

Assessment of Internal Loading of Total Phosphorus in a Northern Everglades Canal Using a Simple Mixing Model

**Keywords: Everglades, Eutrophication, Internal Loading**

**Michael G. Waldon**, and Paul McCormick  
DOI Everglades Program Team, Boynton Beach, FL

The Arthur R. Marshall Loxahatchee National Wildlife Refuge includes one of three areas in South Florida designated to maintain water storage, provide flood control, and provide a refuge for the remnant Everglades ecosystem. In the 1950s and 1960s the refuge was surrounded by perimeter canals and hydrologically isolated from its watershed by levees. Stormwater runoff, primarily from the Everglades Agricultural Area, is pumped into the perimeter canal where it may flow to discharge structures or mix into the rainwater-dominated interior wetland. The pumped stormwater has elevated concentrations of both Cl and P. Data collected primarily by the South Florida Water Management District were analyzed in this study using a simple mixing model to provide a preliminary graphical assessment of P internal loading within the perimeter canal. This technique is analogous to the use of mixing plots or concentration-salinity diagrams in estuarine systems to identify presence of sources and sinks of constituents during seaward mixing. Rather than salinity, Cl is here used to estimate the fraction of each water sample originating in pumped inflow to the canal. This analysis supports the hypothesis that there is an internal P loading source within the canal. It is conjectured that the internal canal P source results from groundwater advection of re-mineralized P in sediment pore water. Recent studies have documented a large pool of P in the highly organic sediments deposited in the perimeter canal since construction. Relationship of internal loading to canal stage and discharge are examined.

**Citation:**

Waldon, M.G., and P.V. McCormick. 2003. Assessment of Internal Loading of Total Phosphorus in a Northern Everglades Canal Using a Simple Mixing Model, Society of Wetland Scientists 24th Annual Meeting, New Orleans, Louisiana, June 2003.

# Assessment of Internal Loading of Total Phosphorus in a Northern Everglades Canal Using a Simple Mixing Model

**Michael G. Waldon\***, and **Paul V. McCormick\*\***

DOI Everglades Program Team,

*Arthur R. Marshall Loxahatchee National Wildlife Refuge*

Boynton Beach, FL



\* [mike\\_waldon@fws.gov](mailto:mike_waldon@fws.gov)

\*\* [pmccormick@usgs.gov](mailto:pmccormick@usgs.gov)

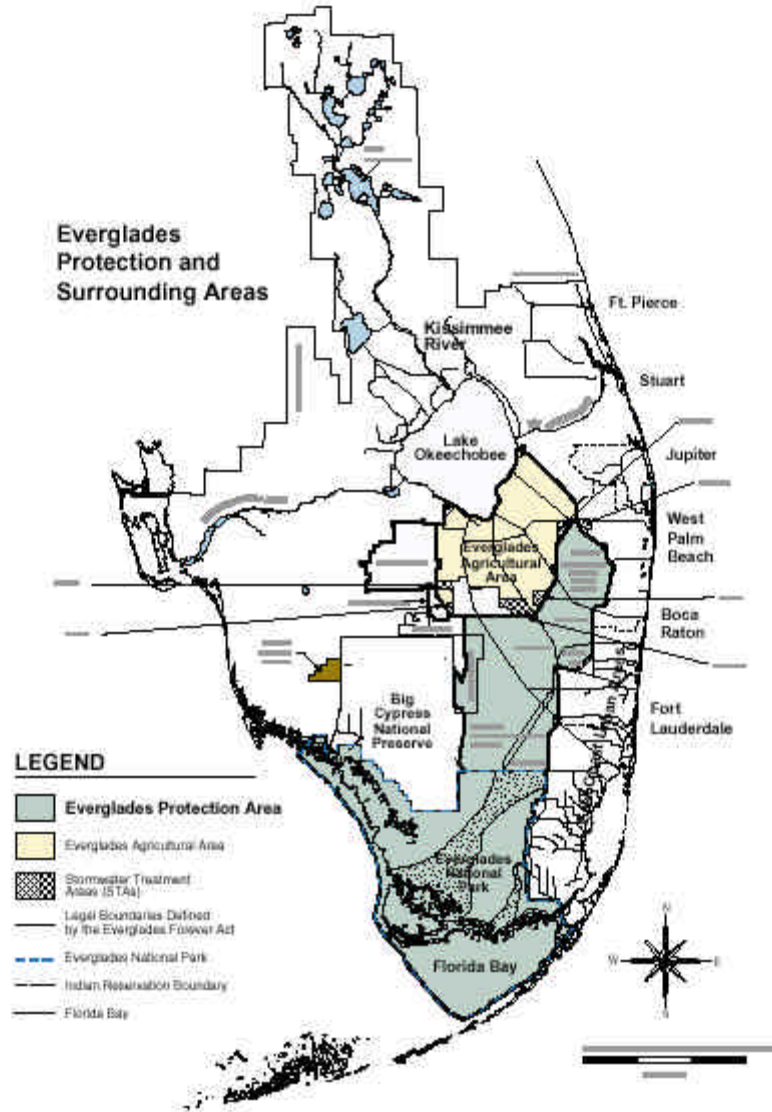


# ***ACKNOWLEDGMENT***

**The South Florida Water Management District provided the data analyzed in this study. Their cooperation & assistance are gratefully acknowledged.**

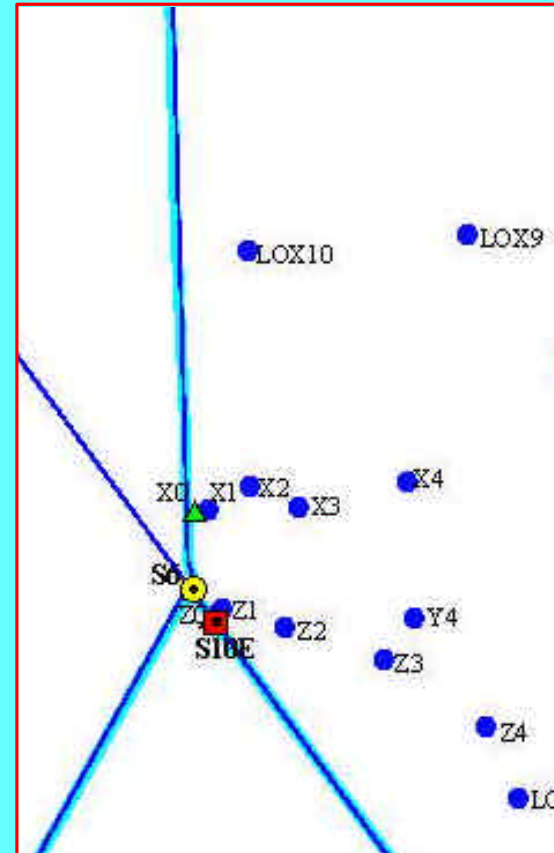
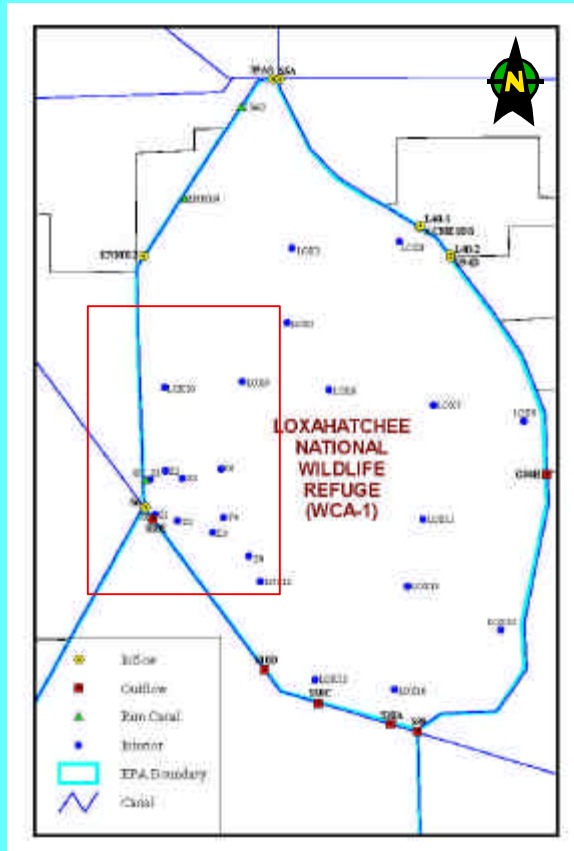


# South Florida and the “Everglades Protection Area”



Source: 2001 *Everglades Consolidated Report*, South Florida Water Management District

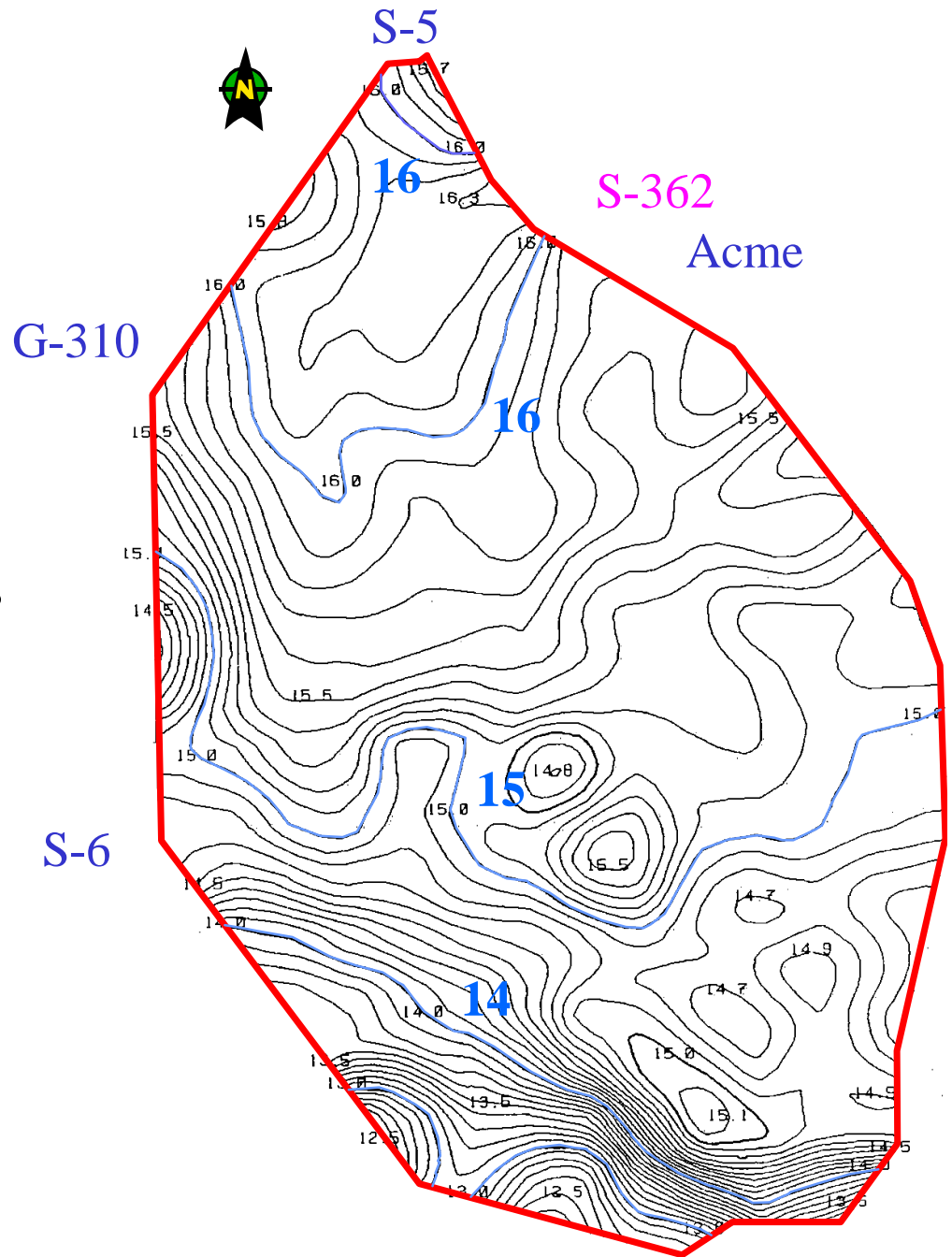
# A.R.M. Loxahatchee National Wildlife Refuge



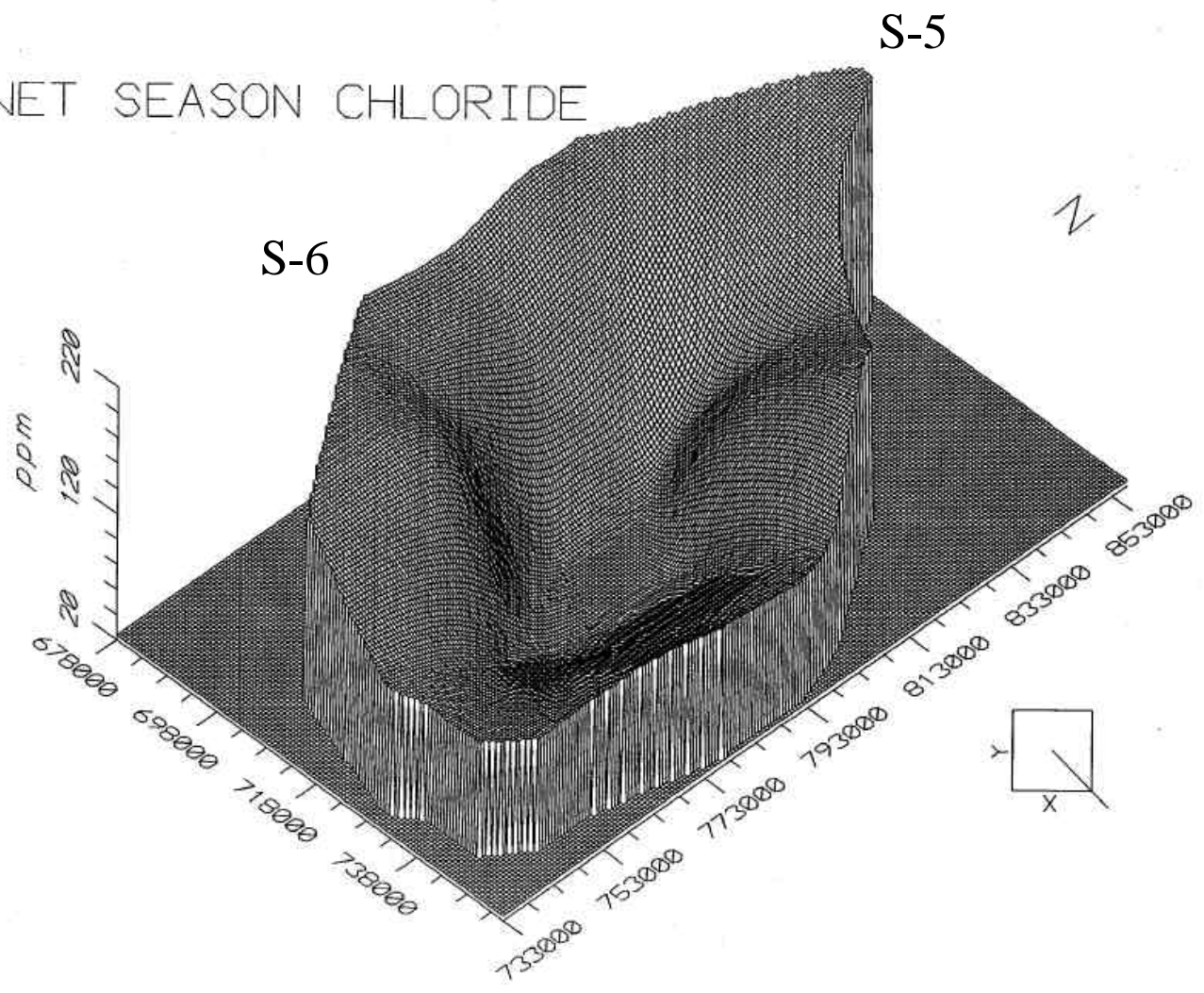
# Contour plot

0.1 foot contour intervals

(Richardson, et al., 1990)

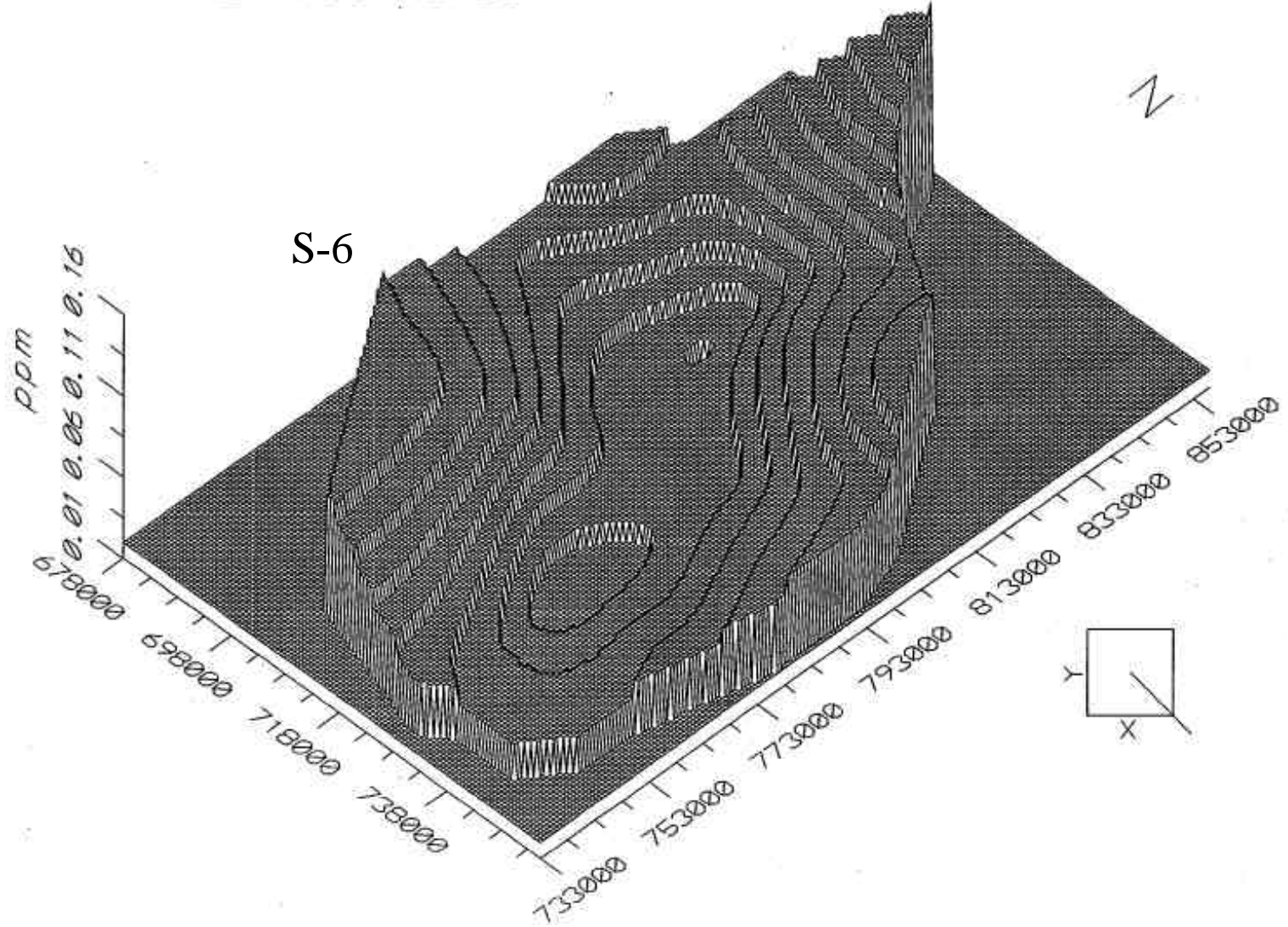


# WET SEASON CHLORIDE



WET SEASON  
TOTAL PHOSPHORUS

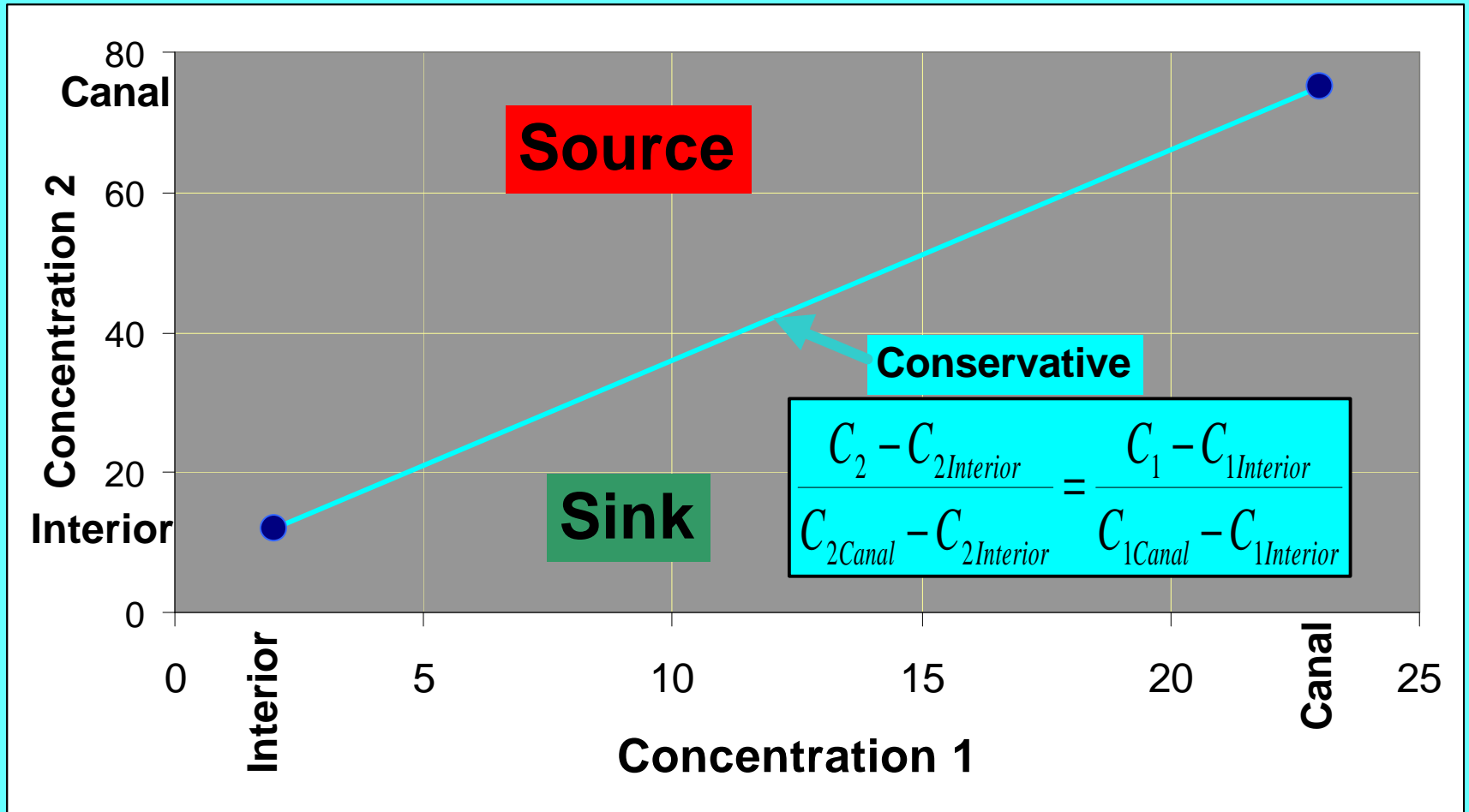
S-5



## Need for an alternative approach:

- Dilution from mixing in WCA-1 confounds interpretation of concentration data
- Mixing-plot uses a conservative constituent to estimate the degree that dilution causes reduced concentration
- The mixing-plot provides a graphical means to qualitatively class constituents as conservative, having a source, or having a sink

# Mixing Plot

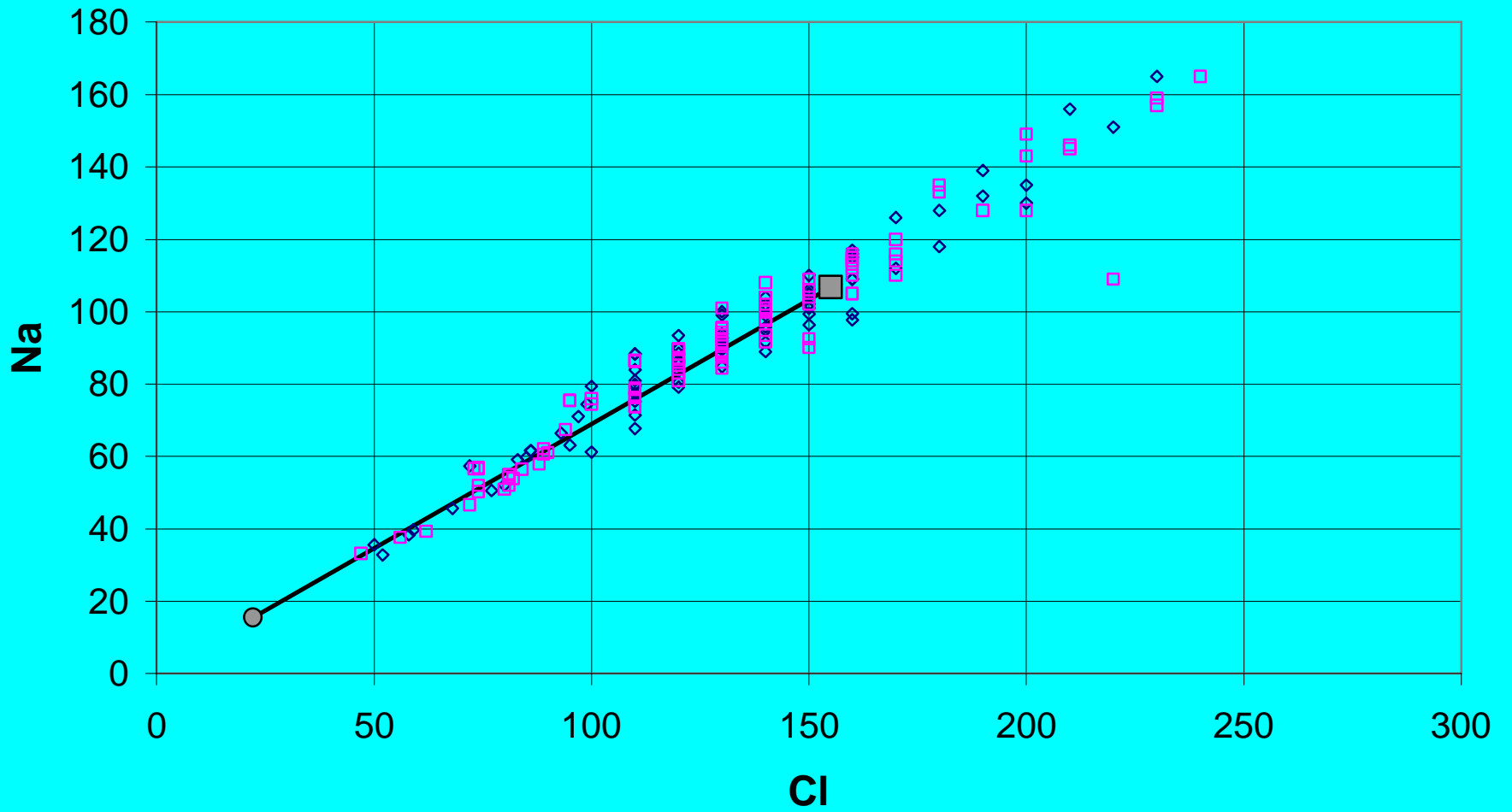


# Estimated Concentrations

Inflow=median canal cond>932; Unimpacted=median sites-4 cond<228.85

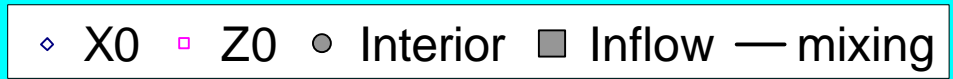
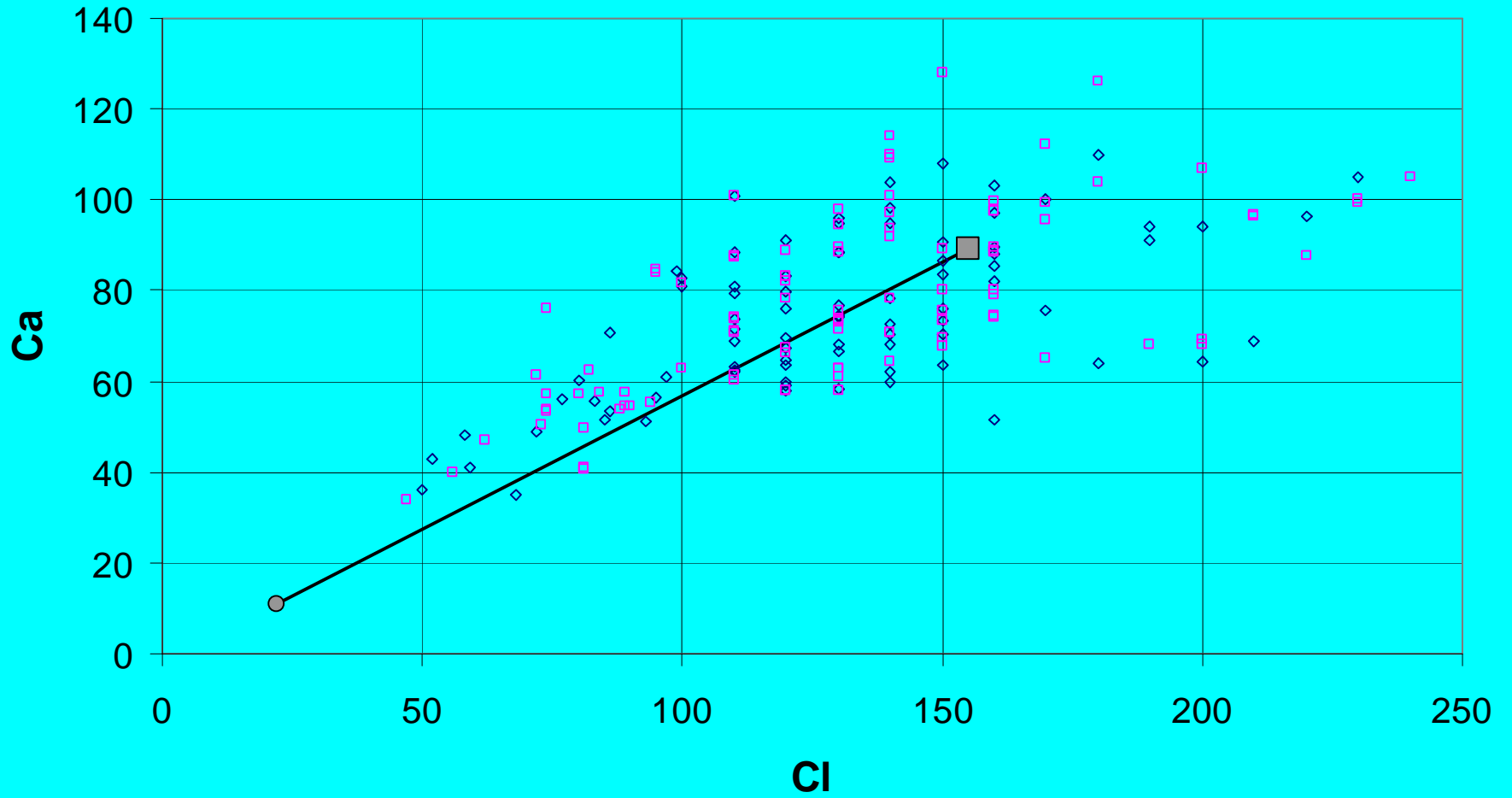
<b>SITE</b>		<b>Inflow</b>	<b>Unimpacted</b>
Conductivity	uS/cm	1101	147
Alkalinity	mg/L	283	37
Chloride (filtered)	mg/L	155.0	22.2
Calcium (filtered)	mg/L	89.1	11.0
Sodium (filtered)	mg/L	106.8	15.5
Silica (filtered)	mg/L	21.5	5.4
Sulfate (filtered)	mg/L	61.5	1.02
Total P	mg/L	0.052	0.008
Total N	mg/L	2.71	0.98
TN/TP (mass)		53	130

# L-7 Canal Sites

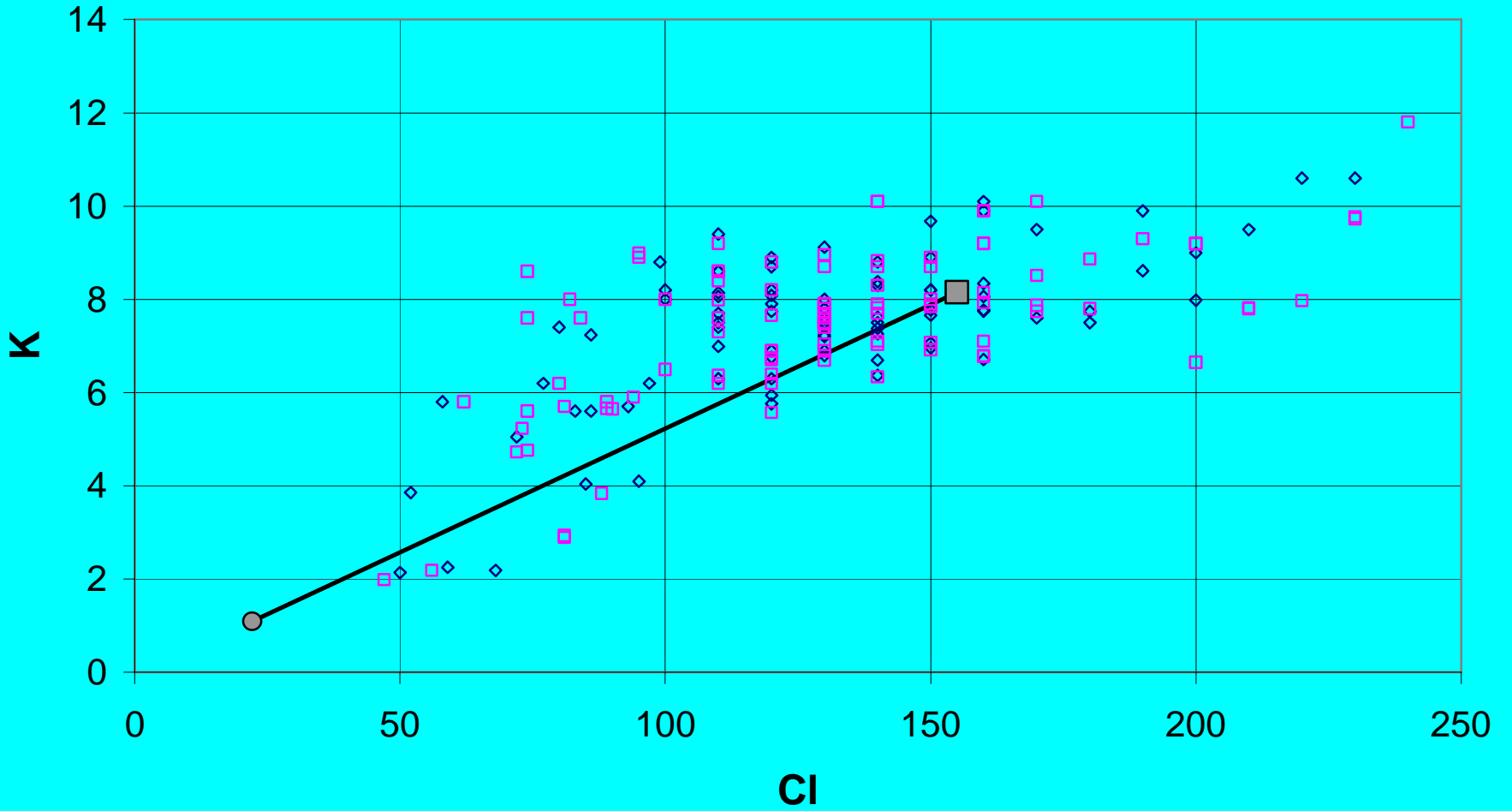


◆ X0    □ Z0    ● Interior    ■ Inflow    — mixing

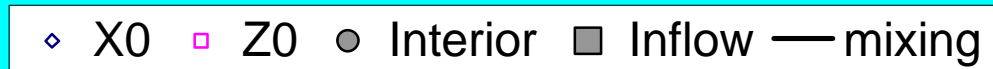
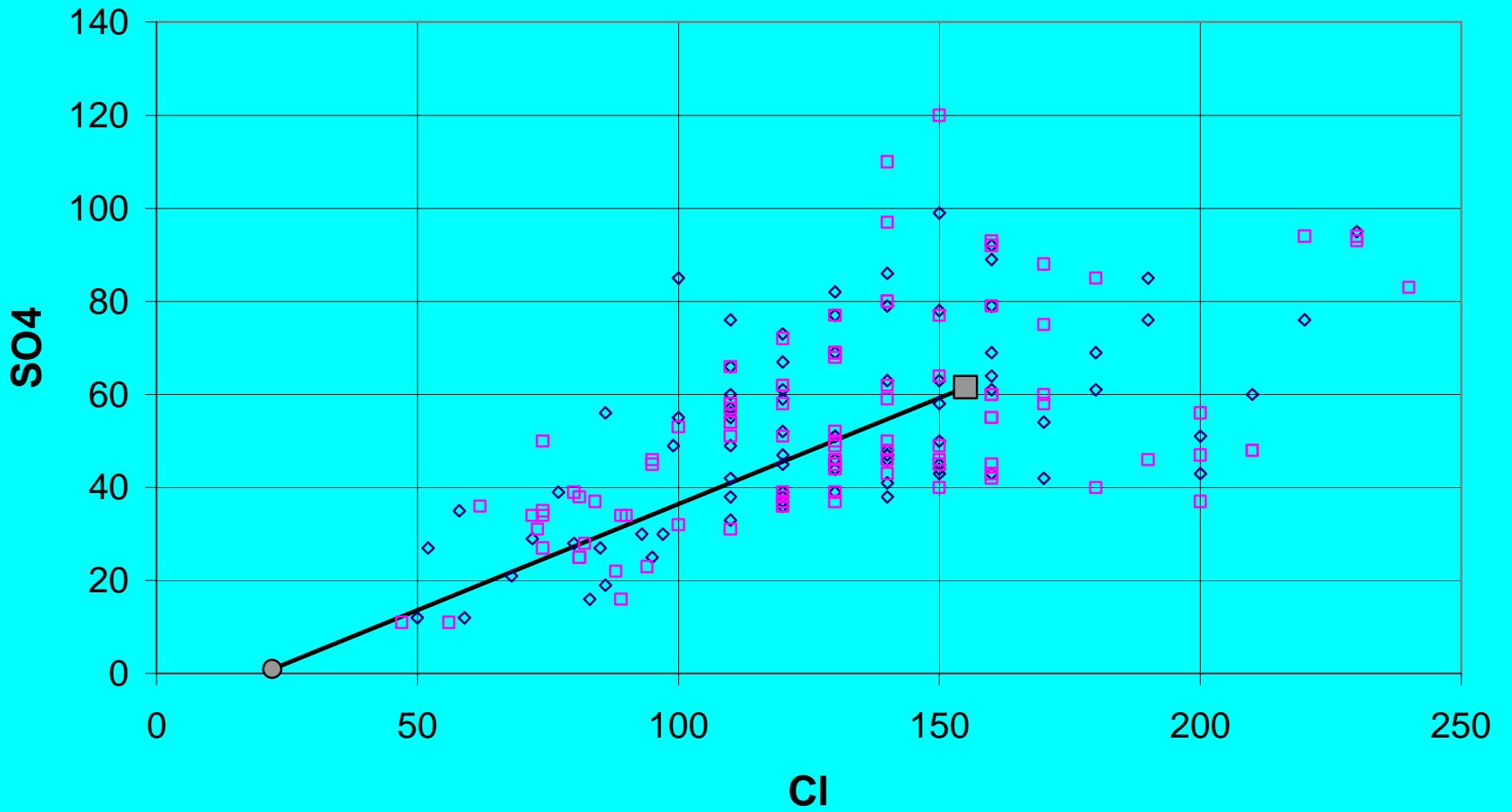
# L-7 Canal Sites



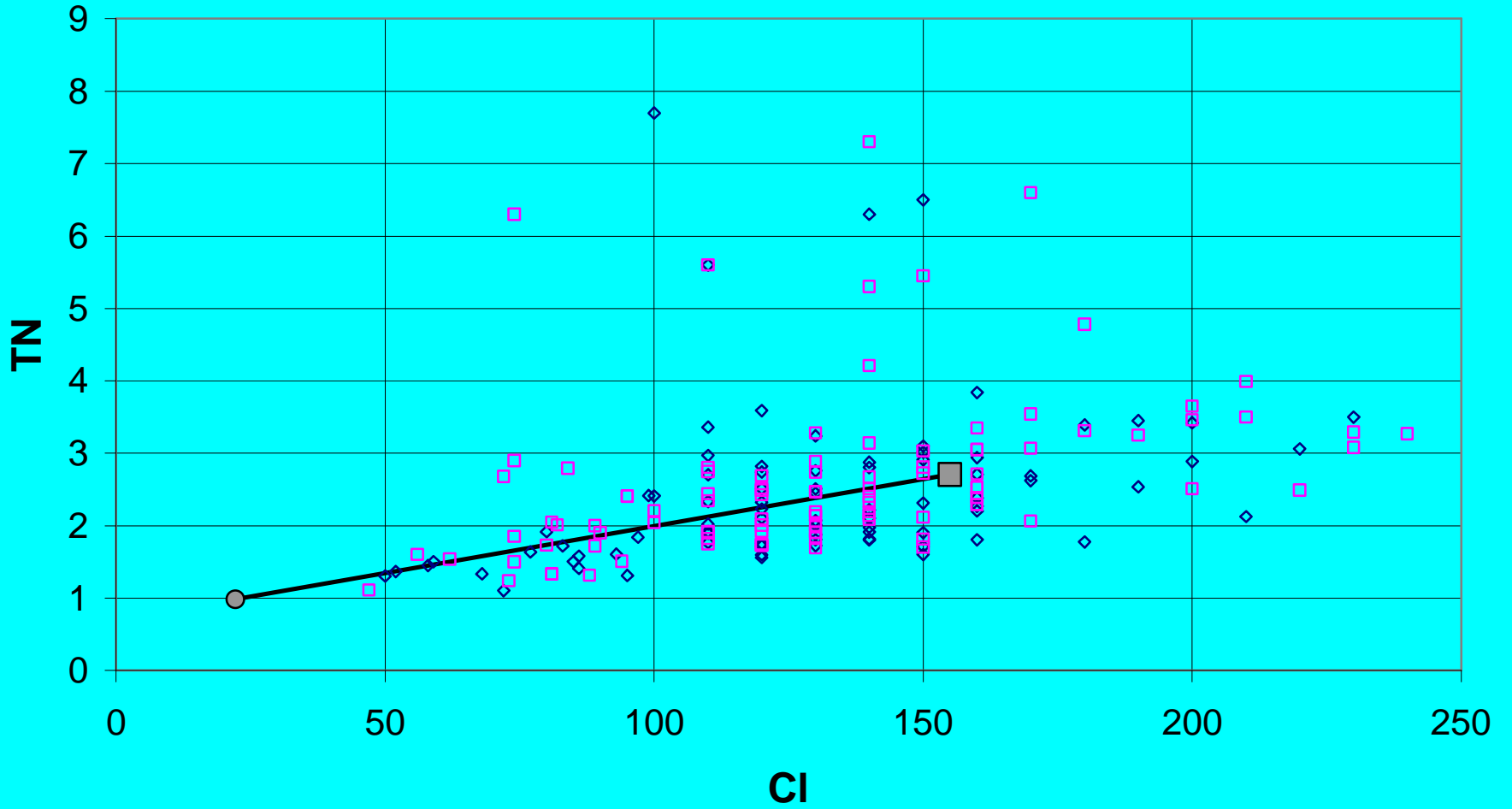
# L-7 Canal Sites



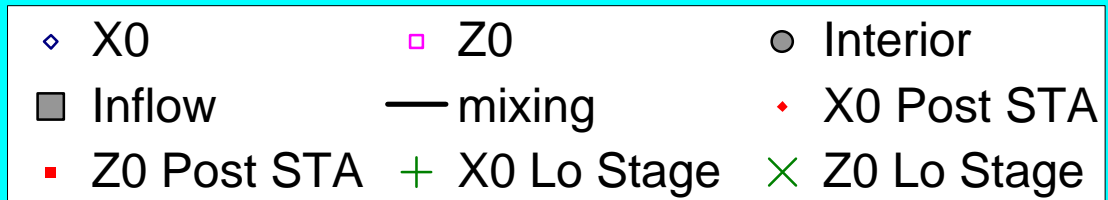
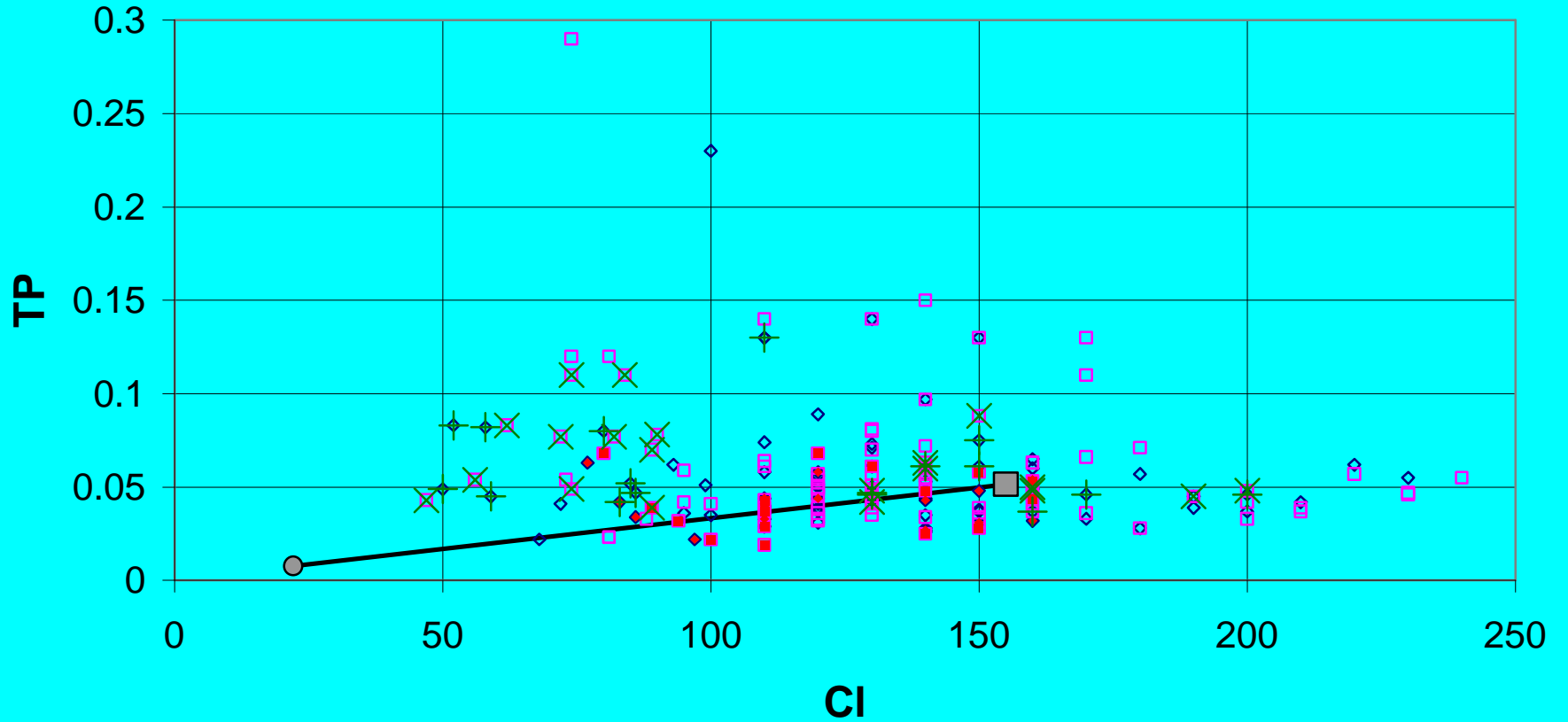
# L-7 Canal Sites



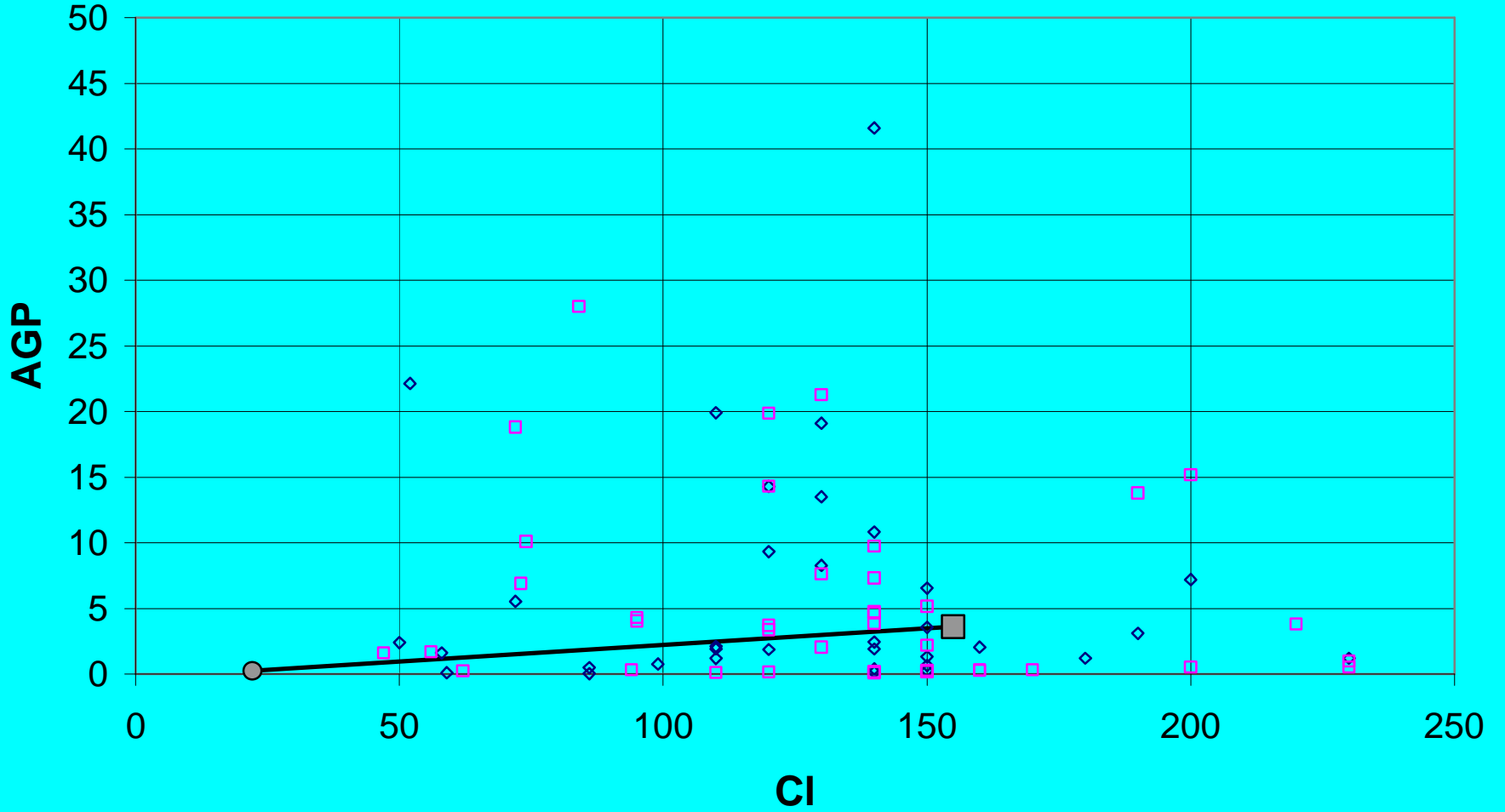
# L-7 Canal Sites



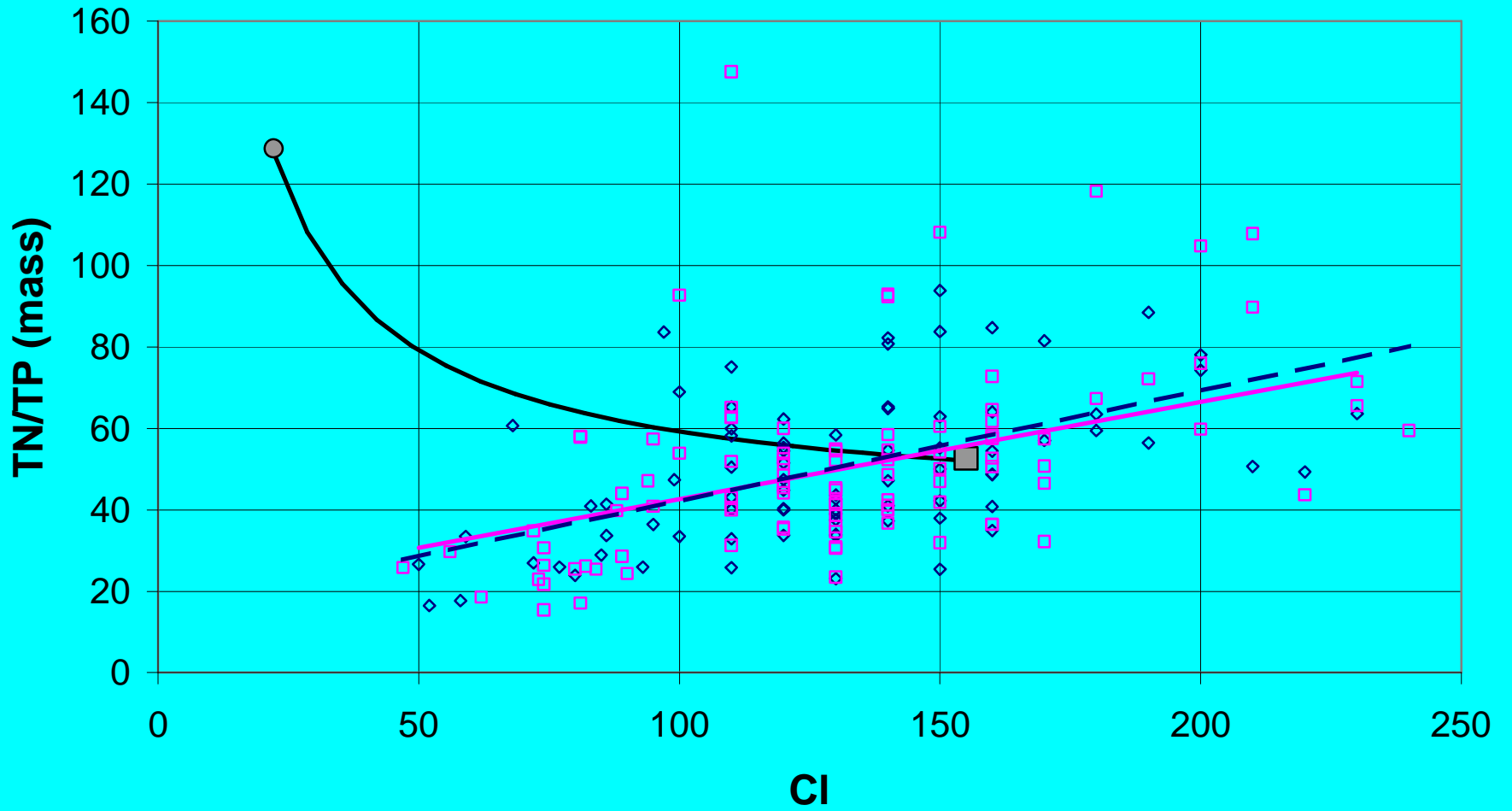
# L-7 Canal Sites



# L-7 Canal Sites



# L-7 Canal Sites



◆ X0    □ Z0    ● Interior    ■ Inflow    — mixing    — Linear (X0)    — Linear (Z0)

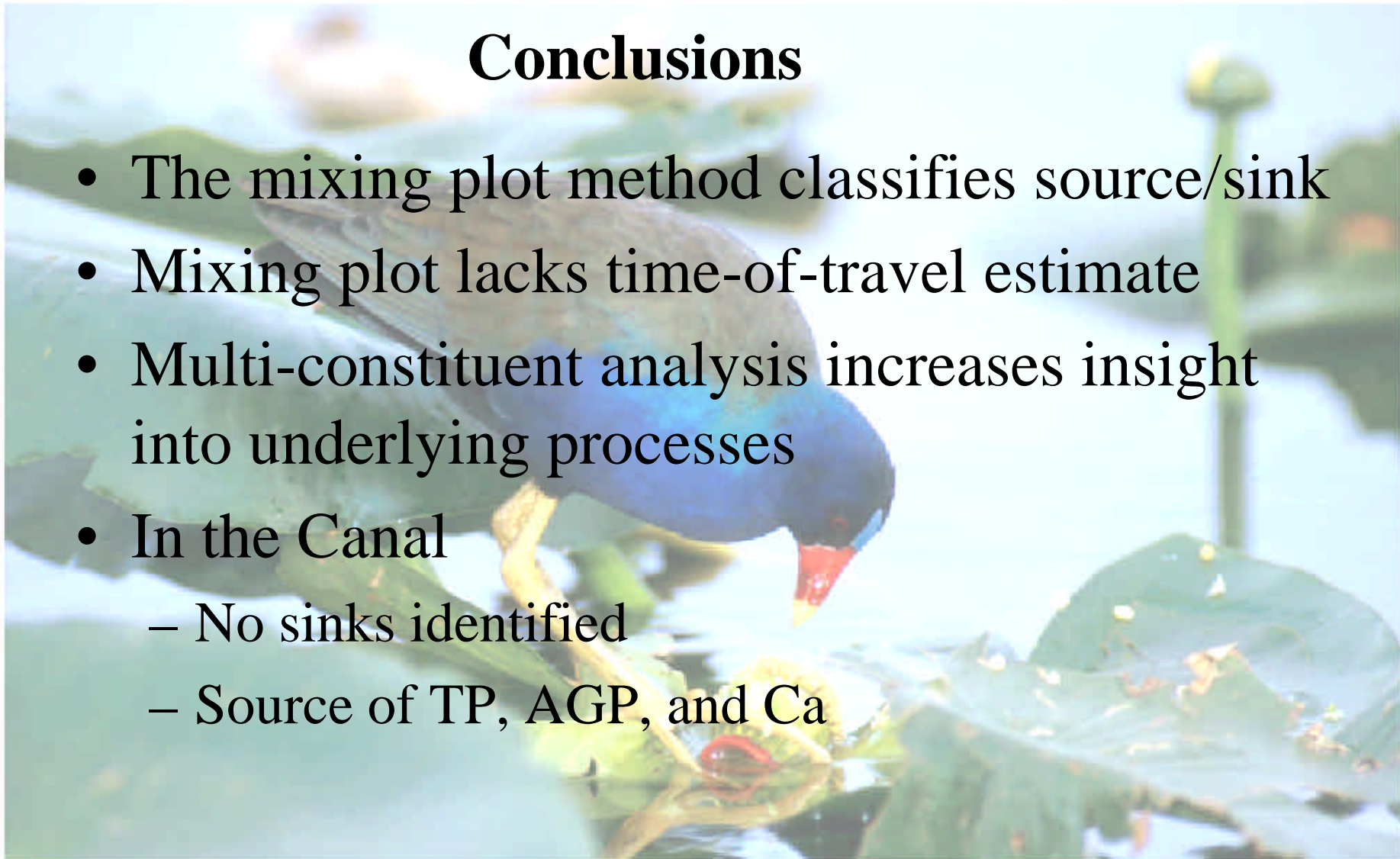
# Characterization of water quality parameters

<u>Parameter</u>	<u>Canal</u>	<u>Interior</u>
Sodium	C	C
Calcium	+	-
Sulfate	C	-
Potassium	+	C
Silica	+/-	+/-
Algal Growth Potential	+	-
Total Nitrogen	C	-
Total Phosphorus	+	-

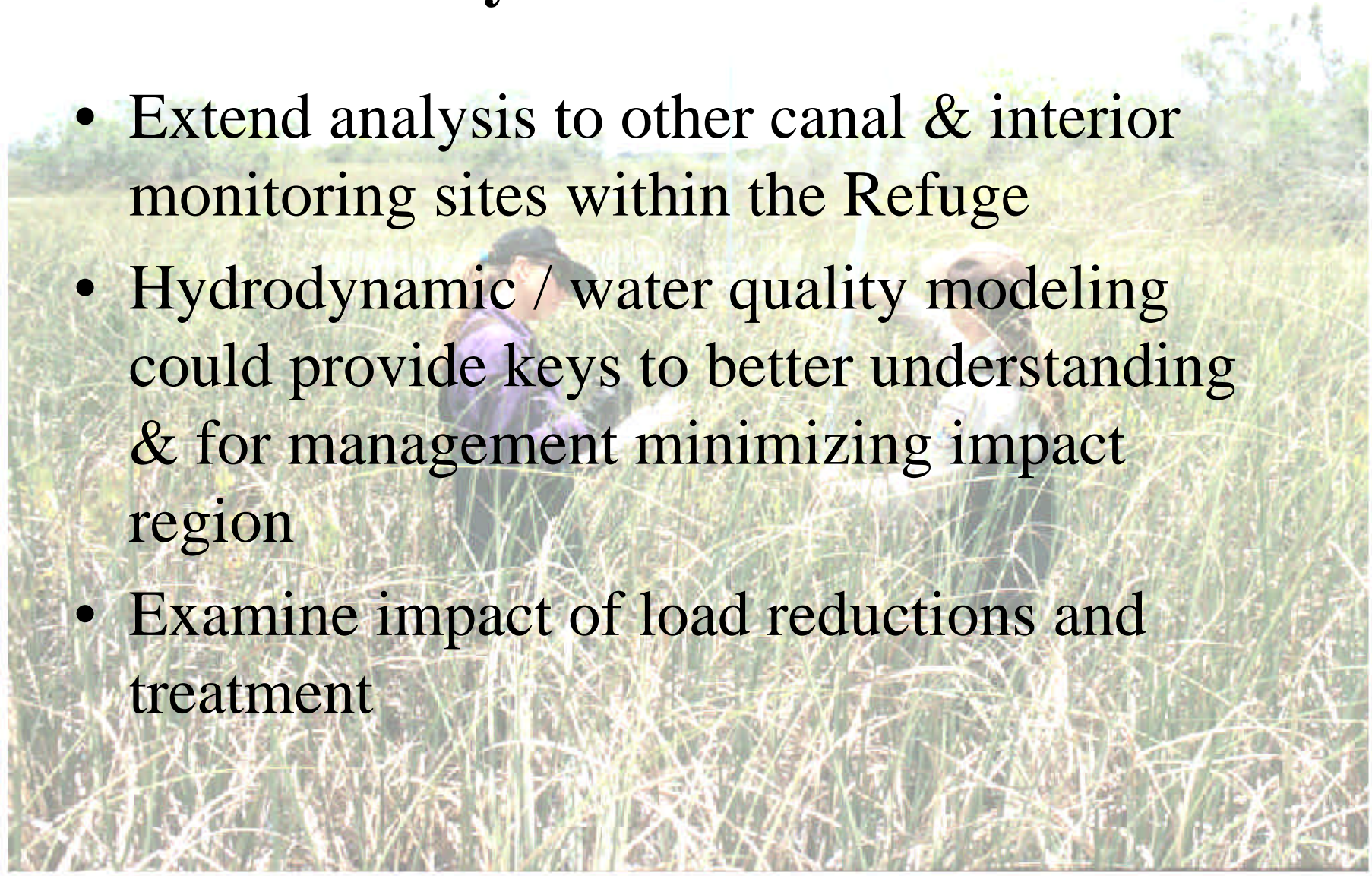
**Conservative = C, source = +, sink = -**

## Conclusions

- The mixing plot method classifies source/sink
- Mixing plot lacks time-of-travel estimate
- Multi-constituent analysis increases insight into underlying processes
- In the Canal
  - No sinks identified
  - Source of TP, AGP, and Ca



## **Study / Research Needs**

- Extend analysis to other canal & interior monitoring sites within the Refuge
  - Hydrodynamic / water quality modeling could provide keys to better understanding & for management minimizing impact region
  - Examine impact of load reductions and treatment
- 
- A photograph of two people, likely researchers, standing in a field of tall, dry grasses. One person is wearing a purple shirt and a dark cap, and the other is wearing a white shirt and a dark cap. They appear to be engaged in a field study or data collection activity. The background shows a line of trees under a bright sky.

# Questions?



*USFWS Photo by S.D. Jewell*