# Appropriate TMDL Development and Implementation

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## Overview

Dr. Lee's presentation at the August 18, 1999 Sacramento Branch GRA meeting will discuss surface water quality management issues associated with complying with court-ordered requirements that all waterbodies comply with Clean Water Act requirements of not experiencing exceedances of water quality standards for protection of the designated beneficial uses of the waterbody. Exceedance of water quality standards requires that Total Maximum Daily Loads(TMDLs) be established to control the exceedance. Complying with water quality standards/TMDL goals will cost public and private interests hundreds of billions of dollars in controlling heavy metals-Cu, Pb Zn Cd, organics-PAHs, nutrients-N and P, fecal coliforms, sediments, etc., in wastewater discharges and especially in urban and rural stormwater runoff. For example, it is estimated that treating Los Angeles area urban stormwater runoff to meet water quality standards will cost in excess of $50 billion. The TMDL program will become the next "Superfund" program for work for engineering and technical services.

The TMDL program, as it is being implemented, is largely based on 1960s level science/engineering, where worst-case-based national water quality standards are being used as TMDL goals. Unless this situation is corrected, large amounts of funds will be spent providing more treatment of stormwater runoff-associated chemical constituents and contact recreation pathogen indicators to meet overly protective water quality standards than is necessary to protect the designated beneficial uses of waterbodies.

Dr Lee will discuss the TMDL process and through examples, discuss some of the technical problems with current regulatory approaches for complying with TMDL goals/water quality standards. Examples include the control of mercury from former mercury and gold mining activities in the Coast range and Sierras. He will also discuss the current efforts to develop TMDLs for aquatic

plant nutrients as they impact the dissolved oxygen in the San Joaquin River near Stockton and excessive algal growth in Upper Newport Bay, Orange County, CA., OP pesticides that are being used in urban areas for control of termites, ants, and lawn and garden pests, heavy metals in urban area street and highway stormwater runoff, and fecal coliforms that impact beach sanitary quality.

While TMDLs focus on surface water issues, in some situations there is a groundwater component. These include geothermal springs as a source of mercury, agricultural nitrate-polluted groundwaters that discharge to surface waters, and groundwater recharge as part of stormwater disposal and conjunctive use projects. Further, it has been found that frequently site investigations and remediation for hazardous chemical sites where the primary focus is polluted groundwaters often have stormwater runoff water quality problems that are not adequately/reliably characterized and controlled.

## Outline of Presentation

### Background to Presentation

Worked on Developing and Appropriately Using Water Quality Criteria/standards since mid 1960s
- Advisor to US EPA on Water Quality Criteria Development Approach and Several Criterion Documents

Worked on Waste Load Allocations since 1970s
- Low DO - Carbonaceous And Nitrogenous BOD
  - Houston, TX Ship Channel
- Excessive Fertilization - Phosphorus - Lake Dillon - Colorado Rocky Mountains

Current TMDL Activities
- Mercury - Sacramento River and its Watershed
  - Cache Creek, Putah Creek, Delta
- Aquatic Life Toxicity - OP Pesticides - Diazinon and Chlorpyrifos
  - Orange County, Sacramento River, Stockton
- Nutrients (N & P) - Orange County, CA - Upper Newport Bay and
  - San Joaquin River Deep Water Channel
- Pathogens and Coliforms
  - Upper Newport Bay, Orange County, CA
- Heavy Metals, Upper Newport Bay and Tributaries

## Overview of TMDL Process

Clean Water Act Requires All States to Evaluate Compliance With Water Quality Standards
- Must Consider Both Specific Numeric Chemical as well as Narrative Standards
  - i.e., Cu, Zn, DO and Excessive Algae, etc.
- Waterbodies That Do Not Comply With Standards Must Be Listed as "Impaired" and Placed on 303(d) List - Where Cause of Impairment is Identified (Constituent of Concern)
- Violation of Water Quality Standard (Objective in CA) Based on Exceedance of Standard by Any Amount More Than Once Every Three Years
- 303(d) Listed Waterbody Must Develop a Total Maximum Daily Load (TMDL) For the Constituent Causing Impairment
- Must Develop Implementation Schedule to Achieve TMDL Goal
- Normally, Water Quality Standard is TMDL Goal
  - Can Lead to Significant Over-Regulation and Waste of Public and Private Funds if Worst Case Based Water Quality Standard is Used as TMDL Goal

Must Develop Waste Load Allocation (WLA - Point Source) and Load Allocation (LA - Non Point Source) For Various Types of Sources of Constituent of Concern
- i.e., Domestic and Industrial Waste Waters, Urban Stormwater Runoff - Regulated as Point Source, Agricultural Runoff and Discharge Waters, "Nature," Atmosphere
- Apportionment of Loads is a Social Decision Which is Often Determined by Political Considerations

TMDLs Require Development of Pollutant Load-Water Quality Response Model
- How Does Water Quality Change With Change in Load of Constituent?

Use Phased Approach
- Set TMDL For Phase I
- Implement Control
- Monitor Constituent Loads and Water Quality Response
- If TMDL Goal Not Achieved, Reduce Allowed Loads in Phase II, etc

## Why TMDLs Now?

- TMDLs Required by Clean Water Act (CWA)
- Ignored by US EPA and State Regulatory Agencies

States Required to Meet Water Quality Standards
- If This is Not Done, US EPA Required to Develop TMDLs That Are to be Implemented by States
- Environmental Groups Sued US EPA For Failing to Develop TMDLs as Required by CWA

Problem Areas: as Being Developed and Implemented, TMDLs Focus On Chemical Concentrations Rather Than Chemical Impacts - Water Quality - Beneficial Uses

Time Table for Development and Implementation of TMDL and WLA and LA Too Short to Develop Technically Valid, Cost Effective TMDL

Margin of Safety Applied to TMDLs

Usually Arbitrarily Developed

Need Financial Resources To:

Assess Water Quality Significance of Violation of WQS on Beneficial Uses of Waterbody, and

Determine Sources of Constituents Responsible For Real Significant Use Impairments of Concern to the Public

Develop Appropriate Water Quality Standards That Serve as Technically Valid, Cost Effective TMDL Goals

Adjust Worst Case Based National Water Quality Standards for Site Specific Conditions

Use US EPA Guidance to Adjust Standards for Site Specific Conditions

Aquatic Chemistry and Toxicology

US EPA National Worst Case Based Water Quality Conditions Were Never Intended to be Mechanically Implemented Into Water Quality Standards

Over-Regulates Most Regulated Constituents, i.e., Those With Water Quality Standards

As Being Implemented, Use of Worst Case Water Quality Criteria Can Cause Large Scale Unnecessary Expenditures of Public and Private Funds Beyond That Needed to Achieve Desired Water Quality

Need to Incorporate at Least Mid-1990s Level Science and Engineering Into TMDL Development and Implementation

For Background Information on the Over Regulation Associated with Implementation of Water Quality Standards and TMDL Consult Lee, G. F. and Jones-Lee, A., "Evaluation Monitoring vs Chemical Constituent Monitoring *Chemical Concentrations vs Chemical Impacts*," Presented at CA Water Environment Association Training Seminar, "*Recent Advances in Receiving Water Monitoring*," Anaheim, CA, February (1999). Available in the water quality section of www.gfredlee.com

## Examples of TMDL Issues/Problems

### TMDL for Mercury

Mercury Occurs in San Francisco Bay, Sacramento River, Sacramento/San Joaquin River Delta, Tributaries to the Sacramento River and Delta Fish at Concentrations Which Are Considered Hazardous for Use of the Fish as Food

Excessive Mercury Causes These Waterbodies to Be Listed as Impaired Waterbodies and Placed on the 303(d) List

Establishes Need for TMDL to Control Mercury Inputs to These Waterbodies

Mercury Sources Are:

- Natural Geothermal Springs in Both the Coast Range and Mt. Lassen Area,
- Former Mercury Mining Areas in the Coast Range, and
- In Gold Mining Areas Where Mercury Was Used to Recover Gold
- In Coast Range Mining Areas Mercury Occurs as Cinnabar and Hg Metal, as Well as Possible Other Forms
- In the Sierra Gold Mining Areas Mercury Occurs as Hg Metal

Large Amounts of Mercury Are Present in Sacramento River and Tributaries, as Well as Delta and San Francisco Bay Sediments from Historical and Current Discharges

Each Year, with High Winter Flows, Substantial Mercury Is Moved from the Former Mining Areas in the Coast Range Down Through Cache Creek and the Yolo Bypass into the Delta and San Francisco Bay. This Is Particulate Mercury, Apparently Largely in the Form of Cinnabar

**Mercury Aquatic Chemistry**

Mercury Exists in Several Chemical Forms

Cinnabar (Mercury Sulfide), Mercury Metal and Mercury Oxides, as Well as Organomercury Compounds Such as Methyl Mercury and Dimethyl Mercury

Methyl Mercury Is the Highly Toxic Form of Mercury That Bioaccumulates in Fish

Mercury Conversion to Methyl Mercury Typically Occurs Under Anoxic (No Oxygen) Conditions in Aquatic Sediments by Certain Bacteria

The Aqueous Environmental Chemistry of Mercury That Leads to Methyl Mercury Formation Is Poorly Understood.

There Is No Relationship Between the Total Amount of Mercury in Sediments or the Total Mercury Load to a Waterbody and the Rate of Conversion of Mercury to Methyl Mercury That Accumulates in Fish Tissue.

**TMDL Goals for Mercury Control**

Conventional TMDL Approach Would Require That the Mercury TMDL Goal Be the US EPA Water Quality Criteria/State Standard

Currently 12 ng/L Total Recoverable Mercury

Soon, under California Toxics Rule, 50 ng/L Total Recoverable Mercury

In the near Future, US EPA Revised Mercury Criteria, 5 ng/L Total Recoverable Mercury

These Criteria Are Based on Worst Case Assumptions of the Bioavailability of Mercury, i.e., the Conversion of Mercury to Methyl Mercury Which Bioaccumulates in Fish

There Are Insufficient Funds Potentially Available to Control All Mercury Sources So That the Concentrations in Stormwater Runoff from Areas Where Mercury Has Accumulated Will Be Less Than 5 ng/L Total Recoverable Mercury

Worst Case Based Water Quality Criteria/State Standards for Mercury Are Not Realistic Control Goals.

Will Never Be Achieved

**Alternative Goal**

Control Mercury Inputs to a Waterbody to Reduce, to the Maximum Extent Practicable, Mercury Bioaccumulation Within Fish Tissue in the Various Waterbodies Where Excessive Mercury Is Now Present in Fish Tissue

San Francisco Bay vs. Central Valley Approaches-Total Mass Load Control vs. Control of Available Forms of Mercury

**Issue That Should Be Addressed**

Are the Current Mercury Residues in Waterbody Sediments Sufficient So That the Amount of Conversion of Mercury in These Sediments to Methyl Mercury That Accumulates in Fish Will Not Be Changed Significantly as a Result of Expenditure of Funds to Control Current Mercury Sources

Large Amounts of Public Funds Could Be Spent Controlling Mercury Sources from Former Mining Areas and Have No Significant Impact on the Mercury Concentrations Within Fish Tissue.

The Aqueous Environmental Chemistry of Current Mercury Loads and Historical Residues Must Be Better Understood in Order to Develop Technically Valid, Cost Effective TMDLs to Control Mercury Inputs to the Sacramento River Watershed, Sacramento/San Joaquin River Delta and Upper San Francisco Bay

Insufficient Time Available to Develop the Necessary Information Before TMDLs Have to Be Developed

**How Will Mercury Be Regulated?**

Will the US EPA Abandon Its Current TMDL Policy of Basing Mercury Control on Worst Case Based Water Quality Criteria/Standards for Chemical Concentrations of Mercury in Favor of Tissue Residues?

## Nutrients (Nitrogen and Phosphorus Compounds)

Excessive Fertilization of Waterbodies (Eutrophication) Is Listed as One of the Major Causes of Water Quality Use Impairment in the United States and in California. Many Waterbodies Are on the 303(d) List Because of Excessive Fertilization

Requires That a TMDL Be Developed for Nutrients (Nitrogen and/or Phosphorus Compounds)

Need to Focus TMDL Nutrient Control Goals on Controlling Algal Available Forms of the Limiting Nutrient

Nitrogen, Nitrate and Ammonia, as Well as the Organic Nitrogen That Converts to Ammonia

Soluble Orthophosphate plus the Total Particulate Phosphate That Converts to Soluble OrthoP

While the Importance of Focusing on Available Forms of Limiting Nutrients Was Well Established in the 1960s and 1970s, Current US EPA Administration Is Ignoring this Issue

Can Result in Large Expenditures for Nutrient Control, with Limited Impact on the Beneficial Uses of Waterbodies That Are Impacted by Nutrients

**TMDL Goals for Nutrients**

No Water Quality Criteria for Nutrients. US EPA Is in the Process of Attempting to Develop Such Criteria. Supposed to Be Available in 2000

As Proposed Now, US EPA Following a Technically Invalid Approach of Assuming That a Single Numeric Value for Nitrogen and Phosphorus Is Applicable to Each Major Type of Waterbody Within a Region

Appropriate Nutrient Control Goal Is Waterbody Specific

Requires Understanding of the Hydrology, Hydraulics and Morphological Characteristics of the Waterbody That Determine How Nutrients Added to a Waterbody in a Certain Chemical Form Are Converted to Algae That Develop and Persist for a Sufficient Time to be Significantly Adverse to Water Quality

While Ignored in Current Nutrient Based TMDLs, Ultimately Need to Understand the Source of the Available Forms of Nutrients That Cause the Excessive Algal Growth

Upper Newport Bay - Ten Day Flushing Time

Excessive Fertilization Problem Is a Summer/Early Fall Problem, Not Late Fall, Winter or Early Spring
Nutrients Added in Stormwater Runoff During Late Fall, Winter and Early Spring Do Not Contribute to Excessive Fertilization During the Summer

Upper Newport Bay, Orange County, CA TMDL Requires the Control of Total Phosphorus, Even Though Phosphorus Is Not a Limiting Element and Most of the Phosphorus Added to the Bay Is in a Particulate Non-available Form

A Potentially Significant Source of Nitrate For Some Waterbodies is Shallow Groundwater That Has Been Polluted by Agricultural Activities, Where the Groundwater Discharges to Surface Waters

In Orange County and in the San Joaquin River Watershed, Nitrate Concentrations of 50 to 75 mg/L N Found in Some Groundwaters Discharging to Surface Waters

Discharge Can Be Above Ground Through Springs or Subsurface

Need to Utilize the Vast Literature on Nutrient Load - Eutrophication Response That Was Developed in the 1960s/1970s in TMDL Development for Excessive Fertilization Control

**Pathogen Control TMDL**

Some Areas Where There Is Contact Recreation at Beaches Experience Beach Closures Due to Excessive Concentrations of Fecal Coliforms

Fecal Coliform Is an Indicator of Human Enteric Pathogens Such as Typhoid Fever and Bacterial Dysenteries

Urban Area Street and Highway Stormwater Runoff High in Fecal Coliforms

Fecal Coliforms Are Also Derived from Animals and Birds - Load Allocation to “Nature”

TMDLs Being Developed to Control Total Fecal Coliform Added to Waterbodies

Known since the 1940s That Fecal Coliforms Are Not a Good Indicator of Human Pathogens in Domestic Wastewaters

Fecal Coliforms Are Not Reliable Indicators of Parasitic Protozoan Diseases Such as That Caused by Cryptosporidium and Garadia, as Well as Those Caused by the Enteroviruses

US EPA Will Require by 2000-2001 Use of E coli and Enterococcus as the Fecal Indicator Organism for Contact Recreation

More Directly Correlatable with Enteric Diseases. Do Not Account for Eye, Ear, Nose Infections Associated with Contact Recreation

People Who Swim Have Greater Numbers of Diseases and More Frequent Disease than Those Who Do Not Swim

Problem; Departments of Health Regulate Contact Recreation

Will Not Likely Terminate the Use of Fecal Coliforms as an Indicator of Unsafe Conditions

Will Likely Find That Not Only Do Beaches Have to Meet Total and Fecal Coliform Standards, but Also Standards for Enterococci and E coli

## Heavy Metals - Potentially Toxic

Copper, Zinc, Lead, Cadmium, Chromium and Nickel

Heavy Metals in Water and Sediments Cause Some Waterbodies to Be Listed as a 303(d) Impaired Waterbody

Based on Concentrations of Heavy Metals in the Water Column Exceeding Worst Case Based Water Quality Standards

Water Quality Criteria/Standards for Heavy Metals Assumes That Heavy Metals Are Present in Toxic/Available Forms for a Sufficient Period of Time to Be Toxic to Aquatic Life

TMDLs Based on Total, as Well as Dissolved Heavy Metals Over-Regulates Potential Impacts of Heavy Metals in Most Waters

Need Site Specific Studies to Determine if Heavy Metals Are in Toxic Available Forms for a Sufficient Period of Time to be Toxic/Adverse to Aquatic Life

Also Need to Evaluate if Toxicity Found is Significantly Adverse to the Beneficial Uses of the Waterbody,

i.e., Alter the Numbers, Types and Characteristics of Desirable Forms of Aquatic Life

Use an Evaluation Monitoring Approach to Determine if There is Need to Control Heavy Metal Impact

Focus on Heavy Metal Impacts (Toxicity) Rather Than Heavy Metal Concentrations

If the Exceedance of a Water Quality Standard for Heavy Metal is an "Administrative" Exceedance, i.e., Not Related to Real Water Quality Impacts, Work Through the Administrative System to Change the Water Quality Standards to Protect Beneficial Uses Without Unnecessary Expenditures for Heavy Mental Control

**Heavy Metals in Sediments**

TMDLs Being Developed Based on Elevated Concentrations of Heavy Metals in Sediments

Thus Far, Approaches Being Used are Not Technically Valid and Will Significantly Over-Regulate Heavy Metals in Aquatic Sediments in Most Waterbodies

Long and Morgan Co-Occurrence Based Sediment Quality Guidelines Unreliable for Assessing Potential Water Quality Significance of Heavy Metals in Sediments

Must First Evaluate Whether the Sediments Toxic? And, if so, Through the Use of toxicity investigation evaluations (TIEs), is the Toxicity Due to Heavy Metals? If the Sediments are Toxic Due to Heavy Metals, Evaluate the Significance of This Toxicity to Beneficial Uses of the Waterbody

If Significant, Control Heavy Metal Inputs From That Source That Cause the Toxic Heavy Metals to be Present in Sediments

Do Not Assume That All Sources of Heavy Metals Contribute Toxic/Available Forms. Requires Site Specific Forensic Studies

## San Joaquin River Deepwater Channel Low DO Control TMDL

The San Joaquin River Near Stockton in the Deepwater Navigation Channel Dissolved Oxygen Concentrations Fall Below the Water Quality Standards of 5/6 mg/L During Summer and Fall

In Addition to Violating Water Quality Standard, Also it is Reported to Block Salmon Migration Upstream During the Fall

San Joaquin River Deepwater Channel on 303(d) List Because of Low DO

TMDLs Being Developed to Control Low DO

TMDL Development Focuses on First Determining the Cause of the Low DO and the Source of the Constituents Responsible

Of Concern is Ammonia and Nitrate Used for Agricultural Fertilizers That Develop Algae That Die and Become Oxygen Demand Source

Ammonia, Nitrate and BOD Discharged by Domestic Wastewaters

Deepening of the San Joaquin River to Create the Deepwater Channel for Large Ship Navigation Created a “Lake” on the San Joaquin River Which, During Low Flow Summer/Fall, Provides Sufficient Time for Large Scale Algal Growth and Die-off

Need to Understand the Relative Significance of Various Sources of Oxygen Demanding Materials and Then Develop an Approach to Limit Their Input to the San Joaquin River System to Prevent Low DO Conditions From Occurring

Possibly Will Need Aeration of the River to Help Keep the DO Above the 5/6 mg/L Minimum

## OP Pesticide Caused Aquatic Life Toxicity

Urban Stormwater Runoff Toxic to Some Zooplankton (Small Animals)

Sacramento, Stockton, Davis, San Francisco Bay Area, Orange County, Los Angeles, San Diego

Toxicity Violation of Narrative Water Quality Standard “No Toxics in Toxic Amounts”

Toxicity Due to Organophosphate Pesticides Diazinon and Chlorpyrifos (Dursban)

Used on Residential Properties for Termite-Ant and Home and Garden Pest Control

Causes Waterbodies to be Listed on 303(d) List of Impaired Waterbodies

TMDL Being Developed to Control Diazinon, Chlorpyrifos and Aquatic Life Toxicity in San Francisco Bay Area,

Sacramento River Watershed, Stockton, Orange County, CA, and San Diego Area

Orange County Uses Over 150,000 Pounds of Diazinon and Chlorpyrifos (Active Ingredient) Each Year in Residential Areas Applied by Commercial Applicators and the Public

Toxicity Found in San Diego Creek As It Enters Upper Newport Bay, Orange County, is Due to About 5 Pounds/Year in Runoff

**Issues in Regulating OP Pesticides**

OP Pesticides Toxic Only to Certain Zooplankton, *Ceriodaphnia* and Mysids Which Are Fish Food

Does This Toxicity Impact Fisheries?

Replacement Used for OP Pesticides Will Result in Another Type of Pesticide Being Used

What Will Be the Alternatively Used Pesticide Public Health and Environmental Impact?

Pesticides Regulated by US EPA Office of Pesticide Programs (OPP)

Allows Toxicity That is Not Significantly Adverse to Beneficial Uses of Waterbody

Also, OP Pesticide Use Causes Aquatic Life Toxicity in Agricultural Stormwater Runoff and Irrigation Tailwater

Orchard Dormant Spray

Future of OP Pesticide Use in Urban Areas Unknown

Will Likely Be Determined by the Courts

## Application of TMDL to Urban Stormwater Runoff

Urban Area and Highway Stormwater Runoff Contains Sufficient Concentrations of Several Potential Pollutants That Could Cause/Contribute to Violations of Water Quality Standards at the Point of Discharge

Could Become Subject to TMDL Limitations for Heavy Metals, PAHs, Fecal Coliforms, Nutrients, OP Pesticides

Application of TMDLs to Urban Stormwater Runoff Should Recognize the Unique Characteristics of Urban Stormwater Runoff as it May Impact Receiving Water Quality

Many Potential Pollutants in Urban Area and Highway Stormwater Runoff in Non-Toxic/Non-Available Forms

Duration of Exposure to Toxic/Available Forms Short Compared to Critical Concentration/Duration of Exposure Relationships

Requires Site Specific Investigations to Establish Appropriate TMDL Goals for Urban Stormwater Runoff Wasteload Allocation to Protect Receiving Water Beneficial Uses

Failure to Adopt This Approach Could Cost the Public Large Amounts of Money With Little or No Improvement in Receiving

Water QualityMassive Public and Private Funds Will Be Spent to Meet TMDL Goals
High Cost of Implementing TMDLs Will Bring About Major Revisions of Water Pollution Control Programs in US

There is Need for Improved Water Pollution Control From Urban, Industrial, and Especially Agricultural Stormwater Runoff and Waste Waters - Irrigation Return - Tail Water

How The TMDL Implementation Will Ultimately be Played Out Unknown

## Addressing Administrative Exceedance of Water Quality Standards

The Use of US EPA National Worst Case Based Water Quality Criteria as State Standards Leads to "Administrative" Exceedances of Water Quality Standards

Administrative Exceedance Equals Violation of Water Quality Standard Without Significant Water Quality Use Impairment
Outgrowth of the Overly Protective Nature of National Water Quality Criteria
If Exceedance of Water Quality Standard Occurs Should Conduct Site Specific Studies to Determine if Exceedance Causes Real Significant Water Quality Use Impairment

If Administrative Exceedance Occurs, Adjust Water Quality Standards to Protect Beneficial Uses Without Over Regulation

If US EPA Allowed Adjustment of Water Quality Standards Does Not Eliminate Administrative Exceedance, Work With Regulatory Agencies, State and Federal Legislatures to Revise Regulations to Protect Beneficial Uses Without Significant Unnecessary Expenditure of Funds for Constituent Non-Pollutant Control

## Additional Information

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**US EPA TMDL Fact Sheet** - http://www.epa.gov/region09/water/tmdl/fact.html
Also consult http://www.epa.gov/OWOW/tmdl/tmdlfs.html for a new US EPA TMDL program.

Many of Drs. Lee and Jones-Lee's Papers and Reports Available From Their Web Site, www.gfredlee.com.