Step 4: Linkage Analysis

Linkage Analysis

The linkage analysis step of the TMDL process aims to "**link**" water quality exceedances, identified in Step 2, with pollutant sources, identified in Step 3. The purpose of the linkage analysis is to establish a cause and effect relationship between identified sources of pollutants and existing water quality. This linkage can then be used to set the load capacity of the waterbody. In the case of bacterial indicators and bacteria TMDLs, the load capacity is commonly set as the applicable water quality objective. The linkage analysis includes an appropriate margin of safety, which is then developed to ensure that water quality objectives will be met, and that any expected future loads can be incorporated. Because the numeric targets and waste load allocations for bacteria TMDLs are commonly set as the water quality objective, the margin of safety is considered to be implicitly incorporated, based on consideration of some critical condition, rather than explicitly developed.

The approach to linkage analysis ranges from the use of simple empirical methods to an analysis of fate and transport of bacteria sources using a variety of modeling techniques. Normally, both complex modeling and simple empirical methods address the linkage between loading and water quality through analysis of existing water quality data. Note, however, that because the SMBB Beaches and Ballona Creek Bacteria TMDLs were concentration or density-based rather than load-based, and the assimilative capacity was defined as the water quality objective, a rigorous linkage analysis was not needed (i.e. by meeting the numeric target, it was certain that the water quality objective would be attained).

Previous Approaches to Linkage Analysis Using Modeling

Modeling of LAR for Metals and Nutrient TMDLs used one-dimensional flow model (EFDC) coupled with the water quality model Hydrologic Simulation Program-FORTRAN (HSPF)[1]. Tetra Tech performed the modeling under contract to the EPA.

Modeling of bacterial indicator loading to Malibu Creek watershed using HSPF was performed by Tetra Tech (Tetra Tech, 2002). The model was used to determine source loads, critical conditions, and ultimately source reductions necessary to meet numeric targets under critical conditions.

[1] The Hydrological Simulation Program - FORTRAN (HSPF) is a set of computer codes that can simulate the hydrologic, and associated water quality, processes on pervious and impervious land surfaces and in streams and well-mixed impoundments (EPA HSPF Manual, 2001).

Modeling for San Diego area bacteria TMDL loading and linkage analysis was performed using a recoded version of HSPF, and was performed by Tetra Tech. The technical approach is similar to modeling approach for Malibu Creek Bacterial TMDL and Los Angeles River Nutrient and Metals TMDLs.

SCCWRP modeling also utilizes HSPF (Ackerman et al., 2005). Recent research and modeling of most interest concerns source loading and application of BMPs to source reduction (Brown and Bay, 2005; Stein and Zaleski, 2005; unpublished modeling on Ballona Creek watershed).

Step 5: Pollutant Allocation

Based on the results of the linkage analysis step, which determines the acceptable assimilative capacity of the waterbody along with the pollutant allocation methodology (e.g. reference watershed/anti-degradation approach or modeled load capacity) the available load is allocated to point and non-point sources.

The allocation step:

- ♣ Translates the TMDL into allowable loads;
- ♣ Distributes loads among sources;
- ♣ Accounts for margin of safety;
- ♣ Accounts for seasonal variation;

And allocations should:

- ♣ Reflect relative size and magnitude of sources
- ♣ Include adequate documentation;
- ♣ Provide reasonable assurance that water quality standards will be attained
- ♣ Involve stakeholders in development.

The Ballona Creek bacteria TMDL both followed Santa Monica Bay Beaches TMDL in determining allocations based on a reference watershed with allowable single sample maximum exceedance days. In other words, portions of the available load were not actually divided among point and non-point sources; all sources were allocated an allowable number of exceedance days. If the number of exceedances are greater than the allowable number, all jurisdictions are considered to be out of compliance.

In the case of LAR indicator bacteria TMDL, the load allocations will be determined under dry weather and wet weather conditions. The high flow suspension of the water quality standards provides for the extreme wet weather condition.

Step 6: Implementation Strategy

The implementation strategy is a recommended, but not required, approach to reaching the goals of the TMDL. The implementation strategy needs to incorporate:

- ♣ Implementation actions;
- ♣ Responsible agents for implementing the actions;
- ♣ A schedule for the implementation and final compliance with the water quality standard;
- ♣ Schedule and format of an adaptive management approach to the TMDL, which provides for incorporation of greater knowledge and adaptation of the TMDL.

The TMDL rules and requirements state that the there must be a reasonable assurance that implementation of the TMDL will result in attainment of water quality standards.

Reasonable assurance requires that the allocations are:

- ♣ Technically feasible;
- ♣ Can be implemented in a reasonable amount of time;

Cost estimates for implementation strategies are required as a precursor to establishing basin plan amendments based on the TMDL.

The schedule needs to outline the timeframe for preparation of a detailed implementation plan, a detailed monitoring and compliance plan, and milestones for meeting compliance. Extension of a compliance schedule has been proposed, in other Southern California bacteria TMDLs, if an integrated watershed approach to implementation is carried out.

For the Los Angeles River, an integrated approach will need to incorporate aspects of the City of LA Integrated Resources Plan (IRP), together with other integrated watershed plans that have been adopted, or that are in the preparation stages. In addition, the integrated approach should include implementation strategies that incorporate multiple TMDLs. A review of projects that are already proposed or in progress will be conducted as part of the preparation of the Implementation Strategy.

A watershed approach for bacteria TMDL implementation will require a range of Best Management Practices (BMP), and incorporate new data regarding effectiveness of specific BMP implementation. SCCWRP watershed modeling can be particularly useful for maximizing BMP effectiveness and efficiently determining scenarios for BMP implementation.

Compliance with the LAR indicator bacteria TMDL could be phased so that resources are allocated to address areas of greatest risk: Protection of sites *where* actual REC-1 use activity occurs, during hydrologic periods *when* REC-1 use is most likely occur, and where the bacteria sources are predominantly human sources. A priority matrix can be developed in association with the phased TMDL to direct resources to where the greatest concerns of exposure exist. An example matrix is presented in Table 8.

Table 8. Matrix for development of phased approach to implementation.

Factor	**Priority**		
	High	**Medium**	**Low**
Recreational Use	Unrestricted REC-1 use. *Score = 5*	High potential for unrestricted REC-1 use *Score = 3*	Rare or low potential for REC-1 activity[1] *Score = 1*
Hydrologic Tier	Dry weather low flow *Score = 5*	Wet weather (moderate flow; 0.1-0.2 in. storm) *Score = 3*	Wet weather (high flow; 0.3-0.4 in. storm) *Score = 1*
Source	Human sources significant *Score = 5*	Human sources variable, but occasionally high *Score = 3*	Non-human sources significant *Score = 1*

[1] (e.g., little or no flow, includes concrete and ephemeral channels)

Sites with the highest scores should be the focus of Phase I. These are most likely to be sites where frequent REC-1 use occurs, human sources are significant and bacteria counts are high during dry weather flow conditions. An example of such a site could be a reach of the LA River that is not concrete lined and high bacteria counts are observed in nuisance flows from storm drains during dry weather conditions.

Jursidictional responsibilities for meeting allocations are generally outlined within this step of the TMDL process, to be taken up in greater detail during preparation of the detailed implementation plan following adoption and EPA approval of the TMDL.

Step 7: Monitoring

The monitoring section of the TMDL defines the key questions the monitoring plan needs to address.

Monitoring should:

- ♣ Incorporate existing monitoring programs;
- ♣ Provide data to evaluate implementation actions;
- ♣ Provide data for adaptive management decisions;
- ♣ Provide basis for evaluating compliance.

A monitoring plan is outlined within the TMDL, with a timeframe scheduled for development of a detailed plan after formal adoption of the TMDL. The detailed monitoring plan should ultimately include:

- ♣ Sampling and analysis plans;
- ♣ Quality Assurance Policies and Procedures;
- ♣ Field sampling protocols;
- ♣ Laboratory analyses required
- ♣ Descriptions of data management and data analysis

Identification of Special Studies

During the data review and analysis process associated with TMDL development and/or during consideration of certain TMDL elements or implementation strategies, identification of data gaps and the need to conduct one or more special studies may be identified. These special studies can provide greater knowledge and understanding not only of the specific waterbody and loading issues, but also of the value of specific BMPs and other control and implementation actions. Often the knowledge that is gained from these special studies is incorporated into the TMDL though an adaptive management schedule and commitments that are made under the implementation plan.

Certain special studies may be required under the TMDL while others are written into the TMDL as recommended special studies. Most special studies described in the TMDL will be recommended and will be designed to refine waste load allocations and/or assist with TMDL implementation. In addition, responsible entities may be requested to undertake beneficial uses investigations of certain reaches and tributaries (e.g. to determine applicability of the high-flow suspension of recreational uses).

Conducting Special Studies

Some special studies that can be implemented in a relatively short timeframe and that directly impact the content of the TMDL may be most appropriately conducted as part of the TMDL Development Process. For example, a monitoring effort funded by the EPA Region 9, with assistance by stakeholders, will be conducted in April and May 2006 in an attempt to further resolve the sources of bacteria along Reach 2 and Reach 4.

Many of the special studies that may be necessary to address significant data gaps and better refine the TMDL or to understand the impact of certain implementation strategies will require a longer period for study development, implementation, and data collection than can be conducted during the TMDL development process. These studies can be implemented during the initial three-year to six-year period after the TMDL is adopted, and if appropriate, results may be used to modify the TMDL at the time the TMDL is revisited. An example would be monitoring conducted in a reference watershed to determine an appropriate number of allowable exceedance days.

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