NONPOINT SOURCE WATER QUALITY IMPACTS AT GRAY LODGE WILDLIFE MANAGEMENT AREA

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APRIL 1989

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SUMMARY

The purpose of this investigation is to evaluate potential water quality impacts caused by nonpoint source agricultural drainage entering Gray Lodge Wildlife Management Area. The Central Valley of California provides vital winter wetland habitat for over 60% of the Pacific Flyway's total waterfowl population, and as many as two million of these waterfowl have been observed at Gray Lodge Wildlife Management Area. The California Department of Fish and Game utilizes three water sources in the management of this facility. Surface water deliveries from the Biggs-West Gridley Water District, ground water from deep wells, and agricultural return flows from surrounding Reclamation District drains are all necessary to meet the firm water supply needs for seasonal marsh management and permanent ponds.

Agricultural drainage from intensive rice production upstream of the area may potentially threaten the beneficial use of this water for wildlife habitat. Trace element concentrations in drainage water evaporation ponds have resulted in toxic effects on wildlife populations in the San Joaquin Valley and Tulare Basin of California. Historical data gathered on the west side of the Sacramento Valley has revealed elevated levels of selenium in fish and water samples, and rice herbicide concentrations have been linked to fish kills in agricultural drains of the Sacramento Valley.

A reconnaissance level water quality monitoring program was established to characterize all three water supply sources to the Gray Lodge Wildlife Management Area. The results of this investigation show that mineral and trace element water quality do not appear to be limiting factors in the beneficial use of water for wildlife habitat at this site. Selenium levels ranged from <0.2 - 0.8 µg/L with a median selenium value of 0.3 µg/L, which is well below the 5 µg/L EPA criterion for the protection of freshwater aquatic life and the 2 µg/L guideline utilized by the U.S. Fish and Wildlife Service in the management of federal refuges. Rice herbicide concentrations in agricultural drainage entering the management area were well below the guidelines established by

the California Department of Fish and Game for the protection of fish and aquatic invertebrates, although the potential affects of these levels on waterfowl are unknown as no criteria have been established for waterfowl protection. Disulfoton, an insecticide used on row crops, was detected at 1.4 µg/L in one sample which exceeds the criterion for the protection of freshwater aquatic life, and signals the possibility of short term exposure of wildlife to agrichemicals. However, the presence of this pesticide was not confirmed in follow-up sampling at the site. Sediment chemistry was evaluated at three drain sites on the management area boundary and compared to natural background levels in the western United States. Nickel was the only trace element present in concentrations above the natural background range. Potential sources and impacts of this elevated nickel are unknown, but nickel has not been associated with problems in other wildlife areas.

LOCATION

The Gray Lodge Wildlife Management Area (WMA) is owned and operated by the California Department of Fish and Game. The original 2540 acre Gray Lodge Gun Club was purchased in 1931 by the Governor's Conservation Fund to establish the first wildlife refuge in the Sacramento Valley. Gray Lodge lies two miles north of the Sutter Buttes in the heart of the Sacramento Valley. The refuge is in Butte and Sutter counties ten miles southwest of Gridley (Fig. 1). Four additional land acquisitions have enlarged the refuge to 8,400 acres. An additional 4,000 acre phased acquisition in 1988 - 1989 is in progress and will further increase the size of the refuge to 12,400 acres. A new management area, the Upper Butte Sink Unit is not contiguous with the current refuge, and water sources for this new wildlife management area are still under consideration. This recent land acquisiton extends the refuge into the Butte Sink which is an overflow area of Butte Creek and the Sacramento River.

LAND USE

The mandate of the wildlife management area is to provide suitable habitat for waterfowl and other wildlife species; to provide and produce native marsh plants and agricultural cereal crops to aid in preventing offsite crop depredation; and to provide recreational opportunities for bird and wildlife observation, hunting, and fishing.

Land uses on the Gray Lodge WMA include 3800 acres of native marsh, 2200 acres of permanent ponds, 1900 acres of uplands, 300 acres of winter wheat cultivation, and 400 acres of administrative grounds. Intensive marsh management including fall flooding and summer irrigation is practiced to provide native marsh food plants and a suitable marsh habitat for resident and migratory waterfowl and other wildlife species.

Rice production and cattle grazing are the major agricultural activities surrounding the wildlife management area. There are also limited plantings of orchard crops south of the refuge on the north flanks of the Sutter Buttes.

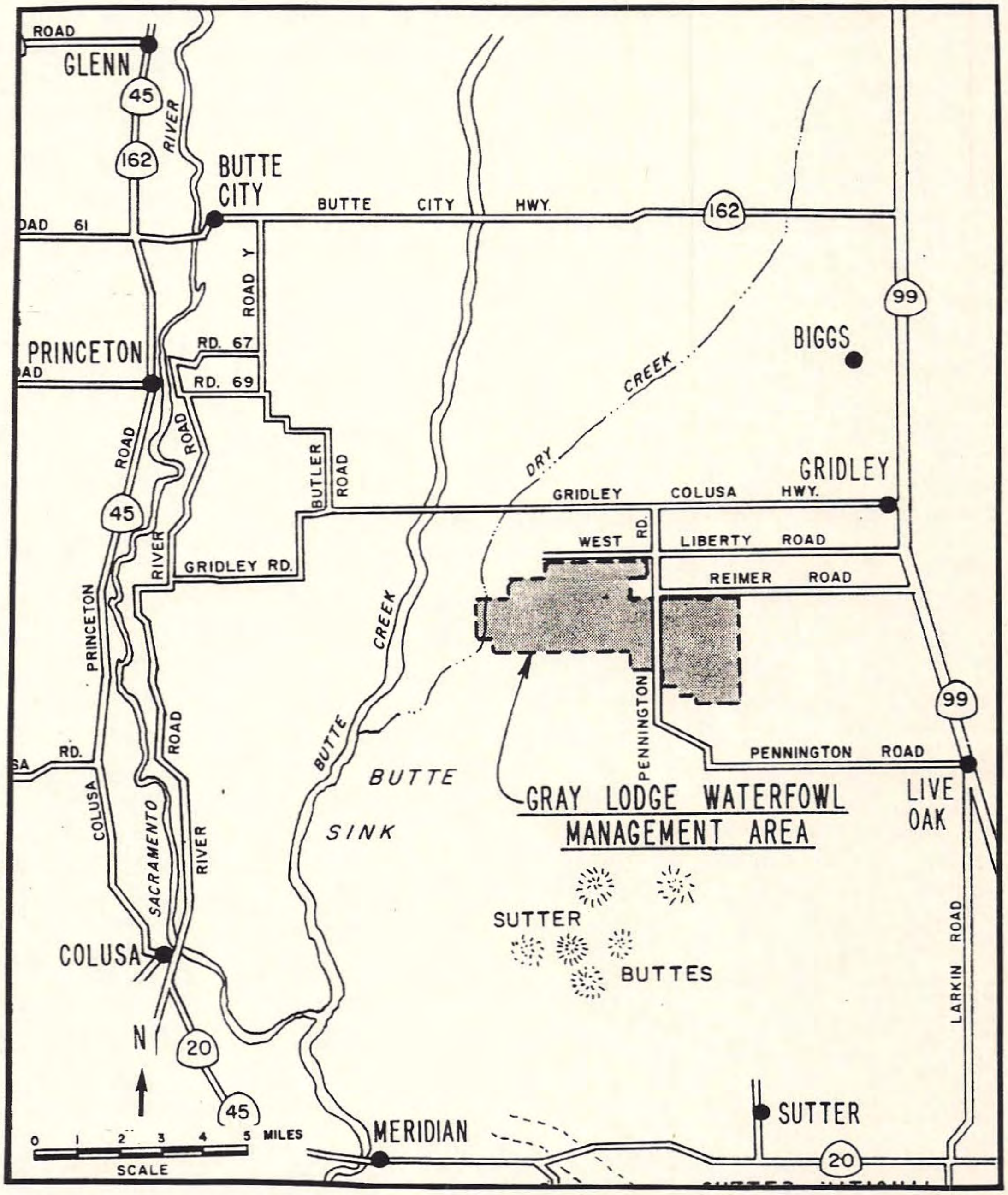


Fig. 1. Location Map

WILDLIFE

Gray Lodge WMA is a significant wintering area for migratory waterfowl of the Pacific Flyway. At peak periods (November through January) as many as two million waterfowl have been observed at the refuge. Pintail ducks are the predominant species, and Mallard, Baldplate, Shoveler, Green-winged Teal, and Gadwall ducks are also common. Mallards, Gadwall, Cinnamon Teal, Pintail, Shovelers, Redheads, and Rudy Ducks are known to nest at Gray Lodge WMA. Snow Goose, White Fronted Goose, Cackling Canada Goose, Ross Goose, Lesser Canada, and Canada Goose all rest and feed at Gray Lodge in the winter months, but none of the geese are year round residents. In addition to these migratory birds, many species of shore and wading birds, songbirds, and raptors, are included in the 225 species which have been observed at Gray Lodge WMA. Other wildlife resources at the refuge include upland game, furbearers, deer, and fish.

WATER SUPPLY AND MARSH MANAGEMENT

The three water supply sources utilized by Gray Lodge WMA include surface water deliveries from Biggs-West Gridley Water District, agricultural return flows from surrounding Reclamation District drains, and ground water from deep wells.

Surface Water Deliveries

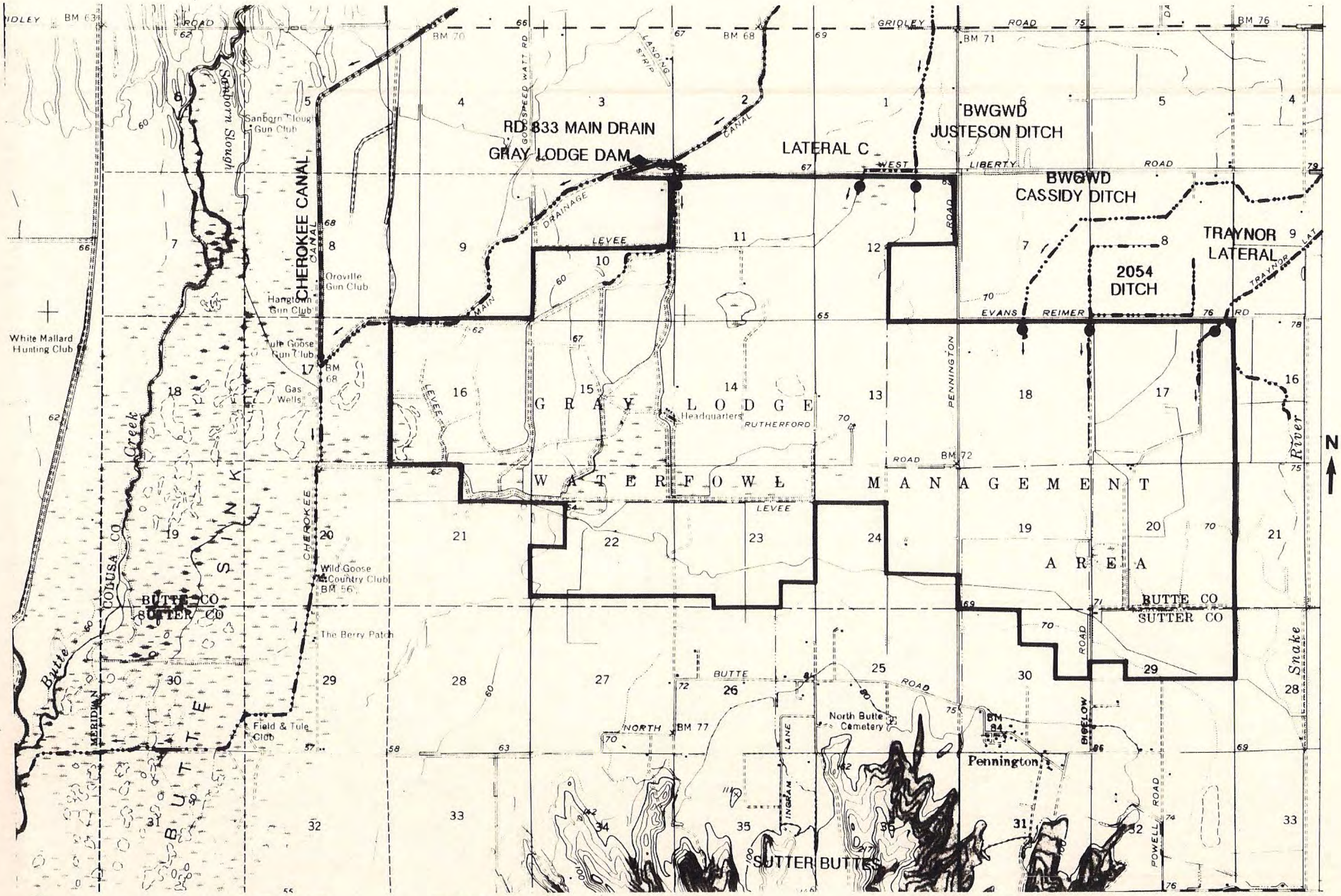
A portion of the Gray Lodge WMA (2600 acres) lies within the Biggs-West Gridley Water District (BWGWD), entitling the wildlife area to a secondary water allotment of 12,000 acre feet per year, if and when the water is available. The BWGWD irrigation season extends from April to October 31 each year, and historically no water has been available to the management area after this time as canals are dewatered for maintenance. The seasonality of the water availability restricts the refuge water purchases to 8,000 to 11,000 acre feet per year. In the 1987 and 1988 seasons, delivery of fresh canal water was extended through December 31 with extended deliveries totaling over 20,000 acre feet. The BWGWD delivers water to the wildlife management area through the Rising River, Cassidy, Justeson, and the Reclamation District 833 Lateral C ditches (Fig. 2). This Feather River water is wheeled to the District from the State Water Project's Thermolito Afterbay near Oroville.

Agricultural Return Flow Supply

Gray Lodge WMA diverts 14,000 to 16,000 acre feet of agricultural return flows from Reclamation District 833 and 2054 drains (Fig. 2). These drains carry irrigation tailwater from the Biggs-West Gridley Water District to Butte Creek and ultimately to the Sacramento River. The Lateral C may also deliver return flows to the wildlife management area. Agricultural land use within BWGWD includes 14,592 acres of rice, 2,654 acres of pasture, 1,278 acres of orchard and row crops, and 569 acres of wheat which receives only one flood irrigation (Jackson, 1987). Therefore, runoff from flooded rice fields accounts for the majority of the drainage water accepted by Gray Lodge WMA. The semi-aquatic rice crop is flooded throughout the growing season (April - September) with near continuous spill of water from check dams.

Marsh management techniques within the wildlife management area include seasonal native plant marshes and permanent ponds. Seasonal native plant marshes are most desirable because they produce the greatest variety and quantity of waterfowl food. Seasonal native marsh management precludes the use of large quantities of water during the summer months when most agricultural drainwater is available. The marshes are flooded in the fall, and water is added to replace evaporative losses and to maintain the ponds at the 4 to 8 inch (0.1 - 0.2 meter) minimum water depths required by waterfowl.

Agricultural drainwater is an important water source for Gray Lodge WMA, but the seasonality of drainwater availability limits its use to permanent ponds which are one to four feet (0.3 - 1.2 meters) deep. These deeper, continuously ponded areas produce fewer pounds of waterfowl food per acre than the seasonal marshes.



● SURFACE WATER MONITORING SITE — FLOW DIRECTION —··— WATER COURSE — REFUGE BOUNDAY

FIG. 2. SURFACE WATER FEATURES AND MONITORING SITES

Ground Water Supply

Gray Lodge WMA relies on ground water to meet its water supply needs from October through January. An average of 14,334 acre feet per year is pumped from 22 deep wells throughout the refuge. These wells account for approximately 40% of the total water supply on the refuge. Ground water pumpage is expensive, and water flow rates are less than ideal for optimum management, as rapid pond flooding and distribution is preferable from a marsh management standpoint.

POTENTIAL WATER QUALITY IMPACTS

Irrigation supply water delivered to Gray Lodge WMA from BWGWD is expected to be of good quality, reflecting its relatively short travel from its source in the Sierra Nevada to the east. The Butte Basin ground water pumped at Gray Lodge WMA is also expected to be of suitable quality for marsh management based on historical quality in the vicinity of the refuge. However, fresh surface water and ground water supply delivered to the refuge had not been evaluated at their point of use at the refuge prior to this investigation.

Agricultural drainage accounts for a substantial portion of the annual water needs at Gray Lodge WMA. The return flows are appropriated from Reclamation District drains which carry water that has been recycled onto fields as many as three times (Jackson, 1987). The quality of this water will reflect the amount of reuse and the type of crop it was applied to and drained from. Rice is the primary crop grown upstream of Gray Lodge WMA.

Rice is typically planted between mid-April and mid-May in the Sacramento Valley. Rice farmers prepare the soil for planting by soaking the fields with water to a depth of four to six inches (0.1 - 0.2 meters). The rice seed is aerially applied to the flooded fields. Rice plants begin to emerge from the water ten to fifteen days after planting. During this time, farmers apply herbicides such as molinate, thiobencarb, and bentazon to control aquatic weeds and sedges. In early to mid-June additional herbicides are applied to control broad-leafed weeds. As the crop grows, organophosphate and carbamate pesticides are applied if needed to control insect pest outbreaks. Copper sulfate is often used in the control of tadpole shrimp. The fields are irrigated throughout the summer, and there is some tailwater spilled to drainage canals which flow into Gray Lodge WMA throughout the growing season. In early August, the rice plants mature and begin to head out as individual grains develop. As the grains begin to ripen, water is drained from the fields in preparation for harvest in September. This field drainage accounts for a major portion of agricultural drainage entering and moving through Gray Lodge WMA.

The use of herbicides for the control of aquatic weeds is a major factor contributing to high yields of rice in the Sacramento Valley. Past monitoring has documented the presence of molinate and thiobencarb in Sacramento Valley canals and the Sacramento River (Cornacchia, et al., 1984). During the 1981 - 1983 rice growing seasons, extensive fish kills in agricultural drains have been attributed to high concentrations of molinate. Growers are now required to hold field water to promote dissipation of this chemical before the tailwater is released into local drains.

Agricultural drainwater in some areas of the Central Valley contains elevated levels of selenium and other trace elements which have been linked to avian reproduction failures and embryonic deformities. Historical data gathered on the west side of the Sacramento Valley has revealed elevated levels of selenium in fish and water samples from Black Butte Reservoir. There has been no direct evidence of a water quality impact on the aquatic ecosystem at Gray Lodge WMA, and there has been no previous attempt to characterize the water quality at this refuge. However, adjacent intensive agricultural land use practices and the reliance on agricultural drainwater as a refuge water supply prompted the need for this reconnaissance level assessment of potential water quality impacts at Gray Lodge WMA.

WATER QUALITY MONITORING

A water quality monitoring program was initiated in August 1986 to assess the quality of the Gray Lodge water supply for the current beneficial use. Surface water quality including agricultural drainage was evaluated for general minerals, trace elements, and pesticide concentrations. Ground water quality during fall floodup was evaluated for selenium and selected mineral composition. Sediment was collected from three drain locations and evaluated for trace element composition.

Water quality guidelines and criteria for the protection of freshwater aquatic life are shown in Table 1.

Table 1. EPA Ambient Water Quality Criteria for the Protection of Freshwater Aquatic Life

	Recommended Criteria		
Constituent	4 day average	1 hour average - µg/l - *	Maximum
pH			9.0 pH units
Alkalinity			> 20,000
Arsenic	190	360	
Cadmium	0.55	1.4'	
Chromium (III)	98	820	
Chromium (VI)	11	16	
Copper	5.4	7.5	
Iron			1,000
Lead (inorganic)	0.99	25	
Mercury	0.012	2.4	
Nickel	73	653	
Selenium	5	20	
Silver			0.84
Zinc	49	54	

* Acid soluble metals, value not to be exceeded more than once every 3 years on the average

' Value increases with hardness increase > 40 mg/L

(References: Marshack, 1988; EPA, 1987; EPA, 1979)

Water quality monitoring results from Gray Lodge WMA have been evaluated with regard to these criteria. It should be recognized that the EPA criteria have been specifically developed for the protection of fish, shellfish, and other invertebrates. Although these criteria may not be directly applicable to the protection of wildlife habitat due to the many differences between the species and potential biomagnification in the food chain, they are still the best guidelines available at the present time for the prevention of negative impacts on the wildlife resource.

Surface Water Quality

Mineral and Trace Element Concentrations

Surface water deliveries to Gray Lodge WMA were sampled monthly August and September 1986, and May through September 1987. Surface water quality monitoring sites are shown in Figure 2. Each drain was sampled if water was flowing into the refuge at the time of collection. These monthly grab samples were analyzed for general minerals and total recoverable trace elements. Water temperature, electrical conductivity, pH, and time of collection were recorded in the field. Mineral samples were kept on ice until submitted to the laboratory for analysis. Selenium and other trace element samples were preserved with ultra-pure nitric acid to lower the pH of the sample to <2 pH units. A quality control and quality assurance program included the evaluation of spike and duplicate samples in the laboratory. In addition, blind replicate samples were collected at ten percent of the field sites, and fifty percent of the blind replicates were spiked for an additional check on laboratory performance. Results reported in Table 2 fall within the quality assurance tolerance guidelines.

Salinity measured as electrical conductivity ranged from 59 - 92 µmhos/cm for the BWGWD supply water and from 77 - 290 µmhos/cm for the agricultural drainwater, and median salinity for all samples was 195 µmhos/cm. A Piper trilinear diagram was evaluated to illustrate the ionic composition of surface water received at Gray Lodge WMA (Fig. 3). This plot shows relative contributions of major cations and anions to the total ionic content of each water sample for which an extensive mineral analysis was performed.

Table 2. Mineral Water Quality of Surface Water Deliveries to the Gray Lodge Wildlife Management Area

SAMPLE SITE	SAMPLE DATE	TEMP. °F	EC µmos/cm	pH	Ca	Mg	Na	K	Cl	SO4	B	TDS	TOTAL ALK.	SUS SOLIDS	TOTAL HARD
								——	mg/l	——					
833 Drain	8/20/86	73	180	7.5	12	9	6	1.2	1	5	<0.01	110	86	19	77
	9/3/86	69	200	7.6	18	11	7	1.5	2	6	<0.01	135	94	25	86
	5/26/87	NO FLOW													
	6/25/87	78	250	7.4			7		2	7	0.16		120		
	7/28/87		220												
	8/20/87		210												
	9/3/87		290						2	7	0.03		130		
833 Lateral C	8/20/86	75	240	7.8	14	13	8	1.6	1	3	<0.01	150	110	19	98
	9/3/86	69	190	7.7	19	12	6	1.5	1	3	<0.01	140	96	21	88
	5/26/87		213	8					<2	5	<0.05				
	6/25/87	77	260	7.5					1	4	0.13		130		
	7/28/87		250						4	6	0.04		120		
	8/20/87	NO FLOW													
	9/3/87								2	4	0.02		110		
Justeson Ditch: BWGID Drain @ W. Liberty Rd.	8/20/86	NO FLOW													
	9/3/86	70	77	7.4	9	3	3	1.2	1	2	<0.01	70	32	36	32
	5/26/87	NO FLOW													
	6/25/87	NO FLOW													
	7/28/87	NO FLOW													
	8/20/87	NO FLOW													
	9/3/87								2	3	<0.02		51		
Cassidy Ditch: BWGID Drain @ Evans Reimer Rd.	8/20/86	NO FLOW													
	9/3/86	NO FLOW													
	5/26/87		85	8.4					<2	<5	<0.05				
	6/25/87		120	6.4					1	2	0.09		38		
	7/28/87	NO FLOW													
	8/20/87	NO FLOW													
	9/3/87	NO FLOW													
2054 Drain @ Evans Reimer Rd.	8/20/86		130	7.1	7	6	4	1.4	2	6	<0.01	76	60	12	56
	9/3/86		175	7.4	14	9	5	1.6	1	3	<0.01	97	72	11	64
	5/26/87														
	6/25/87		270	6.6					1	<2	0.13		92		
	7/28/87								3	3	0.01		100		
	8/20/87	NO FLOW													
	9/3/87								1	4	0.02		96		
Traynor Lateral of Rising River Ditch: BWGID Canal Evans Reimer Rd.	8/20/86		59	8.1	6	3	3	0.9	1	3	<0.01	54	36	12	32
	9/3/86		80	7.5	8	3	3	1.0	1	2	<0.01	40	32	12	28
	7/28/87								1	2	0.03		40		
	9/3/87		92						1	<2	<0.02		40		

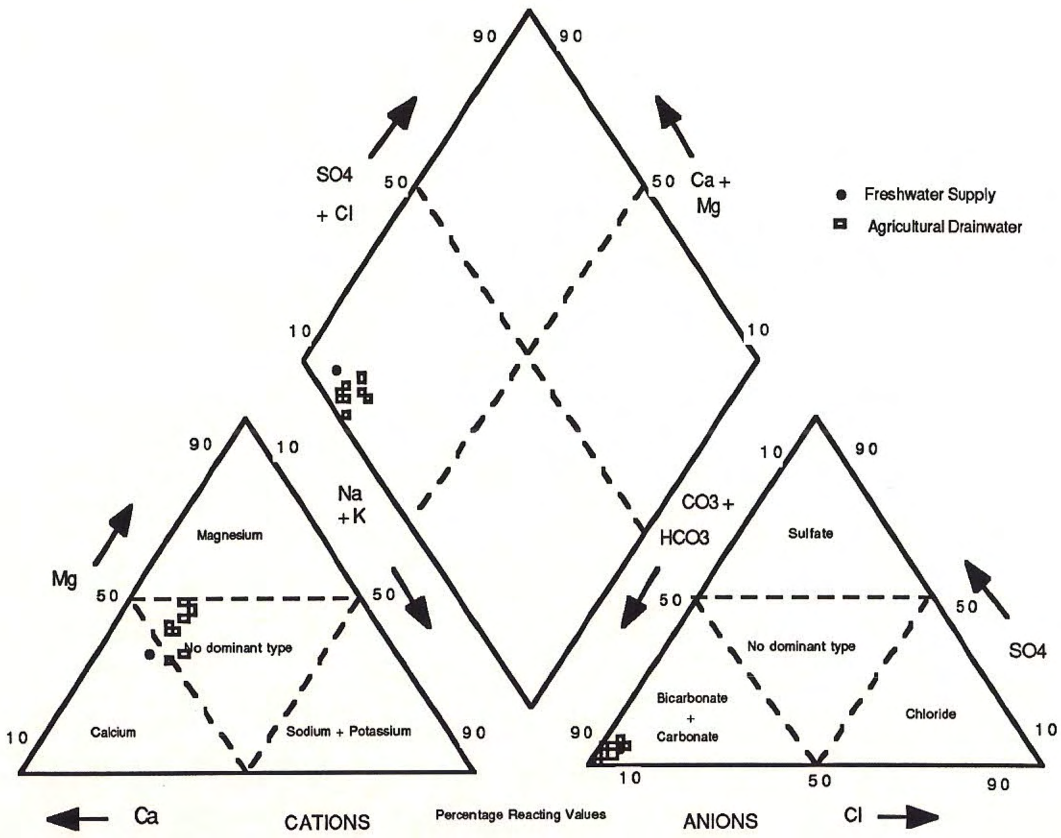


Fig. 3. Major ion composition of freshwater and drainwater deliveries to Gray Lodge.

Thermolito Afterbay fresh water deliveries to Gray Lodge WMA from the Traynor Lateral of the BWGWD Rising River Ditch and agricultural drainage samples show a mixed calcium-magnesium cation character reflecting a history of blending and reuse.

Trace element analyses of surface water samples are reported in Table 3. Selenium levels ranged from <0.2 - 0.8 µg/L with a median selenium value of 0.3 µg/L, which is well below the 5 µg/L EPA criterion for the protection of freshwater aquatic life and the 2 µg/L guideline used by the U.S. Fish and Wildlife Service for management of federal wildlife refuges. Copper compounds are used extensively in rice production. Total recoverable copper concentrations were measured at 1 - 5 µg/L with a median concentration of 2 µg/L. Two samples taken 25 June 1987 approached the EPA criterion of 5.4 µg/L when copper was detected at 5.0 µg/L in the RD 833 drain and the 2054 ditch on Evans - Reimer Road, but none of the samples exceeded this criterion. Zinc was detected in the range of 1 - 13 µg/L but never approached the 49 µg/L criterion established for this constituent. Molybdenum, chromium, lead, nickel, and cadmium were not present in water samples above the limits of analytical detection. Total dissolved arsenic was detected one time in the 833 drain at 14 µg/L, while the current arsenic criterion for the protection of aquatic life is 190 µg/L as trivalent inorganic arsenic. This current arsenic criterion is under review and the EPA has determined that a downward adjustment is necessary. Some aquatic species are adversely affected at water concentrations of 19 - 48 µg/L (Eisler, 1988). Arsenic does not appear to be an element of concern at Gray Lodge WMA. The mineral and trace element water quality do not appear to be limiting factors in the beneficial use of water for wildlife habitat at Gray Lodge WMA.

Pesticides

As it is likely that agricultural chemicals flow into Gray Lodge WMA via return flows from surrounding rice fields, a monitoring program was established to quantify the levels of the chemicals and determine if they may pose a threat to the wildlife resource. A weekly pesticide monitoring program was conducted

Table 3. Trace Element Concentrations in Surface Water at Gray Lodge Wildlife Management Area

SAMPLE SITE	SAMPLE DATE	EC µmhos/cm	Se	Mo	Cu	Cr	Pb	Ni	Zn	As	Cd
			— µg/L total recoverable trace elements —								
833 DRAIN	8/20/86	200	0.4	<5	3	<1	<5	<5	9	<10	<1
	9/3/86	180	0.3	<5	3	2	<5	<5	9	<10	<1
	3/25/87	570	0.3	<5	<1	<1	<5	<5	3	14	<0.1
	6/25/87	220	0.8	<5	5	3	<5	<5	13	<10	<1
	7/28/87	220	<0.2	<5	4	2	<5	<5	5		
	8/20/87	210	0.2								
	9/3/87	290	0.2								
833 Lateral C	8/20/86	175	0.3	<5	3	<1	<5	<5	7	<10	<1
	9/3/86	175	0.3	<5	2	2	<5	<5	5	<10	<1
	5/26/87	200	0.3	<5	2	2	<5	<5	4	<4	<1
	6/25/87	200	0.6	<5	4	3	<5	<5	3	<4	<1
	7/28/87	240	<0.2	<5	2	<1	<5	<5	1		
	8/20/87	260	0.3								
	9/3/87	260	0.2								
BWGID Drain @ W.Liberty Rd	9/3/86	70	0.3	<5	3	3	<5	<5	8	<10	<1
	9/3/87	110	0.4								
BWGID Drain Evans Reimer Rd.	5/26/86	85	0.7	<5	2	1	<5	<5	<1	<4	<1
2054 Drain Evans Reimer Rd	8/20/86	130	0.3	<5	2	<1	<5	<5	7	<10	<1
	9/3/86	175	<0.2	<5	1	1	<5	<5	4	<10	<1
	6/25/87	270	0.4	<5	5	2	<5	<5	2	<10	<1
	7/28/87	180	0.3	<5	<1	<1	<5	<5	1	<10	<1
	8/20/87	180	0.7								
	9/3/87	200	0.3								
BWGID Canal Evans Reimer Rd.	8/20/86	59	0.3	<5	2	<1	<5	<5	5	<10	<1
	9/3/86	80	0.7	<5	2	1	<5	<5	6	<10	<1
	6/25/87	120	0.5	<5	<1	2	<5	<5	<1	<10	<1
	7/28/87	85	0.2	<5	1	2	<5	<5	1		
	8/20/87	80	0.5								
	9/3/87	92	0.3								

13 May 1987 through 3 June 1987. This time period brackets the expected dates of potential peak agricultural chemical runoff from rice fields in the Sacramento Valley. Peak concentrations of rice herbicides are historically detected between 20 May and 1 June in the regional Colusa Basin Drain (CBD). The California Department of Food and Agriculture (CDFA) 1987 rice herbicide monitoring program revealed peak concentrations of rice herbicides in the CBD and the Sacramento River between May 11 and June 4, and the overall mass loading of rice herbicides to the Sacramento River was the lowest ever recorded due to increased grower participation in water recycling programs, longer holding times for field drainage discharges, and record high air temperatures in May which resulted in lower application rates due to phytotoxicity and accelerated volatilization rates of both molinate and thiobencarb (CDFA, 1987).

Samples were taken from the RD 833 Lateral C drainage canal, BWGWD Cassidy Ditch, and the RD 833 main drain. The RD 833 Lateral C was conveying the highest flows to the refuge during this monitoring period, and it was sampled weekly. The remaining drains were only sampled when significant flow was entering the refuge. Pesticide samples were collected in one liter amber glass bottles which were sealed with teflon-lined caps. Samples were collected 0.5 meters (20 inches) below the water surface at the midstream point of each drain. Water bottles were completely filled to allow no air interface with the sample. Samples were placed on ice immediately after collection. Results of this monitoring program are recorded in Table 4.

The California Department of Fish and Game (CDFG) has established recommended guidelines for protecting fish and aquatic invertebrates from rice herbicide exposure in agricultural drains (CDFG, 1986). The recommended interim guideline for molinate (Ordram ®) of 90 µg/L was based on the incipient lethal level to carp during a 21 day exposure. The recommended guideline for thiobencarb (Bolero ®) is 24 µg/L based on the estimated safe level for larval striped bass in the Delta. A thiocarbamate scan was performed on water samples to evaluate concentrations of molinate and thiobencarb. Bentazon (Basagran ®) is a third rice herbicide which is used extensively in the Butte Basin. The EPA and CDFG consider bentazon to be

Table 4. Pesticide concentrations in agricultural drainage canals.

SAMPLE SITE DATE	PESTICIDE (µg/L) Thiocarbamates: Molinate	Thiocarbamates: Thiobencarb	Thiocarbamates: Eptam	Carbamates: Carbofuran	Carbamates: Carbaryl	OP Screen*	Xylene
LATERAL C							
13-May-87	1.3	0.24	ND (0.2)	ND (1.0)	ND (1.0)		
20-May-87	37	ND (0.4)	ND (0.4)			Disulfoton 1.4	
26-May-87	11	ND (0.4)	ND (0.4)			ND (0.4 - 1.0)	ND (0.5)
3-Jun-87	1.8	ND (0.2)	ND (0.2)			ND (0.4 - 1.0)	
BWGID CASSIDY DITCH							
20-May-87	1.1	ND (0.4)	ND (0.4)			ND (0.4 - 1.0)	
26-May-87	ND (0.4)	ND (0.4)	ND (0.4)			ND (0.4 - 1.0)	
RD 833 DRAIN							
3-Jun-87	5.3	ND (0.2)	ND (0.2)			ND (0.4 - 1.0)	

*OP Screen = Organophosphate Pesticides:
Phosdrin, Phorate (Thimet), Diazinon, Disulfoton (Disyston), Dimethoate, Baytex (Fenthion), Dursban (Chlorpyrifos), Methyl parathion, Malathion, Ethyl Parathion, DEF, Ethion, Carbophenothion (trithion), Azinphos-methyl (guthion).

ND = None Detected (Detection Limit Listed) nontoxic to fish and aquatic invertebrates (CDFG, 1986). Therefore, bentazon levels were not considered in this monitoring program. In addition to molinate and thiobencarb, EPTC (Eptam ®) was included in the thiocarbamate scan. This herbicide was not detected in any of the water samples collected at Gray Lodge WMA.

Molinate was the most consistently detected pesticide at Gray Lodge WMA, and it was found in six of seven pesticide samples collected from refuge drains. Molinate concentrations were detectable in The 833 Lateral C Drain, Cassidy Ditch, and the RD 833 drain canal. The range of molinate concentrations detected during the peak rice herbicide runoff season was 1.1 - 37 µg/L (Fig. 4). All detections were below the 90 µg/L recommended level which has been established by CDFG. The peak molinate concentration was detected at 37 µg/L on 20 May 1987 in the 833 Lateral C drain. Figure 4 illustrates the concentrations of molinate with respect to time during the monitoring program.

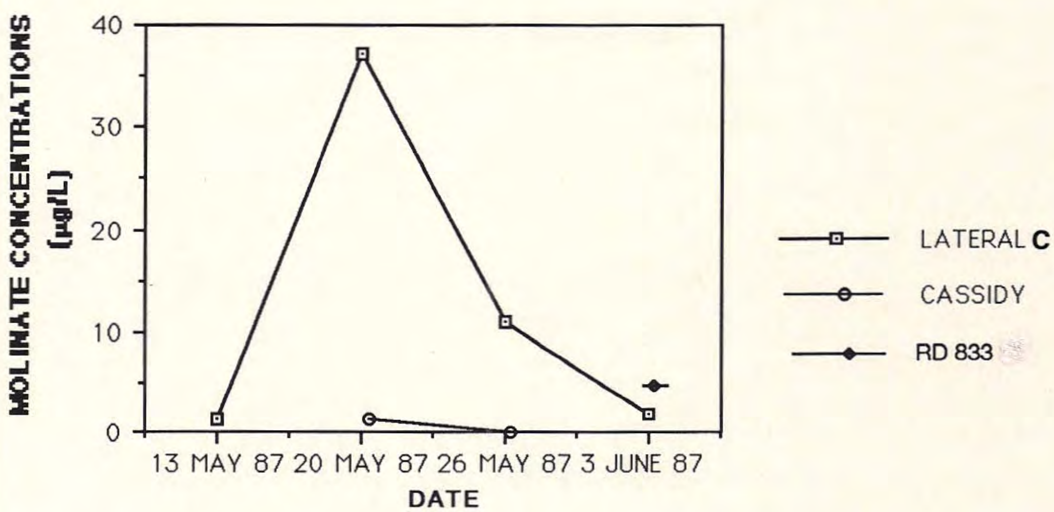


Fig. 4. Molinate concentrations in agricultural return flows entering Gray Lodge Wildlife Management Area.

Thiobencarb was only detected in one sample collected at Gray Lodge WMA. Thiobencarb was recorded at 0.24 µg/L in the 833 Lateral C drain on 13 May 1987, which is well below the 24 µg/L level of concern. The most heavily used rice herbicides do not appear to have impacted the Gray Lodge fish populations during the 1987 runoff season. The potential affects of these rice herbicide levels on waterfowl are unkown as no criteria have been established for waterfowl protection.

CDFG has also been concerned about the pesticides MCPA, methyl paration, ethyl parathion, and carbofuran which are all used on rice, but these pesticides have not appeared at problem levels in past monitoring programs in the Sacramento Valley. The carbamates carbofuran and carbaryl were not detected in a sample analyzed from the RD 833 Lateral C drain. A single sample was analyzed for xylene, and was nondetectable. This volatile organic compound is a common carrier in pesticide formulations. An organophosphate pesticide screen was performed on six water samples collected 20 May 1987 through 3 June 1987. Phosdrin, phorate, diazinon, dimethoate, fenthion, chlorpyrifos, methyl parathion, malathion, ethyl parathion, DEF, ethion, trithion, and azinphos-methyl were not detected in any samples. Disulfoton (Disyston ®) was detected at 1.4 µg/L on 20 May 1987 in the 833 Lateral C drain. Disulfoton is an organophosphate plant systemic insecticide which is toxic to sucking insects which feed on plant juices. Disulfoton is not used on rice, but it is used for insect control on wheat, alfalfa, corn, and sugarbeets which are minor crops upstream of the refuge. The organophosphate pesticides tend to break down quickly in the environment and do not bioaccumulate through the food chain. However, exposure to high levels of disulfoton can be toxic to waterfowl, fish, and aquatic invertebrates (Hudson, et al., 1984 and Johnson, et al., 1980). The current EPA criterion for the protection of freshwater aquatic life is a maximum value of 0.05 µg/L for Dysyston ®. The one time detection of 1.4 µg/L was not confirmed in followup sampling at Gray Lodge WMA, but a high analytical detection limit of 1.0 µg/L was a limiting factor due to matrix interference in the samples. The one time detection does illustrate the possibility of short term exposure to agrichemicals through drainwater which have the potential to impact the wildlife resource.

GROUND WATER QUALITY

Ground water of the Sacramento Valley can be divided into six hydrochemical facies having distinctive chemical compositions (Hull, 1984). Gray Lodge WMA well water is extracted from the Butte Basin hydrochemical facies which coincides with the Butte flood basin. The Butte Basin extends from Chico in the north to Sutter Buttes in the south. The western boundary of the basin is the Sacramento River, and the Feather River delineates the eastern boundary. Butte Creek and the Butte Sink are major surface hydrologic features in the basin.

Reducing conditions in the Butte Basin fine-grained flood basin deposits may result in higher concentrations of iron, manganese, arsenic, and potassium than are found in ground water away from the valley axis, however past monitoring has detected low absolute concentrations of these constituents. The recharge areas for this basin are the Tuscan volcanic rock facies and the Victor Plain to the north and east of the basin, and the alluvial deposits flanking Sutter Buttes. The Tuscan formation contains andesitic sands, extensive tuff deposits, and volcanic glass. Silica concentrations throughout Butte Basin ground water are high due to solution of volcanic glass from the Tuscan volcanics and Sutter Buttes (Hull, 1984).

The ground water elevation under Gray Lodge WMA is 50 to 60 feet below mean sea level. The regional ground water flow is south - southeasterly towards the Sacramento River. Butte Basin ground water is dominated by calcium-magnesium bicarbonate or magnesium calcium bicarbonate ions (Fogelman, 1977).

Refuge wells used for fall flooding of seasonal wetlands were sampled on 22 October 1986 for total recoverable selenium, chloride, sulfate, boron, and total alkalinity. All wells sampled had been pumping contiuously since 15 September 1986. Electrical conductivity and temperature of the samples was measured in the field. The location of these wells is shown in Fig. 5. Analysis

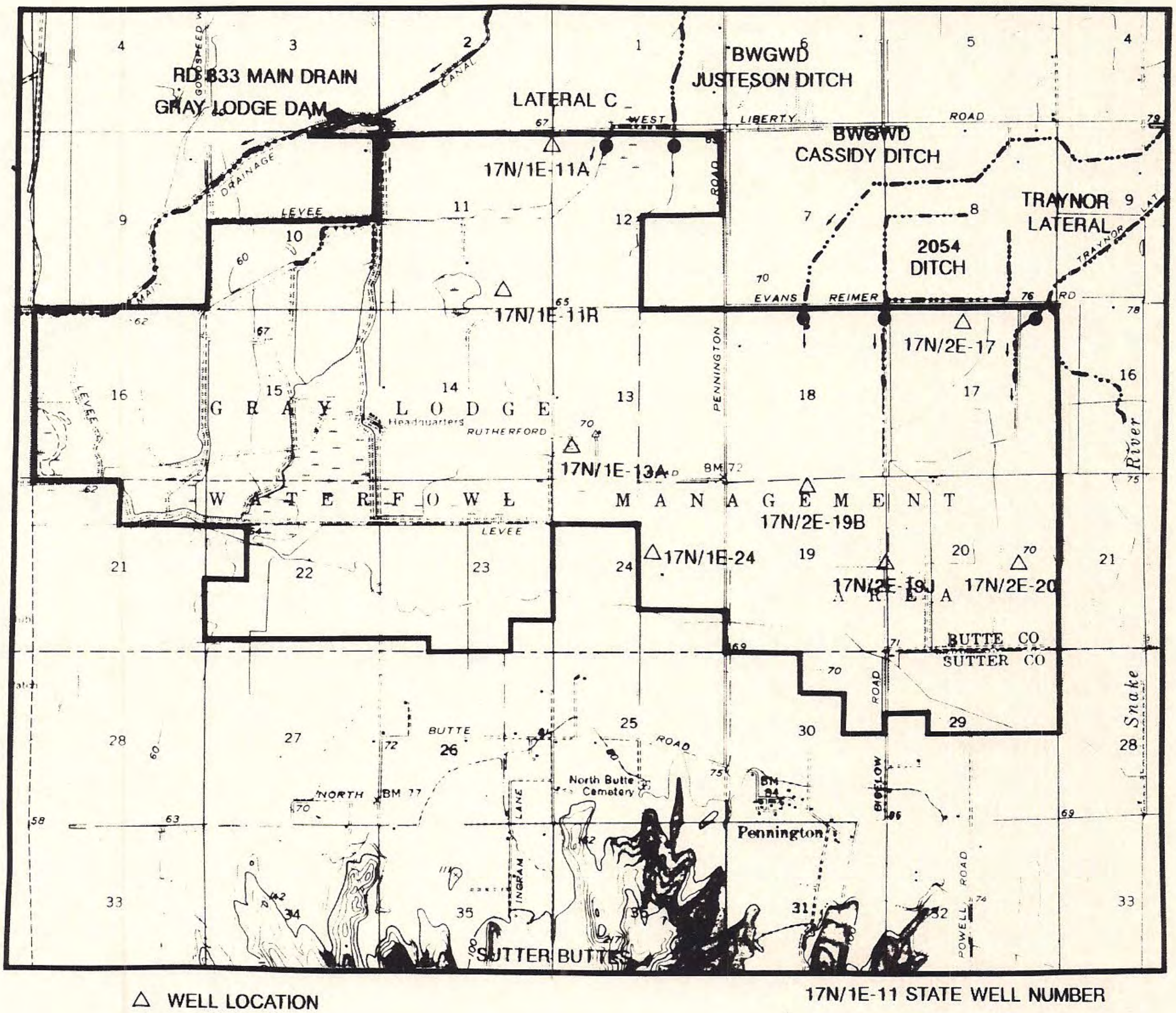


Fig. 5. Ground Water Well Locations

of these samples reveals a high quality ground water supply with low alkalinity, boron, and salt content (Table 5).

Table 5 . GRAY LODGE WILDLIFE MANAGEMENT AREA
GROUNDWATER QUALITY: OCTOBER 22, 1986

STATE WELL NO.	GRAY LODGE WELL NO.	WELL DEPTH-ft	Temp. °F	EC µmos/cm	Se µg/L*	Cl	SO4	B	Total Alkalinity
							mg/L		
17N/1E-24	15	365	65	270	0.5	8	5	0.13	140
17N/1E-13A1	14	500	67	230	0.3	5	4	0.11	120
17N/1E-11R	28	531	64	240	<0.2	8	4	0.05	120
17N/1E-11A	7	500	62	245	<0.2	5	6	0.05	140
17N/2E-19B	17	500	67	245	0.6	6	3	0.13	140
17N/2E-19J	22	362	65	330	0.5	7	4	0.09	180
17N/2E-20	26	252	66	295	0.9	6	4	0.09	160
17N/2E-17	18	250	64	440	0.5	7	9	0.04	270

The range of selenium in the wells used for fall marsh floodup was <0.2 - 0.9 µg/L with a median of 0.5 µg/L. These selenium levels are well below the current 5.0 µg/L Environmental Protection Agency (EPA) criterion for the protection of freshwater aquatic life. The low selenium levels are also well below the U.S. Fish and Wildlife Service recommendation of a maximum 2.0 µg/L selenium in water applied to wildlife habitat.

SEDIMENT CHEMICAL ANALYSIS

Bottom sediment samples were collected from two channels at the refuge boundary which transport agricultural return flows into Gray Lodge WMA. Three samples were analyzed from drains which were carrying return flows at the time of collection. The samples each represent a composite of six collections from a random transect across the drain. Each sample consisted of approximately 100 grams of wet sediment from the top 0 to 7 cm (0 to 3 inch) layer of bottom material. A modified soil sampler with an acid-rinsed PVC collection tube was utilized for the collection of material. Each composite sample was analyzed on a dry weight basis for 13 trace elements, including selenium and arsenic. All data are reported in Table 6.

No specific guidelines have been established for concentrations of trace elements in bottom sediments of natural systems. The relationship between

Table 6. Comparison of Gray Lodge drain sediment chemistry to natural background levels and to sites with documented wildlife impairments.

	Gray Lodge Sample Site			Comparison Data				
	RD 833	2054	2054	Baseline Range	BGM	CA Mean	KR2	TLDD-S
Constituent	Total dissolved, dry weight (mg/kg)							
Mercury	0.10	0.10	0.10	0.0085-0.25	0.046			
Arsenic	8.30	6.45	7.75	1.2 - 22	5.5		< 10	4.00
Selenium	0.55	0.45	0.65	0.039 - 1.4	0.23		**5.2**	0.9
Copper	50	61	50	4.9 - 90	21	14.6	9	6
Zinc	69	81	71	17 - 180	55	60.4	39	20
Nickel	**81**	**72**	**76**	3.4 - 66	15	14.1	32	7
Molybdenum	2	1	2	0.18 - 4.0	0.85		< 2	**18**
Cadmium	<1	<1	<1			0.34	< 2	< 2
Chromium	73	92	75	8.5 - 200	41	15.4	45	12
Strontium	87	66	90	43 - 930	200		330	760
Barium	443	212	462	200 - 1700	580		820	690
Lead	20	20	19	5.2 - 55	17	16.6	20	10
Vanadium	113	88	114	18 - 270	70		55	28

Comparison data:
Baseline Range, Western U.S.: (U.S. Geological Survey, 1984)
BGM = Baseline Geometric Mean (U.S.Geological Survey, 1984)
CA Mean = California Background Mean (University of California, Davis, 1984)
KR2: Kesterson Reservoir, Pond 2 , May 1985 sediment analysis.
TLDD-S: Tulare Lake Drainage District South evaporation basin, November 1987 sediment analysis.
Bold type indicates measurements above natural background levels.

bottom sediment chemistry and concentrations of trace elements in the overlying water is extremely variable and dependant on factors such as water pH, temperature, dissolved oxygen level, biological activity, and solubility characteristics of the individual elements. Trace element availability for dissolution into the water column cannot be determined within the scope of this study. However, analysis of bottom sediment can indicate occurrence of concentrations significantly greater than natural background levels. The analyses can also be compared to data collected at sites with documented problems related to wildlife contact with agricultural drainage.

Because of the absence of trace element criteria for bottom sediment, analytical results from the Gray Lodge WMA samples are compared in Table 6 to geochemical baseline information from soils of the western United States as compiled by the U.S. Geological Survey (Shacklette and Boerngen, 1984). The guidelines have been used to evaluate sediment quality data from the U.S. Department of the Interior's (DOI) agricultural drainage investigations at National Wildlife Refuges throughout the western United States. The expected 95 percent geochemical baseline ranges were calculated from over 700 natural soil samples from locations west of the 97th meridian within the United States. Geometric means of this background data are also reported. The DOI Task Group on Irrigation Drainage has developed guidelines to assist study teams in comparing data to these background levels (Wells, et. al, 1988). The data was also compared to mean background levels of heavy metals in selected California soils (University of California, Davis, 1984). The geochemical baselines have been developed from soil data and can only be compared to sediment data and serve as an indicator of uncommonly high or low trace element concentrations. Data is not available to calculate trace element background levels in natural sediments throughout California or the western United States. For comparison purposes, Table 6 also reports a summary of total bottom-sediment concentrations of trace elements from Kesterson Reservoir and the Tulare Lake Drainage District South agricultural drainage evaporation basin. These extreme examples are sites where agricultural drainage has been associated with documented wildlife deformities.

The selenium content of bottom sediment of these composite samples ranged from 0.45 - 0.65 µg/g, which is greater than the geometric mean selenium concentration of 0.23 µg/g is soils of the western United States, but well within the baseline range of 0.039 - 1.4 µg/g of these soils, and well below the 4.0 µg/g cleanup level which was established for Kesterson Reservoir sediment.

Copper compounds are used as algacides and in the control of tadpole shrimp in rice fields. Copper was detected in bottom sediment at 50 - 61 µg/g which is greater than the background geometric mean copper concentration of 21 µg/g for soils of the western United States, but within the baseline range of 4.9 - 90 µg/g.

Nickel was the only constituent measured in sediment at Gray Lodge which exceeded the baseline range data. Nickel was detected at 72 - 81 µg/g, while the baseline range is 3.4 - 66 µg/g. Potential sources and impacts of this elevated nickel are unknown, but nickel has not been associated with problems in other wildlife areas, and no problems have been observed at Gray Lodge.

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