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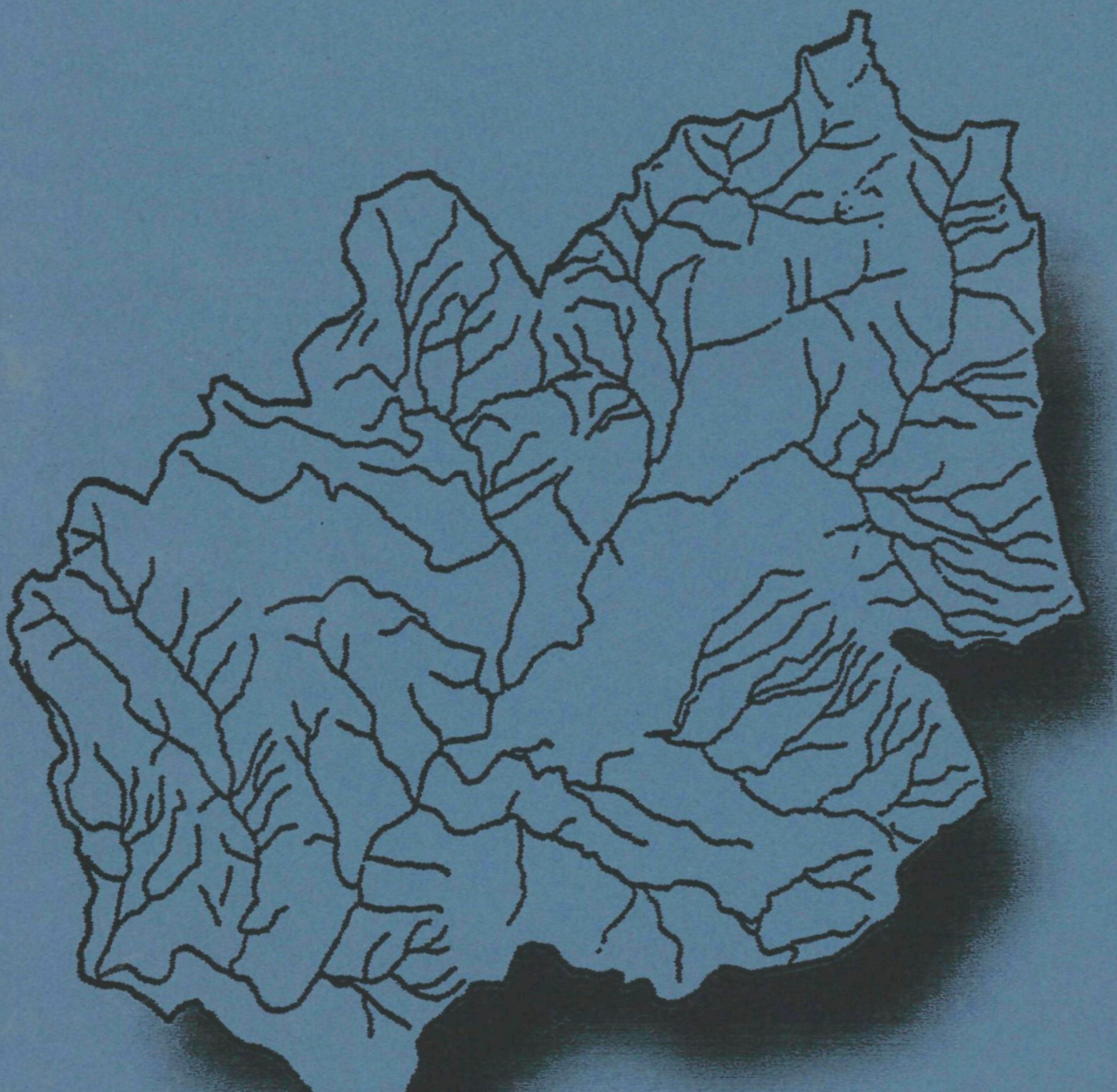
TMDL Development Cost Estimates: Case Studies of 14 TMDLs



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PART I. STUDY OVERVIEW

The U.S. Environmental Protection Agency's (EPA) Office of Water initiated this study to provide information on the costs to state and local water pollution control agencies of implementing requirements for development of total maximum daily loads (TMDLs). TMDLs were established under Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130). This study addresses the need for comprehensive information about costs associated with specific TMDL development activities.

Purpose of the Study

The purpose of this study is two-fold: to estimate development costs for a number of TMDLs through case examples; and to observe patterns from the case examples that help explain costs. In addition to presenting cost estimates, the study illustrates the range of activities involved in TMDL development, representing a variety of budget sizes, water quality impairments and geographic scales. The study also identifies funding sources for each case example. Additionally, in cases where water quality managers were able to describe benefits of TMDLs, the study reports these benefits.

Study Approach

The study's overall approach was to conduct an analysis of costs associated with TMDL development activities for a number of state and local water pollution control entities. This analysis was designed to determine factors that affect TMDL development costs, as well as funding sources that state and local water pollution control entities use for TMDL development. The components of the study methodology are:

- Selection of TMDLs for cost estimation;
- Development of a data collection protocol;
- Collection and review of background documents, including TMDL case studies, summaries, and final reports, CWA Section 319 grant applications, USDA hydrologic unit area (HUA) annual reports, and EPA mini-grant profiles;
- In-depth telephone interviews with regional EPA TMDL coordinators, participating state and local water program directors, state grant coordinators, and other program staff including engineers, water quality specialists, modelers, and analysts;
- Development of TMDL case studies;
- Follow-up and review as necessary; and
- Analysis of information and development of findings.

Given the unique nature of each TMDL, this study is intended to present a range of cost estimates across a number of distinctive TMDLs. It does not try to extrapolate TMDL development costs for broader programs or regions. Rather, it characterizes factors that contribute to cost differentials among individual TMDLs.

Selection of TMDLs for Cost Estimation

A list of candidate TMDLs for cost estimation was compiled from existing EPA TMDL case studies, listings of TMDL/nonpoint source mini-grant projects (FY92-94), and conversations with regional EPA TMDL coordinators. From this list, twenty TMDLs were selected for cost estimation. Those twenty make up a diverse sample, based on geographic location, watershed size, pollutants, and complexity. As a result of quality of information and time constraints, fourteen of the original twenty TMDL case studies were completed for this study. TMDLs were selected for inclusion in the study based on the following considerations:

- **Geographic Distribution** - A study objective was to select two TMDLs in each of the ten EPA regions. Not all EPA regions, however, could recommend candidate TMDLs. Instead, the study selected TMDLs that represented the broadest possible national distribution while meeting other selection criteria. Figure 1 is a map illustrating the geographic distribution of the 14 TMDLs for which case examples were developed.
- **Pollutants** - In selecting candidates for the study, attention was given to the type and number of pollutants addressed in an attempt to represent a range of the most common pollutants for which TMDLs are conducted: nitrogen; phosphorus; low dissolved oxygen; total suspended solids (sediment); toxics; and metals.
- **Scale** - A variety of small and large scale projects, as defined by square mileage of the watershed, were selected for inclusion in the study. Size categories are: small ≤100 square miles; medium ≤1,000 square miles; and large >1,000 square miles.
- **Complexity Level** - Another objective was to represent a range of complexity levels. Sophistication of water quality model was used as a proxy for overall TMDL complexity to guide TMDL selection. Figure 2 is a matrix showing the distribution of the 14 TMDLs for which case examples were developed according to pollutants and complexity level.

Development of a Data and Information Collection System

The interview/data collection guide used to collect information from participating state and local water pollution control officials for this study is based, in large part, on EPA's *Guidance for Water Quality-based Decisions: The TMDL Process,* published in April 1991. EPA's guidance states that a TMDL is composed of four parts: loading capacity (LC), wasteload allocations (WLAs), load allocations (LAs), and an appropriate margin of safety (MOS). According to EPA's Guidance, TMDL development involves quantification of pollutant sources and allocation of allowable loads to sources. Further, TMDL development includes the following five activities:

1. Pollution selection;
2. Estimation of assimilative capacity;
3. Estimation of pollutant loading from all sources;
4. Predicative analysis and TMDL establishment; and
5. Allocation - WLAs, LAs.

Figure 1. TMDLs Selected for the Study

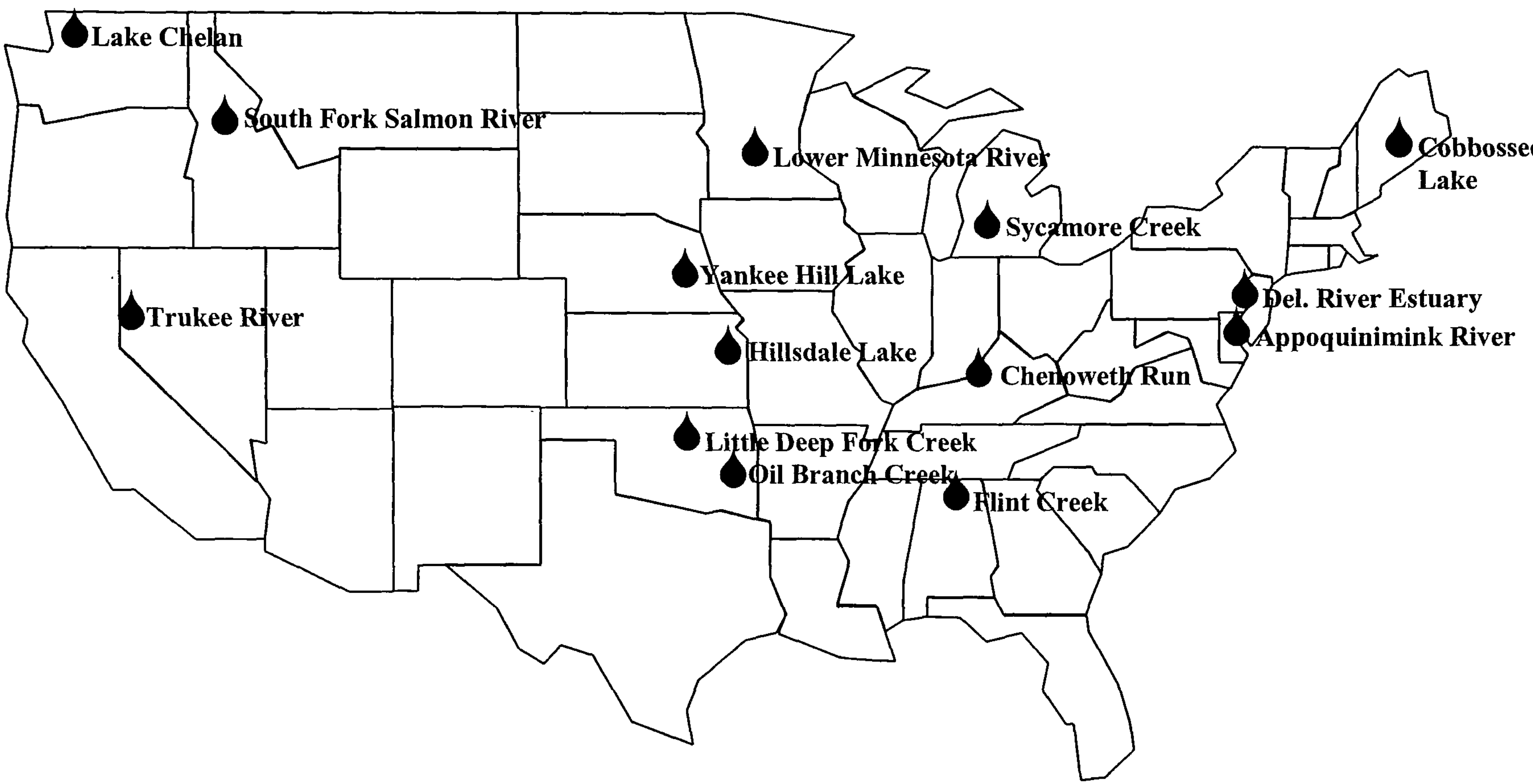


Figure 2. Range of Complexity and Pollutants Covered by Selected TMDLs

		Pollutant					
		N	**P**	**BOD/DO**	**TSS**	**NH_3**	**Metals**
Level of Complexity	Simple	HIL	COB	FLT OIL	SYC YNK	CHN	
	Mid-Range	TRK	CHE	LDF	SAM TRK		
	Complex		APQ	APQ		LMR	DEL

KEY:	
APQ = Appoquinimink River	LDF = Little Deep Fork Creek
CHE = Lake Chelan	LMR = Lower Minnesota River
CHN = Chenoweth Run	OIL = Oil Branch Creek
COB = Cobbossee Lake	SAM = South Fork Salmon River
DEL = Delaware River Estuary	SYC = Sycamore Creek
FLT = Flint Creek	TRK = Truckee River
HIL = Hillsdale Lake	YNK = Yankee Hill Lake

Using EPA's TMDL Guidance and the identified TMDL development activities, an interview/data collection guide was developed for this TMDL Cost Study. The guide is comprised of the following five sections:

- **General Background** - This section addressed demographic and other general background questions relating to many TMDLs. Responses to these questions provided the basis for the cost study and cost comparison.
- **Development Activities** - For the purpose of consistency among case studies, this section broke the TMDL development process into six customary activity categories. For each activity category, participants were asked to provide estimates of number of staff, total time (in years, months, weeks, days, or hours), and average annual salary levels for persons conducting those tasks. Responses to these questions provided estimates of the level of effort required to implement TMDLs.
- **General Water Quality Management Activities** - This section addressed issues related to water program work on TMDLs in relation to other water quality management activities.
- **Historic and Projected Revenue Data** - This section requested sources and amounts of funding for the year or years TMDLs were conducted.
- **Benefits** - This section explored direct and indirect benefits of the TMDL process.

As previously mentioned, for the purpose of comparison across case examples, the TMDL development process was divided into six cost categories. These categories are:

- ***Data Collection/Monitoring*** - Includes compiling available information, analysis of historical data and other available demographic information, identification of data collection needs, collection of ambient water quality samples, monitoring flow, installation and operation of continuous water quality monitoring equipment, collection of point source data, data standardization, and quality assurance/quality control.
- ***Modeling*** - Includes initial calibration, development, and operation of mathematical models to simulate natural processes and pollution within bodies of water. Models range from a simple series of calculations to complex computer programs.
- ***Analysis*** - Includes development of TMDLs, wasteload allocations (WLAs) and load allocations (LAs), pollution control scenarios, and cost analysis.
- ***Outreach*** - Includes public meetings, educational efforts, and creation of citizen advisory and/or TMDL strategy groups.
- ***Formal Public Participation*** - Includes public notice of TMDLs, receiving, compiling and publishing public comment on the TMDL, and public hearings.
- ***Administration*** - Includes inter- and intra-agency planning meetings, scheduling, coordination of field and laboratory staff, grant administration, and development of summary and final reports.

INFORMATION COLLECTION, CASE STUDY DEVELOPMENT, AND FOLLOW-UP

The TMDL background and demographic information included within this study was gathered using a multi-phase collection process. After the interview/data collection guide was developed and TMDLs were selected, background information and documents were solicited from each of the participating agencies. This information includes TMDL case studies, summaries, and final reports; CWA Section 319 grant applications; USDA hydrologic unit area (HUA) annual reports; and EPA mini-grant profiles. Next, in-depth telephone interviews were conducted with water program managers and other relevant TMDL development personnel.

After completion of the telephone interviews, case studies of costs associated with individual TMDLs were developed. Each case study contains comparative demographic information, as well as a range of estimated and potential costs for discrete elements of TMDLs. As a final step, all case study write-ups were sent to water program managers to clarify any remaining questions and confirm profile information.

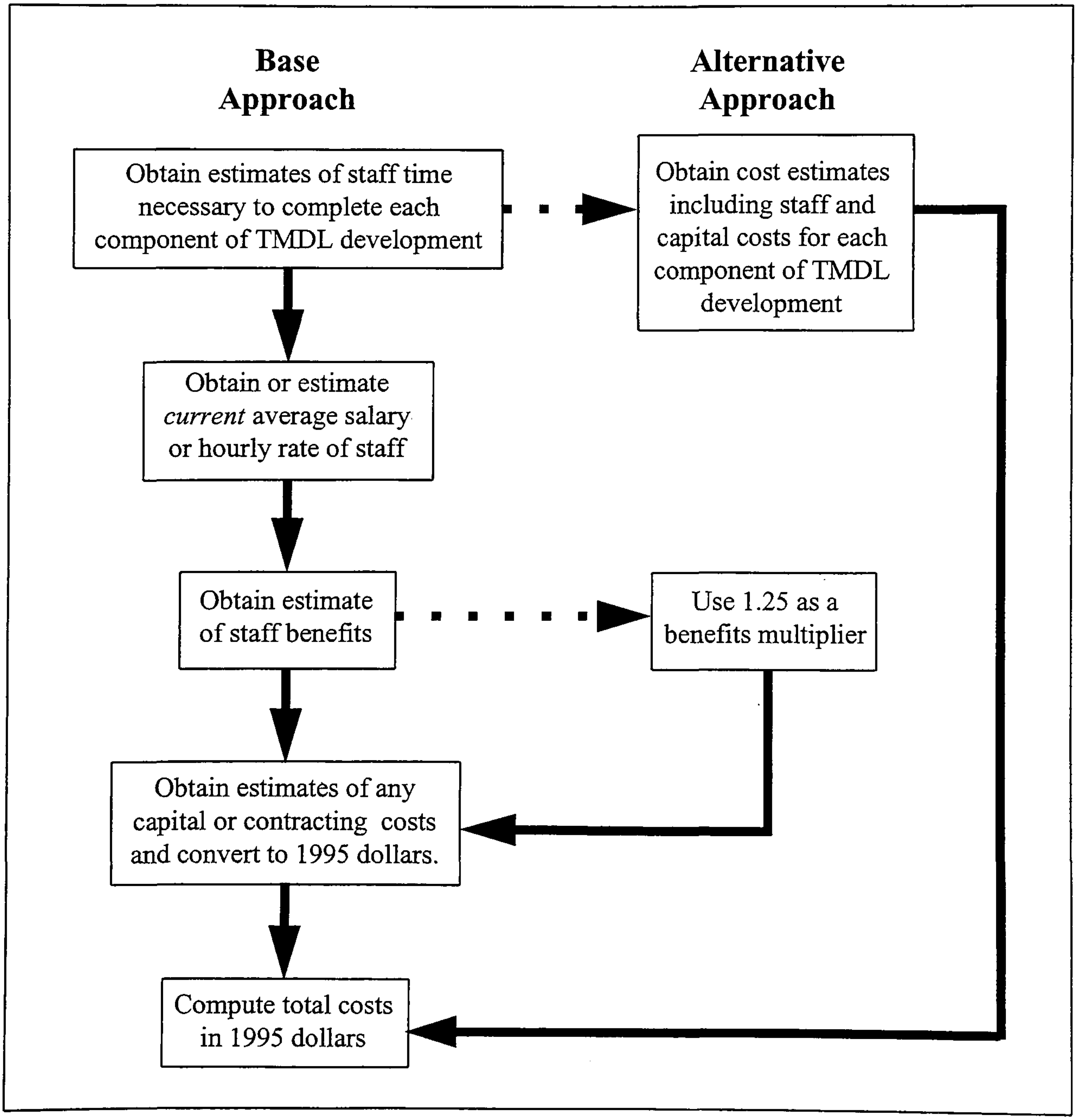
PRESENTING COST ESTIMATES IN FULL-TIME EQUIVALENTS AND DOLLARS

Cost estimates have been developed for level of effort in full-time equivalents (FTEs) and dollars. Both are important to understanding and comparing cost estimates, and for predictive purposes. FTEs normalize cost estimates, eliminating any salary and benefit differentials among studied jurisdictions. FTE estimates also are helpful to program managers in understanding staffing implications of TMDL projects. Dollar estimates are important for determining funding needs and identifying opportunities for grant assistance. Dollars also are typically associated with contract costs, which can be substantial for some TMDL activities. While FTEs are less important for activities that are typically contracted, in some instances water quality programs may consider undertaking selected activities in-house.

PART II. COST ESTIMATION APPROACH

In-depth phone interviews provided most of the information necessary to estimate TMDL costs. In calculating TMDL costs, only costs to the government agency or agencies responsible for TMDLs were counted. Implementation costs, including pollution prevention and control activities which are a result of a TMDL, are not counted. Figure 3 is a flow chart that outlines the strategy for calculating the total cost of each TMDL.

Figure 3. Strategy for Calculating the Cost TMDL Development



Dotted arrows in the flow chart represent the approach taken when the basic approach was not possible. Most programs provided sufficient data to use the basic approach where the starting point is the level of effort expended on each component of TMDLs (See Part I for a description of the cost components of TMDLs). For most TMDLs in this study, only one agency's efforts were estimated. This level of effort is referred to as "in-house" full-time equivalents (FTEs). For other TMDLs that required major efforts from teams of agencies, level of effort was calculated for more than one agency. FTEs in this case are not referred to as "in-house," since they are from multiple agencies.

The level of effort (in FTEs) was multiplied by a 1995 average FTE salary for the staff working on the TMDL to present all personnel costs in 1995 dollars, regardless of the year work actually occurred. This approach assumes that one FTE produces the same output in a recent year as in the current year. The product of staff effort and salary was then multiplied by the benefits multiplier for the particular agency developing the TMDL (the multiplier equals one plus the cost of benefits as percent of total salary). A multiplier of 1.25, which is a mid-range value, was assumed for those agencies that did not provide one. This final output provides the total personnel cost in 1995 dollars.

Other costs that are not part of direct efforts of personnel conducting TMDLs include capital costs, laboratory costs, work by contractors, and in-kind services from other government agencies. Where significant and available, estimates were obtained for these costs. These estimates were converted to 1995 dollars using a price index of state and local government purchases,[1] and added to personnel costs to develop a total cost estimate for TMDLs.

In cases where agencies provided cost estimates rather than level of effort for each component of a TMDL, the costs were converted to 1995 dollars using the same index. Summing these costs yields total TMDL costs. In the case of Lake Chelan, level of effort was estimated from cost estimates rather than vice versa.[2]

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[1] The 1995 figure is currently unavailable for the price index of state and local government purchases. An estimate of the 1995 figure was calculated by averaging the annual percentage increase of the index for the years 1984 to 1994. This average increase was then applied to the 1994 figure to approximate the 1995 figure.

[2] The level of effort for Lake Chelan was calculated as if state personnel conducted all of the activities necessary to develop the TMDL.

PART III. COST SUMMARY

RELATIONSHIPS BETWEEN COSTS AND TMDL FEATURES

Figure 4 on the following page is a matrix that summarizes basic information for each TMDL in this study. The matrix presents total cost to date or projected cost, in-house level of effort measured in full-time equivalents (FTEs), watershed size, model complexity, type of pollution, point sources, nonpoint sources, level of expenditure on public participation activities for each TMDL, and the page number on which each case study can be found. Before analyzing the figures contained in the matrix, several characteristics of the data deserve special attention:

- For most of the TMDL case examples, the TMDL development process has been completed such that the cost represents a total cost. For a few cases, such as Yankee Hill Lake, Chenoweth Run, and the Delaware River Estuary, the TMDL development process is ongoing as of this writing. Thus, those programs are expecting to incur additional costs. For Little Deep Fork, all costs are projected costs.
- *In-House FTEs* represent efforts of only one lead agency in developing the TMDL. Thus, the total level of effort is not necessarily represented. For example, in the case of Flint Creek, the level of effort measured by in-house FTEs (2.00) seems to be disproportionate to the cost of developing the TMDL ($1,023,531). However, many other agencies participated in TMDL activities, contributing approximately 14 FTEs.
- *Model Complexity* is based on an elementary rating system that evaluates modeling efforts as "simple," "mid-range," or "complex." The ratings are adapted from EPA's *Compendium of Watershed-Scale Models for TMDL Development* (EPA841-R-92-002, published in June 1992), as well as information obtained from water quality managers.

The analysis of data in Figure 4 is based on observation only. The sample size does not establish statistical significance for making predictions or determining causality. Observation of the data, however, does produce general patterns of cost that are at least related to, if not determined by, various features of the TMDL.

A close look at cost data in Figure 4 reveals a wide range of costs for TMDL case examples, from $4,039 to $1,023,531. Case examples are listed vertically in the matrix from lowest to highest cost. Figure 5 depicts these costs graphically. In addition to the wide range of total costs, a gap exists in total costs represented by the cases: six TMDLs are below $25,000, and eight are above $100,000. This fact may indicate that TMDLs require either comparatively modest efforts and expenses or relatively concentrated efforts and significant expenses.

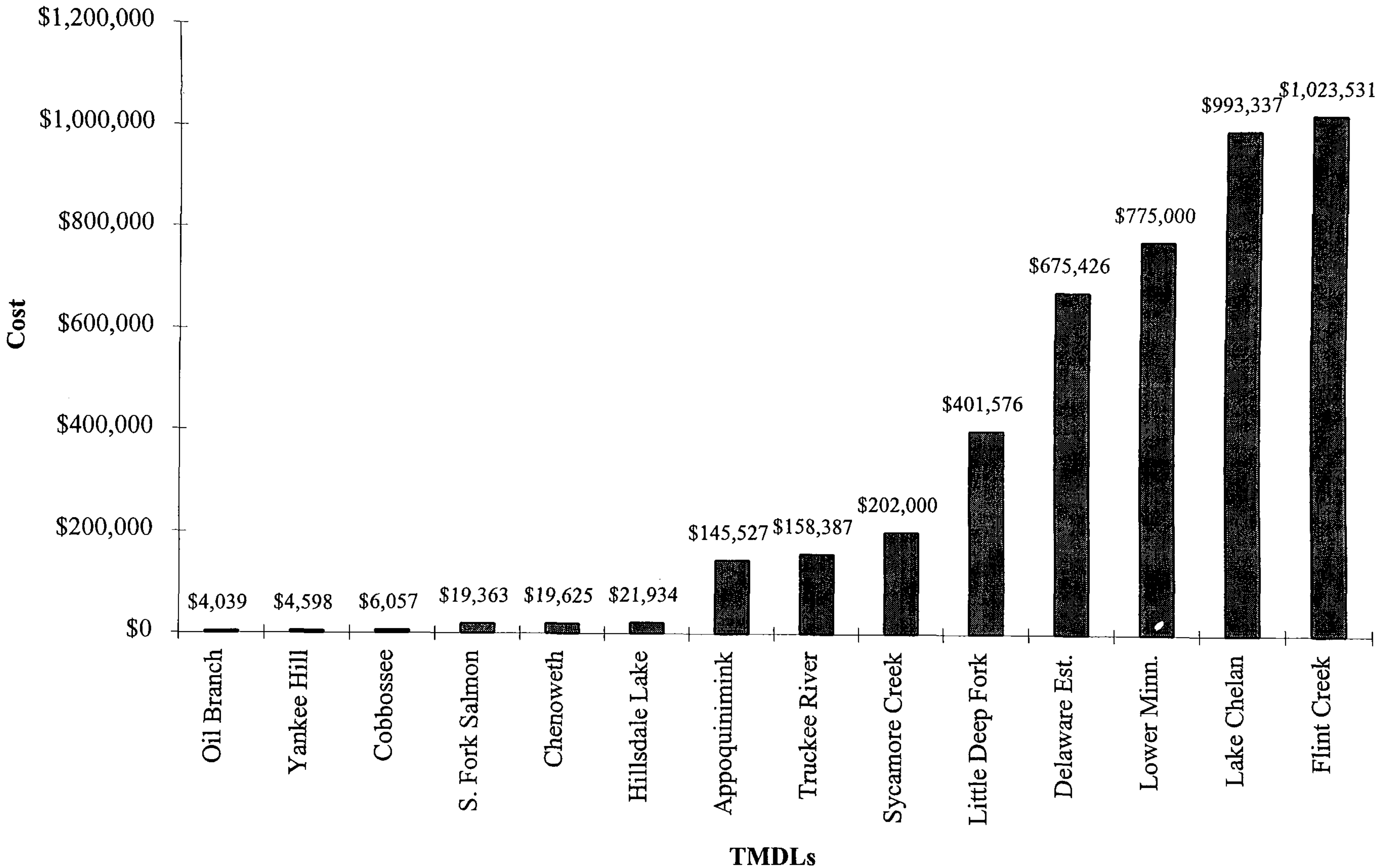
Cost and In-House FTEs

Figure 4 also suggests that several characteristics of a TMDL are correlated to the magnitude of its total cost. For example, the number of in-house FTEs working on a TMDL tends to be directly proportional to the cost. This relationship is intuitive: costs increase as level of effort increases. The Truckee River, Lower Minnesota, and Flint Creek seem to be exceptions,

Figure 4. Costs and Key Features of TMDLs

TMDL Area	Cost	In-House FTEs	Watershed Size (mi^2)	Model Complexity	Pollutants	Point Sources	Nonpoint Sources	Public Partic.	Page No.
Oil Branch Creek	$4,039	0.08	5.0	Simple	Low DO	WWTP	N/A	none	89
Yankee Hill Lake	$4,598	0.18	9.4	Simple	TSS, P, N	None	Agriculture, residential	none	113
Cobbossee Lake	$6,057	0.13	14.9	Simple	P	None	Agriculture	none	44
South Fork Salmon River	$19,363	0.42	370.0	Mid-range	Sediment	None	Silviculture, logging roads, erosion	<$5,000	93
Chenoweth Run	$19,625	0.26	17.0	No model	P, or. phos., TDS, TSS, BOD, NH_3	WWTP, light industry	Urban, pasture	<$5,000	39
Hillsdale Lake	$21,934	0.42	134.5	Simple	P, N, chlorophyll	WWTPs, res. lagoons, quarry	Agriculture	<$5,000	67
Appoquinimink River	$145,527	0.96	47.0	Complex	P, DO	WWTP	Agriculture	<$5,000	26
Truckee River	$158,387	1.00	2,300.0	Mid-range	N, P, TDS	Wastewater reclam. facility	Agriculture	>$5,000	105
Sycamore Creek	$202,000	4.0	37.0	Simple	Sediment	N/A	Agriculture	none	98
Little Deep Fork Creek	$401,576	6.87	240.0	Mid-range	DO, TSS, P, chlordane	WWTPs, storm sewers	Agriculture, surface runoff, petroleum activities	>$5,000	74
Delaware River Estuary	$675,426	10.30	>7,794.0	Complex	Metals, toxics	83 industrial or municipal facilities	Runoff, agriculture, CSOs, ground water infiltration, atmospheric deposition	>$5,000	50
Lower Minnesota River	$775,000	3.56	320.0	Complex	CBOD, NH_3	WWTPs	Agriculture, residential, commercial	none	84
Lake Chelan	$993,337	12.13	924.0	Mid-range	P, bacteria	Salmon pens	Stormwater, forest, & agricultural runoff; ground water inflows, tributaries, septic systems	>$5,000	32
Flint Creek	$1,023,531	2.00	244.0	Simple	Low DO	WWTPs	Agriculture	<$5,000	60

Figure 5. Total Cost for Each TMDL to Date

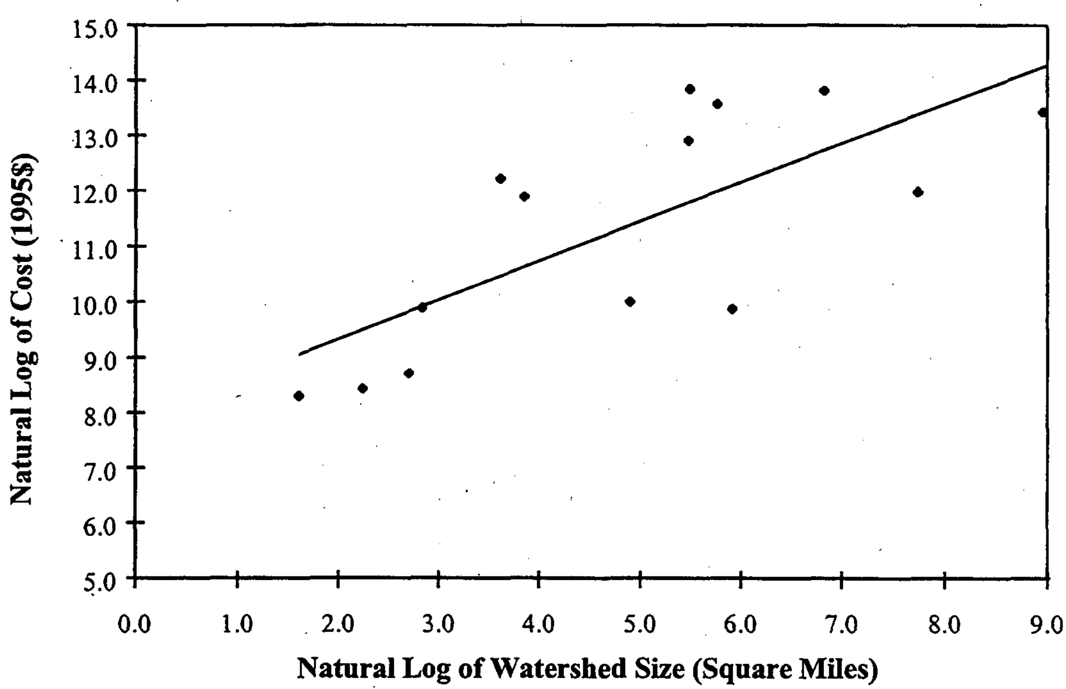


however, in each case, there is a reason for the apparently disproportionate costs. For the Truckee River, all modeling work was completed by a contractor; contractor FTEs are not calculated as TMDL FTEs in this study. For the Lower Minnesota River, a significant percentage of total costs was incurred many years ago (up to 21 years), so converting to current dollars seems to produce disproportionate costs. For Flint Creek, many federal agencies, whose FTEs are not tabulated, contributed a substantial portion of the total effort.

Cost and Watershed Size

The watershed size for a TMDL also seems to correspond to the cost of the TMDL - the smaller the watershed, the lower the cost. This relationship seems to hold true except for the South Fork Salmon River and Hillsdale Lake. Figure 6 illustrates this point. The figure plots each TMDL case example on a chart with natural log of watershed size on the x-axis and natural log of cost on the y-axis. A logarithmic scale is used because a standard linear scale does not produce a discernible relationship.[3] A trend line is included in Figure 6 to estimate the relationship. This trend shows that the percentage change in cost increases in fixed proportion to the percentage change in watershed size.

Figure 6. Relationship between Watershed Size and TMDL Cost



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[3] The compression of scale caused by taking natural logs eliminates outlyer effects that distort the relationship between actual values of cost and size. Other functional forms also can be used to express the relationship between cost and size, but this nonlinear relationship appears appropriate as evidenced by the graph.

Cost and Model Complexity

Model complexity is another factor that appears to influence TMDL cost. As expected, TMDLs with simple models tend to cost less than TMDLs with complex models. Two discernible exceptions to this observation are Sycamore Creek and Flint Creek. Both of these relatively expensive TMDL efforts used simple models. They incurred higher costs for other (non-modeling) aspects of their TMDL development efforts.

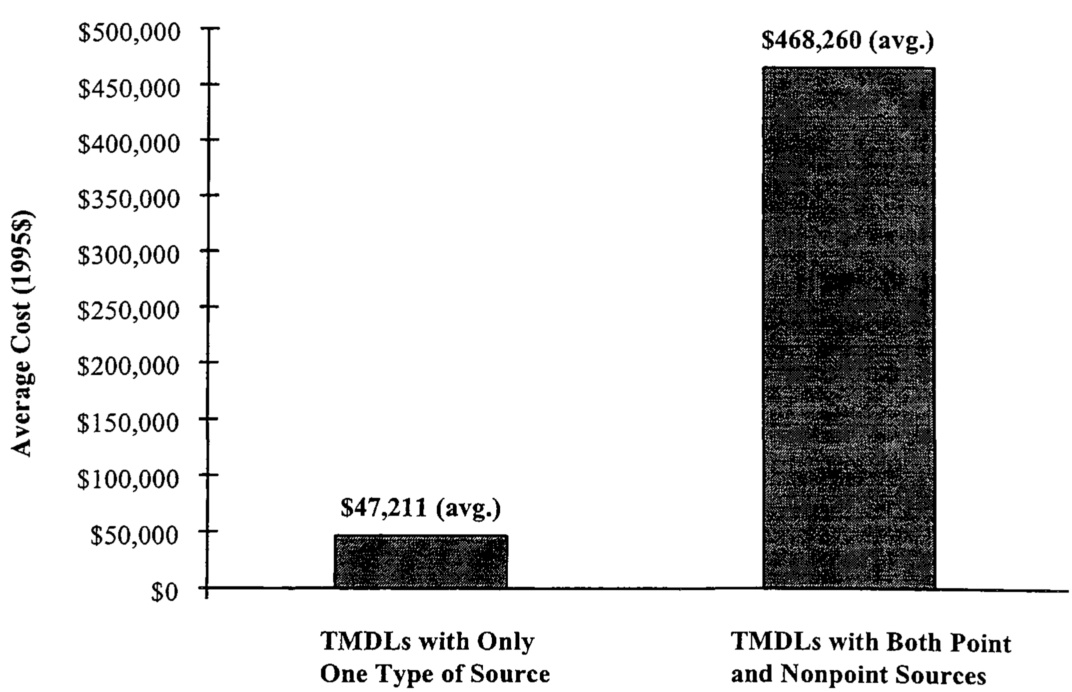
Cost and Pollutants

There does not appear to be a recognizable pattern that associates the cost of a TMDL to the number or type of pollutants for which TMDLs are developed. Lack of such a pattern does not necessarily rule out a relationship between type of pollution and TMDL cost. For instance, with other aspects being equal, a TMDL that must address numerous pollutants including toxic substances is likely to require more effort than one which addresses a single, non-toxic pollutant.

Cost and Distribution of Point and Nonpoint Sources

The distribution of point and nonpoint sources addressed by a TMDL also seems to be related to the cost of a TMDL. Those TMDLs addressing only one type of source (either point or nonpoint) tend to be less expensive than those addressing both types. Figure 7 displays this relationship graphically and demonstrates that average costs of single-source TMDLs are lower than average costs of multiple-source TMDLs.

Figure 7. Relationship between Pollutant Distribution and Cost



Cost and Public Participation

Finally, there appears to be a correlation between TMDL costs and the level of expenditure on activities related to public participation. Relatively inexpensive TMDLs tend to have low or no expenditures on activities related to public participation. There are two apparent exceptions to this observation, Sycamore Creek and Flint Creek. Both of these relatively expensive TMDLs had relatively low expenditures on public participation activities.

EXAMINATION OF TMDL COSTS BY COMPONENT

As stated in Part I, the cost of each TMDL was generated by defining components for TMDL development activities. These components are: data collection and monitoring; modeling; analysis; outreach; public participation; and administration. For the analysis that follows, outreach and public participation are combined into one category (making a total of five categories), because many programs do not make a distinction between these two components. Figures 8a and 8b present the cost of each TMDL, broken down into the five cost categories. Figure 8a contains those TMDLs that cost less than $25,000, and Figure 8b contains those TMDLs that cost more than $25,000. This split at $25,000 renders scales for each figure that allow more illustrative comparisons of TMDLs. Figure 9 displays the component costs of each TMDL as a percentage of total cost. Several important characteristics of the data are noted below:

- Staff who worked on the Appoquinimink River TMDL provided information on level of effort and costs using their own categories rather than the five listed above. Their categories were adjusted to fit the five standard categories as follows:

Appoquinimink Categories		Standard Categories
Planning/Administration	→	Administration
Preliminary Assessment	→	Analysis
Data Collection	→	Data Collection and Monitoring
Modeling Strategy and Model Development	→	Modeling
Public Participation	→	Outreach and Public Participation

- Staff who worked on the Lower Minnesota River TMDL did not make a distinction between modeling and analysis costs. Thus, in Figures 8b and 9, analysis costs are $0 for the Lower Minnesota River, and modeling costs include the cost of analysis. In addition, costs for outreach and public participation are included as part of the cost of administration.

- Staff who worked on the Lake Chelan TMDL did not make a distinction between data collection and modeling costs. Thus, data collection costs have been included in modeling costs.

- The fact that a few cost categories are actually sums of two cost categories (with one of those categories listed at $0) tends to distort the results in Figures 8b and 9. For example, in Figure 8b, Lake Chelan displays very high modeling costs and no data collection costs. This is somewhat misleading, since data collection costs are part of the modeling costs. Likewise, Figure 9 displays Lake Chelan's modeling cost at approximately 80 percent of the total cost of the TMDL. In fact, modeling *and* data collection constitute approximately 80 percent of the total cost.

Figures 8a and 8b show that expenditures on certain components of TMDL development vary extensively among TMDLs in the study. For example, two TMDLs which have a similar total cost, the Delaware River Estuary and the Lower Minnesota River, have significantly different administrative costs. Differences may be caused by one or both of two factors. First, each TMDL development process may be unique and require varying degrees of effort for certain components. Second, each agency may group and report efforts such that cost categories are not directly comparable. It is likely that both of these factors account for the wide swings in expenditures among components. Figure 9 points out these variations more clearly than Figures 8a and 8b. For instance, Figure 9 shows that data collection and monitoring costs, as a percentage of total cost, for each program are highly variable. Other cost categories display similar results, when compared among TMDLs.

Aside from indicating high variance in component costs among TMDLs in the study, Figure 9 shows that the costs of some components tend to be lower than other components. For example, administrative costs and the costs of outreach and public participation are lower than data collection and monitoring costs in almost all cases. Figure 10 illustrates this point more clearly.

Figure 8a. Costs of TMDLs Less Than $25,000, by Component

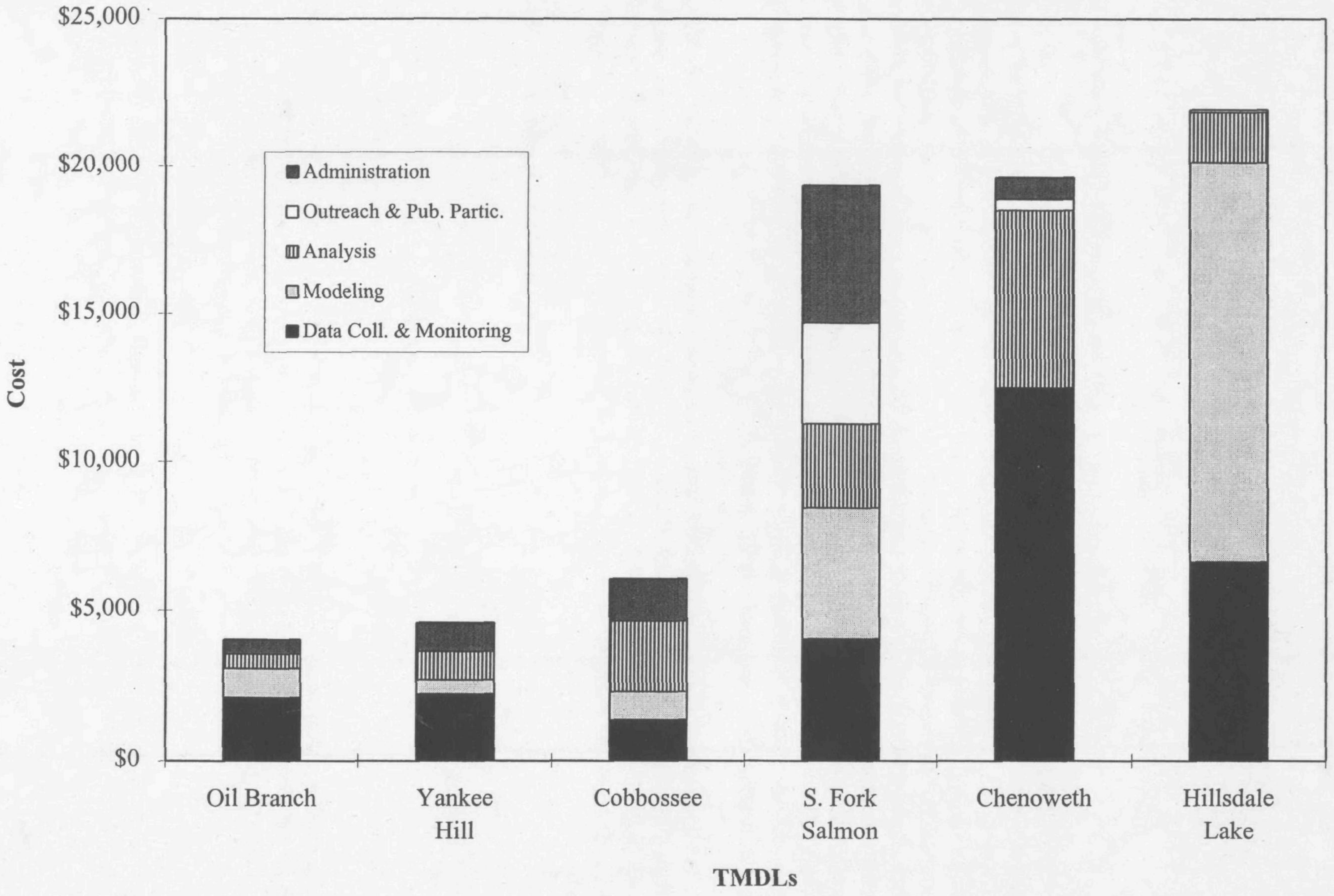


Figure 8b. Costs of TMDLs Greater Than $25,000, by Component

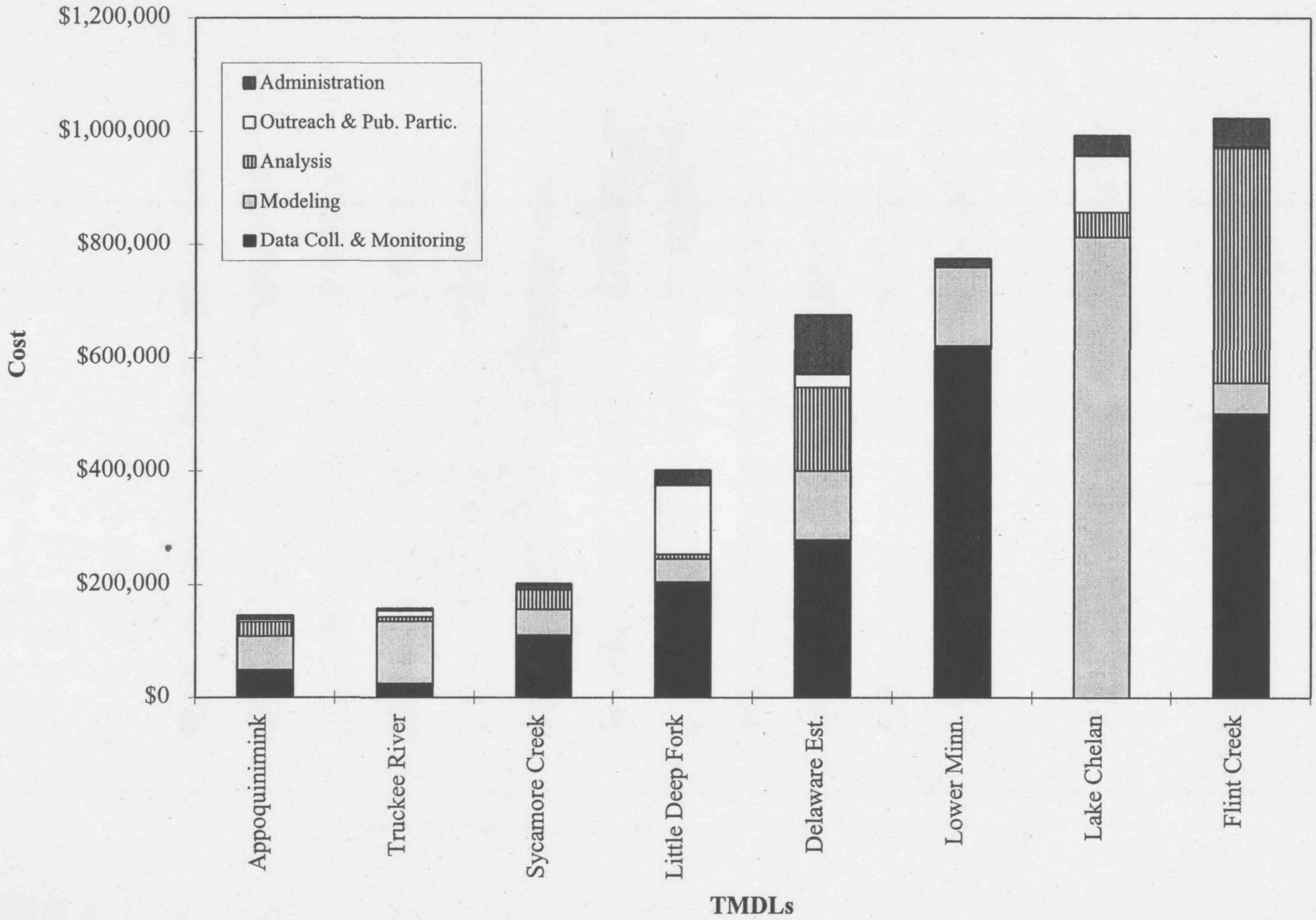


Figure 9. Component Costs of TMDLs, as a Percentage of Total Cost

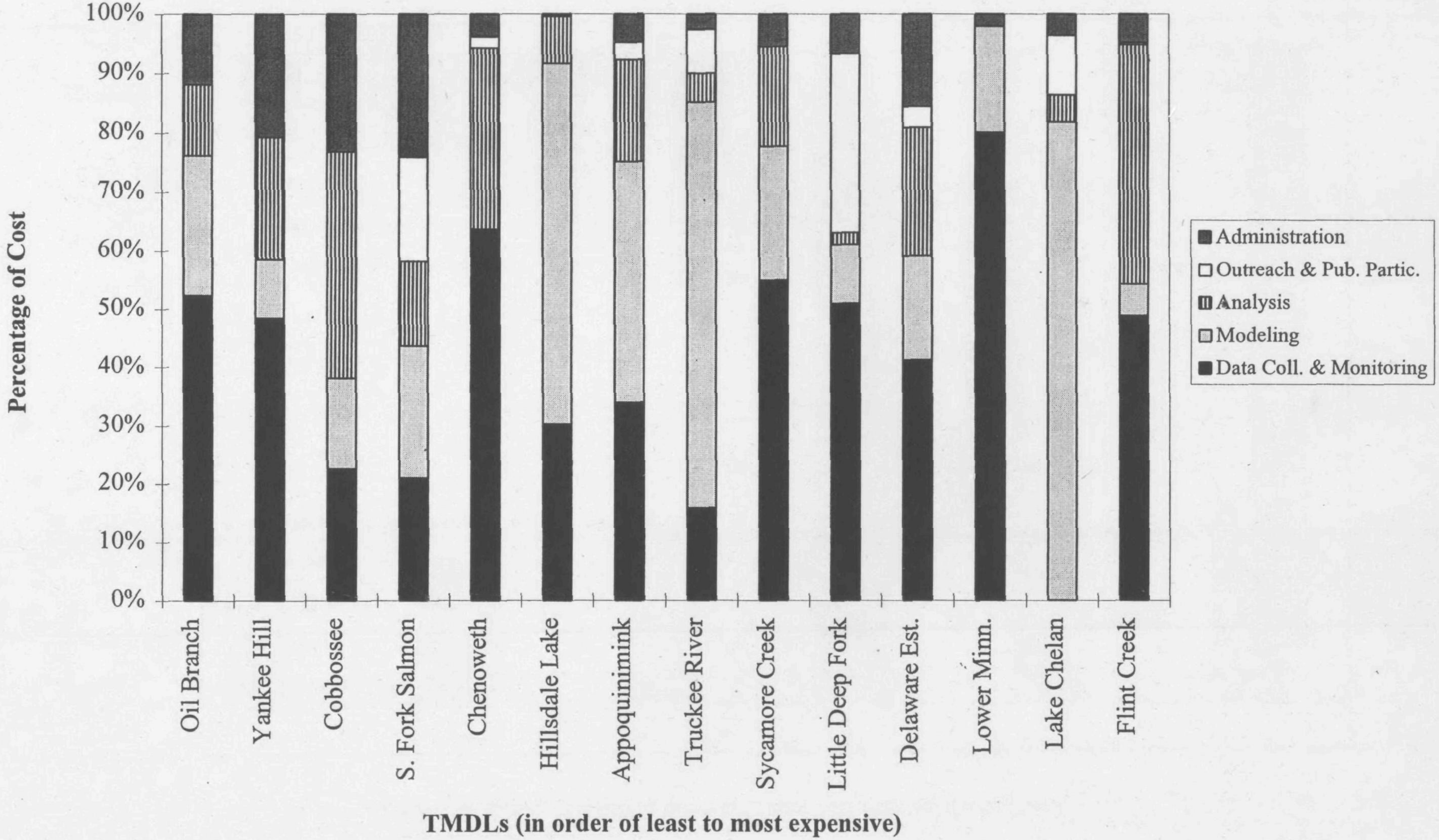
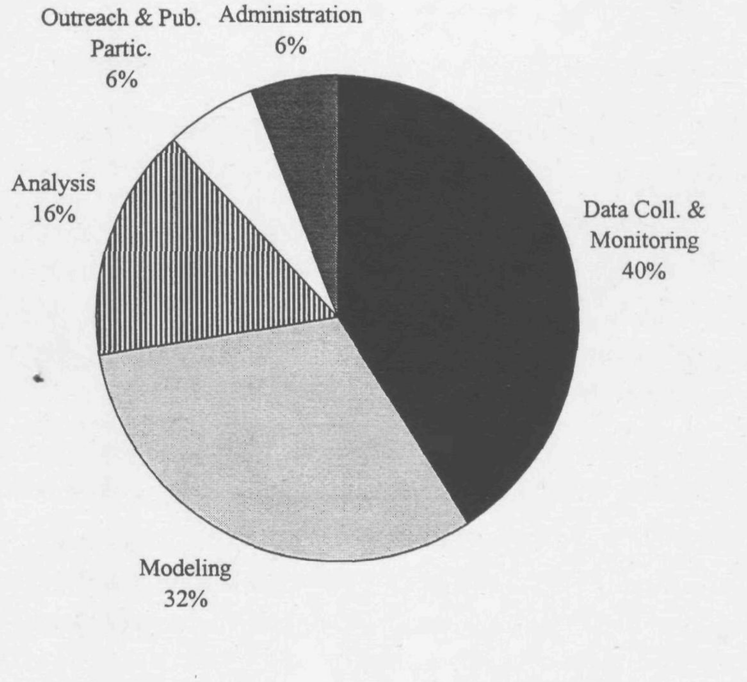


Figure 10 is a pie chart that displays the average cost of each component of a TMDL as a percentage of the total average cost of a TMDL. Remember that the *Modeling* pie piece in Figure 10 includes data collection costs for Lake Chelan and analytical costs for the Lower Minnesota River and is, therefore, somewhat larger than it might be otherwise. Barring differences in the way that various agencies aggregate costs, Figure 10 clearly shows that modeling and data collection/monitoring are, on average, the most costly components of developing a TMDL. Analytical costs are also substantial, while costs associated with administration and outreach and public participation are relatively small.

This cost summary section compares costs and cost components among all of the TMDLs in this study. Such comparisons are useful in identifying patterns and variances among programs, but the individual case studies presented in Part VI provide further insight into the costs of developing a TMDL. First, Part IV summarizes factors influencing decisions about dedicating different levels of effort in developing a TMDL. Part V provides information on federal TMDL resources, including availability of funding and staff who serve as TMDL coordinators.

Figure 10. Component Costs, Average of All TMDLs



PART IV. FINDINGS

This study has shown that level of effort and associated costs necessary to complete TMDL activities varies for any given TMDL project, depending on an array of factors, including:

- Type of water body and geographic features;
- Complexity of the water quality problem;
- Number and type of pollutants;
- Availability of data;
- Complexity of the model used;
- Number and type of sources; and
- Political sensitivity and level of public involvement.

In addition, many other factors can conceivably influence costs of a particular TMDL.

Each TMDL case example provides a section labeled *Cost Analysis* that examines factors such as those listed above that program staff considered during TMDL development. This part of the report summarizes those sections and describes overall findings by synthesizing responses from a number of water quality programs and officials. This is accomplished in five sections: (1) decision factors for amounts spent on TMDL activities; (2) relationship of TMDL to other water quality program activities; (3) cost minimization approaches; (4) funding sources; and (5) benefits of TMDLs.

DECISION FACTORS FOR AMOUNTS SPENT ON TMDL DEVELOPMENT

Many different factors influenced TMDL managers' choices in spending on TMDL development, but several are common among those studied:

- Ability to use TMDL development elements - data, modeling, analysis, as well as outreach, and public participation to support other water quality program activities tended to increase investment in those areas;
- Availability of existing data, models, and analyses decreased the level of additional expenditures necessary in these areas;
- Level of participation in TMDL development by organizations other than the lead agency(ies) is often inversely proportional to the level of in-house (i.e., lead) effort and expenditures; and
- Availability of funding from a variety of sources - state program funds, state grants, local cost-sharing, and federal grants, as well as in-kind contributions increased the amount managers were willing to spend especially with respect to data collection, modeling, and analysis.

The overall magnitude and complexity of a particular TMDL project framed many of the decisions about expenditures in all of the cost categories. This is particularly apparent for expenditures on modeling. In general, TMDL modelers chose to spend an amount that allowed them to capture a level of complexity commensurate with complexity of the waterbody and pollution problems. Two other decision factors cited less often are: prior availability of various types of data that are necessary to conduct a TMDL; and lack of experience in conducting certain TMDL activities, resulting in less attention to and spending on those activities.

Leveraging resources both financial and in-kind services appears to be the most significant factor affecting TMDL expenditure decisions. As illustrated in the case studies, partnerships between agencies involved in water quality management have been key to successful leveraging of resources for TMDL development. Selected decision factors are discussed in more detail below.

RELATIONSHIP OF TMDL TO OTHER WATER QUALITY PROGRAM ACTIVITIES

Overall, managers felt that TMDLs were cost-effective and also increased the cost-effectiveness of other water quality program efforts, because of the strong linkages between TMDLs and other activities. One characteristic noted in almost all TMDL development efforts is that ample opportunities exist to share valuable information among water quality management and protection efforts. Such sharing may occur within one particular agency or among several agencies at different levels of government. In addition, a TMDL may benefit from data that are available, or it may generate data that are useful to other water quality programs. For example, many TMDL analysts noted that their respective agencies would be undertaking water quality monitoring efforts even in the absence of TMDL efforts.

COST MINIMIZATION STRATEGIES

One aspect of TMDL development shared by all of the programs in this study is an attempt to minimize costs where possible. Several methods of cost minimization were used by most or many agencies, such as obtaining data from available sources rather than collecting new data. Data collection can be an expensive undertaking, especially when it involves capital costs for equipment that measures various properties of water quality. Another cost minimization strategy is sharing costs with other water quality initiatives and/or generating information that is useful to other water quality initiatives. This strategy may not decrease costs of developing a TMDL, but it may decrease costs of other initiatives or decrease total costs incurred by a water quality agency. Other cost minimization techniques that were mentioned include:

- Working closely with point source dischargers;
- Organization of multi-agency groups not only to spread costs, but also to take advantage of the skills and resources of additional agencies; and
- Use of in-kind services from other institutions.

FUNDING SOURCES

One hurdle all water quality managers must jump in developing a TMDL is resolving how to fund the costs outlined in this study. A wide variety of federal, state, and local funding sources were used to pay for TMDL activities among the programs in this study, including:

- Water quality program operating funds (typically State general revenues);
- NPDES permit fees;
- State and local grants; and
- A variety of specific federal water quality grants, such as 205 (j) Grants, 319 (h) Grants, and TMDL mini-grants.

BENEFITS

Water quality managers typically described TMDL benefits in two ways: in terms of direct benefits to waterbodies, meaning improved water quality; and in terms of indirect benefits in the form of increased understanding, awareness, and coordination that they felt also will result in water quality improvements. Notably, few quantitative measures of benefits were available. Although several managers cited observed water quality improvement, many indicated it would be a couple years into TMDL implementation before improvements were measurable and/or observable.

Awareness of the benefits of TMDL development is useful in justifying costs of a TMDL. Benefits of TMDL development may relate not only to water quality issues, but also to a broader range of issues involving the effectiveness of government-sponsored environmental initiatives, in water as well as other media.

Water quality managers who participated in a TMDL development process highlighted both direct and indirect types of benefits; some of these are:

- Enhanced public awareness of water quality problems;
- Improved scientific knowledge of chemical, biological, and physical processes within watersheds;
- Heightened coordination of internal and external stakeholders;
- Improved efficiency in conducting aspects of the TMDL process;
- Improved water quality, including fewer violations of pollution standards; and
- Lower risks to human and ecological health.

PART V. FEDERAL TMDL RESOURCES

AVAILABILITY OF FUNDING

The basic funding sources available to states and Indian Tribes under the Clean Water Act (CWA) for implementing the Watershed Approach include: Section 106, which provides base support for overall water quality management programs (e.g., monitoring, permitting, enforcement, etc.); Section 314 (Clean Lakes), which provides funding to assess and mitigate lake water quality problems; Section 319, which provides funding to implement nonpoint source control measures; and Section 604(b), which provides support for water quality planning activities (it does not provide support for implementation of program activities). The approximate annual funding available nationally for each program is as follows: Section 106 - $80 million; Section 314 - not funded in FY 95 (historically averages approximately $5 million); Section 319 - $100 million; and Section 604(b) - $15-20 million. In addition, other program (e.g., Wetlands) and project oriented funding is available under Section 104(b)(3) of the CWA.

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PART VI. TMDL CASE EXAMPLES

APPOQUINIMINK RIVER

LAKE CHELAN

CHENOWETH RUN

COBBOSSEE LAKE

DELAWARE RIVER ESTUARY

FLINT CREEK

HILLSDALE LAKE

LITTLE DEEP FORK CREEK

LOWER MINNESOTA RIVER

OIL BRANCH CREEK

SOUTH FORK SALMON RIVER

SYCAMORE CREEK

TRUCKEE RIVER

YANKEE HILL LAKE

APPOQUINIMINK RIVER, DELAWARE

Key Features

Title:	Appoquinimink River.
Location:	New Castle County, northeastern Delaware; USEPA Region III.
Size/Scope:	5.2 mile tidal freshwater river segment; 47 square mile watershed.
Comparative Size:	Small; ≤100 mi^2.
Pollutant(s):	Phosphorus, dissolved oxygen.
Sources of Pollutants:	Point sources—one discharger (the Middletown-Odessa-Townsend wastewater treatment plant). One wasteload allocation (WLA) developed. Nonpoint sources—extensive agricultural land use. One load allocation (LA) developed.
Model Use and Complexity:	The EUTRO4 version of EPA's WASP4 water quality model and the DYNHYD hydrodynamic submodel were used to run complex simulations of river and pollution processes.
Total Cost	$145,527.
Funding Sources:	EPA nonpoint source TMDL Mini-Grant; State general revenues; Local general revenues.

Summary

Delaware Department of Natural Resources and Environmental Control (DNREC) initiated the TMDL process for the 5.2 mile tidal freshwater portion of the river segment due to low levels of dissolved oxygen (DO). The low DO concentrations are the result of excessive algal growth caused by phosphorus loading from the single wastewater treatment plant and nonpoint sources, primarily agricultural runoff. DNREC developed Phase I of a TMDL for a segment of the Appoquinimink River.

The Appoquinimink River drains a 47 square mile watershed, 61 percent of which is covered by agricultural lands. Forestlands, wetlands, and towns are the other key features of the watershed. Designated uses of the TMDL segment are: primary contact recreation; secondary contact recreation; fish, aquatic life, and wildlife; industrial water supply; and agricultural water supply.

As illustrated in Table 1, DNREC's total in-house effort for the Appoquinimink TMDL to date is 0.96 FTE, at a cost of $145,527. DNREC received assistance from several local institutions in managing the TMDL work, but maintained almost exclusive authority over the project. The work completed to this point has occurred as Phase I of the TMDL. Expenditures for Phase I provided benefits initially through modification and reissuance of the NPDES permit for the wastewater treatment plant. However, water quality standards have not been fully met, and Phase II may be initiated to address remaining water quality violations.

Some factors, such as the presence of only one point source and the availability of information on nonpoint source loading, simplified the TMDL process and lowered costs. Other factors, such as the abundance of nonpoint sources and the intricacy of the modeling effort, complicated the TMDL process.

State general revenues supplied funds for salaries, monitoring, nonpoint source load assessments, installation and maintenance of gauges for stream flow and tide, bathymetric surveys, purchasing and deployment of hydrolabs, and other activities. In FY 1992, DNREC received a nonpoint source mini-grant from EPA in the amount of $8,000 to assist development of a TMDL for the Appoquinimink River.

Table 1. Summary of TMDL Costs for the Appoquinimink River

Activity	**DNREC FTEs***	**Cost ($)**	**Cost as % of Total**
Planning/Administration	0.08	6,875	4.7
Preliminary Assessment	0.33	25,000	17.1
Data Collection	0.26	49,381**	33.9
Preliminary Modeling	0.02	43,917***	30.1
Model Testing	0.21	16,027	11.0
Public Participation	0.06	4,327	2.9
TOTAL	0.96	145,527	99.7****

*1 FTE (Average) = $43,948.
**This cost includes county staff time.
***This cost includes contractor fees.
****Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

The level of expenditures on the Appoquinimink River TMDL were dictated by four principal factors: availability of state and federal funding, state and county wastewater planning priorities, availability of historical water quality data, and level of public participation. Because DNREC obtained a mini-grant from EPA and had access to point and nonpoint source loading data, it was able to devote substantial resources to modeling. DNREC spent relatively few resources on public participation as a result of time constraints and inexperience with public hearings concerned with TMDLs (the Appoquinimink was DNREC's first TMDL, and public involvement is slated to play a more significant role throughout the entire TMDL process in the future).

A portion of the costs of conducting the TMDL, such as data collection, would have been incurred even in the absence of a TMDL. For instance, there is still the need to conduct testing for purposes of general water quality assessments, Section 305(b) reporting, and compliance monitoring for the NPDES program. In addition, certain activities necessary to develop the TMDL generate information that is useful for other water quality programs, increasing the cost-effectiveness of the TMDL.

DNREC used several creative avenues to minimize costs. For example, to reduce costs, DNREC worked with New Castle County to acquire point source discharge data from the Middletown-Odessa-Townsend Wastewater Treatment Plant. This agreement saved approximately $5,446 (1995 dollars) in data collection costs that DNREC would have otherwise incurred. In addition, when possible, DNREC utilized available water quality data. Particularly useful were Rural Clean Water Program studies that were conducted from 1980 through 1986 that measured nonpoint source loading rates for phosphorus and nitrogen.

DNREC also attempted to obtain additional funding where possible to aid its TMDL efforts. In 1992, DNREC sought and received an EPA TMDL mini-grant in the form of contractual support for initial calibration and evaluation of the WASP4 model for point and nonpoint source loading.

According to DNREC staff, the expenditures on the Appoquinimink TMDL have produced or are expected to produce several benefits for the watershed, including:

- Improved water quality, including fewer violations of DO standards;
- Improved scientific knowledge of chemical, biological, and physical processes within the watershed;
- Improved efficiency in conducting aspects of the TMDL process;
- Heightened coordination with both internal and external stakeholders; and
- Enhanced public awareness of problems within the watershed.

Cost Breakdown

DNREC uses a specific set of cost categories for its TMDL development process. While these categories are similar to the standard six categories used in this study, there are some differences. DNREC's categories and descriptions of each are provided below.

- Planning/Administration: *Includes meetings, scheduling, and other general planning activities.*

- Preliminary Assessment: *Includes compiling available information, discussions with other agencies and groups to determine relevant issues, evaluations of water quality, analysis of historical data and other available information, and identification of data needs.*

- Data Collection: *Includes development of a monitoring plan, coordination with field and laboratory staff, collection of water quality and sediment samples, installation and maintenance of gauges for streamflow and tide, bathymetric surveys, operation of continuous water quality monitoring systems (hydrolabs), collection of point source data from the wastewater treatment plant, and standardization and audit of data.*

- Preliminary Modeling: *Includes preparation of work assignments for modeling contractors, initial model calibration, nonpoint source load estimation, and development of written materials.*
- Model Testing: *Includes fine tuning modeling parameters, recalibration of the model, evaluation of various pollution control scenarios, and analysis of costs of different control scenarios.*
- Public Participation: *Includes holding a public hearing and advertising, receiving, and responding to public comment on the TMDL and the NPDES permit for the wastewater treatment plant.*

Planning/Administration for the Appoquinimink River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.08	$6,875	State

Costs associated with planning and administration reflect staff time for various meetings. These meetings included: (1) discussions with officials at the wastewater treatment plant regarding options for attaining water quality standards; (2) meetings with soil conservation districts and other agricultural support groups to discuss the benefits of BMPs; and (3) internal planning sessions. Additional costs were incurred for staff time to conduct scheduling and other general administrative activities. Costs for these activities are computed as the equivalent of one senior engineer working for one month over a two-year period. The state, through DNREC's budget, paid all of the planning and administrative costs. This staff time translates into a cost of $6,875.

Preliminary Assessment for the Appoquinimink River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.33	$25,000	State

All of the costs for preliminary assessment are associated with DNREC staff time. DNREC dedicated the equivalent of one engineer working for four months to complete the preliminary assessment. This staff time translates into a cost of $25,000, which was paid by the state.

DNREC began its assessment of water quality by compiling all readily available and existing information. Spatial and temporal trends in ambient water quality were evaluated and descriptive statistics were produced. The data were then compared against applicable water quality criteria to identify pollutants/stressors of concern and regions of impact. Data gaps were also identified.

Data Collection for the Appoquinimink River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.26	$49,381[1]	State and Local

The total cost of $49,381 for data collection is split between the state and New Castle County. For its staff time, DNREC incurred a cost of $6,575. This time was spent for development of a monitoring plan, coordination with field and laboratory staff, collection of water quality samples, operation of hydrolabs, and standardization and audit of data. An additional cost of $37,360 was paid to the U.S. Geological Survey by DNREC (from state general funds) for various services, including installation, operation, and maintenance of one tide gauge and one stream gauge for a two-year period and measurements of bathymetry and tidal velocity. New Castle County incurred a cost of approximately $5,446 in collecting point source data from the wastewater treatment plant. Several costs are not included in the estimate here. These include capital costs associated with data collection equipment and fees for laboratory analysis. The cost estimate for the state's data collection effort is based on two field technicians working two days per month over a two-year period.

Preliminary Modeling for the Appoquinimink River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.02	$43,917[2]	Federal and State

Development of the Appoquinimink TMDL involved two modeling efforts. The first effort, for which DNREC used contractor services, is referred to as "preliminary modeling." The second effort, which DNREC conducted is described below as "model testing." For preliminary modeling, the contractor used EUTRO4 and DYNHYD5, which are versions of EPA's WASP4 water quality model. This model was set up to simulate concentrations of dissolved oxygen (DO) and nutrients in the river to determine the cause of violations of DO standards. Model simulations used the Full Linear DO Balance, which is defined in the WASP4 user's manual as a fairly complex model. This particular model was chosen for several reasons: (1) ability to analyze both point and nonpoint sources; (2) ability to account for tidal fluctuations; (3) access to user support; and (4) ease of use compared to other models that could accomplish similar tasks.

The majority of the preliminary modeling effort was carried out by a consulting firm, which was paid through the EPA mini-grant and state funding. The only direct non-contracting costs incurred by DNREC were for preparation of the work assignment for the contractor and oversight of contractor activities. These activities required a time

[1] New Castle County's data collection cost was $5,000 in 1992. This cost converts to $5,446 in 1995 dollars, using a price index for government purchases (1.0892).
[2] The contractor's portion of this cost was $40,000 in 1993, which converts to $42,475 in 1995 dollars, using the price index for government purchases (1.061875).

commitment of one week for an engineer. This staff time translates into a cost of $1,442, which was paid by the state.

Model Testing for the Appoquinimink River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.21	$16,027	State

For model testing, DNREC built upon the WASP4 model to include full phytoplankton dynamics, benthic nutrient fluxes, and field-measured sediment oxygen demand (SOD). Then, DNREC re-calibrated the model. In addition, DNREC developed a list of pollution control scenarios and executed the model to determine expected dissolved oxygen response in the river under various control options. Finally, DNREC drafted a report to present the findings from model simulations and highlight the need for the TMDL. Model development required one DNREC engineer to spend three days per week over a period of six months. The state paid the cost of this engineer's time.

Public Participation for the Appoquinimink River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.06	$4,327	State

To involve the public in the TMDL process, DNREC published a public hearing notice to solicit oral and written comments from interested parties. DNREC held the hearing to address the TMDL and to consider comments on the application for reissuance of the NPDES permit to the Middletown-Odessa-Townsend Wastewater Treatment Plant. DNREC also produced a report on the development of the preliminary TMDL and made this report available for public review. The staff time spent to conduct the public participation activities was relatively short, approximately three weeks for an engineer. The state provided the funding for this staff time.

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LAKE CHELAN, WASHINGTON

Key Features

Title:	Lake Chelan.
Location:	Chelan County; Northern Cascades; north-central Washington; USEPA Region X.
Size/Scope:	52 square mile lake; 924 square mile watershed.
Comparative Size:	Medium, ≤1000 mi^2.
Pollutant(s):	Phosphorus, bacteria.
Sources of Pollutants:	Point sources—Chinook salmon net pens.
	Nonpoint sources—Direct precipitation, stormwater runoff; forest runoff; and agricultural runoff; tributaries; groundwater inflows; and septic system inputs.
Model Use and Complexity:	A steady-state mass balance model and Monte Carlo analysis techniques were used to run simulations of river and pollution processes (mid-range complexity).
Total Cost	$993,337.
Funding Sources:	Federal Clean Water Act Section 319 grant; State Centennial Clean Water Fund grant; and State and Local general revenues.

Summary

In 1992, the Washington State Department of Ecology (DOE) developed a TMDL for Lake Chelan to address concerns about nutrient loading resulting from rapid urban development and increased agricultural activities in and around the lake watershed. While the lake was not water-quality limited and did not appear on the state's 303(d) list, population increases and development pressures heightened concerns about maintaining long-term water quality. Pollutant concerns focused primarily around the issue of phosphorus enrichment from nonpoint sources.

Lake Chelan is located in the Northern Cascades approximately 100 miles east of Seattle and 50 miles south of the Canadian border. The Lake stretches over 50 miles and has an average width of approximately one mile. The topography of the lake basin is primarily mountainous. The lake has a surface area of 52 square miles and a watershed of approximately 924 square miles. It is considered one of the most pristine bodies of water in North America, with a high degree of clarity and extremely low nutrient levels. The lake is classified as ultra-oligotrophic, and primary uses of the waterbody include irrigation, production of hydroelectric power, recreation, and fish propagation.

In 1986, DOE conducted its first water quality assessment of the lake to determine the nutrient loading limits necessary to maintain the lake's ultra-oligotrophic nature. In 1990, the Lake Chelan Water Quality Committee, comprised of representatives from local governments, prepared a water quality plan based on the 1986 assessment. The water quality plan also included a TMDL for total phosphorus in Lake Chelan. While a TMDL for total phosphorus was established, load allocations (LAs) and waste load allocations (WLAs) were not set.

As illustrated in Table 2, DOE's total estimated in-house effort for the Lake Chelan TMDL to date is 12.13 FTEs, at a total cost of $993,337. DOE received assistance from several local institutions administering and managing the TMDL, as well as conducting the field work. Expenditures provided benefits initially through establishment of TMDLs for phosphorus within the waterbody.

Some factors, such as the number of nonpoint sources and the lack of historical data, complicated the TMDL process. Other factors, such as the presence of only one point source, and the abundant wilderness areas within the watershed simplified the TMDL process and lowered costs.

State general revenues supplied funds for salaries, monitoring, nonpoint source load assessments, modeling, public outreach and education, and other activities. Furthermore, the Lake Chelan Water Quality Committee received a state Centennial Clean Water Fund Grant in the amount of $80,000 for their work, consultant fees, and associated administration costs. The Centennial Clean Water Fund is a water quality grant program funded through the sale of tobacco products. In FY 1994, DOE received a Clean Water Act Section 319 grant from EPA in the amount of $60,000 to assist with the TMDL for Lake Chelan.

Table 2. Summary of TMDL Costs for Lake Chelan

Activity	**FTEs***	**Cost ($)**	**Cost as % of Total**
Data Collection/Monitoring/Modeling	7.32	813,245	81.9
Analysis	1.20	44,890	4.5
Public Participation/Outreach	2.65	99,222	10.0
Administration	0.96	35,980	3.6
TOTAL	12.13	993,337	100.0

*FTEs for the Lake Chelan TMDL were calculated based on cost figures that were reported by DOE staff and an estimate of the average salary and benefits of DOE staff.

Cost Analysis

The magnitude and complexity of the project were primary factors in determining the cost of the TMDL. The lake's many unique geological features contributed to the enormity of the undertaking. For example, technically, Lake Chelan is a fjord (a glacial lake), which stretches 50 miles and is approximately 1600 feet deep. Furthermore, in the case of Lake Chelan, the retreating glaciers left a large sill in the center of the lake. Both the great depth of the lake and the sill, significantly affect lake turnover and complicate the modeling dynamics.

Funding issues, the number of nonpoint sources, and other factors influenced DOE's decision to undertake the level of effort that it chose for Lake Chelan. Because DOE obtained a CWA Section 319 grant from EPA, it was able to devote substantial resources to its initial data collection, monitoring, and modeling efforts. DOE spent a relatively large amount on activities related to public education and outreach because of the substantial number nonpoint sources.

A portion of the costs of conducting the TMDL, such as data collection, are shared by DOE's other water quality initiatives, including water quality assessments, water quality inventories, and NPDES support. For example, DOE would take water quality samples in the absence of the Lake Chelan TMDL. In addition, certain activities necessary to develop the TMDL generated information that is useful for other water quality programs, increasing the cost-effectiveness of the TMDL.

To reduce costs, DOE worked with the Lake Chelan Reclamation District and other local organizations on activities related to education and outreach for BMP implementation. DOE also sought additional funding to aid its TMDL efforts. In 1994, DOE sought and received an EPA CWA Section 319 grant to assist with development of the TMDL.

Cost Breakdown

For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories.

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

In reporting its costs, DOE has combined data collection, monitoring, and modeling into a single cost category, and also has combined public participation and outreach into one category. With the exception of costs related to public participation and public outreach, costs outlined in this analysis represent only those expenses incurred by DOE. Monitoring and subsequent modeling activities conducted as part of the water quality assessment and other water quality studies required the greatest investment of resources. Throughout the TMDL process, DOE built upon existing information and relied upon in-kind services from other organizations for its public participation and outreach activities.

Because information for the Lake Chelan TMDL was reported in dollars, rather than level of effort, FTE estimates are calculated from costs. All estimates of FTEs in the gray boxes below are based on a 1995 salary of $30,000 and a benefits multiplier of 1.25.

Data Collection/Monitoring/Modeling for the Lake Chelan TMDL		
In-house FTEs	Cost	Funding Source(s)
7.32	$813,245	State and Local

In the mid-1980's, an independent study was conducted indicating that Lake Chelan would support one-quarter to one-half million more residents, and associated septic systems, without affecting the Lake's water quality. Concerned about that finding, local governments within the watershed appealed to the state to conduct another study of the waterbody. In response, DOE conducted some initial scoping of the waterbody, including conducting literature reviews and compiling available information about the watershed.

In 1986, DOE initiated the Lake Chelan Water Quality Assessment. To conduct this assessment, DOE engaged the services of a contractor, which relied on the work of numerous subcontractors to conduct the study. This intensive assessment was designed to: (1) provide baseline water quality data; (2) evaluate the suitability of on-site wastewater disposal systems within the developing lower basin; and (3) estimate the potential sources and impacts of nutrients, bacteria, and other chemicals of concern. Additionally, the assessment determined average spring and summer values for each of the following water quality parameters: secchi disk depth; temperature; pH; dissolved oxygen (DO); total suspended solids (TSS); specific conductance; total phosphorus; total nitrogen; total coliform; particulate N:P; and water column N:P. In addition, the contractor conducted hydrology studies, septic tank evaluations, installed monitoring wells, and conducted limnology studies.

DOE used a steady-state mass balance model and Monte Carlo analysis techniques to determine the maximum allowable load increase from point and nonpoint sources. DOE included a margin of safety by calculating the permissible loading conservatively. In addition, DOE approved the Lake Chelan Water Quality Committee's Plan for Lake Chelan which included a schedule for implementation of pollution control scenarios and the potential costs of implementing those scenarios. Finally, DOE drafted a report to present the findings from model simulations and highlight the need for the TMDL.

Water quality monitoring has been part of ongoing Clean Water Act Section 319 grant implementation activities. Currently, a long-term monitoring strategy is beginning to emerge as coordination is developed among stakeholders and current monitoring gaps are identified. The initial recommendations from the current Water Quality Management Area (WQMA) assessment are that annual monitoring, of unspecified frequency, is required in order to develop long-term trends. This strategy might include installation of permanent water quality monitoring stations to monitor selected water quality parameters on a bi-annual basis (flow, fecal coliform, TSS, turbidity, DO, temperature, pH, clarity, sedimentation, TP, ammonia nitrogen, nitrites, nitrates, and conductivity). This strategy may also assess water quality trends and runoff from agricultural drains to evaluate pollutant loading during worst case conditions. Finally, as part of its general ambient monitoring activities, DOE may conduct monthly total phosphorus sampling at the lake outlet. Due to the quality and importance of Lake Chelan, DOE hopes to obtain Clean Water Act Section 319 funding to enable implementation of its long-term monitoring plan.

All costs for the initial scoping are associated with DOE staff time. DOE dedicated the equivalent of one staff person working full-time for six months to complete initial scoping. This staff time translates into a cost of approximately $30,000 in 1989 ($36,197 in 1995 dollars), which was paid by the state. The majority of the data collection and monitoring activities were carried out by a contracting firm and several sub-contractors, these efforts were paid for with state funding. The cost of the contract was $425,000 over the years 1989 to 1990 ($502,378 in 1995 dollars). Other direct non-contracting costs incurred by DOE were for grant management activities, including preparation of a workplan, and several small water quality studies. These activities cost approximately $80,000 in 1990 ($92,604 in 1995 dollars), and were funded from the Centennial Clean Water Fund. Modeling activities cost approximately $10,000 in 1989 ($12,066 in 1995 dollars) and also were funded with state general revenues. Long-term monitoring activities will be partially funded with a $170,000 (75 percent cost share) grant to the Lake Chelan Reclamation District.

Analysis for the Lake Chelan TMDL		
In-house FTEs	Cost	Funding Source(s)
1.20	$44,890	State

DOE's analysis activities in conjunction with TMDL creation included development of WLAs and LAs for total phosphorus. Although Lake Chelan currently meets water quality standards for all pollutants, DOE established calculations (i.e., assessments of existing loads) for total phosphorus in accordance with EPA's TMDL guidance, which highlights the importance of identifying and protecting pristine waters as well as those classified as water quality-limited (USEPA, 1991).

All costs for analyses in support of the TMDL were incurred by DOE. DOE dedicated staff over a three-year period (1990 to 1992) to perform required analysis and develop appropriate TMDL levels. The staff time cost $40,000 total, which converts to a cost of $44,890 in 1995 dollars.

Public Participation and Outreach for the Lake Chelan TMDL		
In-house FTEs	Cost	Funding Source(s)
2.65	$99,222	Federal, State, and Local

The Lake Chelan TMDL was politically sensitive because of controversies surrounding future development in and around the lake. The Lake's recreational value, concerns about rising population, and increased nutrient loading ecological straining on the Lake have come to the forefront of the political debate. In particular, the concern is that algal growth caused by phosphorus (the primary limiting nutrient) loading will impair the Lake's water quality.

In addition, other issues involving selection of appropriate land uses within the watershed and the preservation of wetlands have involved federal, state, and local government agencies. Government agency involvement includes: the City of Chelan; Chelan County; the Chelan County Public Utility District; the Lake Chelan Reclamation District; the Lake Chelan Sewer District; and the U.S. Forest Service. To coordinate multi-agency interests, DOE organized a Lake Chelan Water Quality Committee and charged it to prepare a Lake Chelan Water Quality Plan.

The purpose of this plan was to develop specific steps to ensure that the water quality within the Lake Chelan watershed is maintained. As a result of the development pressures within the watershed, the plan's primary recommendations were to expand sewage facilities to accommodate future growth. Specific tasks included: on-site wastewater management; stormwater management; agricultural activities; and boat sewage disposal.

As part of this process, DOE staff met with local stakeholders on a routine basis for approximately three years. After this time, DOE provided grant funding so that local stakeholders could attempt to implement the objectives developed in the water quality plan. Currently, the Lake Chelan Water Quality Committee is implementing three grants related to its outreach and public participation activities. The cost for DOE's public participation and outreach efforts is $91,000 over the three-year period from 1991 to 1993. This figure converts to a cost of $99,222 in 1995 dollars.

Administration for the Lake Chelan TMDL		
In-house FTEs	Cost	Funding Source(s)
0.96	$35,980	State

Administrative costs associated with TMDL development included grant administration and staff coordination activities, as well as development of a final report. Additional costs were incurred for staff time required to conduct scheduling and other general administrative activities. These costs total $20,000 in nominal dollars, and were incurred over the five-year period from 1989 to 1993. This figure converts to $22,541 in 1995 dollars. The state, through DOE's budget, paid all of these costs (travel costs are not included in this estimate). Administrative activities of the Lake Chelan Water Quality Committee include oversight of the six subcommittees charged with implementing the Water Quality Plan. These activities were funded with a $12,000 grant in 1991 from DOE. This cost converts to $13,439 in 1995 dollars.

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CHENOWETH RUN, KENTUCKY

Key Features

Title:	Chenoweth Run.
Location:	Jefferson County, north central Kentucky; USEPA Region IV.
Size/Scope:	8.5 mile creek; 17 square mile watershed.
Comparative Size:	Small ≤ 100 mi^2.
Pollutant(s):	Phosphorus, orthophosphate, suspended solids, unionized ammonia, and BOD.
Sources of Pollutants:	Point sources—wastewater treatment plant, light industries.
	Nonpoint sources—urban runoff, pasture lands.
Model Use and Complexity:	No model.
Total Cost	$19,625 current; $35,000 anticipated cumulative.
Funding Sources:	EPA nonpoint source TMDL Mini-Grant; State general revenues; Funding from the Metropolitan Sewer District.

Summary

The Water Division of the Kentucky Department for Environmental Protection (KDEP) is in the process of implementing a TMDL for 8.5 miles of Chenoweth Run. KDEP initiated the TMDL process for Chenoweth Run to address pollutant levels in the creek, at the urging of public interest groups. Existing pollutants include dissolved solids, suspended solids, unionized ammonia, phosphorus, orthophosphate, and BOD. The impetus for initiating the TMDL was to determine the most significant source(s) of pollutants and to allocate specific load restrictions for phosphorus.

The watershed primarily consists of urban lands, with a few open spaces and agricultural fields downstream. The designated uses of the run are primary contact recreation, secondary contact recreation, and warm water aquatic habitat. Sources of pollution include the City of Jeffersontown Wastewater Treatment Plant, light industries, urban runoff, and pasture lands. Chenoweth Run drains a 17 square mile watershed.

As illustrated in Table 3, KDEP's total in-house effort expended by KDEP on the Chenoweth Run TMDL to date is 0.26 FTE, for a total cost of $19,625. KDEP has received substantial technical assistance from both the Metropolitan Sewer District and the U.S. Geological Survey, as well as financial assistance from EPA's mini-grant program. The total expected cost for completion of the TMDL is $35,000. KDEP staff describe this as a relatively simple TMDL that requires only moderate expenditures. At this time, the TMDL is not phased, but KDEP may consider phasing it based on the contribution of nonpoint source loading to the problems of Chenoweth Run.

To date, KDEP has spent $19,625 on the Chenoweth Run TMDL, in total KDEP expects to spend $35,000 on TMDL related activities. KDEP received a total of $35,000: nonpoint source mini-grant from EPA late in 1994 in the amount of $20,000 to develop the TMDL for Chenoweth Run; state general funds have contributed $7,500; and the Metropolitan Sewer District has supplied another $7,500.

Table 3. Summary of TMDL Costs for Chenoweth Run

Activity	**KDEP FTEs***	**Cost ($)**	**Cost as % of Total**
Monitoring/Data Collection	0.08	12,500**	63.6
Modeling	0.00	0	0.0
Analysis	0.15	6,000	30.5
Outreach and Public Participation	0.01	375	1.9
Administration	0.02	750	3.8
TOTAL	0.26***	19,625***	99.8****

*1 FTE (Average) = $39,000.
**The Metropolitan Sewer District paid most of the cost for laboratory analysis.
***These figures represent level of effort as of June 22, 1995. Anticipated total cost for completion of the TMDL is $35,000.
****Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

The level of expenditures on the Chenoweth Run TMDL were dictated by three key factors: the decision not to model the waterbody, the availability of additional grant funding, and the decision to spend relatively little on the public participation and outreach aspects of the TMDL. Cost was a prohibitive factor in deciding whether to develop a model for Chenoweth Run. However, KDEP staff are not sure that modeling would have yielded enough useful information to make the process cost-effective. KDEP staff also believe that the TMDL is not overly complex, and, thus, does not require excessive expenditures in general. One reason why KDEP may have spent relatively few resources on public participation is that public awareness of the state of Chenoweth Run was fairly high. In fact, a local environmental interest group was a major impetus in initiating the TMDL process.

Some of the costs of conducting the TMDL, such as data collection, can be spread over other water quality initiatives. In fact, KDEP does not count its data collection and analysis costs as direct costs of the TMDL. These are counted as general departmental expenditures. In addition, some of the activities necessary to develop the TMDL can generate information that is useful for other water quality programs, increasing the cost-effectiveness of the TMDL.

KDEP used several outside sources to obtain additional funding and cut costs where possible. To reduce costs, KDEP used existing data from the wastewater treatment plant. KDEP also obtained information from a collaborative effort with the U.S.

Geological Survey and the Metropolitan Sewer District. Analysis of data, which to this point has been provided by the Sewer District, has been especially useful to KDEP in its efforts to implement the TMDL.

According to KDEP staff, expenditures on the Chenoweth Run TMDL to date have produced a few notable benefits for the watershed. These include an increased level of public awareness and participation in water quality protection efforts. Furthermore, KDEP staff are hopeful that the TMDL process will help to reduce application of lawn chemicals and encourage voluntary control of nonpoint source pollution from an upstream industrial park, as the study results are made public through the final report and presentations to the stakeholders involved. Upon completion of the TMDL, the desired benefit will be reduced levels of pollutants in the run, especially lower levels of phosphorus discharge from the wastewater treatment plant and other sources. The goal is to restore and maintain the designated uses of Chenoweth Run.

Cost Breakdown

For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories:

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

In reporting its costs, KDEP has combined outreach and public participation into one cost category. Information about activities undertaken within each of these categories and information on costs, FTEs, and funding sources are provided below.

Monitoring/Data Collection for the Chenoweth Run TMDL		
In-house FTEs	Cost	Funding Source(s)
0.08	$12,500	Federal and State

Costs associated with monitoring/data collection to date consist of staff time necessary to collect samples from five monitoring stations along Chenoweth Run ($3,000) plus analysis of water samples. KDEP already has access to five years of water quality data from one monitoring station at the wastewater treatment plant. KDEP's own sampling and data collection efforts began in January 1995 and should be completed by January 1996. The U.S. Geological Survey also has collected water quality samples five or six times over the course of the TMDL process. Costs for U.S. Geological Survey sampling are not included here. The Metropolitan Sewer District has funded most of the water sample analysis efforts to date. The District has analyzed water quality samples collected and sent the results to KDEP for a cost of $7,500. In addition, the laboratory at KDEP has spent approximately $2,000 on sample analysis. This $2,000, along with the $3,000 KDEP spent on sample collection is funded by the federal mini-grant and state general revenues. In the future, further analysis of samples will occur at KDEP's laboratory within the Department of Environmental Services.

Modeling for the Chenoweth Run TMDL		
In-house FTEs	Cost	Funding Source(s)
0.00	$0	N/A

At this stage in the TMDL process, KDEP has not developed a model for phosphorus loading. KDEP is using QUAL2E to model BOD and ammonia concentrations to set permit limits for the wastewater facility. KDEP set up the stream in QUAL2E several years ago, independent of the TMDL process, as part of their normal waste load allocation procedures. As implementation of the TMDL reaches a more advanced stage, the U.S. Geological Survey may conduct modeling of urban runoff and other nonpoint sources.

Analysis for the Chenoweth Run TMDL		
In-house FTEs	Cost	Funding Source(s)
0.15	$6,000	State and Local

Analysis activities for the Chenoweth Run TMDL involve evaluating data that have been collected, writing reports, and producing graphic representations of data. Two KDEP staff spent 40 days of time on these efforts.

Outreach and Public Participation for the Chenoweth Run TMDL		
In-house FTEs	Cost	Funding Source(s)
0.01	$375	Federal and State

To date, outreach and public participation for the Chenoweth Run TMDL consist of a presentation to environmental organizations, a presentation to local governments, meetings, progress reports, and letters. These activities required 2.5 days of one staff person's time. The mini-grant and the state paid the cost of this outreach and public participation.

Administration for the Chenoweth Run TMDL		
In-house FTEs	Cost	Funding Source(s)
0.02	$750	Federal and State

Administration of TMDL activities to date has required 5 days of one KDEP staff person's time. The mini-grant and the state paid this cost.

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COBBOSSEE LAKE, MAINE

Key Features

Title:	Cobbossee Lake.
Location:	Kennebec County, southern Maine; USEPA Region I.
Size/Scope:	Affected watershed 14.86 mi^2.
Comparative Size:	Small, ≤100 mi^2.
Pollutant(s):	Phosphorus.
Sources of Pollutants:	Nonpoint sources—numerous return flows associated with area agricultural activities.
Model Use and Complexity:	Empirical models developed by Vollenweider (1969), and modified by Dillon and Rigler (1974) were used to run simple simulations of the lake and to determine pollutant loading.
Total Cost	$6,057.
Funding Sources:	Federal Clean Water Act TMDL Mini-Grant.

Summary

As a result of severe water quality degradation, in 1993, the Cobbossee Watershed District (CWD) developed a special TMDL for Cobbossee Lake. Since 1992, an accelerated level of eutrophication has impaired water quality in Cobbossee Lake and the surrounding watershed. Phosphorous, the primary limiting nutrient, comes from Annabessacook Lake upstream, as well as the numerous and varied nonpoint sources throughout the watershed.

CWD initiated the TMDL process for the Cobbossee Lake portion of the watershed to determine nonpoint sources, develop nonpoint source load allocations (LAs) to attain established water quality criteria, and to determine the extent to which future development can be conducted while at the same time maintaining water quality. Conducting an assessment of nonpoint sources from the direct Cobbossee Lake watershed and their impact on the waterbody relative to sources in other lake watersheds upstream (e.g., Annabessacook Lake) was a secondary objective of the TMDL. Other TMDL goals included attainment of the State of Maine's water quality standard that mandates the absence or elimination of culturally induced algal blooms.

Cobbossee Lake is a large (approximately 5,000+ acres), deep, highly scenic lake located in Kennebec County, Maine. Approximately 10 miles from the state capitol, the lake, is bordered by five small towns. Local topography varies considerably, ranging from gentle rolling hills to areas which are relatively flat and heavily forested. Primary land uses within the 9,500 acre watershed include: approximately 1,800 acres of agricultural lands; 1,300 acres of lands under residential and commercial development; and 6,400 acres composed of forests, wetlands, and open areas. The TMDL segment of

the Cobbossee Lake watershed is approximately 14.86 square miles and is in the lower reaches of a multiple lake watershed administered by the Cobbossee Watershed District (CWD). Designated uses of the TMDL segment of the watershed include: agriculture; water contact recreation and non-water contact recreation; commercial water supply; municipal and domestic water supply; and propagation of cold water aquatic life.

As depicted in Table 4, the CWD's total in-house effort for the Cobbossee Lake TMDL is 0.13 FTE; for a total cost of $6,057. CWD conducted all of the field and analysis work for the project, but received some technical assistance from the Maine Department of Environmental Protection (MDEP). As part of the TMDL development process, CWD modeled and produced a final load allocation for phosphorus within Cobbossee Lake. Thus far, work completed producing the TMDL for phosphorus has occurred as Phase I of the TMDL process; continued follow-up monitoring for this and other pollutants is ongoing.

In FY 1992, CWD received Clean Water Act (CWA) TMDL mini-grant funding from EPA in the amount of $12,000 to assist with its Cobbossee Lake TMDL activities. This grant covered all TMDL development expenditures to date.

Table 4. Summary of Cobbossee Lake TMDL Costs

ACTIVITY	CWD FTEs	Cost ($)	Cost as % of Total
Monitoring/Data Collection	0.03	1,369	22.6
Modeling	0.02	938	15.4
Analysis	0.05	2,344	38.6
Outreach	0.00	0	0.0
Formal Public Participation	0.00	0	0.0
Administration	0.03	1,406	23.2
TOTAL	0.13	6,057	99.8*

*Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

The level of expenditures on the Cobbossee Lake TMDL were dictated by three principal factors: the relatively simple modeling simulations needed, the small size of the lake watershed, and the availability of over 20 years of historical monitoring data.

Another factor affecting CWD's decision to undertake the level of effort that it chose for the Cobbossee Lake TMDL, was the receipt of federal grant money to assist with nonpoint source load estimation and other TMDL development activities. In fact, EPA TMDL mini-grant funding has paid for all costs associated with TMDL development to date.

CWD devoted no resources to formal public participation and outreach related activities associated with the TMDL. While there was a significant amount of controversy surrounding the TMDL, the fact that no resources were spent on public participation is an indication of a need to use the limited resources on more technical aspects of the TMDL. Since completion of the TMDL, CWD received federal 319 grant funding to begin an educational outreach program for five of the municipalities within the watershed district.

Many of CWD's costs associated with the TMDL, such as monitoring and data collection, also occur as part of other water quality initiatives. Some of CWD's other water quality initiatives are watershed management, technical transfer, public assistance, monitoring and lake restoration.

CWD employed several methods to minimize TMDL costs where possible. For example, whenever possible, CWD used available water quality data. Significant sources of data included over 20 years of data compiled by CWD as part of it's ambient water quality monitoring activities.

The direct benefits of the Cobbossee Lake TMDL include that the lake has been targeted for better management through the development of LAs for phosphorous, as well as an assessment of nonpoint source loading from the TMDL portion of the watershed. In addition, the Cobbossee Lake TMDL will help decision-makers to determine water quality impacts from direct (in lake) pollutant loading relative to the impact of phosphorous loading from upstream lake watersheds. Furthermore, the TMDL has benefited the CWD by serving as a tool to guide future lake/watershed management efforts. With the TMDL, CWD has identified those sources of phosphorous which are either the most significant contributors and/or the most easily addressed within the watershed..

Cost Breakdown

The Cobbossee Lake TMDL has been an evolving process since its inception in the early-1970s when CWD began to monitor the Lake. For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories.

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

All costs outlined in this analysis represent only those expenses incurred by CWD in the TMDL development process. One-time expenses including analysis and administration required the greatest investment of resources. Ongoing expenses include monitoring and model recalibration to account for water quality changes. These activities are undertaken as part of CWD's water quality program.

Monitoring/Data Collection Costs for the Cobbossee Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.03	$1,369	Federal

Water quality monitoring for TMDL development was principally conducted by CWD. CWD, as part of its ongoing ambient water quality monitoring activities, has been monitoring District lakes (approximately 18), including Cobbossee Lake, for over 20 years. In fact, the TMDL portion of Cobbossee Lake watershed has been monitored monthly during the spring, summer, and fall, on an ongoing basis since 1973. Monitored parameters include total phosphorus, temperature, dissolved oxygen (DO), chlorophyll-a, pH, and alkalinity.

Beyond routine monthly water quality sampling, CWD compiled and incorporated land use information as part of the TMDL development procedure. This effort involved compiling all existing land use data by type, subwatershed, and town. In addition, new aerial infra-red photographs were obtained, reviewed, and then confirmed by ground-truthing land use types and boundaries. Selected CWD staff coordinated the water quality sampling and land use verification activities.

Two CWD staff dedicated a total of approximately two and one-half weeks time to water quality sampling and other monitoring activities. CWD plans to continue monitoring Cobbossee Lake. This staff time translates into a cost of $1,219. The cost of purchasing the new aerial infra-red photos was $150. Several costs are not counted in the estimate here, including capital costs associated with data collection and monitoring equipment and fees for laboratory analysis.

Modeling Costs for the Cobbossee Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.02	$938	Federal

Modeling for TMDL development within Cobbossee Lake has evolved to account for changes in the lake as well as the region. Model development was initiated because Cobbossee Lake had been experiencing a decline in water clarity and failed to meet Maine's GPA standard. In addition, total phosphorous concentrations in the lake were high and Secchi disk transparency (SDT) values were below average for Maine lakes. As a result, CWD was concerned about limiting development in watershed communities. Therefore, TMDL activities were initiated in part to guide future development within the watershed.

Model development for the TMDL took place over an two year period beginning in 1993. During this period CWD, utilized two models. The first, a land use-based export coefficient model (developed by Reckhow et al.), helped to determine nonpoint source phosphorus loading to the lake. The second, an empirical model developed by Dillon and Rigler (1974), helped to generate a TMDL for the Cobbossee Lake watershed. As part of this process, CWD used data collected in 1991 and 1992 as well as earlier years, were reviewed to calibrate the model. CWD also incorporated, current and historical water quality values into the model to establish a range of possible phosphorus reduction goals.

CWD's primary remaining concern is that continued development and population growth in neighboring communities could result in total phosphorus levels exceeding lake load allocations. For this reason, CWD has developed several alternative strategies to attain load allocation limits. In addition, if water quality goals are achieved, the District can recalibrate the model and run it using new values to allow for lesser restrictions to development of the watershed.

CWD dedicated approximately 40 hours of one persons staff time to modeling efforts for Cobbossee Lake, which translates into a cost of $938.

Analysis Costs for the Cobbossee Lake TMDL		
In-house FTEs	Costs	Funding Source(s)
0.05	$2,344	Federal

CWD's analysis activities in conjunction with TMDL creation included development of a LA for total phosphorus. Other activities included computer entry of water quality and land use data, and analysis of output. CWD dedicated 100 hours of one staff person's time to performing required analysis and developing an appropriate TMDL level, which translates into a cost of $2,344.

Outreach Costs for the Cobbossee Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0	$0	Not applicable

No educational or other outreach efforts were conducted in conjunction with the Cobbossee Lake TMDL development process. However, CWD recently received a CWA Section 319 grant for educational outreach efforts to five municipalities within the Cobbossee Watershed District.

Public Participation Costs for the Cobbossee Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0	$0	Not applicable

The Cobbossee Lake TMDL development process required no formal public participation activities. In addition, had such activities been required they would have fallen under the purview of the Maine Department of Environmental Protection (MDEP), the state's primary environmental regulatory entity.

Administration Costs for the Cobbossee Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.03	$1,406	Federal

Administrative costs associated with TMDL development included grant administration and staff coordination activities, as well as development of a final report summarizing the TMDL development process and outlining findings. CWD dedicated approximately 60 hours of one staff person's time to these efforts, which translates into a cost of $1,406.

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DELAWARE RIVER ESTUARY, NEW JERSEY

Key Features

Title:	Delaware River Estuary.
Location:	Eastern Delaware; west and southeast New Jersey; southeastern Pennsylvania; within USEPA Regions II & III.
Size/Scope:	Surface water segment 84 miles. Affected watershed drainage area >7,794 mi^2.
Comparative Size:	Large; > 1,000 mi^2.
Pollutant(s):	Metals, approximately ten toxics (bio-organics, PCBs, DDT).
Sources of Pollutants:	Point sources—83 industrial or municipal facilities (110 outfalls). The wasteload allocations (WLAs) developed for up to ten toxic pollutants will be translated into effluent limitations for toxic pollutants for selected National Pollution Discharge Elimination System (NPDES) dischargers to the estuary. Nonpoint sources—stormwater runoff from urban, agricultural and industrial areas; groundwater infiltration and runoff from Superfund sites; atmospheric deposition; combined sewer overflows (CSOs); groundwater infiltration and natural background. Load allocations will be developed during Phase II of the TMDL development process.
Model Use and Complexity:	EPA's WASP4 water quality model and the DYNHYD5 hydrodynamic submodel were used to run complex simulations of river and pollution processes and develop WLAs for human health and chronic aquatic life criteria. Tidal CORMIX, a near-field model which utilizes a modified version of an EPA-supplied model, was used to develop WLAs for modeling acute criteria. DELTOX, a far-field model, was also used to develop WLAs for toxics.
Total Cost	$675,426.
Funding Sources:	Federal Clean Water Act Section 205(j) and Section 106 grants; State (DE, NJ, NY, PA) general revenues; Delaware National Estuary Program funding; and Delaware River Basin Commission general revenues.

Summary

The Delaware River Basin Commission (DRBC) developed Phase I of a TMDL for a segment of the Delaware River Estuary as part of a strategy to control the release of substances toxic to humans and aquatic life. This segment is the 84 mile tidal portion of the river running from the head of the tide at Trenton, New Jersey to Delaware Bay. Numerous point source dischargers release a variety of pollutants into the waterbody including metals and a variety of toxic chemicals. Within the watershed, criteria for toxic pollutants differed considerably among the states bordering the estuary (Delaware, New Jersey, Pennsylvania). DRBC, as part of the TMDL development process, developed a common set of water quality criteria and implementation procedures for toxic pollutants. These new universal criteria replaced the five sets of criteria which previously applied to this segment of the estuary. As with TMDL and wasteload allocation development procedures, the policies used to develop the water quality criteria represented a consensus of the estuary states, EPA, and the Commission.

The Delaware River Estuary drains a 7,794 square mile watershed, a large portion of which is located within the northeastern industrial corridor. Agricultural lands, forestlands, wetlands, and towns are the other key features of the watershed. Designated uses of the TMDL segment include: agricultural, industrial, and public water supplies; wildlife, fish, and other aquatic life; and primary and secondary contact recreation.

As illustrated in Table 5b, DRBC's total in-house effort for the Delaware River Estuary TMDL to date is 10.30 FTEs, for a total cost of $675,426. The Commission received assistance from federal, state, and local institutions in conducting the TMDL work, but maintained primary management authority over the project. The work completed to this point has occurred as Phase I of the TMDL. Expenditures for Phase I provided benefits initially through development of procedures for permitting authorities to select the most stringent wasteload allocation, and establish average monthly and maximum daily effluent limitations for NPDES permits. However, water quality standards have not yet been fully met and DRBC is currently initiating Phase II to address remaining water quality violations stemming from nonpoint sources.

Some factors, such as the size and tidal nature of the waterbody, the abundance of point sources, the intricacy of the modeling effort, and the lack of information on nonpoint sources complicated the TMDL process. Other factors, such as the availability of information on point source dischargers, and the existence of five years of historical ambient water quality data, simplified the TMDL process and lowered costs.

Table 5a below presents a summary of the revenues applied to Delaware River Estuary TMDL development. In addition, a portion of these revenues were leveraged to develop water quality criteria for the tidal Delaware River, the same criteria which were used as the water quality objectives for the TMDL.

As a multi-jurisdictional Commission, DRBC received revenues from a variety of sources, including portions of Clean Water Act (CWA) Section 205(j) grants awarded to the Pennsylvania Department of Environmental Protection (PADEP) and the New Jersey Department of Environmental Protection (NJDEP); a direct CWA Section 106 grant; Delaware National Estuary Program (DELEP) funding; and general program revenues.

Table 5a. Delaware River Estuary TMDL Historical Revenue Data						
Funding Sources	**Fiscal Year 1991**	**Fiscal Year 1992**	**Fiscal Year 1993**	**Fiscal Year 1994**	**Fiscal Year 1995**	**Totals 1990-95**
PADEP 205(j) grants	$78,000	$85,000	$85,000	$70,000	$0	$318,000
NJDEP 205(j) grants	$50,000	$50,000	$82,000	$70,000	$0	$252,000
DELEP	$10,000	$0	$0	$10,000	$0	$20,000
Section 106 grants	$40,000	$0	$0	$0	$0	$40,000
General Revenues	$55,000	$30,000	$30,000	$36,000	$72,000	$223,000
TOTAL	$233,000	$165,000	$197,000	$186,000	$72,000	$853,000

DRBC is currently completing Phase I of the TMDL which focuses on point source discharges from industrial and municipal wastewater treatment plants. Phase II will concentrate on nonpoint sources with emphasis on sources of polychlorinated biphenyls (PCBs) and chlorinated pesticides (particularly DDT and its metabolites), metals and volatile organics. The Commission will be seeking funding from the states and EPA to support monitoring and control strategy development activities.

Table 5b. Summary of Delaware River Estuary TMDL Costs			
ACTIVITY	DRBC FTEs	Cost ($)	Cost as % of Total
Monitoring/Data Collection	2.50	278,733*	41.3
Modeling	2.80	122,103**	18.1
Analysis	2.90	147,000	21.8
Outreach	0.10	8,693***	1.3
Formal Public Participation	0.25	15,000	2.2
Administration	1.75	105,000	15.5
TOTAL	10.30	675,426	100.2****

*Includes lab-related costs

**Includes capital costs for computers

***Includes capital costs for articles and newsletters

****Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

The level of expenditures on the Delaware River Estuary TMDL was dictated by five principal factors:

1. The size of the watershed;
2. The number of point sources;
3. The tidal nature of the waterbody;
4. The complexity of the pollutants; and
5. The multi-jurisdictional nature of the DRBC.

The size of the watershed drove the need for the five year data collection and monitoring efforts. The number of point sources added organizational and coordination challenges, as well as interpersonal dynamic to the data collection efforts. The tidal nature of the waterbody and the number and complexity of the pollutants established the need to undertake extensive complex modeling of the waterbody. The multi-jurisdictional nature of the DRBC provided numerous sources of grant funding and in-kind contributors to leverage TMDL development activities.

Several other factors affected DRBC's decision to undertake the level of effort it chose for the Delaware River Estuary TMDL, including the receipt of federal grant money and the ability to "piggyback" on many of the efforts of the Delaware National Estuary Program. Considered alone, grant funding, in-kind services, and cooperative agreements made up relatively a small portion of the resources devoted to the Delaware River Estuary TMDL; however, together they allowed DRBC to devote substantially more resources to this activity than it otherwise could have.

Many of DRBC's costs associated with TMDL development, such as data collection, monitoring, and establishing water quality criteria, also occur as part of DRBC's other water quality initiatives. Some of the Commission's other water quality initiatives are tracking the movement of the salt front, monitoring reservoir storage, reviewing NPDES permits for compliance with the Commission's water quality standards, issuing permits for withdrawals from surface and groundwater, as well as discharges to surface water, and reviewing any activity for potential impacts on the water resources of the basin (such as Superfund sites and dredging operations). Therefore, DRBC would already be undertaking some water quality activities in the absence of the Delaware River Estuary TMDL. In addition, certain activities necessary to develop the TMDL generated information that is useful for other water quality programs, increasing the cost-effectiveness of the TMDL.

DRBC used several strategies to minimize TMDL costs where possible. For example, DRBC relied upon in-kind contributions from states bordering the estuary for its data collection efforts. As a result, the intensive water quality sampling required for TMDL development was split among multiple agencies. In addition, whenever possible, DRBC used available water quality data. For example, DRBC worked with industrial and municipal sources to acquire point source discharge data. This agreement saved approximately $415,000 in data collection costs that DRBC would have otherwise incurred.

According to DRBC staff, the expenditures on the Delaware River Estuary TMDL to date, have produced several benefits for the watershed, including:

- Identification of toxic pollutants of concern;
- Identification of PCB and DDT Superfund sites;
- Development of a watershed-based approach to controlling toxic pollutants applicable to other areas of the country;

- Demonstrating the benefits of watershed assessments and permitting to both state regulatory agencies and NPDES permittees;
- Increased indirect cost savings through development of procedures targeting monitoring to only specific toxic pollutants of concern;
- Increased coordination of the monitoring efforts of several states; and
- Enhanced ability to target wastewater treatment plant modifications to specific pollutant control.

DRBC staff note that direct environmental benefits of improved water quality are dependent on the achievement of WLAs established under Phase I by the NPDES permittees, as well as the identification of nonpoint sources requiring additional controls to meet water quality objectives in Phase II.

Cost Breakdown

For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories.

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

With the exception of costs related to monitoring/data collection, costs outlined in this analysis represent only those expenses incurred by DRBC. Data collection and ongoing monitoring activities required the greatest investment of resources. For these functions, DRBC hired temporary staff and worked with NPDES permittees to obtain point source discharge data. Throughout the TMDL process, DRBC built upon existing information and relied upon in-kind services from other organizations for their efforts in monitoring/data collection, and modeling activities. For example, the Delaware Department of Natural Resources and Environmental Control (DNREC) assisted with sample collection for several studies and NJDEP provided in-kind services to adapt the EPA-supported DYNHYD5 and WASP4 models to the tidal Delaware River. These costs have not been captured in this analysis.

Monitoring/Data Collection Costs for the Delaware River Estuary TMDL		
In-house FTEs	Cost	Funding Source(s)
2.5	$278,733[3]	Federal, State, and Local

Two stakeholders conduct the majority of water quality monitoring for TMDL development: the point source dischargers regularly conduct monitoring in association with their NPDES permit requirements and DRBC monitors the river regularly as part of its customary ambient water quality monitoring activities. As part of the TMDL development process, DRBC initiated monitoring for specific toxics in both existing water column monitoring programs and a new fish tissue monitoring program. Metals and volatile organics have been monitored in the water column for the past five years. Fish tissue monitoring of chlorinated pesticides, PCBs, polynuclear aromatic hydrocarbons (PAHs), and metals has been conducted at five stations in the estuary for the last four years. Other DRBC monitoring activities include field studies on ambient toxicity and studies on toxics in sediment.

Beyond routine sampling, DRBC incorporated special monitoring as part of the TMDL development procedure to calibrate and validate the model predictions for the estuary. The monitoring consisted of intensive studies conducted over the last two years during low river flows.

Data collection activities for TMDL development consisted of a monitoring effort which involved 83 NPDES permittees, each of which conducted effluent water quality monitoring at their own expense. DRBC estimated that data collection and monitoring costs were approximately $5,000 for each permittee. DRBC staff time went toward preparation of letters, interfacing with permittees, inputting all incoming data into a data base, and preparing a report on data base use.

In addition, many of the data collection and monitoring activities were conducted by neighboring state agencies. For example, the Delaware Department of Natural Resources and Environmental Control was contracted to provide sample collection for several of the studies. The New Jersey Department of Environmental Protection also provided analytical support for sediment and fish tissue analyses under contract to the Commission.

DRBC staff dedicated approximately two and one-half person years to its data collection and monitoring activities, which translates into a cost of $119,550. The cost of laboratory analysis of water samples for TMDL monitoring activities was approximately

[3] Cost computed as 1 senior staff working 1.7 years x $60,000 average annual salary including indirect costs = $102,000; 1 modeler working 0.5 years x $33,000 average annual salary including indirect costs = $16,500; 1 temporary staff working 0.3 years x $3,500 average annual salary including indirect costs = $1,050; and $30,000 per year (1991 to present) for fish tissue and water monitoring = $159,183 (when all dollars are converted to 1995 using a price index for government purchases).

$30,000 per year from 1991 to present. DRBC plans to continue to monitor the Delaware River Estuary.

Modeling Costs for the Delaware River Estuary TMDL		
In-house FTEs	Cost	Funding Source(s)
2.8	$122,103[4]	Federal, State, and Local

Modeling for TMDL development within the Delaware River Estuary has evolved to account for changes in the river as well as the region. The Delaware River Estuary is unique as a result of the number and complexity of pollutants, and the strong tidal action in the waterbody. Given the hydrodynamic complexity of the estuary, the numerous point source discharges, and the various fate processes affecting toxic pollutants, DRBC selected complex mathematical instruments to model the estuary.

To allocate wasteloads for protection of aquatic life from chronic toxicity and the protection for human health DRBC chose the Water Quality Analysis Simulation Program (WASP4), developed and supported by the U.S. Environmental Protection agency. DRBC adapted the model for the tidal Delaware River between Trenton, N.J., and the head of Delaware Bay by specifying physical, hydrodynamic, and chemical characteristics for the estuary.

The modeling process included the development of input files for the hydrodynamic model (DYNHYD5) that described the bathymetry, tidal forces, tributaries and point source inputs, and drinking water withdrawals. Effluent data on toxic pollutant concentrations was gathered by requiring the 83 point sources to perform monitoring. DRBC used this data to develop input files for the water quality model (WASP4). Finally, DRBC conducted field studies to calibrate and validate the model for metals, volatile organics and chronic toxicity.

DRBC chose WASP4 for several reasons: earlier versions of the WASP models had been successfully applied to the Delaware River for allocating CBOD; the one dimensional nature of the hydrodynamic model (DYNHYD5) was deemed appropriate for the Delaware River Estuary based on past scientific studies; and Commission staff familiarity with the model made it easier to use than other models that could accomplish similar tasks.

In addition to its expenditures on model calibration and modeling, DRBC leveraged its TMDL development resources through in-kind services provided by states bordering the estuary. For example, the NJDEP provided in-kind services to help adapt

[4] Costs computed as 1 senior staff working 0.8 years x $60,000 average annual salary including indirect costs = $48,000; 1 modeler working 2.0 years x $33,000 average annual salary including indirect costs = $66,000; and $8,103 in capital costs for two new computers in 1995 (converted from $7,000 in 1990 dollars, using a price index for government purchases).

the EPA-supported DYNHYD5 and WASP4 models for the tidal Delaware River. Additionally, DRBC utilized consultants for sample collection and laboratory analysis of water samples in studies to calibrate and validate the DELTOX far-field model. The DELTOX model, used to develop wasteload allocations for the protection of human health and chronic aquatic life impacts, consists of 90 nodes, and incorporates 11 tributaries, the headwaters of the Delaware River, the C&D Canal, and a seaward boundary. DRBC also engaged a consultant to modify an EPA-supported near-field model (CORMIX) for use in tidal waters. This model, used to develop wasteload allocations for the protection of aquatic life from acute toxicity, is designed to describe the wastefield or dispersion area of estuary discharges under the varying conditions that occur over a tidal cycle.

DRBC dedicated the equivalent of one modeler working for two years and one senior staff person working for almost one year to its modeling activities. In addition, as part of its modeling effort, DRBC incurred approximately $8,103 in capital expenditures for new computers. Staff time and capital expenditures translated into a total cost of $122,103.

Analysis Costs for the Delaware River Estuary TMDL		
In-house FTEs	Costs	Funding Source(s)
2.9	$147,000[5]	Federal, State, and Local

DRBC's analysis activities conducted in conjunction with TMDL creation included development of four WLAs for toxics. DRBC developed WLAs to control impacts to aquatic biota and human health for four specific endpoints. The four specific endpoints are: protecting aquatic life from acute toxicity and chronic toxicity; protecting human health from carcinogenic chemicals; and protection of human health from non-carcinogenic or systemic effects of chemicals. The Commission then translated the four WLAs into a single effluent limitation for toxic pollutants using a LOTUS spreadsheet program developed by DNREC. Other DRBC analysis activities included preparation of basis and background documents to support and defend the TMDLs.

DRBC dedicated two of its staff over approximately a three-year period to perform required analysis and develop appropriate TMDL levels, which translates into a cost of $147,000.

[5] Costs computed as 1 senior staff working 1.9 years x $60,000 average annual salary including indirect costs = $114,000; 1 modeler working 1.0 years x $33,000 average annual salary including indirect costs = $33,000.

Outreach Costs for the Delaware River Estuary TMDL		
In-house FTEs	Cost	Funding Source(s)
0.1	$8,693[6]	Federal, State, and Local

To coordinate multi-agency interests, DRBC organized numerous committees and sub-committees to address different aspects of TMDL development. Committee representatives included members of each state environmental agency bordering the estuary, USEPA, local governments, and the general public. Committee work included the creation of TMDL development and implementation procedures.

DRBC also held public briefings (similar to public hearings, but less formal) prior to developing changes to DRBC regulations. Finally, to keep the public informed about TMDL development activities, the Commission spent $2,693 (in 1995 dollars) for articles in the Newsletter of the Delaware Estuary Program. DRBC dedicated approximately 0.10 FTEs to these efforts, which translates into a cost of $6,000.

Public Participation Costs for the Delaware River Estuary TMDL		
In-house FTEs	Cost	Funding Source(s)
0.25	$15,000[7]	Federal, State, and Local

Thus far, DRBC has conducted no formal public participation activities in conjunction with its TMDL development procedures. However, the Commission developed water quality criteria for the Delaware River that were presented at a public hearing in June 1992. In addition, DRBC developed a rationale document to defend the water quality criteria. These same water quality criteria were later used for TMDL development.

DRBC also integrated the TMDL development process with the Delaware Estuary Program which had significant public involvement through established scientific, local governments and citizen groups. The Commission has scheduled formal public hearings in October 1995 to address WLAs and effluent limitations for NPDES permits. DRBC dedicated a total of approximately three months of one senior staff person's time to these efforts, which translates into a cost of $15,000.

[6] Costs computed as 1 senior staff working 0.1 years x $60,000 average annual salary including indirect costs = $6,000; $2,693 in capital costs for articles in the Newsletter of the Delaware Estuary Program over the years 1990 to 1995 (this is converted from $2,500 in 1990 through 1995, using a price index for government purchases).

[7] Costs are computed as 1 senior staff working 0.25 years x $60,000 average annual salary including indirect costs = $15,000.

Administration Costs for the Delaware River Estuary TMDL		
In-house FTEs	Cost	Funding Source(s)
1.75	$105,000[8]	Federal, State, and Local

Administrative activities associated with TMDL development included: preparation and administration of grants; preparation of progress reports; providing support for subcommittee and committee meetings; substantial interaction with the Delaware Estuary Program; and interaction with state representatives and NPDES permittees. DRBC dedicated one and three-quarter years of one senior staff person's time to these efforts, which translates into a cost of $105,000.

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[8] Costs are computed as 1 senior staff working 1.75 years x $60,000 average annual salary including indirect costs = $105,000.

FLINT CREEK, ALABAMA

Key Features

Title:	Flint Creek.
Location:	North central Alabama; USEPA Region IV.
Size/Scope:	Creek watershed 244 mi^2.
Comparative Size:	Medium, ≤1000 mi^2.
Pollutant(s):	Dissolved oxygen.
Sources of Pollutants:	Point sources—two wastewater treatment plants (WWTPs) one each for the Cities of Hartselle and Falkville. Nonpoint sources—numerous agricultural.
Model Use and Complexity:	Watershed Screening and Targeting Tool (WSTT); modified Streeter-Phelps models; and QUAL2E were used to run simple simulations of river and pollution processes.
Total Cost	$1,023,531.
Funding Sources:	Federal Clean Water Act Section 319 and nonpoint source TMDL Mini-Grants, State and Federal operating budgets.

Summary

The Alabama Department of Environmental Management (ADEM) developed a preliminary TMDL for a segment of Flint Creek to address low levels of dissolved oxygen (DO). The low DO concentrations are the result of excessive algal growth caused by nutrient loading from a two wastewater treatment plants (WWTPs) and agricultural nonpoint sources.

This segment is a 25 mile section of the creek which flows from its headwaters approximately ten miles north of Cullman to Wheeler Lake just south of Decatur. Flint Creek drains a 244 square mile watershed, a large portion of which is covered by agricultural lands. Forestlands, animal operations, and urban areas are the other key features of the watershed. Designated uses of the TMDL segment are: primary contact recreation; fish, aquatic life, wildlife; and livestock water supply.

As illustrated in Table 6, the total inter-agency effort for the Flint Creek TMDL date is 15.72 FTEs, for a total cost of $1,023,531. ADEM received assistance from several federal and local institutions in conducting the TMDL work, but maintained primary authority over project implementation and financing. To date the work completed on the TMDL has revolved primarily around development of a preliminary TMDL for DO. Expenditures for preliminary steps have provided benefits initially through modification and reissuance of the NPDES permit for the wastewater treatment plant. However, water quality standards have not been fully met and best management practices (BMPs) have not yet been initiated in the numbers needed to address remaining water quality violations.

Some factors, such as the extensive data collection necessary, an abundance of nonpoint sources, the geological surveying needed, and the intricacy of the modeling effort, complicated the TMDL process. Other factors, such as the presence of seven point sources throughout the watershed, including the two WWTPs, simplified the TMDL process and lowered costs.

In FY 1992, ADEM received a nonpoint source mini-grant from EPA in the amount of $8,000 (contractual support for the project) to use available data to assess Flint Creek water quality. In FY 1993, ADEM received additional nonpoint source mini-grant funding in the amount of $15,000 to continue to expand the use and applicability of the model developed to assess Flint Creek water quality.

Federal nonpoint source grants supplied funds for salaries, monitoring, data collection, geological surveying, and other activities. In FY 1993, the Geological Survey of Alabama (GSA) received a nonpoint source Section 319 grant from the USEPA Office of Water in the amount of $63,468 for data collection, monitoring, and analysis activities related to the TMDL. In FY 1994 and FY 1995, GSA received additional Section 319 grant funding in the amounts of $68,460 and $77,750 respectively, for geological surveying and additional analysis activities.

Table 6. Summary of TMDL Costs for Flint Creek

Activity	Inter-Agency FTEs	Cost ($)	Cost as % of Total
Data Collection/Monitoring	6.52	500,662	48.9
Modeling	1.00	55,000	5.3
Analysis	7.00	415,207	40.5
Outreach	0.04	1,875	0.1
Public Participation	0.02	1,731	0.1
Administration	1.14	49,056	4.7
TOTAL	15.72	1,023,531	99.6*

*Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

Various types of funding and cooperative efforts were a major influence on the number and depth of TMDL activities that were conducted. Because ADEM obtained four mini-grants from EPA and was able to obtain extensive point and nonpoint data through cooperative agreements with other organizations, it was able to devote substantial resources to modeling and analysis activities. Throughout the TMDL development process, ADEM has built upon existing information and relied upon in-kind services from other organizations for assistance with data collection, monitoring, public participation, outreach, and analysis activities. Monitoring/data collection and analysis activities required the greatest investment of resources. For these functions, ADEM relied upon the assistance of numerous outside organizations. Modeling required the next greatest investment of resources. Because monitoring and data collection aspects of the TMDL are slated to continue through at least 1997, all expenses depicted are currently ongoing.

The Flint Creek TMDL has been developed within a setting of cost-sharing, largely as a result of the number of agencies involved. A portion of each organization's costs associated with conducting the TMDL are shared by other water quality initiatives, both those undertaken by that agency and other cooperating agencies. For example, some of TVA's other water quality initiatives include water quality monitoring, BMP demonstrations, aquatic plant management, habitat enhancement, and environmental education. TVA would be conducting water quality monitoring and environmental education programs in the absence of the Flint Creek TMDL. In addition, by participating in the TMDL, TVA has developed associations with a number of other entities which generate information needed to carry out TVA's other water quality management activities. Therefore, cooperative agreements and information sharing arising from intergovernmental interaction on TMDL activities has further increased the cost effectiveness and long-term benefits of the TMDL.

To reduce costs, ADEM worked with the wastewater treatment plants to acquire point source discharge data. In several instances ADEM had compiled water quality data and other data from other organizations. Particularly useful were the ambient water quality studies compiled by the Geological Survey of Alabama.

ADEM also sought outside funding to aid its TMDL efforts. In 1992, ADEM sought and received an EPA TMDL mini-grant in the form of contractual support to conduct water quality analyses. In 1993, ADEM received additional grant funding to hire a contractor for assistance developing preliminary TMDLs.

According to EPA staff, because BMPs have not yet been fully implemented benefits of the Flint Creek TMDL are not easily quantified. TVA staff, on the other hand, point out that the public (especially conservation district members) recognize the need to address pollution from multiple sources.

Cost Breakdown

For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories.

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

Data Collection/Monitoring for the Flint Creek TMDL		
FTEs	Cost	Funding Source(s)
6.52	$500,662	Federal and State

Four institutions have conducted data collection and monitoring for the Flint Creek TMDL at a total effort of 6.52 FTEs and a combined cost of $500,662 to date. TVA has dedicated 2.15 FTEs at a cost of $102, 375 and $7,500 in equipment to the data efforts thus far. All of TVA's funding is from federal appropriations. GSA has contributed 4.34 FTEs to this point, at a cost of $215,077. GSA's funding for data collection came from a Section 319 Grant and state matching funds. NRCS, using federal appropriations, has supplied 0.03 FTEs to assist with data collection to date, at a cost of $938. The U.S. Geological Survey (USGS) contributed stations for water quality monitoring at a cost of $174,772 over two years.

A preliminary objective of the Flint Creek TMDL was to use available information on mainframe data bases to assess water quality in Flint Creek. Therefore, ADEM began its assessment of water quality by compiling all available information. This included meeting with other state organizations to discuss issues related to attainment of water quality standards, as well as coordination of future data collection and monitoring efforts. ADEM began its monitoring and data collection activities for TMDL development by adding all available information to the Watershed Screening and Targeting Tool (WSTT).

Through a cooperative agreement, the GSA and ADEM are conducting several additional data collection and monitoring activities on an ongoing basis. These activities include data collection from 13 surface water sites, 3 stormwater sites, 20 wells, and 31 springs. The surface water site parameters include: nitrogen; phosphorus; chloride; TDS; TSS; turbidity; pH; temperature; DO; BOD-5; conductance; discharge; and fecal coliform and streptococci bacteria counts. With the exceptions of TDS, TSS, turbidity, DO, and BOD-5, the parameters for ground water samples are the same. Additionally, water pH, conductance, temperature, and DO are continuously recorded at two surface water sites. USGS water quality monitoring stations provide some of these data. Water quality reports are developed and issued at three month intervals.

The Environmental Services Division of USEPA and ADEM conducted other monitoring activities, including two months of benthic macroinvertebrate sampling at ten surface water sites in the lower part of the Flint Creek watershed. USEPA and ADEM also conducted water quality monitoring at 11 sites along Flint Creek and three sites along Crowdabout Creek. Water analysis parameters included nitrogen, phosphorus, chlorophyll-a, algae growth potential (AGP), TOC, TSS, pH, temperature, DO, conductance, and sediment (sieve) analysis.

In addition, TetraTech received a TMDL mini-grant to do a loading analysis in the hydrologic unit area (HUA). This analysis was conducted using data other than that compiled by GSA.

Finally, the Tennessee Valley Authority (TVA) conducted a pollutant loading analysis based on aerial photography of land types and land uses, including agriculture and animal activity in the basin, and urban activity. This aerial inventory of nonpoint sources was conducted using an Excel spreadsheet and was initiated primarily to estimate loads based on a literature review of nonpoint sources.

Modeling for the Flint Creek TMDL		
FTEs	Cost	Funding Source(s)
1.00	$55,000	State

ADEM is conducting all point source modeling for the Flint Creek TMDL. ADEM's effort so far consists of one FTE working for a year at an estimated cost of $55,000. State appropriations are funding the modeling effort.

As noted above, ADEM's modeling efforts began with adding all available information to WSTT. WSTT is a flexible, user-friendly, and relatively low cost PC-based model developed by Region IV and Tetra Tech for use in the TMDL program. WSTT allows users to select and prioritize watersheds using available data from a number of mainframe data bases, as well as user-defined objectives and criteria. In addition to prioritizing capability, WSTT also contains a watershed screening model that can estimate pollutant loading, assess pollutant sources and be used as an additional targeting criteria.

After compiling all available information, ADEM used WSTT to perform a preliminary screening level evaluation of Flint Creek and associated neighboring watersheds. Next, ADEM performed a more detailed analysis using specific mainframe queries and geographic mapping. These preliminary applications of WSTT provided a test of the capabilities and limitations of the model, identified additional outstanding information, and provided a review of currently available information on a more site-specific basis.

ADEM and Region IV used additional grant funding to continue to expand the use and applicability of WSTT in Alabama. As part of this process, a wasteload allocation study was conducted to collect data and calibrate a new modified Streeter-Phelps (S-P) model and a QUAL2E model to set discharge limits for the Hartselle WWTP. As part of this process, a potential DO depression was identified downstream of the WWTP.

ADEM is using QUAL2E to determine the point source WLA. The Department is also using QUAL2E to ascertain the flow necessary for attainment of Flint Creek's use classifications. ADEM staff point out that while other viable models exist, QUAL2E was deemed most appropriate for use on Flint Creek because it has been EPA approved and has a algal option.

Analysis for the Flint Creek TMDL		
FTEs	Cost	Funding Source(s)
7.00	$415,207	Federal and State

Three agencies—NRCS, GSA, and EPA—share the costs for analyses to support the TMDL. NRCS has contributed 4.9 FTEs at a cost of $274,375; GSA has dedicated 1.9 FTEs at a cost of $128,332; and EPA has provided 0.2 FTE at a cost of $12,500. Federal appropriations are funding EPA and NRCS' analysis activities. GSA's revenue sources are Clean Water Act Section 319 Grant funds and state matching funds.

EPA analysis activities included work on nonpoint source loading, and loading estimates were based primarily on GSA data. In addition, EPA used monitoring data collected for the flux portion of the Army Corps of Engineers "BATHTUB" model to incorporate additional pollutant loading calculations for nonpoint sources. Other EPA analysis activities involved work developing TMDLs, including reading related materials, and case studies.

In addition, Tetra Tech received grant funding to determine a preliminary TMDL for the Creek. This TMDL was based on loads from the WWTP as well as runoff estimates from the surrounding watershed. Loads estimated for the nonpoint source portion of the model will be used with the WWTP load information as input to the QUAL2E model. ADEM information will be used to estimate in-stream DO concentrations at different locations along the creek.

Outreach for the Flint Creek TMDL		
FTEs	Cost	Funding Source(s)
0.04	$1,875	Federal

The Alabama Cooperative Extension Service provides some water quality related outreach, however, the costs for the Flint Creek TMDL have been computed as if the local NRCS office is handling all of the outreach. So far, the office has dedicated 0.04 FTEs at a cost of $1,875. To date, outreach activities related to TMDL development have included Watershed Conservancy District Meetings and development and distribution of a project newsletter.

Public Participation for the Flint Creek TMDL		
FTEs	Cost	Funding Source(s)
0.02	$1,731	Federal

ADEM, the local soil and water conservation districts, and NRCS are all involved with public participation activities, however, the costs for the Flint Creek TMDL have been computed as if TVA is the sole agency conducting activities related to public participation. The agency is using its federal appropriations to fund 0.02 FTE at a cost of $1,731.

Administration for the Flint Creek TMDL		
FTEs	Cost	Funding Source(s)
1.14	$49,056	Federal and State

Three agencies—GSA, ADEM, and NRCS—are involved in the administrative aspects of the Flint Creek TMDL. GSA has used federal grant money and state matching funds to pay for 0.13 FTE at cost of $10,931. ADEM has employed state general revenues to fund one FTE for administrative tasks at a cost of $37,500. NRCS has dedicated 0.01 FTE to administrative tasks at a cost of $625. In addition, TVA has also plays a limited role in administration of the Flint Creek TMDL, costs for TVA's efforts were not available as of the date of this report.

Administrative activities for the TMDL include: scheduling, organizing, and conducting Flint Creek TMDL technical committee meetings; development of summary reports and progress updates; and other general grant administration and staff coordination activities.

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HILLSDALE LAKE, KANSAS

Key Features

Title:	Hillsdale Lake.
Location:	Miami County, eastern Kansas; USEPA Region VII.
Size/Scope:	134.5 square mile watershed.
Comparative Size:	Medium, ≤1000 mi^2.
Pollutant(s):	Phosphorus, nitrogen, and chlorophyll-a.
Sources of Pollutants:	Point sources—Gardner wastewater treatment plant (WWTP); Edgerton WWTP; Johnson County Air Industrial Park WWTP; Connestoga Mobile Home Park Lagoon; Lone Elm Estates Lagoon; and Edgerton Quarry Pond Discharge. Nonpoint sources—widespread agricultural fields and animal holding areas.
Model Use and Complexity:	EUTROMOD 2.50 developed specifically for use in lake eutrophication management was used to run simple simulations of the lake and pollution processes.
Total Cost	$21,934.
Funding Sources:	EPA Clean Water Act Section 104 (b) (3) nonpoint source TMDL mini-grant; and State general revenues.

Summary

The Kansas Department of Health and Environment (KDHE), Office of Science and Support conducted a nutrient loading study and developed a TMDL for Hillsdale Lake. KDHE initiated the TMDL process for Hillsdale Lake primarily as a result of concerns about increased nitrogen and phosphorus nutrient loading and the desire to develop eutrophication criteria for the lake. A secondary purpose for undertaking the TMDL included estimation of chlorophyll-a levels. Concerns about eutrophication and nutrient loading are due to rapid urbanization in areas surrounding the lake. Pollution problems are caused by the six municipal point source dischargers and numerous agricultural nonpoint sources.

The surface area of Hillsdale Lake, used to develop the TMDLs, was the conservation pool area of 4,580 acres. Mean lake depth, as supplied by the Army Corps of Engineers, was estimated as 5.3 meters within the conservation pool area. Hillsdale Lake drains a 134.5 square mile watershed, a significant portion of which is covered by forestlands, particularly as compared to most large Kansas lakes. In fact, nearly 20 percent of the Hillsdale Lake watershed is wooded, the majority of which is along riparian corridors and the lake shoreline. Agricultural lands and urban areas are the other key features of the watershed. Designated uses of the TMDL area include: aquatic life support; drinking water supply; contact recreation; and aesthetic quality for general non-contact recreational use.

As illustrated in Table 7, KDHE's total in-house effort for the Hillsdale Lake TMDL to date is 0.42 FTE, for a total cost is $21,934. Some factors, such as the age of the waterbody and the availability of historical loading data, simplified the TMDL process and lowered costs. Other factors, such as the abundance of point and nonpoint sources, complicated the TMDL process. KDHE maintained management authority and conducted all of the field work for the project, utilized information collected by the Army Corps of Engineers and the U.S. Geological Survey. KDHE's intent was that a Hillsdale Lake TMDL work group be the driving force behind the TMDL, but dischargers were reluctant to participate.

Expenditures to date for the TMDL to date will provide benefits initially through modification and reissuance of the permitted point source discharges. However, development pressures and land use changes, make it uncertain that long term water quality standards will continue to be fully met. Therefore, continued monitoring is planned to detect any future water quality violations. Furthermore, subsequent to verified attainment of the waterbody's beneficial uses, further mitigation measures may be initiated to address future water quality violations.

In FY 1992, KDHE received a nonpoint source 104(b)(3) mini-grant from EPA in the amount of $10,000 to develop the TMDL for Hillsdale Lake. State general revenues supplied additional funds for salaries, monitoring, data collection, nonpoint source load assessments, model calibration, and other activities.

Table 7. Summary of TMDL Costs for Hillsdale Lake

Activity	KDHE FTEs*	Cost ($)	Cost as % of Total
Monitoring/Data Collection	0.08	6,642**	30.2
Modeling	0.30	13,478	61.4
Analysis	0.04	1,728	7.8
Outreach/Public Participation	0.00	86	0.3
Administration***	0.00	0	0.0
TOTAL	0.42	21,934	99.7****

*1 FTE (Average) = $44,928.
**Includes $3,186 of donated laboratory services.
***Administrative costs are included in the other costs as an indirect charge of 20 percent.
****Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

KDHE's decision to undertake the level of effort that it chose for Hillsdale Lake was dictated by two primary factors: modeling and data collection requirements for TMDL development. Because KDHE obtained a TMDL/nonpoint source mini-grant from EPA it was able to devote considerable resources to its data collection and modeling activities. Relative to the contentious nature of the TMDL, KDHE spent relatively few resources on outreach and public participation activities. Had further resources been available, KDHE would have been able to conduct more outreach activities, possibly reducing the controversy surrounding the TMDL.

A portion of the costs of conducting the TMDL, such as data collection, are shared by other water quality initiatives, such as water quality assessments, water quality inventories, and NPDES support. For example, KDHE had compiled several years of ambient water quality data on Hillsdale Lake outside of any TMDL related activities. In addition, certain activities necessary to develop the TMDL generated information that is useful for other water quality programs, increasing the cost-effectiveness of the TMDL. For example, water quality samples and data collected as part of the TMDL development process were compared to data provided by point source dischargers for the renewal of their NPDES permits.

KDHE minimized its TMDL development costs by working with the six point source dischargers to obtain water quality data. KDHE also leveraged its TMDL activities by using available water quality data whenever possible. Particularly useful was the ambient water quality data base that had been compiled for Hillsdale Lake beginning in 1985. KDHE also used the department's lab for its water sample analysis needs. This arrangement saved approximately $3,186 in data analysis costs that KDHE would have incurred had it utilized an outside lab. KDHE also sought additional funding to aid its TMDL efforts. In 1992, KDHE sought and received an EPA TMDL mini-grant in the amount of $10,000. Future KDHE funding plans include a FY 1996 request for a federal Section 319 grant in the amount of $600,000 for a Hillsdale Lake water quality project.

The immediate benefits of the Hillsdale Lake TMDL include the development of WLAs for the six point source discharges, as well as an assessment of nonpoint sources and their water quality impacts relative to point sources. Furthermore, KDHE staff developed in-lake eutrophication criteria that will have future applicability to Kansas lakes with similar pollutant and demographic characteristics. In addition, both the development of the TMDLs and the in-lake eutrophication criteria provided KDHE with a better understanding of the potential impacts of rapid urbanization in an area of the state which is expected to have sustained growth. Finally, KDHE gained a greater knowledge of the TMDL process and associated costs.

Cost Breakdown

In reporting its costs, KDHE has combined outreach and public participation into one cost category. Administrative costs have been combined with other costs of the TMDL as a 20 percent indirect charge on other activities. For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories:

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

Monitoring/Data Collection for the Hillsdale Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.08	$6,642	State

A number of organizations conducted water quality monitoring for Hillsdale Lake TMDL development. The primary point source dischargers—Gardner WWTP, Edgerton WWTP, Johnson County Air Industrial Park WWTP, Connestoga Mobile Home Park Lagoon, Lone Elm Estates Lagoon, and Edgerton Quarry Pond Discharge—regularly conduct monitoring in conjunction with their discharge permit requirements. KDHE monitors the lake frequently as part of Kansas' conventional ambient water quality monitoring activities. KDHE began initial monitoring and sampling from Hillsdale Lake in 1985.

In addition to its normal water quality monitoring, KDHE conducted additional monitoring for model calibration and final TMDL development. In order to calculate point source inputs, KDHE collects qualitative samples for total nitrogen and total phosphorus, at intervals, over a one-year period, along with flow estimates for the lagoons and pond. KDHE used flow data collected by staff at the mechanical plants to develop a comprehensive picture of Lake flow dynamics. Furthermore, KHDE obtained effluent nutrient data from dischargers to compare with other data KDHE staff had collected.

Monitoring and sample collection took place over a one year period. During this time, KDHE collected effluent samples in order to include seasonal variations, as well as weekly and daily variations in wastewater treatment plant discharges to the extent possible. Data collection efforts were somewhat constrained by the inability to sample over weekends, holidays, and during nighttime hours.

There are two primary methods to conduct monitoring and data collection used to model waterbodies. KDHE's selected method involves cross-sectional models and available empirical data to develop TMDLs. This approach required less expenditure of existing resources and allowed for a more rapid examination of alternatives. An alternative method that entails collecting empirical data over a long enough time period to be able to construct a pollution budget for the lake and watershed is also available, but this approach requires a long time-frame and a relatively large amount of money for sampling and analysis.

Because KDHE has access to ambient water quality monitoring records for Lake Hillsdale, collected as part of an ongoing project, it spent relatively little to collect additional data specific to TMDLs. A total of 160 hours of staff time provided the level of effort needed to gather necessary data. In addition, the TMDL effort received routine laboratory services worth $3,186 (converted to 1995 dollars). The state paid for data collection.

Modeling for the Hillsdale Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.3	$13,478	Federal and State

Modeling for TMDL development of Hillsdale Lake has evolved to account for changes in the lake as well as the region. Hillsdale Lake is the newest of the federal reservoirs built in the state, and located just southwest of the second largest urban area in Kansas. In 1985, KDHE determined that Hillsdale Lake was potentially threatened by urbanization and/or increasing point source discharges within the watershed. As a result, KDHE developed a simple desk-top nutrient load modeling study of the watershed. The study concluded that urban point source loadings were having a detrimental impact on the lake and that future increases would result in excessive eutrophication.

The study remained in draft form until 1989 when additional empirical data the KDHE Lake and Wetland Monitoring Program had collected was incorporated into the model. To confirm the results of the KDHE desk-top study, Johnson County, a primary stakeholder, undertook a nutrient load study of Hillsdale lake during the period 1989-1990. This initiative, while confirming the validity of the KDHE desk-top modeling, did not yield the data necessary to produce a long term annual average nutrient budget for the lake and watershed. As a result, in 1992, KDHE applied for and received a TMDL mini-grant to conduct nutrient budget modeling and produce TMDLs for Hillsdale Lake.

In 1993, KDHE used EUTROMOD 2.50 to analyze phosphorus and nitrogen loading into the lake and watershed. EUTROMOD was developed by the Duke University School of Forestry and Environmental Studies for use in lake eutrophication management, with an emphasis on uncertainty analysis. This model was based on earlier work in the southeastern United States, and combined with region specific-algorithms to make it applicable to much of the contiguous United States. While KDHE had previously used EUTROMOD on smaller watersheds, this was its first attempt to use the model on a medium-sized waterbody.

Having established total point source nutrient loading for phosphorus and nitrogen, KDHE next turned its attention to nonpoint sources. Almost since the lakes creation in 1982, KDHE has collected water quality data on Hillsdale Lake. As a result, an extensive data base of water quality data currently exists. From this data, KDHE computed historic whole-lake nutrient concentrations and used them for model calibrations and to extrapolate mean water quality estimates using long-term water quality comparisons.

Finally, KDHE staff utilized EUTROMOD to compute nonpoint source nutrient load estimates. Based on the modeling efforts, KDHE determined that crop production, point source discharges, and feedlots were nearly equal contributors of phosphorus to the Hillsdale Lake watershed. The largest source for nitrogen is cropland, followed by pasture land, point sources, and direct precipitation to the lake.

While EUTROMOD did a fairly good job of estimating the point source loading to the lake, it was somewhat less effective in determining nonpoint source contributions for the watershed portion. This was primarily a result of the large size of the watershed, and the resulting inability to clearly identify pollutant trapping zones during land use data collection. If more resources had been available, KDHE could have collected more nonpoint source data, thereby accounting for more pollutant trapping zones, and increasing the nonpoint source load portion of the model.

Modeling costs are equivalent to one staff person spending 30 percent of his/her time, or 0.3 FTEs. With the 20 percent indirect charge, this effort represents a cost of $13,478. Along with state funding, federal grant funds were applied to the modeling efforts.

Analysis for the Hillsdale Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.04	$1,728	State

KDHE's analysis activities in conjunction with TMDL creation included development of waste load allocations (WLA) and load allocations (LA) for phosphorus and nitrogen within the Hillsdale Lake watershed. KDHE also conducted an extensive literature review on in-lake eutrophication criteria and later used the information to develop site-specific eutrophication criteria for Hillsdale Lake. Eutrophication criteria developed for use on Hillsdale Lake, KDHE's first TMDL, will be used to address Kansas lakes with similar pollutant and demographic characteristics in the future. KDHE staff spent a total of 80 hours to complete these activities for the TMDL. The state covered the cost for this staff time.

Outreach and Public Participation for the Hillsdale Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.002	$86	State

To involve the public in the TMDL process, KDHE published a public hearing notice to solicit oral and written comments from interested parties. KDHE also held a nonpoint source meeting in Kansas City to present the project and address questions concerning the TMDL. The staff time required to conduct these outreach and public participation activities was minimal, approximately 4 hours. The state provided the funding for this staff time.

Administration for the Hillsdale Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
indirect	indirect	Federal and State

As mentioned previously, KDHE wanted to form a Hillsdale Lake TMDL work group. Costs associated with initial coordination and start up of this initiative, while minimal, were incurred as part of the TMDL development process. More recently, Clean Water Act Section 319 funds have also been directed to this group. The current title of this workgroup is, the Hillsdale Lake Water Quality Project. Work group meetings have included: discussions with officials at the wastewater treatment plants regarding options for attaining water quality standards; meetings with the agricultural community to discuss the relationship between land uses and water quality; and other general organizational efforts.

KDHE incurred additional costs for staff time required to conduct scheduling and other general administrative activities. Finally, KDHE drafted a report to present the findings from model simulations and highlight the need for the TMDL. Costs for these activities are computed as an indirect charge of 20% on other TMDL activities. This indirect charge roughly equates to $7,488 per FTE, which means that approximately $3,145 of the total cost of the TMDL was spent on administrative activities. The state, through KDHE's budget, paid all of the administrative costs.

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LITTLE DEEP FORK CREEK, OKLAHOMA

Key Features

Title:	Little Deep Fork Creek
Location:	Central Oklahoma; City of Bristow and Town of Depew; USEPA Region VI.
Size/Scope:	Affected watershed 240 mi^2.
Comparative Size:	Medium, ≤1000 mi^2.
Pollutant(s):	Low dissolved oxygen, suspended solids, phosphorus, chlordane, and turbidity.
Sources of Pollutants:	Point sources include: two WWTPs one each for the City of Bristow and Town of Depew and numerous storm sewers. Nonpoint sources include: surface runoff, petroleum activities, non-irrigated crop production, specialty crops, pasture land and range land.
Model Use and Complexity:	QUAL2EU a one-dimensional steady-state model was used to run mid-range complexity simulations of river and pollution processes.
Total Cost	$401,576.
Funding Sources:	Federal Section 319(h), Section 604(b), and Section 104(b)(3) grants; State general revenues; INCOG revenues; and contributions form other participating Federal and State agencies.

Summary

The Indian Nations Council of Governments (INCOG) and the Oklahoma Conservation Commission (OCC) are jointly conducting a Phased TMDL for a segment of the Little Deep Fork Creek to address low levels of dissolved oxygen (DO). As a result of sediment loading and low DO, the warm water aquatic community of the TMDL segment of the Creek is currently threatened. The low DO concentrations stem from excessive algal growth caused by suspected nutrient loading from a variety of sources, including wastewater from the two wastewater treatment plants, and agricultural runoff from non-irrigated crop production, specialty crops, pasture land and range land.

Ambient water quality monitoring on Little Deep Fork Creek and subsequent modeling to determine waste load allocations for two waste water treatment plants (in the City of Bristow and the Town of Depew) indicated the need to control nonpoint sources to allow these point sources to meet water quality standards down stream. The affected river segment drains a 240 square mile watershed. TMDL related activities will focus on a little less than half of the total watershed (approximately 100 mi^2). The single largest land use within the watershed is post oak and blackjack oak forest, comprising almost 40 percent of the watershed. Other land uses within the watershed include cropland and hardwood forests in the bottom lands and pasture and rangelands. Other possible contributing sources include storm sewers, surface runoff, and petroleum activities.

As illustrated in Table 8, INCOG and OCC's total in-house effort on the Little Deep Fork Creek TMDL is estimated to be 6.87 FTEs, for a total cost of $401,576. INCOG and OCC, which share authority over the project, have received assistance from several other federal, state, and local institutions in conducting the TMDL.

Some factors, such as the availability of historical water quality data, confirmation of data quality and stability from earlier studies of the stream, and the presence of only two primary point sources, simplified the TMDL process. Other factors, such as the abundance of nonpoint sources, the number of entities working on the TMDL, the fact that this was the first TMDL undertaken by INCOG, and the intricacy of the modeling effort, complicated the TMDL process and required additional resources.

In FY 1992, INCOG received a 604(b) grant from EPA in the amount of $19,712 to conduct water quality monitoring activities within Little Deep Fork Creek. In FY 1993, INCOG received a 104(b)(3) grant in the amount of $15,000 to conduct initial phases of the TMDL for the Little Deep Fork River including determining the stability of the DO problem and conducting land use studies to identify potential nonpoint sources. In addition, INCOG agreed to contribute at least $790 in staff time and other project costs. Recently, OCC obtained a FY 1995 Section 319(h) grant in the amount of $323,285 to conduct the final phases of the Little Deep Fork Creek TMDL. Matching funds in the amount of $215,523 for the activities conducted under the Section 319 grant will be supplied from state general revenues. Additionally, a number of federal and state agencies are participating in the study and will fund their contributions through their own operating budgets. INCOG and OCC indicate that all phases of the Little Deep Fork TMDL can be fully funded with the existing INCOG grants and the 319(h) grant received by OCC.

The costs outlined in this analysis represent only those expenses incurred by INCOG and OCC. Monitoring and data collection activities required the greatest investment of resources. For these activities, INCOG and OCC will undertake an extensive chemical and biological assessment of the waterbody, as well as land use, stream riparian, and habitat assessments. OCC received sufficient funds (within the FY 95 319(h) grant) for development and implementation of best management practice (BMP) demonstration projects, however, these costs are not included cost estimates presented here, since they are implementation costs rather than development costs.

Table 8. Summary of Projected TMDL Costs for the Little Deep Fork Creek			
Activity	**INCOG/OCC FTEs**	**Cost ($)**	**Cost as % of Total**
Monitoring/Data Collection	2.26	$204,720*	50.9
Modeling	0.23	$40,758**	10.1
Analysis	0.11	$7,994	1.9
Outreach	2.60	$85,275	21.2
Public Participation	1.16	$36,124	8.9
Administration	0.51	$26,705	6.6
TOTAL	6.87	$401,576	99.6***

*Includes $122,000 in capital costs.
**Includes $24,000 in capital costs.
***Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

Availability of funding and the complexity of the pollution were major factors that influenced INCOG and OCC to undertake the level of effort they chose for the Little Deep Fork Creek TMDL. The discovery of nonpoint contributing sources during the initial monitoring and modeling of the river was the primary impetus for initiating a more in-depth, phased TMDL. In addition, because INCOG received 604(b) and 104(b)(3) mini-grant funding, and OCC received a 319(h) grant, they will be able to devote substantial resources to monitoring and data collection activities. This effort will include extensive data collection and analysis activities, performance of reference stream reconnaissance, and water quality monitoring.

It is anticipated that the information obtained as a result of this TMDL will serve future TMDL development efforts within the Little Deep Fork Creek watershed. Additionally, the water quality methods developed under this TMDL should also generate information that is useful for other water quality programs statewide.

During the initial phase of the TMDL process, INCOG and OCC will collect existing information relating to the watershed from other organizations. A number of government agencies will be contributing hours toward the TMDL that will not be covered by the three grants received by INCOG and OCC. These contributions are considered a part of the normal operating budget and function of the respective agency. For example, INCOG and OCC will work with the City of Bristow and the Town of Depew to acquire point source discharge data from their respective wastewater treatment plants. In addition, both the City of Bristow and the Town of Depew will participate in public participation activities related to TMDL development. The Oklahoma Department of Environmental Quality (DEQ) will be providing discharge data, reviewing and commenting on the draft TMDL report, conducting any necessary formal public participation activities related to the TMDL, and processing the NPDES permit revisions. Oklahoma State University Extension Service will perform land use assessments and modeling under contract to OCC. The Office of the Secretary of Environment will administer the grants and coordinate all formal communication among agencies. The U.S. Natural Resources Conservation Service will provide land use data, and help to establish BMPs and education programs with local landowners. Finally, the U.S. Fish and Wildlife Service will assist with watershed improvement programs.

The primary measure of success for the Little Deep Fork TMDL is the improvement of water quality in the vicinity of the towns of Bristow and Depew. Such improvement will enable the segment to assimilate effluent from the Bristow and Depew and maintain downstream water quality standards.

Other measures of success are the number of BMPs implemented and the number of structural measurers implemented. BMPs will be established for the reduction of nutrients and sediments to the creek. Decreased sediment loads improve macroinvertebrate and fish habitat and increase oxygen concentrations by reducing SOD and aquatic plant respiration. While implementation of BMPs is considered integral to the success of the TMDL, such implementation costs are not calculated here.

Other benefits of the TMDL are the reduction and or elimination of nonpoint sources of nutrient loading within the Little Deep Fork Creek watershed. With these reductions, INCOG and OCC can develop final wasteload allocations for the two municipal dischargers. In addition, dissolved oxygen stress will be reduced and/or eliminated within the study area. Finally, the TMDL process should improve water quality awareness within the watershed and help to create an atmosphere of cooperation with local landowners.

Cost Breakdown

For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories:

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

Monitoring/Data Collection for the Little Deep Fork Creek TMDL		
FTEs	Cost	Funding Source(s)
2.26	$204,720	Federal and State

In 1989, INCOG conducted an "intensive 24-hour survey" of several portions of the Little Deep Fork Creek for the purposes of model calibration. INCOG intended to use this model to develop waste load allocations for the City of Bristow and the Town of Depew waste water treatment plants (WWTPs). As part of this effort, parameters relating to model development for DO were measured. Based upon data from this study, EPA concluded that it was likely that nonpoint sources of nutrients were impacting the creek. As a result, wasteload allocation development was confounded and EPA recommended that INCOG conduct a phased TMDL for Little Deep Fork Creek.

The second phase of the TMDL will begin with a characterization of nonpoint source loading into Little Deep Fork Creek. OCC began this assessment by compiling all available land use information. This compilation included a review of a 1985 land use data base, interpreted from satellite data. OCC also plans a ground-based land use inventory to update the 1985 information and provide a more accurate picture of land uses within the study area. This effort will focus on the stream riparian corridor. Additionally, a set of aerial photographs of the riparian corridor will be purchased as a supplement to the information gained through the ground-based land use inventory.

For the next part of the nonpoint source load characterization, OCC plans to contract with Oklahoma State University (OSU) to provide loading estimates of nutrients and sediments within the TMDL watershed. In addition, OCC staff plan to conduct stream riparian area and instream habitat assessments. Upon completion of these assessments, all riparian and instream habitat data will be entered into the OCC GIS. A three to four day water sampling exercise will be conducted within stream segments suspected of contributing to water quality problems (e.g., sites in high cattle use areas or within the urban watershed).

In addition to its nonpoint source load characterization, OCC plans to conduct a variety of ambient water quality monitoring activities in conjunction with TMDL development, including:

- Collection of three years of monthly low flow samples at five sites;
- Conducting annual fish collections and quarterly benthic invertebrate collections to compile three years of biological data to assess attainment of beneficial uses and improvement in water quality;
- Setting monthly periphytometers during the first and last years of the study to measure stream productivity;
- Monitoring diurnal dissolved oxygen profiles at four sites (split among low dissolved oxygen areas and areas upstream of discharges) each summer over two 24-hour periods; and
- Monitoring (including biological and habitat assessment and four months water quality sampling) of three reference streams to ascertain achievable water quality goals.

INCOG's costs for its data collection and monitoring activities are computed as the equivalent of one senior environmental planner working for two months, one civil engineer working for one month, and one project manager working for approximately 17 hours, over a three-year period (0.26 FTEs). This staff time translates into a cost of $19,070, which will be paid for by the federal 604(b) grant and other funding sources.

OCC will dedicate 2 FTEs as well as approximately $122,000 to cover capital costs, for activities related to data collection and monitoring. This translates into a total cost of $185,650, which will be funded 60 percent through federal grant funds and 40 percent through state general revenues.

Modeling for the Little Deep Fork Creek TMDL		
FTEs	Cost	Funding Source(s)
0.23	$40,758	Federal and State

INCOG used the QUAL2EU model to develop the original wasteload allocation. INCOG anticipates that it will use either this model or QUALTX (a version of QUAL2 developed by the Texas Water Commission and popular with EPA Region VI) to develop the actual TMDL for both point and nonpoint sources.

QUAL2EU is a one-dimensional, steady state model. While there are several quasi-dynamic models that could be used that might better simulate nonpoint source impacts on the stream, INCOG staff believed that calibration of such models is extremely difficult and would not be cost effective. Furthermore, INCOG already has developed the QUAL2EU model using the most recent data, data whose accuracy was confirmed through INCOG's first phase studies of the stream. Finally, QUAL2EU and QUALTX allow for nonpoint source loading, enhancing their usefulness in this type of study.

Upon completion of nonpoint source load estimates from the first phase of the OCC FY 95 319(h) study, INCOG will recalibrate the QUAL2EU model to incorporate nonpoint loading estimates. This will involve recalibration of the existing allocation model using the 1989 data set, adjusting CBOD decay rates, and inputting nonpoint source loads using incremental flow functions.

INCOG's costs for its modeling activities are computed as the equivalent of one senior environmental planner working for two months and one project manager working for approximately one-half month, over a three-year period (0.21 FTEs). This staff time translates into a cost of $15,904 which will be funded through INCOG general revenues, the FY 93 104(b)(3) mini-grant, and other sources.

OCC will dedicate 0.02 FTEs as well as approximately $24,000 to cover capital costs for activities related to modeling. This translates into a total cost of $24,854, which will be funded 60 percent through federal grant funds and 40 percent through state general revenues.

Analysis for the Little Deep Fork Creek TMDL		
FTEs	Cost	Funding Source(s)
0.11	$7,994	Federal

Upon completion of nonpoint source loading estimates, INCOG will develop the initial TMDL which will set new allocations for both WWTPs. INCOG will base these WLAs on the assumption that there will be a significant decrease in nonpoint source loading due to implementation of BMPs which are planned for the implementation phase of the TMDL. The TMDL may be revised in the future if water quality goals are not fully achieved after BMP implementation.

INCOG's costs for analysis activities related to this TMDL are computed as the equivalent of one senior environmental planner working for one month, one civil engineer working for approximately one week, and one project manager working for approximately 17 hours, over a three-year period. INCOG staff time translates into a cost of $7,994 which will be funded through the INCOG FY 93 104(b)(3) grant.

Outreach for the Little Deep Fork Creek TMDL		
In-house FTEs	Cost	Funding Source(s)
2.6	$85,275	Federal and State

Public education programs conducted in conjunction with the BMP demonstration projects are the primary outreach activities associated with the Little Deep Fork Creek TMDL. As part of this effort, a citizen advisory group will be formed to educate land owners about structural and cultural best management practices which can reduce or control nutrient and sediment loading. The citizen advisory group will also have project oversight responsibilities and will coordinate project developments with local governments and private stakeholders. OCC will dedicate a half-time water quality specialist to this project to assist land owners, write conservation and waste management plans, and conduct public education programs.

INCOG's costs for its outreach activities are computed as the equivalent of one senior environmental planner working for one month and one civil engineer working for approximately one week, over a three-year period (0.10 FTEs). This staff time translates into a cost of $7,150 which will be paid with pass-through funding from the FY 95 319(h) grant and matching funds of 40 percent from INCOG.

OCC will dedicate 2.5 FTEs to activities related to outreach. This translates into a total cost of $78,125, which will be funded 60 percent through federal grant funds and 40 percent through state general revenues.

Formal Public Participation for the Little Deep Fork Creek TMDL		
FTEs	Cost	Funding Source(s)
1.16	$36,124	Federal and State

To date, no formal public participation activities (i.e., public notices, public hearings, etc.) have been part of TMDL development. Should formal public participation activities become necessary, they would be the responsibility of the Oklahoma Department of Environmental Quality (DEQ), the state's primary regulatory entity.

Additional public participation activities include watershed education meetings. For example, OCC plans to target small groups of land owners in sub-watersheds and communities within the Little Deep Fork watershed for educational/organizational meetings to increase awareness of land-stream interactions. Educational efforts will include presentations of the nature of the problems within the watershed, costs and consequences. Finally, these meetings also will serve to recruit and enroll landowners in the BMP demonstration program.

INCOG's costs for its public participation activities are computed as the equivalent of one senior environmental planner working for one-half month and one civil engineer working for approximately 52 hours, over a three-year period (0.07 FTEs) This staff time translates into a cost of $4,884 which will be paid with pass-through funding from the FY 95 319(h) grant and state general revenues.

OCC will dedicate 1.09 FTEs to activities related to public participation. This translates into a total cost of $31,240, which will be funded 60 percent through federal grant funds and 40 percent through INCOG match.

Administration for the Little Deep Fork Creek TMDL		
FTEs	Cost	Funding Source(s)
0.51	$26,705	Federal and State

One of the first administrative tasks of the TMDL was to establish and formalize a cooperative agreement between INCOG and OCC that defined roles and responsibilities as well as billing procedures for work conducted. Generally, OCC will provide project management for the FY 1995 319(h) grant and conduct most of the field work. INCOG will act as the technical lead for the stream model, the TMDL, and waste load and load allocations. INCOG will also assist with field work, review of data and reports, and public education activities.

A project advisory group will be established to coordinate multi-agency interests and review activities associated with TMDL development. This advisory group will serve the dual purpose of: (1) establishing data quality objectives and providing technical assistance; and (2) involving stakeholders directly affected by the outcome of the TMDL on an ongoing basis. Government agency involvement includes: INCOG; OCC; the

Creek County Conservation District Board of Directors; the Town of Depew; the City of Bristow; EPA; the Office of the Secretary of the Environment; the Oklahoma Department of Environmental Quality; and Oklahoma State University Cooperative Extension.

Other administrative costs associated with this TMDL include development of QA/QC plans, QA oversight, grant administration, staff coordination, data entry, and document preparation tasks. Data entry tasks include inputting all riparian and instream habitat data into the OCC GIS and entering all water quality data acquired into the EPA STORET system. Finally, INCOG and/or OCC will produce a variety of reports, updates, and other written documentation throughout the TMDL development process. Project outputs will include:

- Letter reports of all formal agreements between INCOG and OCC;
- Minutes and attendance of proceedings at quarterly project advisory group meetings;
- A quality assurance/quality control (QA/QC) plan for all data collection activities;
- A report summarizing the land use inventory update;
- A report summarizing stream riparian and habitat assessment data for the Little Deep Fork Creek and selected tributaries;
- A report summarizing watershed modeling for nutrients and sediments including data from calibration;
- Letter reports of all watershed education meetings, including documentation of publication of meeting announcements, number of attendees, agenda, and program enrollees;
- Quarterly progress reports on BMP implementation activities; and
- Quarterly and final reports to document TMDL progress, number of land owner contacts, results of awareness surveys, post implementation monitoring, and documentation of overall TMDL process.

INCOG's costs for its administrative activities are computed as the equivalent of one senior environmental planner working for one month and one civil engineer working for approximately 15 days, over a three-year period (0.13 FTEs). This staff time translates into a cost of $10,062 which is to be paid with pass-through funding from the FY 95 319(h) grant and INCOG matching funds.

OCC will dedicate 0.38 FTEs to activities related to administration. This translates into a total cost of $16,643, which will be funded 60 percent through federal grant funds and 40 percent through state general revenues.

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LOWER MINNESOTA RIVER, MINNESOTA

Key Features

Title:	Lower Minnesota River.
Location:	Southern Minnesota; USEPA Region V.
Size/Scope:	25 mile river segment; 320 square mile drainage area.
Comparative Size:	Medium, ≤1000 mi^2.
Pollutant(s):	Carbonaceous biochemical oxygen demand (CBOD) and ammonia.
Sources of Pollutants:	Point sources—Blue Lake WWTP and Seneca WWTP.
	Nonpoint sources—agriculture and residential and commercial development.
Model Use and Complexity:	The RMA-12 model was used to run complex simulations of river and pollution processes.
Total Cost	$775,000.
Funding Sources:	State operating budget, which includes support from Federal and Local sources of revenue.

Summary

The Minnesota Pollution Control Agency (MPCA) initiated the TMDL process because the lower Minnesota River was experiencing violations of water quality standards for both dissolved oxygen and ammonia. These violations were being caused, in part, by point source discharges from two wastewater treatment plants. Nonpoint source loading from agricultural operations, and residential and commercial development also was contributing to violations. MPCA has been conducting TMDL-related activities for the lower Minnesota River since 1974, when the agency conducted its first intensive stream survey on the lower segment. The TMDL was considered complete in 1987 when discharge limitations were imposed on the two wastewater treatment plants. Other actions, however, which are not included in this cost analysis have been conducted since 1987 that relate to this TMDL. Routine monitoring has continued and MPCA has conducted further modeling and analysis of the river, especially with respect to nonpoint source problems.

The lower Minnesota River is a 25 mile segment at the terminus of an agricultural basin that drains 16,770 square miles. The 320 square mile watershed supports agriculture and residential and commercial development. This segment of the river has two designated use classifications that are delineated at river mile 22. Upstream from river mile 22, the river must support cool or warm water fish and must be suitable for aquatic recreation of all kinds. Downstream from river mile 22, the river is classified as a rough fishery suitable for boating but not recommended for swimming.

Due to the long period of time over which activities were conducted for this TMDL (1974 to 1987), all cost figures have been converted to 1995 dollars using a price index for state and local government purchases.

As illustrated in Table 9, MPCA's total in-house effort on the lower Minnesota River TMDL is 3.56 FTEs, at a total cost of $775,000. MPCA received some assistance from the Metropolitan Council in managing the TMDL work, but it maintained almost exclusive authority over the project.

The TMDL process undertaken to achieve and maintain water quality standards in the lower Minnesota River was fairly complex. Several factors, such as the presence of two wastewater treatment plants, the frequency of water quality violations, and the ongoing need for extensive monitoring and analysis of data, contributed to the complexity of this TMDL. Nonpoint source pollution from the upstream watershed further complicated this TMDL. MPCA considers nonpoint source control to be an integral part of the TMDL process. However, activities such as nonpoint source modeling that have occurred since 1987 are not included in this cost analysis.

Revenues for the TMDL primarily came from MPCA operating budgets. These state budgets, however, include some revenues from federal and local sources. Because the TMDL process was incorporated into broader program activities, a precise breakdown of funding sources is unavailable. Local funds, which were provided by the Metropolitan Council, generally paid for monitoring, laboratory analysis, and river survey costs.

Table 9. Summary of TMDL Costs for the Lower Minnesota River

Activity	MPCA FTEs	Cost ($)	Cost as % of Total
Monitoring/Data Collection	0.40	621,000	80.1
Modeling and Analysis	2.83	138,000	17.8
Public Participation and Administration	0.33	16,000	2.0
TOTAL	3.56	775,000	99.9*

*Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

MPCA was prepared to devote considerable resources to addressing problems within the Minnesota River watershed. The sizable expenditures on monitoring and data collection stem from the fact that MPCA wanted to collect information with a much higher level of detail than could be obtained through normal monitoring and analysis procedures. MPCA uses its Water Quality Management Plan to prioritize river segments where pollution problems may threaten human health. The prioritization process placed the Minnesota River as the highest priority waterbody in need of pollution controls. Similarly, MPCA's substantial expenditures on modeling and analysis are due to the fact that the agency used a state-of-the art model and analyzed many scenarios.

Many MPCA activities within the TMDL process were part of broader programs and their costs are not considered part of the TMDL. Therefore, only those costs that are definitely attributable to the TMDL have been estimated. Even so, some expenditures attributable to the TMDL have produced information that is useful for other water quality programs. Thus, the TMDL may have produced cost savings for other aspects of water quality protection.

According to MPCA staff, the expenditures on the lower Minnesota TMDL produced several benefits for the watershed. Both wastewater treatment plants upgraded their systems to include advanced secondary treatment, increasing levels of dissolved oxygen and decreasing levels of ammonia and resulting in overall water quality improvements. In addition, the TMDL process has spurred a basin-wide effort to assess and control nonpoint source pollution.

Cost Breakdown

The lower Minnesota River TMDL has been an evolving process since its inception in the mid-1970s when MPCA began studying the river. For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories:

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

In reporting its costs, MPCA has combined modeling and analysis into a single cost category, and also has combined public participation and administration into one category. In addition, the agency has discarded outreach as a category.

Monitoring/Data Collection for the Lower Minnesota River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.40	$621,000	State, Local, and Federal

Costs associated with monitoring/data collection consist of staff time necessary to conduct two intensive stream surveys, laboratory analysis of the samples, and the cost of two additional studies on sediment oxygen demand and algal productivity. The first intensive stream survey occurred in 1974, and the second, along with the two studies, occurred in 1980. These intensive stream surveys provided much more information than routine monitoring.

Routine monitoring has been in place on the lower Minnesota since before initiation of the TMDL process. MPCA conducts monthly sampling from one monitoring station, and the Metropolitan Council conducts weekly and bi-monthly sampling at five stations. While data collection and analysis from routine monitoring have been important to the development of the TMDL, the cost of collecting these data is not included in the cost of the TMDL. MPCA and the Metropolitan Council would have conducted this monitoring in the absence of the TMDL.

MPCA's cost for the first intensive survey is based on eight staff scientists working 45 hours each plus a cost of $60,000 to analyze water quality samples. The total cost of this survey in 1995 dollars is $190,000. The cost for the second survey is based on eight staff scientists working 60 hours each plus a cost of $180,000 to analyze water quality samples. The total cost of the second survey is $340,000 in 1995 dollars. In addition, the studies on sediment oxygen demand and algal productivity cost $50,000 in 1980, or $91,000 in 1995 dollars. The cost displayed in the box above is the sum of all of MPCA's monitoring/data collection costs converted to 1995 dollars. This cost was paid by MPCA's operating budget, which includes some revenues from federal and local sources.

Modeling and Analysis for the Lower Minnesota River TMDL		
In-house FTEs	Cost	Funding Source(s)
2.83	$138,000	State, Local, and Federal

In 1985, MPCA used RMA-12, a derivative of the Qual II model, to determine waste load allocations for the lower Minnesota. At the time it was used, RMA-12 was a state-of-the-art model for waste load allocation. The model simulated a wide variety of water quality constituents and physical processes, including phytoplankton algae, chlorophyll-*a*, CBOD, dissolved oxygen, benthic oxygen demand, atmospheric re-aeration, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, and orthophosphate. Subsequent to the RMA-12 model (after the "end" of the TMDL project in 1987), MPCA developed a Hydrologic Simulation Program-Fortran (HSPF) model to assess the effects of nonpoint source pollution loads on water quality in the Minnesota River. MCPA's costs for modeling and analysis of modeling results directly attributable to the TMDL process are related only to the RMA-12 model. Since the HSPF model was developed after 1987, the cost of development and analysis is not included as a cost of the lower Minnesota TMDL.

For development of the RMA-12 model, one engineer spent approximately three months. This translates into a cost of $11,000 in 1985, which converts to a 1995 cost of $15,000. For analysis of model results, a staff scientist spent approximately 31 months, which corresponds to a 1985 cost of $88,000 (or $123,000 in 1995 dollars). The cost in the box above provides these 1985 costs converted to 1995 dollars. MPCA paid this cost with its state operating budget, which includes revenues of federal and local origin.

Administration and Public Participation for the Lower Minnesota River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.33	$16,000	State, Local, and Federal

MPCA's administrative and public participation activities for the lower Minnesota TMDL involved close interaction with the Metropolitan Council and public notification under the NPDES permitting process for the two wastewater treatment plants. For these activities, two MPCA staff people spent two months each, at a cost of $12,000 in 1987 ($16,000 in 1995 dollars). MPCA paid this cost out of its operating budget, which includes federal and local funds along with state revenues.

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OIL BRANCH CREEK, OKLAHOMA

Key Features

Title:	Oil Branch Creek.
Location:	City of Heavener, southeastern Oklahoma; USEPA Region VI.
Size/Scope:	5 square mile watershed.
Comparative Size:	Small, ≤100 mi^2.
Pollutant(s):	Low dissolved oxygen.
Sources of Pollutants:	Point sources—City of Heavener wastewater treatment plant.
	Nonpoint sources—Pasture lands (No TMDL activities were conducted for nonpoint sources).
Model Use and Complexity:	Simple model developed on spreadsheet software for personal computers.
Total Cost	$4,039.
Funding Sources:	State 106 revenues, which ODEQ receives from EPA, and revenues from issuance of permits

Summary

The Water Quality Division of the Oklahoma Department of Environmental Quality (ODEQ) completed a TMDL for Oil Branch Creek in the fall of 1994. ODEQ initiated the TMDL process for Oil Branch Creek to address low dissolved oxygen levels in the creek, attributed to wastewater discharge from the City of Heavener.

Oil Branch Creek drains a five square mile watershed. The watershed consists of 30 percent urban lands, 20 percent pasture lands, and 50 percent forest. While 70 percent of the watershed consists of forest and pasture lands, ODEQ did not address these nonpoint sources in the TMDL process. The designated use of the creek is warm water aquatic habitat.

As illustrated in Table 10, ODEQ's total in-house effort on the Oil Branch Creek TMDL is 0.08 FTE, for a total cost of $4,039. ODEQ was the sole agency involved in developing the TMDL. Because of the relative simplicity of the watershed and the pollution problems, ODEQ did not dedicate significant resources to this TMDL.

Table 10. Summary of TMDL Costs for Oil Branch Creek			
Activity	**ODEQ FTEs**	**Cost ($)**	**Cost as % of Total**
Monitoring/Data Collection	0.04	2,115	52.3
Modeling	0.02	962	23.8
Analysis	0.01	481	11.9
Administration	0.01	481	11.9
TOTAL	0.08	4,039	99.9*

*Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

The Oil Branch Creek TMDL was relatively simple and did not require some of the activities of a more complex TMDL. ODEQ did not have extreme data needs or a necessity to conduct outreach or involve the public. Equipment for this TMDL also was already available to ODEQ staff.

According to ODEQ staff, the expenditures on the Oil Branch Creek TMDL are producing positive impacts for the region. The TMDL process may prevent future downstream water quality impairment.

Cost Breakdown

For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories:

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

ODEQ determined it was unnecessary to contact land owners and therefore did not conduct any outreach or public participation activities for the Oil Branch Creed TMDL. Thus, only four cost categories are presented below. All of the costs for the TMDL were funded by state 106 revenues, which ODEQ receives from EPA, and revenues from the issuance of permits.

Monitoring/Data Collection for the Oil Branch Creek TMDL		
In-house FTEs	Cost	Funding Source(s)
0.04	$2,115	State 106 Funding and Permit Funding

ODEQ's costs associated with monitoring and data collection consist of staff time to travel to the site and conduct a brief study involving flow measurement, cross-sectional analysis, dye analysis, and dissolved oxygen inspection. No follow-up monitoring has been conducted yet. After ODEQ estimates new limits on the Heavener wastewater treatment plant, it will conduct follow-up monitoring. The cost for monitoring and data collection is based on two ODEQ staff spending 44 hours total.

Modeling for the Oil Branch Creek TMDL		
In-house FTEs	Cost	Funding Source(s)
0.02	$962	State 106 Funding and Permit Funding

ODEQ designed and used a relatively simple spreadsheet model to simulate the ecology of the creek. One modeler spent a total of 40 hours developing the model on standard spreadsheet software.

Analysis for the Oil Branch Creek TMDL		
In-house FTEs	Cost	Funding Source(s)
0.01	$481	State 106 Funding and Permit Funding

ODEQ's analysis activities for the Oil Branch Creek TMDL involved evaluating collected data and setting limits on the wastewater discharges from Heavener. One staff spent a total of 20 hours conducting these activities.

Administration for the Oil Branch Creek TMDL		
In-house FTEs	Cost	Funding Source(s)
0.01	$481	State 106 Funding and Permit Funding

Administration of TMDL activities involved 20 hours of one ODEQ staff person's time.

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SOUTH FORK OF THE SALMON RIVER, IDAHO

Key Features

Title:	South Fork of the Salmon River.
Location:	Central Idaho; USEPA Region X.
Size/Scope:	River fork; 370 square mile watershed.
Comparative Size:	Medium, ≤1000 mi^2.
Pollutant(s):	Sediment.
Sources of Pollutants:	Point sources—None.
	Nonpoint sources—Silviculture, logging roads, and natural erosion.
Model Use and Complexity:	Rigorous, localized calculations, as well as the mid-range BOISED model were used to simulate river and sedimentation processes.
Total Cost	$19,363.
Funding Sources:	The State operating budget provided funding for all of the costs, although Federal agencies did support the TMDL process through in-kind services.

Summary

Idaho Division of Environmental Quality (IDEQ), along with its federal partners, initiated a TMDL for the South Fork of the Salmon River to supplement the US Forest Service's managerial efforts aimed at stopping the declining trends in anadromous fish populations. The 1988 Idaho Water Quality Status Report and Nonpoint Source Assessment listed several segments of the river as water quality limited due to fine sediment. Sediment loading, to which forestry activities contribute, is believed to be a primary cause of lower numbers of chinook salmon and steelhead trout in the river (hydroelectric dams and fishing pressure are other causes). The IDEQ received approval from EPA in 1992 for the TMDL it developed.

The South Fork Salmon River is part of a 370 square mile basin where forestlands, mountains, and meadows dominate the landscape. The Boise and Payette National Forest cover most of the basin, and forestry and tourism constitute the majority of economic activity in the area. The South Fork system also is highly valued as a habitat for chinook salmon, and steelhead trout.

As illustrated in Table 11, IDEQ's total in-house effort for the South Fork TMDL is 0.42 FTE, for a total cost of $19,363. IDEQ received substantial assistance, including cost-sharing, technical assistance, and managerial help, from the United States Forest Service (USFS) and EPA. Currently, the TMDL is not phased. If monitoring and future events warrant further efforts, however, this TMDL could launch into a second phase.

Overall, several factors affected the complexity of this TMDL. The fact that sediment was the only pollutant of concern simplified the modeling and analysis aspects of TMDL development for the South Fork. The availability of historical monitoring data also bolstered TMDL development. The multi-jurisdictional nature of this TMDL increased coordination efforts, but should prove helpful for implementation of BMPs, most of which will be implemented on federal lands.

IDEQ's operating budget supplied funds for state employees to participate in all aspects of the TMDL process, including coordinating with federal agencies. The Forest Service and EPA both contributed considerable financial and technical resources to develop the South Fork TMDL.

Table 11. Summary of Idaho's TMDL Costs for the South Fork Salmon River

Activity	IDEQ FTEs	Cost ($)	Cost as % of Total
Monitoring/Data Collection	0.10	4,062	20.9
Modeling	0.08	4,400	22.7
Analysis	0.06	2,818	14.5
Work Group Negotiation	0.02	939	4.8
Public Participation	0.08	3,412	17.6
Administration	0.08	3,732	19.2
TOTAL	0.42	19,363	99.7*

*Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

Public support for a healthy fishery, as well as Forest Service and EPA involvement were significant factors in determining the level of effort expended for the South Fork Salmon River TMDL. Because public support for re-establishing a healthy fishery is high, the IDEQ had backing to expend substantial resources. With the Forest Service and EPA's involvement in developing the TMDL, IDEQ was able to leverage its resources to accomplish TMDL goals. As a result, IDEQ was able to conduct state-of-the-art analyses using specialized technical information without incurring significant costs.

Some of the costs of conducting the TMDL, such as data collection, are shared by other water quality initiatives at both the state and federal levels. For example, both IDEQ and the Forest Service would monitor and analyze water quality in the absence of the South Fork TMDL. In addition, coordination costs for the South Fork TMDL can decrease future coordination costs, as avenues for cooperation are already available.

IDEQ worked closely with federal agencies to tailor the TMDL to minimize costs and leverage its own resources. The Forest Service and EPA played a vital role in the work group that developed the TMDL. In addition, IDEQ used available resources, data, and the expertise of experienced staff to make decisions efficiently.

According to IDEQ staff, the expenditures on the South Fork TMDL produced several benefits for the watershed, including:

- Development of a remedial framework and strategy through which the Forest Service can work to improve water quality in the stream;
- Development of monitoring criteria to assess the effectiveness of remedial projects, including a feedback mechanism that allows managers to implement the appropriate amount of remedial work; and
- Improvement in sediment load levels and concurrent improvement in beneficial uses (e.g., increased salmon population) which will not be realized immediately—sediment balance improvements in streams occur over periods of five to ten years.

Cost Breakdown

For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories:

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

Monitoring/Data Collection for the South Fork Salmon River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.10	$4,062	State

IDEQ spent relatively little on monitoring and data collection for the TMDL because USFS researchers have been monitoring sediment in the South Fork for 25-years prior to TMDL development. Monitoring and data collection continued through the TMDL process, and effectiveness monitoring will be conducted by IDEQ to determine the necessity of further actions. The cost for monitoring and data collection consists of two IDEQ scientists spending a total of five weeks of time. Under the management of USFS, the South Fork Monitoring Committee has conducted the majority of data collection. The Committee's costs are not included in this analysis because they would occur in absence of the TMDL. In addition, capital costs for monitoring equipment are not included.

Modeling for the South Fork Salmon River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.08	$4,400	State

IDEQ used the BOISED variant of the R1/R4 model to simulate sediment loading to the South Fork. The model calculates estimated sediment yields from the Idaho Batholith soils. IDEQ considered other models, but judged the BOISED model to be superior. In addition, IDEQ scientists used sophisticated, site-specific calculations to estimate sediment loads from the South Fork Salmon River Road. IDEQ contributed the services of one staff for one month to the modeling effort. In addition, USFS researchers provided valuable technical assistance for the modeling process.

Analysis for the South Fork Salmon River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.06	$2,818	State

The South Fork Salmon River TMDL was developed by a work group comprised of USFS land managers, and IDEQ and EPA hydrologists and government regulators. Analysis efforts for the TMDL focused on three main issues: (1) establishing numeric goals for instream conditions; (2) allocating loads among various sources of sediment; and (3) designing BMPs to slow sediment transport. Work group members selected a core set of sediment reduction projects designed to meet the numeric standards. However, the group also chose an additional set of projects that will be implemented if the initially selected ones fail to achieve water quality standards. For this analysis effort, two IDEQ staff spent a total of three weeks of time.

Work Group Negotiation for the South Fork Salmon River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.02	$939	State

In reporting its costs, IDEQ has replaced the "Outreach" category with "Work Group Negotiation." Work group negotiation refers to attending interagency meetings to discuss how to manage various aspects of the TMDL process.

IDEQ and its federal partners established a work group to develop the South Fork TMDL. This work group was composed of land managers, hydrologists and regulators from IDEQ, USFS, and EPA. In order to coordinate with other members, two IDEQ staff spent a combined total time of one week in work group meetings.

Public Participation for the South Fork Salmon River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.08	$3,412	State

The draft TMDL underwent a public comment process, which produced revisions for a final TMDL. IDEQ staff also produced a summary document responding to all comments received during the public comment process. For this public participation effort, two IDEQ staff spent a total of 168 hours.

Administration for the South Fork Salmon River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.08	$3,732	State

One IDEQ manager spent 168 hours handling administrative activities. The Forest Service also contributed substantial resources to project administration, but its costs are not included here.

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SYCAMORE CREEK, MICHIGAN

Key Features

Title:	Sycamore Creek.
Location:	Ingham County; southern Michigan; USEPA Region V.
Size/Scope:	Total affected watershed 106 mi^2; subwatershed 37 mi^2.
Comparative Size:	Small; $\leq$100 mi^2.
Pollutant(s):	Sediment.
Sources of Pollutants:	Nonpoint sources—agricultural erosion, stream bank erosion, and urban runoff. Three load allocations (LAs) developed.
Model Use and Complexity:	A simple quasi steady state DO model (O'Conner and DiToro, 1970) was used to predict DO concentrations in the Creek during drought conditions.
Total Cost	$202,000.
Funding Sources:	State general revenues.

Summary

In 1992, the Michigan Department of Natural Resources (MDNR) initiated Phase I of a TMDL for Sycamore Creek to address high levels of oxygen demanding substances causing decreased dissolved oxygen (DO) levels in the Creek. A primary objective of the TMDL was conducting an assessment of demand sources and their impact on water quality, particularly sediment oxygen demand (SOD) under drought conditions. A 1989 biological survey of the Sycamore Creek watershed indicated that the creek was not meeting its designated uses, impairing fish and macroinvertebrate communities.

Designated uses of the TMDL segment of the creek include: support of warm-water fish; support of other indigenous aquatic life and wildlife; total body contact recreation; navigation; and industrial and agricultural water supply. Sycamore Creek is a small, warm-water stream and is a tributary of the Red Cedar River. The Red Cedar River flows into the Grand River, which flows into Lake Michigan. The topography of the stream is varied, ranging from gently rolling hills to primarily flat plains. The Sycamore Creek watershed drains approximately 106 square miles, but TMDL related activities have focused on a 37 square mile subsection.

Approximately 52 percent (35,453 acres) of the 67,738 acre watershed are used for agriculture, including croplands and pasturelands. Residential/commercial development, business/industrial development, forestlands, wetlands, idle agricultural lands, open land, transportation corridors, and gravel pits and wells are the other primary features of the watershed. Primary sources of sediment loading are stream bank erosion, agricultural erosion and urban runoff. While there are no industrial point source discharges into Sycamore Creek, a municipal plant, the Mason Wastewater Treatment Plant (WWTP), provides advanced treatment for the City of Mason.

As depicted in Table 12, MDNR's Surface Water Quality Division (SWQD) total in-house effort for the Sycamore Creek TMDL, to date is 4.0 FTEs, for a total cost of $202,000. MDNR received assistance from several agencies conducting the TMDL work, but maintained primary management authority over the project. MDNR modeled and produced final LAs for sediment within Sycamore Creek. Work completed to date producing the TMDL for total suspended solids (TSS) has occurred as Phase I of the TMDL process. MDNR plans to conduct follow-up monitoring for this pollutant. All revenues for TMDL development were derived from state general funds.

Table 12. Summary of Sycamore Creek TMDL Costs

ACTIVITY	MDNR FTEs	Costs ($)	Cost as % of Total
Monitoring/Data Collection	2.2	111,000	54.9
Modeling	0.9	46,000	22.7
Analysis	0.7	34,000	16.8
Outreach/Public Participation	0.0	0[9]	0.0
Administration	0.2	11,000	5.4
TOTAL	4.0	202,000	99.8*

*Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

The level of expenditures on the Sycamore Creek TMDL to date were dictated by four principal factors: (1) lack of historical monitoring data; (2) the number of nonpoint source contributors; (3) the extensive modeling and analysis efforts undertaken; and (4) a lack of experience conducting TMDLs. Despite the relatively small watershed size, the lack of historical data drove the need for extensive data collection and monitoring efforts. The three different types of nonpoint sources—bank erosion, agricultural runoff, and urban runoff—complicated the modeling effort. Finally, MDNR inexperience conducting TMDLs added to the expense of the project. This was because more effort went into research and selection of methodologies (i.e., evaluation of models, appropriate data collection methods, etc.), literature reviews, analysis, writing, and other TMDL development activities because the Department had no institutional knowledge to serve as a base for TMDL activities.

The Sycamore Creek TMDL represented a unique opportunity for MDNR to leverage its TMDL development resources by utilizing overlapping resources from other water quality initiatives being undertaken within the watershed. For example, several government agencies are working on activities related to the USDA funded Sycamore

[9] Due to the inseparability of public participation/outreach costs from other TMDL activities, the cost is recorded as $0.

Creek Hydrologic Unit Area (HUA) project and the Ingham County Health Department has received grant money to conduct ground water monitoring within the watershed.

Several costs associated with the TMDL may have been incurred by MDNR in the absence of development of TMDLs for Sycamore Creek. Many of these costs, such as monitoring and data collection, also occur as part of MDNR's other water quality initiatives. In addition, extensive water quality monitoring was undertaken as part of the HUA project. Finally, in 1995, MDNR applied for and received a CWA Section 319 National Water Quality Monitoring Program Project grant.

According to MDNR staff, direct water quality benefits from the TMDL will be realized after implementation of Phases II and III (follow-up monitoring will determine progress). MDNR staff anticipate that reducing sediment loading will improve water quality by:

- Increasing oxygen concentrations by reducing SOD and aquatic plant respiration;
- Improving fish and microinvertebrate habitat;
- Providing a firmer stream bottom that is more appealing for recreation; and
- Deepening the channel, thereby improving navigation potential.

Finally, MDNR staff feel that the Sycamore Creek TMDL was an invaluable learning experience because the creek is similar in its both geographic and pollutant features to a number of creeks throughout lower Michigan. Therefore, MDNR staff feel that by selecting a TMDL with a pervasive problem which is applicable to a number of other creeks they have increased the long-term cost effectiveness of the TMDL.

Cost Breakdown

For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories.

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

With the exception of costs related to public participation and educational outreach, costs outlined in this analysis represent only those expenses incurred by MDNR. For the purposes of this analysis, outreach and public participation have been combined into one category because all outreach and education related activities were conducted by the Ingham Soil Conservation District and the Ingham County Cooperative Extension Service (CES). The Ingham Soil Conservation District received a Clean Water Act (CWA) Section 205(j) grant from USEPA and CES received USDA HUA project area grant funding to provide educational outreach to the farmers and general public within the watershed.

Overall, monitoring and data collection activities required the greatest investment of MDNR resources. One-time expenses included outreach, public participation, analysis, and administrative activities. Ongoing expenses include monitoring and model recalibration to account for water quality changes.

Monitoring/Data Collection Costs for the Sycamore Creek TMDL		
In-house FTEs	Cost	Funding Source(s)
2.2	$111,000	State

After biological surveying revealed that Sycamore Creek was not meeting its designated uses, MDNR undertook an extensive monitoring and data collection effort to confirm results and develop models. In addition to ongoing state ambient water quality monitoring initiatives, this endeavor comprised extensive channel surveying and land use studies, continuous DO monitoring, and special monitoring to collect sediment and nutrient loading data.

MDNR has monitored the Sycamore Creek watershed on an ongoing basis since 1990. Chemical monitoring parameters include total suspended solids (TSS), turbidity, total phosphorus, total kjeldahl nitrogen, nitrite (NO_2-N) and nitrate (NO_3-N), chemical oxygen demand (COD), orthophosphorus (OP), and ammonia (NH_3). Other measured explanatory variables include rainfall, flow, and an erosion-intensity index.

As part of its land use monitoring, MDNR measured channel dimensions and sediment depth at 49 sites in the watershed using a survey rod and hand level. In addition, in order to determine how active channel erosion was at each site MDNR staff made observations of bank erosion and riparian vegetation.

MDNR conducted continuous DO monitoring at eight locations. Monitoring lasted from six to 103 days at each location. In addition, MDNR conducted DO surveys twice with sampling at nine locations during summer low flows to provide data to calibrate a low flow DO model. MDNR also analyzed a 24 hour sample of effluent from the Mason WWTP as part of this study.

Next, MDNR undertook a special water quality monitoring program during 1990 and 1991 to collect sediment and nutrient loading information. This program monitored stormflow and baseflow water quality within three subwatersheds—Marshall Drain, Willow Creek, and Haines Drain—from March through July of each project year. The Haines Drain subwatershed is outside the Sycamore Creek watershed and served as a control. Best Management Practices (BMPs) were implemented within Haines Drain prior to the initiation of monitoring in 1990. This monitoring process involved collecting water quality samples by hand two times each month during baseflow and using automatic samplers at one to four hour intervals during runoff events. MDNR also monitored two urban watersheds using an automatic sampler at one and on half to four-hour intervals. These watersheds were monitored to assist with the identification of urban pollution sources.

MDNR dedicated approximately two and one-quarter person years to its data collection and monitoring efforts, which translates into a cost of $111,000.

Modeling Costs for the Sycamore Creek TMDL		
In-house FTEs	Cost	Funding Source(s)
0.9	$46,000	State

Model development for the TMDL took place over a two year period beginning in 1990. MDNR used a relatively simple, quasi-steady state DO model to predict DO concentrations in the creek during varying flow conditions. Modeling focused on determining pollutant levels during drought conditions. MDNR calibrated the model using data collected during the 1990-91 special monitoring program, as well as continuous DO data collected at one location during the 1988 drought.

Modeling indicated it was highly unlikely that Sycamore Creek would meet designated DO standards during drought flow conditions. As a result, MDNR estimated sediment loads for all urban and agricultural subwatersheds. MDNR used a simple urban load estimation model (Driver and Tasker, 1988) to predict pollutant loads from the Mason urban area. This model utilized rainfall, drainage area, impervious area, population density, and mean temperatures to predict sediment loading. Department staff used available city maps, aerial photographs, and census population density values as model inputs. Finally, MDNR used six years of available site-specific monitoring data and simple regression models to calculate total suspended solid (TSS) loads for each of three agricultural subwatersheds.

MDNR dedicated approximately one person year to its data collection and monitoring efforts, which translates into a cost of $46,000.

Analysis Costs for the Sycamore Creek TMDL		
In-house FTEs	Costs	Funding Source(s)
0.7	$34,000	State

MDNR's analysis activities in conjunction with TMDL creation included development of LAs for the following sources of sediment: organic and loamy soil from stream banks; agricultural fields; and urban runoff. Analysis indicated that suspended solids would have to be reduced by 52 percent in order to reduce DO levels sufficiently to meet water quality standards at all locations.

MDNR dedicated a little less than three-quarters of one person year to performing required analysis and development of appropriate TMDL levels, which translates into a cost of $34,000.

Outreach and Public Participation Costs for the Sycamore Creek TMDL		
In-house FTEs	Cost	Funding Source(s)
0.00	$0[10]	Federal and Local

The Ingham County Cooperative Extension Service (CES) was responsible for all information and education activities within the watershed. Information, education, and publicity activities were developed and implemented in conjunction with the U.S. Department of Agriculture (USDA) Sycamore Creek Hydrologic Unit Area (HUA) project. Activities included public awareness campaigns; conservation tours; media events such as news releases and radio shows; display set-ups; workshops; short courses; farmer-targeted newsletters; homeowner-targeted newsletters, on-farm demonstrations; meetings; and presentations. In fiscal year 1995, total public participation, education, and outreach funding was $169,835. This amount includes U.S. Department of Agriculture Hydrologic Unit Area grant funding and local general revenues. A portion of this funding, which cannot be estimated, was used for education and outreach activities related to Sycamore Creek TMDL development.

To date, MDNR has issued public notice of all completed TMDLs, but there have been no formal public hearings or other public participation activities. However, jurisdictional issues involving different agricultural interests have brought federal, state, and local government agencies into the TMDL development process. Government agency involvement includes: the Agricultural Stabilization and Conservation Service; the Ingham County Cooperative Extension Service; the Ingham County Health Department; the Ingham Soil Conservation District; the Michigan Department of Natural Resources; the USDA; and the USEPA.

Administration Costs for the Sycamore Creek TMDL		
In-house FTEs	Cost	Funding Source(s)
0.2	$11,000	State

Administrative costs associated with TMDL development included grant administration and staff coordination activities, as well as development of summary and final findings reports about different aspects of the TMDL. MDNR dedicated approximately three months of one staff person's time to these efforts, which translates into a cost of $11,000.

[10] Due to the inseparability of public participation/outreach costs from other TMDL activities, the cost is recorded as $0.

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TRUCKEE RIVER, NEVADA

Key Features

Title:	Truckee River.
Location:	East-central California/Western Nevada; USEPA Region IX.
Size/Scope:	Affected watershed 2,300 mi^2.
Comparative Size:	Large, > 1000 mi^2.
Pollutant(s):	Nitrogen, phosphorus, total dissolved solids.
Sources of Pollutants:	Point sources—one discharger Truckee Meadows Wastewater Reclamation Facility. Three wasteload allocations (WLAs) were developed.
	Nonpoint sources—numerous irrigation return flows associated with area agricultural activities. Three load allocations (LAs) were developed.
Model Use and Complexity:	DSSAM III was used to run mid-range simulations of river and pollution processes.
Total Cost	$158,387.
Funding Sources:	Clean Water Act (CWA) Section 205(j)5, Section 205(j)(l), and Section 604(b) grants; State general revenues; Local general revenues.

Summary

The Nevada Department of Environmental Protection (NDEP) developed a TMDL for the Truckee River to address high levels of nitrogen and phosphorus loading that, in combination with extended periods of low flow, have caused a variety of water quality problems, including decreased dissolved oxygen (DO) levels in the river. Primary sources of nitrogen and phosphorus loading are the Truckee Meadows Wastewater Reclamation Facility, located in Reno, and irrigation return flows associated with surrounding agricultural activities. The fundamental objective of the TMDL was to attain beneficial uses by improving the oxygen condition in the lower river through control of nutrient loading.

The Truckee River emerges from the California side of Lake Tahoe and flows approximately 70 miles downstream to Pyramid Lake in Nevada. The topography of the river basin is mixed, ranging from high mountains to plains with both low and high mountains. The Truckee River watershed stretches approximately 2,300 square miles and is a closed hydrologic system. Designated uses of the TMDL segment of the river include: irrigation; livestock watering; water contact recreation; non-water contact recreation; industrial water supply; municipal and domestic water supply; wildlife propagation; and propagation of aquatic life.

As depicted in Table 13, NDEP's total in-house effort for the Truckee River TMDL to date is 1.01 FTEs, for a total cost of $158,387. NDEP received assistance from several agencies conducting the TMDL work, but maintained primary management authority over the project. NDEP modeled and produced a final TMDL for nitrogen within the Truckee River. Work completed to date producing TMDLs for phosphorus and dissolved solids has occurred as Phase I of the TMDL process, with continued follow-up monitoring for these pollutants.

From FY 1990 through FY 1992, NDEP received Clean Water Act (CWA) Section 205(j)5 grant funding in the amount of $14,729 to assist with its Truckee River TMDL activities. In addition, in FY 1992, NDEP received CWA Section 205(j)(l) and 604(b) grant funding in the amount of $9,000. Other funding for TMDL development is provided by a variety of sources, state general revenues, county general revenues, and municipal general revenues.

Table 13. Summary of Truckee River TMDL Costs

ACTIVITY	NDEP FTEs*	Cost ($)	Cost as % of Total
Monitoring/Data Collection:	0.55	25,200	15.9
Modeling	0.00	109,778**	69.3
Analysis	0.17	7,576	4.7
Outreach	0.19	10,707	6.7
Formal Public Participation	0.02	1,009	0.6
Administration	0.08	4,117	2.5
TOTAL	1.01	158,387	99.7***

*1 FTE (Average) = $36,800

**This cost includes payments to contractors from NDEP, EPA, Washoe County, and cities.

***Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

The level of effort that NDEP undertook to develop TMDLs for the Truckee River was affected by two primary factors: (1) ongoing federal financial support for model and other TMDL development activities, and (2) inter-agency assistance with development efforts. Grant money allowed NDEP to devote substantially more resources to modeling than it otherwise would have. Inter-agency involvement in the process allowed NDEP to leverage its expenditures on data collection and monitoring for TMDL development.

NDEP devoted a relatively small amount of resources to formal public participation activities associated with the TMDL. Despite some controversy surrounding the TMDL, the relatively low formal public participation costs indicate success of the public education and outreach activities undertaken by NDEP. Recognizing that the waterbody has historically been highly controversial, NDEP organized Truckee River Strategy meetings to allow stakeholder involvement in the TMDL development process on an ongoing basis. While cost savings from these efforts are not easily quantified, the relatively low formal public participation costs in what is clearly a controversial situation are somewhat reflective of these savings.

Several costs associated with the TMDL may have been incurred by NDEP in the absence of development of TMDLs for the Truckee River. Many TMDL activities, such as monitoring and data collection, also occur as part of NDEP's other water quality initiatives, such as, groundwater protection, nonpoint source control, issuing discharge permits, and development of water quality standards.

NDEP used multi-agency cooperation and available data to minimize TMDL costs where possible. As part of this effort, NDEP organized multi-agency data collection efforts and split the intensive water quality sampling required for TMDL development among three agencies. These efforts saved approximately $12,600 in data collection costs that NDEP would have otherwise incurred. In addition, whenever possible, NDEP utilized available water quality data. Significant sources of data were the 1985-1987 river modeling efforts, the Truckee Meadows Wastewater Reclamation Facility (TMWRF), and DRI's data compiled as part of Nevada's ambient water quality monitoring activities.

The TMDL resulted in WLA and LAs that NDEP staff believe resulted in water quality improvements. Additional TMDL benefits included increased coordination among the different government agencies and other constituencies involved in the TMDL development process. Finally, the development of the TMDL allowed NDEP to assess nonpoint sources and their water quality impacts relative to point sources.

Cost Breakdown

The Truckee River TMDL has been an evolving process since its inception in the mid-1980s when EPA provided initial grant money to model the river. For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories.

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

With the exception of costs related to monitoring/data collection and modeling, the costs outlined in this analysis represent only those expenses incurred by NDEP. One-time expenses included outreach, public participation, analysis, and administrative activities. Ongoing expenses include monitoring and model recalibration to account for water quality changes. Model development and ongoing modeling activities required the greatest investment of resources. For these functions, NDEP relied upon the expertise of an outside consultant and support from EPA. Throughout the TMDL process, NDEP built upon existing information and relied upon in-kind services from other organizations for their efforts in monitoring/data collection, public participation, and outreach activities. Among these only monitoring/data collection costs have been captured within this analysis because these are the only activities for which NDEP was able to accurately estimate city and county costs.

Monitoring/Data Collection Costs for the Truckee River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.55	$25,200	Federal, State, and Local

The Truckee Meadows Wastewater Reclamation Facility (TMWRF) and the Desert Research Institute (DRI) conducted the majority of water quality monitoring for TMDL development. TMWRF, the sole major point source discharger, regularly conducts monitoring as a requirement of their NPDES permit. DRI monitors the river monthly as part of Nevada's customary ambient water quality monitoring activities. Beyond such routine monthly sampling, TMWRF, NDEP, and Washoe County incorporated intensive sampling to support model development. This sampling involved following the same parcel of water downstream and collecting samples every four hours for 24 hours at each site.

A multi-agency data collection team initially conducted intensive sampling in 1988, the year advanced (tertiary) treatment processes were installed at TMWRF, and again in 1989, to collect data during different river flow conditions. This effort involved four staff from NDEP, and a similar number from Washoe County and the City of Reno. Eight staff conducted monitoring and data collection activities, 12 hours per day for eight days. Finally, the team conducted intensive sampling three times in 1993 to refine model development. In this case, eight staff conducted monitoring and data collection activities on three separate occasions, working for four days, a total of eight hours each day. NDEP plans to continue monitoring the Truckee River.

Only half of the stated costs were incurred by NDEP; the city and county contributed half of the staff and incurred associated costs. The staff time translates into a cost of $25,200. TMWRF provided laboratory analysis of the samples.

Modeling Costs for the Truckee River TMDL		
In-house FTEs	Cost	Funding Source(s)
*	$109,778	Federal, State, and Local

* Because modeling activities were conducted by a consultant, total FTE costs are not calculated.

Modeling efforts for TMDL development on the Truckee River have varied over time to account for changes in the river as well as the region. The Truckee is a managed or "flow regulated" waterbody. As a result, the model has been adjusted repeatedly to account for variations in flow. In addition, other factors have spurred reconfiguration and upgrading of the model, including upgrades to the TMWRF, increased population levels, and modified agricultural practices.

Model development for the TMDL took place over an eight to ten-year period beginning in the mid 1980s. During the period from 1985 to 1987, EPA, in conjunction with an outside consultant, applied the Dynamic Stream Simulation and Assessment Model, Version III (DSSAM III) to assess the potential water quality changes resulting from an upgrade to the TMWRF to advanced wastewater treatment. DSSAM III is based on three previously utilized stream models: the Stream Simulation and Assessment Model, Version IV (SSAM IV); the Lotic Periphytoin Simulation Model (LPSM); and the U.S. Geological Survey's Truckee River Water Quality Model.

DSSAM III is designed to determine water quality in the Truckee River under certain flow and nutrient loading conditions. The model is intended to address ecological process that are specific to the Truckee River. Pollutant sources addressed included point and nonpoint sources. The major point source is the TMWRF; others include industrial non-contact cooling water, an aquaculture operation, water treatment plants, stormwater outfalls, and groundwater discharges. Primary nonpoint sources include agricultural and urban runoff. Initial modeling efforts were used to set waste load allocations (WLA) and load allocations (LA) for total nitrogen.

In 1988, NDEP used DSSAM III to monitor the river during installation of tertiary treatment processes at TMWRF. In the following year, when the facility upgrade was fully functional, researchers obtained the clearest insight into nitrogen and phosphorus loading processes in the river. NDEP used this September 1989 data to calibrate DSSAM III. In 1990, findings demonstrated that pollutant levels were still not adequate to allow many of the river's designated beneficial uses. As a result, NDEP began a new modeling effort to develop more stringent standards to meet state waterbody classifications. The Bureau of Reclamation is currently using the model to conduct an environmental impact statement (EIS) of the Truckee River watershed basin and has provided some additional funding for improvements to the model.

Presently, TMWRF is approaching its limit for the discharge of total nitrogen. Continued population growth in the Cities of Reno and Sparks is chiefly responsible for this situation. If population trends continue as expected, the TMWRF could exceed its WLA for total nitrogen in coming years. As a result, TMWRF is currently exploring alternative means to attain discharge limits, including flow augmentation through the purchase of water rights from agricultural interests. If this occurs, the model will be rerun using new flow conditions.

The cost for consultants to customize a prior model of the Truckee River is $53,094 in 1995 dollars, approximately $24,000 of which was contributed by NDEP from 1990 to 1993. The prior modeling effort was conducted over an eight-year period, and served as a basis for the TMDL model customization. This modeling effort cost approximately $55,684 in 1995 dollars. Additional costs associated with the time NDEP staff dedicated to early modeling activities are not available. The costs of modeling efforts to date have been shared among federal grants, state general revenues, and monetary contributions from both the county and city governments. Additionally, Washoe County provided technical guidance and review.[11]

Analysis Costs for the Truckee River TMDL		
In-house FTEs	Costs	Funding Source(s)
0.17	$7,576	State

NDEP's analysis activities in conjunction with TMDL creation included development of WLAs and LAs for total dissolved solids and total phosphorus. Although the Truckee currently meets water quality standards for total dissolved solids, conservative "simple mass balance" calculations (i.e., assessments of existing loads) were developed for total dissolved solids in accordance with EPA's TMDL guidance, which recommends taking a proactive pollution prevention approach to water quality management (EPA, 1991).

Water quality standards for phosphorus are not currently being met on the Truckee River. Since phosphorus behaves in a manner similar to dissolved solids, NDEP used similar "simple" calculations to arrive at a reasonable TMDL for phosphorus.

NDEP dedicated two staff over a two-month period to perform analysis and develop appropriate TMDLs. The staff time translates into a cost of $7,576.

Outreach Costs for the Truckee River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.19	$10,707	State

The Truckee River TMDL is politically sensitive because of controversies involving water rights in the West. Since the activation of Derby Dam in 1915, the majority of river flow has been withdrawn for agricultural purposes. During times of rising population and increased nutrient loading, this has placed an ecological strain on the river. In particular, low dissolved oxygen (DO) levels have impaired the river's ability to support Lahontan cutthroat trout, a threatened species that supports a local recreational fishery, and cui-ui, a national endangered species that has historically been a staple in the diet of the local Pyramid Lake Paiute Tribe.

[11] The $50,000 model customization effort occurred in 1993. Converting to 1995 dollars using a price index for government purchases yields a cost of $53,094. The applicable portion (approximately 10%) of the modeling costs from prior efforts consists of $45,000 evenly distributed over the years 1985 to 1992. When converted to 1995 dollars, the $45,000 becomes $55,684.

In addition, other jurisdictional issues involving water rights, inter-basin water transfers, and preservation of wetlands have brought involvement of federal, state, and local government agencies. Government stakeholders include: the Pyramid Lake Paiute Tribe; Washoe County; the City of Reno; the City of Sparks; NDEP; the EPA; the U.S. Geological Survey; and the U.S. Army Corps of Engineers. To coordinate multi-agency interests, NDEP organized a Truckee River Strategy that included development of a framework for progress evaluation, establishment of water quality standards for the Truckee River, and preservation of the water quality within Pyramid Lake. TMDL development was discussed at Truckee River Strategy meetings and other meetings.

NDEP dedicated 400 hours of staff time to these efforts over a period of five years. Converting this staff time to cost and adjusting for inflation yields a cost of $10,707. The time dedicated by other organizations is not represented in this cost.

Public Participation Costs for the Truckee River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.02	$1,009	State

As a result of the politically sensitive nature of various aspects of TMDL development, extensive public participation activities were undertaken in addition to the Truckee River Strategy meetings discussed above, including placement of public notices and a presentation of the TMDL at a public hearing of the State Environmental Commission. NDEP dedicated 40 hours of staff time to these efforts. This translates into a cost of $1,009 in 1995 dollars

Administration Costs for the Truckee River TMDL		
In-house FTEs	Cost	Funding Source(s)
0.08	$4,117	State

Administrative costs associated with TMDL development included grant administration and staff coordination activities, as well as development of a rationale document to support and defend the TMDL. NDEP dedicated one month of one staff person's time to these efforts.

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YANKEE HILL LAKE, NEBRASKA

Key Features

Title:	Yankee Hill Lake.
Location:	Southeastern Nebraska; USEPA Region VII.
Size/Scope:	9.4 square mile watershed.
Comparative Size:	Small, ≤100 mi^2.
Pollutant(s):	Suspended solids, phosphorus, and nitrogen.
Sources of Pollutants:	Point sources—none.
	Nonpoint sources—agricultural lands and rural residential areas.
Model Use and Complexity:	AGNPS is the nonpoint source loading model and EUTROMOD is the receiving water quality model. These models are relatively simple.
Total Cost	$4,598 to date, plus $5,402 to cover ongoing monitoring and analysis efforts.
Funding Sources:	EPA nonpoint source TMDL Mini-Grant.

Summary

The Nebraska Department of Environmental Quality (NDEQ) is in the process of completing a TMDL for total suspended solids in Yankee Hill Lake. NDEQ received a mini-grant from EPA to develop a TMDL for the lake, which had been demonstrating high levels of pollutants from agricultural practices in the area.

Yankee Hill Lake is a small lake in a 9.4 square mile watershed and is approximately seven miles from Lincoln. The Army Corps of Engineers originally constructed the lake as a flood control project. Land use in the Yankee Hill Lake watershed is primarily agricultural, with some rural residential areas. The lake is protected for full-body contact recreation, agricultural water supply, and warm water aquatic life uses.

As illustrated in Table 14, NDEQ's total in-house effort on the Yankee Hill Lake TMDL to date is 0.18 FTE, for a total cost of $4,598. NDEQ expects to expend a total of $10,000. NDEQ has received substantial assistance from both the Army Corps of Engineers and the Natural Resource Conservation Service in the form of access to data, as well as a nonpoint source mini-grant from EPA in 1992 in the amount of $10,000. NDEQ will not exceed this amount in developing the TMDL, due to the relatively simple nature of the tasks involved.

Table 14. Summary of TMDL Costs for Yankee Hill Lake			
Activity	**NDEQ FTEs**	**Cost ($)**	**Cost as % of Total**
Monitoring/Data Collection	0.10	2,229	48.4
Modeling	0.02	465	10.1
Analysis	0.03	952	20.7
Administration	0.03	952	20.7
TOTAL	0.18	4,598	99.9*

*Cost as a percent of total does not add to exactly 100 as a result of rounding.

Cost Analysis

NDEQ staff believe that the Yankee Hill TMDL is fairly straightforward and that modest costs will yield successful results. NDEQ further believes that it can accomplish all its objectives with the $10,000 mini-grant.

NDEQ achieved substantial cost savings by obtaining data from federal agencies that were already actively monitoring the lake. In addition, NDEQ may be able to realize future cost savings, as some of the activities necessary to develop the TMDL can generate information that is useful for other water quality programs.

According to NDEQ staff, the expenditures on the TMDL to date are producing several positive impacts for the lake, including probable attainment of all water quality standards, extension of the life of the lake, and development of measures to lessen sediment loads.

Cost Breakdown

For the purpose of consistency among case studies, the TMDL development process is divided into the following six cost categories:

- Monitoring/Data Collection;
- Modeling;
- Analysis;
- Outreach;
- Public Participation; and
- Administration.

NDEQ has not conducted any outreach or public participation activities for the Yankee Hill Lake TMDL. Thus, only the other four cost categories are presented below.

Monitoring/Data Collection for the Yankee Hill Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.10	$2,229	EPA Mini-Grant

Costs associated with monitoring/data collection to this point consist of staff time to: (1) compile data that the Army Corps of Engineers and the Natural Resource Conservation Service had collected; (2) conduct additional in-house monitoring efforts to collect necessary data; and (3) conduct follow-up, evaluative monitoring. NDEQ was able to obtain ten years of data from federal agencies. NDEQ's own monitoring of the lake began in 1994, and is currently ongoing on a monthly basis.

NDEQ's cost for monitoring and data collection to date is based on one analyst working for 80 hours, one senior analyst working for 60 hours, and one intern working for 60 hours.

Modeling for the Yankee Hill Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.02	$465	EPA Mini-Grant

NDEQ used a relatively simple, two-stage modeling process. The agency employed the AGNPS model to evaluate event based nonpoint pollutant loadings and the EUTROMOD model to estimate annual loadings. The cost of running these models reflects 40 hours of work by one analyst.

Analysis for the Yankee Hill Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.03	$952	EPA Mini-Grant

NDEQ's analysis activities for the Yankee Hill Lake TMDL involved interpreting model results and prescribing BMPs for the watershed. The cost for these efforts is based on one senior analyst working for 60 hours (20 of which have not yet been logged as of June 22nd, 1995).

Administration for the Yankee Hill Lake TMDL		
In-house FTEs	Cost	Funding Source(s)
0.03	$952	EPA Mini-Grant

NDEQ's administration of TMDL activities to this point has involved one NDEQ senior analyst spending a total of 60 hours, to write reports and conduct manager related tasks.

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APPENDIX A
Interview/Data Collection Guide for TMDL Cost Study

For U.S. EPA's Office of Water, Apogee Research Inc., is preparing a report that (1) illustrates TMDL costs and (2) outlines methods for determining costs. Through case examples Apogee plans to explicate administrative, data collection, and other costs associated with TMDL development. The case examples include a variety of large and small-scale projects, simple and complex analyses, and cover a variety of different geographic regions. Drawing from the existing TMDL case studies, a listing of TMDL/nonpoint source mini-grant projects, and conversations with regional TMDL coordinators, the **{Insert TMDL}** has been selected for inclusion in this study.

To date Apogee has been collecting demographic and other background information on the selected TMDLs. Now we are requesting a phone interview with you and other staff involved in TMDL development, to (1) fill in any remaining "gaps" in the background information and (2) obtain more in-depth programmatic and cost information. We would be pleased to walk through the following questions with you and provide any additional information or explanations you might desire, or, feel free to respond to the questions in the spaces provided and fax your answers to Dennis Alvord at Apogee Research, (301) 654-9355.

GENERAL BACKGROUND

The following questions address demographic and other general background questions relating to many TMDLs. Responses to these questions will provide the comparative foundation for the cost study.

1.1) What level/type of public involvement did the TMDL development process entail (i.e., public hearings, volunteer activities, etc.)?

1.2) Was monitoring conducted as part of the TMDL process? What type and for how long? Who conducted the monitoring? Was monitoring conducted prior to the TMDL or special for the TMDL? Will there be follow up monitoring?

1.3) What model was utilized? Describe the modeling process undertaken? Could you have utilized a different model? Why/why not?

1.4) How many staff worked on the TMDL? How many hours per week do staff typically work?

1.5) Did consultants work on the TMDL? What was their role?

1.6) Did any other agencies work on the TMDL? What was their role?

TMDL DEVELOPMENT ACTIVITIES

For the purposes of this study we have broken TMDL development into the following seven categories:

- Modeling;
- Data Collection;
- Outreach;
- Public Participation;
- Analysis;
- Administration;
- Monitoring; and
- Miscellaneous.

Please feel free to revise the activity categories to match your TMDL process.

From these categories, we hope to generate an estimate of the level of effort necessary to fully implement the TMDL. For each activity, a table is provided indicating required information. For each category please provide estimates of

1) The number of staff who worked on the activity?
2) The amount of time (in hours, days, weeks, or months, whichever is most appropriate) they spent on it?
3) The average annual salary of the employee(s) working on the particular activity?
4) Any other expenses related to the activity (i.e., equipment, training, etc.)?

Additional space has been provided under each activity for your comments. An example is provided below.

EXAMPLE

ACTIVITY	Number of Staff	Total Time	Average Annual Salary	Other (specify)
Example	Fred Mary	2 weeks 1 month	$35,000	0

Comments:

2.1) MODELING

ACTIVITY	Number of Staff	Total Time	Average Annual Salary	Other (specify)
Modeling				

Comments:

2.2) DATA COLLECTION

ACTIVITY	Number of Staff	Total Time	Average Annual Salary	Other (specify)
Data Collection				

Comments:

2.3) OUTREACH

ACTIVITY	Number of Staff	Total Time	Average Annual Salary	Other (specify)
Outreach				

Comments:

2.4) PUBLIC PARTICIPATION

ACTIVITY	Number of Staff	Total Time	Average Annual Salary	Other (specify)
Public Participation				

Comments:

2.5) ANALYSIS

ACTIVITY	Number of Staff	Total Time	Average Annual Salary	Other (specify)
Analysis				

Comments:

2.6) ADMINISTRATION

ACTIVITY	Number of Staff	Total Time	Average Annual Salary	Other (specify)
Administration				

Comments:

2.7) MONITORING

ACTIVITY	Number of Staff	Total Time	Average Annual Salary	Other (specify)
Monitoring				

Comments:

2.8) MISCELLANEOUS

ACTIVITY	Number of Staff	Total Time	Average Annual Salary	Other (specify)
Other				

Comments:

GENERAL WATER QUALITY MANAGEMENT ACTIVITIES

The following questions address issues related to your programs overall work on TMDLs relative to other water quality management activities.

2.9) How many FTEs currently work on activities related to this TMDL?

2.10) What other water quality management activities are undertaken by your agency? If possible, please provide an estimate of the costs associated with undertaking these activities.

2.11) What percentage of your total water quality program is composed of TMDL related activities as opposed to other water quality management initiatives?

HISTORICAL AND PROJECTED REVENUE DATA

3.1) Please identify sources of funding for the year or years the TMDL was conducted (i.e., federal grants, state general revenues, local, private). If possible, please provide dollar amounts for those funding sources. An example is depicted in the shaded rows in *TABLE 3.1*. Space for your comments and/or explanations has been provided below the table.

3.1 Historical Revenue Data							
Funding Sources (Please List)	**Fiscal Year 1989**	**Fiscal Year 1990**	**Fiscal Year 1991**	**Fiscal Year 1992**	**Fiscal Year 1993**	**Fiscal Year 1994**	**Fiscal Year 1995**
Example: Section 319 Grant	$0	$0	$10,000	$15,000	$0	$0	$0
Example: State General Revenues	$3,000	$5,000	$8,000	$9,500	$7,350	$6,900	$3,750

Comments:

3.2) If the TMDL is ongoing, what plans are there for future funding?

Benefits

4.1) Please explain what direct and indirect benefits have been realized through the TMDL process (i.e., water quality improvements, scenic improvements, etc.)?