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# Effects of basin morphology and urban non-point source loading on Lake Madeline water quality.

Kelli Haskett, George Guillen, Susan Moore and Heather Biggs

Environmental Institute of Houston and School of Science and Computer Engineering, University of Houston Clear Lake,

## Introduction

Lake Madeline is a 47.7 acre man-made lake located in the middle portion of Galveston Island. With only limited monitoring in the area, local citizens had expressed complaints about periodic fish kills, floating debris of sanitary sewer origin, and foul odors within the lake. The City of Galveston contracted EIH to conduct a study from June to October 2006. The objectives of our study were to delineate the distribution of bacteriological indicators and potential violations of state water quality criteria within the Lake Madeline watershed and identify the origin of the indicator bacteria.

## Materials and methods

Twenty-four sites within the Lake Madeline watershed and adjacent areas were studied to determine the potential sources of indicator bacteria (Figure 1). Samples were compared from potential sources with open water "control" sites. Eighteen sites were monitored during dry weather events, while an additional six sites were added to the three wet weather events. Enterococci was used as the primary indicator bacteria group, with fecal coliform being taken for comparison to historical data. Water quality and physical data were also measured.

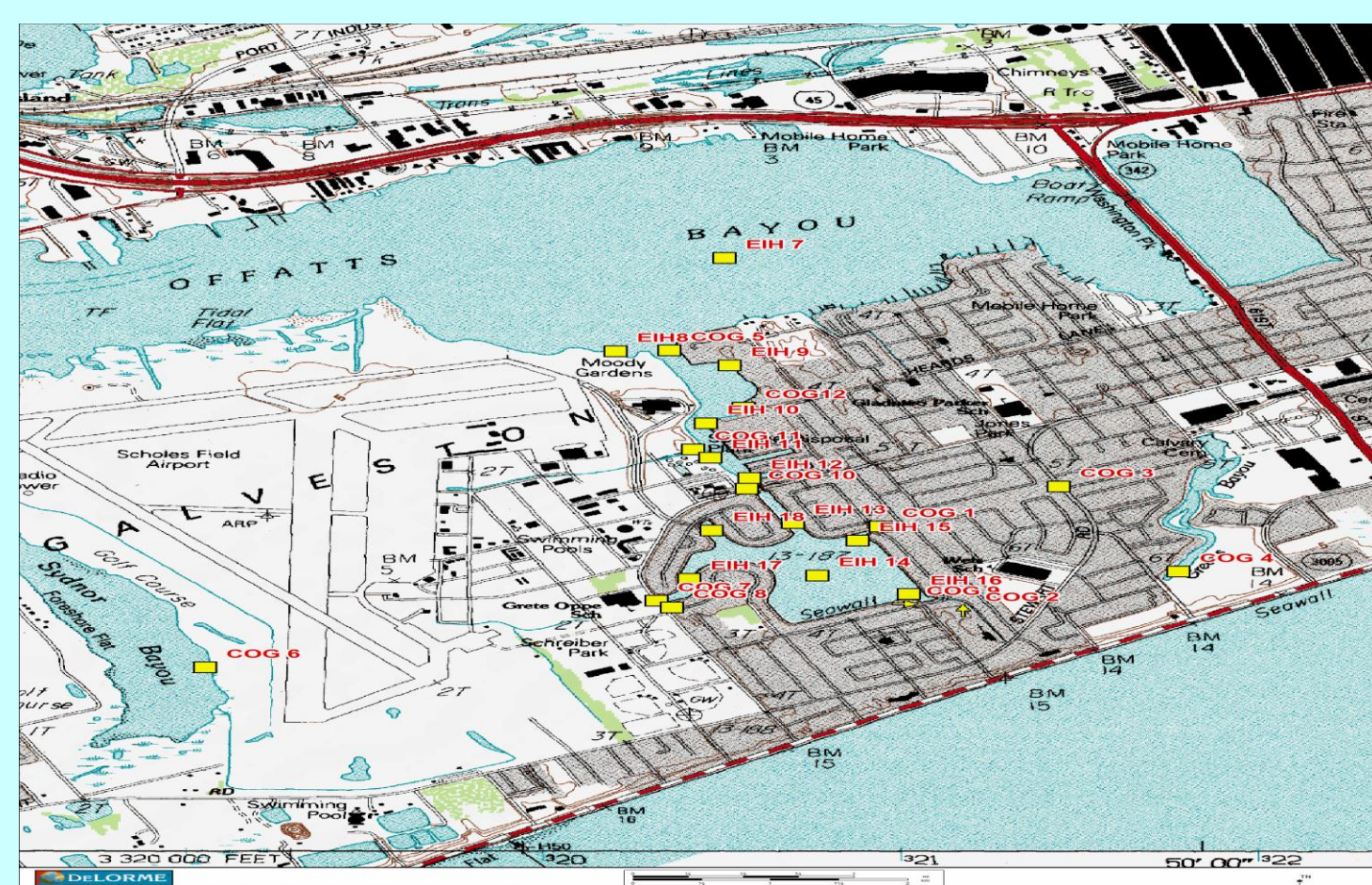


Figure 1. Location of study sample sites.

## Results

- The current contact recreation water quality standard for West Bay is a geometric mean of 35 enterococci colonies per 100ml. In addition, single samples should not exceed 89 colonies per 100 ml.
- Historical data suggests that Lake Madeline has experienced elevated levels of indicator bacteria since 1999.
- During our study the geometric mean level of enterococci at open water sites within Lake Madeline was 212 colonies/ 100 ml. Seventy-five percent of the samples exceeded the standard (Figure 2).
- The geometric mean concentration of enterococci measured at storm sewers and other discharge points during all sampling events was 2,807 colonies/100 ml.
- Enterococci levels at discharge points during wet and dry weather events averaged 13,759 colonies/ 100 ml and 478 colonies/ 100 ml respectively. There was a positive relationship between enterococci levels measured at storm sewers and precipitation levels (Figure 2). Lower levels of Enterococci were generally encountered at control watersheds although levels were quite variable due to the influence of precipitation (Figure 3).
- Fecal coliform and fecal streptococcus bacteria levels were monitored on four different occasions. FC/FS ratios used to estimate the potential origin of the elevated indicator bacteria levels suggest that 54% of the samples most likely originated from human sources, 29% from animal sources, and 16% from mixed sources.
- A physical survey of Lake Madeline revealed that the middle portion is quite deep (> 35 feet).
- Hypoxia and violations of state single sample minimum criteria (4 mg/l) occurred more frequently in the deeper more saline portions of Lake Madeline when compared to other sites (Figure 4-6).

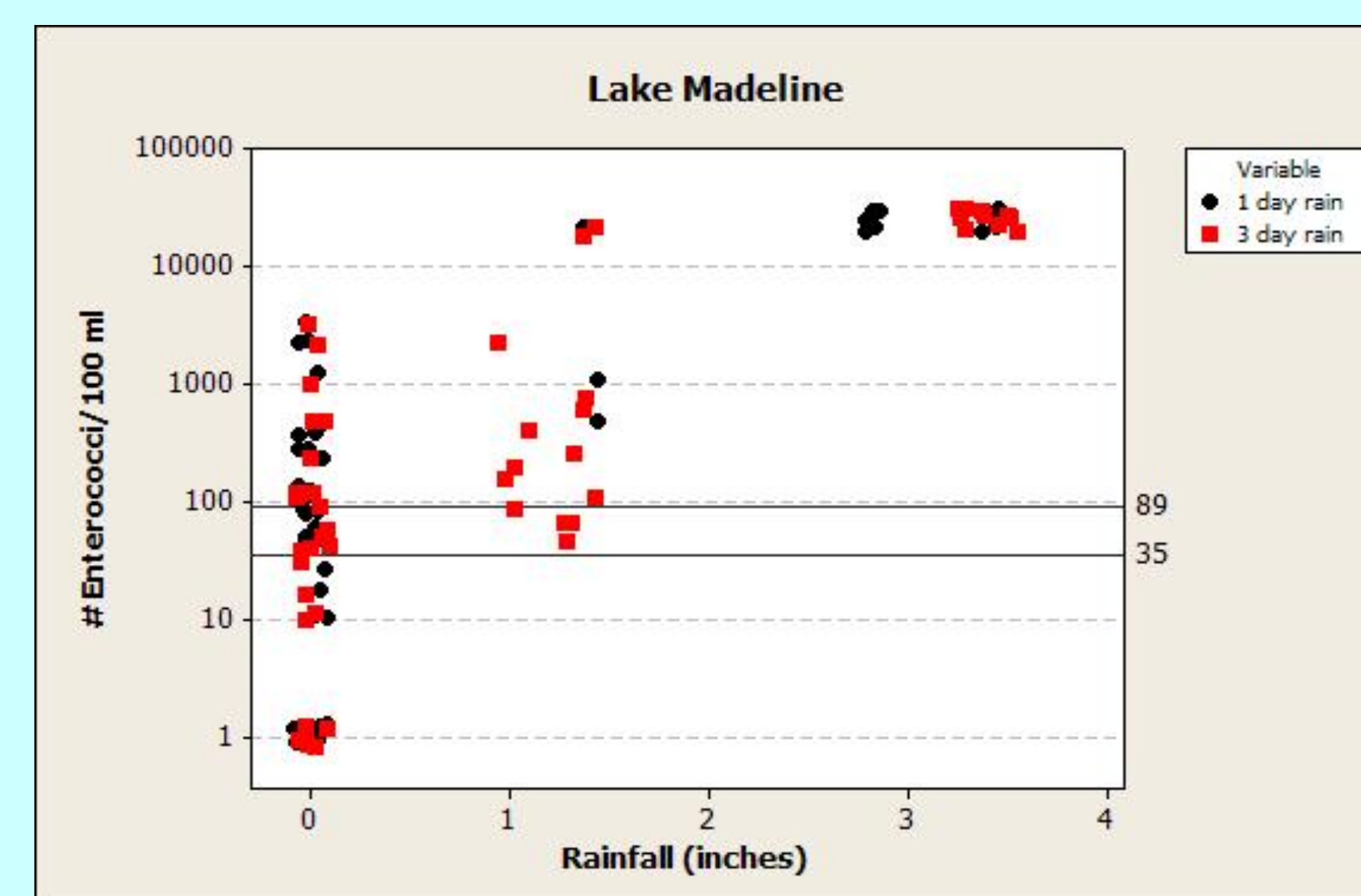


Figure 2. Comparison of enterococci levels and 1 and 3 day rainfall amounts during 2006.

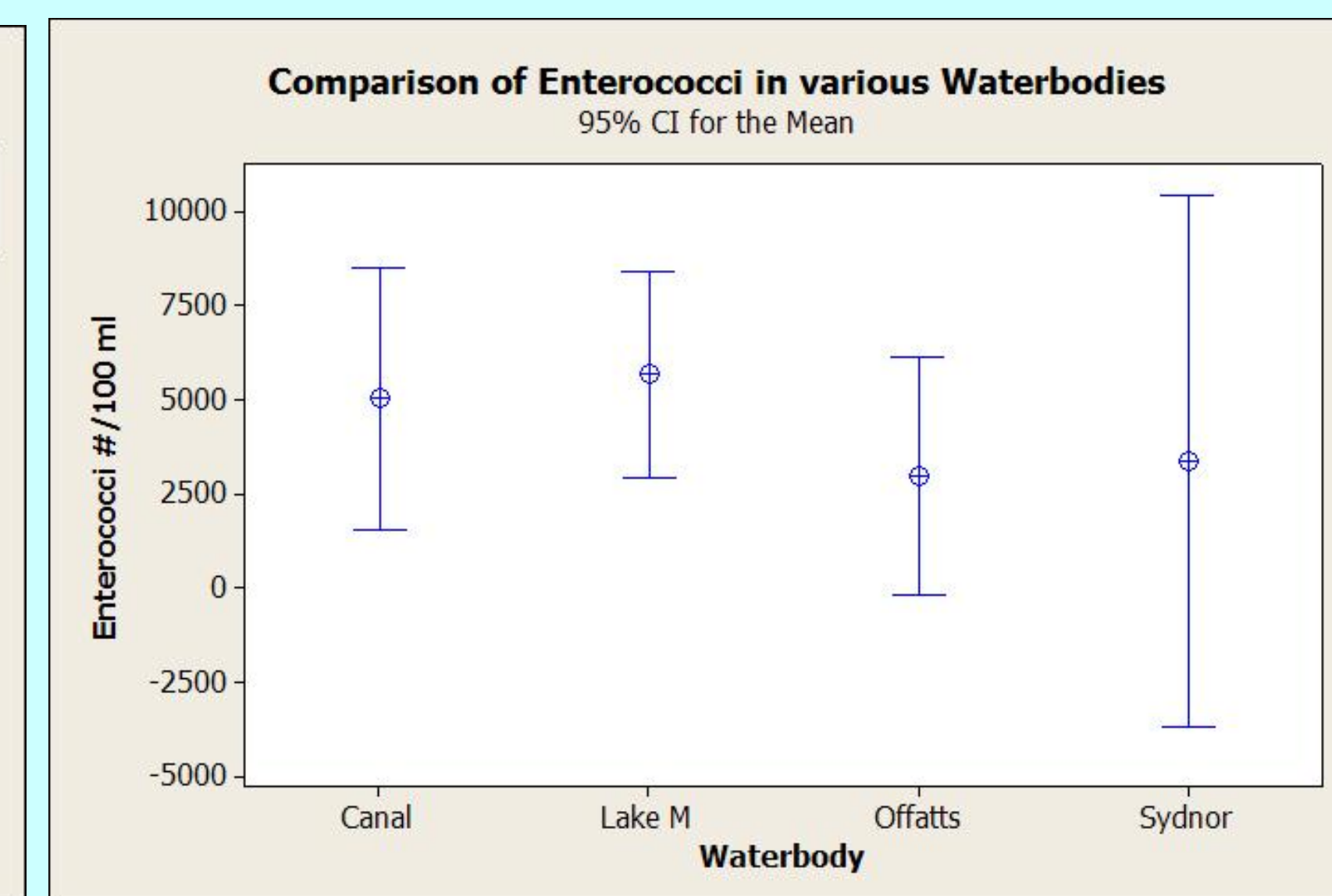


Figure 3. Comparison of enterococci levels at Lake Madeline and adjacent water bodies.

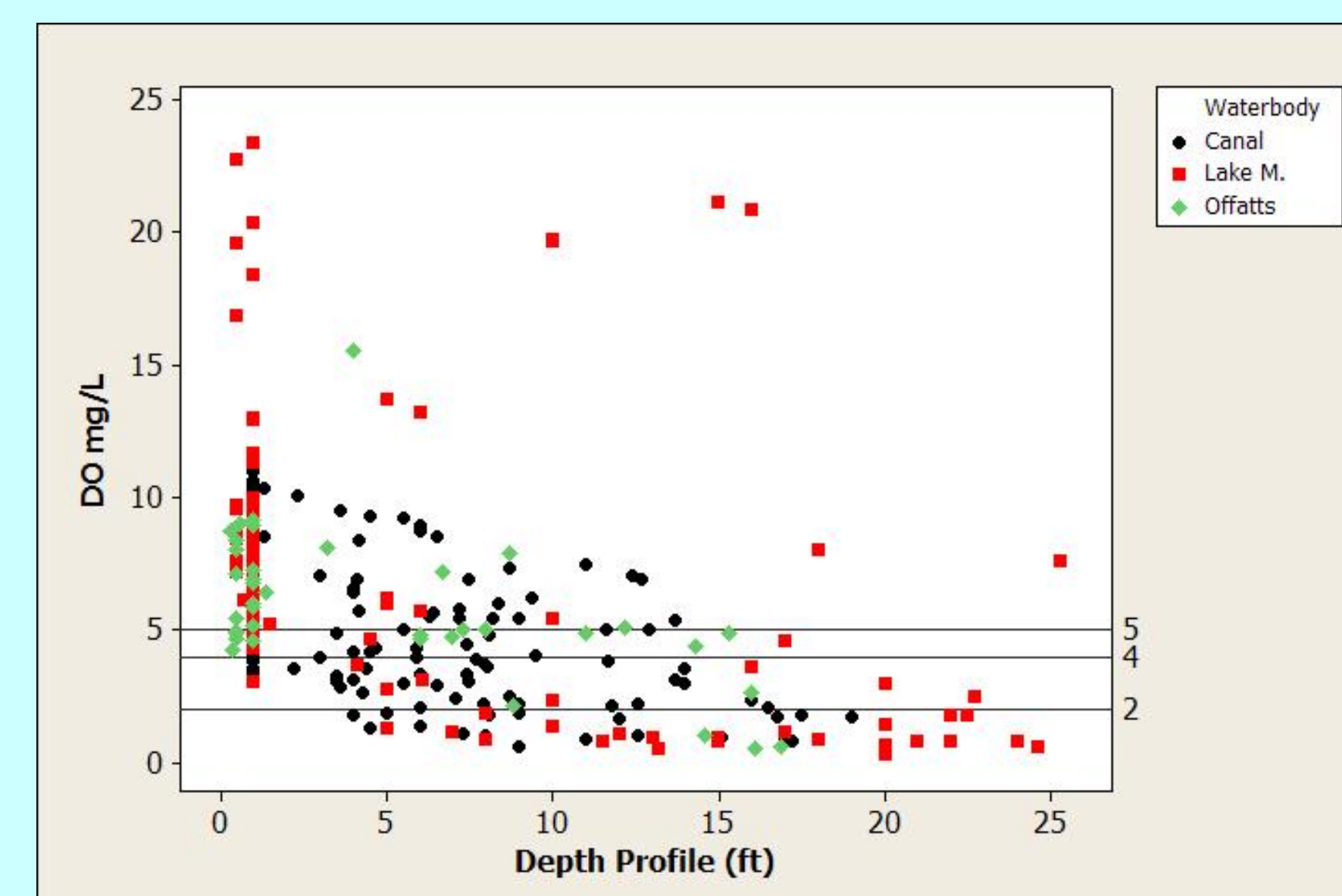


Figure 4. Comparison of dissolved oxygen levels in Lake Madeline and adjacent water bodies.

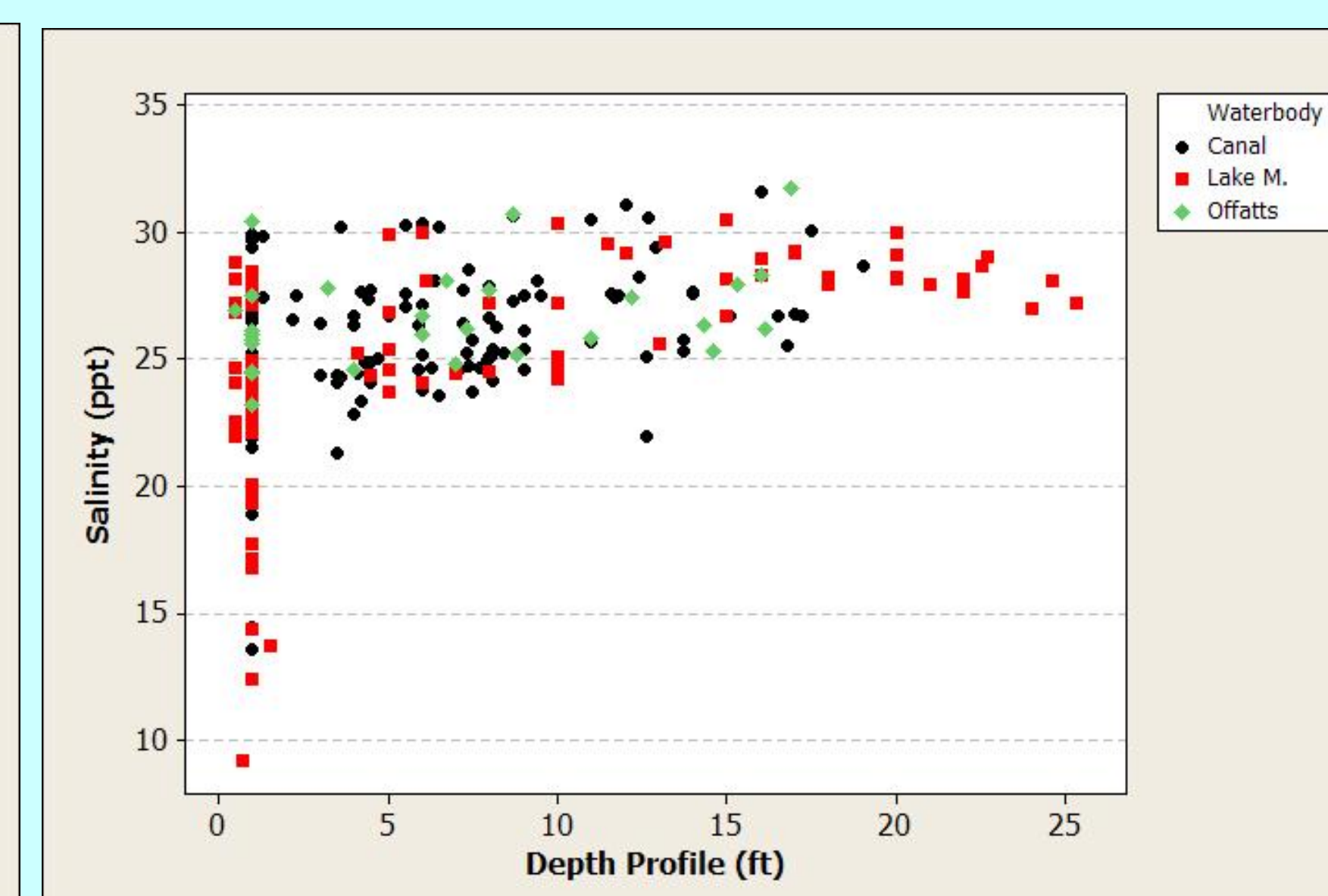


Figure 5. Comparison of salinity levels in Lake Madeline and adjacent water bodies.

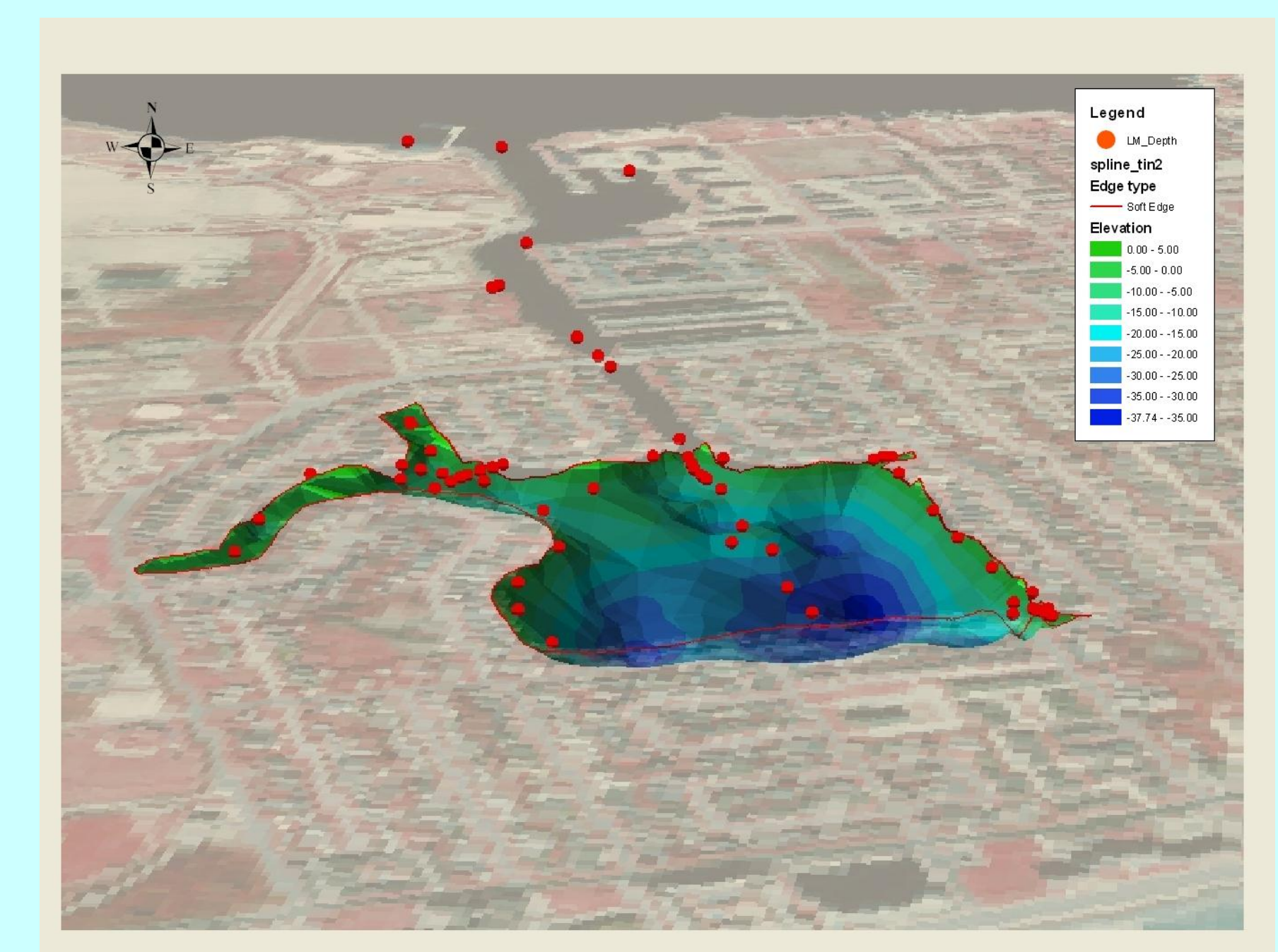


Figure 6. Lake Madeline basin morphology.

## Conclusions

- Lake Madeline is not meeting contact recreation water quality standards for indicator bacteria.
- Contaminated storm water runoff is a major source of indicator bacteria within Lake Madeline Major sources include leaking wastewater collection systems. Other potential sources include wastewater discharges during wet weather and wildlife.
- The deep basin morphology, salinity stratification, and natural low tidal amplitude enhances retention of sewage derived waste and promotes anoxic conditions.

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## For further information

Please contact [guillen@uhcl.edu](mailto:guillen@uhcl.edu).

