## Conceptual Models for Constituents of Drinking Water Concern in the Central Valley and Delta: Organic Carbon, Nutrients and Pathogens

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**Prepared for:**
US Environmental Protection Agency, Region IX

and

Central Valley Drinking Water Policy Workgroup



## Overview

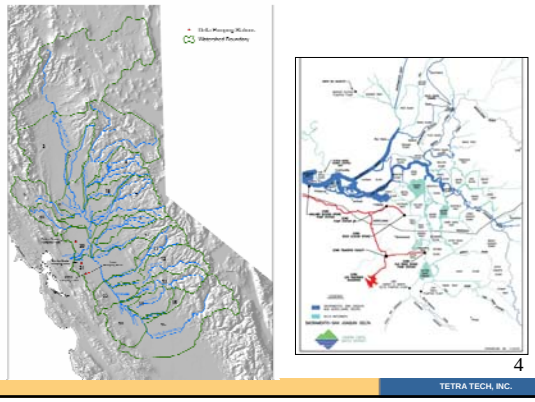
- Goals of conceptual model development
- Provide a summary of key results from conceptual model development for:
  - Organic carbon
  - Nutrients
  - Pathogens and pathogen indicators (ongoing)
- Recommendations for future monitoring and modeling



## Why these Constituents Matter

- Organic carbon: A precursor for trihalomethanes and haloacetic acids during chlorine disinfection. These are carcinogenic, and regulations require very low concentrations in treated drinking water.
- Nutrients: Can increase algae growth, some species of which can impart taste and odor, others produce toxins. Excess nutrients can result in elevated organic carbon in water supplies.
- Pathogens: Removal of these is the primary goal of water treatment.

## Geographic Setting



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## Role of the Conceptual Models

- **Using existing data, summarize current understanding of the behavior of the selected constituents in the Central Valley and Delta**
- **Particular focus on magnitudes of different sources and transport in the Central Valley and Delta**
- **Communicate information to wide audience: illustrate key assumptions and processes; identify data gaps**
- **Provide technical basis for future planning: identify data, analysis and modeling needs**

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## Organic Carbon Transport in the Central Valley-Delta Ecosystem


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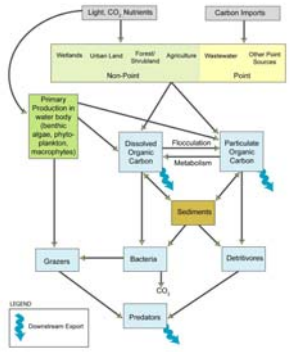
## Organic Carbon in the Aquatic Environment




- OC can exhibit an wide range of age and bioavailability to organisms, a property independent of reactivity to form DBPs
- POC more available than DOC; DOC less important to the food web
- OC derived primary production more bioavailable and considered a higher-quality food source

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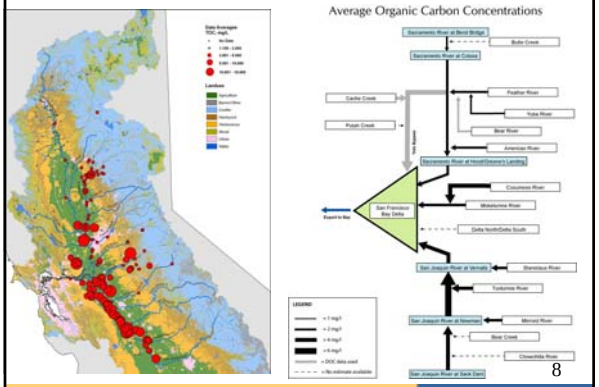
## TOC Concentrations

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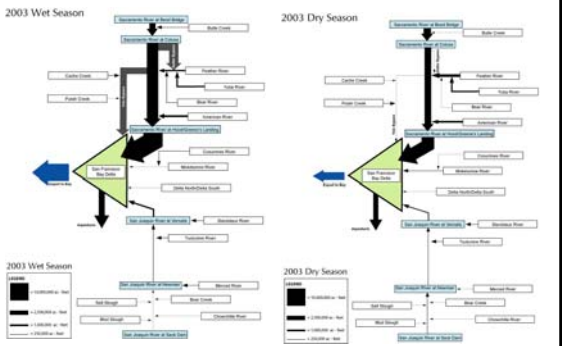
## Wet Year (2003) Flows

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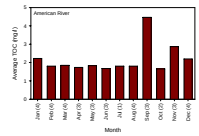
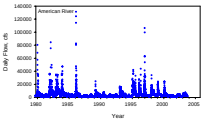
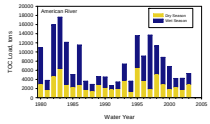
## Load Calculation Approach




**Monthly average concentration**

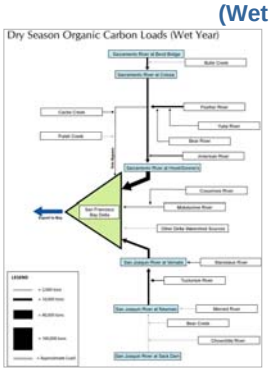
**x Monthly average flow**

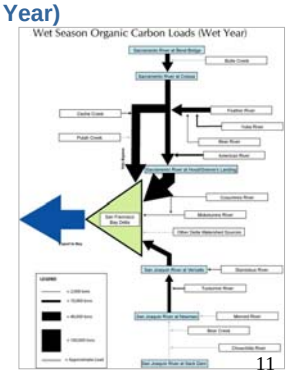
**=**

**Monthly load**



## Organic Carbon Loads Dry and Wet season (Wet Year)






## Using Land-Use Specific Export Rates




**Larger Watershed**

Area (A): 1,000 km²
Land use: 40% Forest (400km²) and 60% Agriculture (600km²)

Watershed Load (estimated) : ΣQC
= Forest export + Agriculture export
= 400 km² x 1ton/km²/yr + 600 km² x 2.5 ton/km²/yr
= 1900 tons/yr

Average Export = 1.9 tons/km²/yr

## Export Rates of Organic Carbon from Major Land Uses in the Central Valley

| Land Use | Dry Year Loads (tons/km²/yr) | | Wet Year Loads (tons/km²/yr) | | Source | |
|---|---|---|---|---|---|---|
| | *Sac-ramento* | *San Joaquin* | *Sac-ramento* | *San Joaquin* | *Sacramento* | *San Joaquin* |
| Agriculture[1] | 0.56 | 1.9 | 1.6 | 2.6 | Colusa Basin Drain | Harding Drain[2] |
| Urban Runoff | 1.3 | 0.67 | 2.4 | 1.2 | Arcade Creek | Calculated from Sacramento value |
| Forest/Rangeland | 0.41 | 0.21 | 1.7 | 0.85 | Yuba River | Calculated from Sacramento value |
| Wetland-Dominated[3] | 1.4 | 0.69 | 2.0 | 1.0 | Calculated from San Joaquin value | Average of Salt and Mud Slough |

[1]Available data do not allow separation into crop types.
[2]May include a small POTW influence.
[3]Wetland-dominated land may include a portion that is agricultural land.

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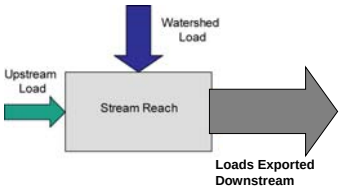
## Stream Reach Load Diagram

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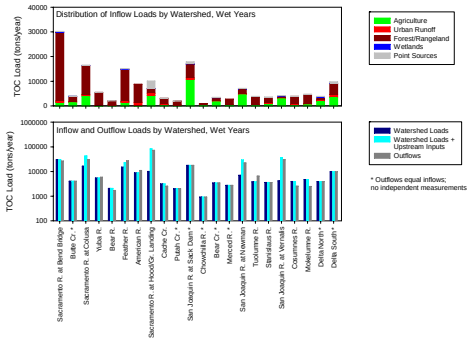
## Organic Carbon Watershed Loads by Source

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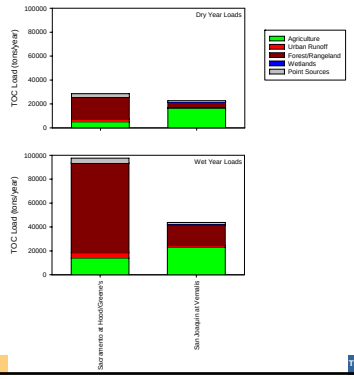
## Summary of Organic Carbon Loads from the Delta Watershed



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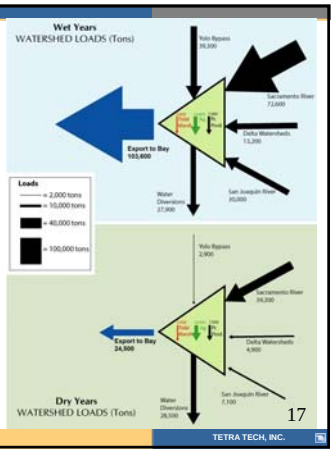
## Delta Organic Carbon Loads



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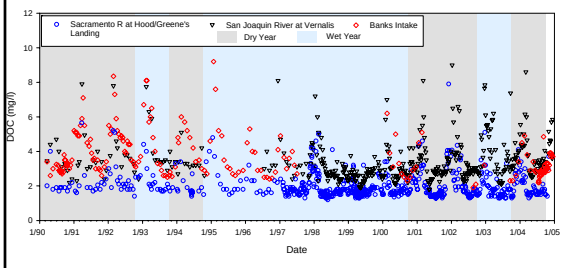
## Concentrations at Key Delta Stations



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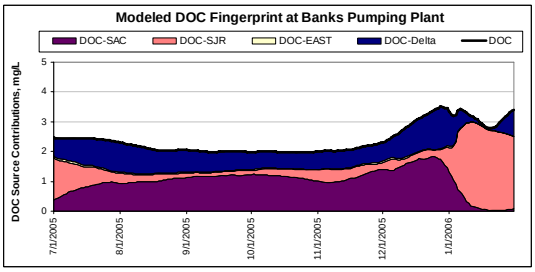
## DWR DSM2 Model Fingerprinting Results

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## What Did We Learn and How Can We Use It?

- Dry year loads for the Sacramento and San Joaquin Rivers are similar, although in wet years, the Sacramento River is a much greater contributor.
- There are many streams in the Central Valley for which organic carbon data were not available or are very limited. Some of these data gaps have been filled through ongoing efforts, and some locations may need additional monitoring.
- Land-use specific export rates, especially for different agricultural practices and undeveloped lands, has the potential to improve the accuracy of source characterization, and should be considered for refinement.
- Organic carbon exports from forested watersheds in the wet seasons can be a significant source, not very different from agricultural lands.
- Although organic carbon chemical characterization has the potential to more closely relate it to THM formation potential, the data that do exist are limited spatially and temporally. Given the inter- and intra-year variability of flows and loads in the Delta, greater coverage of such analysis is strongly recommended.

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## Nutrients Conceptual Model

- Emphasis is on nitrogen and phosphorus
- Usually, the impact of nutrients on drinking water quality is indirect, and occurs through increased primary productivity, with the potential for higher TOC, taste/odor and toxin concerns (Exception: Nitrate and nitrite)
- Nutrient impacts are more likely to express themselves during transport in aqueducts and storage in reservoirs, that at the intakes.
- The conceptual model looked at nutrient loads and concentrations, not on the secondary indicators

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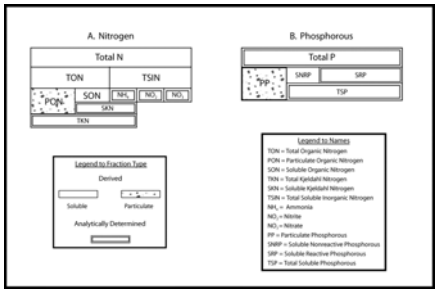
## Nutrient Species

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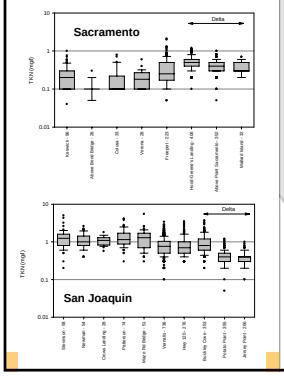
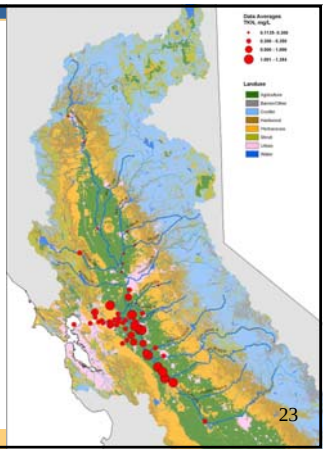
## Total Nitrogen

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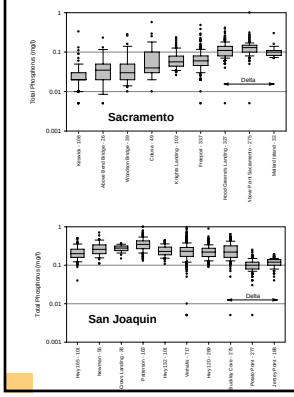
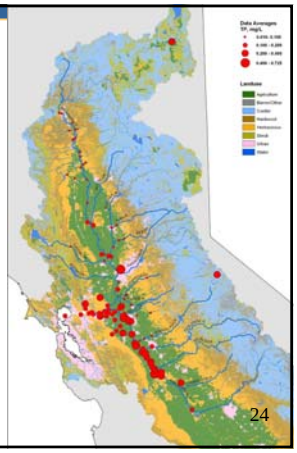
## Total Phosphorus

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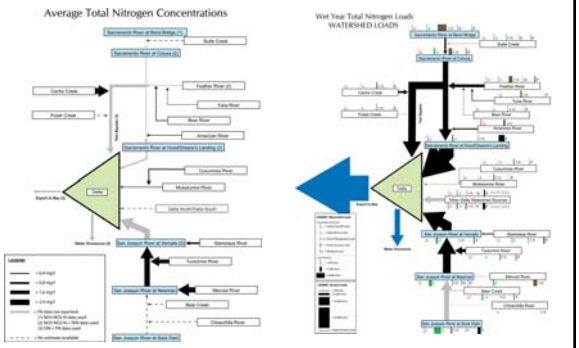
## Total Nitrogen

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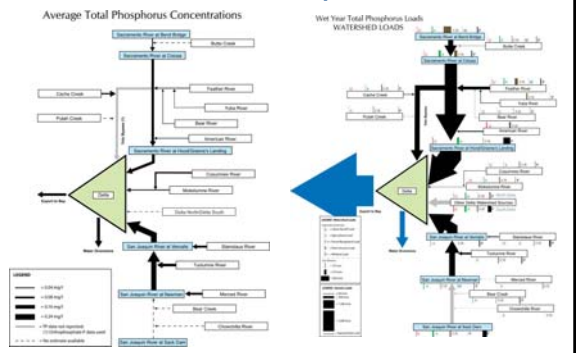
## Total Phosphorus

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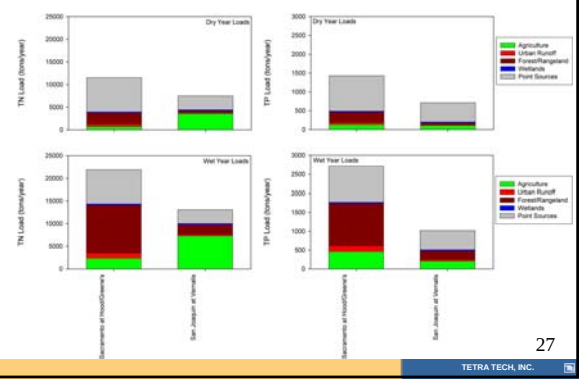
## Nitrogen and Phosphorus Loads by Watershed and Source

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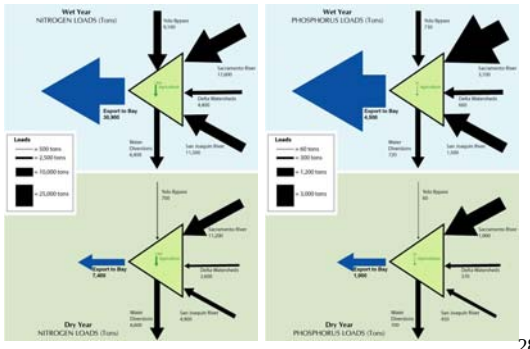
## Nutrient Loads Entering and Leaving the Delta

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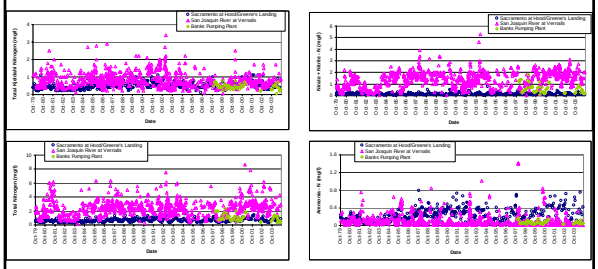
## Nitrogen Species Concentrations in the Delta



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## What Did We Learn and How Can We Use It?

- **Point sources are a major contributor of nutrients, and in dry years, can constitute more than 50% of the total loads.**
- **Exports from forested land/rangeland in the wet seasons are a significant source, often larger than point source loads in the wet season. Improved estimates of land-use specific export rates, especially for different agricultural practices and undeveloped lands are needed, as noted earlier for organic carbon.**
- **Concentrations of nitrogen and phosphorus in the Delta are indicative of eutrophic waters, although the primary productivity is not as high, likely due to light limitation because of suspended solids. Concentrations of nutrients at the Banks Intake are relatively uniform over different years and seasons.**
- **When Delta waters are extracted and transported long distances or stored, suspended particles can settle out, reducing the light limitation and enhancing algal productivity. This can lead to adverse impacts on drinking water quality. More research of behavior of Delta water after withdrawal is needed.**

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## Pathogens and Pathogen Indicators

- Most available data is for indicator organisms: total coliforms, fecal coliforms, and *E. Coli*
- Limited data on *Cryptosporidum* and *Giardia*
- Although it is understood that specific pathogens may be more long-lived than indicator coliforms, there is no consensus on alternate indicators
- Of necessity, the pathogen conceptual model (now in progress) will be less quantitative than conceptual models for organic carbon and nutrients

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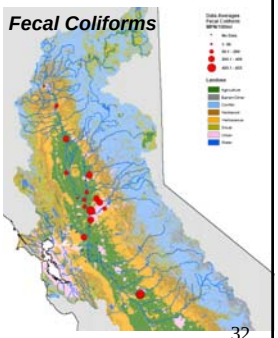
## Pathogen Indicators

*E. Coli*

*Fecal Coliforms*



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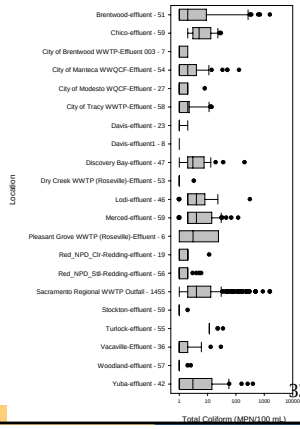
## Total Coliform Counts in Wastewater Discharge

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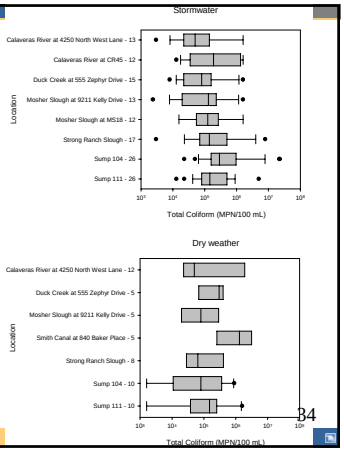
## Total Coliform Counts at Runoff Locations

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## Summary

- **Conceptual models present a synthesis of the magnitudes and variability of loads of different constituents from different sources**
- **Highlight data gaps in data and understanding, and identify uncertainties that need to be reduced**
- **Suggest needs for additional data collection, mechanistic modeling, and analysis**

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## Data/Modeling Needs for Selected Constituents

- **Monitor indicator watersheds to get better estimates of export rates from specific land uses**
- **Agricultural drain maps to improve resolution of agricultural sources**
- **More reservoir data to calculate reservoir exports of organic carbon**
- **Quantification of flows from Delta agricultural drainage**
- **Better quantification of tidal marsh exports through ongoing studies**
- **For wastewater sources, evaluate differences by process type**
- **Mechanistic modeling of processes in Delta using DSM: consider modeling nutrients**
- **Modeling of nutrient processes following withdrawal from Delta**

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