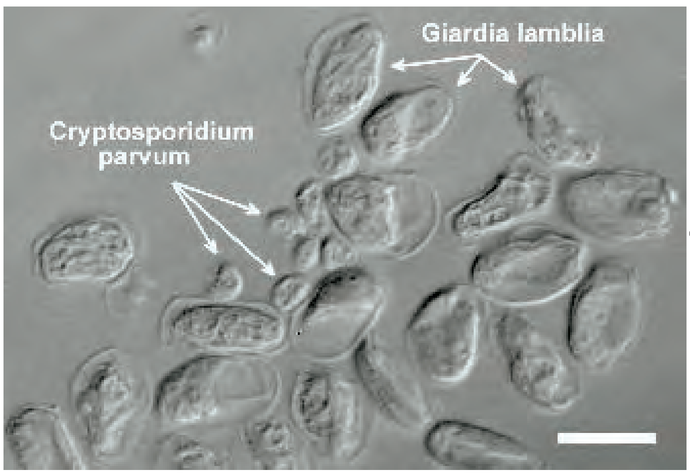
Conceptual Model For

Pathogens and Pathogen Indicators in the Central Valley and Sacramento-San Joaquin Delta

August 24, 2007



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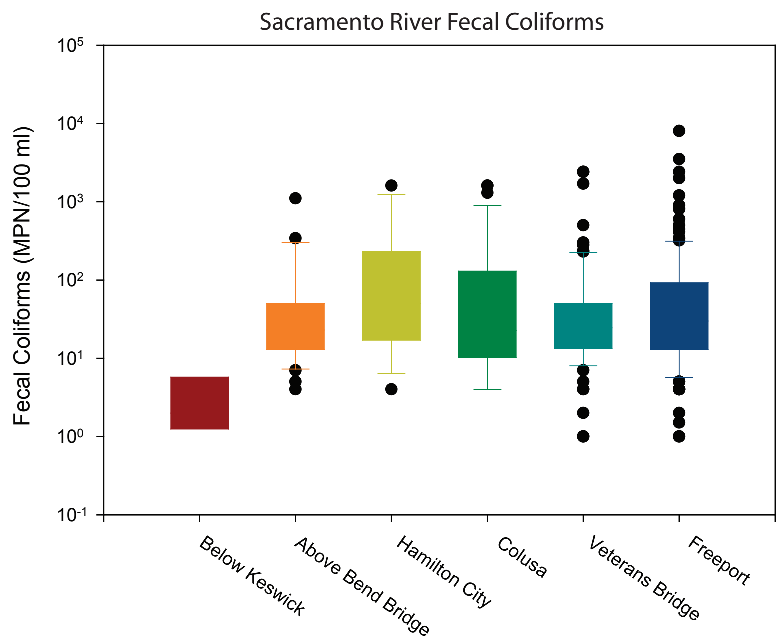
Bar = 10 Micron



Prepared for:

US Environmental Protection Agency, Region IX

Central Valley Drinking Water Policy Workgroup

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CONCEPTUAL MODEL FOR

PATHOGENS AND PATHOGEN INDICATORS IN THE CENTRAL VALLEY AND SACRAMENTO-SAN JOAQUIN DELTA

FINAL REPORT

Prepared for

US Environmental Protection Agency, Region IX

Central Valley Drinking Water Policy Workgroup

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EXECUTIVE SUMMARY

This report presents a conceptual model of pathogens and indicators for pathogens in the Central Valley and the Sacramento-San Joaquin Delta. The conceptual model was based on previously collected data from a variety of monitoring programs over the last decade and can be used to direct future investigations to improve understanding of pathogen sources, transport, and impacts to drinking water quality. The underlying data used in this work was focused on fecal indicators (total coliforms, fecal coliforms, *Escherichia coli*, and other bacteria) that are widely used in lieu of data on pathogens. Pathogens, because of their typically low abundance in most waters used for drinking water supply, are much less abundant and therefore much harder to detect than indicator bacteria.

Evaluation of the data performed as part of the conceptual model development included mapping and plotting of available data by location and source type across the Central Valley and Delta. Although a large quantity of data was available for this analysis, the size of the Central Valley watershed, and complexity of fecal indicator and pathogen response, especially rapid dieoff, prevented a detailed quantitative analysis of indicator loads in the manner performed in prior work for organic carbon and nutrients (Tetra Tech, 2006a, 2006b). Of the known sources of coliforms into the waters of the Central Valley, it was found that wastewater total coliform concentrations for most plants were fairly low (<1000 MPN/100 ml). Coliform loads from the largest wastewater treatment plant in the Central Valley were substantially lower than from a canal draining a rapidly urbanizing watershed (NEMDC). In general, the highest total coliform concentrations in water (>10,000 MPN/100 ml) were observed near samples influenced by urban areas. Similar total coliform concentration data were not available for the San Joaquin Valley (the highest values were capped at ~2400 MPN/100 ml). However, *E. coli* data were not similarly capped, and for this parameter, comparably high concentrations were observed for waters affected by urban environments and intensive agriculture in the San Joaquin Valley. Finally, wetland sites in the Delta and the San Joaquin Valley had elevated concentrations of coliforms, likely as a result of the contribution of aquatic wildlife.

Fecal indicator data showed minimal relationships with flow rates, although most of the high concentrations were observed during the wet months of the years, possibly indicating the contribution of stormwater runoff.

Data on true pathogens was available primarily for *Cryptosporidium* and *Giardia* along the Sacramento River. Where monitored, these parameters were often not detected, and when detected, the concentrations were generally very low, typically less than one organism per liter. Given the flows of the Sacramento River and estimates of *Cryptosporidium* generation by mammals, typical loads flowing into the Delta from the Sacramento River are of the same order of magnitude as the number of organisms generated by a single calf (one of the most prolific producers of *Cryptosporidium*). This result could be caused by the presence of natural or artificial barriers/processes that limit transport to water, by the significant die off of oocysts that do reach the water, as well as limitations in the analytical detection of *Cryptosporidium* oocysts in natural waters.

Coliform bacteria are recognized to be less than ideal indicators for pathogens, and a wide variety of new indicators are under development although their applicability, generality, and cost remain concerns. For the foreseeable future, it appears that despite all limitations coliform measurements, these will remain the *de facto* standard for identifying the presence of pathogens. It is recommended that the Central Valley Drinking Water Policy Workgroup continue to support collection of data on coliforms for consistency with historical data, but also continually evaluate new analysis techniques for systematic application in the Central Valley.

Unlike chemical constituents analyzed as part of other conceptual models developed for the Central Valley Drinking Water Policy Workgroup, coliform indicators vary by orders of magnitudes over small distances and short time-scales. Accurate quantification of such parameters requires substantial data, which are often not available. A key observation of the source evaluation presented in this report is that fecal indicator levels are most responsive to sources and events in close proximity to the monitoring location, and that large scale modeling, with consideration of transport over many days, may be of limited benefit. While the large watershed modeling approach, i.e., on the scale of the Central Valley, is appropriate for somewhat stable parameters such as total dissolved solids and organic carbon, a fundamentally different approach is recommended for modeling fecal indicator loading, with an emphasis on relatively small watershed and surface water areas. Within these smaller areas of interest, individual sources, for example, wild and domestic animals, aquatic species, urban stormwater runoff, discharge from wastewater treatment plants, and agricultural point and non-point sources such as confined feeding lots and runoff, can be characterized with greater precision. Given the strength of the stormwater source, more detailed evaluation needs to be performed of the linkage between rainfall and coliform loads, with a view to develop management practices for minimizing the loading from stormwater.

Although, computer tools can be used to make more detailed estimates of bacterial loads in surface waters, the additional effort and data collection needed to make such predictions meaningful has to be weighed against the collection of data on pathogens. In this respect, somewhat greater data collection, particularly in the San Joaquin Valley, is recommended for *Cryptosporidium* and *Giardia*. Sampling of *Cryptosporidium and Giardia* from potential sources such as wastewater, urban stormwater runoff and agricultural drainage will also help characterize the pathogen loads to surface waters. In general, sampling of San Joaquin and Sacramento River source waters for a wide range of potential pathogens including bacteria and viruses of concern, even on a limited scale and frequency, will provide valuable information on the health of this extremely critical water source.