# CONTROL OF AGRICULTURAL DRAINAGE WATER AND RESTORATION OF WETLAND WATER SUPPLY CHANNELS

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GBP

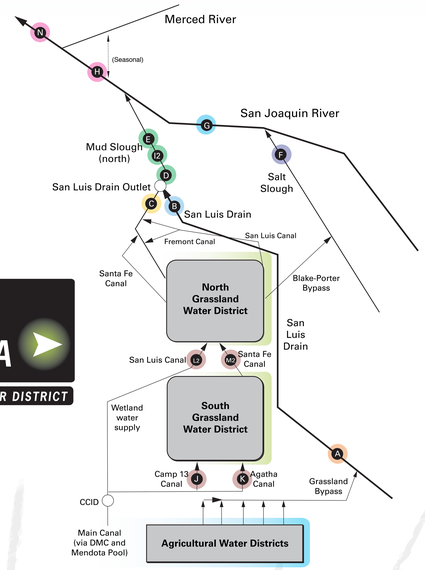
Grassland Bypass Project

## INTRODUCTION

The Grasslands Basin of Central California includes more than 97,000 acres of highly productive farmland that has historically drained through 160,000 acres of wetland habitat. Soils are primarily derived from rocks that form the Diablo Range and are elevated in salt and trace element concentrations. Irrigation of farms released selenium and other constituents harmful to aquatic wildlife into local waterways, resulting in severe impacts on water quality for state and federal wildlife refuges and private wetlands (Ohlendorf et al. 1990). Starting in 1997, the Grassland Bypass Project (GBP) has separated agricultural drainage water from the wetland water supply channels. The Project is run by local farmers in coordination with state and federal agencies and Environmental Defense. The Project is subject to a Waste Discharge Requirement that strictly limits the load of selenium that can be discharged to Mud Slough. The farmers have significantly reduced the loads of salt, selenium, and boron through source control, water conservation, and improved irrigation efficiency, recycling of irrigation water and reuse of tail water on salt tolerant crops, tiered water pricing, etc. The Grassland Bypass Project monitors contaminant concentrations throughout the drainage area and studies effects on fish, invertebrate, and plant tissue, as well as bird eggs.

## The PROJECT AREA

SCHEMATIC MAP OF THE GRASSLAND WATER DISTRICT




## MONITORING PROGRAM

The monitoring plan for the GBP includes measurement of water quality, flow, sediment quality/quantity, biota, and chronic toxicity data at various sites throughout the Grasslands Basin to assess the environmental effects of the Project. Sampling sites are located at the inlet (Site A) and the outlet (Site B) of the San Luis Drain, in water supply channels leading to (Sites J, K, L2, and M2) and from (Site C) the wetland areas. Three sites (Site D, E, and I2) are used to monitor effects on Mud Slough, and two sites evaluate effects of the Project in the San Joaquin River (Sites H and N). Reference sites are located along Salt Slough (Site F) and the upper part of the San Joaquin River (Site G).

Station B is the primary sampling location for measuring flow, salt, selenium, and boron loads. Data are collected daily to evaluate whether the discharge requirements near the terminus of the San Luis Drain are met.

## RESULTS

Within the first seven years of the Project, the drainage volume from the Grassland Drainage Area has been reduced by 46%, the salt load was reduced by 41%, and the selenium and boron load showed a decline of 61% and 34%, respectively (Table 1) (US Bureau of Reclamation et al. 2004).

| Water Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | % Reduction to 1996 |
|---|---|---|---|---|---|---|---|---|---|---|
| Drainage Discharge (acre feet)[a] | 51,079 | 37,478 | 46,244 | 32,253 | 30,208 | 28,008 | 28,411 | 27,425 | 28,300 | 45 |
| Selenium Load (lbs)[b] | 9,560 | 6,856 | 8,882 | 4,990 | 4,506 | 4,300 | 4,167 | 3,983 | 3,675 | 62 |
| Boron Load (1000 lbs)[b] | 730 | 729 | 941 | 642 | 606 | 545 | 273 | 281 | 380 | 48 |
| Salt Load (tons)[b] | 191,141 | 169,234 | 208,900 | 146,543 | 128,568 | 119,246 | 117,552 | 118,747 | 118,040 | 38 |

**Table 1** Grassland Bypass Project Summary of Annual Volumes and Loads at San Luis Drain (Site B).
Data Source: a – U.S. Geological Survey, b – Loads calculated from California Regional Water Quality Control Board.

## BIOLOGICAL MONITORING

At seven different sites selenium concentrations in small and medium fish, invertebrates, vegetation, and bird eggs were measured to study the ecological effects of the Grassland Bypass Project. In general, selenium concentrations in Mud Slough (at Site D) and downstream before the confluent with the San Joaquin River (Site E) exceeded the threshold of toxicity frequently and the overall hazard of selenium to the ecosystem continued to be high according to Lemly's index (Lemly 1995, 1996). This aquatic risk assessment was designed to provide an estimate of ecosystem effects of selenium and is based on maximum contaminant concentrations, rather than means, which makes it a highly sensitive tool.

In Salt Slough, a wetland water supply channel, where agricultural drainage water has been removed by the GBP, selenium concentrations declined predominantly during the first year of the Project and stayed well below the concern threshold levels since.

| | WY 1996 | | WY 1997 | | WY 1998 | | WY 1999 | | WY 2000 | | WY 2001 | | CY 2002 | | CY 2003 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly |
| **Mud Slough** | | | | | | | | | | | | | | | | |
| Water | 19.0 | High | 80.0 | High | 104.0 | High | 5.1 | High | 66.0 | High | 51.0 | High | 55.0 | High | 48.0 | High |
| Sediment | 0.4 | None | 0.8 | None | 2.0 | Low | 4.8 | High | 4.4 | High | 3.5 | Moderate | 8.5 | High | 7.8 | High |
| Invertebrates | 1.6 | None | 3.3 | Low | 11.0 | High | 7.0 | High | 15.3 | High | 7.1 | High | 7.5 | High | pending | |
| Fish Eggs | 14.2 | Moderate | 56.1 | High | 34.2 | High | 39.6 | High | 46.5 | High | 54.8 | High | 51.5 | High | pending | |
| Bird Eggs | 3.1 | Minimal | 4.4 | Minimal | 6.6 | Low | 10.0 | Low | 5.1 | Low | 7.0 | Low | 3.2 | Minimal | pending | |
| **Salt Slough** | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly | Se | Lemly |
| Water | 38.0 | High | 3.0 | Moderate | 5.0 | High | 1.5 | Minimal | 1.7 | Minimal | 2.1 | Low | 1.1 | Minimal | 1.3 | None |
| Sediment | 0.8 | None | 0.9 | None | 2.1 | Low | 0.9 | None | 0.7 | None | 0.8 | None | 0.7 | None | 0.8 | None |
| Invertebrates | 4.7 | Moderate | 2.6 | Minimal | 3.2 | Low | 2.8 | Minimal | 2.7 | Minimal | 0.7 | Minimal | 2.4 | Minimal | pending | |
| Fish Eggs | 28.1 | High | 17.8 | Moderate | 12.9 | Moderate | 11.2 | Moderate | 14.5 | Moderate | 12.5 | Moderate | 13.8 | Moderate | pending | |
| Bird Eggs | 5.2 | Low | 3.6 | Minimal | 3.7 | Minimal | 2.7 | None | 4.9 | Minimal | 4.0 | Minimal | 2.7 | None | pending | |

**Table 2** Aquatic Hazard Assessment of Selenium in Mud Slough and Slat Slough. WY: Water Year, CY: Calendar Year, Se: maximum selenium concentration (µg/L), Lemly: Lemly Aquatic Index.

### References

Lemly, A.D. 1995. A Protocol for Aquatic Hazard Assessment of Selenium. Ecotoxicology and Environmental Safety, Vol. 32, No. 2808288

Lemly, A.D. 1996. Assessing the Toxic Threat of Selenium to Fish and Aquatic Birds. Environmental Monitoring and Assessment, Vol. 43, No. 19835

Ohlendorf, H.M., R.M. Hoshem, C.M. Bunck, and K.C. Marois. 1990. Bioaccumulation of Selenium in Birds at Kesterson Reservoir, California. Archives of Environmental Contamination and Toxicology, Vol. 19, No 4, pp. 495-507.

US Bureau of Reclamation et al. 2004. Grassland Bypass Project, Annual Report: 2001-2002. Prepared by the San Francisco Estuary Institute, Oakland, CA.

### For More Information

www.sfei.org/grassland/reports/gbppdfs.htm
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