users. The Sacramento Valley Water Management Agreement (SVWMA) is an alternative to the State Water Board's Phase 8 proceedings. The SVWMA, entered into by DWR, Reclamation, Sacramento water users, and export water users, provides for a variety of local water management projects that will increase water supplies cumulatively. An environmental document is being prepared for the program (USBR July 2009, 6-14).

4. Terminated Delta Projects

Some of these terminated projects were implemented, while others were planned, but never initiated. We describe these projects here for informational purposes, in the event that they are reinitiated.

South Delta Improvement Project Stage 2 (29)

As described above, the SDIP is divided into Stages 1 and 2 (USBR July 2009). State 2 consists of increasing the permitting diversion amount at Clifton Court Forebay (CCF) to 8,500 cfs. All of SDIP was evaluated in an EIS/EIR, finalized in 2006. DWR and Reclamation are currently preparing a supplemental document for Stage 1. Neither agency intends to pursue Stage 2 in the near future, but it is included in the cumulative analysis because it could be foreseeable if Delta conditions improve and DWR and/or Reclamation decide to pursue it (USBR July 2009, 6-8).

Delta Mendota Canal Recirculation Project (30)

The DWR and the Bureau of Reclamation are preparing a Draft EIR/EIS, expected to be completed in late 2009, on this project to evaluate recirculation of Delta water pumped from the Jones Pumping plant (CVP), back through waterways into the San Joaquin River (USBR 2007). This would reduce salinity and maintain adequate flows in the river, reducing reliance on New Melones Reservoir water supplies. The USBR and DWR are studying the potential impacts of recirculation, an option that was recommended in the CALFED Record of Decision. This project may not be implemented.

In-Delta Storage Project (31)

In-Delta Storage would increase the reliability, operational flexibility, and water availability for south-of-Delta water users (USBR July 2009). An in-Delta storage location can capture peak flows through the Delta in the winter when the CVP and SWP systems do not have the capacity or ability to capture those flows. Water can then be released from the in-Delta reservoirs during periods of export demands, typically summer months. Storing water in the Delta provides the opportunity to change the timing of Delta exports and the ability to capture flows during periods of low impacts on fish. In May 2006, the DWR completed the "2006 Supplemental Report to 2004 Draft State Feasibility Study In-Delta Storage Project," and recommended that further detailed study of the In-Delta Storage Project be suspended until a proposal is submitted by potential participants detailing their specific interests, needs, and objectives that support re-initiation (USBR July 2009, 6-7). The Delta Wetlands Project, described earlier, is a private in-Delta storage project that is closer to implementation.

Lower San Joaquin Flood Improvements (32)

The primary objective of this potential project is to "design and construct floodway improvements on the lower San Joaquin River and provide conveyance, flood control, and ecosystem benefits" (CALFED ROD in USBR July 2009). This potential project would construct setback levees in the South Delta Ecological Unit along the San Joaquin River between Mossdale and Stockton, and convert adjacent lands to overflow basins and nontidal wetlands or land designated for agricultural use. The levees are necessary for future urbanization and will be compatible with the Sacramento and San Joaquin River Basins comprehensive study. Progress has been indefinitely delayed with no scheduled date for completion. Nevertheless, if implemented, the potential project may also include the restoration of riparian and riverine aquatic habitat, increased riparian habitat, restrictions of and on dredging and sediment disposal, reduction of invasive plants, and protection and mitigation of effects on threatened or endangered species. This potential project could contribute to ecosystem improvements in the lower San Joaquin River (USBR July 2009, 6-9).

North Delta Flood Control Ecosystem Restoration Project (33)

The purpose of the North Delta Flood Control and Ecosystem Restoration Project is to implement flood control improvements in the northeast Delta in a manner that benefits aquatic and terrestrial habitats, species, and ecological processes (USBR July 2009). The North Delta project area includes the North and South Fork Mokelumne Rivers and adjacent channels downstream of I-5 and upstream of the San Joaquin River. Solution components being considered for flood control include bridge replacement, setback levees, dredging, island bypass systems, and island detention systems. The project will include ecosystem restoration and science actions in this area, and improving and enhancing recreation opportunities. In support of the environmental review process, a Notice of Preparation/Notice of Intent (NOP/NOI) was prepared and public scoping was held in 2003. An EIR was prepared in 2008, but the project is not currently funded for implementation (USBR July 2009, 6-10).

B. Assessment of Cumulative Impacts

There is widespread acknowledgement among California policymakers that the Delta is in crisis. As the Governor's Delta Vision Blue Ribbon Task Force stated, "ecosystems have eroded, levees have deteriorated, fish populations have collapsed, and our system of delivering water has become ever more precarious" (Isenberg et al. 2008). There are numerous efforts, at the federal, State, and local level, to improve conditions in the Delta. The WHCP operates within this context of a deteriorated Delta environment, and an active array of public programs seeking to reverse this deterioration.

Table 7-1, starting on page 7-16, compares the environmental resource areas for which the WHCP has potentially significant impacts, with those of 33 other Delta projects and programs. All of the identified programs are intended to improve conditions in the Delta, for sensitive species and habitats, agriculture, or water quality, or some combination of these areas. However, in creating these improved conditions, each program also has the potential to result in significant environmental impacts, at least temporarily. Most of these 33 other Delta programs identified in this Chapter have significantly greater scope, and scale, than the WHCP. The WHCP affects only a relatively small percentage of the total Delta, while many of these programs have, or will have, Delta-wide affects. Currently, several of these programs are still in the planning and permitting phases. Only the EDCP is of a similar small scale to the WHCP.

The two environmental resource areas that are most likely to be affected by cumulative impacts of the WHCP, combined with these other Delta projects and programs, are biological resources, and hydrology and water quality. Several projects and programs identified in Table 7-1 are in the planning phase, and have not completed environmental impact reports. However, given the scope of these project efforts, it is reasonable to assume that impacts to biological resources are likely.

To the extent that any of these Delta projects create stress (of any kind) on special status species and habitats, this stress could be compounded by the combined impacts of each program. For example, while the potential impacts of the WHCP on special status fish may be limited, if special status fish are already impacted by other Delta projects, the cumulative impact on special status fish may be significant.

The WHCP will implement mitigation measures, as described in Chapter 3, to minimize WHCP impacts to biological resources. In addition, as these other projects and programs are implemented, they will also implement mitigation measures to minimize impacts on biological resources.

The potential for cumulative impacts to hydrology and water quality are similar to those of biological resources. The WHCP will potentially result in unavoidable, potentially unavoidable, or avoidable impacts to water quality. Several of these other Delta programs may also result in at least temporary impacts to water quality, that when combined with the WHCP impacts, would be cumulatively considerable. WHCP mitigation measures, as described in Chapter 5, will minimize the WHCP's contribution to water quality degradation in the Delta. These other Delta projects will also implement mitigation measures to minimize impacts to hydrology and water quality.

For projects with construction-related impacts to biological resources, hydrology and water quality, or hazards and hazardous materials, the DBW will coordinate with the respective implementing agencies to avoid conducting WHCP treatments in locations where construction is taking place. This simple action will reduce or eliminate the potential for cumulative impacts during the construction phase of any Delta project.

The program with the greatest potential to result in cumulative impacts with the WHCP is the EDCP, due to the similar nature of the two programs, and the similar nature of their potential impacts. However, the EDCP and WHCP utilize different herbicides, and do not conduct treatments in the same areas of the Delta during the same time periods. As a result, the likelihood of significant cumulative impacts is low. In addition, both programs implement mitigation measures to reduce their respective impacts.

Table 7-2, following Table 7-1, provides a summary of the potential cumulative impacts resulting from the WHCP. It is likely that these cumulative impacts, should they occur, will be reduced, to some extent, by mitigation measures implemented by the WHCP, and the other programs.

Table 7-1
Comparison of Potential Impacts of the WHCP and Projects in the Delta

Project	Objective	Environmental Resource Area Potential Cumulative Impacts: Agriculture	Biological Resources	Hydrology and Water Quality	Hazards and Hazardous Materials	Utilities and Service Systems	Potential for Benefits	Status (as of July 2009)
Water Hyacinth Control Program	Controlling growth and spread of water hyacinth in the Delta	**X**	**X**	**X**	**X**	**X**	Yes	Existing
1. *Egeria densa* Control Program	Controlling growth and spread of *Egeria densa* in the Delta	X	X	X	X	X	Yes	Existing
2. Central Valley Project and State Water Project	Water storage and delivery		X	X			Yes	Existing
3. Environmental Water Account	Protect fish; increase water supply reliability		X	X			Yes	Existing
4. South Delta Temporary Barriers Project	Benefit migrating salmon and benefit agricultural water users		X	X			Yes	Existing
5. USFWS BO – Reasonable and Prudent Alternative	Protection of delta smelt		X				Yes	Existing
6. NOAA-Fisheries BO – Reasonable and Prudent Alternative	Protection of salmon, steelhead, and green sturgeon		X				Yes	Existing
7. Old River and Rock Slough Water Quality Improvement Project	Minimize salinity and other constituents in CCWD drinking water			X			Yes	Existing
8. CalFed Levees Program	Improve Delta levees		X	X			Yes	Existing
9. CalFed Ecosystem Restoration Program (DRERIP)	Refine and develop new ecosystem restoration projects		X				Yes	Existing
10. Stockton East Water District Efficiency Enhancement Project	Increase drinking water supplies in Stockton area		X	X			Yes	Existing
11. CCWD Alternative Intake Project	Improve drinking water quality		X	X	X		Yes	Near Future
12. City of Sacramento Water Facilities Expansion Project	Increase sustainable capacity of Sacramento water treatment facilities		X	X			Yes	Near Future
13. Sacramento River and Stockton Deep Water Ship Channels	Maintenance dredging and long-term channel improvements		X	X			Yes	Near Future
14. Delta Wetlands Project	Divert and store Delta water and wetlands and wildlife habitat improvements		X	X			Yes	Near Future
15. San Joaquin River Agreement and Vernalis Adaptive Management Plan	Protect juvenile salmon		X				Yes	Near Future
16. San Joaquin River Restoration Program	Restore fish, maintain water supplies		X				Yes	Near Future
17. Bay Delta Conservation Plan	Recover sensitive species and habitats while maintaining water supplies		X	X			Yes	Near Future

Table 7-1

Comparison of Potential Impacts of the WHCP and Projects in the Delta *(continued)*

Project	Objective	Environmental Resource Area Potential Cumulative Impacts					Potential for Benefits	Status (as of July 2009)
		Agriculture	Biological Resources	Hydrology and Water Quality	Hazards and Hazardous Materials	Utilities and Service Systems		
18. Franks Tract Project	Improve water quality and fisheries conditions in the Delta		X	X			Yes	Near Future
19. Two-Gate Project	Protect delta smelt from entrainment at the SWP and CVP facilities		X				Yes	Near Future
20. Suisun Management Plan	Restore and enhance tidal wetlands		X	X			Yes	Near Future
21. Delta Water Supply Project	Develop a new water supply for the Stockton area		X	X			Yes	Near Future
22. South Delta Improvement Program Stage 1	Benefit migrating salmon, benefit agricultural water users, and increase water deliveries		X	X			Yes	Longer-Term Future
23. Upper San Joaquin River Basin Storage Investigation	Determine interest in projects to expand water storage capacity and reliability		X	X			Yes	Longer-Term Future
24. Tracy Fish Test Facility	Develop and implement new procedures to improve fish protection at major water diversions		X				Yes	Longer-Term Future
25. Delta Cross Channel Re-operation and Through-Delta Facility	Determine how changing operations of the DCC would improve fisheries and avoid water quality disruptions		X	X			Yes	Longer-Term Future
26. Bay Area Water Quality and Reliability Program	Encourage regional agencies to develop and coordinate regional projects to improve water quality			X			Yes	Longer-Term Future
27. North Bay Aqueduct Intake Project	Construct a new intake for the North Bay Aqueduct		X	X			Yes	Longer-Term Future
28. Sacramento Valley Water Management Agreement (Phase 8)	Developing approaches to meet flow-related water quality standards in the Delta			X			Yes	Longer-Term Future
29. South Delta Improvement Program Stage 2	Increasing permitted diversion at Clifton Court Forebay		X	X			Yes	Terminated
30. Delta Mendota Canal Recirculation Project	Reduce salinity and maintain water flows		X	X			Yes	Terminated
31. In-Delta Storage Project	Increase the reliability, operational flexibility, and water availability for south-of-Delta water users		X	X			Yes	Terminated
32. Lower San Joaquin Flood Improvements	Design and construct floodway improvements on the Lower San Joaquin River		X	X			Yes	Terminated
33. North Delta Flood Control Ecosystem Restoration Project	Implement flood control improvements in the northeast Delta		X	X			Yes	Terminated

Table 7-2
Summary of Potential Cumulative Impacts Resulting from the WHCP

Resource Area and Potential Impact	Cumulative Impact	Description
II. Agricultural Resources		
d) Adversely impact agricultural crops or agricultural operations, such as irrigation	[X]	The WHCP may result in adverse impacts to agricultural crops through herbicide overspray or herbicide toxicity. The WCHP may also result in clogging of irrigation pumps from plant fragments. The EDCP has the potential to result in the same adverse impacts to agricultural crops and irrigation pumps
IV. Biological Resources		
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS	[X]	The WCHP may result in adverse impacts to special status species present in treatment areas through herbicide overspray, herbicide toxicity, food web effects, dissolved oxygen levels, and/or treatment disturbances. There is a potential for these listed projects to result in temporary or permanent adverse effects to special status species
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFG or USFWS	[X]	The WHCP may result in adverse impacts to riparian or other sensitive habitats due to herbicide overspray, dissolved oxygen levels, treatment disturbances, and/or plant fragmentation. There is a potential for these listed projects to result in temporary or permanent adverse effects to riparian or other sensitive habitats
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means	[X]	The WHCP may result in adverse impacts to wetlands through herbicide overspray, dissolved oxygen levels, treatment disturbances, and/or plant fragmentation. There is a potential for these listed projects to result in temporary or permanent adverse effects to wetlands
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites	[X]	The WHCP may result in adverse impacts to migratory fish through herbicide toxicity, food web effects, dissolved oxygen levels, and/or treatment disturbances. There is a potential for these listed projects to result in temporary or permanent adverse effects to migratory fish
VII. Hazards and Hazardous Materials		
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials in the environment	[X]	The WHCP may result in exposure to hazardous materials due to accidental spills of herbicide. The EDCP may result in exposure to hazardous materials due to accidental spills of herbicide. During the construction phase , the CCWD Alternative Intake Project may result in exposure to hazardous materials due to accidental spills
VIII. Hydrology and Water Quality		
a) Violate any water quality standards or waste discharge requirements	[X]	The WHCP may result in violations of water quality standards due to chemical constituents, pesticides, toxicity, dissolved oxygen levels, floating material, and/or turbidity. There is a potential for these listed projects to result in temporary or permanent violations of water quality standards
f) Otherwise substantially degrade water quality	[X]	The WHCP may degrade water quality due to chemical constituents, pesticides, toxicity, dissolved oxygen levels, floating material, and/or turbidity. There is a potential of these listed projects to result in temporary or permanent degradation of water quality
g) Otherwise substantially degrade drinking water quality	[X]	The WHCP may result in degradation of drinking water quality through chemical constituents, pesticides, and/or toxicity. There is potential for these listed projects to result in temporary or permanent degradation of drinking water quality
XVI. Utilities and Service Systems		
h) Result in problems for local or regional water utility intake pumps	[X]	The WHCP may result in adverse impacts to utility service intake pumps from plant fragments. The EDCP has the same potential to result in adverse impacts to utility service intake pumps

References

References

1. Acquavella, J.F. and D. Farmer. 1999. Review of: Hardell L, Eriksson M. A case-control study of non-Hodgkin lymphoma and exposure to pesticides. Cancer 1999;85:1353-1360, Letter to editor of New Scientist. Monsanto Company.
2. Acquavella, J.F., B.H. Alexander, J.S. Mandel, C. Gustin, B. Baker, P. Chapman, and M. Bleeke. 2004. Glyphosate biomonitoring for farmers and their families: results from the Farm Family Exposure Study. Environmental Health Perspectives. 112:3: 321-326.
3. Acquavella, J.F., C. Gustin, B.H. Alexander, and J.S. Mandel. 2005. Implications for epidemiologic research on variation by pesticide in studies of farmers and their families. Scandinavian Journal of Work and Environmental Health. 31(S1):105-109.
4. Adami, H.O., and D. Trichopoulos. No date. Review of the study by Hardell and Eriksson on non-Hodgkin lymphoma and exposure to pesticides. Cancer 1999;85:1353-1360, Letter to editor of New Scientist. Harvard University.
5. Akers, R.P. and M.J. Pitcairn. 2006. Biological control of water hyacinth in the Sacramento-San Joaquin Delta year 3 – final report. California Department of Food and Agriculture. Sacramento, California. 12pp.
6. Alavanja, M.C., C. Samanic, M. Dosemeci, J. Lubin, R. Tarone, C. Lynch, C. Knott, K. Thomas, J. Hoppin, J. Barker, J. Coble, D. Sandler, and A. Blair. 2003. Use of agricultural pesticides and prostate cancer risk in the Agricultural Health Study Cohort. American Journal of Epidemiology. 157:9:800-814.
7. Alavanja, M.C., J.A. Hoppin, and F. Kamel. 2004. Health effects of chronic pesticide exposure: cancer and neurotoxicity. Annual Review of Public Health. 25:155-197.
8. Alavanja, M.C., D.P. Sandler, C.F. Lynch, C. Knott, J.H. Lubin, R. Tarone, K. Thomas, M. Dosemeci, J. Hoppin, and A. Blair. 2005. Cancer incidence in the Agricultural Health Study. Scandinavian Journal of Work and Environmental Health. 31(S1):39-45.
9. Alavanja, M.C.. 2007. Behavioral findings from the Agricultural Health Study, presentation to the 2007 North American Pesticide Applicator Certification and Safety Education Workshop. Portland, Maine.
10. Alexander, H.C., F.M. Gersich, and M.A. Mayes. 1985. Acute toxicity of four phenoxy herbicides to aquatic organisms. Bull. Envir. Contam. Toxicol. 35:314-321.
11. Anderson, L.W.J. 1982. Experimental application of 2,4-dichlorophenoxy acetic acid (2,4-D) for the control of water hyacinth in the delta. Davis, California. United States Department of Agriculture, Agricultural Research Service. 7pp.

12. Aprea, C., C. Colosio, T. Mammone, C. Minoia, and M. Maroni. 2002. Biological monitoring of pesticide exposure: a review of analytical methods. Journal of Chromatography B: Analytical Technologies in the Biomedical and Life Sciences. 769:2:191-219.

13. Arambura, Margit. 2005. Update on acquisition of land in the Primary Zone since January 1, 1993 by public agencies and nonprofit groups. Sacramento, California. Delta Protection Commission, Agenda Item, January 14, 2005.

14. Arbuckle, T.E., S.M. Schrader, D. Cole, J.C. Hall, C.M. Bancej, L.A. Turner, and P. Claman. 1999. 2,4-dichlorophenoxyacetic acid residues in semen of Ontario farmers. Reproductive Toxicology. 13:6:421-429.

15. Armor, Chuck et al. 2005. Interagency Ecological Program synthesis of 2005 work to evaluate the pelagic organism decline (POD) in the Upper San Francisco Estuary. Sacramento, California. IEP.

16. Barr, D.B., K. Thomas, B. Curwin, D. Landsittel, J. Raymer, C. Lu, K.C. Donnelly, and J. Acquavella. 2006. Biomonitoring of exposure in farmworker studies. Environmental Health Perspectives. 114:6:936-942.

17. Bartodziej, W. and G. Weymouth. 1995. Waterbird abundance and activity on water hyacinth and Egeria in the St. Marks River, Florida. Journal of Aquatic Plant Management. 33:19-22.

18. Batcher, M.S. 2000. Element Stewardship Abstract for *Eichhornia crassipes* (Martius) Solms water hyacinth. Prepared for The Nature Conservancy, Arlington Virginia. 10pp.

19. Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gringras, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Summer, and K. Souza. 2008a. Pelagic organism decline progress report: 2007 synthesis of results. Interagency Ecology Program. January 2008. 78pp.

20. Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gringras, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Summer, and K. Souza. 2008b. Interagency Ecology Program 2008 work plan to evaluate the decline of pelagic species in the upper San Francisco Estuary. Interagency Ecology Program. June 2008. 124pp.

21. Bayer Crop Science. 2004. Material safety data sheet, Agridex® non-ionic surfactant. Available at: www.bayercropscience.com.au.

22. Beedy, E.C. 2008. Tricolored blackbird *(Agelaius tricolor)*, in: Shuford, W.D. and Gardali, T., editors. 2008. California Bird Species of Special Concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento, California. 450pp.

23. Benedetti, A.L., C. Vituri, A.G. Trentin, M.A. Domingues, and M. Alvarez-Silva. 2004. The effects of sub-chronic exposure of Wistar rats to the herbicide Glyphosate-Biocarb®. Toxicology Letters. 153:2:227-232.

24. Bennett, William A.. September 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. *San Francisco Estuary and Watershed Science* 3, no.2. http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art1.

25. Beseler, C., L. Stallones, J.A. Hoppin, M. Alavanja, A. Blair, T. Keepfe, and F. Kamel. 2008. Depression and pesticide exposures among private pesticide applicators enrolled in the Agricultural Health Study. Environmental Health Perspectives. National Institute of Environmental Health Sciences. http://www.ephonline.org.

26. Bharadwaj, L., K. Dhami, D. Schneberger, M. Stevens, C. Renaud, and A. Ali. 2005. Altered gene expression in human hepatoma HepG2 cells exposed to low-level 2,4-dichlorophenoxyacetic acid and potassium nitrate. Toxicology in Vitro. 19:5:603-619.

27. Blair, A. and S. Hoar Zahm. 1995. Agricultural exposures and cancer. Environmental Health Perspectives. 103:S8:205-208.

28. Blankenship and Associates. 2004. Clear Lake ecological risk assessment. Prepared for County of Lake. 152pp.

29. Bond, G., K. Bodner, and R.Cook. 1989. Phenoxy herbicides and cancer: insufficient epidemiologic evidence for a causal relationship. Toxicological Sciences. 12:1:172-188.

30. Bongiovanni, B., P. De Lorenzi, A. Ferri, C. Konjuh, M. Rassetto, A.M. Evangelista De Duffard, D.P. Cardinali, and R. Duffard. 2007. Melatonin decreases the oxidative stress produced by 2,4-dichlorophenoxyacetic acid in rat cerebellar granule cells. Neurotoxicity Research. 11:2:93-99.

31. Bortolozzi, A.A., R. O. Duffard, and A.M. Evangelista De Duffard. 1999. Behavioral alterations induced in rats by a pre- and postnatal exposure to 2,4-dichlorophenoxyacetic acid. Neurotoxicology and Teratology. 21:4:451-465.

32. Bortolozzi, A.A., A.M. Evangelista De Duffard, R.O. Duffard, and M.C. Antonelli. 2004. Effects of 2,4-dichlorophenoxyacetic acid exposure on dopamine D_2-like receptors in rat brain. Neurotoxicology and Teratology. 26:4:599-605.

33. Boussard, A. 1981. The reactions of roach (*Rutilus rutilus*) and rudd (*Scardinius erythrophthalmus*) to noises produced by high speed boating. Pages 188–200 in *Proceedings of 2nd British Freshwater Fisheries Conference, Southampton*.

34. Broddrick, R. 2007. Statement presented by Ryan Broddrick, Director, California Department of Fish and Game to U.S. House of Representatives, Committee on Natural Resources Subcommittee on Water and Power. Oversight hearing on “extinction is not a sustainable water policy: the Bay Delta crisis and the implications for California water management. Vallejo, California. July 2, 2007.

35. Brusco, A., J.P. Saavedra, G. Garcia, P. Tagliaferro, A.M. Evangelista De Duffard, and R. Duffard. 1997. 2,4-dichlorophenoxyacetic acid through lactation induces astrogliosis in rat brain. Molecular and Chemical Neuropathology. 30:175.

36. Bukowska, B.E. 2003. Effects of 2,4-D and its metabolite 2,4-dichlorophenol on antioxidant enzymes and level of glutathione in human erythrocytes. Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology. 135:4:435-441.

37. Bukowska, B. and K. Hutnik. 2006. 2,4-D and MCPA and their derivatives: effect on the activity of membrane erythrocytes acetylcholinesterase (in vitro). Pesticide Biochemistry and Physiology. 85:3:174-180.

38. Bukowska, B., B. Rychlik, A. Krokosz, and J. Michalowicz. 2008. Phenoxyherbicides induce production of free radicals in human erythrocytes: oxidation of dichlorodihydrofluorescine and dihydroorhodamine 123 by 2,4-D-NA and MCPA-Na. Food and Chemical Toxicology. 46:1:359-367.

39. Buranatrevedh, S. and D. Roy. 2001. Occupational exposure to endocrine disrupting pesticides and the potential for developing hormonal cancers. Journal of Environmental Health. 64:17-29.

40. Burger, J. 1998. Effects of Motorboats and Personal Watercraft on Flight Behavior over a Colony of Common Terns. *The Condor* 100:528–534.

41. Burns, C.J., K.K. Beard, and J.B. Cartmill. 2001. Mortality in chemical workers potentially exposed to 2,4-dichlorophenoxyacetic acid (2,4-D) 1945-94: an update. Occupational and Environmental Medicine. 58:24-30.

42. Burns, C. 2005. Cancer among pesticide manufacturers and applicators. Scandinavian Journal of Work and Environmental Health. 31(S1):9-17.

43. Burroughs, B., R. Tarone, J.S. Kesner, and V.F. Garry. 1999. Toxicology and Industrial Health. 15:1-2:160-168.

44. CALFED Bay-Delta Program. June 1999. Multispecies Conservation Strategy Technical Report. Sacramento, California. CALFED.

45. CALFED Bay-Delta Program. July 2000. Multi-Species Conservation Strategy. Sacramento, CA: CALFED Bay Delta Program.

46. CALFED Bay Delta Program. 2000. Ecosystem Restoration Program (ERP) Volume 1. Sacramento, California: Prepared for the CALFED Bay Delta Program. CD-ROM version.

47. Calflora. Accessed 2006. Information on California plants for education, research and conservation. Berkeley, California. The Calflora Database. http://www.calflora.org.

48. Calflora. Accessed July 17, 2008. Information on California plants for education, research and conservation. Berkeley, California. The Calflora Database. http://www.calflora.org.

49. California Department of Fish and Game (CDFG). 1992. Estuary dependent species. Entered by the CDFG for the State Water Resources Control Board 1992 Water Quality/Water Rights Proceedings of the San Francisco Bay-Sacramento-San Joaquin Delta. WRINT-DFG-6. 97pp.

50. CDFG. 1994. Impact of water management on splittail in the Sacramento-San Joaquin Delta. WRINT-DFG-5. 7pp.

51. CDFG. July 2003. Aquatic toxicology laboratory report. Elk Grove, California. Department of Fish and Game Aquatic Toxicology Laboratory. 11pp.

52. CDFG. July 2005. The status of rare, threatened and endangered plants and animals in California, 2000-2004. Sacramento, California. CDFG.

53. CDFG. Accessed 2006a. Sacramento Splittail. Sacramento, California. CDFG, Habitat Conservation Planning Branch. http://www.dfg.ca.gov/hcpb.

54. CDFG. Accessed 2006b. River Lamprey. Sacramento, California. CDFG, Habitat Conservation Planning Branch. http://www.dfg.ca.gov/hcpb.

55. CDFG. Accessed 2006c. Sturgeon Study. CDFG, Central Valley Bay-Delta Branch. http://www.delta.dfg.ca.gov/baydelta/monitoring/stur.asp.

56. CDFG. Accessed July 2, 2008. "Natural Community Conservation Planning (NCCP). http://www.dfg.ca.gov/habcon/nccp/index.html.

57. CDFG. Accessed July 1, 2008. Suisun Marsh Charter. http://www.delta.dfg.ca.gov/suisunmarsh/charter/index.asp.

58. CDFG. Accessed June 30, 2008. Delta Regional Ecosystem Restoration Implementation Plan. http://www.delta.dfg.ca.gov/erpdeltaplan/default.asp.

59. CDFG. Accessed July 1, 2008. VAMP – Vernalis Adaptive Management Program. http://www.delta.dfg.ca.gov/jfmp/vamp.asp.

60. CDFG. Accessed July 3, 2008. California's Endangered Species Act listing process. http://www.dfg.ca.gov/wildlife/species/t_e_spp/list_proced.html.

61. California Department of Food and Agriculture (CDFA). 2007. California Agricultural Resource Directory 2007. Sacramento, California. California Department of Food and Agriculture.

62. California Department of Industrial Relations, Division of Occupation Safety and Health (CalOSHA). 2008a. Heat illness prevention: what you need to know. Oakland, California. CalOSHA.

63. CalOSHA. 2008b. Heat hazards in agriculture: a guide for employees to carry out tailgate training for workers. Berkeley, California. Prepared by the Labor Occupational Health Program, UC Berkeley.

64. California Department of Pesticide Regulation (DPR), Medical Toxicology Branch. 1992. Summary of toxicology data, glyphosate. Sacramento, California. DPR. 19pp.

65. California Department of Pesticide Regulation (DPR), Medical Toxicology Branch. 2006. Summary of toxicology data, 2,4-D. Sacramento, California. DPR. 23pp.

66. California Native Plant Society (CNPS). 2006. Inventory of rare and endangered plants (online edition, v7-06c). Sacramento, California. http://www.cnps.org/inventory.

67. CNPS. 2008. Inventory of rare and endangered plants (online edition, v7-08c, 7/09/08). Sacramento, CA. http://www.cnps.org/inventory.

68. California Natural Diversity Database (CNDDB). 1992. Sacramento, California. California Department of Fish and Game, Wildlife and Habitat Data Analysis Branch.

69. California Natural Diversity Database (CNDDB). 1997. Sacramento, California. California Department of Fish and Game, Wildlife and Habitat Data Analysis Branch.

70. California Natural Diversity Database (CNDDB). 2006. Sacramento, California. California Department of Fish and Game, Wildlife and Habitat Data Analysis Branch.

71. California Natural Resources Agency. March 2009. BDCP Bay Delta Conservation Plan, a collaborative approach to restore the Delta ecosystem and protect water supplies. Sacramento, California. Natural Resources Agency.

72. California Urban Water Agencies (CUWA). 1994. Evaluation of potential effects of the proposed EPA salinity standard on the biological resources of the San Francisco Bay/Sacramento-San Joaquin Estuary (Draft). Sacramento, California. Prepared by R2 Resource Consultants, Inc. for the California Urban Water Agencies. 65pp.

73. California State Water Resources Control Board (SWB). December 2006. Water quality control plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Sacramento, California. California Water Boards. 48pp.

74. SWB. January 2, 2007. Memo: new pesticide regulation. To Tom Howard, Acting Executive Director, from Michael A.M. Lauffer, Chief Counsel. Sacramento, California. SWB. 5pp.

75. SWB. June 2008. Strategic workplan for activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Sacramento, California. State Water Resources Control Board, Central Valley Regional Water Quality Control Board, and San Francisco Bay Regional Water Quality Control Board. 92pp.

76. Center for Biological Diversity (CBD), The Bay Institute, and Natural Resources Defense Council. March 8, 2006. Emergency Petition to List the Delta Smelt (*Hypomesus transpacificus*) as an Endangered Species Under the Endangered Species Act. San Francisco, California. CDB.

77. Center for Biological Diversity. Accessed 2006. Green Sturgeon Listing. http://www.biologicaldiversity.org/swcbd/species/grnsturgeon/index.htm.

78. Center for Biological Diversity. Accessed July 22, 2008. Sacramento splittail. http://www.biologicaldiversity.org/species/fish/Sacramento_splittail/index.html.

79. Center for Collaborative Policy. January 2008. Delta Protection Commission management plan update concept. Prepared for the DPC by Center for Collaborative Policy, California State University, Sacramento. 11pp.

80. Center, T.D., F.A. Dray Jr., G.P. Jubinsky, and M.J. Grodowitz. 1999. Biological control of water hyacinth under conditions of maintenance management: can herbicides and insects be integrated? Environmental Management. 23:241-256.

81. Central Valley Regional Water Quality Control Board (CVRWQCB). 2006. Statewide general National Pollution Discharge Elimination System Permit for the discharge of aquatic pesticides for aquatic weed control in waters of the United States, general permit no. CAG990005. Rancho Cordova, California. CVRWQCB.

82. CVRWQCB. 2007. The water quality control plan (basin plan) for the California Regional Water Quality Control Board Central Valley Region, fourth edition, the Sacramento River Basin and the San Joaquin River Basin. Sacramento, California. CVRWQCB. Revised October 2007 (with approved amendments).

83. CVRWQCB. June 2007. 2006 CWA Section 303(d) list of water quality limited segments requiring TMDLs. Sacramento, California. CVRWQCB. 32pp.

84. CVRWQCB. 2008. Study to evaluate potential effects of ammonia on delta smelt, status update – 30 July 2008. Sacramento, California. CVRWQCB. 2pp.

85. Charduttan, R. 2001. Biological control of water hyacinth using pathogens: opportunities, challenges, and recent developments. In: Biological and Integrated Control of Water Hyacinth, *Eichhornia crassipes*. Edited by M.H. Julien, M.P. Hill, T.D. Center and Ding Jianqing. ACIAR Proceedings 102.

86. Charles, J.M., D.W. Dalgard, H.C. Cunny, R.D. Wilson, and J.S. Bus. 1996a. Comparative subchronic and chronic dietary toxicity studies on 2,4-dichlorophenoxyacetic acid, ,amine, and ester in the dog. Fundamental and Applied Toxicology. 29:78-85.

87. Charles, J.M., D.M. Bond, T.K. Jeffries, B.L. Yano, W.T. Stott, K.A. Johnson, H.C. Cunny, R.D. Wilson, and J.S. Bus. 1996b. Chronic dietary toxicity/oncogenicity studies on 2,4-dichlorophenoxyacetic acid in rodents. Fundamental and Applied Toxicology. 33:166-172.

88. Charles, J.M., H.C. Cunny, R.D. Wilson, J.S. bus, T.E. Lawlor, M.A. cifone, M.Fellows, and B. Gollapudi. 1999. Ames assay and unscheduled DNA synthesis assays on 2,4-dichlorophenoxyacetic acid and its derivatives. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. 444:1:207-216.

89. Charles, J.M., T.R. Hanley Jr., R.D. Wilson, B.van Ravenzwaay, and J.S. Bus. 2001. Developmental toxicity studies in rats and rabbits on 2,4-dichlorophenoxyacetic acid and its forms. Toxicological Sciences. 60: 121-131.

90. Chernoff, N. R.W. Setzer, D.B. Miller M.B. Rosen, and J.M. Rogers. 1990. Effects of chemically induced maternal toxicity on prenatal development in the rat. Teratology. 42:6:651-658.

91. City of Sacramento Department of Utilities. 2009. Sacramento River WTP expansion options. Sacramento, California. City of Sacramento Department of Utilities.

92. Cohen, A.N., and J.T. Carlton. 1995. Nonindigenous aquatic species in a United States estuary: A case study of the biological invasions of the San Francisco Bay and Delta. Prepared for the United States Fish and Wildlife Service, Washington D.C. and the National Sea Grant College Program Connecticut Sea Grant. 218pp.

93. Cohen, M. 2007. Environmental toxins and health, the health impacts of pesticides. Australian Family Physician. 36:12:1002-1004.

94. Contra Costa Times. March 3, 2006. Science vs. politics. ContraCostaTimes.com.

95. Contra Costa Water District. May 2006. Alternative intake project draft environmental impact report/environmental impact statement. Concord, California. CCWD.

96. Contra Costa Water District. December 2006. Alternative intake project. CCWD. 2pp.

97. Corcoran, D.P., D.B. Cohen and G.W. Bowes. 1994. Glyphosate use in forestry (Roundup) and aquatic weed control (Rodeo): a water quality assessment. Sacramento, California. California State Water Resources Control Board.

98. County of Lake. January 2005. Draft Program EIR, Clear Lake Integrated Aquatic Plant Management Plan. Lake County, California.

99. Cullen, M.R. 1999. Review of Hardell and Eriksson, A case-control study of non-Hodgkin lymphoma and exposure to pesticides. Cancer 1999;85:1353-1360, Letter to editor of New Scientist. Yale University School of Medicine.

100. Dallegrave, E., and F.D. Mantese, R.S. Coelho, J.D. Pereira, P.R. Dalsenter, and A. Langeloh. 2003. The teratogenic potential of the herbicide glyphosate-Roundup® in Wistar rats. Toxicology Letters. 142:1-2:45-52.

101. Daruich, J., F. Zirulnik, and M.S. Gimenez. 2001. Effect of the herbicide glyphosate on enzymatic activity in pregnant rats and their fetuses. Environmental Research. 85:3:226-231.

102. de la Rosa, P., J.B. Barnett, R. Schafer. 2004. Characterization of thymic atrophy and the mechanism of thymocyte depletion after in vivo exposure to a mixture of herbicides. Journal of Toxicology and Environmental Health, Part A. 68:2:81-98.

103. De Moliner, K.L., A.M. Evangelista De Duffard, E. Soto, R. Duffard, and A.M. Adamo. 2002. Induction of apoptosis in cerebellar granule cells by 2,4-dichlorophenoxyacetic acid. Neurochemical Research. 27;11:1439-1446.

104. De Roos, A.J., S.H. Zahm, K.P. Cantor, D.D. Weisenburger, F.F. Holmes, L.F. Burmeister, and A. Blair. 2003. Integrative assessment of multiple pesticides as risk factors for non-Hodgkin's lymphoma among men. Occupational and Environmental Medicine. 60:e11

105. De Roos, A.J., A. Blair, J.A. Rusiecki, J.A. Hoppin, M. Svec, M. Dosemeci, D.P. Sandler, and M.C. Alavanja. 2005. Cancer incidence among glyphosate-exposed pesticide applicators in the Agricultural Health Study. Environmental Health Perspectives. 113:1:49-54.

106. Delta Protection Commission (DPC). June 2008. Land use and resource management plan for the primary zone of the Delta, update 2008, profiles of ongoing planning processes and planning documents for consideration. Sacramento, California. 35pp.

107. DPC. 2008. Lower Yolo bypass planning forum. http://www.delta.ca.gov/pdf/loweryolo.pdf. 3pp.

108. DPC. January 2001. Background report on agriculture. Sacramento, California. Delta Protection Commission. February 1994, reprinted January 2001.

109. DPC. May 2001. Update on agriculture in the primary zone of the Delta. Sacramento, California. Delta Protection Commission.

110. DPC. November 1997. Inventory of recreational facilities. Sacramento, California. Delta Protection Commission.

111. Delta Vision Blue Ribbon Task Force. January 2008. Blue Ribbon Task Force Delta Vision. Sacramento, California. Task Force. 79pp.

112. Delta Vision Blue Ribbon Task Force. June 2008. Delta Vision Strategic Plan Preliminary Draft. Sacramento, California. Task Force. 86pp.

113. Delta Wetlands Project. 2009. Project overview and program chronology. http://www.deltawetlands.com.

114. Department of Boating and Waterways (DBW). 1985 Summary of Operations: Water hyacinth Control Program. Sacramento: California Department of Boating and Waterways. 13pp.

115. DBW. 1991 Summary of Operations: Water hyacinth Control Program. Sacramento: California Department of Boating and Waterways. 36pp.

116. DBW. 1998 Summary of Operations: Water hyacinth Control Program. Sacramento: California Department of Boating and Waterways. 39pp.

117. DBW. 1999 Summary of Operations: Water hyacinth Control Program. Sacramento: California Department of Boating and Waterways. 37pp.

118. DBW. 2001. *Egeria Densa Control* Program, Volume I: Final Environmental Impact Report. Prepared by the California Department of Boating and Waterways, with consultation from the California Department of Water Resources, Environmental Services Office, and the NewPoint Group, Management Consultants. Sacramento, California.

119. DBW. 2008. WHCP Operations Management Plan. Sacramento, California. California Department of Boating and Waterways. 78pp.

120. Department of Conservation, Division of Land Resource Protection. 2006. California farmland conversion report 2002 -2004. Sacramento, California. http://www.conservation.ca.gov/dlrp/fmmp/pubs/2002-2004/Pages/FMMP_2002-2004_FCR.aspx.

121. Department of Water Resources (DWR). 1992. Bay-Delta fish resources. Sacramento, CA. Department of Water Resources. WRINT-DWR-30. 46pp.

122. DWR. 1994. Summary of sensitive plant and wildlife resources in Suisun Marsh during water years 1984-1994. Sacramento, California. DWR Environmental Services Office. 107pp.

123. DWR. 1996. Water quality conditions in the Sacramento-San Joaquin Delta, 1970-1993. Report to the State Water Resources Control Board in accordance with Water Right Decision 1485, Order 4(f). Sacramento, California. DWR Environmental Services Office. 102pp.

124. DWR. 2005. State Water Plan. Sacramento, California. DWR.

125. DWR. October 2005. South Delta Improvements Program EIS/EIR, Volume 1c:Chapter 6. Sacramento, California. California Department of Water Resources.

126. DWR. 2006. South Delta Improvements Program EIS/EIR, Volume 1d:Chapters 7-13. Sacramento, California. California Department of Water Resources.

127. DWR. Accessed July 1, 2008. Delta Risk Management Strategy. http://www.drms.water.ca.gov/.

128. DWR. Accessed June 26, 2008. South Delta improvements program (SDIP). http://baydeltaoffice.water.ca.gov/sdb/sdip/index_sdip.cfm.

129. DWR. Accessed June 26, 2008. Temporary barriers project information. http://baydeltaoffice.water.ca.gov/sdb/tbp/web_pg/tembar.cfm.

130. DWR. Accessed June 26, 2008. Aeration facility program. http://baydeltaoffice.water.ca.gov/sdb/af/index_af.cfm.

131. DWR. Accessed June 26, 2008. Franks tract project. http://baydeltaoffice.water.ca.gov/ndelta/frankstract.index.cfm.

132. DWR. No date. South Delta improvements program. Sacramento, California. 6pp.

133. DWR. March 2008. Notice of preparation, environmental impact report and environmental impact statement for the Bay Delta Conservation Plan. Sacramento, California. DWR. 12pp.

134. DWR and U.S. Bureau of Reclamation. 1994. Biological assessment: effects of the Central Valley Project and State Water Project on delta smelt and Sacramento splittail. Prepared for the USFWS. Sacramento, California.

135. Department of Water Resources (DWR) and Department of Fish and Game (CDFG). January 2008. "Risks and Options to Reduce Risks to Fishery and Water Supply Uses of the Sacramento/San Joaquin Delta." Sacramento, California. 37pp.

136. Dick, G. O., J. K. Smith, and R. M. Smart. September 2004. Migratory waterfowl habitat selection in relation to aquatic vegetation. Lewisville, TX. U.S. Army Corps of Engineers Lewisville Aquatic Ecosystem Research Facility, September 2004.

137. Dosemeci, M., M.C.R. Alavanja, A. Rowland, D. Mage, S.H. Zahm, N. Rothman, J.H. Lubin, J.A. Hoppin, D.P. Sandler, A. Blair. 2002. A quantitative approach for estimating exposure to pesticides in the Agricultural Health Study. Annals of Occupational Hygiene. 46:2:245-260.

138. Duffard, R., G. Garcia, S. Rosso, A. Bortolozzi, M. Madariaga, P. Di Paolo, and A.M. Evangelista De Duffard. 1996. Central nervous system myelin deficit in rats exposed to 2,4-dichlorophenoxyacetic acid throughout lactation. Neurotoxicology and Teratology. 18:6:691-696.

139. East Contra Costa County Habitat Conservation Plan Association. October 2006. The final East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan, An Introduction. Martinez, California. ECCHCPA. 12pp.

140. ECOTOX. 2008. United States Environmental Protection Agency, ECOTOX database of aquatic and terrestrial toxicology. www.epa.gov/ecotox.

141. ECOTOX. 2001. United States Environmental Protection Agency, ECOTOX database of aquatic and terrestrial toxicology. www.epa.gov/ecotox.

142. Edginton, A.N., P.M. Sheridan, H.J. Boermans, D.G. Thomson, J.D. Holt, and G.R. Stephenson. 2004. A comparison of two factorial designs, a complete 3x3 factorial and a central composite rotatable design, for use in binomial response experiments in aquatic toxicology. Environmental Contamination Toxicology. 46:2:216-223.

143. Environmental News Service. 2009. Court cancels EPA Clean Water Act exemption for pesticides. Environmental News Service. http://www.ens-newswire.com/ens/jan2009/2009-01-07-093.asp. Accessed January 8, 2009.

144. Eriksson, M., L. Hardell, M. Carlberg, and M. Akerman. 2008. Pesticide exposure as risk factor for non-Hodgkin lymphoma including histopathological subgroup analysis. International Journal of Cancer. 123:7:1657-1663.

145. ESA/Madrone. 1984. Environmental data report, Water hyacinth control plan for the Sacramento-San Joaquin Delta. Sacramento, California. Prepared for the U.S. Army Corps of Engineers.

146. EXTONET. (June 1996). Extension Toxicology Network, pesticide information profiles. Oregon State University. http://extonet.orst.edu. Accessed June 19, 2008.

147. Faustini, A., L. Settimi, R. Pacifici, V. Fano, P. Zuccaro, and F. Forastiere. 1996. Immunological changes among farmers exposed to phenoxy herbicides: preliminary observations. 53:583-585.

148. Federal Register. April 15, 2004. Volume 69, Number 73, 19975.

149. Federal Register. November 27, 2006. Application of pesticides to waters of the United States in compliance with FIFRA. 71:227:68483-68492.

150. Federal Register. December 24, 2008. Petition to revoke all tolerances and cancel all registrations for the pesticide 2,4-dichlorophenoxyacetic acid; notice of availability. 73:248:79100-79102.

151. Fenske, R.A.. 2005. State-of-the-art measurement of agricultural pesticide exposures. Scandinavian Journal of Work and Environmental Health. 31(S1):67-73.

152. Ferri, A., R. Duffard, and A.M. Evangelista De Duffard. 2007. Selective oxidative stress in brain areas of neonate rats exposed to 2,4-dichlorophenoxyacetic acid through mother's milk. Drug and Chemical Toxicology. 20:1:17-30.

153. Ferris, S. 2008. Cal-OSHA to review handling of heat cases. The Sacramento Bee. December 31, 2008. P.A3.

154. Feyrer, F. and M.P. Healey. 2003. Fish community structure and environmental correlates in the highly altered southern Sacramento-San Joaquin Delta. Environmental Biology of Fishes. 66:123-132.

155. Feyrer, F., M.L. Nobriga, and T.R. Sommer. 2007. Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal Fish Aquatic Science. 64:723-734.

156. Figgs, L.W., N.T. Holland, N. Rothman, S.H. Zahm, R.E. Tarone, R. Hill, R.F. Vogt, M.T. Smith, C.D. Boysen, F.F. Holmes, K. Vandyck, and A. Blair. 2000. Increased lymphocyte replicative index following 2,4-dichlorophenoxyacetic acid herbicide exposure. Cancer Causes and Control. 11:373-380.

157. Florida Department of Environmental Protection. 2007. Status of the aquatic plant maintenance program in Florida public waters: annual report for fiscal year 2006-2007. Department of Environmental Protection. Florida. 67pp.

158. Folmar, L.C. et al. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates. Arch. Environmn. Contam. Toxicol. 8:269-278.

159. Folmar, L.C. 1980. Effects of short-term field applications of acrolein and 2,4-D (DMA) on the flesh of rainbow trout. Bull. Environ. Contam. Toxicol. 24:217-224.

160. Freedman, M. 2001. Amytrophic lateral sclerosis and occupational exposure to 2,4-dichlorophenoxyacetic acid. Occupational and Environmental Medicine, electronic letters. http://oem.bmj.com/cgi/eletters/58/1/24.

161. Garabrant, D.H., and M.A. Philbert. 2002. Review of 2,4-dichlorophenoxyacetic acid (2,4-D) epidemiology and toxicology. Critical Reviews in Toxicology. 32:4:233-257.

162. Garcia, G., P. Tagliaferro, A. Ferri, A.M. Evangelista de Dufffard, R. Duffard, and A. Brusco. 2004. Study of tyrosine hydroxylase immunoreactive neurons in neonate rats lactationally exposed to 2,4-dichlorophenoxyacetic acid. NeuroToxicology. 25:6:951-957.

163. Garry, V.F., R.E. Tarone, I.R. Kirsh, J.M. Abdallah, D.P. Lombardi, L.K. Long, B.L. Burroughs, D.B. Barr, and J.S. Kesner. 2001. Biomarker correlations of urinary 2,4-D levels in foresters: genomic instability and endocrine disruption. Environmental Health Perspectives. 109:5:495-500.

164. Gollapudi, B.B., J.M. Charles, V.A. Linscombe, S.J. Day, and J.S. Bus. 1999. Evaluation of the genotoxicity of 2,4-dichlorophenoxyacetic acid and its derivatives in mammalian cell cultures. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. 444:1:217-225.

165. Gopal, B. 1987. Aquatic Plant Studies 1. Water Hyacinth. Elsevier Publishing, New York, New York, USA. 471pp.

166. Gonzalez, M., S. Soloneski, M.A. Reigosa, and M.L. Larramendy. 2005. Genotoxicity of the herbicide 2,4-dichlorophenoxyacetic and a commercial formulation, 2,4-dichlorophenoxyacetic acid dimethylamine salt. I. Evaluation of DNA damage and cytotoxic endpoints in Chinese hamster ovary (CHO) cells. Toxicology in Vitro. 19:2:289-297.

167. Green, R.M. and A.A. Abdelghani. 2004. Toxicity of a mixture of 2,4-dichlorophenoxyacetic acid and monosodium methanearsonate to the red swamp crawfish, *Procambarus clarkia*. Int. Journal of Environ. Res. Public Health. 1:35-38.

168. Greenfield, B.K., M. Blankinship, and T.J. McNabb. 2006. Control costs, operation, and permitting issues for non-chemical plant control: case studies in the San Francisco Bay-Delta region, California. Journal of Aquatic Plant Management. 44:40-49.

169. Greenfield, B.K., N. David, G.S. Siemering, T.P. McNabb, D.F. Spencer, G.G. Ksander, M.J. Donovan, P.S. Liow, W.K. Chan, S.B. Shonkoff, S.P. Andrews, J.C. Andrews, M. Rajan, V. Howard, M. Sytsma, S. Earnshaw, and L.W.J. Anderson. 2005. Aquatic Pesticide Monitoring Program Nonchemical Alternatives Year 3 Final Report. APMP Technical Report: SFEI Contribution 390. Oakland, California. San Francisco Estuary Institute.

170. Greenfield, B.K. and T.P. McNabb. 2005. Chapter 2: Control costs, operation, and permitting issues for non-chemical plant control: case studies in the San Francisco Bay-Delta region, California. Journal of Aquatic Plant Management. In: Aquatic Pesticide Monitoring Program Nonchemical Alternatives Year 3 Report. Oakland, California. San Francisco Estuary Institute. 15-24.

171. Gren, G.G. 1983. Office report. Jacksonville, Florida. United States Army Corps of Engineers. August 3, 1983.

172. Halter, M.T. 1980. 2,4-D in the aquatic environment, in literature reviews of four selected herbicides: 2,4-D, dichlobenil, diquat and endothal. Municipality of Seattle.

173. Hammond, L.E. 1996. New perspectives on an essential product: 2,4-D. Down to Earth. 50:2.

174. Hardell, L. and M. Eriksson. 1999. A case-control study of non-Hodgkin lymphoma and exposure to pesticides. Cancer. 85:6:1353-1360.

175. Harley, K.L.S, M.H. Julien, and A.D. Wright. 1996. Appendix 7: Water hyacinth: a tropical worldwide problem and methods for its control. Prepared for the Second International Weed Control Congress, Copenhagen. 9pp.

176. Heimlich, Ralph E. et al. September 1998. Wetlands and Agriculture: Private Interests and Public Benefits. Washington D.C. U.S. Department of Agriculture, Agricultural Economic Report No. 756.

177. Henry, C.J. et al. 1994. Acute toxicity and hazard assessment of Rodeo, X-7 spreader, and Chemitrol to aquatic invertebrates. Arch. Environ. Contam. Toxicol. 27:392-399.

178. Herbold, B. and P.B. Moyle. 1989. The ecology of the Sacramento-San Joaquin Delta: a community profile. Washington D.C.. USFWS National Wetlands Research Center.

179. Hoar, S., A. Blair, F. Holmes, C. Boysen, R. Robel, R. Hoover, and J. Fraumeni. 1986. Agricultural herbicide use and risk of lymphoma and soft-tissue sarcoma. Journal of the American Medical Association. 256:9:1141-1147.

180. Hokanson, R., R. Fudge, and D. Busbee. 2007. Alteration of estrogen-regulated gene expression in human cells induced by the agricultural and horticultural herbicide glyphosate. Human and Experimental Toxicology. 26:9:747-752.

181. Holland, N.T., P. Duramad, N. Rothman, L.W. Figgs, A. Blair, A. Hubbard, and M.T. Smith. 2002. Micronucleus frequency and proliferation in human lymphocytes after exposure to herbicide 2,4-dichlorophenoxyacetic acid in vitro and in vivo. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. 521:1-2:165-178.

182. Hong, S., Hong, J. H. Gil, J. Yang, E. Lee, and D. Jeong. 2006. Effects of repeated pesticide exposure on peripheral and central nervous systems. Toxicological and Environmental Chemistry. 88:4:595-601.

183. Hosea, R.C., K.Z. Bjurstrom, and E.E. Litrell. 2004. Acute oral and dermal toxicity of aquatic herbicides and a surfactant to garter snakes. Rancho Cordova, California. California Department of Fish and Game, Pesticide Investigations Unit. 22pp.

184. Howe, C.M., M. Berrill, B.D. Pauli, C.C. Helbing, K. Werry, and N. Veldhoen. 2004. Toxicity of glyphosate-based pesticides to four North American frog species. Environmental Toxicology and Chemistry. 23:8:1928-1938.

185. Ibrahim, M.A., G.G. Bond, T.A. Burke, P. Cole, F.N. Dost, P.E. Enterline, M. Gough, R.S. Greenberg, W. E. Halperin, E. McConnell, I.C. Munro, J.A. Swenberg, S.H. Zahm, and J.D. Graham. 1991. Weight of evidence on the human carcinogenicity of 2,4-D. Environmental Health Perspectives. 96:213-222.

186. Industry Task Force II on 2,4-D Research Data. 2006. Reviews by European Commission, U.S. Environmental Protection Agency and World Health Organization Confirm 2,4-D not a health risk. Ottawa, Canada. Industry Task Force II press release. http://www.24d.org.

187. Interagency Ecological Program (IEP). Accessed 2006a. Bay Delta and tributaries Project – data retrieval, green sturgeon. Sacramento, California. IEP. http://www.iep.ca.gov/data.html.

188. IEP. Accessed 2006b. Bay Delta and tributaries project – data retrieval, starry flounder. http://www.iep.ca.gov/data.html.

189. IEP. Accessed 2006c. Bay Delta and tributaries project – data retrieval, English sole. http://www.iep.ca.gov/data.html.

190. IEP. January 2008. Pelagic organism decline progress report: 2007 synthesis of results. Sacramento, California. IEP. 78pp.

191. IEP. June 2008. Interagency Ecology Program 2008 work plan to evaluate the decline of pelagic species in the Upper San Francisco Estuary. Sacramento, California. IEP. 101pp.

192. Isenberg, Phillip, Monica Florian, Richard M. Frank, Thomas McKernan, Sunne Wright McPeak, William K. Reilly, and Raymond Seed. October 2008. Delta Vision Strategic Plan. Sacramento, California. Governor's Delta Vision Blue Ribbon Task Force.

193. Jaramillo, A. 2008. Yellow-headed blackbird *(Xanthocephalus xanthocephalus),* in: Shuford, W.D. and Gardali, T., editors. 2008. California Bird Species of Special Concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento. 450pp.

194. Johnson, W.W. and M.T. Finley. 1980. Handbook of acute toxicity of chemicals to fish and aquatic invertebrates. Washington D.C. Resource Publications 137. U.S. Department of Interior, Fish and Wildlife Service. 10-38.

195. Julien, M.H. 2001. Biological control of water hyacinth with arthropods: a review to 2000. In: Biological and Integrated Control of Water Hyacinth, *Eichhornia crassipes*. Edited by M.H. Julien, M.P. Hill, T.D. Center and Ding Jianqing. ACIAR Proceedings 102.

196. Kaioumova, D., F. Kaioumov, G. Opelz, and C. Süsal. 2001. Toxic effects of the herbicide 2,4-dichlorophenoxyacetic acid on lymphoid organs of the rat. Chemosphere. 43:801-805.

197. Kamel, F., L. Engel, B. Gladen, J. Hoppin, M. Alavanja, and D. Sandler. 2005. Neurologic symptoms in licensed private pesticide applicators in the Agricultural Health Study. Environmental Health Perspectives. 113:7:877-882.

198. Kogevinas, M., T. Kauppien, R. Winklemann, H. Becher, P.A. Bertazzi, H.B. Bueno-de-Mesquita, D. Coggon, L. Green, E. Johnson, M. Littorin, E. Lynge, D.A. Marlow, J.D. Mathews, M. Neuberger, T. Benn, B. Pannett, N. Pearce, and R. Saracci. 1995. Soft tissue sarcoma and non-Hodgkin's lymphoma in workers exposed to phenoxy herbicides, chlorophenols, and dioxins: two nested case-control studies. Epidemiology. 6:4:396-402.

199. Kreutzweiser, D.P., P.D. Kingsbury, and J.C. Fengi. 1989. Drift response of stream invertebrates to aerial application of glyphosate. Bull. Envir. Contam. Toxicol. 43:378-385.

200. Krimsky, S. 2005. Public health matters: the weight of scientific evidence in policy and law. American Journal of Public Health. 95:S1:S129-S136.

201. Labrada, R. 1995. Status of water hyacinth in developing countries. Food and Agricultural Organization of the United Nations (FAO). Rome, Italy. 5pp.

202. Lancar, L. and K. Krake. 2002. Aquatic weeds and their management. International Commission on Irrigation and Drainage. 65pp.

203. Lavy, T.L., J.D. Walstad, R.R. Flynn, and J.D. Mattice. 1982. (2,4-dichlorophenoxy)acetic acid exposure received by aerial application crews during forest spray operations. Journal of Agric. Food Chem. 30:2:375-381.

204. Lavy, T., J. Cowell, J.R. Steinmetz, and J.H. Massey. 1992. Conifer seedling exposure to glyphosate. Arch. Environ. Contam. Toxicol. 22:6-13.

205. Lee, K., V.J. Johnson, and B.R. Blakley. 2001. The effect of exposure to a commercial 2,4-D formulation during gestation on the immune response in CD-1 mice. Toxicology. 165:1:39-49.

206. Li, S.N, and R.K. Kole. 2004. Response of gill ATPase and liver esterase of *pseudorasobora parva* to a two month exposure to glyphosate and metsulfuron methyl. Toxicological and Environmental Chemistry. 86:4:239-245.

207. Lin, N. and V.F. Garry. 2000. In vitro studies of cellular and molecular developmental toxicity of adjuvants, herbicides, and fungicides commonly used in Red River Valley, Minnesota. Journal of Toxicology and Environmental Health, Part A. 60:6:423-439.

208. Linnainmaa, Kaija. 2003. Induction of sister chromatid exchanges by the peroxisome proliferators 2,4-D, MCPA, and clofibrate in vivo and in vitro. Carcinogenisis. 5:6:703-707.

209. López, O., A.F. Hernández, L. Rodrigo, F. Gil, G. Pena, J.L. Serrano, T. Parrón, E. Villanueva, and A. Pla. 2007. Changes in antioxidant enzymes in humans with long-term exposure to pesticides. Toxicology Letters. 171:3:146-153.

210. Zeljezic, D., and V. Garaj-Vrhovac. 2004. Chromosomal aberrations, micronuclei and nuclear buds induced in human lymphocytes by 2,4-dichlorophenoxyactetic acid pesticide formulation. Toxicology. 200:1:39-47.

211. Mager RC, Doroshov SI, Van Eenennaam JP. 1996. Development of laboratory culture of delta smelt, *Hypomesus transpacificus*. Sacramento, California. California Department of Water Resources report (DWR B-59306). 65 p.

212. Maire, M.A., C. Rast, Y. Landkocz, and P. Vasseur. 2007. 2,4-dichlorophenoxyacetic acid: effects on Syrian hamster embryo (SHE) cell transformation, c-Myc expression, DNA damage and apoptosis. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. 631:2:124-136.

213. Mandel, J.S., B.H. Alexander, B.A. Baker, J.F. Acquavella, P. Chapman, and R. Honeycutt. 2005. Biomonitoring for farm families in the Farm Family Exposure Study. Scandinavian Journal of Work and Environmental Health. 31(S1):98-104.

214. Marc, J., O. Mulner-Lorillon, and R. Bellé. 2004a. Glyphosate-based pesticides affect cell cycle regulation. Biology of the Cell. 96:245-249.

215. Marc, J., R. Bellé, J. Morales, P. Cormier, and O. Mulner-Lorillon. 2004b. Formulated glyphosate activates the DNA-response checkpoint of the cell cycle leading to the prevention of G2/M transition. Toxicological Sciences. 82:436-442.

216. Mattsson, J.L., J.M. Charles, B.L. Yano, H.C. Cunny, R.D. Wilson, and J.S. Bus. 1997. Single-dose and chronic dietary neurotoxicity screening studies on 2,4-dichlorophenoxyacetic acid in rats. Fundamental and Applied Toxicology. 40:111-119.

217. McDuffie, H.H., P. Pahwa, R.R. McLaughlin, J.J. Spinelli, S. Fincham, J.A. Dosman, D. Robson, L.F. Skinnider, and N.W. Choi. 2001. Non-Hodgkin's lymphoma and specific pesticide exposures in men: cross-Canada study of pesticides and health. Cancer Epidemiol. Biomarkers Prev. 10:11:1155-1163.

218. McInnis, Rodney R.. September 1, 2006. Letter to Lars W.J. Anderson, USDA-ARS regarding section 7 consultation. Sacramento, California. NOAA-Fisheries.

219. Mecum, W. Lee. Spring 2005. Zooplankton monitoring. *IEP Newsletter* 18: 10-15.

220. Meng, L. 1993. Status report on Sacramento splittail and longfin smelt. University of California Davis. Submitted to the U.S. Fish and Wildlife Service. 15pp.

221. Mi, Y., C. Zhang, and K. Taya. 2007. Quercetin protects spermatological cells from 2,4-D-induced oxidative damage in embryonic chickens. Journal of Reproduction and Development. 53:4:749-754.

222. Monroy, C.M., A.C. Cortés, and H.G. de Restrepo. 2005. Cytotoxicity and genotoxicity of human cells exposed in vitro to glyphosate. Biomedica. 25:3:335-345.

223. Monsanto Company. January 2002. AquaMaster technical fact sheet. http://www.monsanto.com/ito/pdfs/aquaFactSheet.pdf. (Accessed August 4, 2008).

224. Monsanto Company. February 2005. Aquamaster™ herbicide material safety data sheet. St. Louis, Missouri. Monsanto Company.

225. Monsanto Corporation. April 2005. Backgrounder: glyphosate and environmental fate studies. Monsanto Corporation. 4pp.

226. Mortelmans, K. S. Haworth, W. Speck, and E. Zeiger. 1984. Mutagenicity testing of agent orange and related chemicals. Toxicology and Applied Pharmacology. 75:1:137-146.

227. Mossler, M.A. and K.A. Langeland. 2006. Florida crop/pest management profile: aquatic weeds. University of Florida, Institute of Food and Agricultural Sciences (IFAS) Extension. 9pp. http://edis.ifas.ufl.edu.

228. Moyle, P.B., R. M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. June 1995. Fish species of special concern in California. Department of Wildife and Fisheries Biology, University of California Davis. 272pp.

229. Moyle, P.B. 1976. Inland fishes of California. Berkeley, California. University of California Press. 405pp.

230. Munro, I.C., G.L. Carlo, J.C. Orr, K.G. Sund, R.M. Wilson, E. Kennepohl, B.S. Lynch, M. Jablinske, and N.L. Lee. 1992. A comprehensive, integrated review and evaluation of the scientific evidence relating to the safety of the herbicide 2,4-D. International Journal of Toxicology. 11:5:559-664.

231. Mustonen, R. J. Kangas, P. Vojolahti, and K. Linnainmaa. Effects of phenoxyacetic acids on the induction of chromosome aberrations in vitro and in vivo. Mutagenesis. 1:4:241-245.

232. National Oceanic and Atmospheric Administration Fisheries (NOAA-Fisheries). April 2004., Essential Fish Habitat Consultation Guidance, Version 1. Silver Springs, Maryland. NOAA-Fisheries Service, Office of Habitat Conservation.

233. NOAA-Fisheries. February 2005. Green Sturgeon (*Acipenser medirostris*) Status Review Update. Santa Cruz, CA. NOAA-Fisheries, Southwest Fisheries Science Center, Biological Review Team.

234. NOAA-Fisheries. June 2005. Updated status of Federally Listed ESUs of West Coast salmon and steelhead, NOAA Technical Memorandum NMFS-NWFSC-66 . Seattle, Washington. NOAA-Fisheries.

235. NOAA-Fisheries. April 2006. Water hyacinth control program biological and conference opinion. Long Beach, CA. NOAA-Fisheries Southwest Region. 123pp.

236. NOAA-Fisheries. 2007. 2007 recovery outline for the evolutionarily significant units of winter-run and spring-run Chinook salmon (*Oncorhynchus tshawytscha*) and the distinct population segment of California Central Valley steelhead (*O. mykiss*). NOAA-Fisheries, Southwest Region. May 7, 2007. 41pp.

237. NOAA-Fisheries. Accessed July 1, 2008. NOAA-Fisheries Office of Protected Resources, Endangered Species Act. http://www.nmfs.noaa.gov/pr/laws/esa.

238. NOAA-Fisheries. June 2009. Biological opinion and conference opinion on the long-term operations of the Central Valley Project and State Water Project. Long Beach, California. NOAA-Fisheries, Southwest Region.

239. National Pesticide Telecommunications Network (NPTN). Accessed June 19, 2008. 2,4-D. Oregon State University. http://ace.orst.edu/info/nptn/.

240. Natural Heritage Institute (NHI). 1992a. Causes of decline in estuarine fish species. Testimony of the Natural Heritage Institute presented by Dr. Peter Moyle, University of California Davis, to the State Water Resources Control Board. 35pp.

241. NHI. 1992b. Petition for listing longfin smelt and Sacramento splittail under the Endangered Species Act. Submitted by the Natural Heritage Institute to the U.S. Fish and Wildlife Service. 32pp.

242. Nobriga, M.L., F. Feyrer, R.D. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river delta: spatial patterns in species composition, life history strategies, and biomass. Estuaries. 28:5:776-785.

243. Nobriga, M.L., T.R. Sommer, F. Feyrer, and K. Fleming. February 2008. Long-term trends in summertime habitat suitability for delta smelt (Hypomesus transpacificus). San Francisco Estuary and Watershed Science. 6:1:1-13.

244. Nufarm. 2006. Weedar® 64 broadleaf herbicide material safety data sheet. Burr Ridge, Illinois. Nufarm, Inc.

245. Oliveira, A.G., L.T. Telles, R.A. Hess, G. Mahecha, and C.A. Oliveira. 2006. Effects of the herbicide Roundup on the epididymal region of drakes *Anas platyrhynchos*. Reproductive Toxicology. 23:2:182-191.

246. Oruc, E.O, and N. Uner. 2000. Combined effects of 2,4-D and azin phosmethyl on antioxidant enzymes and lipid peroxidation in liver of *Oreochromis niloticus*. Comparative Biochemistry and Physiology Part C: Pharmacology, Toxicology and Endocrinology. 127:3:291-296.

247. Oruc, E.O. and N. Uner. 2002. Marker enzyme assessment in the liver of *cyprinus carpio (L.)* exposed to 2,4-D and azinophosmethyl. J Biochem Mol Toxicol. 16:4:182-188.

248. Oruc, E.O., Y. Sevgiler, and N. Uner. 2004. Tissue-specific oxidative stress responses in fish exposed to 2,4-D and azinphosmethyl. Comparative Biochemistry and Physiology Part C: Toxicology and Pharmacology. 137:1:43-51.

249. Pacific Fishery Management Council (PFMC). August 1999. Appendix A, Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon, Amendment 14 to the Pacific Coast Salmon Plan. Portland, Oregon. PFMC.

250. PFMC. January 28, 2005. Information sheet: the Magnuson-Stevens Act. Portland, Oregon. PFMC. http://www.pcouncil.org.

251. PFMC. November 2005. Pacific Coast groundfish fishery management plan for the California, Oregon, and Washington Groundfish Fishery, Appendix B, Part 2, groundfish life history descriptions. Portland, Oregon. PFMC.

252. PFMC. July 24, 2006. Essential fish habitat. Portland, Oregon. PFMC. http://www.pcouncil.org.

253. PFMC. September 2006. Pacific coast groundfish fishery management plan for the California, Oregon and Washington groundfish fishery, as amended through Amendment 19. Portland, Oregon. PFMC. Chapter 7.

254. PFMC. 2008. Preseason Report I, Chapter II, Chinook salmon assessment. Portland, Oregon. PFMC.

255. PFMC. Accessed July 3, 2008. Backgrounder: The Magnuson-Stevens Act; Backgrounder: Essential Fish Habitat. www.pcouncil.org.

256. PFMS. 2009. Preseason Report I, Stock abundance analysis for 2009 ocean salmon fisheries. Portland, Oregon. PFMC.

257. Pearce, N., and D. McLean. 2005. Agricultural exposures and non-Hodgkin's lymphoma. Scandinavian Journal of Work and Environmental Health. 31(S1):18-25.

258. Perkins, P.J., H.J. Boermans, and G.R. Stephenson. 2000. Toxicity of glyphosate and triclopyr using the frog embryo teratogenesis assay – *Xenopus*. Environmental Toxicology and Chemistry. 19:4:940-945.

259. Pesticide Action Network (PAN). 2000. PAN chemical information database. http://pesticideinfo.org.

260. Radke, L.D. 1966. Distribution of smelt, juvenile sturgeon and starry flounder in the Sacramento-San Joaquin Delta. Pages 115-119. In: S.L. Turner and D.W. Kelley, eds., Ecological studies of the Sacramento-San Joaquin Estuary, Pt. 2. California Department of Fish and Game Fish Bulletin 136.

261. Ralston, Stephen. 2005. An assessment of starry flounder off California, Oregon, and Washington. Santa Cruz, California. NOAA Fisheries, Southwest Fisheries Science Center.

262. Rawlings, N.C., S.J. Cook, and D. Waldbillig. 1998. Effects of the pesticides carbofuran, chlorpyrifos, dimethoate, lindane, triallate, trifluralin, 2,4-D, and pentachlorophenol on the metabolic endocrine and reproductive endocrine system in ewes. Journal of Toxicology and Environmental Health, Part A. 54:1:21-36.

263. Reigart, J.R., and J.R. Roberts. 1999. Recognition and management of pesticide poisonings, fifth edition. Washington D.C.. U.S. Environmental Protection Agency, Certification and Worker Protection Branch. http://www.epa.gov/pesticides/safety/healthcare.

264. Resources Agency. October 2005. Delta smelt action plan. Sacramento, California. Resources Agency. 75pp.

265. Resources Agency. March 2007. Pelagic fish action plan. Sacramento, California. Resources Agency. 84pp.

266. Resources Agency. 2008. BDCP Bay Delta Conservation Plan brochure. Sacramento, California. http://www.resources.ca.gov/bdcp/. 2pp.

267. Rich, Jim. 2007. The value of the agricultural output of the California Delta, a revised DWR draft paper. Sacramento, California. Department of Water Resources. September 21, 2006, revised February 22, 2007. 12pp.

268. Riley, F. and S. Finlayson. 2003 (estimated). Acute toxicities of herbicides used to control water hyacinth and Brazilian elodea on larval delta smelt and Sacramento splittail. Elk Grove, California. California Department of Fish and Game, Aquatic Toxicology Laboratory. 10pp.

269. Riley, F. and S. Finlayson. 2004. Chronic toxicities of herbicides used to control water hyacinth and Brazilian elodea on neonate cladocern and larval fathead minnow. Elk Grove, California. California Department of Fish and Game, Aquatic Toxicology Laboratory. 30pp.

270. Rockwell, H.W. Jr. 2003. Summary of a survey of the literature on the economic impact of aquatic weeds. Prepared for the Aquatic Ecosystem Restoration Foundation. 18pp.

271. Rogers, J. A., 1998. Sworn Affidavit of James A. Rogers, Jr., Ph.D., Wildlife Biologist, Florida Game and Freshwater Fish Commission, United States District Court, Southern District of Florida (Monroe County), Aug. 10, 1998, 5 p.

272. Rogers, J. A. 2000. Buffer Zone Distances to Protect Foraging and Loafing Waterbirds from Disturbances by Personal Watercraft in Florida. (Study 7520, in *Annual Report*.) Gainesville, Florida. Florida Bureau of Wildlife Diversity Conservation.

273. Rosenfield, J.A. and R. D. Baxter. 2007 (estimated). Population dynamics and distribution patterns of longfin smelt in the San Francisco Estuary. University of California, Davis Center for Integrated Watershed Science and Management and CDFG. 45pp.

274. San Francisco Estuary Project (SFEP). March 1992. Status and trends report on aquatic resources in the San Francisco Estuary. Public Report. Oakland, California. San Francisco Estuary Project. 257pp.

275. SFEP. State of the estuary 1992-1997: vital statistics, new science, environmental management. Oakland, California. San Francisco Estuary Project.

276. San Joaquin County. November 2000. San Joaquin County Multi-Species Habitat Conservation and Open Space Plan. San Joaquin County. 534pp.

277. San Joaquin River Group Authority. January 2008. 2007 Annual technical report on implementing and monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. Prepared for the California Water Resources Control Board.81pp.

278. San Joaquin River Restoration Program (SJRRP). December 2007. Fact sheet. SJRRP. 4pp.

279. Sarikaya, R. and M. Selvi. 2005. Investigation of acute toxicity of (2,4-dichlorophenoxy) acetic acid (2,4-D) herbicide on larvae and adult Nile tilapia (*Oreochromis niloticus* L.). Environmental Toxicology and Pharmacology. 20:2:264-268.

280. Scholik, A. R., and Yan, H. Y. 2002. Effects of boat engine noise on the auditory sensitivity of the fathead minnow, Pimephales promelas. Environmental Biology of Fishes 63:203–209.

281. Schuette, J. Environmental fate of Glyphosate. Sacramento, California. Department of Pesticide Regulation, Environmental Monitoring Program. 13pp.

282. Shuford, W.D. and Gardali, T., editors. 2008. California Bird Species of Special Concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento. 450pp.

283. Siemering, G.S., J.Hayworth, and B.K. Greenfield. 2008. Assessment of potential aquatic herbicide impacts to California aquatic ecosystems. Arch. Environ. Contam. Toxicol. (not yet published).

284. Siemering, G.S., J. Hayworth, and A. Melwani. February 2005. Aquatic Pesticide Monitoring Program final report. Oakland, California. San Francisco Estuary Institute. 51pp.

285. Siemering. G.S. 2006. Technical report for the Interagency Ecological Program (IEP) Pelagic Organism Decline (POD) workgroup: Tier 1 risk assessment of California Department of Boating and Waterways aquatic herbicide use in the Sacramento-San Joaquin River Delta, Draft. Oakland, California. San Francisco Estuary Institute. 14pp.

286. Sikka, H.C., H.T. Appleton, and E.O. Gangstad. 1977. Uptake and metabolism of dimethylamine salt of 2,4-dichlorophenoxyacetic acid by fish. Journal of Agriculture and Food Chemistry. 25:5:1030+.

287. Siepmann, S. 1995. Preliminary hazard assessment of the herbicide glyphosate to aquatic organisms. Draft report. Rancho Cordova, California. Pesticide Investigations Unit.

288. Smelt Working Group. June 16, 2008. Weekly advice to the Service for delta smelt. Interagency Ecology Program. 6pp.

289. Solomon, K., A. Anadón, A.L. Cerdeira, J. Marshall, and L. Sanin. 2005. Environmental and human health assessment of the aerial spray program for coca and poppy control in Colombia. Washington, D.C.. Prepared for the Inter-American Drug Abuse Control Commission section of the Organization of American States. 121pp.

290. Soloneski, S., N.V. Gonzalez, M.A. Reigosa, and M.L. Larramendy. 2007. Herbicide 2,4-dichlorophenoxyacetic acid (2,4-D)-induced cytogenic damage in human lymphocytes in vitro in presence of erythrocytes. Cell Biology International. 31:11:1316-1322.

291. Sommer, T., R. Baxter, and B. Herbold. 1997. The resilience of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society. 126:961-976.

292. Sommer, T., L. Conrad, G. O'Leary, F. Feyrer, and W.C. Harrell. 2002. Spawning and rearing of splittail in a model floodplain wetland. Transactions of the American Fisheries Society. 131:966-974.

293. Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the Upper San Francisco Estuary. Fisheries. American Fisheries Society. 32:6: 270-277.

294. Sparling, D.W., C. Matson, J. Bickham, and P. Doelling-Brown. 2006. Toxicity of glyphosate as Glypro® and LI700 to red-eared slider (*Trachemys scripta elegans*) embryos and early hatchlings. Environmental Toxicology and Chemistry. 25:10:2768-2774.

295. Spencer, D.F. and G.G. Ksander. 2005. Seasonal growth of water hyacinth in the Sacramento/San Joaquin Delta, California. Journal of Aquatic Plant Management. 43:91-94.

296. Spencer, D.F., G.G. Ksander, M.J. Donovan, P.S. Liow, W.K. Chan, B.K. Greenfield, S.B. Shonkoff, and S.P. Andrews. 2006. Evaluation of water hyacinth survival and growth in the Sacramento Delta, California, following cutting. Journal of Aquatic Plant Management. 44: 50-60.

297. Stebbins, R. C. 1985. A field guide to western reptiles and amphibians. 2nd edition. Boston, MA. Houghton Mifflin Company.

298. Steinhart, P. 1990. California's wild heritage: threatened and endangered animals in the golden state. California Department of Fish and Game. 108pp.

299. Stephenson, M. and G.L. Mackie. 1986. Effects of 2,4-D treatment on natural benthic macroinvertebrate communities in replicate artificial ponds. Aquatic Toxicology. 9:243-251.

300. Stewart, Ian J. May 25, 2005. Status of the U.S. English sole resource in 2005. Seattle, Washington. NOAA-Fisheries, Northwest Fisheries Science Center.

301. Stockton East Water District. 2009. History. Stockton, California. http://www.sewd.net/history.htm.

302. Stürtz, N., A.M. Evangelista de Duffard, and R. Duffard. 2000. Detection of 2,4-dichlorophenoxyacetic acid (2,4-D) residues in neonates breast-fed by 2,4-D exposed dams. Neurotoxicology. 21:1-2:147-154.

303. Stürtz, N., B. Bongiovanni, M. Rassetto, A. Ferri, A.M. Evangelista De Duffard, and R. Duffard. 2006. Detection of 2,4-dichlorophenoxyacetic acid in rat milk of dams exposed during lactation and milk analysis of their major components. Food and Chemical Toxicology. 44:1:8-16.

304. Stürtz, N., R.P. Deis, G.A. Jahn, R. Duffard, and A.M. Evangelista De Duffard. 2008. Effect of 2,4-dichlorophenoxyacetic acid on rat maternal behavior. Toxicology. 247:2-3:73-79.

305. Swan, S.H., R.L. Kruse, F. Liu, D.B. Barr, E.Z. Drobnis, J.B. Redmon, C. Wang, C. Brazil, J.W. Overstreet, and the Study for Future Families Research Group. 2003. Semen quality in relation to biomarkers of pesticide exposure. Environmental Health Perspectives. 111:12:1478-1484.

306. Taugher, Mike. December 26, 2005. Water quality can be hard to swallow. Contra Costa Times.

307. Teixeira, M.C., J.P. Telo, N.F. Duarte, and I. Sa-Correia. 2004. The herbicide 2,4-dichlorophenoxyacetic acid induces the generation of free-radicals and associated oxidative stress in yeast. Biochemical and Biophysical Research Communications. 324:3:1101-1107.

308. The Essex Partnership. May 2009. DRERIP Evaluations of BDCP Draft Conservation Measures Summary Report, Draft. Sacramento, California. California Natural Resources Agency. 26pp.

309. Toft, J.D. 2000. Community effects of the non-indigenous aquatic plant water hyacinth (*Eichhornia crassipes*) in the Sacramento/San Joaquin Delta, California. University of Washington. 86pp.

310. Toft. J.D., C.A. Simenstad, J.R. Cordell, and L.R. Grimaldo. 2003. The effects of introduced water hyacinth on habitat structure, invertebrate assemblages, and fish diets. Estuaries. 26: 746-758.

311. Tsui, M.T.K., and L.M. Chu. 2004. Comparative toxicity of glyphosate-based herbicides: aqueous and sediment porewater exposures. Archives of Environmental Contaminant Toxicology. 46:3:316-323.

312. Tu M., C. Hurd, and J.M. Randall. 2,4-D. 2001. In Weed Control Methods Handbook. The Nature Conservancy. pp7a.1-7a.10.

313. Tuschl, H., and C. Schwab. 2003. Cytotoxic effects of the herbicide 2,4-dichlorophenoxyacetic acid in HepG2 cells. Food and Chemical Toxicology. 41:3:385-393.

314. United States Army Corps of Engineers. 1985. State Design Memorandum Water hyacinth Sacramento-San Joaquin Delta California. Sacramento District, U.S. Army Corps of Engineers. 24pp.

315. United States Army Corps of Engineers. 2009. San Francisco Bay to Stockton navigation improvement study. http://www.spn.usace.army.mil/projects/stockton_navigation/project_status.html.

316. United States Bureau of Reclamation (USBR) and DWR. April 2007. Delta Mendota Canal recirculation project public scoping meeting, project fact sheet. Sacramento, California. Bureau of Reclamation and DWR. 2pp.

317. United States Bureau of Reclamation. July 2003. Environmental water account draft environmental impact statement and environmental impact report. Sacramento, California. USBR.

318. United States Bureau of Reclamation. April 2008. Environmental water account, latest news release. Sacramento, California. USBR. 2pp.

319. United States Bureau of Reclamation. August 2008. Biological assessment on the continued long-term operations of the Central Valley Water Project and the State Water Project. Sacramento, California. USBR Mid-Pacific Region. 1,089 pp.

320. United States Bureau of Reclamation. June 2009. Draft environmental impact statement, Delta-Mendota California aqueduct intertie. Sacramento, California. USBR.

321. United States Department of Agriculture (USDA). 2005. Summary of county agricultural commissioner’s reports: gross values by commodity groups. Sacramento, California. USDA, National Agricultural Statistics Service.

322. United States Environmental Protection Agency (USEPA). 2000. Office of Pesticide Programs, Pesticide Ecotoxicity Database (at ECOTOX).

323. USEPA. 2005. Reregistration eligibility decision for 2,4-D. Washington DC. USEPA, Prevention, Pesticides and Toxic Substances, EPA 738-R-05-002.

324. United States Fish and Wildlife Service (USFWS). 1992. Federal Register. Endangered and threatened wildlife and plants: 90-day finding and commencement status reviews for a petition to list the western pond turtle and California red-legged frog. Department of Interior. 57(193): 45761-45762. October 5, 1992.

325. USFWS. 1995. U.S. Department of Interior Intra-Service Section 7 Evaluation – and Pesticide Use Proposals for the Stone Lakes National Wildlife Refuge.

326. USFWS. November 26, 1996. Recovery plan for the Sacramento-San Joaquin Delta native fishes. Portland, Oregon. USFWS , Region 1.

327. USFWS. March 31, 2004. 5-Year Review *Hypomesus transpacificus* (delta smelt). Sacramento, CA. USFWS, Sacramento Fish and Wildlife Office.

328. USFWS. May 21, 2004. Reinitiation of formal endangered species consultation on the proposed water hyacinth control program in the Sacramento-San Joaquin Delta in nine counties, California. Sacramento, California. USFWS, Sacramento Fish and Wildlife Office. 59pp.

329. USFWS. 2004c. Endangered and threatened wildlife and plants: 90-Day finding on a petition to list Three species of lampreys as threatened or endangered. Oregon. USFWS.

330. USFWS. 2005. Habitat Conservation Plans: Section 10 of the Endangered Species Act. http://www.fws.gov/endangered/hcp/.

331. USFWS. 2005a. Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. Portland, Oregon. USFWS.

332. USFWS. Accessed 2006. Sacramento Splittail. Sacramento, California. USFWS, Sacramento Office. http://www.fws.gov/sacramento/es/animal_spp_acct/sac_splittail.htm.

333. USFWS. Accessed July 3, 2008. Migratory birds and habitat programs. http://www.fws.gov/pacific/migratorybirds/mbta.htm.

334. USFWS. 2009. Service decision June 16, 2009. Sacramento, California. USFWS.

335. United States Department of Agriculture, Forest Service (USFS). 2003. Glyphosate – human health and ecological risk assessment. Arlington, Virginia. Prepared by Syracuse Environmental Research Associates, Inc., for USFS Forest Health Protection.

336. United States Department of Agriculture, Forest Service (USFS). 2006. 2,4-D – human health and ecological risk assessment. Arlington, Virginia. Prepared by Syracuse Environmental Research Associates, Inc., for USFS Forest Health Protection.

337. United States District Court, Eastern District. 2009. Findings of fact and conclusions of law and order re plaintiffs' motion for preliminary injunction in San Luis and Delta-Mendota Water Authority; Westlands Water District v. Kenneth Lee Salazar, as Secretary of the Interior. Case 1:09-cv-00407-OWW-DLB, filed May 29, 2009.

338. United States Geological Service (USGS). Accessed 2006. Longhair sedge. (Northern Prairie Wildlife Research Center. USGS. http://www.npwrc.usgs.gov/resource/plants/floramw/species.

339. United States National Library of Medicine. 2001. Hazardous Substances Databank. Bethesda, Maryland.(Cited as HSDB 2001).

340. University of California. 2005. Pesticide choice: best management practice (BMP) for protecting surface water quality in agriculture, Publication 8161. University of California, Division of Agriculture and Natural Resources. http://anrcatalog.ucdavis.edu. 8pp.

341. URS Corporation. May 2007. Status and Trends of Delta-Suisun Services. Sacramento, California. California Department of Water Resources. 53pp.

342. Venkov, P., M. Topashka-Ancheva, M. Georgieva, V. Alexieva, and E. Karanov. 2000. Genotoxic effect of substituted phenoxyacetic acids. Archives of Toxicology. 74:560-566.

343. Walters, J. 1999. Environmental fate of 2,4-Dichlorophenoxyacetic acid. Sacramento, California. Department of Pesticide Regulation, Environmental Monitoring Program. 12pp.

344. Wang, C.S. 1986. Fishes of the Sacramento-San Joaquin Estuary and adjacent waters, California: a guide to the early life histories. Prepared for the Interagency Ecology Study Program for the Sacramento-San Joaquin Estuary. Technical Report 9.

345. Wang, Y.S., C.G. Jaw, and Y.L. Chen. 2004. Accumulation of 2,4-D and glyphosate in fish and water hyacinth. Water, Air, and Soil Pollution. 74:397-403.

346. Washington (State) Department of Agriculture (WSDA). 2005. Memorandum: proposed SEPA review to permit use of eight spray adjuvants. From Erik W. Johansen to Kelly McLain. Olympia, Washington. 3pp.

347. Washington State Department of Ecology (WSDE). 2001. Herbicide risk assessment for the aquatic plant management final supplemental environmental impact statement, appendix C, volume 3: 2,4-D. Olympia, Washington. Department of Ecology.

348. Weiser, Matt. 2008. Ammonia from Sacramento waste could hurt Delta ecosystem. Sacramento, California. The Sacramento Bee. June 1, 2008. Page A8.

349. Weiser, Matt. 2009. Wastewater ammonia found 'likely' to add to Delta woes. Sacramento, California. The Sacramento Bee. April 23, 2009. Page B1.

350. Westerdahl, H.D. and K.D. Getsinger. 1988. Aquatic plant identification and herbicide use guide, Volumes I and II. Mississippi. U.S. Army Corps of Engineers, Waterways Experiment Station.

351. Wigle, D.T., R.M. Semenciw, K. Wilkins, D. Riedel, L. Ritter, H.I. Morrison, and Y. Mao. 1990. Mortality study of Canadian male farm operators: non-Hodgkin's lymphoma mortality and agricultural practices in Saskatchewan. Journal of the National Cancer Institute. 82:7:575-582.

352. Williams, G.M., R. Kroes, and I.C. Munro. 2000. Safety evaluation and risk assessment of the herbicide Roundup and its active ingredient, glyphosate, for humans. Regulatory Toxicology and Pharmacology. 31:2:117-165.

353. Wilson, J.R., M. Rees, N. Holst, M.B. Thomas, and G. Hill. 2001. Water hyacinth population dynamics. In, Biological and Integrated Control of Water Hyacinth, *Eichhornia crassipes*, edited by M.H. Julien, M.P. Hill, T.D. Center, and D. Jianqing. ACIAR Proceedings 102:96-102.

354. Xie, L. K. Thrippleton, M.A. Irwin, G.S. Siemering, A. Mekebri, D. Crane, K. Berry, and D. Schlenk. 2005. Evaluation of estrogenic activities of aquatic herbicides and surfactants using an rainbow trout vitellogenin assay. Toxicological Sciences. 87:2:391-398.

355. Yolo County. 2008. Yolo natural heritage program. http://www.yoloconservationplan.org.

356. Zahm, S.H., and A. Blair. 1992. Pesticides and non-Hodgkin's lymphoma. Cancer Research (Supplement). 52:5485s-5488s.

357. Zeiner, D.C., W.F. Laudenslayer Jr., and K.E. Mayer (eds). 1988. California's wildlife: Volume 1 amphibians and reptiles. Sacramento, California. California Department of Fish and Game. 272pp.

358. Zeiner, D.C., W.F. Laudenslayer, Jr., and K.E. Mayer, editors. 1990. California's wildlife: Volume II birds. Sacramento, California. California Department of Fish and Game. 272pp.

359. Zeljezic, D., and V. Garaj-Vrhovac. 2004. Chromosomal aberrations, micronuclei and nuclear buds induced in human lymphocytes by 2,4-dichlorophenoxyactetic acid pesticide formulation. Toxicology. 200:1:39-47.

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