Memorandum

(36)

To : Ms. Carolyn Brown
Caltrans District 03
Marysville, California 95901

Date : March 4, 1993

From : Department of Fish and Game

Subject : Final Report--Giant Garter Snake Study

Enclosed are two (2) copies of the Final Report for Interagency Agreement 03E325 (FG7550).

I have enclosed two complete copies including photo copies (black and white) of the original color photos. The captions for figures 6, 11, and 13 have been revised (corrected) and I have enclosed two copies of these on blank pages for use with your original color photos.

The only thing I see that may need some revision (on your part) is the identification of the parties involved with "canal management" (see page 17).

The following information has been added to the final report: 1) a brief description of the results of the feeding studies (page 21) and 2) a section on movements (pages 30-34).

I have also reformatted the paper so the headings and subheadings are more consistent.

This should complete our contract. Any minor changes you wish to make can certainly be incorporated before the report is made available for "distribution". Availability of the report is probably something we should discuss.

Happy Reading!

John M. Brode
Endangered Species Project
Inland Fisheries Division

JMD:alg

cc: Mr. George E. Hansen

Results of Relocating Canal Habitat of the Giant Garter Snake (*Thamnophis gigas*) During the Widening of State Route 99/70 in Sacramento and Sutter Counties, California

by

George E. Hansen 2/

and

John M. Brode 3/

ABSTRACT

Newly constructed or modified agricultural canals were monitored to determine the time and conditions required for establishment of habitat suitable for the giant garter snake (*Thamnophis gigas*). Although it was determined that giant garter snakes had the ability to travel the distances required to colonize the new canals, none of the new canals studied provided suitable giant garter snake habitat by the end of the four-year study, and none were colonized by giant garter snakes. Continual or annual grading, mowing, and chemical treatment were the main factors that prevented the establishment of vegetative cover and other physical attributes of giant garter snake habitat.

dispersal ability?

threats

1/ Final Report for Caltrans Interagency Agreement 03E325 (FG7550) (FY 87/88-91/92).

2/ Consulting Environmental Biologist, 3230 Brookwood Road, Sacramento, California, 95821.

3/ California Department of Fish and Game, Inland Fisheries Division, 1701 Nimbus Road, Suite C, Rancho Cordova, 95670.

STUDY AREA AND DESIGN

The study area is located within the American Basin north of Sacramento within Sacramento and Sutter counties (Figure 1). It comprises nearly 15 square miles of agricultural land (mainly devoted to rice culture) distributed along and bisected by approximately seven miles of SR 99/70. An intricate network of canals and drainage ditches provide the area with the irrigation water required by rice and other crops during the warm summer growing season. The drainage system also removes runoff during storms, protecting the area from widespread flooding. GGS are known to inhabit this drainage and irrigation system.

During the course of widening SR 99/70 from 1988-1991, approximately 32 miles of the study area's nearly 50 miles of major drains and canals were relocated (filled in and reconstructed at another location) or channelized (cleared of vegetation and sediment, and banks compacted). These "disturbed canals" (DC's) served as project study sections where habitat recovery and GGS recolonization were monitored. Undisturbed waterways served as project control sections (CS's). Sampling along the nearly 18 miles of CS's provided a means of comparing seasonal habitat and GGS activity within undisturbed habitat with that along the recovering project DC's.

Originally, the study area included all DC's within one mile east and west of SR 99/70 and from 0.6 miles north of Elverta Road to 1.2 miles north of Sankey Road, Sacramento and Sutter counties (Figures 2 and 3). This area encompassed all proposed construction and habitat disturbance associated with the American Basin portion of this highway project. The study area was expanded to the south during 1989 to include portions of the East Drainage Canal (located north of Elverta Road and within one and one half miles east of SR 99/70) in order to include examples of both recently recovered and undisturbed GGS habitats as control study sections and to increase the potential for GGS sightings.

Control study sections (CS's) were chosen along undisturbed canals (UC's) where they interconnected with different DC's (Figure 4). Photo Stations (PS's) were established to document habitat recovery along the DC's and to provide views of intersecting UC's where appropriate (Figure 4). Additionally, CS's and PS's were established east and west of Route 99 at Howsley Road. GGS sampling stations were established throughout the study area, on UC's and DC's and at their intersections (Figure 5).

Continual disturbance by construction and maintenance activities in the northern and western sections of the study area prevented habitat recovery there during 1988-89. Therefore, the study area was modified. During 1990-1991, GGS sampling was concentrated

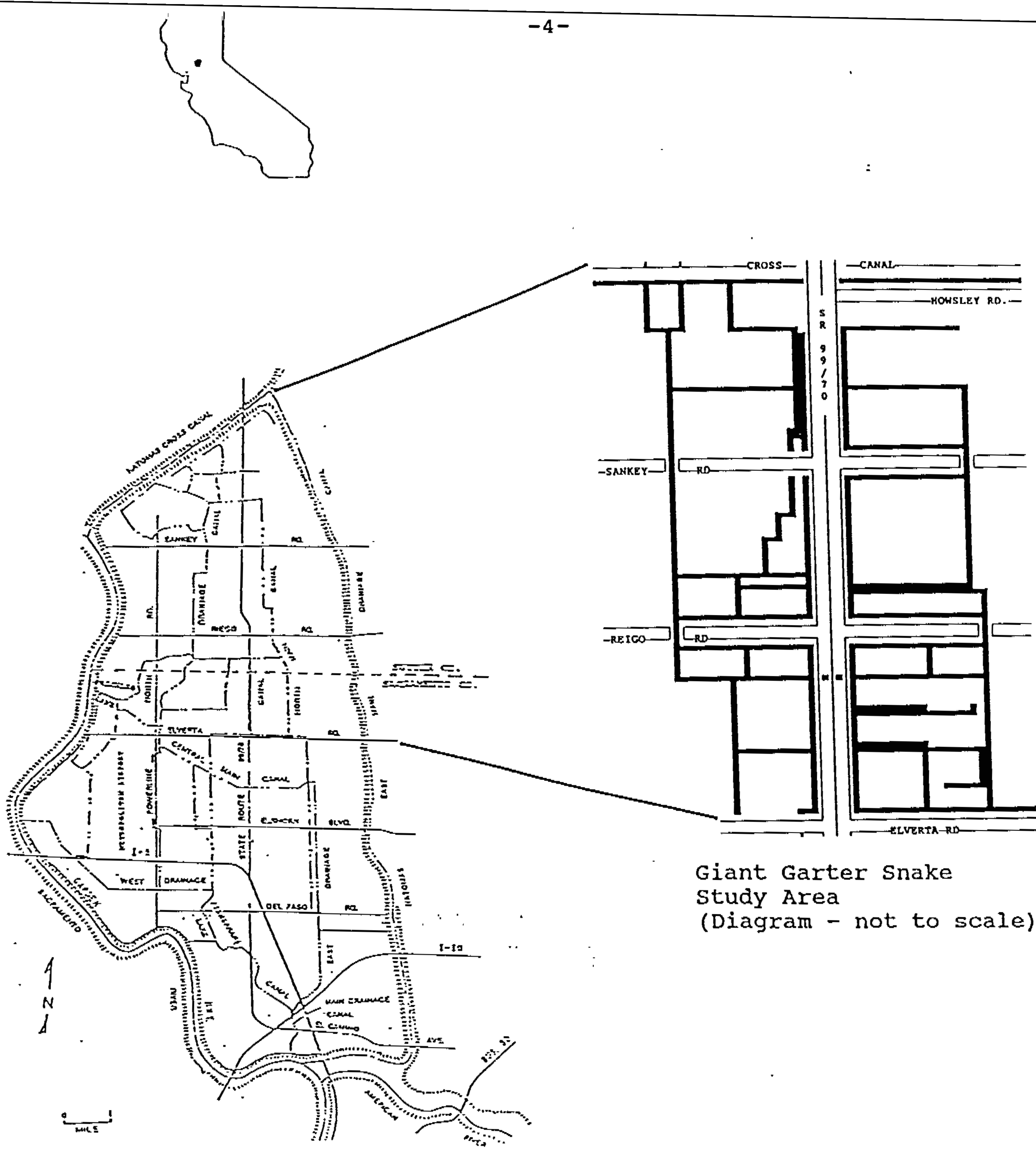

Figure 1. Map of the giant garter snake study area and its location within the American Basin, Sacramento and Sutter counties.

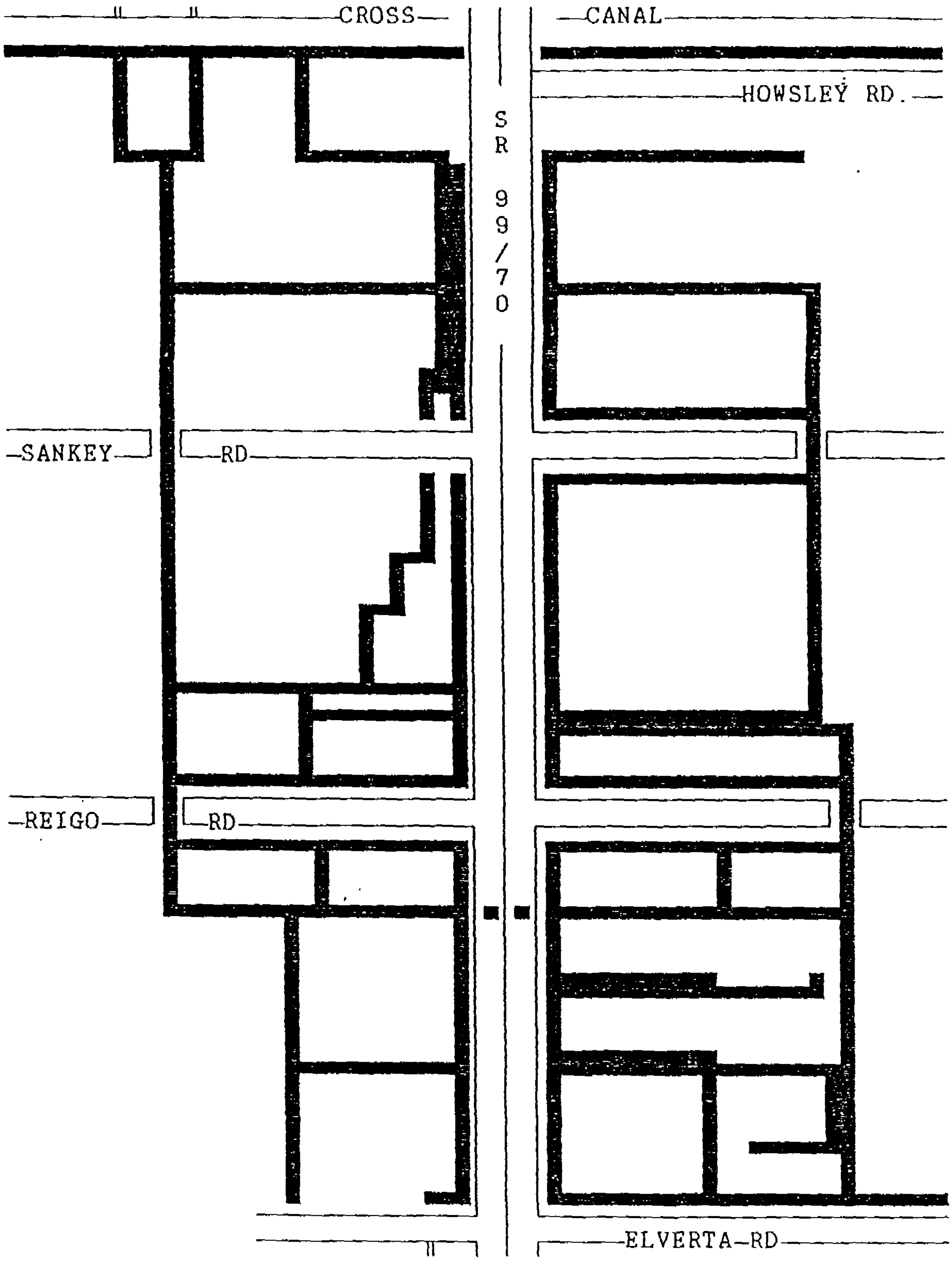

Figure 2. Pre-Construction Distribution of GGS Canal/Ditch Habitat During 1988 (Shown shaded ▬▬)

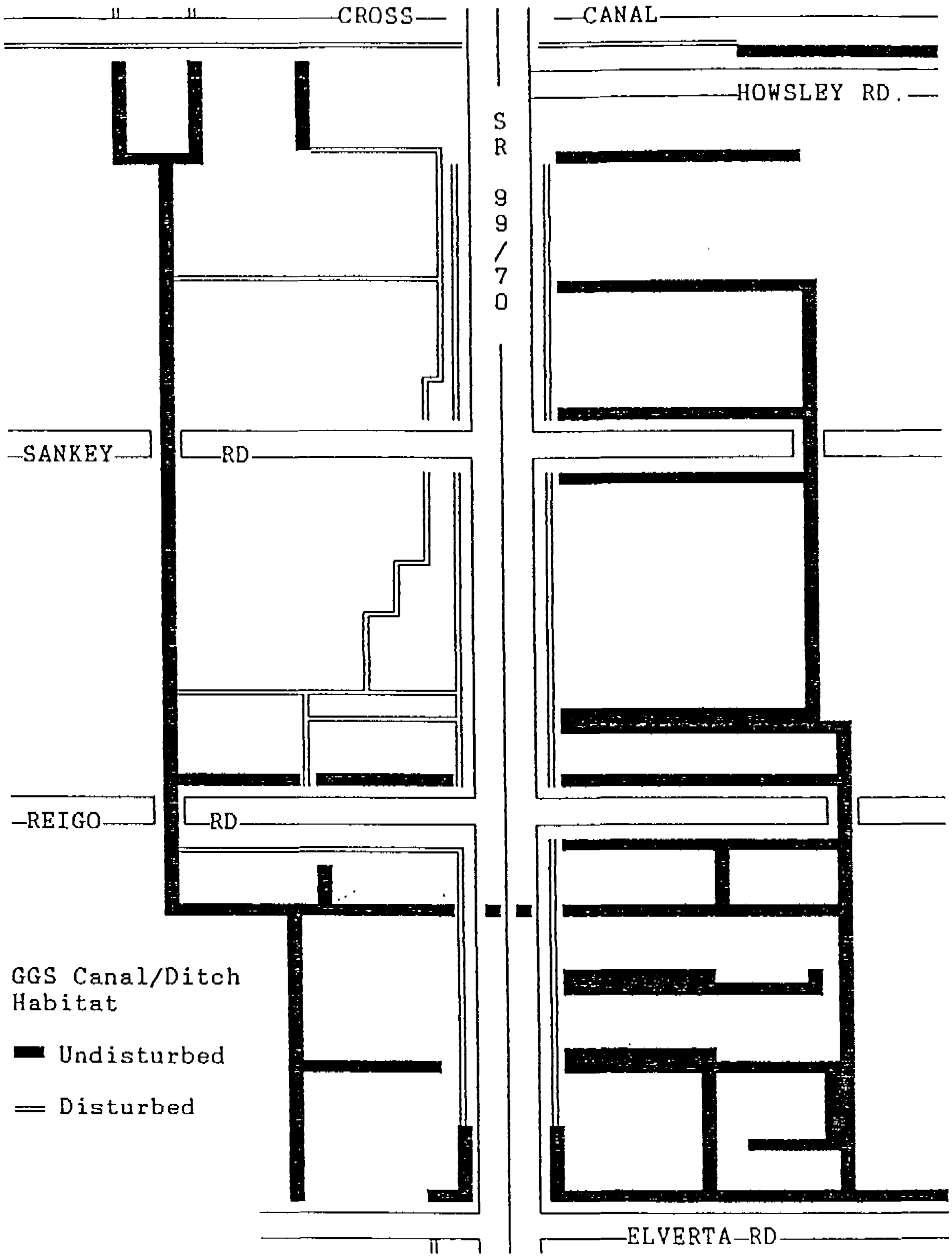

Figure 3. Post-Construction Distribution of GGS Canal/Ditch Habitat (1991).

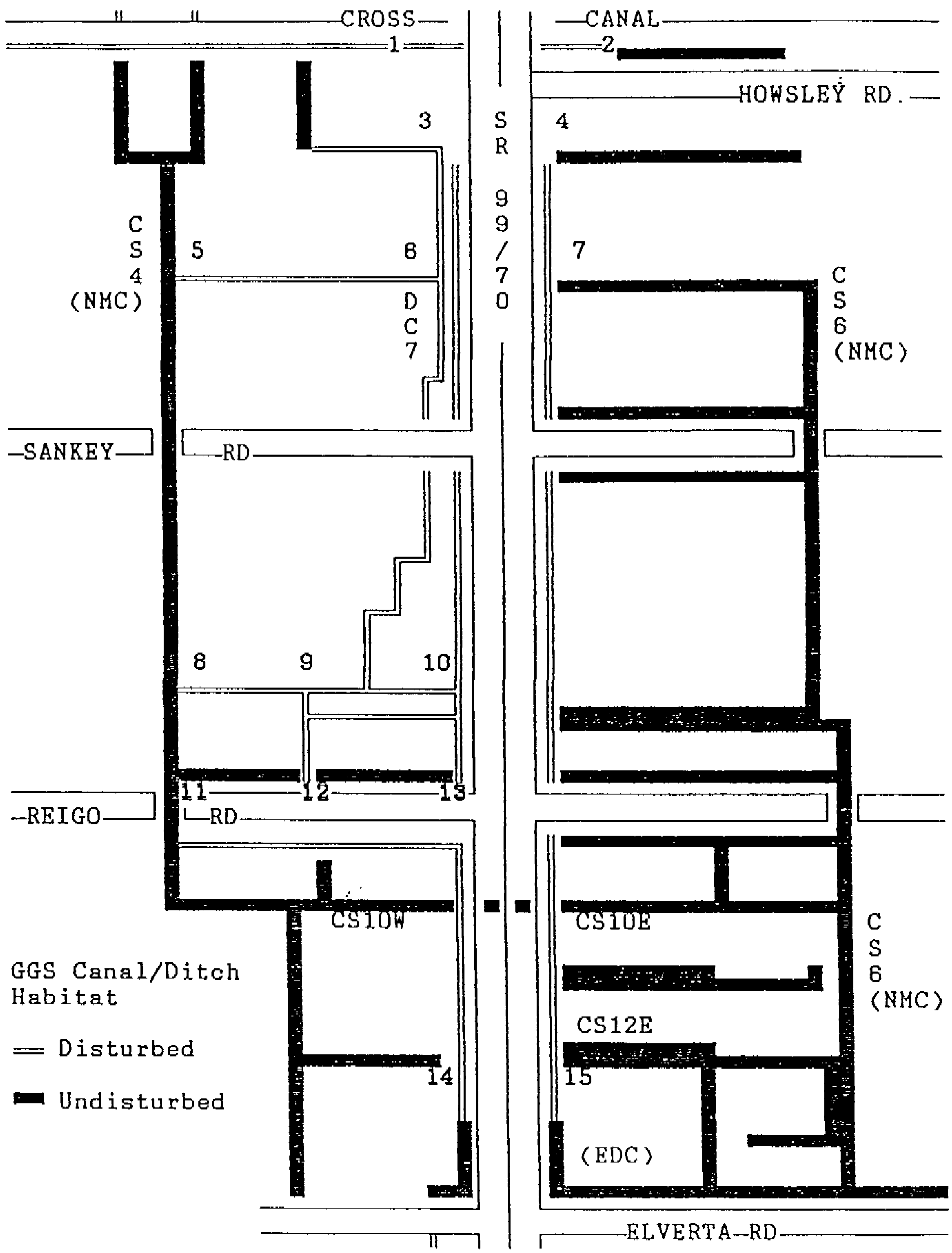

Figure 4. Locations of GGS Photo Stations and Major Project Features.

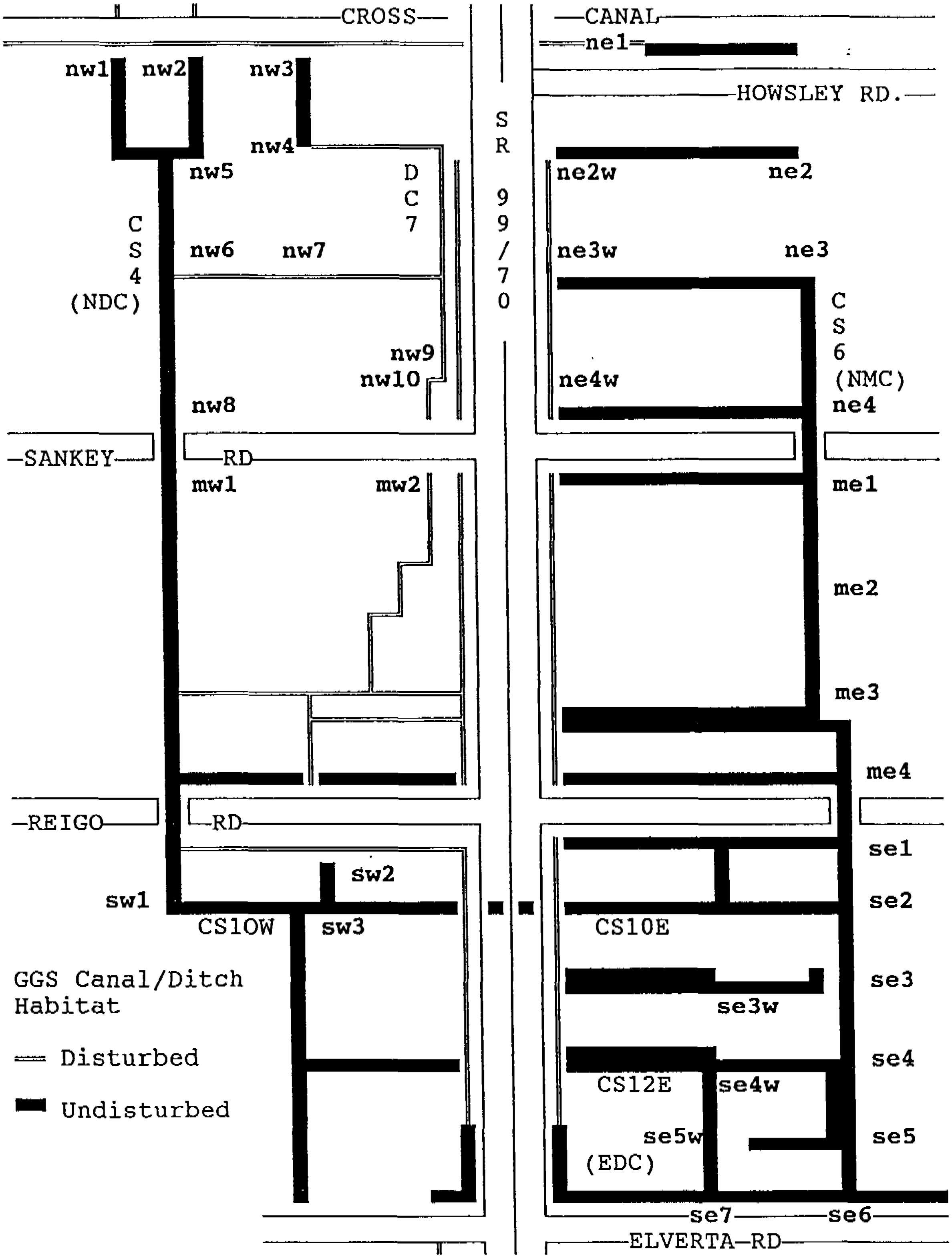

Figure 5. Locations of GGS Sample Stations and Major Project Features.

along the DC's to the east of SR 99/70 where recovery had proceeded at a faster pace and where there seemed a better chance to document GGS recolonization. PS's and other study features remained as previously described.

METHODS

Photo Surveys

Photos (35 mm color slides) were taken quarterly throughout the study period in order to document habitat recovery and show habitat conditions at each PS. The number of photos shot at each PS varied with the number of canals intersecting at that PS, since at least one photo was taken of each of the intersecting canals.

Additional photos were taken throughout the duration of this study and throughout the study area to document examples of habitat and its use by GGS and its prey and predators. Maintenance activities (mowing, channel cleaning and dredging) and their results were also photographed.

Prey Base Sampling

Potential prey of the GGS (i.e. fish and frogs) were sampled opportunistically during the study, but at least quarterly. A dipnet (18"x18"; 1/16" mesh smelt net) was used to sample aquatic or amphibious prey inhabiting waterways and rice fields.

During 1989-1991, prey base sampling was augmented by GGS feeding and growth studies that were conducted concurrently under captive conditions. Young GGS (six young each from two wild-bred/captive born clutches) were maintained in captivity for periods of up to 15 months and offered a variety of potential prey organisms obtained from study area waterways in order to determine prey preference. Captive adult GGS were also offered a similar variety and their preferences noted.

GGS Surveys

The study area was searched by walking and driving along potential GGS habitats. Binoculars were helpful for examining promising basking or resting sites. GGS were also located by lifting rocks, boards and other surface debris. Locations and movements of GGS were determined by visual sightings and captures. GGS were captured when possible by hand or hand held noose, examined, then released at the point of capture. Distinctive natural marks (e.g. color pattern, scars, etc.) were used to identify individual GGS rather than the standard method of clipping ventral scutes (Appendix 1). This method was used because there appeared to be a high incidence of infections among those GGS that were initially marked by scute clipping.

During 1988, capturing and marking of GGS was concentrated within the study area CS's. These marked GGS would presumably be among the snakes to recolonize the DC's, and marking them prior to their return to the DC's would provide a means to document this. The North Main Canal (CS-6) was chosen as the main study area control section because of the consistent sightings of GGS.

During 1989, GGS surveys were concentrated along CS-6 rather than along other less productive control sections. This permitted capturing and marking a much larger number of GGS, thereby increasing the opportunity to identify the source of any GGS recolonizing the recovering DC's.

During 1990 and 1991, GGS surveys were concentrated along the DC's and within the rice fields, in an attempt to locate GGS summer activity centers. Less time was spent along CS-6.

RESULTS

A chronological summary of study activities and observations is presented in Appendix 2.

Habitat Replacement and Reestablishment

Pre-Construction Conditions

Vegetation. Pre-Construction photo surveys of the study area were begun during November and December 1987, at the request of CalTrans/CDFG. The ditches, canals and drains within the study area supported emergent aquatic vegetation at that time. Habitat used by GGS along these canals included common tules (*Scirpus acutus*), cattails (*Typha* sp.), or grasses which grew in continuous stands or isolated patches at or below the high water line (Figure 6). Most berms and levees associated with these waterways were also vegetated except for the wheel tracks along the tops of those used as roadways. Ruderal vegetation dominated by mustard (*Brassica geniculata*), milk thistle (*Silybum mirianum*) and star thistle (*Centaurea* sp.), saltgrass (*Distichlis spicata*), and smartweed (*Polygonum* sp.) covered the dry berms and banks above the water line. Vegetation was present either as growing green stands or as dry tangles throughout the year and provided shelter for the GGS and protection from predators (Figure 7).

burrows? **Substrate**. The banks of those canals that supported aggregations of GGS were riddled with cracks, rodent burrows and crayfish burrows which GGS were frequently observed entering and exiting (Figure 8).

Water Cycle. By late 1988 many of the new roadside DC's were dry, as were the smaller agricultural drains and supply canals (DC's and UC's). Only the North Drainage Canal (NDC),

A

B

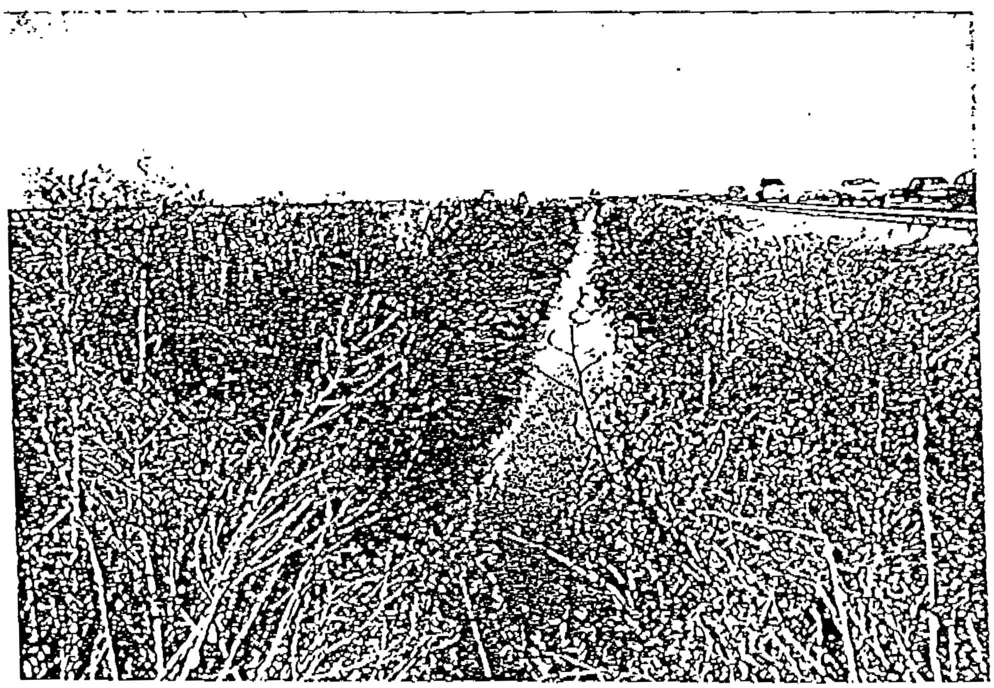

Figure 6. Pre-construction canal habitat of the GGS adjacent to State Route 99/70. (A) DC-7, looking north from Photo Station 6, July 1988; (B) DC-7, looking north from sample station NW-10, July 1988. Photos by George E. Hansen.

A

B

Figure 7. Pre-construction berm (upland) habitat of the GGS. (A) CS-12E, looking east from photo station PS-15, September 1990; (B) SE-4/5, looking west, September 1990. Photos by George E. Hansen.

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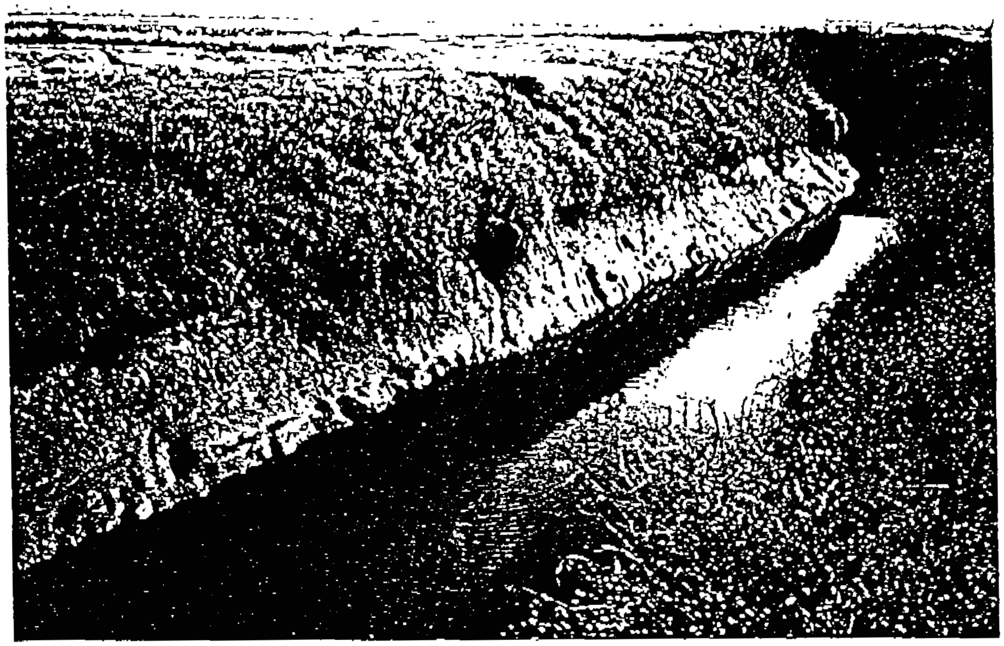

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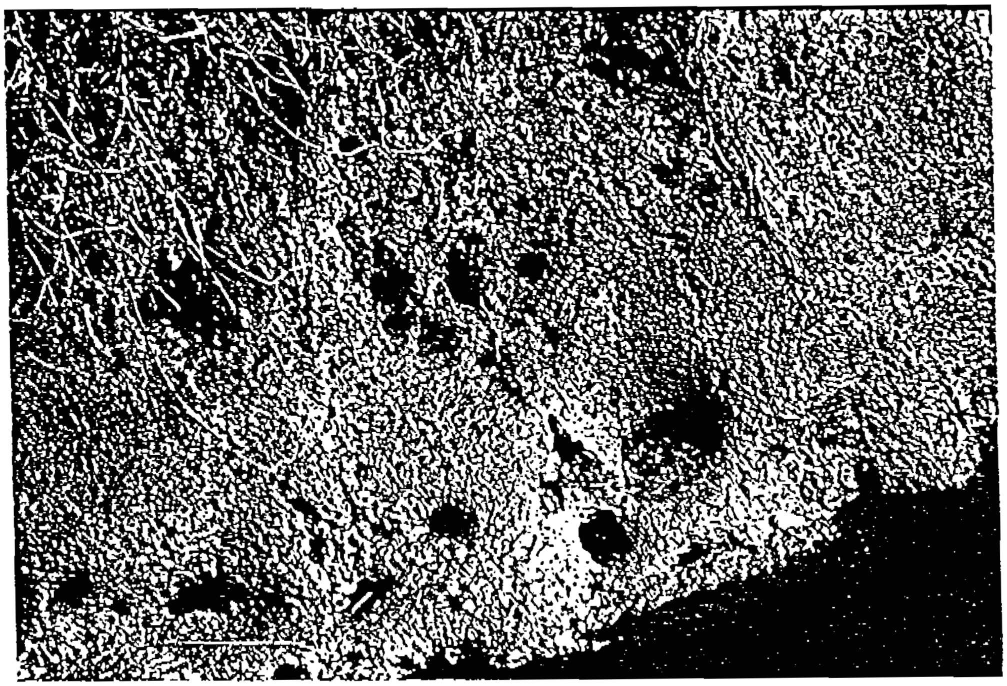


Figure 8. Undisturbed canal showing holes in the banks utilized by GGS. (A) CS-4, looking south from SW-1, November 1989; (B) same area showing close-up of holes exposed during low water, November 1989. Photos by George E. Hansen.

the North Main Canal (NMC) and the East Drainage Canal (EDC) remained flooded at year's end. Most ditches and canals remained dry through mid April 1989 while agricultural fields were being cultivated, graded, and prepared for planting.

During late April, water entered the area's canal system at pumps along the Cross Canal and flowed through the study area from north to south. Most fields within the study area were devoted to rice culture, and were irrigated by flooding during the last week of April or the first two weeks of May. Irrigation was accomplished by closing check dams to raise the water level within the supply canals (such as CS-6). This allowed water to be diverted into the lateral ditches supplying the rice fields.

By mid-May, nearly all of the study area was under water except the roadways, ditch and canal banks, and a relatively few acres devoted to sugar beets, milo or other irrigated crops (Figure 9).

normal rice water cycle

The rice fields and most study area ditches and canals remained flooded through July and August while agricultural fields were being irrigated. They then began drying during September as rice fields were drained and irrigation deliveries ceased. They remained dry (except for temporary rainwater pools and runoff following storms) from October through March.

This pattern of summer flooding and winter drying along the study area waterways was repeated during 1990 and 1991 and probably represented the normal water cycle in this agricultural basin.

<u>Structures</u>. Prior to canal reconstruction, check dams, culvert headwalls, and associated rip-rapped banks provided cover for the GGS. Water entering a canal in the vicinity of these structures usually eroded an "outfall pool" where persistent water supported aquatic prey prior to drying completely (Figure 10). Rip-rap (broken pieces of concrete from culverts, drain pipes, roadways, and other structures) had usually been added to the canal banks at these locations to slow erosion.

Holes under the concrete rip-rap and check dams, and spaces between pieces of rip-rap or flotsam provided accessible shelter for GGS foraging within the canal or outfall pool associated with each structure. Vegetative cover usually grew undisturbed within the rip-rap and other structural elements along canals because of the difficulty of using maintenance equipment here. These structures also served as basking, breeding, and hibernating sites for GGS.

Conditions During Construction

During replacement, the existing canals were filled with soil (often spoil excavated from the replacement canal); the soil along berms, levees, banks and newly filled canal was compacted;

A

B

Figure 9. Rice fields in study area during spring flooding. (A) SE-5, looking west from a point west of CS-6, prior to vegetation growth, May 1991; (B) SE-4/5, looking west from a point west of CS-6, showing vegetation growth along rice field berm (access road), May, 1991. Photos by George E. Hansen.

A

B

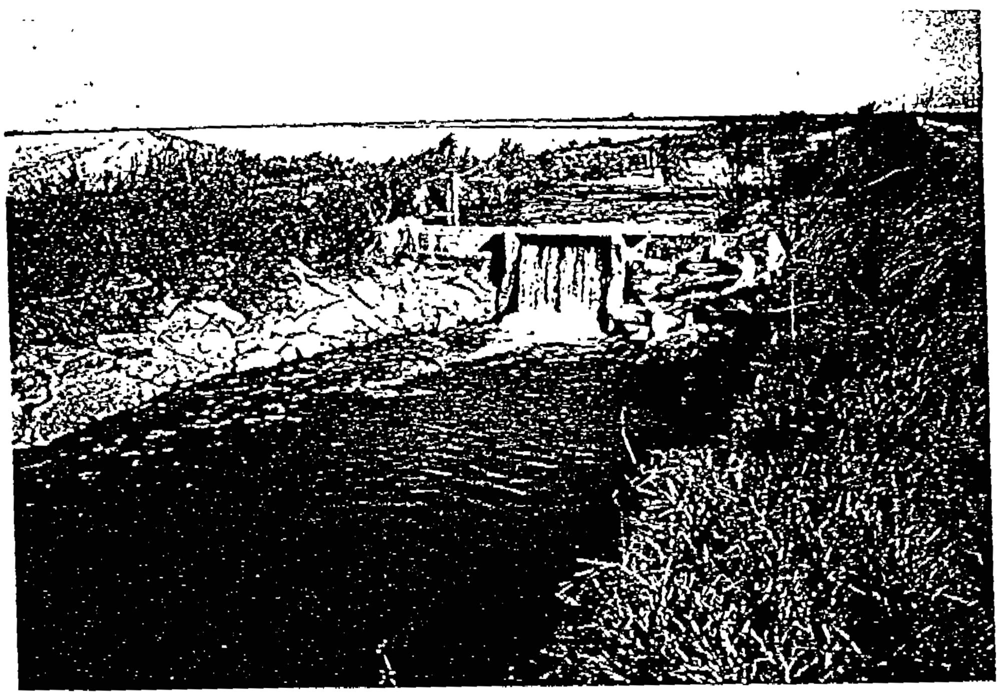


Figure 10. Two examples of "outfall pools" that form at the culverts and check dams along the study area waterways, note the rip-rap placed around the structures. (A) CS-12E looking west from SE-4W, July 1990; (B) CS-6 at SE-3N, looking north west, fall 1987. Photos by George E. Hansen.

and the area was graded. New canals (DC's) were either excavated below the level of the surrounding land or were created by building up berms to contain them above the level of the surrounding land. In both cases the banks were then compacted and graded uniformly. At completion, no vegetation or burrows existed along the new DC's (Figure 11).

By mid November 1988, construction activity had slowed as the southern portion of this project neared completion. All waterways bordering SR 99/70 from Photo Stations 3 and 4 south to 0.5 miles north of Elverta Road had been replaced or reconstructed by the end of 1988. Additionally, over four miles of adjacent waterways were reconstructed (widened) during this period (Figure 3). Most culverts and flow control structures south of Howsley Road were in place.

Construction continued north of Photo Stations 3 and 4 through 1990 and 1991.

Post-Construction Conditions

Vegetation. Drought conditions that persisted through February 1989 slowed habitat recovery along the new berms and banks of the DC's. Revegetation finally began as above normal precipitation fell during March 1989 and encouraged a belated spring growth of mustard, thistles and grasses on the disturbed banks and berms of the DC's (Figure 12).

thwarts - prevent reestablish

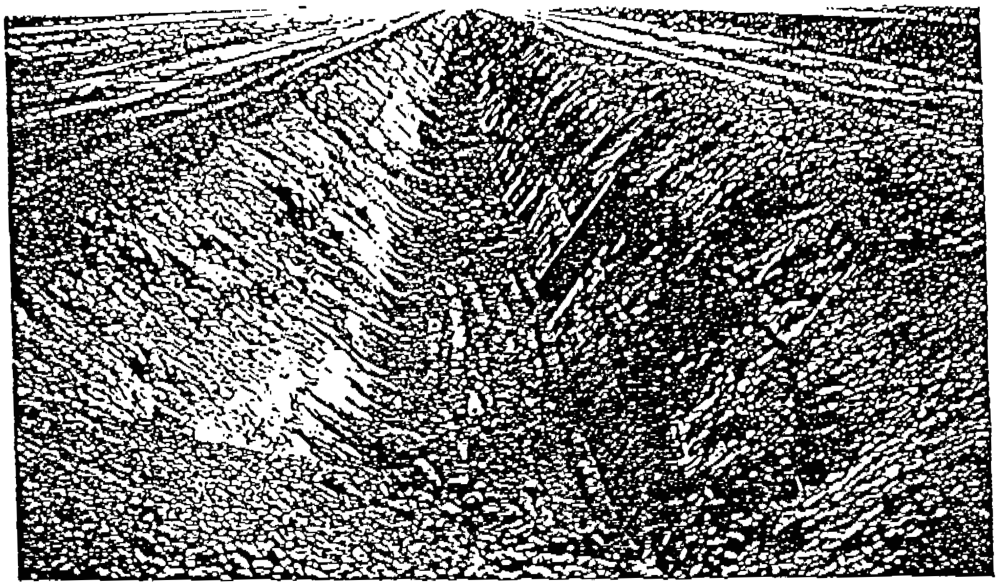
During 1989, vegetation did not recover along DC-7 north of Sankey Road. Defoliants were apparently used here during that spring as evidenced by the sudden and uniform yellowing and subsequent death of all new vegetation. These canal banks remained bare or later became sparsely vegetated by morning glory (*Convolvulus* sp.) and star thistle. Continued chemical defoliation, mowing, and scraping here prevented reestablishment of sheltering vegetation through the end of 1990.

custom burn maintenance

By the end of 1990, vegetation had recovered along several of the smaller DC's (drainage ditches) bordering SR 99/70, but recovery was incomplete along the larger DC's because of continued maintenance by the water management agencies (Figure 13). This slow recovery was originally due to herbicide spraying but was prolonged by additional spraying and scraping throughout the study period. East side DC's did recover faster but they were small drains and only occasionally held adequate water. West side ditches perpendicular to SR 99/70 were considered as larger DC's. These were recovering faster than the large DC parallel to the west side of SR 99/70, but were disturbed less frequently.

By the end of 1991, vegetation along the larger DC's bordering SR 99/70 had still not recovered. Although small stands of tule, cattail or Johnson grass (*Sorghum halepense*) appeared occasionally, these were usually killed with herbicides or mowed.

A



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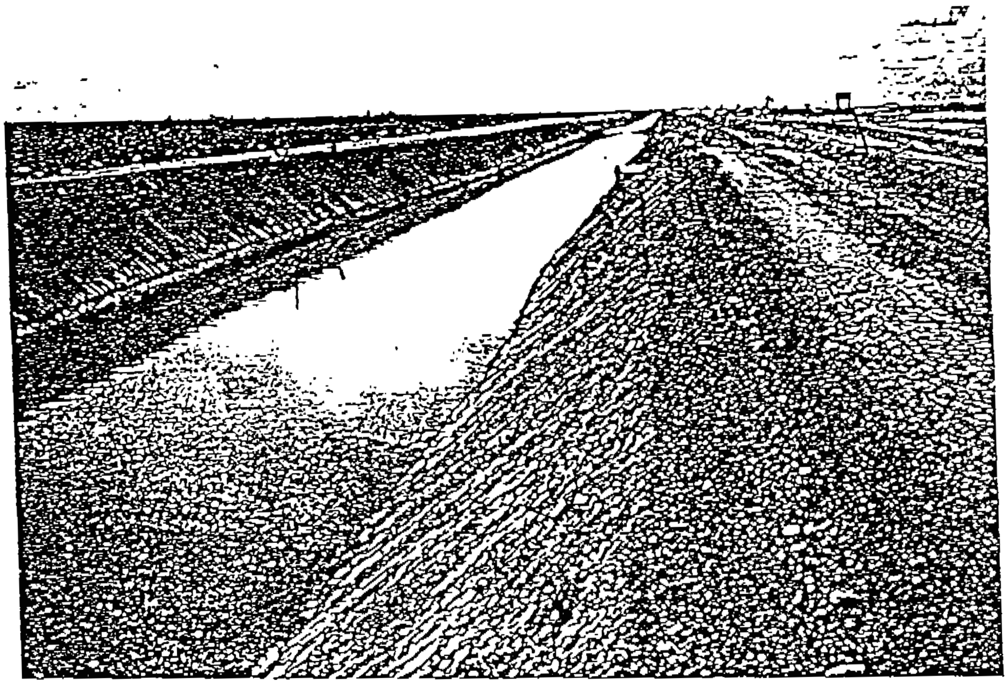


Figure 11. Newly constructed canals in the GGS study area. Note the compacted banks and berms. (A) DC-7, looking south from Photo Station 3, April 1988; (B) East Drainage Canal, looking south from Photo Station 15, July 1988. Photos by George E. Hansen.

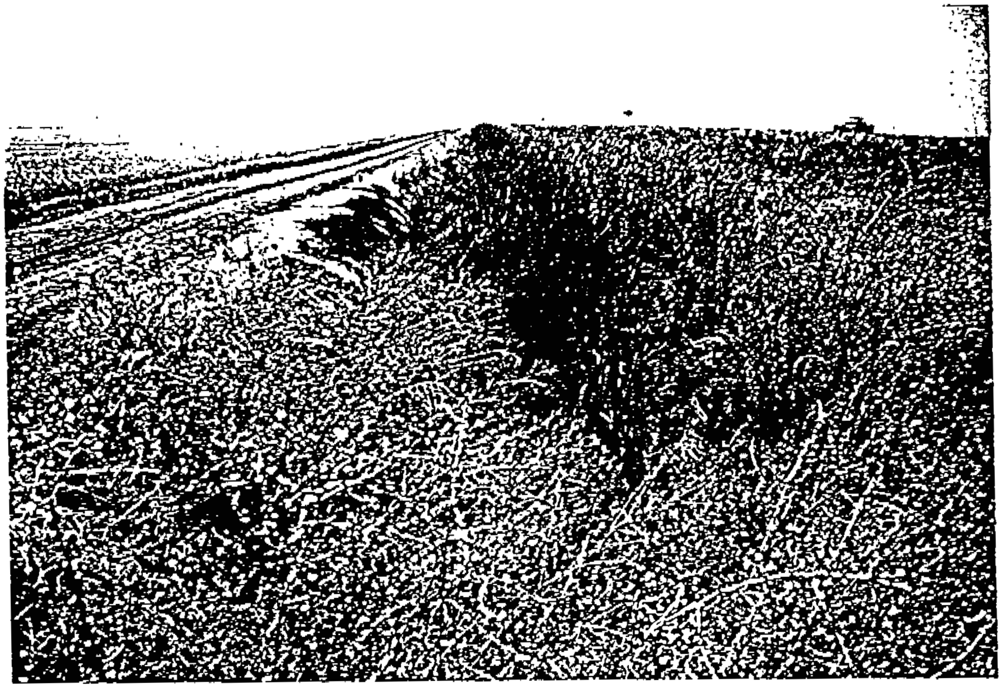


Figure 12. Recovering vegetation along one of the study area disturbed ditches, looking south from Photo Station 7, September 1989. Photo by George E. Hansen.

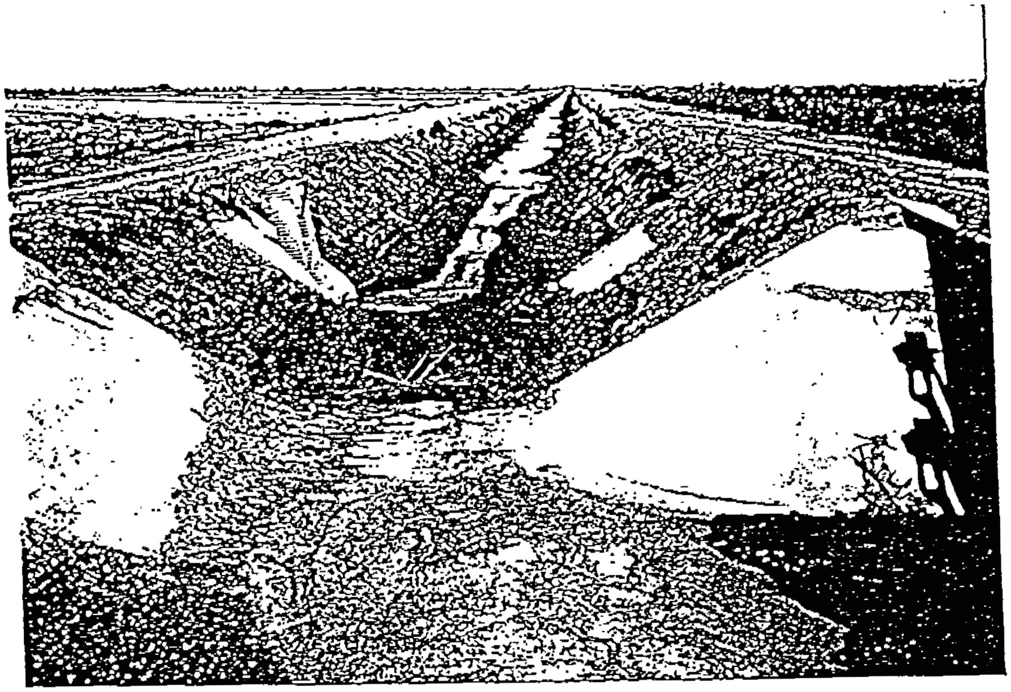


Figure 13. Reconstructed large canal showing little or no recovery of vegetation, looking north along DC-7 from Photo Station 6, February 1990. Photo by George E. Hansen.

Construction activity continued along SR 99/70 north of Photo Stations 3 and 4 throughout 1989 and 1990 and prevented the recovery of habitat there throughout the period of this study.

Substrate. Rodent and other burrows and cracks suitable for GGS cover became established faster where weed abatement was not practiced.

Along DC's that did recover, retreats suitable for GGS usually reappeared first as crayfish burrowed into the substrate below the high water line. Other burrows then appeared above and below the high water line as animals modified cracks and crayfish burrows exposed during low water. Cracks then appeared in the banks, usually near the top of the canal berm where the bank was beginning to erode and slump away. Additional shelter was provided as animals burrowed among the pieces of rip-rap, flotsam and other debris that had been mixed into the substrate during canal construction or subsequent maintenance.

The above scenario was not observed along the larger DC's where intensive weed abatement or channel maintenance was practiced.

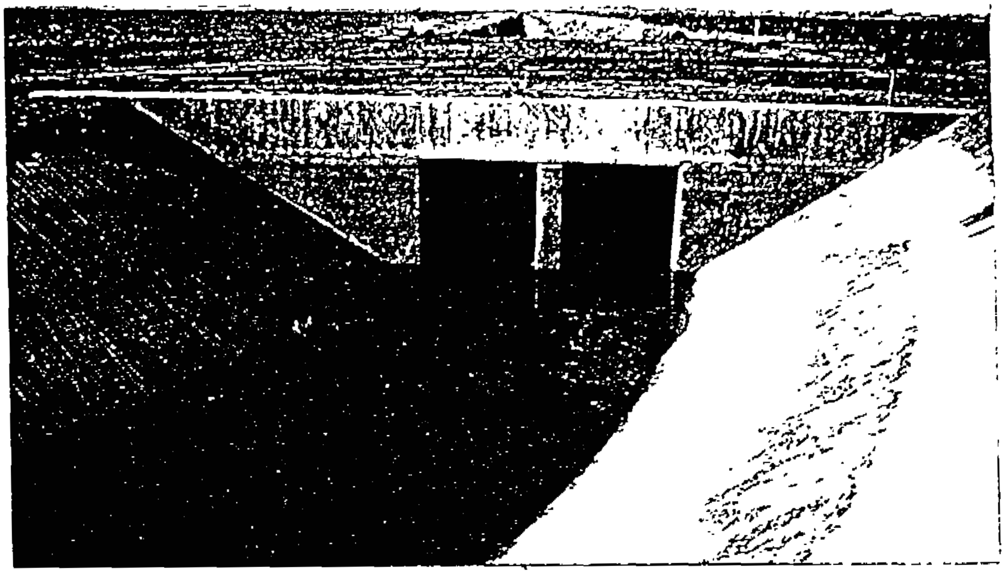
Water Cycle. The pattern of winter drying and summer flooding within study area waterways described in the previous section (Pre-Construction Conditions: Water Cycle) was repeated each year and probably represents a continuation of what has become the normal water cycle in this agricultural basin.

Structures. New concrete check dams, culvert headwalls, and concrete canal linings (Howsley Road at SR 99/70) were designed and constructed as solid structures that when new provide no shelter for GGS (Figure 14). These will probably crack, erode, or be excavated by burrowing animals in time, but will probably never replace the original structures and their accompanying rip-rap in GGS habitat value.

Prey Base. Prey base sampling was begun during the first quarter of 1988 when visual observations of mosquitofish (*Gambusia affinis*), carp (*Cyprinus carpio*) and bullfrogs (*Rana catesbeiana*) were made throughout the study area's waterways. During studies of prey preference that we conducted concurrently with these field studies, these two fish species and tadpoles of the bullfrog and the Pacific treefrog (*Hyla regilla*) were readily eaten by captive GGS, and all four prey species were frequently found among the stomach contents regurgitated by recently captured GGS.

By June 1988, the flooded rice fields also supported mosquitofish, carp and other minnows, and sunfish (*Lepomis* spp.). The tadpoles of bullfrogs and Pacific treefrogs (*Hyla regilla*) were plentiful by late June.

A



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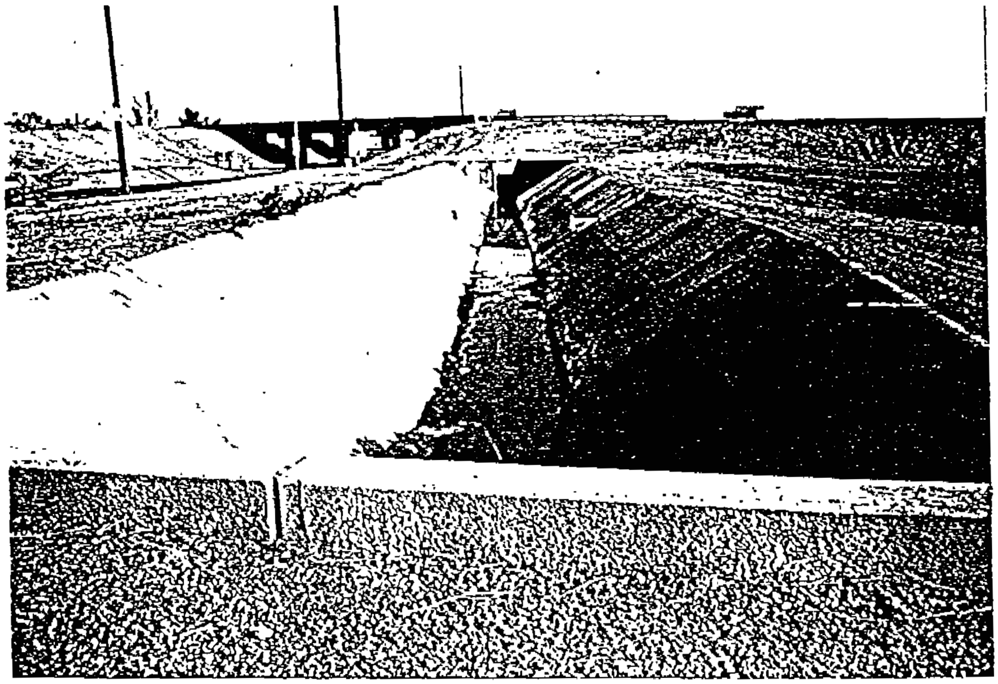

Figure 14. Concrete structures along one of the new canals in the study area. These structures provide no habitat or shelter for the GGS. (A) CS-3W, looking west from Photo Station 3, February 1990; (B) CS-1W, looking east from Photo Station 1, December 1990. Photos by George E. Hansen.

By September, rice fields were drying and prey were being flushed back into the major canals (UC's and DC's) and concentrated in diminishing pools near culverts and rice boxes. Few fish large enough to prey upon neonate GGS were found within the rice fields.

The recovery of vegetation, substrate, water, and prey base following canal replacement/reconstruction is summarized in Table 1.

GGS Surveys

GGS were not observed during November-December 1987 pre-construction surveys. They had no doubt retired to spend the winter dormant period within underground retreats along the berms and levees of the area's waterways. However, GGS were observed within the study area during prior studies by Hansen (1988) (Table 2).

road kills 4 yrs

During this study, 685 sightings of GGS were recorded. Of these, 225 GGS were captured and their unique identifying marks recorded; 59 of these were subsequently recaptured one or more times. Another 31 were found dead on the area's roadways.

ggs activities

GGS generally emerged from winter dormancy during March and April. Seasonal surface activity peaked during April and May and then declined, ceasing in October or early November depending on weather (Figure 15).

Daily activity of GGS generally included 1) emergence from burrows in the bank after sunrise; 2) basking to warm their bodies up to activity temperatures during cool weather or on cool early mornings, and 3) foraging or courting activity throughout the remainder of the day. GGS were observed several times after sunset during hot weather, usually lying motionless on warm pavement or dirt roads.

rice as nursery habitat

Early in the course of this study, during 1988-89, it was noticed that GGS were either inactive during mid- to late summer or were moving out of the waterways into the rice fields or perhaps, even leaving the study area (Figure 16). During the summers of 1990 and 1991, GGS were searched for and found along the berms of the flooded rice fields (Figure 17). By that time the rice fields supported a rich prey base of mosquitofish and treefrog tadpoles, and may have served as nursery areas for newborn GGS (most GGS found were gravid or recently parturated females). Vegetation covered the berms and rice checks, and rice plants provided shelter within the flooded fields (Figure 18). The use of the rice fields by GGS is being further studied and evaluated, and will be discussed in more detail in a separate paper. was this completed

TABLE 1. Length of Time Required for Establishment of Suitable GGS Habitat and Prey Base Following Canal Construction. Rates of Establishment/Recovery are Compared for Newly Constructed Disturbed Canals (Sprayed and Unsprayed) and Undisturbed Control Canals.

CANAL TYPE	Year that Recovery (R), Presence (P) or Suitability (S) of GGS Supporting Element was Observed.			
	1988	1989	1990	1991
DISTURBED CANALS				
Sprayed				
Vegetation				
Substrate				
Water	P	P	P	P
Prey		P	P	P
Not Sprayed				
Vegetation		R	R	R
Substrate			R	R
Water	P	P	P	P
Prey		P	P	P
CONTROL CANALS				
Vegetation	S	S	S	S
Substrate	S	S	S	S
Water	P	P	P	P
Prey	P	P	P	P

TABLE 2. Known Localities of the Giant Garter Snake within the American Basin Prior to 1988, Based on Literature, Museum, and California Department of Fish and Game Records (adapted from Hansen 1988).

CNDDB OCC.#	Locality	County	Year last reported
18.	Reigo Rd., 0.5 miles W Hwy. 99	Sutter	1976
59.	Canal N Howsley Rd., 0.8 miles E El Centro Blvd.	Sutter	1986
60.	Canal W side El Centro Blvd., 0.4 miles N Sankey Rd.	Sutter	1986
61.	Canal Crossing Riego Rd., 0.7 miles E Power Line Rd.	Sutter	1986
62.	Power Line Rd., 0.2 miles S canal (0.7 miles S Riego Rd.).	Sutter	1986
63.	Prichard Lake area, 1 mile W Power Line Rd., 1 mile N Elverta Rd.	Sacramento	1986
64.	Small drain 0.5 miles N Elverta Rd., 1 mile W Power Line Rd.	Sacramento	1986
65.	Canal crossing Power Line Rd., 0.25 miles N Elverta Rd.	Sacramento	1985
9.	Elverta Rd., 1.5 miles E Garden Hwy.	Sacramento	1976
66.	Canal-Marsh 0.3 miles W Power Line Rd., 0.3 miles S Elverta Rd.	Sacramento	1986
67.	Canal N Elkhorn Rd., E East Drainage Canal	Sacramento	1986
68.	Canal E Power Line Rd., 0.9 miles S Elverta Rd.	Sacramento	1986
69.	Meister Rd. at Lone Tree Rd.	Sacramento	1986
70.	Bayou Way, 0.5 miles SW Hwy 99 x I-5 interchange, 1 mile E Power Line Rd.	Sacramento	1986
71.	Power Line Rd., 0.2 miles S Bayou Way	Sacramento	1986
11.	Fisherman's Lake area from El Centro Blvd. to Del Paso Rd.	Sacramento	1986
72.	Del Paso Rd. at El Centro Rd.	Sacramento	1986
73.	Canal N Del Paso Rd., W East Drainage Canal	Sacramento	1986
74.	East Drainage Canal at lateral drain, 0.3 miles S Del Paso Rd.	Sacramento	1986
75.	East Drainage Canal at lateral drain, 1.5 miles S Del Paso Rd.	Sacramento	1986
--.	Del Paso Rd. 1.6 miles E El Centro Blvd.	Sacramento	1982

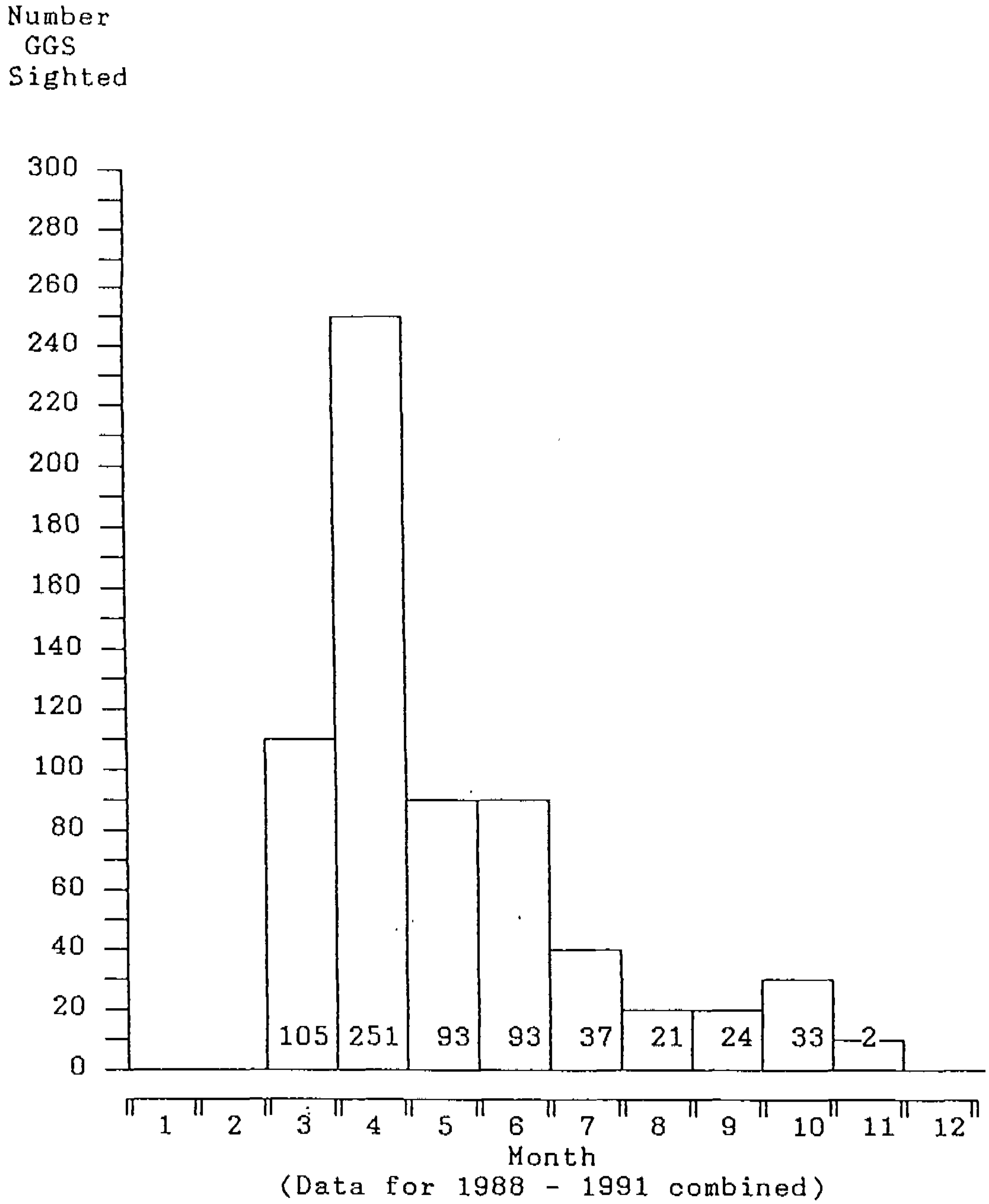

Figure 15. GGS sighted per month for 1988-1991 combined (n=659).

GGS activity

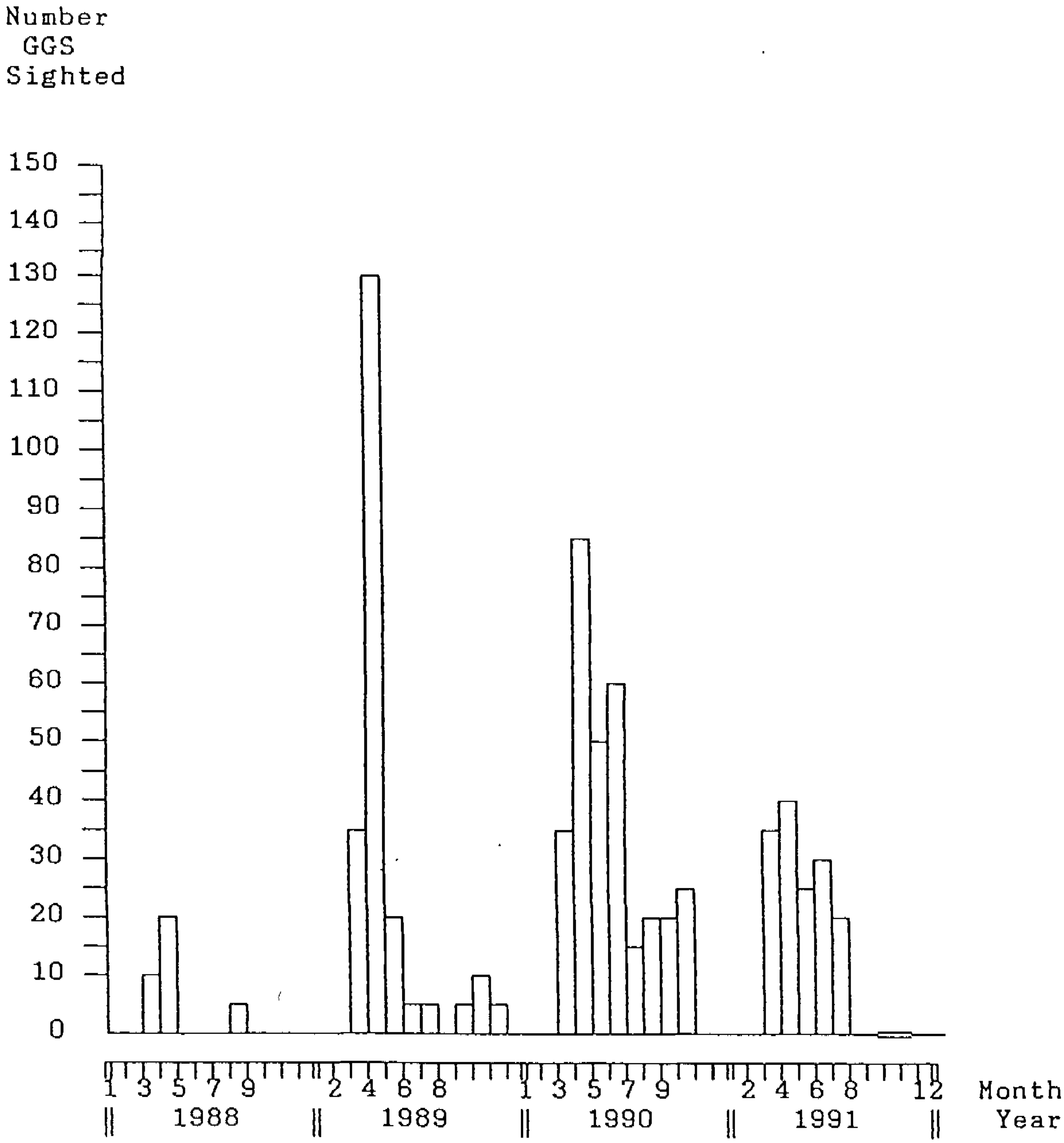

Figure 16. GGS sighted near study area per month (n=682).

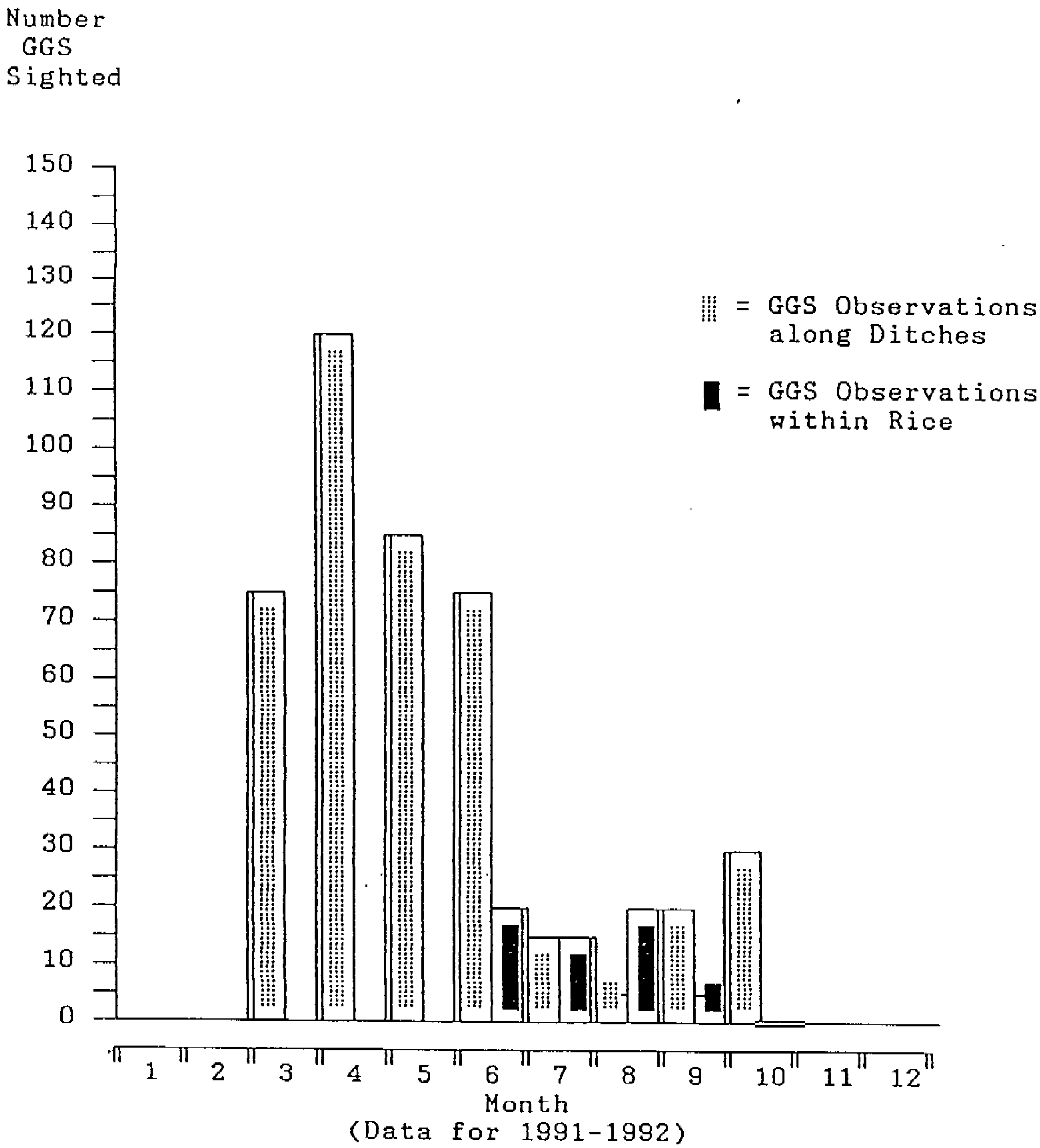

Figure 17. Seasonal occurrence of GGS within ditches and rice fields during 1991-1992.

GGS use of rice fields

Figure 18. A rice field in late summer, showing the GGS cover provided by the densely vegetated berm and rice plants, west of CS-6 at SE-4, looking southwest, August 1990. Photo by George E. Hansen.

Nearly all GGS observed during this study were found along the area's undisturbed CS's. GGS were encountered most frequently where old rip-rap, rank vegetation and rodent burrows provided permanent shelter. The most productive control sections in terms of GGS sightings (such as CS-6 and CS-12E) were bordered by rice fields and included at least two parallel UC's separated by an undisturbed, vegetated berm. Within this environment, GGS were seen to aggregate in areas where check dams, rip-rap, dense stands of vegetation, deep pools, and steep banks riddled with cracks and burrows coincided. Each of these factors seems to be important, but all apparently interact at certain locations. When GGS residing at such a site were disturbed frequently, such as in the course of capturing and marking, or if the site suddenly became popular with fishermen, they would often disperse or relocate as a group to another similar site. Neglected canal intersections appeared to be especially favored.

Although an attempt was made to devote equal attention to both UC's and DC's while surveying GGS, results along the DC's were very discouraging. As described in the Habitat Replacement and Reestablishment section, those DC's that were large enough to support an adequate and varied prey base were either completed too late to recover by the end of the study, or were prevented from recovering by maintenance activities (defoliation and grading) that were conducted regularly after completion of the DC's.

Those DC's that did revegetate were mainly the smaller roadside drains along the east side of SR 99/70 (Figure 12). Unfortunately, these apparently lacked the water and prey necessary to function as more than movement corridors for GGS.

Movements

Observations on the movements of GGS recorded during prior studies (Hansen 1986, Hansen 1988) showed that GGS not only can move long distances but will relocate at least 1/4 mile from the small lateral ditches and drains into the larger canals such as the EDC. Several GGS that were captured, marked, and released along agricultural ditches near the intersection of Elverta Road and the EDC (2 miles south of this study area) were subsequently recaptured, some having moved distances exceeding 1/2 mile in as little as one day. Adult female GGS #4-86 was captured, identified and released at five locations along agricultural drains near the Earnst Road Ditch at Elkhorn Road during March, April, and May, 1986. She was recaptured the following year, along the undisturbed EDC (June 1987) over 1/2 mile to the northeast (nearly one "ditch" mile if she followed the ditch to reach the EDC). Another adult female GGS (#16-86) was captured, identified and released at three locations along the same agricultural drains near Earnst Road ditch at Elkhorn Road during

April and May, 1986. She was subsequently recaptured over 1/4-mile east along the undisturbed EDC during June 1986, also having moved from the smaller drains into the EDC (Figure 19).

These and other similar observations led to the hypothesis that GGS would relocate into the newly constructed CALTRANS study area channels soon after they became vegetated. Because of continued maintenance, the new channels did not recover as expected, so this study did not adequately test this hypothesis.

During this study, GGS were observed to readily relocate distances of over one mile along project UC's, and GGS were observed to routinely move from one project UC to another. GGS were observed to move along the smaller connecting UC;s, and several were seen to approach the edge of the unvegetated EDC without entering. For example, adult female GGS #34 was captured and recaptured at five locations along one mile of the undisturbed CS-12E between April 10, 1989 and October 11, 1992 (Figure 20). This female was among three GGS encountered at the intersection of CS-12E and the EDC on October 9, 1992; and that had fled from the east bank of the EDC into CS-12E when approached. When GGS #34 was returned to her capture point at the EDC/SC-12E intersection the following day (October 10, 1992), she fled into CS-12E as had her two companions the day before. GGS #34 was next recaptured 1/2-mile east at SE 4W on October 11, 1992, illustrating a movement of 1/2 mile away from the EDC in one day.

Recaptures of other GGS during this study also demonstrate this ability to move long distances over short periods, and to return to previous locations from great distances. Adult female GGS #7 was captured and identified at five locations along study area canals, drains, and within flooded rice fields between April 7, 1989 and October 8, 1992 (Figure 20). This female was originally captured along UC's at SE 4 during 1989 and was not identified again until 1992. On September 8 and 17, 1992 this GGS was recaptured at two locations within the flooded rice fields over 1/2 mile SW of her original capture location. On September 23, 1992, she was recaptured again, this time having returned over 1/2-mile from the rice fields back to the UC's at SE 4 in 5 days or less.

The rate of recolonization of GGS along the study area's DC's will depend upon habitat recovery. Until adequate cover (vegetation and subterranean retreats) becomes reestablished along the DC's, any GGS entering them will be vulnerable to predators. During this and prior studies, GGS were observed to move the distances required for recolonization of these area DC's. GGS also appeared capable and willing to move from UC's into vegetated portions of the EDC. Failure of the EDC to become vegetated appears to be the reason why GGS did not recolonize this channel during the study period.

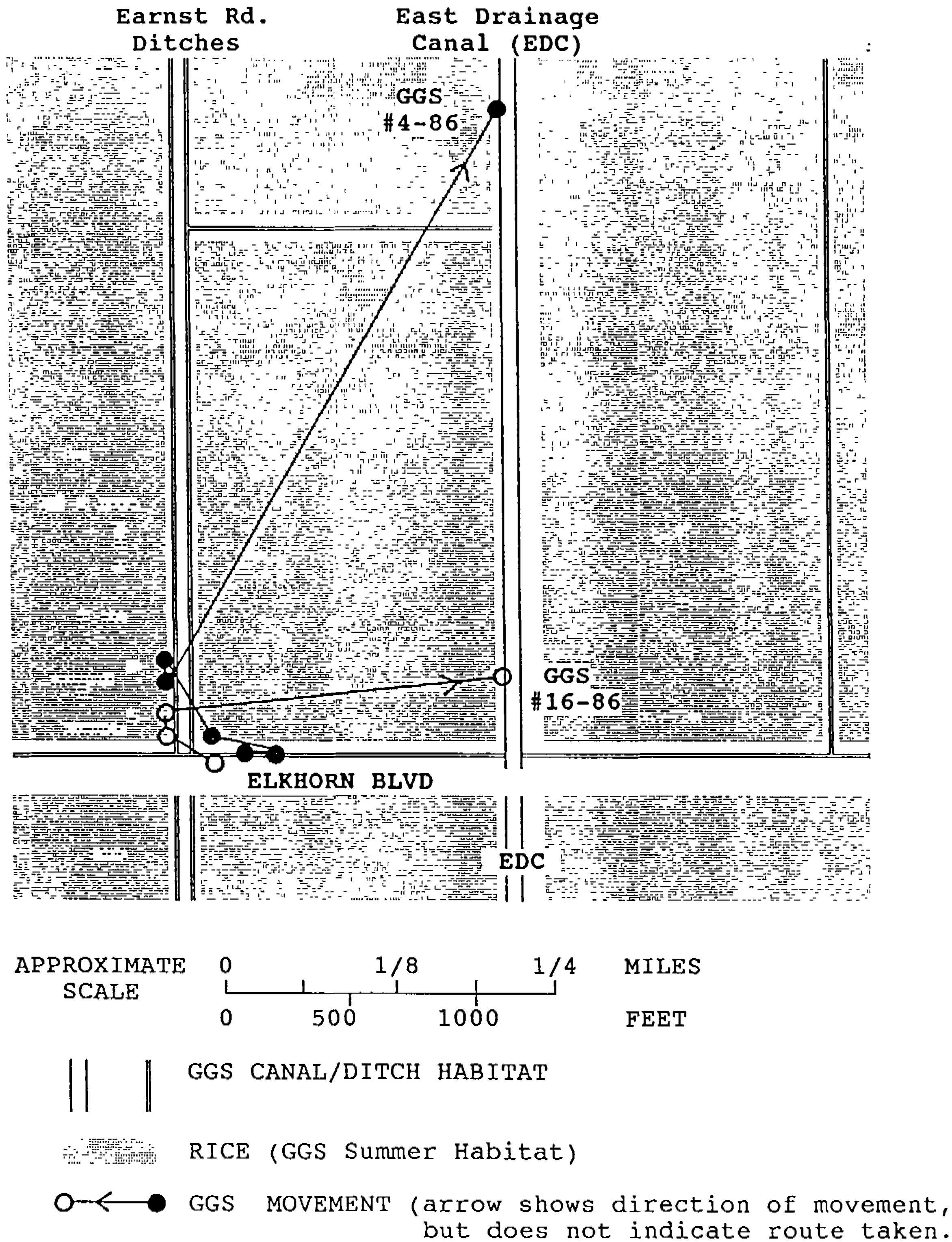

Figure 19. Movements of Two GGS Based on Recaptures Between March 1986 and June 1987.

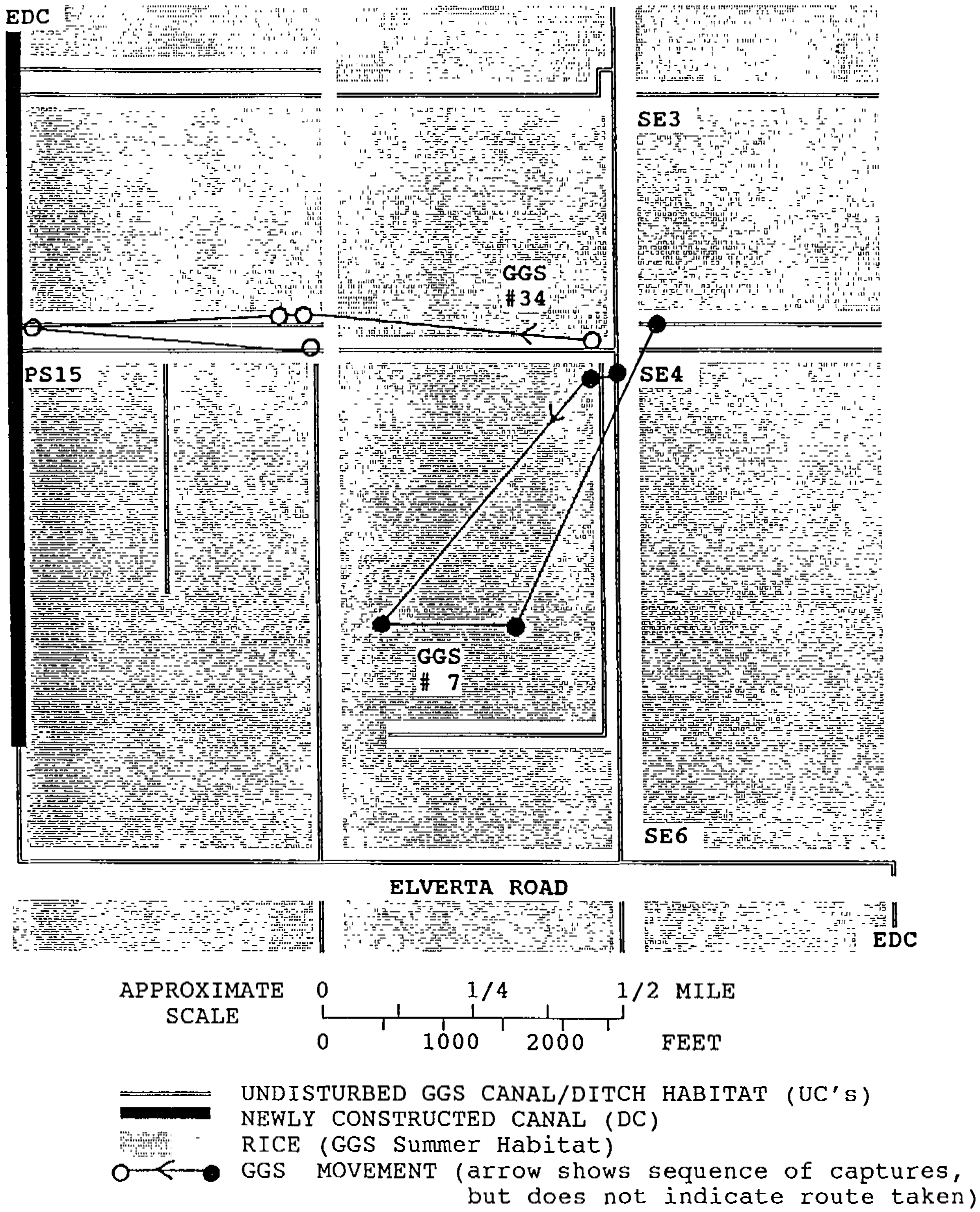

Figure 20. Movements of Two GGS Based on Recaptures Between April 1989 and October 1992.

The reconstruction (grading and dredging), during 1988, of several miles of the canals connecting the SR 99/70 west side DC's with CS-4 probably also slowed recovery along the highway DC's. Because CS-4 is the nearest major undisturbed habitat on the west side of SR 99/70, most of the GGS that survived construction in the study's northwestern two/thirds were probably displaced to CS-4. To return to the west side highway DC's the GGS would have to travel approximately one mile along unrecovered DC's. This has apparently not occurred.

DISCUSSION

The most productive control sections in terms of GGS sightings (such as CS-6 and CS-12E) were bordered by rice fields and included at least two parallel UC's separated by an undisturbed, vegetated berm. Canal intersections appear to be especially favored. GGS activity was concentrated in areas where check dams, rip-rap, dense stands of vegetation, deep pools, and steep banks riddled with cracks and burrows coincided. Each of these factors seems to be important, and all must apparently interact when they occur at the same location. Each factor also benefits from neglect and is rendered less suitable for GGS by most maintenance practices.

Productive CS's contained adequate water during spring and summer to support prey.

Within the rice fields, emergent rice plants and shallow standing water provided cover and food during the summer. Rice checks and other small vegetated berms within the rice fields provided shelter, basking, and resting sites.

The favorable physical habitat features of the pre-construction ditches were not replaced nor was the vegetation allowed to recover along the larger project DC's. After over three years of herbicide applications, mowing, scraping, grading, and burning, conditions along these waterways remain nearly as inhospitable to GGS as when they were constructed in 1988. These results fell short of our expectation of a rapid recovery of disturbed habitat to pre-construction conditions, and undoubtedly contributed to the lack of recovery by GGS.

The newly constructed check dams, culverts, and culvert headwalls were poured as solid concrete structures. These have failed to provide the sheltering maze of corridors found within the rip-rap, old check dams, and accompanying vegetation that they replaced. Concrete lined channels, such as those constructed east and west of SR 99/70 at Howsley Road, extended these detrimental effects along substantial lengths of canals, making them inhospitable traps where any GGS that inadvertently wandered into them would be exposed to predators. Again, the expected replacement/recovery of protective cover did not occur.

Other newly constructed project DC's (primarily those smaller drainage channels located east of SR 99/70 and north of Reigo Road) were not subjected to intensive maintenance. Vegetation and substrate recovered much more quickly here than within the managed canals. Prey species were usually present on the rare occasions that adequate water could be found. These smaller drainage channels seldom hold permanent water, but receive overflow and seepage from adjacent irrigated fields. No recolonization by GGS was observed, although these ditches may have recovered sufficiently to serve as dispersal and movement corridors.

Because habitat was not allowed to recover along the larger roadside DC's, we were unable to adequately test our hypothesis that rapid recovery of favorable habitat along the reconstructed or replaced canals would encourage recolonization there by GGS.

No recolonization by GGS was observed, nor is it expected to occur until suitable supporting habitat is allowed to recover.

CONCLUSIONS AND RECOMMENDATIONS

The expected recovery of GGS canal habitat and recolonization by GGS along newly reconstructed canals did not occur during the study period because the new canals were not allowed to remain undisturbed so that vegetation and other GGS habitat features could become established.

When relocating or reconstructing GGS habitat, great attention must be paid to details of timing and habitat structure if the specialized needs of GGS are to be served. Efforts to create or rehabilitate GGS habitat should emphasize the duplication of these special features.

Because newly created GGS habitat takes several years to reach maturation, replacement of existing GGS habitat requires compensation at a 2:1 or greater ratio to achieve viable GGS population levels. Compensation greater than parity is needed to overcome interim population declines that occur during the time between destruction of the original habitat and maturation of the new habitat. Also, a 2:1 or greater replacement would allow one or more of the "mitigation habitats" to remain undisturbed as dedicated GGS habitat, thereby avoiding the "maintenance" problems encountered during this study.

The procedures and timing for these activities were developed during this study and have been incorporated into DFG guidelines (Appendix 3).

Once GGS habitat has been established, the present procedures for maintaining the canals and ditches are, for the most part, compatible with GGS. Certain practices are, however, detrimental to the GGS and its habitat. The detrimental practices are: 1) spraying or otherwise removing the vegetation from the banks of the canals, 2) lining the canals with cement or gunite, and 3) excavating canals during the GGS dormant season (October 1-May 1).

Adverse impacts to the GGS during maintenance operations can be lessened by adhering to the following guidelines:

1) Excavate from only one side of the canal during a given year. Avoid excavating the banks above the high water level. Preferably, one side of the canal should be left undisturbed indefinitely (the preferred side would be the west or north side).

b) Excavate the canals during the GGS active season. This is approximately May 1 to October 1.

c) Limit the excavation to the bottom of the canals, leaving the vegetation on the tops and upper sides of the canals undisturbed.

d) Restrict auto traffic along the canals to maintenance or other official vehicles.

ACKNOWLEDGEMENTS

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APPENDIX 1

Individual GGS Identification

Standard methods of marking individual snakes for future recognition that required injuring the snake (including scale clipping, tattooing, or branding with heat or cold) were avoided due to the high incidence of unhealed, open and often infected or necrotic wounds being found on local GGS (Hansen field notes). Additionally, several American Basin GGS that were marked by ventral scale clipping during March 1986 had developed infections by the time that they were recaptured, unlike more terrestrial snake species in which these "marks" nearly always heal quickly and cleanly, leaving only a characteristic scar (Hansen unpublished).

To ensure recognition of GGS recaptured on the study area, each was examined at each capture and the following characteristics recorded:

Color Pattern. Attempts to identify individual GGS by the color pattern method described here has proven effective, but very time consuming. The natural marks noted for GGS (see Scars and Anomalies: below) have proven more useful for differentiating among the large numbers of GGS examined.

The color of each scale in a series was recorded, beginning with the first dorsal scale on the snake's left at the level of anterior corner of the tenth ventral scale posterior to the posterior angle of the snake's jaw. If the scale was bi- or even tricolored, this is noted. This was repeated for each in a series of adjacent scales, each dorsal and anterior to the last, until the middle scale of the mid-dorsal stripe was recorded. The series then proceeded downward (ventrally) and posteriorly on the right side of the snake, mirroring the left side. A series of (usually) 21-23 color codes was produced which recorded both the color pattern and the dorsal scale pattern at the level of the tenth ventral scale, both of which were variable from snake to snake, or from side to side on an individual snake.

Redundancy was obtained by recording a similar series at the level of the anterior corner of the tenth ventral scale anterior to the vent, including the ventral plate.

Scars and Anomalies. Permanent scars, wounds, and unusual scale or color pattern features were described and their location on the snake were noted. Locations on the snake were noted by dorsal scale row number (beginning with the nearest low lateral scale and counting in a dorsal direction the number of scale rows to the location in question and noting left or right side) and by ventral scale number (beginning at the posterior angle of the jaw and counting in a posterior direction the number of ventral scales to the location in question). The locations of "marks" on the posterior portion of the snake were noted as above except that ventral scales were counted in an anterior direction beginning at the vent and the ventral scale number noted as a minus number.

Size and Gender. Each GGS captured was weighed, measured (snout-vent and tail lengths) and examined to determine its sex. Individual GGS recaptured after only a month or so were released immediately after identification, GGS recaptured after longer periods were weighed and measured again prior to release. Used in conjunction with notes on color, scars, and anomalies, this information helped to confirm individual identities of GGS captured.

APPENDIX 2.
GGS Survey - Summary by Quarters

<u>1988-1</u>. GGS surveys were begun as unseasonably warm and dry weather throughout February and March prompted GGS to emerge. Sightings of active individuals were obtained in the project vicinity throughout March and April. Courting and breeding activity was observed during early April. Activity slowed during the cool weather of late April and early May.

<u>1988-2</u>. Although apparent GGS activity slowed during May and June, several were located and captured by hand, recorded and replaced. No GGS activity has been observed in any of the new or disturbed ditches.

Nine GGS were found dead (killed by passing vehicles) on Reigo Road between Photo Stations 8 and 9 during early June. GGS displaced from DC's (such as that between Photo Stations 6 and 9) may have contributed to this unusual concentration of DORs. Increases in vehicular traffic along this recently quiet country road may have also contributed.

<u>1988-3</u>. Apparent GGS activity slowed during this quarter. No GGS activity has been observed in any of the DC's. Three dead GGS were found on newly constructed berms within the project area, apparently run over during construction activity.

Two more dead GGS were found on Reigo Road between Photo Stations 8 and 9 during this quarter, bringing to 11 the total found there since early June.

<u>1988-4</u>. Apparent GGS activity continued at low levels during October. Although no GGS were sighted along the study area's DC's, several were observed alive and three were found DOR along the dirt roads paralleling the undisturbed portions of CS-4 south of Reigo Road and CS-10W between 99 and its confluence with CS-4. Of these three DOR GGS, one adult was purposely run over by a fisherman, and two young-of-the-year juveniles were run over (probably inadvertently) by farm equipment removing rice from an adjacent field.

One GGS was observed during November and none during December.

<u>1989-1</u>. During this quarter, no GGS were observed within any of the study area's new or disturbed ditches or canals, nor along any undisturbed Control Section (CS).

GGS were observed to be active beginning March 13 along undisturbed portions of CS-13E and other waterways near the project area (ditches along north and south sides of Elkhorn Rd., east and west of SR 99/70). Seven of these were captured, examined, recorded and released. Others were left undisturbed once sighted and observed and photographed from a distance.

1989-2. By mid June, 181 GGS had been observed and positively identified on the study area (Table 1). Of these, 88 were captured, marked and released (Table 2). All were found along undisturbed CS's, and most were found along CS-6 within the southeastern portion of the study area.

Prior to the flooding of ditches and canals for irrigation during late May, GGS were found to be concentrated at the small pools at check dams, bridges and culvert outfalls. Concrete rip rap apparently enhanced these sites by providing shelter. Nervous GGS would quickly withdraw into the water or rip rap at my approach.

Adult males could be seen seeking and courting females at these pools throughout March and April. Limited courtship was seen in May.

Only limited movement data has resulted thus far. All but one of the thirteen recorded movements were of short distance (0-30 meters). However, one large female (SE-24, 1075 mm S-V) relocated 0.5 miles (~870 meters) upstream following the flooding of CS-6.

1989-3. Only seven GGS (six adults, one small juvenile) were observed alive on the study area during this quarter. The adults were located along CS-6 within the southeastern portion of the study area. None of these had been captured or recorded previously.

One juvenile was found crawling across Riego Road 0.1 miles east of CS-6 nearly an hour after sunset on August 5, 1989. Additionally, four GGS adults were found dead on Elverta Road between SE-7 and SE-6 during August and September. Two were found freshly killed after dark in areas that had been surveyed and found to be clear at sundown. The other two were found just after sunrise in areas that had been surveyed and found to be clear as late as two hours after sunset the night before. All four dead GGS appeared to have been killed at night by vehicles.

Unlike the situation this spring when GGS were found to be concentrated at the small pools at check dams, bridges and culvert outfalls, GGS are now difficult to locate. Whether this is a result of decreased surface activity, nocturnal habits, or wide dispersal throughout the now-flooded network of canals, ditches and fields has not yet been determined.

1989-4. Only 12 GGS (seven adults, one subadult and four small juveniles) were observed alive on the study area during this quarter. Of the adults, three were captured at SE-5 and four were captured at SE-4. Of the juveniles, one neonate was captured at NW-3, one at SE-5, and one subadult was captured at SE-4. One neonate escaped into vegetation at SE-4, and another escaped into the newly constructed ditch east of SR 99 one mile south of Reigo Road.

This latter snake is the first GGS observed in a newly constructed waterway (DC) during this study. Six of the seven adults captured were recorded and released. One adult died two days after her capture of injuries received sometime earlier and that had failed to heal. Four of the adults (27, 34, 47, and 64) had been captured and recorded previously. Only GGS 27 was found more than 20 meters from her previous location. This adult female returned 0.5 miles from SE-4 to SE-5 between 5-6-89 and 10-10-89. This snake had previously relocated from SE-5 (4-10-89) to SE-4.

During October and November, two GGS adults were found dead on Elverta Road in the vicinity of SE-6; one neonate was found dead on the dirt road west of SE-7; and one adult was found dead on Reigo Road west of SE-1.

1990-1. Twenty-four GGS (23 adults, one juvenile) were observed alive on the study area during this quarter (March 19-25). Of these, 20 were captured as they basked in mild weather along CS-6 from SE-3 south to SE-5/6. Most attempted escape into thick vegetation or burrows rather than into the shallow water remaining in CS-6.

No GGS were observed along the DC's bordering SR 99/70.

1990-2. One hundred ninety-two GGS (188 adults, one juvenile, and three of last season's young) were observed alive on the study area during this quarter (March 26-June 23). Of these, 69 were captured a total of 82 times as they basked in mild weather along CS-6 from SE-3 south to SE-5/6 or along CS 12E. Most attempted escape into water once the canals were flooded instead of into the thick vegetation or burrows preferred during low water conditions. Individual movements of up to 0.5 miles were observed.

No GGS were observed along the DC's bordering SR 99, although GGS are now being sighted along CS-12E as far west as its intersection with the DC (EDC) at PS-15.

1990-3. Fifty-three GGS were observed alive and five DOR on the study area during this quarter (June 23-September 30). Of these, 19 were captured a total of 20 times along CS-6 from SE-3 south to SE-5/6 or along CS 12E. Most attempted escape into water once the canals were flooded instead of into the thick vegetation or burrows preferred during low water conditions.

No GGS were observed along the DC's bordering SR 99/70.

1990-4. Twenty-five GGS were observed alive and one DOR on the study area during this quarter (October 1-December 31). Of these, four were captured along CS-6 from SE-3 south to SE-5/6 or along CS 12E. Most attempted escape into water.

No GGS were observed along the DC's bordering SR 99/70.

__1991-1__. Sixty-six GGS were observed alive on the study area during this January-April, 1991 Period. Of these, 24 were captured along the CS's east of SR 99/70. Most attempted escape into thick vegetation or burrows rather than into the shallow water remaining in the CS's.

Nine dead snakes, including at least three GGS, were found on berms bordering rice fields soon after these fields were disked for the first time this year. These were represented mainly by mummified, partially eaten specimens exposed by recent cultivation and carried to the field's edge by rats. These snakes were probably killed and buried during fall cultivation.

No GGS were observed along the DC's bordering SR 99.

__1991-2__. Seventy-two GGS were observed alive on the study area during this May-July, 1991 Period. Of these, 21 were captured along the CS's east of SR 99/70. Most attempted escape into burrows, or the relatively warm water of the rice fields rather than into the cooler water flowing in the CS's.

Two GGS were observed along the DC's bordering SR 99. One adult male was seen crossing the road/berm between the rice and the DC just south of PS-15. Another, a juvenile male, was seen swimming along CS-7 near NW-9. Each may have been using these DC's as movement corridors.

__1992-3__. No GGS were observed alive on the study area during this August-December, 1991 Period. One adult female GGS was found DOR on Elverta Road during October.

Since this was this last period of field work for this study sampling effort was concentrated almost entirely along study area DC's in a last effort to demonstrate recolonization.

Appendix 3

Guidelines for Procedures and Timing of Activities Related to the Modification or Relocation of Giant Garter Snake Canal or Stream Habitat[1]

Background

These procedures were developed to minimize adverse impacts to the giant garter snake (*Thamnophis gigas*) during construction activities in and around giant garter snake (GGS) habitat. The timing is based on present knowledge of the GGS seasonal activity cycle which may vary somewhat from year to year depending upon the weather.

GGS Activity Cycle

- o GGS begin emerging from winter retreats around April 1.
- o By April 15, most GGS are active and beginning to search for food.
- o By May 1, all GGS have usually emerged and are actively foraging.
- o Around October 1, GGS begin seeking winter retreats. Foraging and other activities are sporadic at this time and dependant upon weather conditions.
- o By November 1, Most GGS are in winter retreats and will remain there until spring.

Habitat Relocation Procedures and Timing

- o No grading, excavating, or filling may take place in or within 30 feet of GGS habitat between October 1 and May 1 unless authorized by the Department of Fish and Game (DFG).
- o Construction of replacement habitat may take place at any time of the year, but summer is preferred.
- o Water may be diverted as soon as the new habitat is completed, but placement of dirt dams or other diversion structures in the existing habitat will require on-site approval by the DFG.
- o The new habitat will be revegetated with suitable plant species as directed by DFG or as stipulated in the environmental documents.

[1] Prepared by John M. Brode, Department of Fish and Game, Inland Fisheries Division, October 1990.

- Dewatering of the existing habitat may begin any time after November 1, but must begin by April 1.

- Any GGS surveys required by the DFG will be completed to the satisfaction of the DFG prior to dewatering.

- All water must be removed from the existing habitat by April 15, or as soon after as weather permits, and the habitat must remain dry (no standing water) for 15 consecutive days after April 15 and prior to excavating or filling the dewatered habitat.

- DFG will be notified when dewatering begins and when it is completed. DFG will inspect the area to determine when the 15-day dry period may start.

The above procedures are subject to revision and may be modified by DFG to accommodate special situations.