# California Regional Water Quality Control Board
## North Coast Region
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**Jerry Brown**
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## MEMORANDUM

Date: 31 May 2011

To: File: Laguna de Santa Rosa; TMDL Development and Planning

From: Steve Butkus

Subject: Sediment Quality of the Laguna de Santa Rosa

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The Laguna de Santa Rosa Foundation, in collaboration with Philip Williams and Associates (PWA), Tetra Tech, and a Technical Advisory Group developed a conceptual model of the Laguna water quality problems (Sloop et al. 2007). The conceptual model was prepared to help direct the Laguna TMDL development to a watershed-scale. The conceptual model report made recommendations on the data collection needed to support the TMDL development.

The conceptual model report recognized that sediments play an important role as both a source and a sink of nutrients in lakes (Nürnberg 1987). The forms and quantity of phosphorus (P) and nitrogen (N) in lakes are a function of such factors as the external nutrient inputs and outputs, and their interchange between the sediment and the water compartments (Reddy et al. 1996). The modeling recommendations from Sloop et al. (2007) included the collection of sediment nutrient concentrations and a study assessing sediment flux rates within the Laguna watershed surface waters.

Regional Board staff have previously collected surface sediment samples for analysis of nutrient concentrations during several past studies in the Laguna Watershed that were not presented in the conceptual model report. The conceptual model report did not Sediment quality samples were collected in Laguna surface waters between 1985 and 2000. These sediment data have been compiled in Table 1. Times series plots and box plots of sediment nutrient concentrations are presented in Figures 1-10. Sediment organic carbon and fine sediment contents are shown in Figures 11-14.

Box plots provide a concise graphical display summarizing the distribution of a data set (Helsel and Hirsch, 2002). The top and bottom of the box represent the lower and upper quartiles with the band near the middle of the box showing the median. The whiskers represent the $10^{th}$ and $90^{th}$ percentiles. The mean is shown as a cross system on the box plot. Similar concentrations were observed for most constituents. Two exceptions were higher relative ammonium-N concentrations at Highway 12 and higher relative nitrate-N concentrations at Stony Point Road.

Fine particulate sediment and total organic carbon data was collected from a core sample by PWA (2004). Fine particulate sediment, defined as the percent of clay and silt particles, and total organic carbon was in a similar range as reported in PWA (2004). A 75-inch deep sediment core was extracted and analyzed for particle size distribution (PWA, 2004: see Figure 62). The sample was found to contain 55-85 percent clay, 15-45 percent silt and 5-10 percent total organic carbon. The sample contained only small amounts of medium and fine sand (0-2 percent).

The lowest silt content coincides with the depth believed to correspond to the 1940s-1950s. Silt content increased continually since that period. This period represented an increase in farming and construction and silt delivery. In addition, the channelization of streams and drainage ditches increased delivery of silt that previously would have been deposited in channels or on adjacent land surfaces.

Time series plots provide a visual representation of trend. Available data are not adequate to conduct a statistical trend analysis. However, visual inclinations in the data were apparent in several of the time series plots. Total phosphorus, total nitrogen and ammonium all visually showed increasing inclinations in concentration. There is insufficient evidence to conclude if these visual inclinations represent changes in environmental conditions.

## REFERENCES

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Nurnberg, G.K. 1984. The prediction of internal phosphorus load in lakes with anoxic hypolimnia. Limnology and Oceanography, 29: 111-124.

PWA, 2004. Sediment sources, rate and fate in the Laguna de Santa Rosa, Volume II. prepared for U.S. Army Corps of Engineers, San Francisco District, Project Number 1411-08. Philip Williams and Associates, Ltd.

Reddy, K.R., Fisher, M.M., and Ivanoff, D. 1996. Resuspension and diffusive flux of nitrogen and phosphorus in a hypereutrophic lake. J. Environ. Qual. **25** : 363–371.

Sloop, C., Honton, J., Creager, C. Chen, L., Andrews, E.S. and Bozkurt, S. 2007. The Altered Laguna: A Conceptual Model for Watershed Stewardship. Laguna de Santa Rosa Foundation, Santa Rosa CA.

## TABLES

Table 1. Nutrient Concentrations of Laguna Sediments

| Location | Sample Date | $NO_3$-N (mg/kg dry wt) | $NH_4$-N (mg/kg dry wt) | Total-N (mg/kg dry wt) | Diss-P (mg/kg dry wt) | Total-P (mg/kg dry wt) | Total Organic Carbon % | Silt+Clay Particles % |
|---|---|---|---|---|---|---|---|---|
| **Laguna** at Stony Point Road | 6/26/1996 | | | 1860 | | 562 | 2.2 | |
| | 11/1/1985 | 4.09 | 3 | 1156 | 1.1 | 773 | | |
| | 1/1/1986 | 13.81 | 7 | 1601 | 1.0 | 317 | | |
| | 7/13/1994 | 0.77 | | 1932 | 158.8 | 1030 | | 66 |
| **Laguna** at Hwy 12 | 10/1/1997 | < 0.5 | 1186 | 7094 | < 20 | 1326 | 7.6 | - |
| | 10/1/1997 | < 0.5 | 1083 | 4505 | < 20 | 1198 | 2.7 | - |
| | 10/1/1997 | < 0.5 | 1063 | 5655 | < 20 | 1068 | 4.6 | 68 |
| | 6/1/1998 | < 0.5 | 5 | 3705 | 10.3 | 1448 | 3.4 | - |
| | 6/1/1998 | < 0.5 | 5 | 2677 | 18.4 | 1268 | 3.6 | - |
| | 6/1/1998 | 2.7 | 5 | 4351 | 24.3 | 830 | 4.1 | 78 |
| | 9/1/1998 | < 0.5 | 349 | 4612 | < 0.5 | 731 | 4.6 | 46 |
| | 9/1/1998 | < 0.5 | 933 | 4612 | 0.5 | 938 | 5.4 | 38 |
| | 9/1/1998 | < 0.5 | 676 | 3515 | < 0.5 | 703 | 4.7 | 38 |
| | 6/1/1999 | 11.4 | 99 | 8184 | < 0.5 | 315 | 3.5 | 71 |
| | 6/1/1999 | 9.7 | 216 | 6028 | < 0.5 | 649 | 4.4 | 75 |
| | 6/1/1999 | < 0.5 | 73 | 5689 | < 0.5 | 799 | 4.4 | 77 |
| | 6/26/1996 | | | 1576 | | 580 | 2.4 | |
| **Laguna** at Occidental Road | 6/26/1996 | | | 1406 | | 273 | 1.8 | |
| | 11/1/1985 | 1.85 | < 0.5 | 2039 | 5.2 | 481 | | |
| | 1/1/1986 | 38.18 | 1 | 2947 | 11.1 | 165 | | |
| | 10/1/1997 | < 0.5 | 655 | 3230 | < 20 | 1331 | 2.5 | - |
| | 10/1/1997 | < 0.5 | 648 | 3593 | < 20 | 1215 | 2.6 | - |
| | 10/1/1997 | < 0.5 | 641 | 3325 | < 20 | 1369 | 4.8 | - |
| | 6/1/1998 | < 0.5 | 5 | 2598 | 61.0 | 1662 | 2.9 | - |
| | 6/1/1998 | 4.53 | 82 | 2475 | 12.8 | 891 | 4.2 | 68 |
| | 6/1/1998 | 3.91 | 5 | 3508 | 15.7 | 1095 | 3.8 | - |
| | 9/1/1998 | < 0.5 | 69 | 2707 | 1.9 | 2122 | 3.3 | 75 |
| | 9/1/1998 | < 0.5 | 5 | 3565 | 1.8 | 611 | 4.0 | 60 |
| | 9/1/1998 | < 0.5 | 100 | 3152 | 2.0 | 2407 | 4.4 | 84 |
| | 6/1/1999 | < 0.5 | 6 | 2663 | 5.3 | 1050 | 3.7 | 77 |
| | 6/1/1999 | < 0.5 | 22 | 3706 | 2.7 | 2564 | 3.5 | 93 |
| | 6/1/1999 | < 0.5 | 20 | 4277 | 4.2 | 724 | 4.2 | 87 |
| **Laguna** at Guerneville Road | 6/26/1996 | | | 626 | | 271 | 1.2 | |
| **Laguna** at River Road | 6/26/1996 | | | 1337 | | 526 | 1.6 | |

| Location | Sample Date | $NO_3$-N (mg/kg dry wt) | $NH_4$-N (mg/kg dry wt) | Total-N (mg/kg dry wt) | Diss-P (mg/kg dry wt) | Total-P (mg/kg dry wt) | Total Organic Carbon % | Silt+Clay Particles % |
|---|---|---|---|---|---|---|---|---|
| **Laguna** at Trenton-Healdsburg Road | 7/13/1994 | 0.55 | | 2790 | 231.8 | 1030 | | 60 |
| **Santa Rosa Creek** at Mouth | 7/13/1994 | 0.64 | | 3820 | 19.3 | 185 | | 27 |
| **Santa Rosa Creek** at Mouth | 11/1/1985 | 1.27 | 1 | 204 | 0.5 | 633 | | |
| **Santa Rosa Creek** at Willowside Road | 7/13/1994 | 0.66 | | 3348 | 42.9 | 987 | | 54 |

## FIGURES

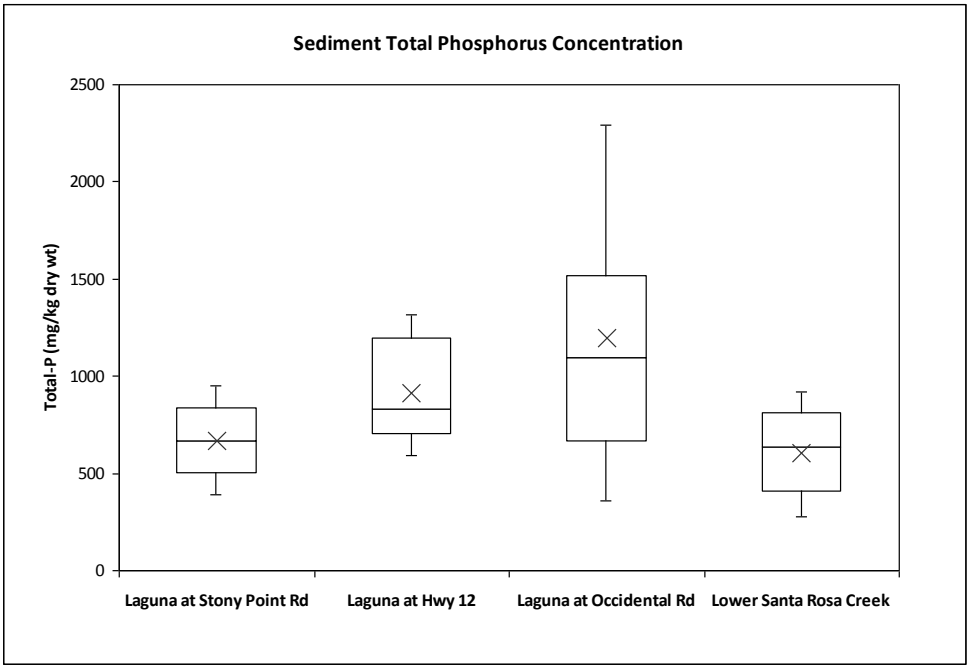


Figure 1. Distribution of Sediment Total Phosphorus Concentrations

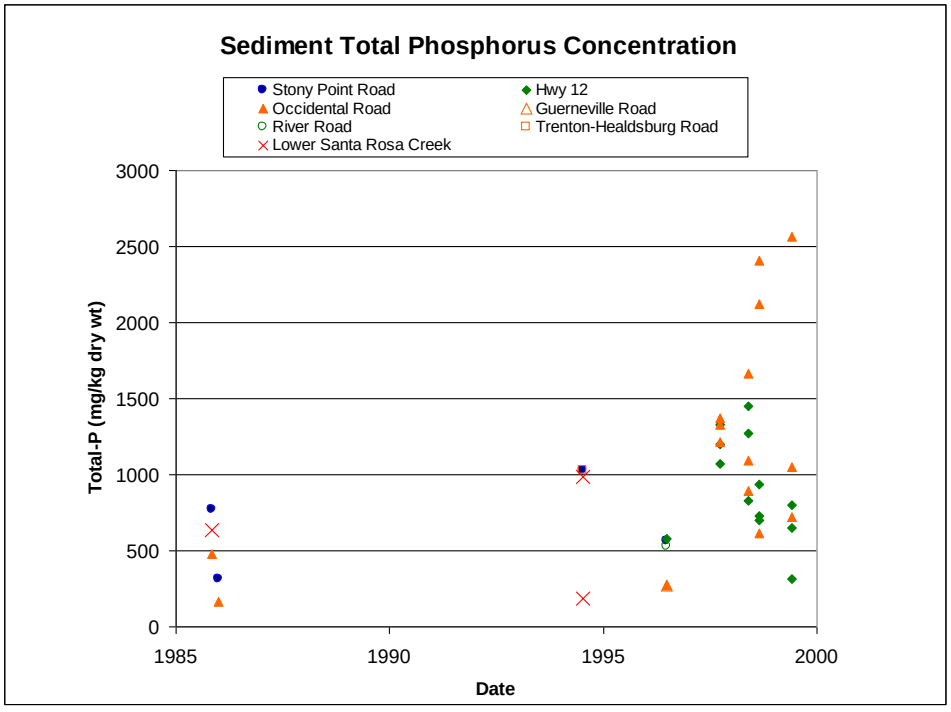


Figure 2. Sediment Total Phosphorus Concentration Time Series Plot

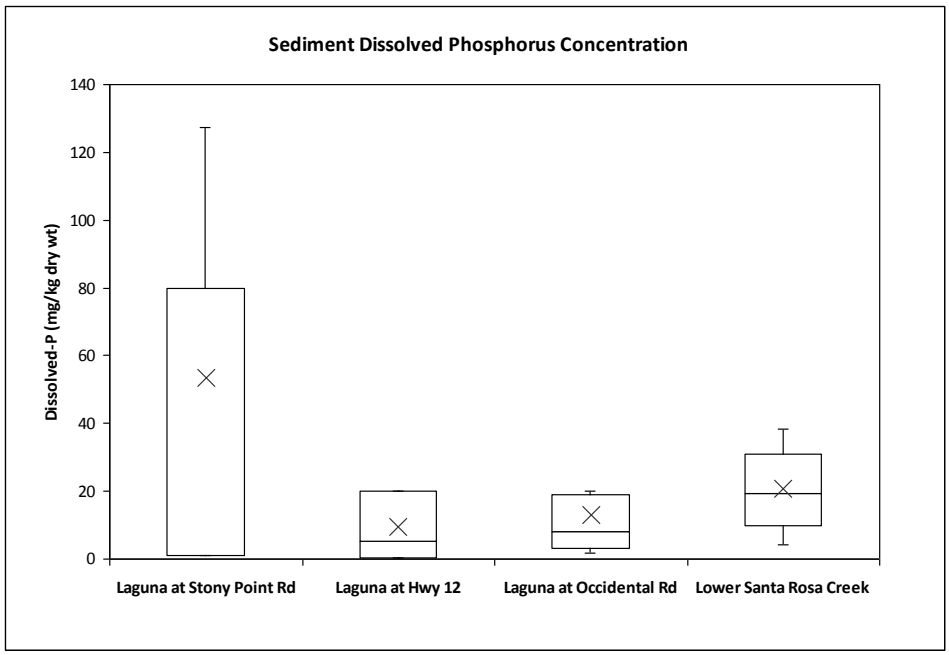


Figure 3. Distribution of Sediment Dissolved Phosphorus Concentrations

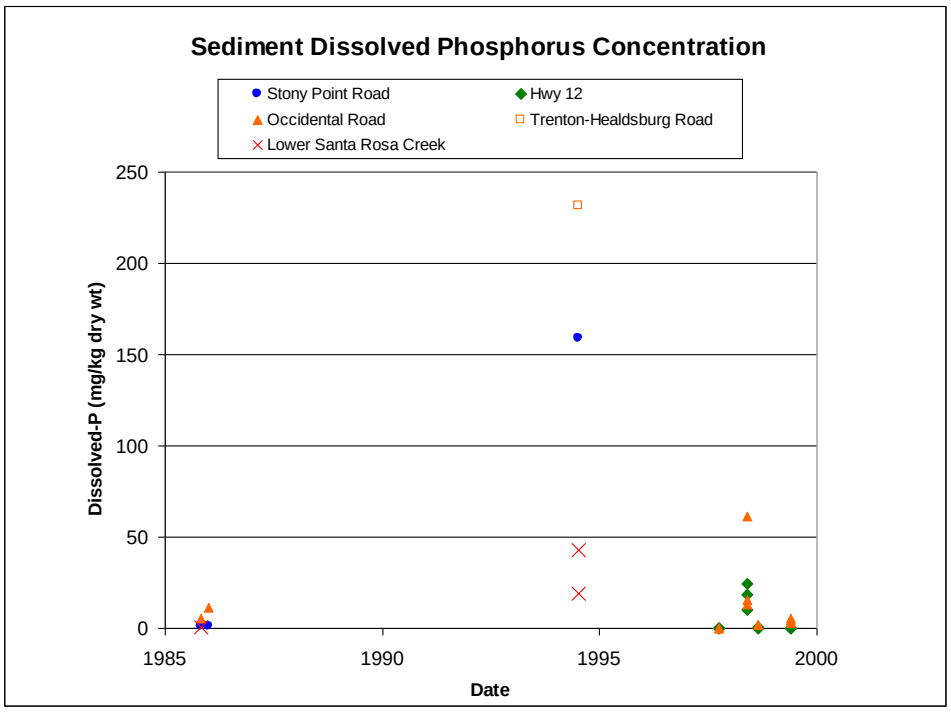


Figure 4. Sediment Dissolved Phosphorus Concentration Time Series Plot

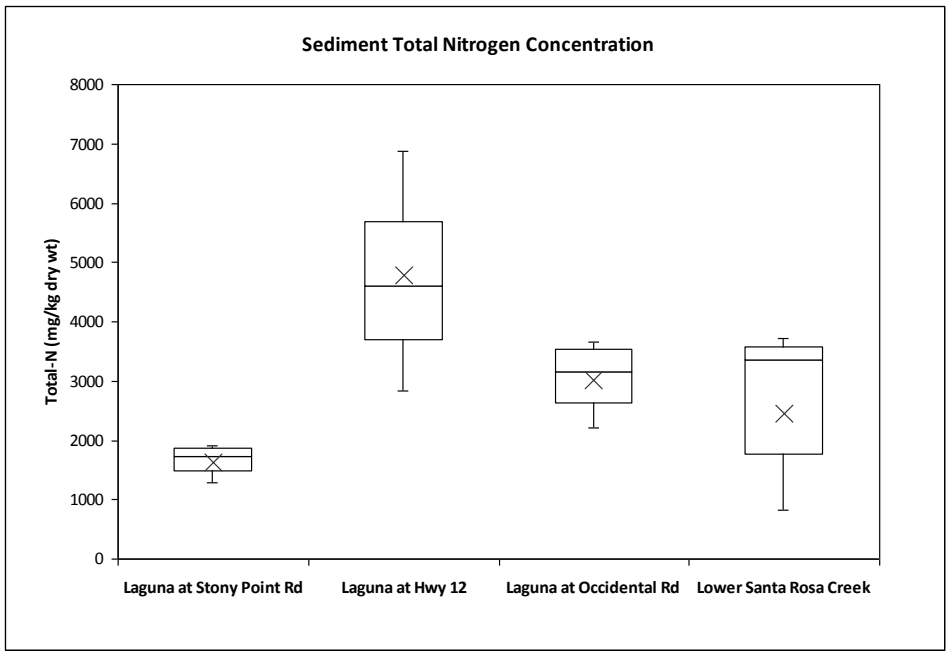


Figure 5. Distribution of Sediment Total Nitrogen Concentrations

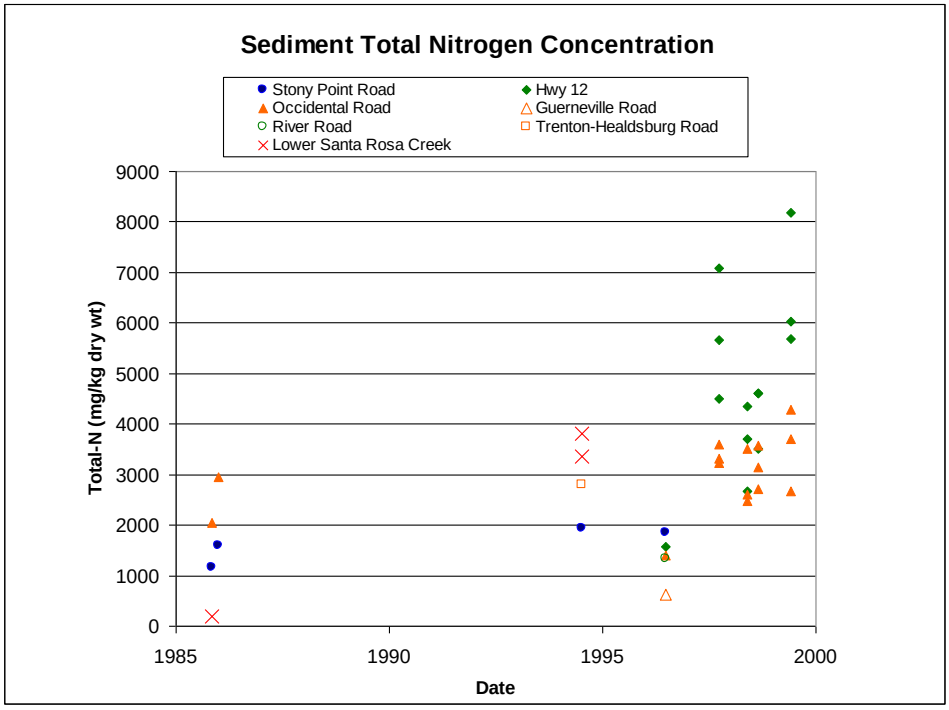


Figure 6. Sediment Total Nitrogen Concentration Time Series Plot

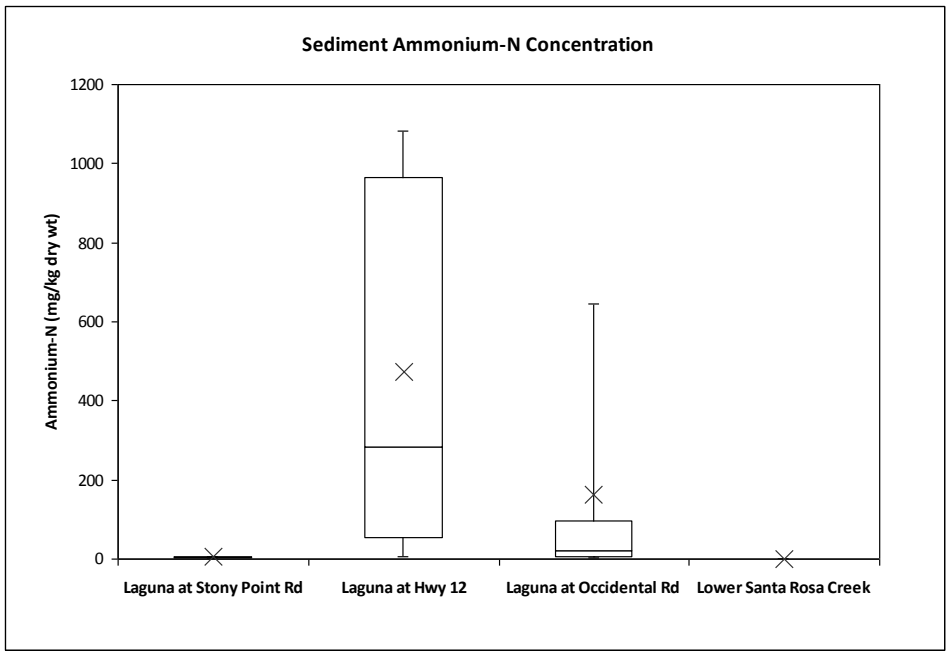


Figure 7. Distribution of Ammonium-N Phosphorus Concentrations

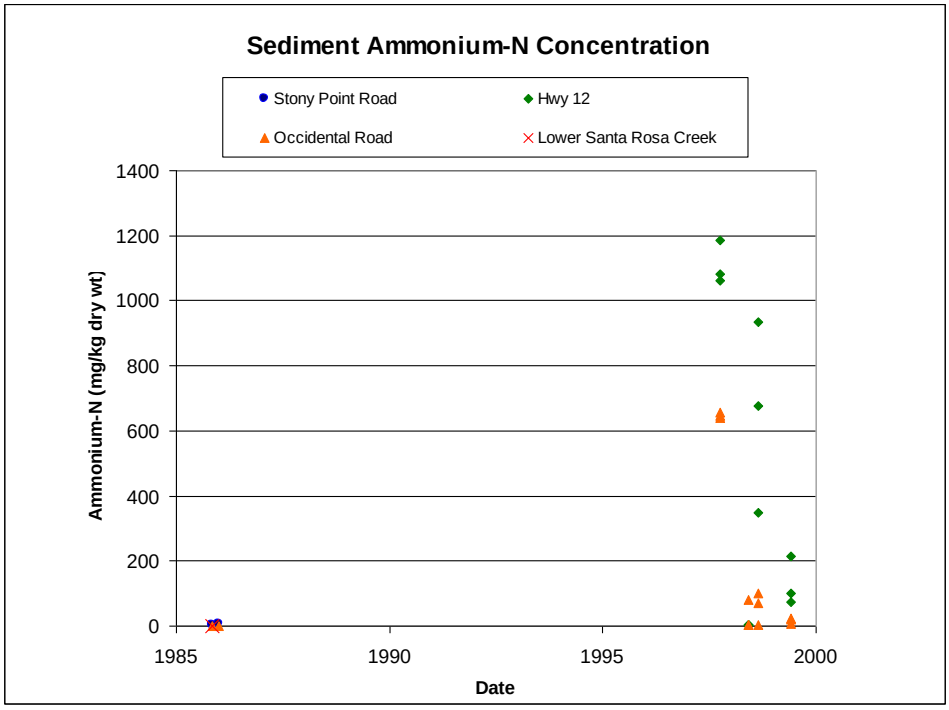


Figure 8. Sediment Ammonium-N Concentration Time Series Plot

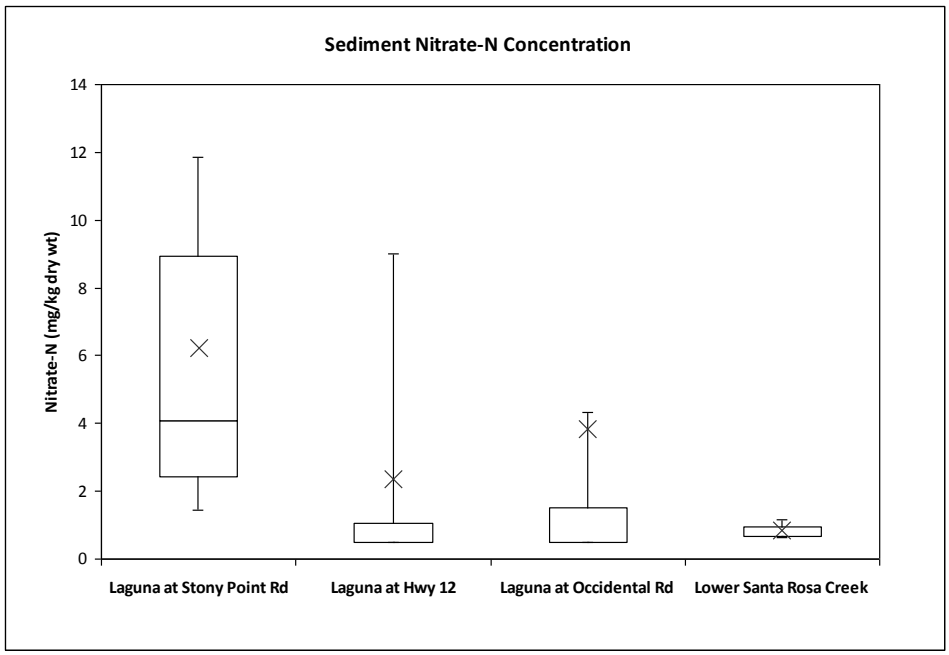


Figure 9. Distribution of Sediment Nitrate-N Concentrations

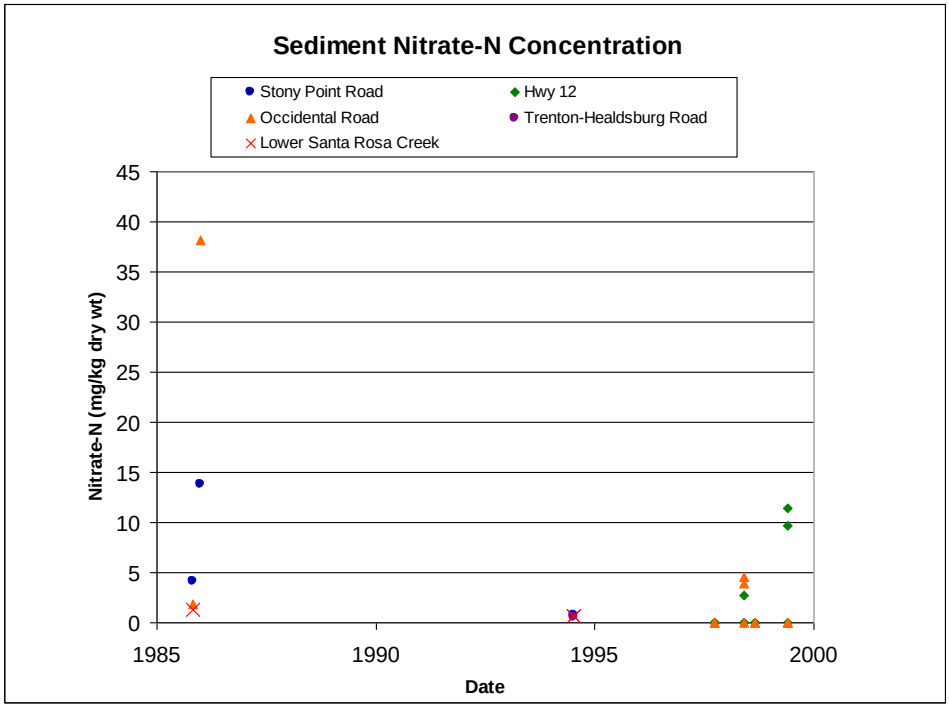


Figure 10. Sediment Nitrate-N Concentration Time Series Plot

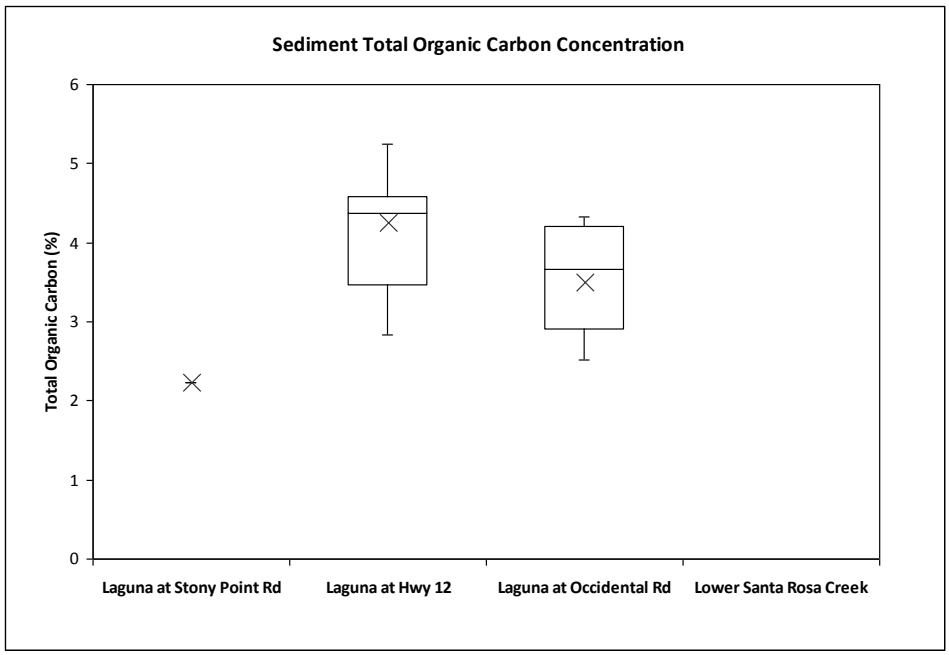


Figure 11. Distribution of Sediment Total Organic Carbon Concentrations

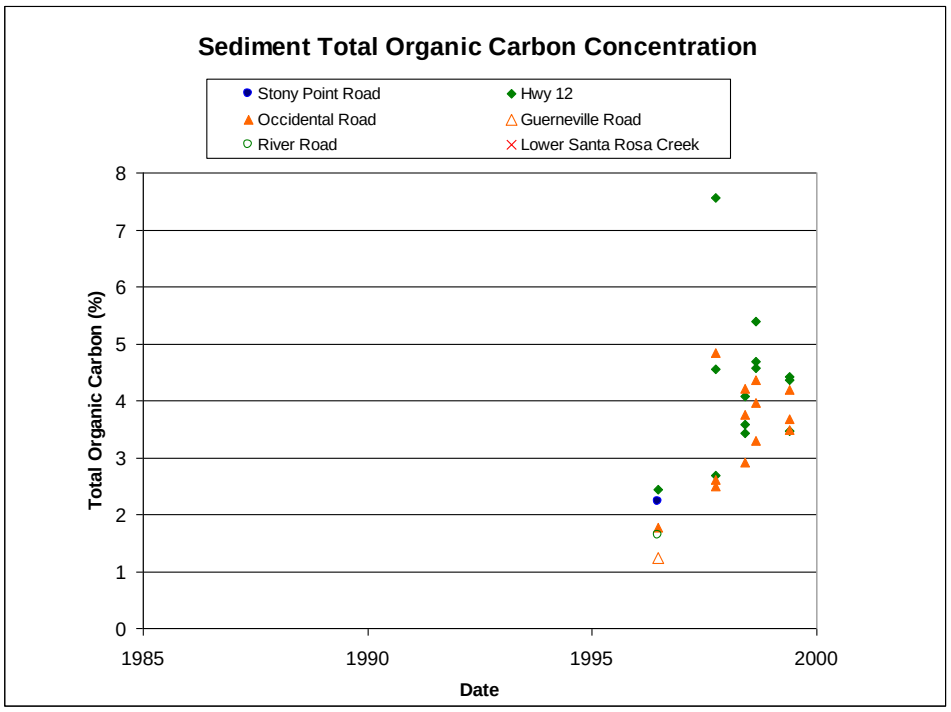


Figure 12. Sediment Total Organic Carbon Concentration Time Series Plot

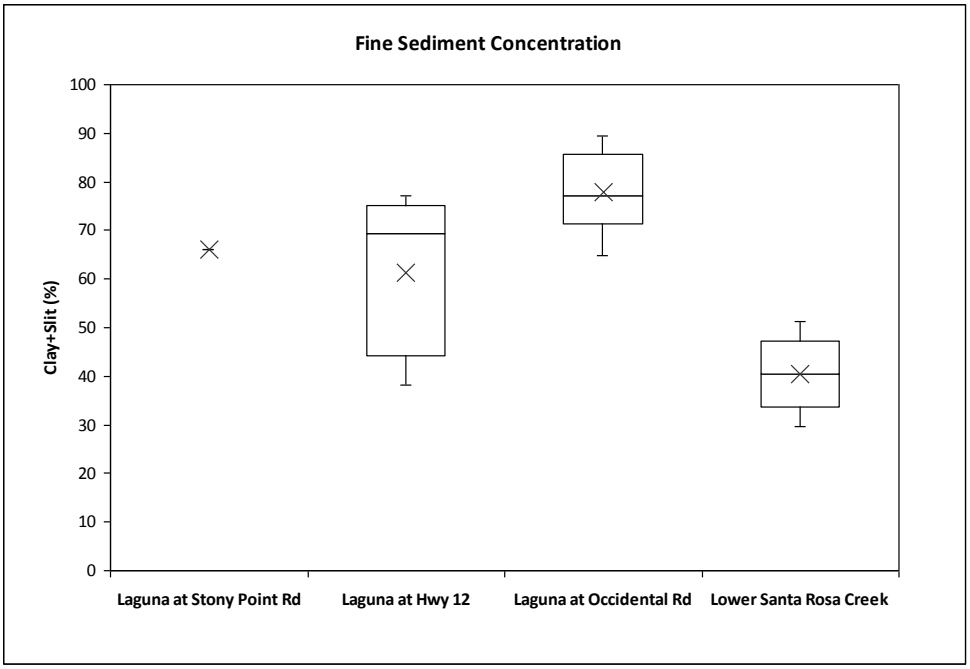


Figure 13. Distribution of Fine Sediment Concentrations

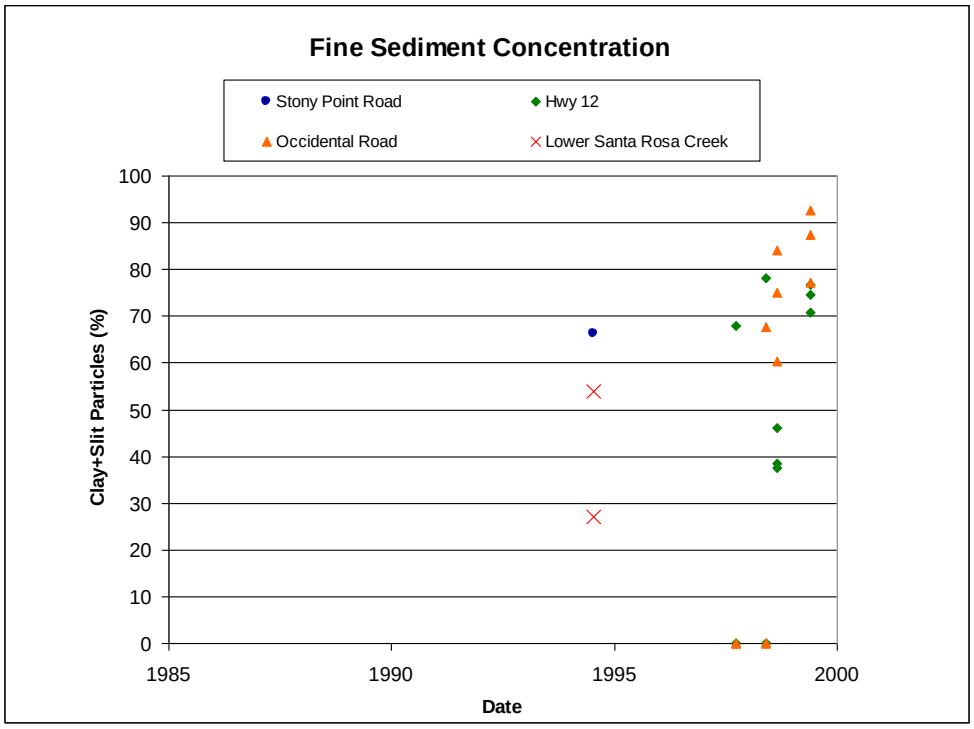


Figure 14. Fine Sediment Concentration Time Series Plot