PANOCHE DRAINAGE DISTRICT

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July 28, 2006

Michael Delamore
US Bureau of Reclamation
1243 N Street
Fresno CA 93721-1813

Subject: San Joaquin River Water Quality Improvement Project, 2005 Wildlife Monitoring Report

Dear Mike:

Enclosed is the 2005 Monitoring Report for the San Joaquin River Water Quality Improvement Project (SJRIP) prepared by H.T. Harvey & Associates. This is the fifth year of bird egg monitoring at the project site. Eggs were collected from recurvirostrids (black-necked stilt) and killdeer.

The overall geometric mean egg selenium concentrations in the project area for stilts (12 eggs) in 2005 was 35.3 ppm (dry weight). In comparison, geometric mean egg selenium concentration in 17 stilt eggs collected at an off-site reference location was 12.4 ppm.

Because of the elevated levels of selenium in the recurvirostrid eggs a mitigation plan has been recommended by HT Harvey in the report and implemented by Panoche Drainage District for the project. The recommendations start on page 23 of the report and continue through page 27. Mitigation measures implemented include:

1) **Reduced exposure potential by reducing attractiveness of irrigation ditches for nesting**: Irrigation and drainage ditches within the project site were reshaped prior to the nesting season to reduce attractiveness for birds. We feel this was one of the most significant sources of selenium to the birds as higher selenium is in the drainage channels as the project corps are developed and able to handle higher salt concentrations.
2) **Reduced exposure potential by hazing birds from nesting near, and foraging in, irrigation (and drainage) ditches**: A hazing program has been implemented by shooting "cracker shells" in the vicinity of birds to discourage nesting within the project area.

Board of Directors: John F. Bennett, *President* • Suzanne Redfern, *Vice-President* • Michael Stearns, *Secretary*
Edward Koda • Michael Linneman • Dennis Falaschi, *General Manager*

3) **Flooded field contingency plan**: Panoche Drainage District has had in place this contingency plan since a field was inadvertently flooded in 2003. A copy is included in Appendix G of the HT Harvey report.
4) **Provide compensation breeding habitat**: A 50 acre compensation habitat was constructed as described in the HT Harvey report and per the attached details. The monitoring program was expanded to include testing on the mitigation site for the Spring of 2006. Preliminary results indicated significant nesting on the compensation habitat.

Questions regarding this data should be directed toward Joe McGahan, Drainage Coordinator for the Grassland Bypass Project. He can be reached at 559-582-9237.

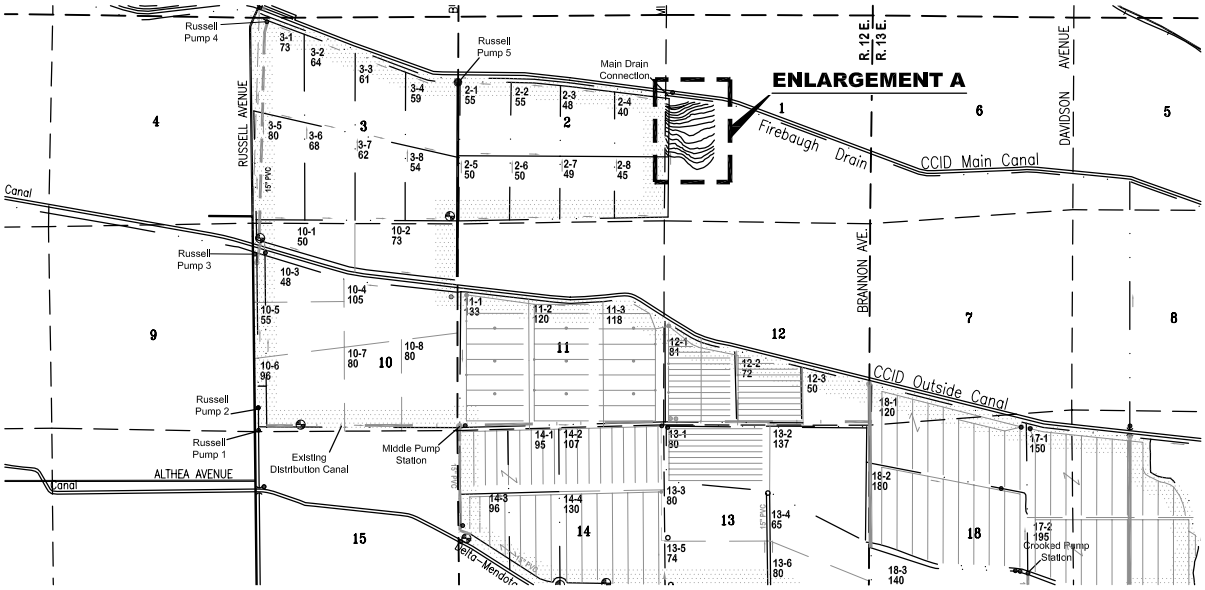
Very truly yours,

Dennis Falaschi
General Manager

Cc: Kathy Wood
US Bureau of Reclamation
1243 N Street
Fresno CA 93721-1813

Compensation Breeding Habitat

A 50 acre compensation breeding habitat was developed in 2006. This habitat was developed in an agricultural rice operation adjacent to the San Joaquin River Water Quality Improvement Project. The habitat included the construction of “mitigation islands”. Both the location and “mitigation island” designs are shown on the attached drawings. The aerial photo shows the island locations within each rice check. The total area is 1,320 feet by 1,650 feet or 50 acres. The rice fields were flooded with water out of the Central California Irrigation District delivery system.



LOCATION MAP

ENLARGEMENT A

▭ 7' x 30' ISLANDS

SJRIP
Mitigation Map

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APRIL 2006

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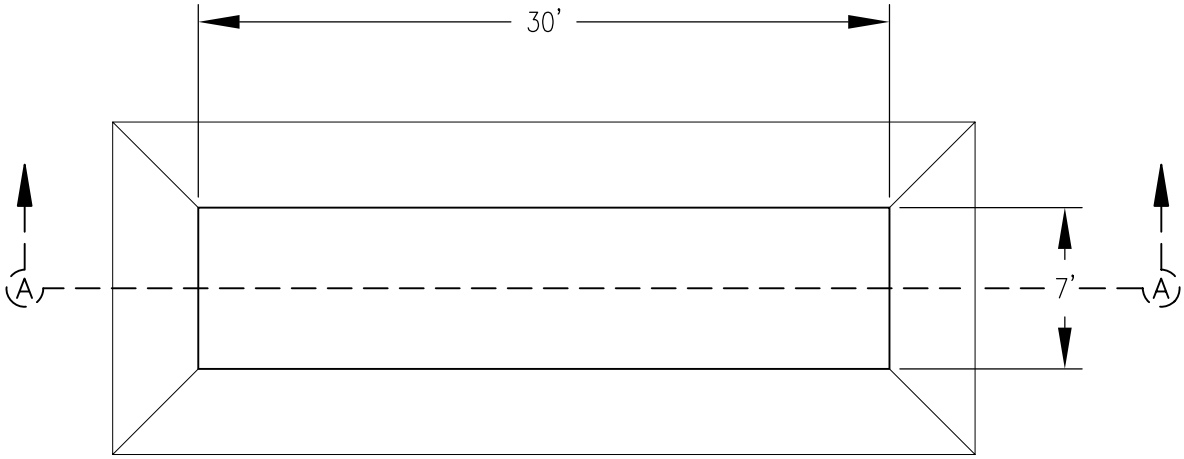
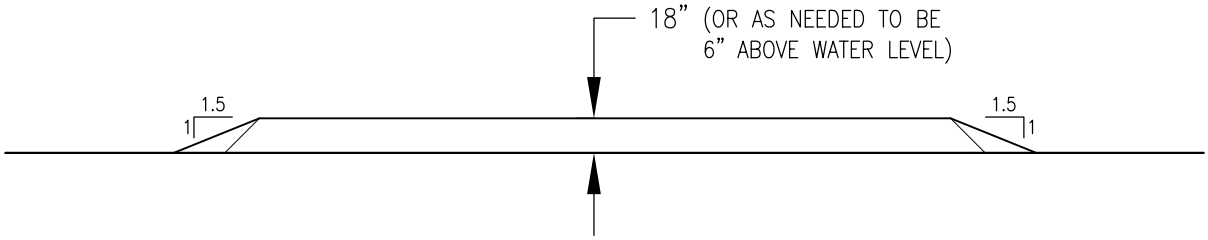


PLAN



SECTION A–A

SJRIP
MITIGATION ISLANDS

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APRIL 2006

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SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT, PHASE I WILDLIFE MONITORING REPORT 2005

Prepared by:

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Prepared for:

PANOCHE DRAINAGE DISTRICT

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June 5, 2006 File No. 1960-05

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INTRODUCTION

To reduce the amount of salt and selenium delivered to the San Luis Drain and Mud Slough through the Grassland Bypass Project, the Panoche Drainage District implemented Phase I of the San Joaquin River Water Quality Improvement Project (SJRIP). The Panoche Drainage District, acting as the lead agency under the California Environmental Quality Act (CEQA), prepared a Negative Declaration for SJRIP in September 2000. The Negative Declaration included the provision of a biological monitoring program, to be developed in collaboration with the U. S. Fish and Wildlife Service (USFWS), which would detect migratory bird impacts resulting from the project. This report represents the biological monitoring results for the fourth year (2005) of Phase I of the SJRIP.

PROJECT DESCRIPTION AND SETTING

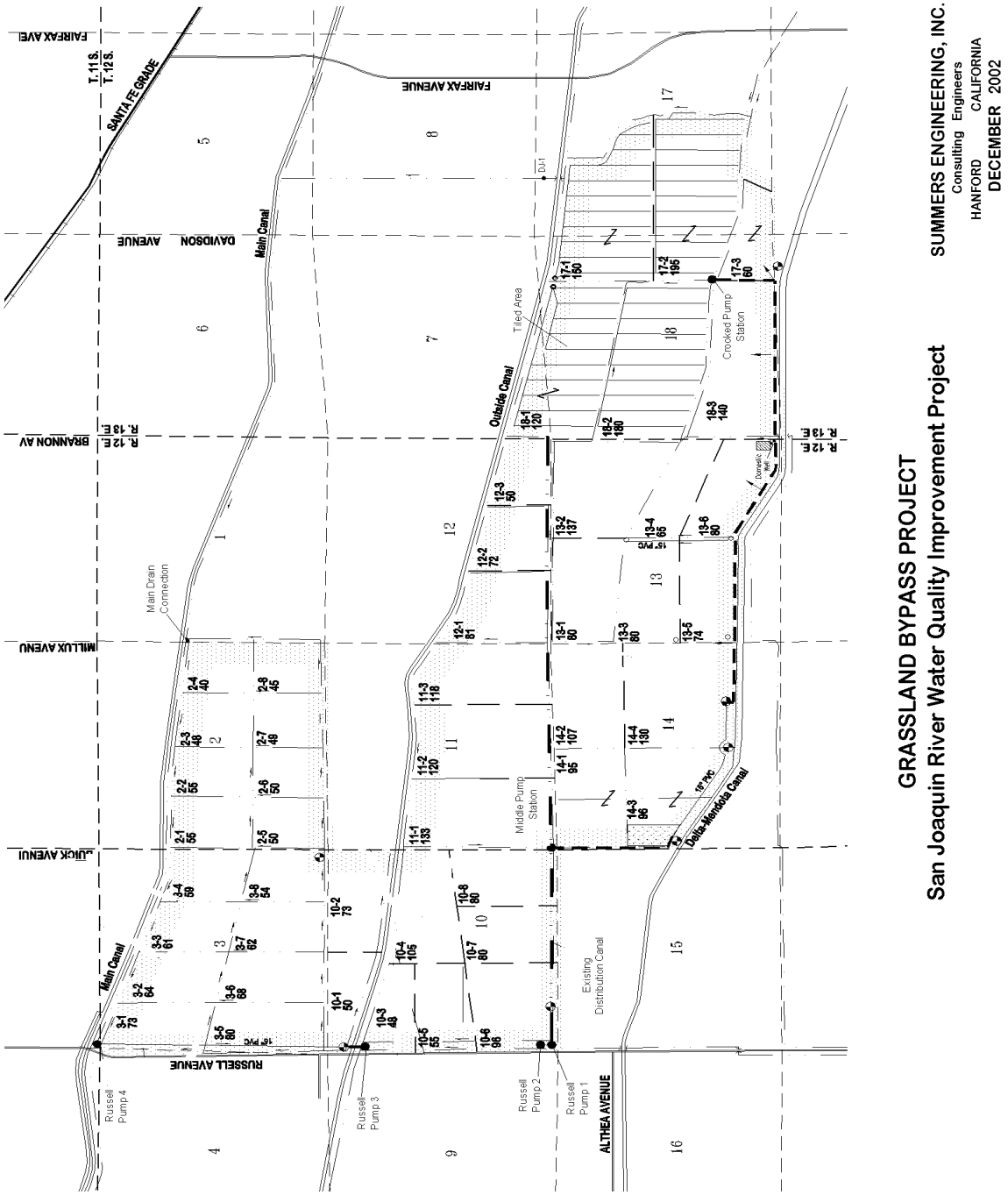
Only a portion of Phase I was put into effect in 2005. Crops were planted on approximately 3,500 of the 4,000 acres obtained by the Panoche Drainage District. The project site is located west of the city of Firebaugh in Fresno County, California. The irregularly shaped project site is bordered on the north by the Main Canal and on the south by the Delta-Mendota Canal. Russell Avenue borders the eastern edge of the project site and the western edge extends nearly to Fairfax Avenue (Figure 1).

The project is the initial development of an In-Valley Treatment/Drainage Reuse Facility on up to 6,200 acres of land within the Grassland Drainage Area (GDA) (Figure 1). The 6,200 acres of GDA land designated for purchase is made up of irrigated field crops and related irrigation ditches, drain ditches, conveyance canals, and farm structures. The topography is nearly level to grade and flood/furrow irrigated. The highest elevation is found near the southeast corner at 164 feet above mean sea level, while the lowest point is found near a north-central point at 136 feet above mean sea level. Thus, the elevation change within the 6,200-acre property is approximately 28 feet. The shape of the property is irregular, conforming to the area's adjacent canals. Russell Avenue provides access to the property via a paved county road. Typical, improved farm roads provide access to the interior of the site.

The reuse facility will dedicate specific lands for the irrigation of salt-tolerant crops with subsurface drainwater to reduce drainwater volume; treat the concentrated drainwater to remove salt, selenium and boron; and eventually dispose of the removed elements to prevent discharge into the San Joaquin River. The reuse facility will process up to one-quarter of the total drainwater produced in the GDA (25 percent of 52,000 acre-feet or approximately 15,000 acre-feet) and will be implemented in three phases, described below:

- Phase I: Purchase of land and planting of salt-tolerant crops
- Phase II: Installation of subsurface drainage and collection systems, initial treatment system
- Phase III: Complete construction of treatment removal and salt disposal systems

Figure 1. Location of the Panoche Drainage District's San Joaquin River Water Quality Improvement Project.



In Phase I, subsurface drainwater from the GDA is used to irrigate salt-tolerant crops on ideally situated land. Channels containing collected drainwater flow adjacent to this location, so water can easily be captured and placed on the land. Also, because this land is at the lowest elevation within the drainage area, collected water can be applied without excessive pumping costs.

Approximately four thousand acres have been purchased by the Panoche Drainage District to date. Approximately 3,500 acres of crops have been planted since 2001 and irrigated with water that otherwise would have been discharged into the San Joaquin River. Soil and water constituents at this project site will continue to be monitored to prevent irreversible soil changes and to protect groundwater from contamination.

In Phase II of the SJRIP, the application of saline water to lands developed in Phase I will continue. Subsurface drainage systems will be installed to leach the land and maintain a favorable salt balance. The water percolating below the root zone will be captured in the drainage system and passed on to more salt-tolerant crops. In Phase II, the system will sequentially reuse drainwater on increasingly salt-tolerant crops to concentrate, and decrease, the volume of drainwater produced. Salt, selenium, and other constituents will be conveyed by water exiting the subsurface drainage systems. An initial treatment phase will remove the salt, the selenium, and much of the other constituents, leaving water for beneficial uses such as agriculture. The treatment system will be designed to incorporate into the reuse system at any point. The remaining salt will be deposited into approved waste units that will result in additional reductions in salt and selenium discharges into the San Joaquin River.

The third and final phase of the SJRIP will maximize improvement in water-quality and meet reductions needed for future water-quality objectives. This phase will expand the initial treatment (under Phase II) to include additional treatment facilities and waste-disposal units.

Each phase of the facility will significantly reduce the amount of drainwater discharged to the San Joaquin River. Water sufficient for reuse on GDA agricultural lands could also be produced by the treatment systems. The project will be designed to assist Grasslands Area Farmers in meeting applicable water-quality objectives for the 2006 water year (October 1, 2005). The 2006 annual, selenium-load limit, based on the current applicable total maximum monthly load, is 3,087 pounds (lbs). In comparison, the load value for the 2001 water year was 5,661 lbs. This reduction in load size requires implementation of additional drainage management methods.

An Initial Study and Negative Declaration adopted September 9, 2000 by Panoche Drainage District, evaluated Phase I of the facility. The second and third phases of the facility were evaluated in the Grassland Bypass Project EIS/EIR, finalized May 25, 2001. Phase I is independent and does not exclude the consideration of alternatives to the larger project or project site. Even if the In-Valley Treatment/Drainage Reuse Project progress was to halt at Phase I, the drainage management alone would be valuable. In addition, the proposed cropping patterns are reversible should later phases of the project not be implemented.

In 1997, a portion of the project site was evaluated for conversion to salt-tolerant crops and drainage reuse by Mercy Springs Water District, which encompasses 3,392 acres (55 percent) of the site. The Mercy Springs Water District prepared an Environmental Assessment for the

transfer of its Central Valley Project Class I water supply to the Pajaro Valley Water Management Agency (ESA 1997). A Finding of No Significant Impact approved the transfer of 13,300 acre-feet of annual water supply to the Pajaro Valley Water Management Agency on November 6, 1998. In 1999, a Final Environmental Assessment and Finding of No Significant Impact were issued for the transfer of 6,260 acre-feet per year of annual Central Valley Project contract water to the Pajaro Valley Water Management Agency, Santa Clara Valley Water District, and Westlands Water District (Provost & Pritchard 1999). These documents covered the impact of water transfers, including drainwater reuse, groundwater pumping, and cumulative effects. The current phase of the proposed In-Valley Project does not include water transfers or additional groundwater pumping over existing conditions.

MATERIALS AND METHODS

BIRD CENSUSES

An ornithologist from H. T. Harvey & Associates monitored bird use at the project site on six occasions from April 22 to June 16, 2005. Censuses were completed by driving the perimeter roads of each field. Birds were identified and counted using 10X binoculars and a 20-60X spotting scope mounted on a tripod. Censuses were conducted to determine species composition and relative abundance of bird species on the project site during the breeding season.

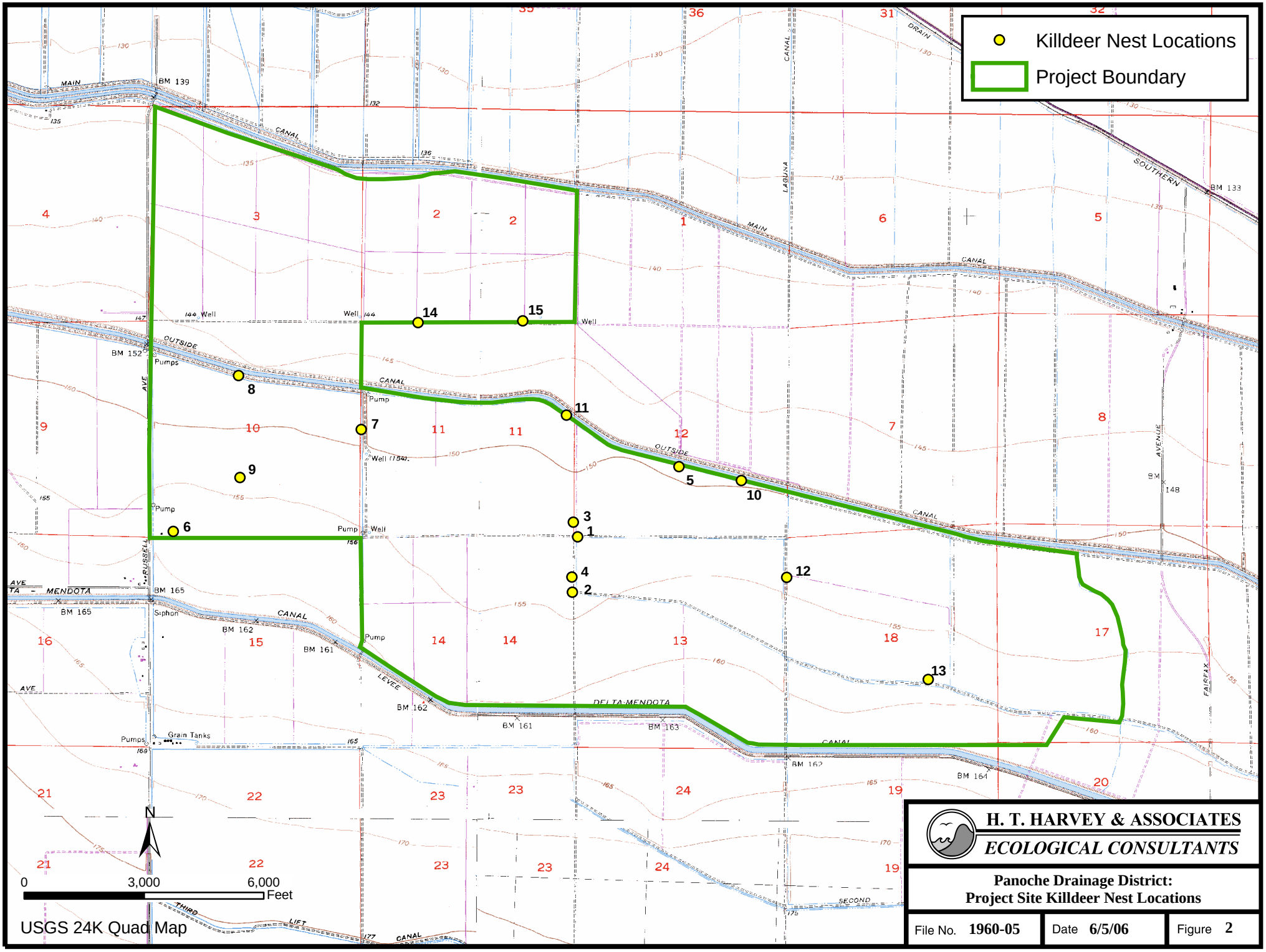
EGG COLLECTION AND PROCESSING

Fifteen Killdeer (*Charadrius vociferus*) eggs and 12 eggs from American Avocets (*Recurvirostra americana*) or Black-necked Stilts (*Himantopus mexicanus*) (recurvirostrids) eggs were collected from the project site for selenium and boron analysis. The locations from which Killdeer and recurvirostrid eggs were collected from the project site are illustrated in Figures 2 and 3; respectively. Scientific collecting permits were obtained from the California Department of Fish and Game (CDFG) and the U. S. Fish and Wildlife Service (USFWS) for the collection of bird eggs on the site. One egg was randomly collected from separate, full-clutch (four eggs) nests. Three additional sets of 15 reference Killdeer eggs (Figure 4) and 17 recurvirostrid eggs (Figure 5) were collected from the project vicinity to provide reference data on regional selenium and boron concentrations outside the project area.

All eggs were labeled with a permanent marker, placed in an egg carton, and transported from the field. Upon returning to the lab, all of the egg contents (including membranes) were removed from the shell and transferred to 1-ounce Dynalon jars. The embryos were photographed and examined for abnormalities and to determine the stage of incubation (age). Eggs were also examined to determine whether embryos were alive or dead. Egg contents were stored by freezing (0° C).

EGG CHEMISTRY ANALYSIS

All egg contents collected by H. T. Harvey & Associates were shipped overnight, on dry ice, to the Oscar E. Olson Biochemical Laboratory at South Dakota State University. Selenium concentrations were determined using the Association of Official Analytical Chemists (AOAC) method 996.16. The boron was done on a nitric acid/peroxide digest in a microwave oven and quantitation by an inductively coupled plasma optical emission spectrometer (ICPOES). All egg-selenium and egg-boron concentrations were presented as parts per million (ppm) based on dry tissue weight (dry weight). For quality control, selected sub-samples were divided into two aliquots. The duplicate was spiked with known amounts of selenium or boron, and the samples were tested to determine the accuracy of analysis.


Killdeer Nest Locations
Project Boundary
MAIN CANAL
OUTSIDE CANAL
DELTA-MENDOTA CANAL
SOUTHERN DRAIN
LAGUNA CANAL
RUSSELL AVE
FAIRFAX AVENUE
LEVEE
THIRD LIFT CANAL
SECOND
BM 139
BM 152
BM 165
BM 162
BM 161
BM 163
BM 164
BM 133
Pumps
Pump
Well
Siphon
Grain Tanks
1
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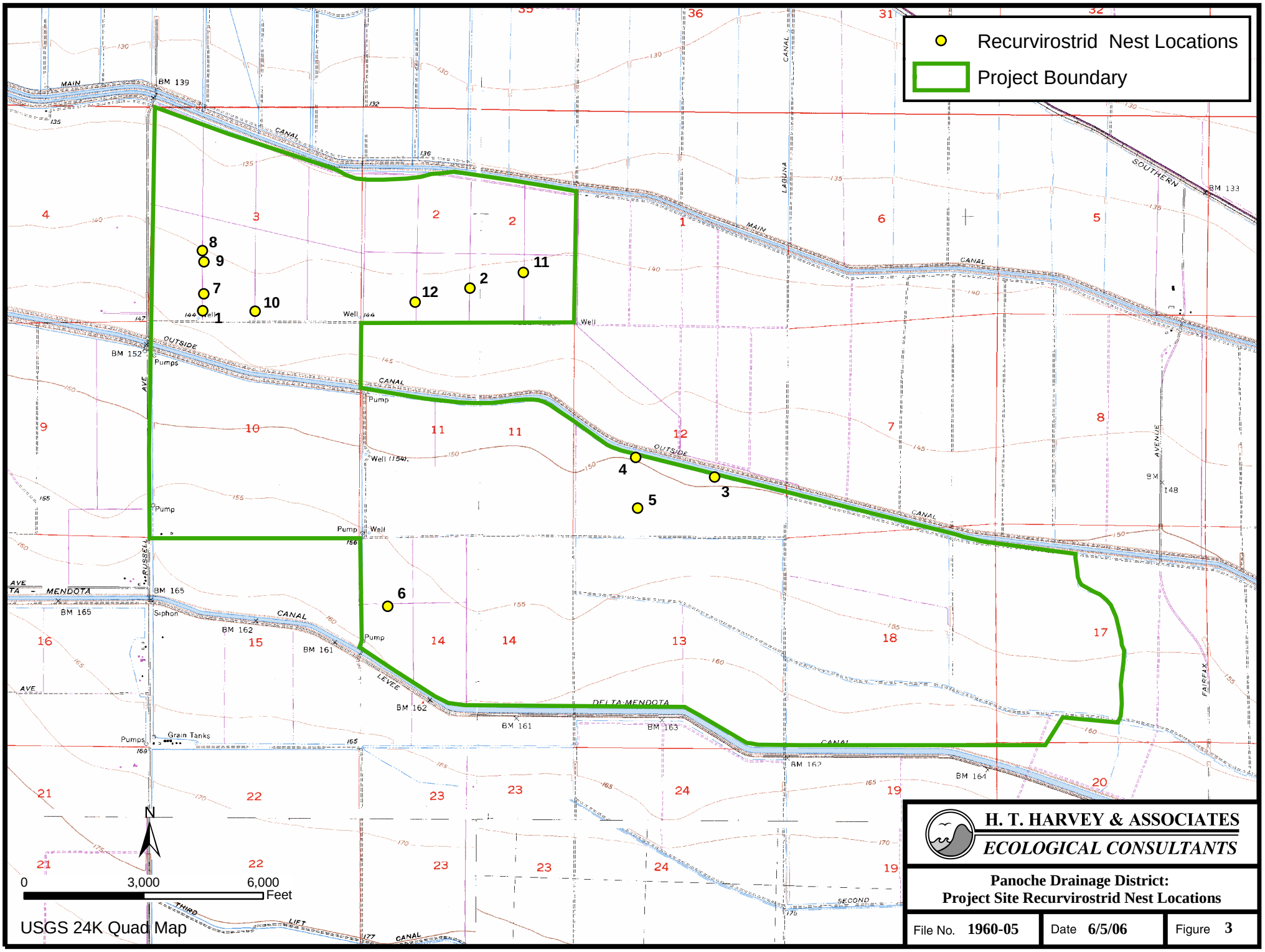
Feet
USGS 24K Quad Map
H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS
Panoche Drainage District:
Project Site Killdeer Nest Locations
File No. 1960-05
Date 6/5/06
Figure 2


Recurvirostrid Nest Locations
Project Boundary
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MAIN CANAL
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DELTA-MENDOTA CANAL
LEVEE
SOUTHERN
LAGUNA
RUSSELL AVE
FAIRFAX AVENUE
BM 139
BM 133
BM 152
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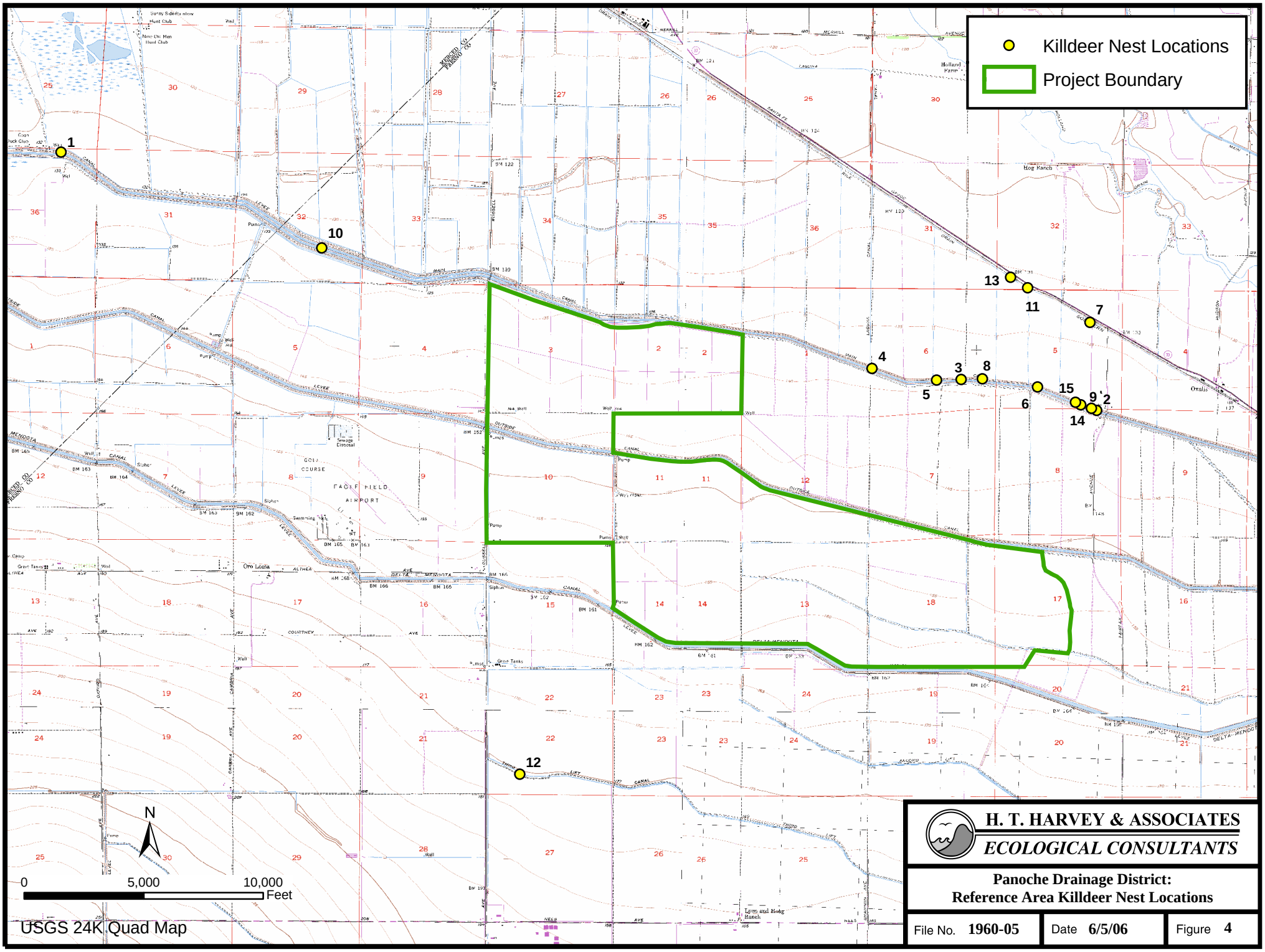
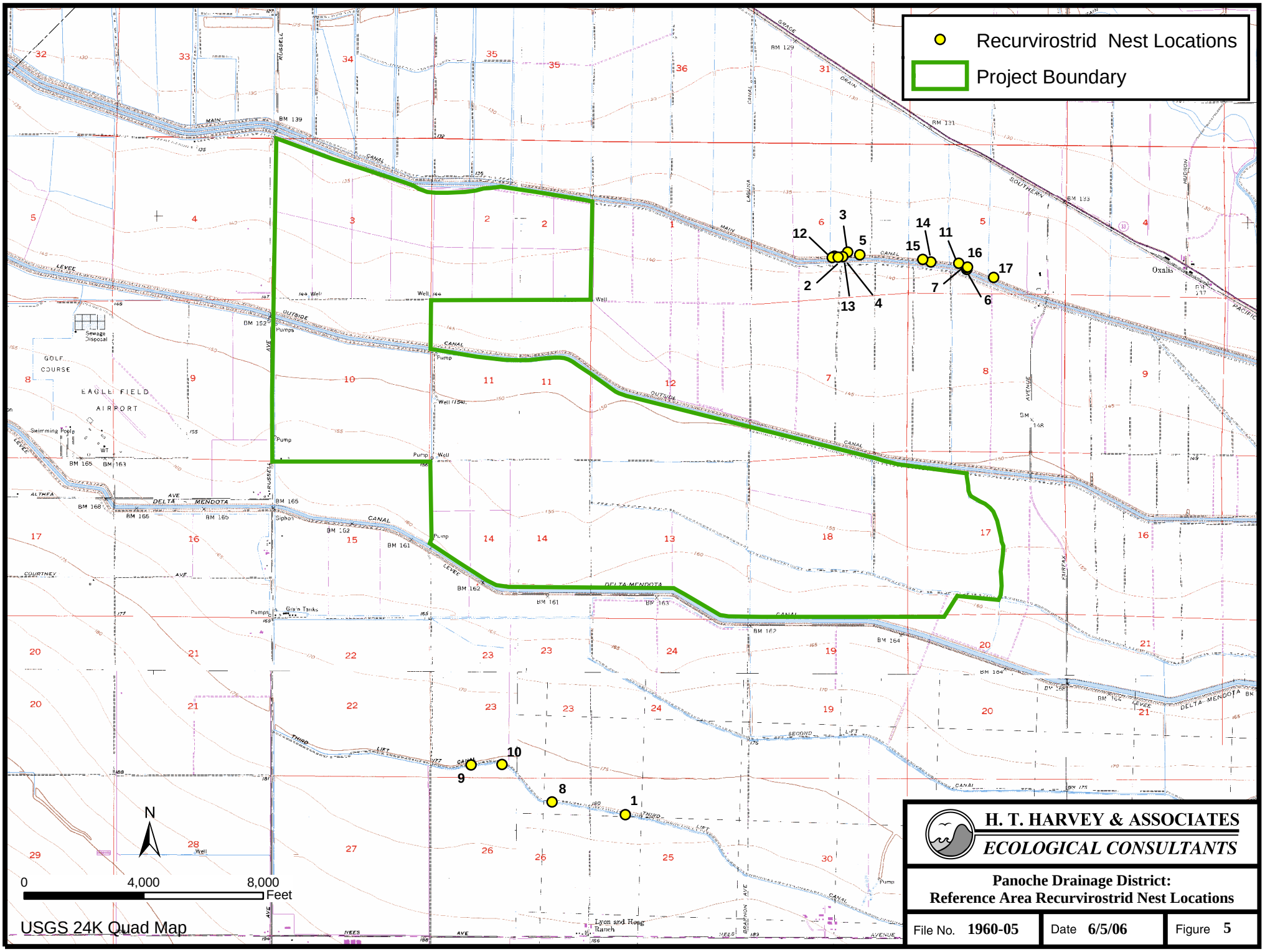
USGS 24K Quad Map
H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS
Panoche Drainage District:
Project Site Recurvirostrid Nest Locations
File No. 1960-05
Date 6/5/06
Figure 3



H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

Panoche Drainage District:
Reference Area Killdeer Nest Locations

File No. 1960-05	Date 6/5/06	Figure 4


Recurvirostrid Nest Locations
Project Boundary
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Feet
USGS 24K Quad Map
H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS
Panoche Drainage District:
Reference Area Recurvirostrid Nest Locations
File No. 1960-05
Date 6/5/06
Figure 5

Within species groups, a standard t-test was used to examine differences between means of project site and reference area egg-selenium and egg-boron concentrations. Selenium and boron concentration values were log-transformed (log base 10) to satisfy assumptions of normality. For Killdeer and recurvirostrids, multiple regression analyses were used to statistically examine relationships between egg-selenium levels, sites (project versus reference), and years (2002 to 2005 for Killdeer and 2003 to 2005 for recurvirostrids) using STATA (Stata Corp 1995). The analysis of recurvirostrid egg-selenium concentrations from 2003 to 2005 excluded eggs collected from a pasture that was accidentally flooded in 2003. Recurvirostrid eggs collected from this site in 2003 contained significantly higher egg selenium concentrations than recurvirostrid eggs collected from the remainder of the project site (H. T. Harvey & Associates 2005). Egg-selenium concentration was the dependent variable in this analyses. The selenium concentration values were log-transformed (log base 10) to satisfy assumptions of normality in the regression model (Skewness/Kurtosis Test for Normality of Residuals, $P > 0.05$). In the regression analysis, site and year were analyzed as continuous terms.

RESULTS

BIRD CENSUSES

In the Phase I area, 43 avian species were observed between April 22 and June 16, 2005 (Table 1). Avian numbers were highest in April and early May, when Cattle Egrets (*Bublucus ibis*) and migrating shorebirds such as Whimbrels (*Numenius phaeopus*) were present (Table 1). Red-winged Blackbird was the most numerous avian species observed on the project site. Seventeen species were either observed nesting, or were suspected of nesting on the site, based on observations of courtship behavior or young. Total bird numbers declined in late May and June as fewer migrants were detected.

EGG COLLECTION AND PROCESSING

Twenty-seven eggs, comprising 15 Killdeer and 12 recurvirostrid (all Black-necked Stilt) eggs were collected from the project site. Three of the Killdeer embryos were twelve or more days old and were alive and in normal condition. Another six Killdeer embryos were alive, but too young (three to nine days old) to determine their condition. The remaining six Killdeer embryos were less than three days old (Table 2). Eight of the recurvirostrid eggs contained a live, normal, greater than nine-day-old embryo. Three stilt embryos were too young (less than nine days old) to determine the embryo condition, though three were old enough (more than three days old) to determine that they were alive. The remaining stilt embryo was less than three days old (Table 3).

Thirty-two eggs, 15 Killdeer and 17 recurvirostrid (14 Black-necked Stilts and three American Avocets) were collected from the vicinity of the project site. Five of the Killdeer embryos from the reference area were more than nine days old, were alive and in normal condition. Another six Killdeer embryos were alive, but too young (three to nine days old) to determine their condition. The remaining four Killdeer embryos were less than three days old (Table 4). Six of the recurvirostrid eggs contained a live, more than nine-day-old embryo. Five stilt and avocet embryos were too young (fewer than nine days old) to determine the embryo condition, though three were old enough (greater than three days old) to determine that they were alive. The remaining six recurvirostrid embryos were less than three days old (Table 5).

Table 1. Avian census results at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

		2005					
	Species	April 22	May 02	May 13	May 23	June 06	June 16
	American Bittern		1	1			
	Great Blue Heron	3	1	2	2	3	2
	Great Egret	7	12	16	1	1	1
	Snowy Egret	8	21	37	2	2	3
	Cattle Egret	84	146	31	4	12	
	Black-crowned Night Heron	5	7	4		2	1
	White-faced Ibis	38	108	141	14		
*	Mallard	7	6	8	10	11	14
	Northern Pintail	5	2		1		
	Cinnamon Teal	2	2		4	1	
	Gadwall		2		6		
	Northern Harrier	2	2	1	2	3	1
	Swainson's Hawk	1	2	61	2	1	2
*	Red-tailed Hawk	3	4	5	6	6	3
	American Kestrel	2	2	1	2	2	2
*	Ring-necked Pheasant		1		13		
*	Killdeer	23	22	38	41	44	52
*	Black-necked Stilt	9	18	25	24	24	26
*	American Avocet	4	5	4	2	3	2
	Greater Yellowlegs	5	21	7			
	Whimbrel	346	279	162	31		
	Long-billed Curlew	5	46	4			
	Black Tern		1	1	4	5	3
*	Mourning Dove	5	14	7	8	4	5
*	Burrowing Owl	15	14	22	34	41	32
*	Western Kingbird	27	31	30	30	28	27
*	Loggerhead Shrike	4	6	5	6	4	5
	Common Raven	13	48	56	44	10	2
*	Horned Lark	17	24	13	7		3
	Tree Swallow	14	5	2			
	Northern Rough-winged Swallow	2		5			
	Barn Swallow	5	6	12	5	4	3
	Cliff Swallow	4	6	3	11		
	American Pipit	21	7				
	Savannah Sparrow	37	16	12	7		
*	Song Sparrow	19	20	20	24	26	28
*	Red-winged Blackbird	224	271	304	265	211	176
	Tricolored Blackbird	26	42	87			
*	Western Meadowlark	27	34	33	35	28	21
*	Brewer's Blackbird	27	34	35	24	22	20
*	Brown-headed Cowbird	13	19	17	16	7	6
*	House Finch	16	24	22	26	29	25
	House Sparrow	10	10	9	10	7	
	Total	**1085**	**1342**	**1243**	**723**	**541**	**465**
	* = Species for which evidence of nesting was observed this year.						

Table 2. Project site Killdeer concentrations at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

ID Number	Species	Date 2005	Embryo Condition [a]	Embryo Status[b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	Killdeer	May 2	U	U	<3	30.2	1.4800	
02	Killdeer	May 16	U	U	<3	12.0	1.0792	
03	Killdeer	May 16	L	U	6	32.2	1.5079	
04	Killdeer	May 16	L	U	3-6	28.2	1.4502	
05	Killdeer	June 4	U	U	<3	6.90	0.8388	
06	Killdeer	June 21	L	N	12	23.7	1.3747	
07	Killdeer	June 21	L	U	3-6	23.4	1.3692	
08	Killdeer	June 21	L	N	12	22.4	1.3502	
09	Killdeer	June 21	L	U	6	20.0	1.3010	
10	Killdeer	June 23	U	U	<3	10.1	1.0043	
11	Killdeer	June 23	L	N	20+	10.7	1.0294	
12	Killdeer	June 27	U	U	<3	9.66	0.9850	
13	Killdeer	June 27	L	U	6-9	15.4	1.1875	
14	Killdeer	June 29	U	U	<3	10.3	1.0128	
15	Killdeer	June 29	L	U	6-9	11.4	1.0569	
Arith/**Geo Mean**						17.8	1.2018	***15.9***
SD						8.4	0.2141	***1.6***
SE							0.0958	***1.2***
95% CI							1.0141	***10.3***
							1.3895	***24.5***

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

Table 3. Project site recurvirostrid egg-selenium concentrations at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

ID Number	Species	Date 2005	Embryo Condition [a]	Embryo Status[b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	Black-necked Stilt	May 31	L	N	19	26.1	1.4166	
02	Black-necked Stilt	June 14	L	N	20+	41.5	1.6180	
03	Black-necked Stilt	June 14	U	U	<3	23.9	1.3784	
04	Black-necked Stilt	June 14	L	U	3-6	40.4	1.6064	
05	Black-necked Stilt	June 14	L	U	3-6	34.9	1.5428	
06	Black-necked Stilt	June 14	L	N	20+	45.4	1.6571	
07	Black-necked Stilt	June 14	L	N	20+	44.3	1.6464	
08	Black-necked Stilt	June 14	L	U	<3	22.6	1.3541	
09	Black-necked Stilt	June 14	L	N	19	40.9	1.6117	
10	Black-necked Stilt	June 14	L	N	20+	31.7	1.5011	
11	Black-necked Stilt	June 14	L	N	20+	38.6	1.5866	
12	Black-necked Stilt	June 14	L	N	17-18	45.7	1.6599	
Arith/**Geo Mean**						36.3	1.5483	***35.3***
SD						8.4	0.1103	***1.3***
SE							0.0493	***1.1***
95% CI							1.4516	***28.3***
							1.6449	***44.2***

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

Table 4. Reference area Killdeer egg-selenium concentrations at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

ID Number	Species	Date 2005	Embryo Condition [a]	Embryo Status [b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	Killdeer	April 22	U	U	<3	3.19	0.5038	
02	Killdeer	April 22	L	U	3-6	4.31	0.6345	
03	Killdeer	May 2	U	U	<3	7.76	0.8899	
04	Killdeer	May 13	L	N	12-15	7.31	0.8639	
05	Killdeer	May 13	L	U	6-9	7.62	0.8820	
06	Killdeer	May 13	L	U	6	6.10	0.7853	
07	Killdeer	May 16	U	U	<3	4.74	0.6758	
08	Killdeer	May 19	L	U	3-6	6.25	0.7959	
09	Killdeer	May 19	L	N	9	6.17	0.7903	
10	Killdeer	May 31	L	N	9	3.20	0.5051	
11	Killdeer	May 31	U	U	<3	6.16	0.7896	
12	Killdeer	June 6	L	U	3-6	6.26	0.7966	
13	Killdeer	June 6	L	N	9	5.50	0.7404	
14	Killdeer	June 6	L	U	3-6	4.08	0.6107	
15	Killdeer	June 9	L	N	19	6.75	0.8293	
Arith/**Geo Mean**						5.7	0.7395	***5.5***
SD						1.5	0.1260	***1.3***
SE							0.0563	***1.1***
95% CI							0.6291	***4.3***
							0.8500	***7.1***

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

Table 5. Reference area Recurvirostrid egg-selenium concentrations at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

ID Number	Species	Date 2005	Embryo Condition [a]	Embryo Status[b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	Black-necked Stilt	May 5	U	U	<3	14.3	1.1553	
02	Black-necked Stilt	May 13	L	N	17+	14.4	1.1584	
03	Black-necked Stilt	May 13	L	U	6	9.85	0.9934	
04	Black-necked Stilt	May 13	L	N	9	32.7	1.5145	
05	Black-necked Stilt	May 16	L	U	6	7.62	0.8820	
06	Black-necked Stilt	May 31	U	U	<3	14.7	1.1673	
07	American Avocet	May 31	L	U	3-6	21.2	1.3263	
08	Black-necked Stilt	June 6	L	U	6	17.6	1.2455	
09	Black-necked Stilt	June 6	L	N	9	19.9	1.2989	
10	Black-necked Stilt	June 6	L	N	17	16.6	1.2201	
11	Black-necked Stilt	June 6	U	U	<3	6.94	0.8414	
12	Black-necked Stilt	June 6	U	U	<3	11.6	1.0645	
13	Black-necked Stilt	June 9	U	U	Infertile	6.16	0.7896	
14	American Avocet	June 9	U	U	<3	8.05	0.9058	
15	American Avocet	June 14	L	U	3-6	5.89	0.7701	
16	Black-necked Stilt	June 16	L	N	10-12	16.6	1.2201	
17	Black-necked Stilt	June 16	L	N	17	11.6	1.0645	
Arith/**Geo Mean**						13.9	1.0952	***12.4***
SD						6.8	0.2083	***1.6***
SE							0.0932	***1.2***
95% CI							0.9125	***8.2***
							1.2778	***19.0***

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

EGG CHEMISTRY ANALYSIS

Egg-Selenium Data Analysis Between Sites

Egg-selenium concentrations were significantly higher in eggs collected from the project site relative to eggs collected from the reference area in 2005 for both Killdeer (t-test, $t = 7.38$, $P < 0.0001$, Table 6) and recurvirostrids (t-test, $t = 6.627$, $P < 0.0001$, Table 6).

Table 6. Geometric mean egg-selenium concentrations from Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

Selenium			
Species **Location**	**n**	**Geo. Mean** **ppm se (dry wt)**	**Range**
Killdeer			
Project Site	15	15.9	6.90-32.2
Off-site Reference Samples	15	5.5	3.19-7.76
Significance difference ($t = 7.3764$, $P < 0.0001$) between sites.			
Recurvirostrids			
Project Site	12	35.3	22.6-45.7
Off-site Reference Samples	17	12.4	5.89-32.7
Significance difference ($t = 6.6239$, $P < 0.0001$) between sites.			

Egg-Selenium Data Analysis Across Years

Egg-selenium levels were significantly higher at the Project site than at the Reference site, and were higher among recurvirostrids than killdeer. Selenium levels differed significantly among years due to a significantly higher level in 2005 compared to 2004 (Sidak test, $P < 0.05$, Appendix A).

However, there was a significant interaction between bird species and study site (Table 7), indicating that the relation between egg-selenium concentration and bird species differed between study sites. Specifically, the interaction reflected a greater difference in selenium concentration between killdeer and recurvirostrids at the project site compared to the reference site (Appendix A). There also was a significant interaction between year and study site (Table 7), indicating that the relation between egg-selenium concentration and year differed between study sites. This interaction reflected a much greater difference in selenium values compared between sites in 2005 than in 2002 through 2004 (Appendix A), due to the large increase in selenium concentration at the project site in 2005. The interaction between species and year was insignificant (Table 7), indicating that significantly higher egg-selenium levels in 2005 compared to 2004 was a consistent pattern in both killdeer and recurvirostrids.

Table 7. Multiple regression analysis to examine selenium levels (log-base 10) as related to study site (Project vs. Reference), year (2002 through 2005), and species (Killdeer vs. Recurves).

Term	Coefficient	*F*-value	*P*-value	df
Model: $F_{[5,65]}$ = 23.83, 64.7% of variance explained.				
Main effects:				
Site	(-)	104.03	<0.0001	1
Year	ns*	5.67	<0.001	3
Species	(+)	79.89	<0.0001	1
Interaction:				
Species * Year	ns*	3.19	0.6	3
Year * Site	----	2.97	<0.025	3
Site * Species	----	18.89	<0.0001	2
* ns = not significant				
The interaction between "year" and "site" was tested after the main effects for the two respective variables had been tested.				

Egg-Boron Analysis

Boron concentrations were significantly higher in Killdeer eggs collected from the project site than Killdeer eggs collected from the reference area (t-test, t = 2.633, P < 0.014, Table 8). There was no significant difference in recurvirostrid eggs collected from the two sites (t-test, t = 1.182, P = 0.248, Table 8). The raw boron data are presented in Appendices B and C.

Table 8. Geometric mean egg-boron concentrations from Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

Boron			
Species **Location**	**n**	**Geo. Mean** **ppm B (dry wt)**	**Range**
Killdeer			
Project Site	15	4.0	1.69-25.7
Off-site Reference Samples	15	1.9	0.631-8.27
Significance difference (t =2.3325, P <0.0351) between sites.			
Recurvirostrids			
Project Site	12	5.9	1.10-14.4
Off-site Reference Samples	17	3.1	0.576--23.2
No significant difference (t =1.1589, P = 0.248) between sites.			

QUALITY ASSURANCE/QUALITY CONTROL ANALYSIS

The selenium recovery rate for seven egg samples spiked with 0.08 ug of selenium ranged between 87 percent and 119 percent with a mean selenium recovery rate of 107 percent (Appendix D). Additionally, an average value of 0.709 ug/g Se was obtained on NIST Standard Reference Material 1577b (certified value = 0.73 $\pm$ 0.06 ug/g). An average value of 0.389 ug/g Se was obtained on an in house selenate standard (value = 0.400 ug/g Se). The standard deviation of duplicate egg samples ranged between 0.0000 and 0.6573 with a mean standard deviation of 0.1134 (Appendix E).

The standard deviation of boron results from 31 duplicate egg samples ranged between 0.0141 and 0.7637, and the mean standard deviation was 0.1196 (Appendix F).

DISCUSSION

MONITORING RESULTS

The census data indicate that the project site is utilized by bird species common in San Joaquin Valley agricultural habitats. Both species diversity and relative abundance are lower than expected in native, undisturbed habitats. The tall vegetation within several pastures provided nesting habitat for Red-winged Blackbirds. Irrigation of pastures and alfalfa provide temporary foraging opportunities for birds such as White-faced Ibis (*Plegadis chihi*), Whimbrels, and blackbirds.

Swainson's Hawks (*Buteo swainsoni*), which are listed as threatened by the state of California, were observed foraging on the project site. In 2005, as in each year since 2002, one pair of Swainson's Hawks successfully nested just north of the project site. Three species listed as "species of concern" by the state of California, the Burrowing Owl (*Athene cunicularia*), the Loggerhead Shrike (*Lanius ludovicianus*), and the California Horned Lark (*Eremophila alpestris actia*) were observed nesting on the project site. The White-faced Ibis, another "species of concern" was observed foraging, but not nesting, on the project site.

Eggs are the best biotic indicator for selenium transfer and toxic biological effects to avian species (Skorupa and Ohlendorf 1991, Ohlendorf *et al.* 1993). Less than 3-ppm (dry wt) egg-selenium is the accepted population (or *geometric mean*) background level for birds (Skorupa and Ohlendorf 1991, CH2M-Hill *et al.* 1993, Maier and Knight 1994). Eight ppm (dry wt) egg-selenium is considered the threshold level at which the probability of impaired hatchability increases in a population (Skorupa and Ohlendorf 1991, CH2M-Hill *et al.* 1993, Maier and Knight 1994). Eight-ppm selenium is the approximate lower boundary for mean egg-selenium levels associated with population-level impaired hatchability for stilts and avocets in the Tulare Lake Basin (Skorupa and Ohlendorf 1991). Ten ppm (dry wt) selenium is the lower boundary for impaired embryo viability associated with an individual egg (Skorupa and Ohlendorf 1991). The threshold for mean egg-selenium associated with increased teratogenic effects in bird populations ranges from 13 to 24 ppm (Skorupa and Ohlendorf 1991, CH2M-Hill *et al.* 1993). The Cumulative Impact Report on impacts of agricultural evaporation basins in the southern San Joaquin Valley (CH2M-Hill *et al.* 1993) used the midpoint of 18-ppm selenium as the teratogenic threshold. Ohlendorf *et al.* (1993) reported that mean egg-selenium concentrations greater than 20 ppm were associated with increased reproductive impairment within a given population.

Based on additional data collected in 1993, the embryo-toxicity threshold for Black-necked Stilts is between 6 and 7-ppm selenium (Skorupa 1998). Because stilt embryos have been shown to be more sensitive than avocets to *in ovo* selenium exposure (Skorupa 1998), it is assumed safe to apply this threshold to recurvirostrids as a whole. In addition, based on updated recurvirostrid egg-selenium data, the USFWS has proposed increasing the performance standard for mitigation sites to a maximum geometric mean of 4.0-ppm selenium (J. Skorupa, pers. comm.).

More recently, additional papers on selenium toxicity thresholds have been published. A recent analysis of laboratory data for Mallards (CH2M-Hill 2000) suggests that there is a 10 percent depression in egg hatchability at 8.4-ppm egg-selenium concentration. Fairbrother *et al.* (1999) and Adams *et al.* (2005) have proposed alternative selenium toxicity thresholds for birds. Adams *et al.* (2005) argue that about 12 to 15 ppm selenium in Mallard eggs is required to create a 10 percent depression in egg hatchability, based on a review of lab studies. The authors also argue that, based on their analysis of USFWS field data on stilts, a 10 percent depression in egg hatchability does not occur until a 21 to 31 ppm selenium threshold is reached. The above authors calculated threshold findings based on locating the EC 10 (*i.e.*, the concentration level at which 10 percent of the population is effected) level, whereas, Skorupa (1998) calculated the 6 to 7 ppm threshold by locating the EC 3 level.

Four reference-site recurvirostrid eggs contained selenium concentrations within the range (3 to 7.9 ppm) associated with an increased probability of effects on avian reproduction. Ten of the recurvirostrid eggs from the reference area contained eggs with selenium concentrations within the range (8 to 18 ppm dry wt) associated with an increased probability of reduced hatchability within a population (CH2M-Hill *et al.* 1993). The remaining three reference area recurvirostrid eggs and all of the recurvirostrid eggs from the project site were in the range (>18 ppm) associated with a high probability of population-level reproductive effects, including reduced hatchability and increased occurrence of embryo deformities (teratogenesis) (CH2M-Hill *et al.* 1993).

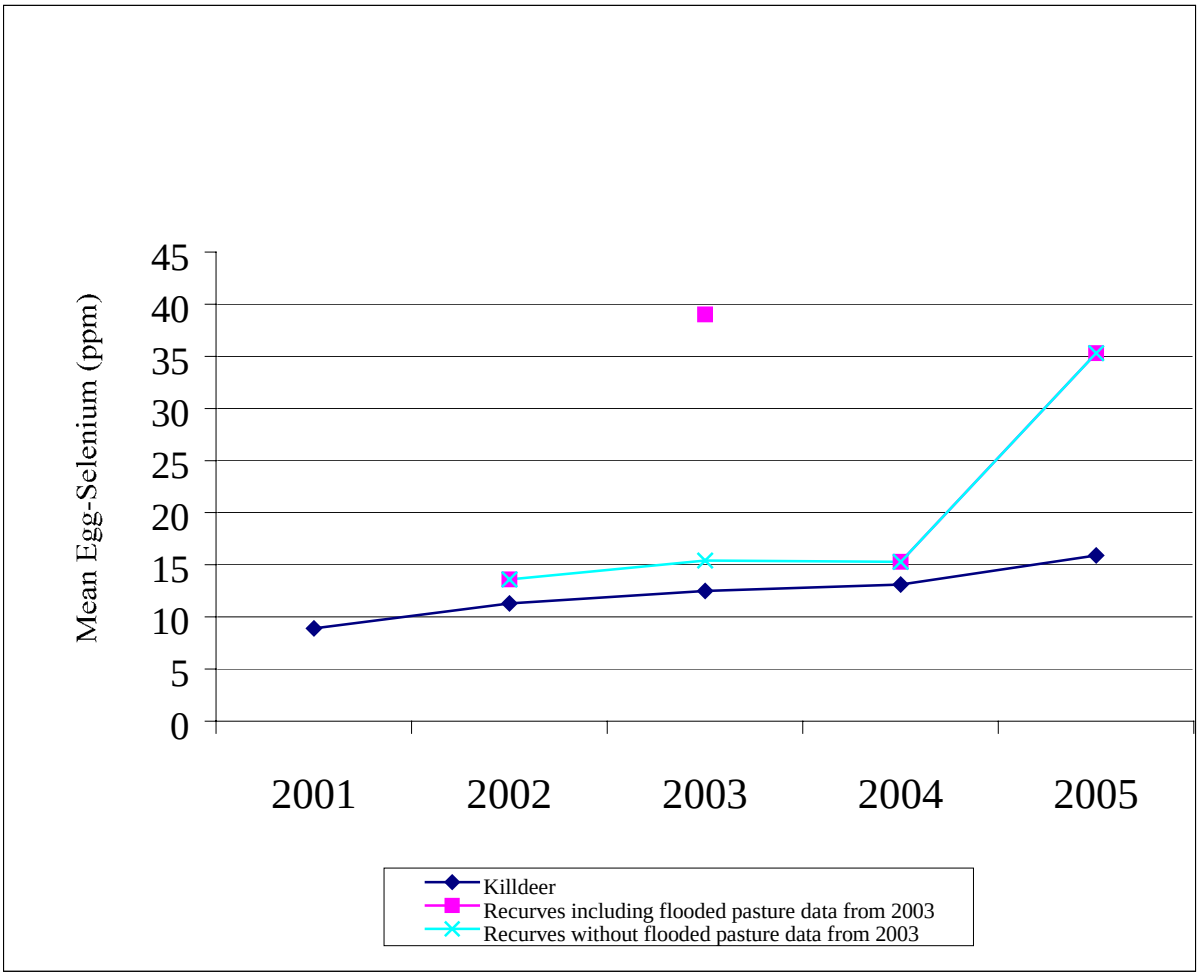
There were four Killdeer eggs from the reference area and one egg from the project site that were below the background standard of 3 ppm (CH2M-Hill *et al.* 1993). All fifteen reference area Killdeer eggs and one project site Killdeer egg contained selenium concentrations within the range (3 to 7.9 ppm) associated with an increased probability of effects on avian reproduction (CH2M-Hill *et al.* 1993). Seven Killdeer eggs from the project site contained selenium concentrations within the range (8 to 18 ppm dry wt) associated with an increased probability of reduced hatchability within a population. The remaining seven Killdeer eggs from the project site were in the range (>18 ppm) associated with a high probability of reproductive effects, including reduced hatchability and increased occurrence of embryo deformities (teratogenesis) in a population.

The project-site Killdeer eggs collected in 2005 contained significantly higher selenium concentrations than project-site Killdeer egg collected in previous years. Killdeer eggs did not differ significantly in selenium concentration between years from 2002 to 2004. Reference-area Killdeer eggs have not differed significantly in selenium concentration between years from 2002 to 2005. Project site Killdeer eggs have had significantly higher egg-selenium concentrations than reference area Killdeer eggs in each of those years and when the years are considered together.

Project-site recurvirostrid eggs collected in 2005 contained significantly higher selenium concentrations than recurvirostrid eggs collected from the project site in 2002 and 2004 as well as reference area recurvirostrid eggs from 2002 to 2005. Recurvirostrid eggs did not differ significantly in selenium concentration between 2002 and 2004 for eggs collected from either the project site or reference area when the eggs collected from the accidentally flooded pasture in

2003 are not included. The mean project-site egg-selenium concentrations for both Killdeer and recurvirostrids from 2001 to 2005 are illustrated in Figure 6.

Figure 6. Project site mean egg-selenium results at Panoche Drainage District's San Joaquin River Water Quality Improvement Project 2001 to 2005.



It has been suggested that boron impacts wildlife at the evaporation basins in the San Joaquin Valley (Ohlendorf *et al.* 1993). Boron has only one oxidation state (+3), with boric acid being the primary form in evaporation basins, but may convert to borax as evaporation concentrates the salts (Tanji and Grismer 1989). Boron bioconcentrates in aquatic organisms (plants and invertebrates), but evidence is lacking that biomagnification occurs in aquatic ecosystems (Maier and Knight 1991). Most sets of avian eggs from evaporation basins average less than 5-ppm boron (Ohlendorf *et al.* 1993). Current information indicates that slightly elevated boron in eggs does not cause embryo toxicity (Ohlendorf *et al.* 1993).

Egg-boron concentrations in Killdeer eggs from the project site were higher than in reference-area Killdeer. The boron analysis of the Killdeer eggs collected from the project site (mean = 4.0 ppm, range = 1.69-25.7 ppm), the project-site recurvirostrid eggs (mean = 5.9 ppm, range = 1.1-

14.4 ppm), and the reference-area recurvirostrid eggs (mean = 3.1 ppm, range = 0.58-23.2 ppm) indicated that the egg-boron concentrations in the species groups were slightly above the 3-ppm dry weight background level. The presence of elevated boron-egg content indicates that eggs collected from the project site should continue to be monitored for boron.

The elevated selenium levels in reference recurvirostrid and Killdeer eggs, collected in the vicinity of the project site indicate that pathways to selenium exposure may exist outside of the immediate project site. Especially when considering the background levels in true control Killdeer eggs, which were collected elsewhere in the San Joaquin Valley. Thus, selenium contamination at this site may be complex in relation to the agricultural drainwater basin systems.

IMPACTS AND PROPOSED MITIGATION

The Negative Declaration for SJRIP adopted in September 2000 included provisions for wildlife monitoring capable of assessing project related impacts to wildlife. Provisions were also included for appropriate mitigation measures to be adopted if the monitoring program detected project related negative impacts.

Based on waterborne and egg-selenium levels at the existing project site, lethal and sublethal effects on waterbirds breeding at the proposed project site are probable. Water samples from the sources of drainwater used to irrigate the existing project site ranged from 43 to 761-ppb selenium from 2003 to 2005 (Panoche Drainage District data). Such levels are well above the level of waterborne selenium (32-ppb) associated with a high probability of reduced hatchability and increased probability of teratogenesis (CH2M-Hill *et al*. 1993). Egg-selenium monitoring at the existing project site has found elevated egg-selenium levels in both recurvirostrids and Killdeer (H. T. Harvey & Associates 2002, 2003, 2004, and 2005). Egg-selenium levels in both groups have been higher than in similar sets of reference eggs collected from the project vicinity. Annual geometric mean, egg-selenium levels from recurvirostrid eggs have varied, but from 2003 to 2005, most means were also above the level (18-ppm) associated with an increased probability of reduced hatchability and teratogenesis. The repeated and prolonged exposure of breeding shorebirds in this region to selenium resulting in lethal and sublethal effects constitute a significant impact. The following mitigation measures are proposed to offset negative impacts to breeding waterbirds detected by the monitoring program.

Mitigation 1: Reduce exposure potential by reducing attractiveness of irrigation ditches for nesting

The majority of shorebird nesting on the existing project site consists of Killdeer and recurvirostrids nesting within, or adjacent to, the irrigation ditches that deliver drainwater to the site. Adults associated with nests near irrigation ditches feed primarily in these ditches, though this is more typical of recurvirostrids than Killdeer. Reducing the attractiveness of the ditches and their immediate surroundings will reduce the level of shorebird exposure to selenium by reducing nesting proximal to selenium-laden foraging habitat.

Actions that will reduce nesting attractiveness in and near irrigation ditches include removing sediment that has collected on the bottom of irrigation ditches and maintaining smooth sides and borders along irrigation ditches. Removing sediment that has collected on the bottom of irrigation ditches will remove potential nest substrate when water levels are low. Killdeer and recurvirostrid often use rough surfaces such as disked areas to conceal nests. Smoothing ditch banks and borders, and removing weedy vegetation will reduce the attractiveness of the area for nesting.

Mitigation 2: Reduce exposure potential by hazing birds from nesting near, and foraging in, irrigation ditches

Shorebird use of the existing project site is not homogenous (H. T. Harvey & Associates 2004 and 2005). As noted above, shorebird nests at the existing project site are concentrated in the vicinity of irrigation ditches. Additionally, stilts and avocets are semi-colonial, often nesting in close vicinity to each other. Hazing desirable shorebird habitat, as identified during monitoring, will reduce exposure by reducing the number of nesting birds. Methods of hazing could include firing noise making devices such as cracker shells, 15-mm bird bombs, and bird whistlers from a vehicle to discourage breeding birds from establishing nest sites. In addition, propane operated cannons can be left operating on 24-hour basis, if required. Cannon locations should be changed periodically to lessen acclimation.

Mitigation 3: Flooded field contingency plan

In the spring of 2003, a pasture at the existing project site attracted waterfowl when it was inadvertently flooded. This flooded area created ideal ecological conditions for shorebird foraging and nesting and thus, a number of pairs responded opportunistically and bred in the field. Recurvirostrid eggs collected near the pasture had highly elevated selenium concentrations compared to other recurvirostrid eggs collected elsewhere on the site. The Panoche Drainage District has since developed a contingency plan for accidental flooding. This plan is presented in Appendix G. The plan includes provisions for immediate removal of unintended drainwater as well as for increased monitoring near flooded sites.

Mitigation 4: Provide compensation breeding habitat

If after employing Mitigation Measures 1, 2, and 3, monitoring determines nesting shorebirds are exposed to elevated selenium levels as a result of the proposed project, compensation habitat for residual impacts should be provided.

Compensation Habitat Protocol

In 1995, the USFWS formulated "compensation habitat protocols" for avian impacts from agricultural drainwater evaporation basins with elevated levels of waterborne selenium. The motivation for the protocol was to develop a risk-based approach to compensation for impacts that increase accuracy, minimize monitoring costs, and provide incentive to minimize contaminant risk. The foundation of this approach was the observation that both nonlethal and lethal impacts result from avian exposure to elevated levels of selenium and that impacts could not be determined by mortality counts alone. Therefore, the USFWS provided a risk-based

approach that relies on egg-selenium levels as an easily verified measure of avian exposure to selenium and associated impacts.

In addition to the compensation habitat protocol, the USFWS produced "alternative habitat protocols". The alternative habitat protocol was formulated to dilute, but not eliminate, avian exposure to contaminants at evaporation basins by providing alternative, fresh-water wetlands close to evaporation basins. The In-Valley Treatment /Drainage Reuse project does not include drainwater evaporation basins and, therefore, does not create a situation in which birds would be discouraged from using evaporation basins (via reconfiguration and hazing) in favor of using clean alternative wetland habitats in the functional landscape of the basins. Rather, shorebirds (primarily recurvirostrids and Killdeer) are likely exposed to elevated levels of selenium while foraging in drainwater conveyance canals and irrigated fields and pastures, which are ephemeral in distribution and extent. Thus, a modified form of the USFWS's compensation habitat protocol is appropriate (as opposed to the alternative habitat protocol) as a mitigation approach to selenium induced impacts at the In-Valley Treatment /Drainage Reuse project. The compensation habitat protocol, as well as the modifications to render it suitable for the In-Valley Treatment /Drainage Reuse project, are presented below.

As mentioned above, the compensation habitat protocol is based on measures of selenium concentrations in the eggs of recurvirostrids and the number of nesting recurvirostrids exposed to elevated levels of selenium at a particular location. Egg levels of selenium represent an accurate and repeatable measure of risk exposure in these birds (*e.g*., Ohlendorf *et al*. 1993). A premise of this risk-based approach is that habitats that expose more birds to elevated selenium or to higher concentrations of selenium require relatively more compensation than habitats with lower selenium concentrations or lower numbers of birds.

The USFWS presented two compensation habitat protocols, an "eggwise" basis and a "henwise" basis. The USFWS concluded that the henwise protocol is statically "cleaner" and utilizes more detailed exposure-response data actually collected from studies of recurvirostrids nesting at evaporation basins. Thus, the henwise approach is employed here. It is modified slightly to render it suitable for the In-Valley Treatment /Drainage Reuse project situation as opposed to an evaporation basin. The formula for calculating compensation (mitigation) habitat is:

Compensation Habitat = CC x NN

Where,

CC = HU x [(F1 x L1) + (F2 x L2) +(F3 x L3) +(F4 x L4) +(F5 x L5)]

Where,

CC = compensation coefficient, the multiple of a site's breeding waterbird population that, on average, would be required in predominately shallow wetland acreage to replace lost production

F1 = the proportion of randomly sampled eggs containing 0 to 5 ppm selenium,

F2 = the proportion of randomly sampled eggs containing 5.1 to 20 ppm selenium

F3 = the proportion of randomly sampled eggs containing 21 to 40 ppm selenium

F4 = the proportion of randomly sampled eggs containing 41 to 70 ppm selenium

F5 = the proportion of randomly sampled eggs containing over 70 ppm selenium

L1 = the proportion of production lost when egg selenium is from 0 to 5 ppm selenium (L1 = 0.0 from premise HP3 in Appendix H)

L2 = the proportion of production lost when egg selenium is from 5.1 to 20 ppm selenium (L2 = 0.1889 from premise HP3 in Appendix H)

L3 = the proportion of production lost when egg selenium is from 21 to 40 ppm selenium (L3 = 0.2551 from premise HP3 in Appendix H)

L4 = the proportion of production lost when egg selenium is from 41 to 70 ppm selenium (L4 = 0.5083 from premise HP3 in Appendix H)

L5 = the proportion of production lost when egg selenium is from over 70 ppm selenium (L5 = 0.9261 from premise HP3 in Appendix H)

HU = the relative habitat quality for the project site (HU = 1)

Habitat utility (HU) in this equation has been modified from the USFWS's model (see premises GP-7 and GP-8 in Appendix H). The USFWS model was developed for evaporation basins in the Tulare Lake Basin and assumes that shallow compensation habitat with islands will exhibit about 2.5 times the habitat utility of evaporation basins without islands. This estimation was based on observations based on the performance of a mitigation site under optimal circumstances in the Tulare Lake Basin where population densities of recurvirostrids are much higher than in the In-Valley Treatment /Drainage Reuse project vicinity (Shuford *et al*. 1998)

"NN", or number of nests, replaces "EH", the evaporation basin surface area in the original protocol calculation. In the original protocol, EH is used as a measure of degree of exposure with larger basins providing more habitat for more birds than relatively smaller basins. There are no basins in the In-Valley Treatment /Drainage Reuse project system. Therefore, actual number of nests (NN) is used as a direct measure of the number of birds potentially exposed to drainwater in the system. Values are derived from monitoring data and plugged into the equation to calculate compensation habitat acreage requirements.

At the In-Valley Treatment /Drainage Reuse project site, the primary species exposed to elevated levels of selenium are recurvirostrids (American Avocet and the Black-necked Stilt) and Killdeer. Killdeer eggs contain significantly less selenium than recurvirostrid eggs at the existing project site (H. T. Harvey & Associates 2002, 2003, 2004, and 2005). Thus, if Killdeer egg-selenium levels are combined with the recurvirostrid levels, the Killdeer results dilute the

derived impacts estimates for avocets and stilts. Therefore, compensation acreage for Killdeer will be calculated separately from stilts and avocets. Compensation habitat acreages for the two groups will then be combined to determine the total amount of compensation habitat to be provided.

Using this modified compensation habitat protocol with recurvirostrid egg selenium results from 2003 to 2005 (Table 9) and using an estimated number of 100 recurvirostrid nests during that time, F1 was zero, F2 was 0.286, F3 was 0.326, F4 was 0.286, and F5 was 0.102, and the compensation coefficient (cc) was 0.377 (Table 10). The resulting compensation habitat calculation is 38 acres (Table 10). Adding Killdeer egg selenium results from 2003 to 2005 (Table 9) and using an estimated number of 60 recurvirostrid nests during that time, F1 was 0.04, F2 was 0.76, F3 was 0.2, and F4 and F5 were zero, and the compensation coefficient (cc) was 0.195 (Table 10). The resulting compensation habitat calculation is 12 acres (Table 10). The resulting requirement for mitigating for both recurvirostrids and Killdeer would be 50 acres of compensation habitat.

A number of evaporation basin operators have adopted the USFWS protocol approach, or a similar approach, for determining mitigation habitat acreages. In some cases, following the protocol is included in the operators' Regional Water Quality Control Board waste discharge requirements. This approach involves an iterative monitoring/mitigation adjustment process in which the amount of compensation habitat provided is based on three years of monitoring. That amount of compensation habitat is then provided for the following three years. After three more years of monitoring, the compensation habitat is then adjusted based the monitoring results for those three years and so forth. This iterative process rewards operators for reducing or eliminating impacts by reducing subsequent mitigation requirements. Likewise, if increased numbers of birds are impacted, mitigation requirements increase accordingly. This approach is recommended for the In-Valley Treatment /Drainage Reuse project.

Table 9. Egg results from 2003 to 2005 at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

Recurvirostrids ppm Se			Killdeer ppm Se		
2003	**2004**	**2005**	**2003**	**2004**	**2005**
9.8	5.65	22.6	5.8	2.79	6.90
10.1	7.53	23.9	7.4	4.29	9.66
11	7.75	26.1	8.2	7.54	10.1
14.3	8.59	31.7	8.5	7.98	10.3
26.5	9.36	34.9	9.4	9.98	10.7
32.3	10.1	38.6	9.7	11.0	11.4
32.8	11.2	40.4	10.3	13.9	12.0
38.9	11.3	40.9	10.4	14.3	15.4
40.9	14.1	41.5	10.8	17.1	20.0
50	15.2	44.3	13.1	17.6	22.4
50.3	21.9	45.4	13.8	18.2	23.4
50.5	23.4	45.7	14.1	18.7	23.7
58.7	25.8		14.1	30.6	28.2
63.8	26.9		14.6	31.3	30.2
64.8	27.5		15.4	39.2	32.2
71.8	39.5		16.9		
74	48.7		18.2		
74.9			18.3		
80.2			18.6		
98.9			33.5		

Table 10. Recurvirostrid compensation habitat F1, F2, CC, and NN values.

	Proportion of egg-selenium (ppm) within				
	0.0 to 5.0	5.1 to 20	21 to 40	41 to 70	> 71
	F1	F2	F3	F4	F5
N = 10	0	0.286	0.326	0.286	0.102

Compensation Wetland Estimate

F1	L1	F1 x L1	F2	L2	F2 x L2	F3	L3	F3 x L3	F4	L4	F4 x L4	F5	L5	F5 x L5	Sum	HU	CC	NN	Comp Acres
0	0	0	0.286	0.1889	0.0540	0.326	0.2551	0.0832	0.286	0.5083	0.1454	0.102	0.9261	0.0945	0.3770	1	0.377	100	***38***

Table 11. Killdeer compensation habitat F1, F2, CC, and NN values.

	Proportion of egg-selenium (ppm) within				
	0.0 to 5.0	5.1 to 20	21 to 40	41 to 70	> 71
	F1	F2	F3	F4	F5
N = 50	0.04	0.760	0.2	0	0

Compensation Wetland Estimate

F1	L1	F1 x L1	F2	L2	F2 x L2	F3	L3	F3 x L3	F4	L4	F4 x L4	F5	L5	F5 x L5	Sum	HU	CC	NN	Comp Acres
0.04	0	0	0.76	0.1889	0.1436	0.2	0.2551	0.0510	0.0	0.5083	0.0000	0.0	0.9261	0.0000	0.1946	1	0.195	60	***12***

Biological monitoring will be required to determine the level of impacts and appropriate mitigation. This monitoring will need to include both:

1. Egg sampling for selenium analysis sufficient to determine the compensation coefficient (from the above equation) for both recurvirostrids and Killdeer, and
2. A census effort sufficient to determine the number of nests for both recurvirostrids and Killdeer.

Biological monitoring has been conducted at the existing project site since 2001. The existing monitoring design should be modified to meet the above criteria.

Panoche Drainage District proposes to provide 50 acres of compensation habitat designed to maximize use by nesting water birds, specifically Black-necked Stilts and American Avocets. A combination of shallow water foraging areas four to eight inches deep and large nesting islands, which are key features for recurvirostrid nesting habitat, will be provided. Shallow water depths may be maintained with the use of contour dikes similar to those used in rice farming.

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APPENDIX A. DATA FOR EGG-SELENIUM ANALYSIS ACROSS YEARS AND SITES.

Species Location	n	Geo Mean (ppm Se)	Mean Se (log transformed)	Standard Deviation
Killdeer				
2002	10	8.4	0.9229	± 0.2518
2003	31	8.4	0.9228	+ 0.2994
2004	30	6.7	0.8283	± 0.3713
2005	30	9.3	0.9707	± 0.2917
Project Site	55	12.8	1.1088	± 0.2295
Reference Site	46	4.5	0.6507	± 0.1603
Recurvirostrids				
2003	16	16.5	1.2179	± 0.2170
2004	34	12.8	1.1088	± 0.3197
2005	29	19.2	1.2826	± 0.2849
Project Site	23	20.4	1.3097	± 0.2782
Reference Site	27	12.7	1.1032	± 0.2799

APPENDIX B. 2005 KILLDEER EGG-BORON CONCENTRATIONS AT PANOCHE DRAINAGE DISTRICT'S SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT.

Project Site				Reference Area			
ID Number	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**	**ID Number**	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**
01	6.76	0.8299		01	5.95	0.7745	
02	2.93	0.4669		02	8.27	0.9175	
03	1.69	0.2279		03	3.13	0.4955	
04	1.80	0.2553		04	6.63	0.8215	
05	6.22	0.7938		05	3.24	0.5105	
06	6.82	0.8338		06	0.983	-0.0074	
07	2.61	0.4166		07	1.95	0.2900	
08	5.78	0.7619		08	1.27	0.1038	
09	2.50	0.3979		09	0.631	-0.2000	
10	7.17	0.8555		10	1.25	0.0969	
11	25.7	1.4099		11	0.820	-0.0862	
12	2.87	0.4579		12	1.76	0.2455	
13	3.12	0.4942		13	0.688	-0.1624	
14	2.77	0.4425		14	1.84	0.2648	
15	2.21	0.3444		15	1.21	0.0828	
Arith/**Geo Mean**	5.40	0.5992	***4.0***	Arith/**Geo Mean**	2.64	0.2765	***1.9***
SD	6.0	0.3121	***2.1***	SD	2.4	0.3577	***2.3***
SE		0.1396	***1.4***	SE		0.1600	***1.4***
95% CI		0.3257	***2.1***	95% CI		-0.0370	***0.9***
		0.8728	***7.5***			0.5900	***3.9***

APPENDIX C. 2005 RECURVIROSTRID EGG-BORON CONCENTRATIONS AT PANOCHE DRAINAGE DISTRICT'S SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT.

Project Site				Reference Area			
ID Number	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**	**ID Number**	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**
01	3.47	0.5403		01	2.63	0.4200	
02	13.5	1.1303		02	23.0	1.3617	
03	1.80	0.2553		03	4.96	0.6955	
04	1.10	0.0414		04	19.8	1.2967	
05	5.60	0.7482		05	2.57	0.4099	
06	12.5	1.0969		06	3.12	0.4942	
07	10.4	1.0170		07	0.576	-0.2396	
08	4.01	0.6031		08	2.07	0.3160	
09	5.03	0.7016		09	1.20	0.0792	
10	6.78	0.8312		10	1.29	0.1106	
11	14.3	1.1553		11	1.64	0.2148	
12	14.4	1.1584		12	23.2	1.3655	
13				13	9.31	0.9689	
14				14	10.3	1.0128	
15				15	2.35	0.3711	
16				16	4.07	0.6096	
17				17	3.38	0.5289	
Arith/**Geo Mean**	7.74	0.7733	***5.9***	Arith/**Geo Mean**	6.79	0.5892	***3.9***
SD	5.00	0.3671	***2.3***	SD	7.74	0.4709	***3.0***
SE		0.1642	***1.5***	SE		0.2106	***1.6***
95% CI		0.4515	***2.8***	95% CI		0.1765	***1.5***
		1.0950	***12.4***			1.0019	***10.0***

APPENDIX D. SELENIUM ANALYSIS QUALITY ASSURANCE/QUALITY CONTROL RESULTS

Selenium Control Spikes.

ID Number	Tissue	Spiked Selenium (ug)	% Recovery
PD-P-K-04	egg	0.08	100
PD-R-K-04	egg	0.08	101
PD-R-K-13	egg	0.08	119
PD-P-R-04	egg	0.08	110
PD-P-R-04	egg	0.08	87
PD-P-R-11	egg	0.08	117
PD-R-Rc-08	egg	0.08	112
		Mean	106.6
		Standard deviation	11.3

Additionally, an average value of 0.709 ug/g Se was obtained on NIST Standard

Reference Material 1577b (certified value = 0.73 $\pm$ 0.06 ug/g).

An average value of 0.389 ug/g was obtained on an in-house selenate Standard (value + 0.400 ug/g Se)

APPENDIX E. SELENIUM QA/QC SUMMARY, 2005.

Duplicates. (SD = Standard Deviation)

ID Number	*Replication*	*Result Selenium*	*ID Number*	*Replication*	*Result Selenium*
PD-P-K-01	1	8.00	PD-R-Rc-04	1	8.10
	2	7.84		2	8.08
SD*		***0.1131***		3	8.31
PD-P-K-02	1	3.00	***SD***		***0.1274***
	2	3.04	PD-R-Rc-05	1	1.99
SD		***0.0283***		2	1.98
PD-P-K-03	1	8.43		3	2.16
	2	8.35	***SD***		***0.1012***
SD		***0.0566***	PD-R-Rc-06	1	3.66
PD-P-K-04	1	7.85		2	4.09
	2	7.50	***SD***		***0.3041***
SD		***0.2475***	PD-R-Rc-07	1	5.06
PD-P-K-05	1	1.58		2	5.26
	2	1.55	***SD***		***0.1414***
SD		***0.0212***	PD-R-Rc-08	1	4.33
PD-P-K-06	1	6.55		2	4.21
	2	6.65	***SD***		***0.0849***
SD		***0.0707***	PD-R-Rc-09	1	4.99
PD-P-K-07	1	6.28		2	4.94
	2	6.40	***SD***		***0.0354***
	3	6.48	PD-R-Rc-10	1	4.23
	4	6.36		2	4.25
SD		***0.0833***	***SD***		***0.0141***
PD-P-K-08	1	7.01	PD-R-Rc-11	1	1.52
	2	7.20		2	1.50
SD		***0.1344***	***SD***		***0.0141***
PD-P-K-09	1	5.65	PD-R-Rc-12	1	2.66
	2	5.59		2	2.50
SD		***0.0424***	***SD***		***0.1131***
PD-P-K-10	1	2.62	PD-R-Rc-13	1	1.530
	2	2.46		2	1.540
SD		***0.1131***	***SD***		***0.0071***

Appendix E. Selenium QA/QC Summary, 2005. Duplicates (continued)

ID Number	*Replication*	*Result Selenium*	*ID Number*	*Replication*	*Result Selenium*
PD-P-K-11	1	2.75	PD-R-Rc-14	1	1.99
	2	2.75		2	1.79
SD		***0.0000***	***SD***		***0.1414***
PD-P-K-12	1	2.41	PD-R-Rc-15	1	1.41
	2	2.24		2	1.35
SD		***0.1202***	***SD***		***0.0424***
PD-P-K-13	1	4.17	PD-R-Rc-16	1	4.04
	2	4.16		2	4.10
SD*		***0.0071***	***SD***		***0.0424***
PD-P-K-14	1	2.56	PD-R-Rc-17	1	2.87
	2	2.64		2	2.85
SD		***0.0566***	***SD***		***0.0141***
PD-P-K-15	1	2.97	BZA-01	1	3.05
	2	3.13		2	2.95
	3	2.49	***SD***		***0.0707***
SD		***0.3331***	BZA-02	1	1.41
PD-P-R-01	1	6.64		2	1.42
	2	6.35	***SD***		***0.0071***
SD		***0.2051***	BZA-03	1	0.832
PD-P-R-02	1	7.76		2	0.848
	2	8.11	***SD***		***0.0113***
SD		***0.2475***	BZA-04	1	0.608
PD-P-R-03	1	5.82		2	0.612
	2	6.14	***SD***		***0.0028***
SD		***0.2263***	BZA-05	1	2.43
PD-P-R-04	1	11.0		2	2.38
	2	9.78	***SD***		***0.0354***
	3	10.7	BZG-01	1	0.274
	4	11.3		2	0.295
SD		***0.6573***	***SD***		***0.0148***
PD-P-R-05	1	9.39	BZG-02	1	0.433
	2	9.33		2	0.446
SD		***0.0424***	***SD***		***0.0092***
			BZG-03	1	0.363
				2	0.370

Appendix E. Selenium QA/QC Summary, 2005. Duplicates (continued)

ID Number	*Replication*	*Result Selenium*	*ID Number*	*Replication*	*Result Selenium*
PD-P-R-06	1	8.32	*BZG-03*	1	0.363
	2	8.25		2	0.370
	3	8.65	***SD***		***0.0049***
SD		***0.2136***	BZG-04	1	0.273
PD-P-R-07	1	9.98		2	0.332
	2	11.2	***SD***		***0.0417***
	3	10.5	BZG-05	1	0.561
	4	10.9		2	0.582
SD		***0.5280***	***SD***		***0.0148***
PD-P-R-08	1	5.93	LHE-01	1	12.6
	2	5.54		2	12.4
SD		***0.2758***	SD		***0.1414***
PD-P-R-09	1	10.1	LHE-02	1	15.2
	2	9.36		2	15.4
	3	9.72	***SD***		***0.1414***
	4	9.41	LHE-03	1	25.6
SD		***0.3411***		2	25.6
PD-P-R-10	1	7.58	***SD***		***0.0000***
	2	7.28	LHE-04	1	2.75
SD		***0.2121***		2	2.76
PD-P-R-11	1	7.71	***SD***		***0.0071***
	2	7.73	LHE-05	1	12.3
SD		0.0141		2	11.8
PD-P-R-12	1	10.8		3	11.6
	2	10.9	***SD***		***0.3606***
SD		***0.0707***	LHM-01	1	1.07
PD-R-K-01	1	0.875		2	1.09
	2	0.856	***SD***		***0.0141***
SD		***0.0134***	LHM-02	1	1.62
PD-R-K-02	1	1.19		2	1.52
	2	1.24	SD		0.0707
SD		***0.0354***	LHM-03	1	3.75
PD-R-K-03	1	2.22		2	3.60
	2	2.18	***SD***		***0.1061***
SD		***0.0283***			

Appendix E. Selenium QA/QC Summary, 2005. Duplicates (continued)

ID Number	*Replication*	*Result Selenium*	*ID Number*	*Replication*	*Result Selenium*
PD-R-K-04	1	2.05	LHM-04	1	0.949
	2	2.03		2	1.04
SD		***0.0141***	***SD***		***0.0643***
PD-R-K-05	1	2.50			
	2	1.76	LHM-05	1	4.27
	3	1.97		2	4.13
SD		***0.3814***	***SD***		***0.0990***
			TH-01	1	3.52
PD-R-K-06	1	1.82		2	3.49
	2	1.53	***SD***		***0.0212***
SD		***0.2051***	TH-02	1	3.75
PD-R-K-07	1	1.34		2	3.76
	2	1.04	**SD**		**0.0071**
SD		***0.2121***	TH-03	1	3.44
PD-R-K-08	1	1.54		2	3.50
	2	1.55	***SD***		***0.0424***
SD		***0.0071***	TH-04	1	2.17
PD-R-K-09	1	1.84		2	2.12
	2	1.58	***SD***		***0.0354***
SD		***0.1838***	TL-C-01	1	0.805
PD-R-K-10	1	0.728		2	0.872
	2	0.908	***SD***		***0.0474***
SD		***0.1273***	TL-C-02	1	0.536
PD-R-K-11	1	1.52		2	0.585
	2	1.71	***SD***		***0.0346***
SD		***0.1344***	TL-C-03	1	0.474
PD-R-K-12	1	1.69		2	0.485
	2	1.73	***SD***		***0.0078***
SD		***0.0283***	TL-C-04	1	0.600
PD-R-K-13	1	1.45		2	0.591
	2	1.59	SD		***0.0064***
SD		***0.0990***	TL-C-05	1	0.573
				2	0.614
			SD		***0.0290***

Appendix E. Selenium QA/QC Summary, 2005. Duplicates (continued)

ID Number	*Replication*	*Result Selenium*	*ID Number*	*Replication*	*Result Selenium*
PD-R-K-14	1	1.03	TL-S-01	1	5.91
	2	1.17		2	5.92
SD		***0.0990***	***SD***		***0.0071***
PD-R-K-15	1	1.64	TL-S-02	1	3.96
	2	1.86		2	4.13
SD		***0.1556***	***SD***		***0.1202***
PD-R-Rc-01	1	3.78	TL-S-03	1	4.23
	2	3.60		2	4.22
SD		***0.1273***	***SD***		***0.0071***
PD-R-Rc-02	1	3.21	TL-S-04	1	5.64
	2	3.79		2	6.32
	3	3.39	***SD***		***0.4808***
SD		***0.2969***	TL-S-05	1	3.08
PD-R-Rc-03	1	2.98		2	3.19
	2	2.11	***SD***		***0.0778***
SD		***0.6152***	WLS-01	1	7.21
				2	7.06
			SD		***0.1061***

Mean SD **0.1134**
Low SD: **0.0000**
High SD: **0.6573**

APPENDIX F. BORON ANALYSIS QUALITY ASSURANCE/QUALITY CONTROL RESULTS

Boron Control Spikes.

ID Number	Tissue	Spiked Selenium (ug)	% Recovery
PDP-K-12	egg		100
PDR-K-07	egg		102
PDR-Rc-01	egg		100
PDR-Rc-11	egg		99
		Mean	101
		Standard deviation	1.4

Boron QA/QC Summary, 2005.

Duplicates. (SD = Standard Deviation)

ID Number	Replication	Result Selenium	ID Number	Replication	Result Selenium
PDP-K-02	1	0.70	PDR-K-06	1	0.330
	2	0.779		2	0.210
SD*		***0.0566***	***SD***		***0.0849***
PDP-K-07	1	0.720	PDR-K-08	1	0.360
	2	0.740		2	0.270
	3	0.670	***SD***		***0.0636***
SD		***0.0361***	PDR-K-09	1	0.0999
PDP-K-09	1	0.529		2	0.250
	2	0.759	***SD***		***0.1061***
	3	0.819	PDR-K-10	1	0.380
SD		***0.1531***		2	0.260
PDP-K-11	1	6.72	***SD***		***0.0849***
	2	6.56	PDR-K-11	1	0.260
SD		***0.1131***		2	0.170
PDP-K-13	1	0.859	***SD***		***0.0636***
	2	0.83	PDR-K-13	1	0.140
SD		***0.0212***		2	0.260
PDP-K-15	1	0.571		3	0.170
	2	0.541	***SD***		***0.0624***
SD		***0.0212***	PDR-K-14	1	0.589
				2	0.400
			SD		***0.1336***

Appendix F. Boron QA/QC Summary, 2005. Duplicates (continued)

ID Number	*Replication*	*Result Boron*	*ID Number*	*Replication*	*Result Boron*
PDR-K-03	1	0.969	PDR-K-15	1	0.370
	2	0.859		2	0.260
	3	0.829	***SD***		***0.0778***
SD		***0.0737***	PDP-R-01	1	0.890
PDR-K-05	1	0.741		2	0.840
	2	0.941	***SD***		***0.0354***
	3	0.971			
SD		***0.1250***			
PDP-R-02	1	2.44	PDP-Rc-02	1	5.27
	2	2.73		2	5.76
SD		***0.2051***	***SD***		***0.3465***
PDP-R-06	1	2.17	PDP-Rc-05	1	0.729
	2	2.27		2	0.689
	3	2.47		3	0.650
SD		***0.1528***	***SD***		***0.0395***
PDP-R-07	1	2.51	PDP-Rc-06	1	0.899
	2	2.49		2	0.749
SD		***0.0141***	***SD***		***0.1061***
PDP-R-08	1	0.869	PDP-Rc-10	1	0.320
	2	1.03		2	0.340
	3	1.16	***SD***		***0.0141***
SD		***0.1458***	PDP-Rc-11	1	0.240
PDP-R-11	1	3.22		2	0.341
	2	2.80		3	0.491
	3	2.52	***SD***		***0.1263***
SD		***0.3523***	PDP-Rc-13	1	2.25
PDP-R-12	1	2.39		2	2.39
	2	3.47	***SD***		***0.0990***
SD		***0.7637***	PDP-Rc-14	1	2.40
				2	2.42
			SD		***0.0141***

Appendix F. Boron QA/QC Summary, 2005. Duplicates (continued)

ID Number	*Replication*	*Result Boron*	*ID Number*	*Replication*	*Result Boron*
PDP-Rc-16	1	0.961	PDP-Rc-15	1	0.450
	2	1.03		2	0.599
SD		***0.0488***		3	0.599
			SD		***0.0860***

Mean SD: 0.1196
Low SD: 0.0141
High SD:0.7637

APPENDIX G. CONTINGENCY PLAN FOR BIOLOGICAL MONITORING OF ACCIDENTAL FLOOD EVENTS WITHIN THE PROJECT SITE

San Joaquin River Water Quality Improvement Project
Biological Monitoring Contingency Plan

Background

Panoche Drainage District adopted a negative declaration for the Phase 1 San Joaquin River Water Quality Improvement Project on September 19, 2000. This project provided for the application of subsurface drainage water on salt tolerant crops on lands within the in-valley treatment area known as San Joaquin River Water Quality Improvement Project (SJRIP). The negative declaration was adopted with the following impact avoidance measure: "A biological monitoring program will be developed in collaboration with U.S. Fish and Wildlife Service that would be capable of detecting migratory bird impacts and, if necessary, capable of providing the data for formulating project adjustments to avoid such impacts" (Negative Declaration, page 2, paragraph 5. Impact Avoidance Measures).

The monitoring program was developed with input from the US Fish & Wildlife Service and H. T. Harvey & Associates was contracted to perform the monitoring. Monitoring began in the spring of 2001. The monitoring program has been modified based on the initial monitoring in 2001 to respond to the conditions within the SJRIP and has been ongoing annually since then. Modifications have included sampling Red-Winged Blackbird eggs in addition to Black-necked Stilt, American Avocet, and Killdeer eggs, sampling eggs from within the project site and from non-project lands in the vicinity of the project, and to significantly increase the number of eggs sampled and analyzed. It was known that the subsurface drainage water that would be applied to the crops within the SJRIP would be fairly high in selenium and it was indicated in the initial study for the project that "…irrigation with drainwater will be monitored/controlled to avoid the ponding of water such that wetlands containing water high in selenium would not be created on the site." (Page 12, CEQA Initial Study). In the spring of 2003, a pasture at the SJRIP attracted waterfowl when it was inadvertently flooded. Stilt and avocet eggs collected near the pasture had elevated selenium concentrations.

Immediate instructions to field staff that operate the SJRIP were not to allow ponding that inadvertently occurred in 2003, consistent with statements in the CEQA Initial Study to avoid ponding water. A procedure has been established to prevent future ponding of this sort. This document further identifies those procedures and establishes a contingency plan in the unlikely event that ponding reoccurs in the future.

Contingency Plan in the Event of Inadvertent Flooding

If inadvertent flooding occurs due to the breakage of a supply canal or delivery facility, ponded water shall be eliminated through the discharge of the water into a tail-water return system or by pumping the water into one of the supply channels in SJRIP or a tail-water return system. This will be performed to prevent any ponding of water over 24 hours on any lands within the SJRIP.

Project field personnel will be tasked with daily monitoring of water conditions on the project site during the breeding season for birds (March through July). Any ponding that occurred would be reported to the Drainage Coordinator and through him to the U.S. Fish and Wildlife Service

(USFWS) and the California Department of Fish and Game (DFG). Immediate collection of water samples would be made and analyzed for selenium and boron content.

In the event of inadvertent flooding for a period longer than 24 hours, an event specific monitoring plan will be developed to monitor the impacts to bird species resulting from exposure to ponded water. Any monitoring program will include:

1) the date of the event,
2) selenium concentration of the floodwater,
3) number of birds using the flooded area,
4) duration of exposure,

and, if nesting occurs, will also include:

5) selenium and boron concentrations in eggs,
6) hatchability of eggs, and
7) the assessment of collected embryos.

The results would be included in the annual monitoring report and incorporated into the three-year mitigation assessment reports. The exposure effects will be determined using the egg effect equation provided in the Environmental Impact section of this report. This equation was modified for use at this project site from the equation developed by the U.S. Fish and Wildlife Service for use at evaporation basins (USFWS 1995). The number of birds exposed (number of nest attempts at the project site) and the degree of exposure (egg-selenium content) are the biggest factors determining the amount of required mitigation. The USFWS and/or DFG would have the option of collecting supplemental monitoring data and biological samples in full coordination with Panoche Drainage District.

References

[USFWS] U.S. Fish and Wildlife Service. 1995. Compensation habitat protocol for drainwater evaporation basins. Sacramento, CA. 20 pp.

APPENDIX H. U.S. FISH AND WILDLIFE SERVICE COMPENSATION HABITAT PROTOCOL FOR DRAINWATER EVAPORATION BASINS

EXHIBIT 6

U.S. Fish and Wildlife Service

Description:

Final Compensation Habitat Protocols.

COMPENSATION HABITAT PROTOCOL
USFWS
FOR DRAINWATER EVAPORATION BASINS
January 1995

INTRODUCTION

Two compensation protocols are presented here. Both protocols share a common set of general premises (labeled GP-l to GP-8 below). The two protocols differ with regard to their risk function premises. One is based on the same eggwise risk function premises (labeled EP-l to EP-4 below) employed in 1991 (Skorupa l99la), and the other is based on newly available henwise risk function premises (labeled HP-l to HP-3 below). Both protocols retain most of the conceptual criteria proposed by the U.S. Fish and Wildlife Service (Service) in 1991 (Skorupa 199la).

The Service has developed a risk-based approach for compensation to increase accuracy, minimize monitoring costs, and provide incentive to minimize contaminant risk. Compensation protocols based primarily on dead-body counts are inadequate. Adverse impacts to wildlife caused by evaporation basins include both lethal and nonlethal impacts (*e.g.*, Euliss *et al.* 1989; Barnum 1992; CH2M-Hill *et al.* 1993; White l993). Nonlethal impacts, by definition, cannot be accounted for by body counts. Body counts for each lifestage (embryonic, juvenile, adult) are extremely expensive to obtain and are inherently biased toward underestimating true impacts (*i.e.*, there are numerous circumstances that result in dead bodies going uncounted, but rarely, if ever, is a dead body counted more than once). The Service prefers a risk-based approach that employs easily verified measures of wildlife exposure to contaminants and exposure-response risk functions. Given adequate risk- functions, not only are measures of exposure more reliable (*i.e.,* less uncertain) than body counts, they are orders of magnitude less expensive to obtain.

Any compensation protocol should be based on clearly stated premises that are amenable to empirical validation and, when applicable, periodic re-evaluation. Furthermore, any compensation scheme must be realistic to implement, that is, it should optimize the certainty/cost ratio by relying on data that can be measured with high certainty and can be collected with relatively low cost. Therefore, the protocols developed here are based on measures of selenium concentrations in the eggs of recurvirostrids (stilts and avocets) and nest densities of recurvirostrids. Selenium concentrations in recurvirostrid eggs and recurvirostrid nest densities can be measured with a high degree of replicability (certainty), and usually require only a day per week during the breeding season (per study site) to obtain the necessary samples and/or data. Recurvirostrid eggs sampled at evaporation basins have generally proven to be reliable indicators of basin-specific contaminant conditions (*e.g.*, Ohlendorf *et al.* 1993; Skorupa 1994), and there exists a substantial base of scientific data from both laboratory and field studies relevant to estimating risk functions (*e.g.*, Ohlendorf *et al.* 1986; Heinz *et al.* 1987; Schroeder *et al.* 1988; Ohlendorf 1989; Williams *et al.* 1989; Heinz *et al.* 1989; Whiteley and Yuill 1989; Skorupa and Ohlendorf 1991; CH2M-Hill *et al.* 1993; Ohlendorf *et al.* 1993).

RISK-BASED APPROACH

Our approach for compensation is based on the degree of basin contamination and the extent of wildlife exposure. Basins exposing more birds to higher concentrations of selenium require more compensation habitat and vice-versa. Presently, this generally translates into two factors being the primary determinants of compensation habitat obligations: (1) the size of a basin (all else equal, bigger basins attract more wildlife), and (2) the concentration of selenium in water discharged to a basin (as reflected in recurvirostrid eggs). As alternative habitats (see alternative habitat protocol) are established and standard design and operating procedures for evaporation basins are modified to discourage use of the basins by wildlife, these changes will translate into reduced compensation obligations through reduced exposure of wildlife.

GENERAL PREMISES (GP)

Basin Design and Operation

(GP-1) On-shore vegetation control at basins will effectively eliminate most nesting habitat for waterfowl.

One caveat applicable to premise GP-l is that removal of on-shore vegetation at evaporation basins may have minimal impact on the number of breeding ducks that are foraging at evaporation basins because ducks are commonly known to be capable of nesting long distances (miles) away from the nearest shoreline of their foraging areas. One locally specific example of this is illustrated by the only duck nest (a gadwall nest) monitored by the Service on Kern NWR during the dry breeding season of 1989. The

nest was more than 3 kilometers (ca. 2 miles) from the nearest known potential shallow water foraging area, an evaporation pond, and the concentration of selenium in a random sample egg (7.3 ppm, or about 3-4 times a normal background concentration) confirmed that the hen was probably foraging for significant amounts of time at the distant evaporation pond.

(GP-2) Zn-basin control of submergent aquatic vegetation (*e.g.*, widgeon-grass) will effectively eliminate most nesting habitat for eared grebes (*Podiceps nigricollis*).

(GP-3) Removal of all islands and wave-break levees will effectively eliminate most nesting habitat for terns.

The combined implications of the above premises are a shift in species composition of breeding birds at evaporation basins to nearly complete dominance by shorebirds. Recurvirostrids would be, by far, the primary shorebird taxa of focus for compensation purposes. USFWS 1987-1989 nest records revealed that recurvirostrids comprised about 75% of all breeding birds even prior to complete implementation of the above stated premises (*e.g.*, Skorupa *et al.* 1993; CH2M-HILL *et al.* 1993). With complete implementation, recurvirostrids are expected to comprise greater than 90% of all breeding birds at evaporation basins. Thus, selenium in recurvirostrid eggs is the most appropriate standard for assessing wildlife exposure. Accordingly, recurvirostrid exposure-response data will be preferred for estimating wildlife risks associated with the operation of evaporation basins (recurvirostrids are neither the most sensitive nor least sensitive taxa to selenium)

The focus on recurvirostrid data may not be appropriate during the nonbreeding season when waterfowl and species of shorebirds other than recurvirostrids such as sandpipers and phalaropes are more prominent (*e.g.*, Jehl 1988; CH2M-Hill *et al.* 1993). By default, compensation protocols must rely primarily on breeding season data due to a lack of extensive "response" data for nonbreeding birds. Consequently, compensation obligations can be met by providing breeding season habitat. Therefore, true compensation habitat obligations are necessarily underestimated. Presumably, however, the year- round alternative habitat obligations required for effective hazing and for creating a bird safe local landscape around evaporation basins will eliminate the primary risks to nonbreeding birds such as directly fatal poisoning, impaired ability to migrate, impaired ability to avoid predators, immune suppression, and various long-term demographic consequences associated with impaired, body condition (*e.g.*, adult longevity, age of first breeding, fecundity, etc.).

Predation Losses

(GP-4) The inherent viability (= hatchability) of a recurvirostrid egg is a probabilistic function of its selenium content at the time of oviposition.

Accordingly, basin operators are obligated to compensate for all selenium-caused inviability of eggs. The fact that a predator "naturally removes" an already "doomed" egg

does not release a basin operator from the obligation to compensate for that egg. A chemically inviable egg's fate (and a basin operator's responsibility) has already been determined at the time of oviposition (*i.e.,* when the egg leaves the hen's body). This is more a question of legal liability with regard to definitions of "take" than a question of biology. From a liability perspective, one must distinguish between the number of eggs chemically destroyed and the net biological impact of that destruction. Under statutes such as the Migratory Bird Treaty Act an operator assumes liability for any verifiable "take" without consideration of whether the "take" has population-level impacts or not (*i.e.*, "take" is unconditionally prohibited).

As a matter of biology, some reviewers of the draft Compensation Habitat Protocol advocated releasing operators from compensating for chemically inviable eggs that are subsequently predated up until the normal "background level" of predation is exceeded. The primary problem with that approach is that background levels of predation depend on the quality of the nesting habitat. Recurvirostrids show a very strong attraction to islands as nesting habitat. Such preferred (high quality) nesting habitat would be associated with near-zero background predation rates under undisturbed natural conditions or artificial conditions that mimic historically pristine conditions. For example, H.T. Harvey and Associates (1995) reported for Westlake Farms' section 3 alternative habitat (which possessed continuously isolated islands throughout the breeding season) a 5% nest predation rate and Sidle and Arnold (1982) reported for an island in the Mud Lake Waterfowl Production Area of North Dakota a 0% nest predation rate. The island they studied was thought to have supported the largest colony of breeding avocets documented in the scientific literature up to that publication date. Subsequently, if the "background level" of nest predation is established based on the good quality nesting habitat that recurvirostrids naturally seek out, the legal and biological perspectives converge on the same outcome, virtually all chemically-induced inviability of eggs should be compensated for.

(GP-5) Eggs lost to predators (or other causes of nest failure) in compensation wetlands do not provide a compensation benefit.

In the extreme case of total loss of eggs to predators in a compensation wetland, it is obvious that no compensation benefit has been provided. The relative habitat utility of compensation wetlands is devalued in direct proportion to predation losses and other sources of nest failure to yield the operational habitat utility. Not only is it important to maximize the attractiveness of compensation habitat to breeding birds (= habitat utility), it is also important to maximize the reproductive output from compensation habitat (= operational habitat utility). Thus, successful efforts to provide predator-safe nesting sites at compensation wetlands will yield higher operational habitat utility and lower compensation habitat obligations.

Relative Habitat Utility

The long-term average density of breeding birds attracted to an evaporation basin or compensation wetland is a measure of the site's attractiveness or utility as nesting habitat (*i.e.*, the degree to which the habitat is utilized for nesting). Relative habitat utility is the attractiveness of one type of habitat, such as evaporation basins, relative to the attractiveness of another type of habitat, such as compensation wetlands. It is important to recognize the distinction between habitat utility and habitat quality. Habitat utility is established by the level of use, whereas habitat quality is established by the outcome of that use. Habitat utility is not a measure of habitat quality.

(GP-6) The primary determinants of habitat utility are predator-safe nesting sites and areas of shallow water supporting at least a threshold density of aquatic invertebrates.

Recurvirostrids exhibit a strong attraction to (predator-safe) islands or perceived islands, such as internal levees of artificial ponds, as nesting sites. Although recurvirostrids are known to utilize a wide variety of nesting substrates (Grinnell *et al.* 1918; Bent 1927; Johnsgaard 1981), the highest densities of nests occur on islands (*e.g.*, Sidle and Arnold 1982; Salmon *et al.* 1991).

The densities of birds at saline-sink wetlands are generally believed to be food-limited in some fashion (*e.g.*, Mono Basin Ecosystem Study Committee 1987) and the Service's Waterfowl Management Handbook recommends maintaining a density of at least 100 midge larvae per square meter to "...successfully attract and hold shorebirds." (Eldridge 1992). A study of foraging behavior among black-necked stilts (*Himantopus mexicanus*) at a manmade pond system in Puerto Rico revealed that abundance of invertebrates was a strong determinant of where the stilts were foraging (Cullen 1994). Cullen's study seems particularly relevant because his focal species (black-necked stilt), study site (manmade salt ponds), and primary aquatic invertebrate (waterboatman) all match-up well with Tulare Basin evaporation basins.

(GP-7) On a unit basis, Predominantly shallow compensation wetlands with islands will exhibit about 2.5 times the habitat utility for breeding recurvirostrids as a traditional evaporation basin without islands.

In the first season (1994) of nest monitoring at Westlake Farms' demonstration wetland, it was estimated that 2.0 avian nesting attempts per acre were supported within the intensively monitored area (Cell G; Medlin 1994). Between 1987-1993, traditional evaporation basins without islands supported 0.41 to 1.41 avian nesting attempts per acre with a median of 0.81 (N=9 cases of relatively complete nest monitoring effort in space and time; USFWS, unpubl. data; see exhibit titled, Appendix of Unpublished Data). Additional estimates of habitat utility for compensation wetlands are needed to get a good sense for how variable they might be over time and between different sites, but the first-season data from Westlake Farms' demonstration wetland and alternative wetland

currently constitute the best available information. The high habitat utility achieved by Westlake Farms in 1994 appears, to some extent, to be dependent on maintaining predominantly shallow wetlands. By comparison, the Corcoran Sewage Ponds, which are physically more similar to evaporation basins (*i.e.*, offer just a near-shore strip of shallow water) supported only 0.67 nesting attempts per acre in 1989 (Skorupa 1991a). Thus, the relative habitat utility of a predominantly shallow, compensation wetland with islands is estimated at (2.0)/(0.8l) = 2.47 times the habitat utility of traditional evaporation basins without islands.

(GP-8) The relative, habitat utility of predominantly shallow compensation wetlands is devalued by about 30% due to nest predation and other causes of nest failure.

In the first season (1994) of nest monitoring at Westlake Farms' demonstration wetland, it was estimated that about 50% of avian nesting attempts within the intensively monitored area survived to hatching (Cell G; Medlin 1994). H.T. Harvey and Associates (1995) reported a nesting success rate of 95% for recurvirostrids nesting at Westlake Farms' alternative habitat in section 3. Accordingly the average nest failure rate for these two sites was about 30%. Additional estimates of devaluation factors for the relative habitat utility of compensation wetlands are needed to get a good sense for how variable they may be over time and between different sites, but the first-season data from Westlake Farms' demonstration wetland currently constitute the best available information. Based on currently available data, an operational relative habitat utility of 0.59:1 for evaporation basins versus compensation wetlands is employed in this protocol.

Actual performance at properly designed compensation wetlands may consistently come closer to the 95% nest success observed in section 3 than to the 50% observed at Westlake Farms' section 16 demonstration wetland in 1994 because anti-predator designs, and water delivery capacity were not completed to design specifications at section 16 in time for the 1994 breeding season. As actual performance in designing compensation wetlands up to specification on schedule is demonstrated, the predation devaluation factor will be revised. Presumably, over time, improved management techniques for maintaining predominantly shallow wetlands without compromising the predator safety of nesting sites will be developed so that in the future there will be little devaluation of relative habitat utility at compensation wetlands.

EGGWISE PREMISES (EP)

Eggwise Exposure-Response Risk Functions

(EP-l) There is an elevated probability of contaminant-mediated juvenile mortality due to immune dysfunction when eggs contain 3.9 ppm or more selenium (all selenium concentrations are presented on a dry weight basis).

A study of selenium exposure and the ability of mallard (*Anas platyrhynchos*) ducklings to survive a disease challenge (Whiteley and Yuill 1989) led to the suggestion that disease resistance may be affected more by the selenium concentration in a duckling's egg than by dietary exposure to elevated selenium after the duckling hatches. Duckling mortality following a challenge with duck hepatitis virus 1 (DHV1) was twice as high (67%, N=24 vs. 30%, N=37) among ducklings from eggs that averaged 3.9 ppm selenium than among ducklings from eggs with background concentrations of selenium (averaging 0.4 to 1.7 ppm).

(EP-2) There is an elevated probability of direct embryotoxicity, and an elevated probability of contaminant-mediated post-hatch juvenile mortality (due to depressed growth rates) when eggs contain 10 ppm or more selenium.

The logistic regression for eggs. of black-necked stilts reported in Ohlendorf *et al.* (1986) shows that for individual eggs the threshold for embryotoxicity is about 10 ppm egg-selenium (Skorupa and Ohlendorf 1991). By comparison, a population-level (geometric mean) threshold of 8 ppm egg-selenium was reported by Skorupa and Ohlendorf (1991). For compensation purposes, individual-level risk functions are the most appropriate functions because they directly determine biological impacts.

Embryonic exposure to 10 ppm or more egg-selenium was associated with depressed rates of growth among recurvirostrid chicks (Skorupa *et al.* unpubl. data; see Appendix of Unpublished Data). Early growth rates are strong predictors of juvenile survivorship in shorebirds (Cairns 1982). Contaminant-depressed growth rates can be expected to cause increased juvenile mortality.

Because the eggs in the study of recurvirostrid chicks were artificially incubated and the chicks were fed only uncontaminated food after hatching, it was demonstrated that egg-selenium alone is sufficient to cause post-hatch growth depression in recurvirostrids (as was also found for mallard ducklings by Heinz *et al.* 1989) and therefore can serve as a direct predictor for such effects.

(EP-3) For eggs containing 3.9 to 9.9 ppm selenium it is estimated that the average long-term probability of contaminant-mediated juvenile mortality is about 10%.

Based on Whiteley and Yuill (1989; see EP-l for a summary), a minimum contaminant mortality add-on of (67-30%)=37% is the assumed response to a pathogen challenge or similar "stress." It is presumed that this mortality is at least partially compensatory (*i.e.*, compensated for in part by reduced competition and therefore density-dependent increased viability of the survivors; Hill 1988) and that stresses "events" are intermittent (not occurring every year). Therefore the effect has been reduced arbitrarily by one-half, or down to 18.5%. Furthermore, it is presumed that not all chicks are exposed to pathogens, parasites, or other stresses during a stress event. Therefore the contaminant-mediated mortality has been arbitrarily reduced again to 10%. Although the resultant "10% premise" is simply an educated guess, a crude guess is still preferable to completely

neglecting the empirically demonstrated immunobiological risk for chicks hatched from eggs with 3.9 ppm selenium or more. As more immunobiological research is completed, this educated guess can be revised.

(EP-4) Between about 10 to 100 ppm egg-selenium the central probability of embryotoxicity or juvenile mortality is about 30%.

Heinz *et al.* (1989) experimentally demonstrated that when mallard eggs averaged about 11 ppm, 37 ppm, and 60 ppm selenium (from selenomethionine), production of 6-day-old ducklings declined by about 10%, 45%, and 100% compared to eggs that averaged less than 3 ppm selenium (background levels).

Ohlendorf *et al.* (1986) presented field data showing that as black-necked stilt eggs go from 10 ppm selenium to 60 ppm selenium the production of viable embryos should decline by about 35% to 70%.

In nature, the percent loss of avian production at the lower end of the 10 ppm to 60 ppm egg-selenium range will be higher than suggested by the above studies because the above studies do not fully assess the risk associated with the post-hatch to recruitment phase of the reproductive cycle. For example, the Ohlendorf *et al.* (1986) data are for losses expected to occur between fertilization and hatch, but at Kesterson Reservoir losses occurring between hatch and recruitment were also thought to be substantial (Ohlendorf 1989; Williams *et al.* 1989).

Also, at evaporation basins, the upper range of egg-selenium extends to about 100 ppm (excluding extreme outliers). That is substantially beyond the upper end of 60 ppm in the response curve for Kesterson Reservoir stilts (Ohlendorf *et al.* 1986).

In light of the studies by Heinz *et al.* (1989) and Ohlendorf *et al.* (1986), and their limitations, the "30% premise" proposed here would have to be considered a low estimate of the central probability for embryo or juvenile toxicity. An apparently low estimate was chosen intentionally because reproductive data for American avocets (*Recurvirostra americana*) indicate less sensitivity to selenium poisoning than is typically exhibited by ducks or stilts (Skorupa *et al.* 1993; CH2M-Hill 1994). Consequently, the "30% premise" attempts to take that species difference into consideration. Applying a Single point-estimate risk function across an order of magnitude of embryo exposure to selenium is imprecise, but is dictated by the imprecision of available eggwise exposure-response data (*e.g.*, see the wide confidence boundaries on Ohlendorf *et al.*'s (1986) exposure-response curves). As more detailed eggwise exposure-response data for recurvirostrids at evaporation basins become available, this premise could be revised.

COMPENSATION COEFFICIENTS: EGGWISE BASIS

Based on general premises GP-1 to GP-8, and the eggwise risk function premises EP-l to EP-4, compensation coefficients for each evaporation basin can be calculated using the following equation:

$$CC = HU \times [(F1 \times L1) + (F2 \times L2)]$$

where, CC = Compensation coefficient the multiple of an evaporation basin's acreage that, on average, would be required in predominantly shallow wetland acreage to replace lost production,

F1 = the weighted proportion of randomly sampled eggs at an evaporation basin containing 3.9 to 9.9 ppm selenium, where all species/year estimates are weighted equally (see example below),

F2 = the weighted proportion of randomly sampled eggs at an evaporation basin, containing 10 or more ppm selenium, where all species/year estimates are weighted equally,

L1 = proportion of production lost when egg contamination is from 3.9 to 9.9 ppm selenium (L1 = 0.10 from premise EP-3),

L2 = proportion of production lost when egg contamination is 10 ppm selenium or more (L2 = 0.30 from premise EP-4),

HU = the relative habitat utility of evaporation basins (HU = 0.59; from premises GP-7 and GP-8).

Egg-selenium data for stilts and avocets, and from all years sampled at each evaporation basin, are weighted equally to derive the coefficients Fl and F2 for this first iteration of the calculations. Because there has been no compensation for historic impacts of evaporation basins, all available egg-selenium data are utilized to reflect average pre-compensation conditions. As compensation calculations are updated at regular intervals, and egg-selenium is systematically monitored at all evaporation basins, the calculations can be based on egg-selenium data more uniformly matched to a specific compensation period.

Example Calculation of a Compensation Coefficient

If the proportions of contaminated eggs sampled from each taxa were distributed as shown below:

TAXON-YEAR	PROPORTION OF EGGS WITH 3.9 TO 9.9 PPM SELENIUM	PROPORTION OF EGGS WITH 10 PPM OR MORE SELENIUM
Stilts – Year 1	0.25	0.10
Stilts – Year 2	0.30	0.20
Stilts – Year 1	0.05	0.0
Stilts – Year 2	0.25	0.10
Stilts – Year 3	0.35	0.50

then,

$$F1 = (0.25) + (0.3) + (0.05) + (0.25) + (0.35) / 5 = 1.2/5 = 0.24$$

and,

$$F2 = (0.1) + (0.2) + (0.0) + (0.1) + (0.5) / 5 = 0.9/5 = 0.18$$

and,

$$CC = 0.59\ [(0.24)\ (.10) + (0.18)\ (.30)] = 0.047$$

In this example, an area of compensation wetlands 4.7% the size of the evaporation basin would be required to compensate for estimated contaminant damage (*i.e.*, 4.7 acres of compensation wetlands per 100 acres of evaporation basin).

Tulare Basin Compensation Coefficients: Eggwise Basis

Based on randomly sampled recurvirostrid eggs collected in 1986-1993 the following compensation coefficients have been calculated for evaporation basins in the Tulare Basin:

EVAPORATION BASIN	SAMPLE SIZE	F1	F2	COMPENSATION COEFFICIENT
Souza	--	----	----	---
Lindemann	--	----	----	---
Britz South Dos Palos	--	----	----	---
Sumner Peck	38	0.04	0.96	0.1723
Britz Davenport 5-Pts.	5	0.33	0.67	0.1381
Stone Land Company	18	0.22	0.17	0.0431
Lemoore Naval Air Station	8	0.26	0.0	0.0153
Westlake Farms North	51	0.16	0.02	0.130
Fabry Farms	9	0.0	0.93	0.1646
Meyers Ranch	2	N/A	N/A	N/A
Barbizon Farms	--	----	----	.---
TLDD North	49	0.27	0.0	0.0159
Westlake Farms South	22	0.86	0.03	0.0561
Liberty Farms	18	0.85	0.10	0.0679
Pryse Farms	71	0.57	0.25	0.0779
Bowman Farms	15	0.33	0.67	0.1381
Morris Farms	29	0.24	0.76	0.1487
Martin Farms	10	0.53	0.47	0.1145
Smith Farms	--	----	----	---
Four-J Corporation	15	0.45	0.48	0.1115
Nickell	--	----	----	---
TLDD Hacienda	34	0.70	0.27	0.0891
TLDD South	62	0.30	0.60	0.1239
Westfarmers	286	0.12	0.83	0.1540
Carmel Ranch	10	0.40	0.0	0.0236
Lost Hills Ranch	13	0.27	0.0	0.0159
Rainbow Ranch	68	0.42	0.57	0.1257
Chevron Land Company	--	----	----	---

Tulare Basin Compensation Acreage: Eggwise Basis

From the compensation coefficients listed above, the following acreages of shallow compensation wetlands would be required to balance the loss of avian production on evaporation basins:

EVAPORATION BASIN	EVAPORATION BASIN ACREAGE	COMPENSATION COEFFICIENT	COMPENSATION ACREAGE
Souza	10	No Data	No Data
Lindemann	100	No Data	No Data
Britz South Dos Palos	50	No Data	No Data
Sumner Peck	100	0.1723	17
Britz Davenport 5-Pts.	25	0.1381	3
Stone Land Company	210	0.0431	9
Lemoore Naval Air Station	80	0.0153	1
Westlake Farms North	260	0.0130	3
Fabry Farms	7	0.1646	1
Meyers Ranch	59	Insufficient Data	Insufficient Data
Barbizon Farms	95	No Data	No Data
TLDD North	301	0.0159	5
Westlake Farms South	740	0.0561	42
Liberty Farms	(160)	0.0679	11
Pryse Farms	(40)	0.0779	3
Bowman Farms	15	0.1381	2
Morris Farms	35	0.1487	5
Martin Farms	13	0.1145	1
Smith Farms	7	No Data	No Data
Four-J Corporation	25	0.1115	3
Nickell	20	No Data	No Data
TLDD Hacienda	1026	0.0891	91
TLDD South	1832	0.1239	227
Westfarmers	542	0.1540	83
Carmel Ranch	180	0.0236	4
Lost Hills Ranch	90	0.0159	1
Rainbow Ranch	100	0.1257	13
Chevron Land Company	65	No Data	No Data
TOTALS	6107 (5760 sampled)	---	525

NOTES: Evaporation basin acreage in parentheses are for sites that routinely had less than the full system capacity flooded up during most of the study period. Other acreages are from an October, 1994, Regional Water Quality Control Board statistical compilation.

HENWISE PREMISES (HP)

Henwise Exposure-Response Risk Functions

(HP-1) For any given exposure category (egg-selenium) the magnitudes of embryonic and post-hatch losses are approximately equal.

Heinz *et al.* (1987) found that when mallard hens were fed diets supplemented with 10 ppm selenium as selenomethionine and the ducklings they produced were fed the same diet (as would occur in nature), there was both a 47% depression in egg hatchability and a 51% depression of post-hatch juvenile survival as compared to a control group. In a follow-up study, Heinz *et al.* (1989) fed mallard hens diets supplemented with 1, 2, 4, 8, and 16 ppm selenium as selenomethionine, but fed a clean diet to all the ducklings those hens produced. As would be expected, the embryotoxic effects were about the same as in the 1987 study (*i.e.*, at the 8 ppm treatment level there was a 42% depression in egg hatchability), but the depression in post-hatch juvenile survivorship was much lower (only 18%). Field studies at Kesterson Reservoir suggested that, at high levels of contamination, post-hatch losses may greatly exceed embryonic losses (Ohlendorf 1989; Williams *et al.* 1989). For recurvirostrids, a depression in egg hatchability on the order of 10% was reportedly associated with a 100% depression in juvenile survivorship. Birds hatched in the wild face many stresses and risks that birds hatched in captivity (such as in Heinz's studies) don't face and that can magnify the post-hatch effects of contaminant exposure. Thus, a 1:1 premise for embryonic versus post-hatch adverse effects likely underestimates total reproductive impairment.

Under the premise that embryonic and post-hatch losses follow similar response curves it is possible to estimate total reproductive losses from embryonic losses alone. For example, if the proportion of embryonic losses is represented as "p" then the proportion of embryos surviving to hatch will be 1-p. If post-hatch mortality is about equal to embryo mortality (= p), then proportional post-hatch mortality will equal $p(1-p)$ or $p-p^2$. Thus, total proportional reproductive losses will equal embryo mortality (= p) plus post-hatch mortality (= $p-p^2$), which together add up to $2p-p^2$. Because a rigorous set of embryonic exposure-response data for recurvirostrids, on a henwise basis, has been collected at evaporation basins (Ohlendorf *et al.* 1993; Skorupa 1994), a fairly precise henwise-based risk function can be developed.

Henwise-based compensation calculations are presented for comparison to the eggwise-based calculations. The henwise-based protocol is statistically cleaner because only hens (not eggs) are independent data points. It also utilizes more detailed exposure-response data that was actually collected from studies of recurvirostrids nesting at evaporation basins. Additionally, it precisely incorporates the substantial species differences in sensitivity to selenium between stilts and avocets. Another advantage is that henwise compensation is the most appropriate approach from a population genetics perspective. Losses attributable to a given number of genetically distinct hens are replaced by an equal number of genetically distinct hens. By comparison, on an eggwise basis, 40 hens that each lost 1 egg could be compensated for by only 10 hens each producing 4 eggs. The

disadvantage of the henwise approach is that you cannot compensate for a "partial hen." Any hen that is reproductively impaired, regardless of degree, is compensated for. That disadvantage, however, is counterbalanced by uncertainties regarding effects of selenium exposure on immune dysfunction, adult longevity, and age of first breeding (among other factors), all of which could impose demographic impacts on recurvirostrid populations that this compensation protocol does not take into account.

(HP-2) The long-term ratio of breeding stilts to avocets at evaporation basins is approximately 1:1.

Surveys conducted by the Service during, 1987-1989 revealed an overall 1:1 ratio of breeding stilts and avocets (*i.e.*, 2,285 stilt vs. 2,254 avocet nest 12 records; Skorupa *et al.*, unpubl. data; see Appendix of Unpublished Data), although basin-specific ratios can be highly variable from year to year. Likewise, it was estimated that approximately a 1:1 ratio of stilts and avocets was attracted to Westlake Farm's demonstration wetland near Kettleman City during the 1994 breeding season (*i.e.*, estimates of 199 stilt vs. 180 avocet nesting attempts; Medlin 1994).

(HP-3) Weighting the stilt and avocet data equally, estimates of $2p - p^2$ for exposure categories of 0-5 ppm, 5.1-20 ppm, 21-40 ppm, 41-70 ppm, and ≥71 ppm egg-selenium are:. 0.0, 0.1889, 0.2551, 0.5083, and 0.9261 respectively.

The above henwise risk function is based on 354 stilt clutches and 229 avocet clutches that survived to full-term incubation and that also had a randomly selected sample egg analyzed for selenium (Skorupa *et al.*, unpubl. data; see Appendix of Unpublished Data). The data were collected during 1983-1994 at Kesterson Reservoir, Volta Wildlife Management Area, Grasslands Resource Conservation District, and at evaporation basins and reference sites within the Tulare Lake Basin. Clutches were classified as impaired or normal based on whether or not they contained any fail-to-hatch eggs. Based on 141 recurvirostrid clutches with a sample egg containing 0-5 ppm selenium, the background value for p (the proportion of impaired clutches) was estimated as 0.08. By comparison, Holmes (1972) estimated that the normal proportion of impaired clutches among western sandpipers (*Calidris mauri*) nesting on the Yukon-Kuskokwim Delta of Alaska was 0.09. Like recurvirostrids, western sandpipers are shorebirds that normally produce four-egg clutches. Due to its remoteness, presumably the Yukon-Kuskokwim Delta is a relatively uncontaminated environment. Thus, background $p = 0.08$ (and background $1-p = 0.92$) was taken to represent normal reproductive performance (*i.e.*, zero contaminant-induced reproductive depression), and all measures of reproductive depression for other egg-selenium (exposure) categories were calibrated accordingly (*i.e.*, $\{(\text{calibrated } p) = 1 - [(1-\text{raw } p) / (0.92)]\}$).

COMPENSATION COEFFICIENTS: HENWISE BASIS

Based on general premises GP-1 to GP-8, and the henwise risk function premises HP-1 to HP-3, compensation coefficients for each evaporation basin can be calculated using the following equation:

$$CC = HU \times [(F1 \times L1) + (F2 \times L2) + (F3 \times L3) + (F4 \times L4) + (F5 \times L5)]$$

where,

CC = compensation coefficient the multiple of an evaporation basin's acreage that, on average, would be required in predominantly shallow wetland acreage to replace lost production,

Fl = the proportion of randomly sampled eggs containing 0 to 5 ppm selenium,

F2 = the proportion of randomly sampled eggs containing 5.1 to 20 ppm selenium,

F3 = the proportion of randomly sampled eggs containing 21 to 40 ppm selenium,

F4 = the proportion of randomly sampled eggs containing 41 to 70 ppm selenium,

F5 = the proportion of randomly sampled eggs containing 71 or more ppm selenium,

L1 = proportion of production lost when egg contamination is from 0 to 5 ppm selenium (Li = 0.0 from premise HP-3),

L2 = proportion of production lost when egg contamination is from 5.1 to 20 ppm selenium (L2 = 0.1889 from premise HP-3),

L3 = proportion of production lost when egg contamination is from 21 to 40 ppm selenium (L3 = 0.2551 from premise HP-3),

L4 = proportion of production lost when egg contamination is from 41 to 70 ppm selenium (L4 = 0.5083 from premise HP-3),

L5 = proportion of production lost when egg contamination is 71 or more ppm selenium (L5 - 0.9261 from premise HP-3),

HU = the relative habitat utility for evaporation basins (MU - 0.59; from premises GP-7 and GP-8).

Tulare Basin Compensation Coefficients: Henwise Basis

Based on randomly sampled recurvirostrid eggs collected in 1986-1993 the following compensation coefficients have been calculated for evaporation basins in the Tulare Basin:

EVAPORATION BASIN	SAMPLE SIZE	F1	F2	F3	F4	F5	COMPENSATION COEFFICIENT
Souza	--	----	----	----	----	----	----
Lindemann	--	----	----	----	----	----	----
Britz South Dos Palos	--	----	----	----	----	----	----
Sumner Peck	38	----	.021	.016	.034	.029	.03079
Britz Davenport 5-Pts.	5	----	.080	0.20	----	----	.01192
Stone Land Company	18	0.94	0.06	----	----	----	0.0007
Lemoore Naval Air Station	8	0.88	0.12	----	----	----	0.0134
Westlake Farms North	51	0.86	0.12	0.02	----	----	0.0164
Fabry Farms	9	0.11	0.33	0.33	0.22	----	0.1524
Meyers Ranch	--	----	----	----	----	----	----
Barbizon Farms	--	----	----	----	----	----	----
TLDD North	49	0.86	0.14	----	----	----	0.156
Westlake Farms South	22	0.55	0.45	----	----	----	0.0502
Liberty Farms	18	0.17	0.83	----	----	----	0.0925
Pryse Farms	71	0.38	0.61	0.01	----	----	0.0695
Bowman Farms	15	0.07	0.53	0.40	----	----	0.1193
Morris Farms	29	0.03	0.55	0.28	0.14	----	0.1454
Martin Farms	10	----	0.80	0.20	----	----	0.1192
Smith Farms	--	----	----	----	----	----	----
Four-J Corporation	15	0.13	0.87	----	----	----	0.0969
Nickell	--	----	----	----	----	----	----
TLDD Hacienda	34	0.09	0.85	0.06	----	----	0.1038
TLDD South	62	0.03	0.89	0.06	0.02	----	0.1142
Westfarmers	286	0.01	0.23	0.38	0.33	0.05	0.2091
Carmel Ranch	10	0.90	0.10	----	----	----	0.0112
Lost Hills Ranch	13	1.00	----	----	----	----	0.0000
Rainbow Ranch	68	0.03	0.72	0.18	0.03	0.03	0.1328
Chevron Land Company	--	----	----	----	----	----	----

Tulare Basin Compensation Acreage: Henwise Basis

From the compensation coefficients listed above, the following acreages of shallow compensation wetlands would be required to balance the loss of avian production on evaporation basins:

EVAPORATION BASIN	EVAPORATION BASIN ACREAGE	COMPENSATION COEFFICIENT	COMPENSATION ACREAGE
Souza	10	No Data	No Data
Lindemann	100	No Data	No Data
Britz South Dos Palos	50	No Data	No Data
Sumner Peck	100	0.3079	31
Britz Davenport 5-Pts.	25	0.1192	3
Stone Land Company	210	0.0007	0
Lemoore Naval Air Station	80	0.0134	1
Westlake Farms North	260	0.0164	4
Fabry Farms	7	0.1524	1
Meyers Ranch	59	Insufficient Data	Insufficient Data
Barbizon Farms	95	No Data	No Data
TLDD North	301	0.0156	5
Westlake Farms South	740	0.0502	37
Liberty Farms	(160)	0.0925	15
Pryse Farms	(40)	0.0695	3
Bowman Farms	15	0.1193	2
Morris Farms	35	0.1454	5
Martin Farms	13	0.1192	2
Smith Farms	7	No Data	No Data
Four-J Corporation	25	0.0969	2
Nickell	20	No Data	No Data
TLDD Hacienda	1026	0.1038	106
TLDD South	1832	0.1142	209
Westfarmers	542	0.2091	113
Carmel Ranch	180	0.0112	2
Lost Hills Ranch	90	0.00	0
Rainbow Ranch	100	0.1328	13
Chevron Land Company	65	No Data	No Data
TOTALS	6107 (5760 sampled)	---	554

NOTES: Evaporation basin acreages in parentheses are for sites that routinely had less than the full system capacity flooded up during most of the study period. Other acreages are from an October 1994, Regional Water Quality Control Board statistical compilation.

CONCLUDING DISCUSSION

Based on best available information and empirically testable premises, it is estimated that about 550 acres of shallow nondrainwater wetlands would be needed to compensate for breeding season avian losses on about 5,760 acres of Tulare Basin evaporation basins. Overall, that's a ratio of approximately 0.10 acres compensation for every acre of evaporation pond. For the ten basins (ca. 5,000 acres) that were listed as active by the Regional Water Quality Control Board as of October 1994, it is estimated that about 490 acres of compensation wetlands would be needed. The cumulative compensation acreage is nearly identical for eggwise versus henwise calculations; however, obligations for individual basins often differ under the two sets of calculations. The henwise risk functions are more responsive to the nonlinear increase in risk associated with increasing exposure to selenium. Consequently, the main difference between eggwise and henwise calculations is that highly contaminated evaporation basins bear a higher proportion of the total obligation for compensation under the henwise protocol. The Service, as well as most reviewers of the draft Compensation Habitat Protocol, prefer the henwise calculations because they are based on more detailed and qualitatively superior (*i.e.*, nonlinear) response functions.

It was envisioned that the task of setting compensation obligations would be a continuous cyclic process whereby there would be an initial iteration of compensation obligations that would be in effect for a 3-year period, then any new data collected or research findings reported during the compensation cycle would be incorporated into an updated iteration of compensation obligations, which in turn would be in effect for another 3-year compensation cycle and so on. The only way to realistically implement such a process is to base the compensation protocol on data that can be measured with reasonable certainty and at low cost. Thus, this protocol relies principally on measures of egg-selenium, exposure-response, functions, and long-term average comparative habitat utility (which is based on nest densities and therefore is responsive to changes in absolute abundances of breeding birds) for evaporation ponds versus compensation wetlands.

Egg-selenium can be measured with greater certainty and precision than any other biological variable potentially relevant to assessing compensation obligations, and therefore provides the single most appropriate and equitable foundation upon which to build a compensation protocol. The structure of the protocol built upon that foundation will change as the state of knowledge regarding exposure-response functions and comparative habitat utility change. Accordingly, research and monitoring resources can be efficiently focused on those topics.

The Service prefers the concept of long-term relative habitat utility (HU) to site-specific absolute counts of birds or nests because site-specific absolute counts vary unpredictably from year-to-year under even under relatively constant basin management and are of dubious certainty due to the myriad of potential biases in effect (for several reviews of such biases see the papers in Ralph and Scott 1981). For example, at TLDD South in June, 1990, within the same week, a standard park'n'drive count of birds conducted by two experienced observers (Todd Sloat & William Erickson, UCD Dept. Wildlife and Fisheries Biology hazing research team) was followed by an intensive on-foot

simultaneous count of snowy plovers by 19 observers deployed to achieve rapid complete coverage of the basin. The standard count yielded an estimate of 45 snowy plovers inhabiting the basin, whereas the complete coverage simultaneous count yielded an estimate of 95 snowy plovers inhabiting the basin...more than a 100% difference (Skorupa 1990). Despite the large uncertainty in the accuracy of standard park'n'drive absolute counts, the **relative** utility of habitats can be measured with good certainty if the biases affecting absolute counts are relatively uniform between habitats. If as envisioned by the Service, compensation habitat is Concentrated at one or two regional compensation sites of well-documented and relatively constant habitat utility, then changes in HU due to changing nest densities monitored at evaporation basins will directly track absolute numbers of breeding birds.

Additionally, it is important to remember that the compensation protocols presented here do not explicitly address many potential impacts of evaporation basins on avian populations, including:

(1) Historic contaminant-induced louses not previously compensated.

Some basins were operational in the 1970's, and all basins were operational by 1985 (Westcot *et al.* 198a). The earliest studies (1984-1986) of environmental contamination and avian exposure to contaminants at evaporation basins revealed "potentially harmful levels" of exposure to selenium and impaired avian reproduction (Barnum and Gilmer 1986; Fujii 1968; Schroeder *et al.* 1988). From those earliest studies in the mid 1960's until the early 1990's avian exposure to selenium has been fairly constant (Skorupa *et al.*, unpubl. data; see Appendix of Unpublished Data). The first compensation wetland, however, was not established until 1994. Consequently, markedly elevated avian exposure to selenium at evaporation basins has gone completely uncompensated for a decade or more.

(2) Contaminant-induced losses not detected among birds nesting outside the normal search radius of biologists conducting nest monitoring.

Agricultural fields and other "cover" habitat within several miles of an evaporation basin could harbor nesting ducks that are foraging at evaporation basins. See discussion of this topic under premise GP-1 above for an example. Biologists monitoring avian nests at evaporation basins rarely search for nests outside the perimeter levees of the basin system. Thus, adverse effects (if any) suffered by nesting ducks or any other species of waterbirds "commuting" to an evaporation basin would not be detected or compensated.

(3) Losses due to hazing during the breeding season.

Losses due to off-road vehicle activity associated with hazing efforts have been documented at one evaporation basin for western snowy plovers (*Charadrius alexandrinus*) and for recurvirostrids (Skorupa 1991b). These losses were discovered incidentally, and adverse impacts of hazing could easily have gone undetected at other evaporation basins.

(4) Losses due to levee grading, vegetation removal and managed water level fluctuations during the breeding season.

Several incidents of levee grading during the breeding season have been documented at three evaporation basins with the resultant loss of hundreds of recurvirostrid eggs (Skorupa 1991b; Skorupa *et al.*, unpubl. data; see Appendix of Unpublished Data). Vegetation removal at two pond systems during the breeding season has been documented to have caused substantive (but not fully monitored) losses of waterbird eggs (Skorupa pers. comm.). Managed water level fluctuations during the breeding season have also been documented to have caused losses of waterbird eggs (particularly eared grebes and black- necked stilts) at several evaporation basins (Skorupa *et al.*, unpubl. data; see Appendix of Unpublished Data).

(5) Losses due to the use of automobile tires for levee stabilization.

The occurrence of losses of recurvirostrid chicks trapped inside automobile tires used to stabilize basin levees was documented at one evaporation basin (Skorupa *et al.*, unpubl. photographs).

(6) Losses due to other physical barriers such as wave-induced foam, open pit blinds, and experimental shoreline, netting.

Most ponds produce a ring of wave-induced foam along downwind shorelines. Foam encrustation of the down or feathers of recurvirostrid chicks has been documented to cause juvenile mortality (Main and Anthony 1995). Several ponds retain concrete pit blinds, presumably originally intended for duck hunting, that are generally left uncovered. A variety of dead and dying wildlife and other animals have been found trapped in these blinds ranging from recurvirostrid chicks, to long-tailed weasels (*Mustela frenata*), to domestic sheep (*Ovis* spp.) (Skorupa *et al.*, pers. obs.). Experimental shoreline netting at one evaporation basin has been documented to cause mortality of juvenile and adult shorebirds (Skorupa *et al.*, unpubl. photographs; Barnum *et al.*, in prep.).

(7) Losses due to contaminants other than selenium.

Although concentrations of trace elements other than selenium in avian eggs at evaporation basins do not exceed concentrations demonstrated to cause embryotoxicity (Ohlendorf *et al.* 1993), concentrations of arsenic and boron in the food chain at some evaporation basins are high enough to cause post-hatch adverse effects (*e.g.*, Camardese *et al.* 1990; Hoffman *et al.* 1990). In addition, the spatial distribution of eared grebe colonies experiencing complete failure of eggs (directly bathed in drainwater) is not explained by the selenium content of the water (Skorupa *et al.*, unpubl. data; see Appendix of Unpublished Data). Finally, in addition to a possible role in the grebe reproductive failures, the high salinity of drainwater has been documented to cause adverse effects (severe feather damage) for ruddy ducks (Euliss *et al.* 1989).

(8) Secondary hazards to predators of birds and their eggs.

Peregrine falcons (*Falco peregrinus*), northern harriers (*Circus cyaneus*), and burrowing owls (*Athene cunicularia*) have been observed preying on shorebirds at evaporation basins (Skorupa *et al.*, pers. obs.). Gopher snakes (*Pituophis catenifer*), and mammalian predators have been observed preying on avian eggs at evaporation basins (Skorupa *et al.*, pers. obs.). No studies of secondary hazards have quantified the risk that such predators are exposed to at evaporation basins. A peregrine falcon that was too weak to fly was recovered from a wheat field near an evaporation basin in 1992. A blood sample from the peregrine revealed a markedly elevated concentration of selenium as did feather samples. The peregrine quickly recovered when placed on a clean diet (consistent with selenium poisoning, but not conclusively diagnostic). A fresh cinnamon teal (*Anas cyanoptera*) carcass that a peregrine falcon was observed feeding from was recovered at the same evaporation basin and found to exhibit markedly elevated selenium concentrations (Detwiler 1991; White 1993; Skorupa *et al.*, unpubl. data; see Appendix of Unpublished Data).

(9) Nonlethal impacts during the breeding season.

Lower mean body weights have been documented for breeding black-necked stilt hens collected from a medium-selenium and a high-selenium evaporation basin as compared to hens collected from a low-selenium evaporation basin (White 1993). The implications, if any, of this generally reduced body condition with regard to average adult longevity or other "fitness" parameters is unknown. Barnum (1992) notes, however, that poor body condition has been linked to lowered fitness (*i.e.,* survival and future reproductive success) in several species of waterfowl.

(10) Lethal and nonlethal impacts occurring outside the breeding season.

There is a general lack of information on this topic. Barnum (1992) summarized available information on trends in body condition of birds wintering at evaporation ponds. He concluded that in general waterbirds wintering on evaporation ponds appeared to exhibit lower overall body condition, significantly enlarged salt glands, and elevated concentrations of breast and/or liver-selenium. He further noted a general trend suggesting that increasing selenium exposure results in decreasing body condition; a trend that was statistically significant only for ruddy ducks (*Oxyura jamaicensis*). Based on a large program of experimental research conducted on behalf of the San Joaquin Valley Drainage Program, it was estimated that survival of wintering birds would be protected by not permitting food items to become contaminated with more than 10 ppm selenium on a dry weight basis (Heinz 1989; Patuxent Wildlife Research Center 1990). The widespread occurrence of food items with greater than 10 ppm selenium at evaporation basins (Moore *et al.* 1989) establishes the plausibility of substantive biological impacts outside the breeding season. As mentioned earlier, to the extent that such impacts may occur, they may also be partially or wholly alleviated by the provision of year-round alternative habitat as part of hazing and mitigation requirements.

Finally, there is a very important caveat associated with this protocol that was brought to our attention via the review comments of Ms. Carolyn Marn, a Ph.D. candidate at Oregon State University who conducted her Ph.D. research at Tulare Basin evaporation basins (for details see Ms. Marn's letter in the collection of comment letters, USFWS exhibit #10). Ms. Marn outlines mathematically several permutations of regional demographic conditions for avian populations under which our proposed Compensation Habitat Protocol would provide inadequate compensation. Since those conditions require the regional population of birds to behave as a demographically closed population, which the Service currently views as unlikely (especially for species that are not year-round territory holders), the outcomes modeled by Ms. Marn are probably not applicable (but, that has not been factually established). Nonetheless, Ms. Marn's line of reasoning does bring up the issue that if our protocol works regionally because of a demographic subsidy from outside the region, then strictly speaking there may extra-regional demographic impacts that would constitute yet another class of impacts that this compensation protocol does not explicitly address.