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KING COUNTY

ORANGE COUNTY SANITATION DISTRICT
PROTECTING THE ENVIRONMENT

SRCSD

Executive Summary

MULTI-AGENCY

Benchmarking Project

September 1999

September 1999

Dear Reader:

This Executive Summary presents findings of the Multi-Agency Benchmarking Project, a collaborative effort among seven large West Coast wastewater utilities. Initiated in 1997 and now in its second phase, the project was launched by three utilities a few years earlier (the Tri-Agency Benchmarking Project). Both phases had similar goals: to identify common work areas among utilities in the wastewater treatment business, develop tools to compare functions and costs, collect comparative data, and analyze the results.

The challenges were daunting. Each agency conducts its business with its own set of local conditions, regulations, politics, organizational strategies, and natural resource constraints. In recognition of these differences, tools to identify and categorize common functions had to be developed before any data could be gathered. This step was critical to producing cost data that could be meaningfully compared across the spectrum of participating agencies. Now that the data has been collected and analysis is under way, participants can begin to examine how they do business in new and enlightened ways.

This summary focuses on the project's findings. To help you better understand the findings, more background about the Multi-Agency Benchmarking Project and its goals is included in the introduction following this letter. An explanation of the methodology used and a profile of each participating agency are included as appendixes.

We, the project Steering Committee, feel it is safe to say that everyone involved in this project benefited far beyond their initial expectations. Individual agencies are understandably studying their own performance as reflected in these findings, but other benefits arose from the benchmarking process itself. Participants in the information-sharing process formed valuable relationships with colleagues and counterparts at other participating agencies, a byproduct that holds real promise for future collaborations.

Our thanks to all the participants in the Multi-Agency Benchmarking Project, now entering its third year. We hope you enjoy reading the results of our work.

Sincerely,

Multi-Agency Benchmarking Project

Executive Summary

Participating Agencies

Central Contra Costa Sanitation District
City of Los Angeles Bureau of Sanitation
City of Portland Bureau of Environmental Services
East Bay Municipal Utility District
King County Department of Natural Resources
Orange County Sanitation District
Sacramento Regional County Sanitation District

In Consultation With

DSWA DAMON S. WILLIAMS ASSOCIATES, L.L.C.
Consulting Civil and Environmental Engineers

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Acronyms and Abbreviations

BOD	biochemical oxygen demand
CCCSD	Central Contra Costa Sanitary District
CLABS	City of Los Angeles Bureau of Sanitation
CSO	combined sewer overflow
CPBES	City of Portland Bureau of Environmental Services
EDMUD	East Bay Municipal Utility District
FTE	full-time equivalent
FY	fiscal year
gpd	gallons per day
HHW	household hazardous waste
IU	industrial user
KCDNR	King County Department of Natural Resources
LIMS	laboratory information management system
mgd	million gallons per day
mg/L	milligrams per liter
mgy	million gallons per year
MOU	memorandum of understanding
NPDES	National Pollutant Discharge Elimination System
OCSD	Orange County Sanitation District
O&M	operations and maintenance
SIU	significant industrial user
SRCSD	Sacramento Regional County Sanitation District
TSS	total suspended solids
US EPA	United States Environmental Protection Agency

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Introduction

Since its formal introduction as a business practice in the 1950s, benchmarking has become an increasingly useful tool for both private and public sector organizations. There are now many types and ways to conduct benchmarking, but all of them arise from the same motivation: to improve an organization's performance.

Benchmarking is the systematic process of searching for the best practices, innovative ideas, and highly effective operating procedures that lead to superior performance.

Using the Water Environment Federation's definition, benchmarking is "the systematic process of searching for the best practices, innovative ideas, and highly effective operating procedures that lead to superior performance, and then applying those practices, ideas, and procedures to enhance the performance of one's own organization."

A Short History of the Multi-Agency Benchmarking Project

The Multi-Agency Benchmarking Project is a collaborative effort among seven West Coast wastewater utilities to compare their processes, performance, and costs. Recognizing the mutual benefits that could emerge, these seven participants agreed to share cost information in an effort to pursue some meaningful comparisons and ultimately create efficiencies for the ratepaying public.

The seven agencies that participated in the project include:

- Central Contra Costa Sanitary District (CCCSD)

- City of Los Angeles, Bureau of Sanitation (CLABS)
- City of Portland, Bureau of Environmental Services (CPBES)
- East Bay Municipal Utility District (EBMUD)
- King County Department of Natural Resources (KCDNR)
- Orange County Sanitation District (OCSD)
- Sacramento Regional County Sanitation District (SRCSD)

The benchmarking effort has been conducted in two phases, and this Executive Summary presents the findings of the second phase. In the first phase, three participating agencies (EBMUD, OCSD[1], and SRCSD) performed detailed benchmarking analyses to accurately and completely compare their respective operating costs. The three agencies, collectively known as the Tri-Agencies, developed a methodology to collect and compare operational costs between plants with different configurations, thus addressing one of the largest challenges faced by the wastewater treatment industry in benchmarking and comparative analysis.

The second phase, launched in mid-1997, expanded the project to include four more wastewater agencies (CCCSD, CLABS, CPBES, and KCDNR), which provided a more comprehensive collection of cost data. The Multi-Agencies collaborated to expand and refine the work done in the first phase of the project, allowing the participants to share information with confidence in the collection methodology used.

Why This Project Was Launched

By collecting and studying process and performance information, the participants intended to improve their own business practices, thereby reducing costs, gaining efficiencies, and ultimately improving service delivery to ratepayers. Secondary goals were to develop and foster open communications among participating agencies, leading to an ongoing commitment to exchange information among participants.

How the Work Was Accomplished

The participating agencies agreed on five shared functions for intensive study:

- Operations and maintenance;
- Engineering;
- Administration;
- Source control; and
- Laboratory.

A Work Group for each area of study was designated, recognizing that there would be some overlap among the areas. A Steering Committee (consisting of one person from each agency plus a lead or coordinator from each of the five Work Groups) was formed to oversee and direct the project. A consultant was retained to develop a database and assist the engineering and operations and maintenance Work Groups.

The first step for each Work Group was to collaborate on a tool or template that would allow each agency to account for its costs and business activities within a common framework, thus enabling across-the-board comparisons to be made more easily. Each agency was responsible for ensuring that all costs were accounted for in the data collection process.

The participants proceeded to perform both performance and process benchmarking. *Performance benchmarking* is the development of cost data for comparison purposes among the participants. *Process benchmarking* is a more subjective, analytical analysis of how each agency does business.

For consistency and accuracy, the cost data used in performance benchmarking was divided into five cost centers: operations, maintenance, technical support (including laboratory and source control), administration/general, and other non-wastewater treatment operating costs. Work Groups also conducted process benchmarking in the five functional areas noted above.

The Work Group reports, and selected findings from those reports presented in this Executive Summary, help shed light on differences in costs revealed by the performance benchmarking effort. Linking the two efforts provides context for understanding apparent differences in how agencies performed. It also helps provide direction for agencies to develop strategies for improving some practices.

See *Appendix A* for more details about methodology, including sample tools used in performance and process benchmarking.

1. In the first phase of this study, OCSD operated under the name "County Sanitation Districts of Orange County."

Understanding Benchmarking Data

Raw data without context is rarely a meaningful measure, and the data in this report is no exception. Each agency's performance is aided and constrained by its unique operating environment, including factors that may not be apparent in the data. The limits set by state and federal regulations on the kind and level of wastewater treatment an agency performs, for example, are one of the most important parameters within those differing environments, and over which individual agencies have no control. (Individual permit limits are discussed in the agency profiles in *Appendix B*.)

Other factors that can cause an agency's performance to compare favorably or unfavorably include differences in local regulations; organizational autonomy (some agencies pay overhead costs to a larger, umbrella organization); public involvement and mitigation programs; local prevailing costs for labor, power, chemicals, services, and parts; and participation in preventive, research, and innovative programs.

No cost data in this report refers to any of the participating agencies by name, but instead uses a letter designation for each agency whenever cost information is presented. This is in keeping with standard benchmarking practice and in consideration of the sensitive data presented here.

How to Use This Executive Summary

The information in *General Findings* presents some common findings that apply to all areas studied. Some of this information was presented earlier in the Multi-Agency Benchmarking Project Technical Memorandum, published in January 1999.

Immediately following, each of the five Work Groups presents select findings from their benchmarking efforts. The findings are preceded by details about each Work Group's individual methodology, and in some cases include specific recommendations. Some Work Groups included exhibits and figures in their report to support their findings.

The final section of the Executive Summary, *Recommendations for Future Phases of This Project,* recommends future benchmarking activities based on the experience of participants in phases one and two of the project.

Appendix A includes more details about the methodology used to accomplish the work. *Appendix B* contains an in-depth organizational profile provided by each participating agency. *Appendix C* is a list of project participants.

For Additional Information

Complete reports for each Work Group are available from Work Group or participating agency leads (see *Appendix C*).

Other publications that may be of interest include:

- *Multi-Agency Benchmarking Project Technical Memorandum*, published January 1999.
- *Tri-Agency Benchmarking Project Executive Summary*, published April 1997.
- *Benchmarking Wastewater Operations—Collection, Treatment, and Biosolids Management*, Water Environment Research Foundation, 1997.
- *Benchmarking: The Search for Industry Best Practices that Lead to Superior Performance*, Camp, 1989.
- *Water Environment & Technology*, Vol. 11, No. 7, July 1999, pp. 24—39.

General Findings

This Executive Summary contains selected findings from each of the five Work Groups (Operations and Maintenance, Engineering, Administration, Source Control, and Laboratory). Some general findings, however, were shared by all five Work Groups, or do not fit neatly into the purview of any single group. These findings are captured here, followed by summaies of the individual Work Group reports. Those summaries are followed by some recommendations for future phases of the Multi-Agency Benchmarking Project.

The opportunity to exchange information proved to be one of the most valuable aspects of the project.

Assessing Overall "Lessons Learned"

- **The value of exchanging information can't be overemphasized.** Participants receive valuable information for making process improvements during tours and meetings at various plant sites and extensive discussions about agency practices. Sharing experiences enables participants to learn from others' mistakes and avoid duplication of effort. While not wholly unexpected, the opportunity to exchange information proved to be one of the most valuable aspects of the project. Agencies interested in ways to compare performance with their peers could consider less formal arrangements to achieve the same goal.
- **Understanding how external factors influence data is critical.** All of the participants are affected in varying degrees by factors outside their immediate control. The lowest cost agency for any process, for exam-

ple, frequently enjoys a unique operational environment not available to others.

- **Good communications can improve performance.** Employees at agencies with clear and deliberate communications policies have more information about their agency's goals and initiatives, and consequently are better able to support those goals and initiatives.
- **Keep up with power deregulation issues.** Participants agreed that staying informed about potential changes in the electrical power industry is necessary to manage options and fully benefit from the trend toward deregulation.
- **Continue benchmarking efforts.** Participants in the Multi-Agency Benchmarking Project recommend benchmarking as one of the best avenues available to improve business practices and achieve superior performance. Continued benchmarking will measure changes and note trends resulting from improvements to optimize performance.

Calculating Costs of Wastewater Treatment

One of the first goals of the study was to compare total costs for wastewater treatment among participants. Collection system costs were not studied in this phase of the project and were not included as a component of the cost to treat wastewater.

In FY 1997, the average operating cost among participants to treat wastewater was $729 per million gallons treated, with costs ranging from $530 to $976 per million gallons (Figure 1). Figure 2 shows the average distribution of these costs by cost center among all agencies.

The total cost to treat wastewater includes these components:

- **Administration and general costs.** This category includes the costs for overall utility management and clerical functions, human resources, legal services, training, employee benefits (including sick leave, vacation, and holiday pay), and similar functions.

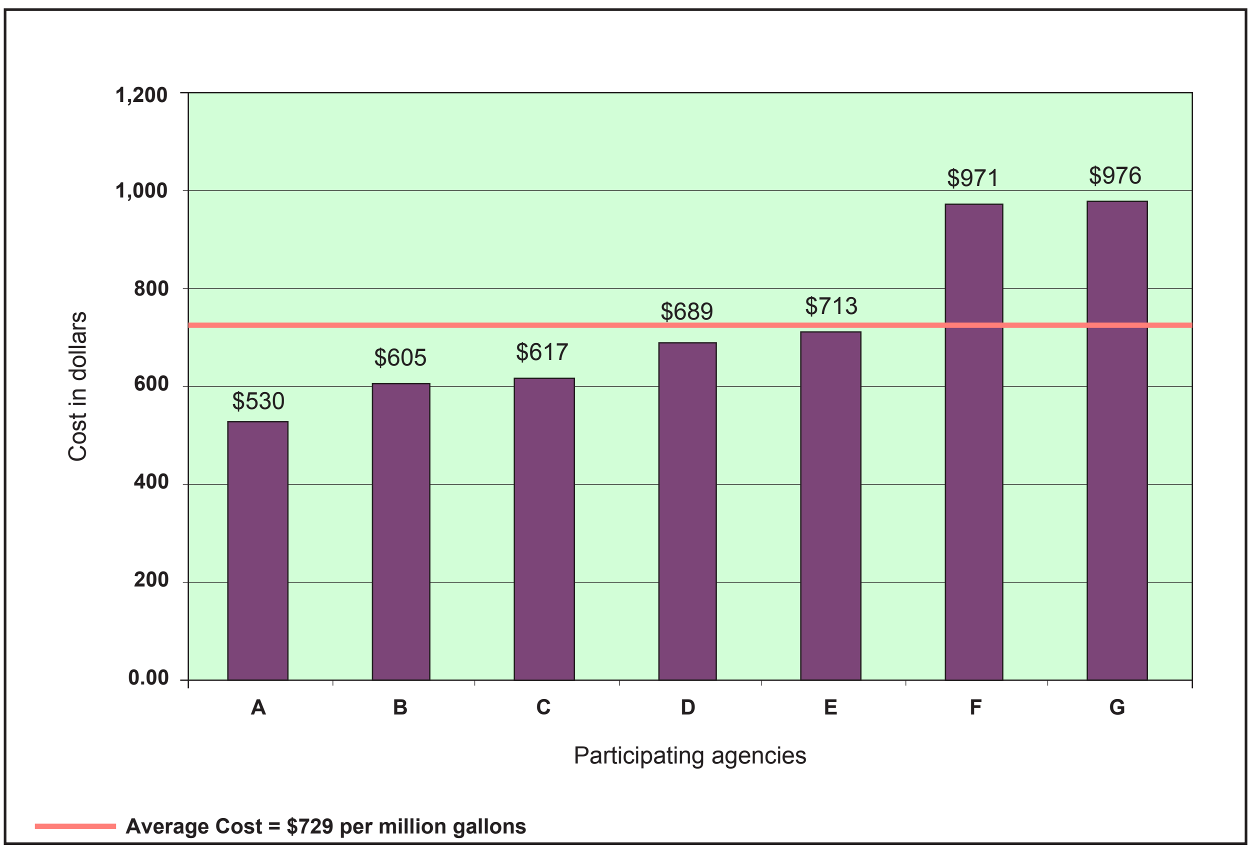


Figure 1. Comparison of Treatment Costs per Million Gallons Treated

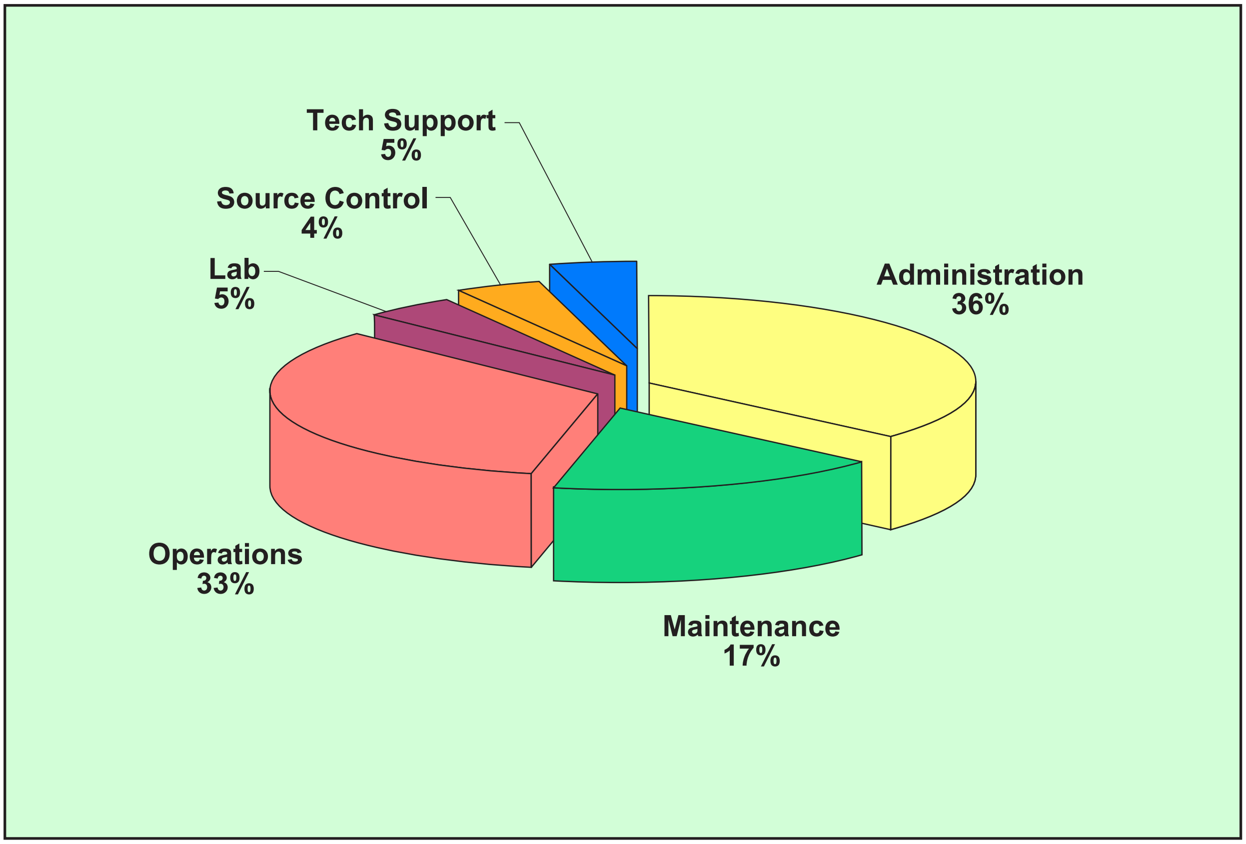


Figure 2. Distribution of Treatment Costs

- **Operations and maintenance costs.** All costs associated with operating and maintaining a wastewater treatment plant, including all unit processes, plant clerical support, and other functions such as landscape maintenance, are included here.
- **Laboratory costs**. The cost for laboratory services includes monitoring, research, and laboratory administration.
- **Source control costs**. This category includes the costs for core pretreatment programs, pollution prevention, and rate development and implementation.
- **Technical support costs**. Permit administration, regulatory compliance, research and development, and documentation are included as technical support costs.

Analyzing Accounting Practices

Some of the participants in the Multi-Agency Benchmarking Study use accounting systems that do not directly allocate costs to unit processes, making allocation of past expenditures more difficult. Some participants modified their existing systems to match the cost-collection template so that requests for this type of information could be accommodated more efficiently.

The participants identified these general findings and recommendations about accounting practices:

- **Develop or modify accounting or financial information systems.** Agencies should make necessary changes to use activity-based budgeting and tracking. Costs should continue to be tracked so staff can analyze how actions affect operational costs.
- **Analyze cost process data.** Cost collection data and the associated graphs and charts are significant benefits of the project. Participants should compare costs and question any differences. Investigating significant differences could improve operating practices and procedures. Initial efforts should focus on the largest cost centers because they offer the greatest potential for cost savings.
- **Low cost does not necessarily correlate to high efficiency.** Cost is driven by many factors, in-

cluding site constraints, policy decisions, and regulatory requirements.

- **Detailed tracking and allocation of costs is advantageous.** Some participating agencies can track and allocate all of their costs to specific cost centers, and can distinguish costs for core activities from costs for non-core activities. Being able to do so allows these agencies to more clearly evaluate the budget impacts of providing value-added services to customers, and to set policies accordingly.
- **Careful tracking of resources is beneficial.** Some participating agencies focus more on tracking and delineating resources, both internal and external, than others. Discussions and data tend to indicate agencies that track resources are in better control of them. Those agencies use such mechanisms as internal service agreements between departments, for example, and external agreements that clearly assign and allocate responsibilities between the agency and the contractor.

Improving Labor-Management Relations

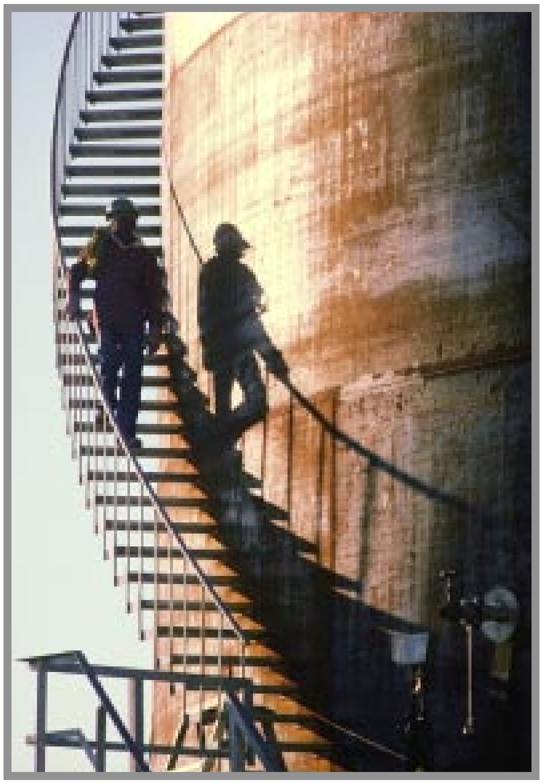
Some participants in the project successfully improved labor-management relations in the following areas:

- **Creative compensation packages.** Some participants have added innovations such as skill-based pay and gainsharing programs to their compensation packages. In addition to rewarding employees who improve their skills, participating agencies may benefit by being able to operate more efficiently with a smaller, better-trained workforce.
- **Alternative dispute resolution practices.** Innovations such as joint labor-management committees increase collaboration and cooperation. These practices can lead to improved decision making and better labor-management relations.

Striving to Improve Efficiency

All of the participants are either implementing or evaluating ways to be more efficient, including:

- **Restructuring.** Several participating agencies are now undergoing restructuring efforts to increase efficiency and decrease costs. These efforts include embarking on multi-year restructuring plans, changing business practices, and adopting targeted reductions. The results of these restructuring efforts are not reflected in this phase of the project but should be evident in future phases.
- **New technologies.** Keeping current with new technologies and practices is challenging but critical. Some of the participating agencies continually track and evaluate new technologies and business practices to determine their cost effectiveness.
- **Joint studies.** Joint studies among agencies, as well as in collaboration with environmental organizations such as the Water Environment Research Federation, enable participants to share the work and cost of evaluating alternative technologies and practices.



Operations and Maintenance Work Group

The operations and maintenance (O&M) of wastewater treatment facilities supports wastewater utilities' key mission. As shown in Figure 2, in FY 1997 each participating agency spent about 50 percent of its operating budget on plant O&M. Thus an agency's ability to improve O&M business practices should provide an exceptional opportunity for savings.

An agency's ability to improve O&M business practices should provide an exceptional opportunity for savings.

With that in mind, the O&M Work Group developed tools to effectively compare costs (performance benchmarking) and identify distinguishing factors and practices that strongly influence costs (process benchmarking). Linking business practices to cost is important in determining why one agency is more cost effective than others, and assists in the identification of best practices. The significant findings of the O&M Work Group are summarized here, as well as recommendations to improve O&M efficiencies and for future benchmarking efforts.

Methodology

The O&M Work Group developed a detailed data collection template to generate comparable costs (performance benchmarking). Regular meetings were held to refine the template and review cost allocations. Costs were allocated to the level of detail for which an agency provided information. Costs were normalized on the basis of process flow, tons of biochemical oxygen demand (BOD) removed, and other appropriate factors to make reasonable cost comparisons. Staffing levels, expressed as FTEs, were tracked in the template as a separate cost factor, along with energy, chemicals, materials, contracts, and miscellaneous. Maintenance cost factors included predictive maintenance, preventive maintenance, repair, parts, and miscellaneous. Only operating budget expenditures were used to compare costs in this O&M report; capital budget costs were not included.

Each agency completed 14 separate process benchmarking surveys, developed by the Work Group to collect detailed information on specific business practices. The subjects ranged from new technology development, automation, and information management to predictive maintenance, off-shift staffing, labor-management relationships, and biosolids.

O&M subcommittee meetings were routinely held at participating agencies' plant sites. Facilities tours during meetings of the O&M Work Group's subcommittees also provided a first-hand opportunity to learn about a facility's specific, and sometimes unique, O&M practices. These meetings were essential to developing comparable costs, understanding how work practices influence costs, and identifying "best practices."

Total O&M Costs and FTE Summary

Figure 3 presents total O&M costs and FTEs for each agency, normalized for influent flow volume, mass of BOD removed, and mass of total suspended solids (TSS) removed. Total O&M costs for the seven participating agencies averaged $367 per million gallons of influent flow, $478 per ton of BOD removed, and $418 per ton of TSS removed. Total O&M FTEs averaged 3.1 FTEs per billion gallons of influent flow, 2.06 FTEs per million pounds of BOD removed, and 1.79 FTEs per million pounds of TSS removed. The data, when compared against actual flow volumes, suggests economies of scale; that is, the higher-flow agencies tend to have lower normalized costs and staffing levels.

Figure 4 shows total O&M costs, divided between operations and maintenance activities, for each agency. Operations costs included direct operations labor as well as most non-FTE costs, such as energy and chemicals. Maintenance costs basically included maintenance labor and parts. Operations costs accounted for two-thirds of the total O&M costs, while operations FTEs accounted for half of all O&M FTEs, on average. Operations costs, as a percentage of total O&M costs, ranged from 57 percent to 80 percent. Operations FTEs, as a percentage of total O&M FTEs, tended to fall into two bands: either between 40 and 45 percent or between 55 and 65 percent.

The two participating agencies with the highest cost-per-million-gallons and FTEs-per-million-gallons had distinguishing circumstances that affected staffing levels and costs (see Figure 4, F and G). The participating agency with the highest percentage of operations FTEs among the participating agencies had a relatively high number of FTEs partly due to a union contract that prohibited any reduction in represented staff until the next contract negotiation. The other agency utilizes several sophisticated, high-technology processes that demand highly skilled O&M staff. The sophistication of the technology also suggests higher maintenance costs for repair and replacement. In fact, this agency had more maintenance staff than operations staff.

Significant Findings

O&M costs are strongly influenced by labor costs. Labor and staff costs constitute the largest component in O&M costs; other cost factors include energy, chemicals, materials, and contracts. This is true for most unit processes but not all (for example, secondary treatment). The influence of staffing on overall costs is apparent in Figure 3, which shows that the agencies with the highest total O&M cost per million gallons also had the highest FTEs per billion gallons. Various factors drive the number and cost of O&M staff, such as degree of automation, complexity of facilities, and labor contract provisions.

Most agencies find that increased levels of automation reduce operations staffing requirements, thereby reducing operations costs. Those participating agencies with the greatest workforce flexibility had the lowest maintenance costs in this study. Cross training all staff in the lower-level skills within each work unit can greatly decrease "waiting time" and equipment downtime, thereby decreasing labor costs. Greater collaboration between labor and management develops stronger relationships to better manage change and improve the workplace. Some agencies use novel business practices, such as gainsharing and skill-based pay, to involve employees in the "success" of an agency. All the agencies are working with staff to develop business practices that reduce overall costs by utilizing labor more effi-

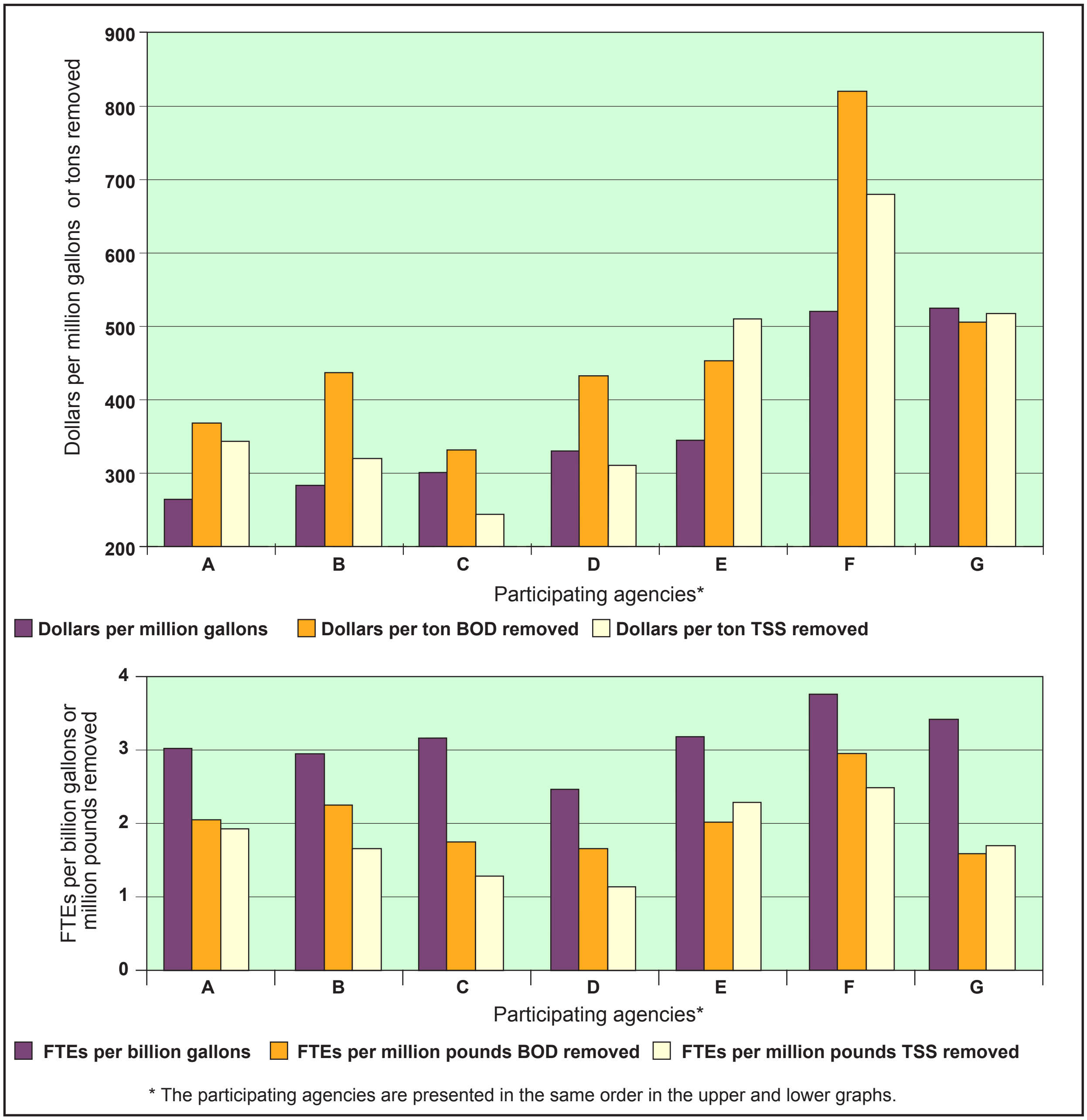


Figure 3. Total O&M Costs and FTEs per Influent Flow, Mass of BOD Removed, and Mass of TSS Removed

ciently. (Note: Costs associated with benefits and indirect labor expenses are not included in the O&M Work Group template; they are included in the Administration Work Group template.)

Recommendations to improve efficiency and reduce labor and staff costs include the following:

- **Efficient staffing.** Develop and implement reinvention plans that most efficiently utilize agency staff (for example, job progression, skill-based pay, cross-organizational teams, and off-shift staffing).
- **Training.** Invest and commit to programs that provide safety training, technical training, cross training, and business and cultural training.
- **Automation.** Increased automation should reduce operational staffing requirements. The effectiveness of increased automation must be weighed against the additional maintenance

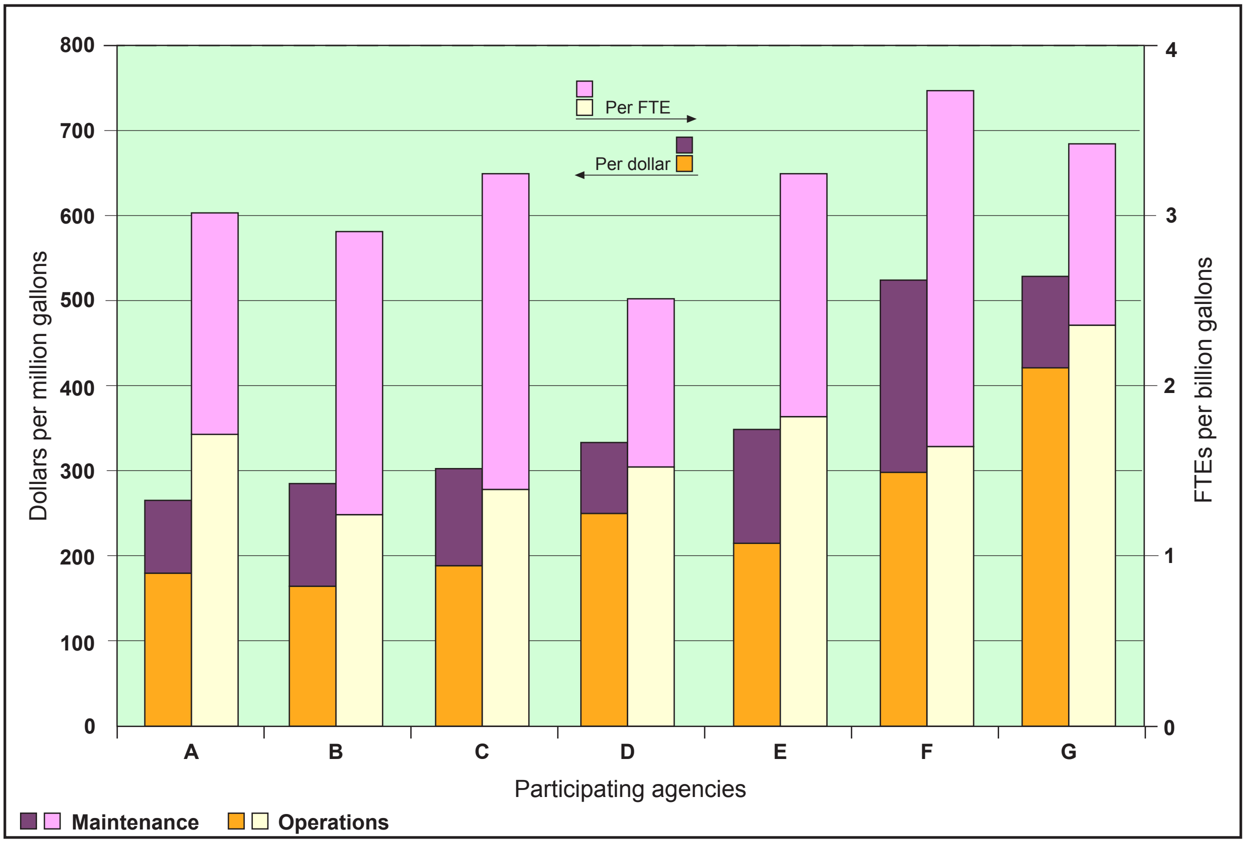


Figure 4. Comparing Operations and Maintenance Costs and FTEs

staff required. Hot backups should be installed to back up computer systems at critical facilities.

- **Flexibility.** Agencies with the greatest workforce flexibility realize the lowest maintenance costs. Maintenance work should be coordinated across all crafts and with operations to make the best use of equipment downtime.

Power costs are the second largest cost factor within total O&M costs. Costs can best be managed by accessing and producing cheaper energy, using more efficient equipment, and utilizing designs that require less energy. All the participating agencies have slightly different approaches to managing energy at their facilities, depending upon energy costs and demands, regulatory requirements, treatment processes, technology, and unique conditions. The different approaches vary from using purchased gas to generate 100 percent of the energy needed onsite to 100-percent reliance on offsite electricity with digester gas sales to gas utilities. These different approaches and conditions make it difficult to accurately compare efficiencies and effectiveness, except between specific generation facilities.

Onsite generation is a reliable, low-cost source of power. It is especially cost effective for facilities with high power rates. Agencies that generate all (or nearly all) of their power requirements onsite using digester gas (and supplemental natural gas) to run steam turbines had the lowest energy costs among the participants. Internal combustion co-generation is less reliable and requires considerably more maintenance. Some facilities sell digester gas to neighboring power-generation facilities and purchase power at wholesale prices. Deregulation of the energy market should help most of the agencies reduce their energy costs into the early 21st century.

Many factors that influence energy costs are difficult to manage. For example, colder wastewater requires less energy to aerate. A facility that depends largely on gravity for conveyance will have lower energy demands than systems that require pumping. And power costs tend to be driven by regional power rates. Even with all these uncontrollable influences, facilities can improve their energy usage by using more energy-efficient equipment and operating equipment at its optimum range. Specific actions include taking facilities offline, using variable frequency drives, minimizing equipment operation during peak hours, negotiating power costs, and designing facilities to minimize energy consumption.

On average, secondary treatment uses more energy than any other process. Thus, efforts to reduce energy used in secondary treatment and lower unit-power costs can achieve significant savings. Agencies with air-activated sludge have reduced their energy costs significantly by installing high-efficiency blowers and fine-bubble diffusers. Also, surface mixers are more efficient than submerged turbines for mixing and aerating pure-oxygen activated-sludge systems.

Recommendations for using power more efficiently and reducing costs include the following:

- **Diffusers and blowers**. For air-activated sludge, install fine-bubble diffusers and, where blowers are used, install high-efficiency blowers with inlet and outlet guide vanes.
- **Facilities**. Change the number of in-service units to match the flow and load conditions. Facilities that are designed to operate in wet-weather conditions realize costs savings when some systems and/or processes are not operated in dry weather.
- **Steam turbine technology**. Use steam turbine technology for power generation; it is more reliable and requires lower maintenance than internal combustion, engine-driven technology.
- **Gravity**. Whenever possible, use gravity for conveyance to and within the treatment plants.
- **Competitive bids**. Encourage competition with multiple bidders for energy sources.

Residuals processing and handling account for nearly 39 percent, on average, of all O&M costs. Residuals processing and handling includes sludge thickening, digestion, dewatering, haul and application, incineration, and grit and screenings disposal. The proportion of the O&M budget dedicated to residuals processing and handling has increased at participating agencies over the past years. This increase is due to lower costs in liquids processing and higher costs in residuals processing, handling, and management. Liquids processing costs have dropped due to more energy-efficient equipment (such as fine-bubble diffusers) and more efficient operation due to automation. Residuals costs at the participating agencies have increased primarily due to higher biosolids reuse costs, a function of haul and application costs, and new regulations and policies. The higher reuse costs, in turn, have triggered higher dewatering costs to produce a drier biosolids product. Also, odor control costs for residuals processing and handling are higher than those incurred for liquids processing.

Figure 5 presents residuals costs for the seven participating agencies normalized for tons of raw dry solids produced. Residuals processing costs vary considerably between the agencies, ranging from \$47 to \$188 per dry ton of raw sludge or solids, with an average of \$119. The agency in this study with the lowest residual costs uses digested sludge lagoons and onsite disposal; it plans to retrofit existing dedicated land disposal areas with clay liners and continue its practice of onsite disposal. The participating agency with the highest residual costs also had the highest dewatering costs (due to high polymer demands) and highest reuse costs. Interestingly, the agency that utilized incineration did not have the highest reuse cost.

The seven participating agencies have tried various approaches both inside and outside the treatment facility to reduce overall residuals costs. To gather information on these approaches, a process benchmarking survey on biosolids was completed by each agency. One agency experienced a 30-percent decrease in biosolids reuse costs when multiple bidders competed for the contract. Two agencies have installed high-solids centrifuges to produce drier biosolids. Some agencies claim that adding ferric chloride before primary treatment reduces the dry tons and wet tons of biosolids hauled, and provides odor control. Two agencies use ferric chloride and have lower residuals costs than most of the other participating agencies. One agency eliminated a composting program that was extremely costly and inefficient to operate and maintain. Another agency will convert from centrifuge thickening to gravity belt thickening to reduce costs. Several agencies use biosolids storage hoppers to allow multiple hauling contracts.

Regulations, policy, and public perception have a major impact on biosolids disposal and reuse. Efforts to reduce residuals costs and, most notably, reuse costs, must be weighed against the risks inherent in such dynamic environments. Land use issues, especially in California, may have a strong impact on disposal and reuse of biosolids in the near future. The site where two participating agencies apply the majority of their biosolids, just passed legislation to ban all land application of Class B bio-

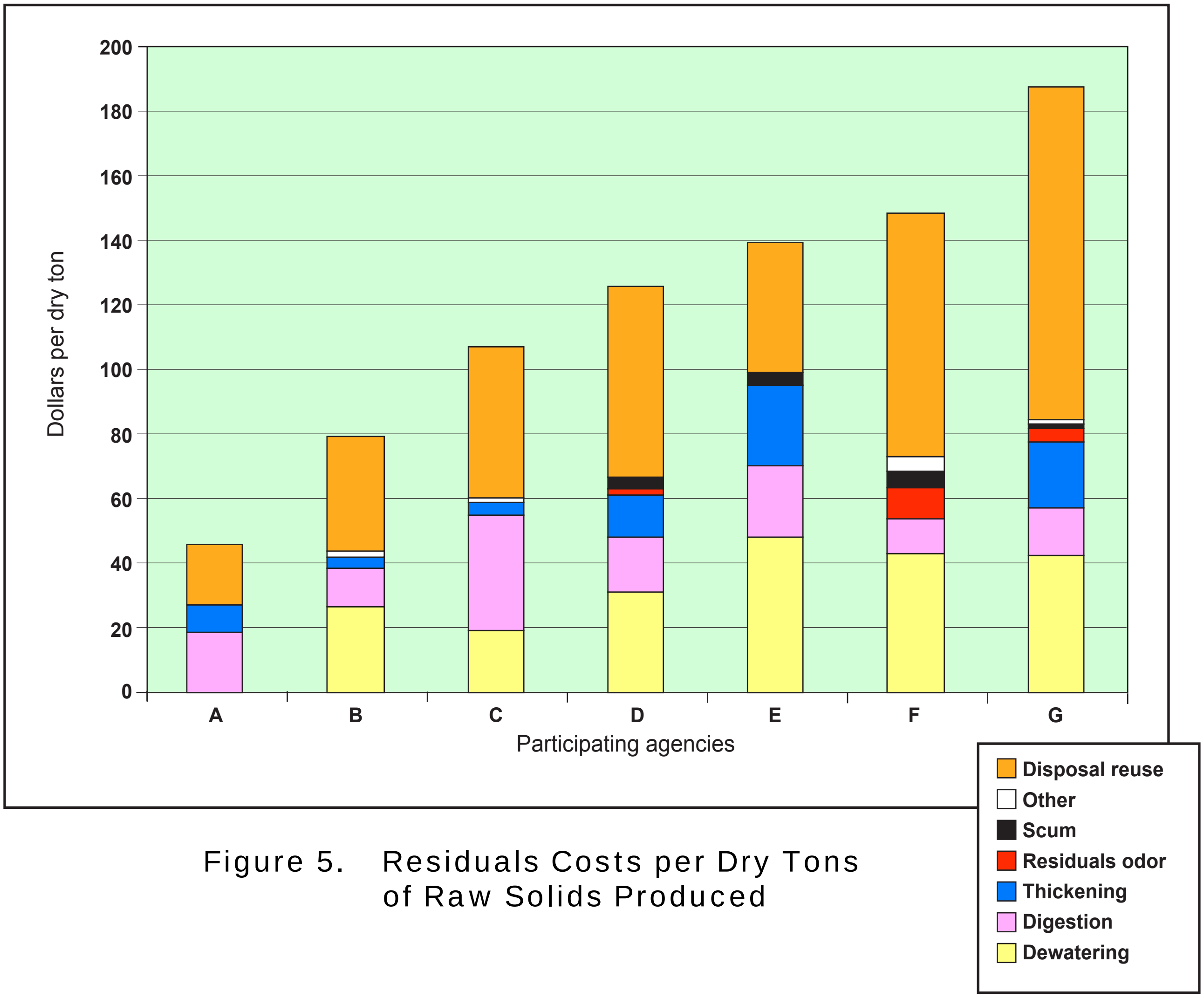


Figure 5. Residuals Costs per Dry Tons of Raw Solids Produced

solids in three years. Another agency operates under a settlement agreement to reduce biosolids truck trips to five per day, which has increased operating costs. Actively participating in outreach programs and nurturing long-term relationships with contractors, users, regulators, and the public has helped the participating agencies manage some of these issues.

Recommendations for managing residuals more efficiently and cost effectively include the following:

- **Competitive bids.** Seek competitive bids from multiple bidders to reduce biosolids hauling and application costs. Install biosolids storage capacity to take advantage of multiple haulers.
- **Diversity**. Plan diverse biosolids disposal and reuse programs; alternative reuse methods must balance risk with cost to provide a safe, acceptable alternative to current methods.
- **Change.** Future approaches for biosolids processing and reuse will need to consider costs, regulations and permitting, technology, markets, and marketing. These may be in a constant state of flux as these issues interrelate. The ability to effectively manage change may provide both program reliability and competitive cost control.
- **Class A biosolids.** The generation of Class A biosolids opens up more ultimate reuse or disposal options and may decrease hauling costs in exchange for higher capital and processing costs. Continue to evaluate the potential markets for, and the costs and benefits associated with, Class A biosolids.
- **Collaboration.** Be active and work together to develop new regulations affecting the wastewater industry.

- **Outreach.** Promote long-term relationships with contractors, regulators, farmers, and the public. Participate actively in outreach programs that market biosolids and educate the public.
- **Inspections**. Offsite inspections using in-house staff have identified potential problems and compliance issues and prevented violations. These inspections also reduce the possibility that contractors "filter" or "block" information.

Secondary treatment accounts for about 16 percent of all O&M costs on average, is the highest energy use of any process, and is one of the higher cost processes in the treatment plant. In this study, secondary treatment costs averaged $50 per million gallons of secondary flow and $117 per ton of secondary BOD removed (the range is from $80 to $144 per ton). The cost to produce and/or transfer oxygen into wastewater is the largest cost factor. Agencies with air-activated sludge have reduced their energy costs significantly by installing high-efficiency blowers and fine-bubble diffusers. Agencies with pure oxygen systems have reduced costs by renegotiating oxygen production contracts, converting to surface mixers, and cycling mixer operation. A limited turndown capability on an oxygen production facility can limit savings in energy costs. Pure oxygen systems, in general, are more expensive to operate than air systems because of the energy required to produce oxygen and maintain the oxygen generation plant. Oxygen plant selection has often been predicated on land use and air emissions restrictions. Trickling filters are significantly less expensive to operate than either air- or oxygen-activated sludge. However, trickling filters need a considerable footprint and do not routinely meet 30/30 discharge permit limits; only one facility in the study uses trickling filters.

Other factors also have an impact on secondary costs and performance. Two agencies use enhanced primary sedimentation (that is, ferric chloride and polymer addition) to decrease secondary loads, and thus aeration costs. Because of their NPDES permits (60 mg/L SS and 100 mg/L BOD), these agencies also have the advantage of providing secondary treatment to only part of their influent flow. (One of the two agencies will provide 100-percent secondary treatment by year-end 1999.) Aeration costs are also relatively low because none of the permits require ammonia reduction or nitrogen removal. In fact, all of the facilities use a common approach: avoid nitrification. Aeration costs and oxygen production costs would substantially increase (and could potentially double) if a facility were required to nitrify.

Recommendations to improve efficiency and reduce costs include the following:

- **Energy-efficient equipment.** Convert to high-efficiency blowers and equipment to reduce energy costs.
- **Surface aerators**. Use surface aerators for pure oxygen dissolution to help decrease energy usage.
- **Onsite oxygen generation**. If operating a high-purity-oxygen activated-sludge process, evaluate the cost of generating the oxygen onsite using plant staff.
- **Clarifiers**. Design secondary clarifiers with some reserve capacity to provide operational stability. (The clarifiers should be 18 to 20 feet deep, and operate at an overflow rate of 400 to 600 gpd per square foot.)
- **Membrane technology.** Evaluate membrane technology in lieu of secondary clarifiers.

Chemical addition in the plant influent (such as ferric chloride) has multiple benefits, and may substantially reduce overall operating costs. Ferric chloride and anionic polymer addition for enhanced primary treatment have significantly reduced total operating costs at two of the participating agencies and offset the cost of the chemicals. The major savings using advanced primary treatment has been the capital cost savings in reduced secondary treatment costs. One agency that implemented advanced primary treatment had a 25 percent decrease in BOD to secondary treatment, and was able to shut down 25 percent of its secondary facilities.

Ferric chloride and anionic polymer can significantly increase primary solids removal, which reduces both secondary aeration costs and secondary sludge production. Residuals processing and handling costs, even with the additional chemical sludge, also appear to be lowered due to the greater proportion of primary to secondary sludge (primary sludge digests and dewaters better than secondary sludge). These agencies have minimal expenditures for additional solids-stream odor control.

The overall reduction in operating costs easily offsets the cost of chemicals. In fact, primary treatment costs (per dry ton of SS removed) with chemicals are similar to costs without chemicals because of the additional solids removed. One agency, which adds ferric chloride without polymer, has not experienced the benefits that the two agencies that use ferric chloride and anionic polymer addition have enjoyed. It appears that some polymer addition is necessary to obtain the enhanced primary removal benefits. Other agencies have attempted enhanced primary treatment with other chemicals, such as alum. Their success has varied because of high wet-weather flows and low-alkalinity water.

Recommendations related to chemical addition include the following:

- **Pilot studies.** Other agencies should perform pilot studies to determine if chemical addition can be an effective process for reducing overall operating costs, even on a seasonal basis.
- **WERF.** Provide joint agency input to Water Environment Research Foundation projects to research process optimization efforts.

Disinfection and dechlorination costs vary greatly due to NPDES permit requirements, safety concerns, and product cost. Disinfection and dechlorination costs primarily depend on NPDES permit requirements and secondarily on product cost. Permit requirements vary widely among the participating agencies, ranging from a stringent 23 per 100ml total coliform and 0.018 mg/L chlorine residual to permits that do not require disinfection. Less stringent disinfection requirements are often tied to more aggressive receiving water monitoring requirements, such as extensive ocean monitoring programs.

Chlorine and sulfur dioxide are very economical. However, safety and regulatory concerns (including EPA's Process Safety Management) have compelled several agencies to convert to the more expensive hypochlorite/sodium bisulfite or ultraviolet (UV). Product cost also varies among agencies. Two agencies pay almost twice as much for bulk chlorine as does another agency in the study; that agency significantly lowered its cost for bulk chlorine by bidding jointly with other public agencies.

Disinfection and dechlorination costs equal 3 to 5 percent of total O&M costs for most of the agencies. For the two agencies with very stringent permit requirements, however, these costs account for 13 and 15 percent respectively of their total O&M costs. The highest cost agency in the study ($78 per million gallons) has subsequently reduced its disinfection and dechlorination costs by renegotiating its permit. Also, effective automation and instrumentation are necessary to minimize the amount of disinfectant used and thus lower the amount of dechlorinating agent required. The participants will continue to improve automation as technology improves.

Recommendations include the following:

- **Instrumentation.** Continue to invest in instrumentation to improve chemical dosing and reduce overall operating costs.
- **Permit conditions.** Actively work with permitting agencies to renegotiate permit conditions that protect receiving water quality but reduce disinfection and dechlorination requirements.
- **Chemicals**. The use of chlorine and sulfur dioxide must be balanced against the safety, public perception, and risk management issues associated with storing and handling these chemicals.
- **Purchasing**. Encourage market competition for bulk purchase of chemicals by promoting multiple bidders and using joint contracts.

Standardizing equipment and systems can lower operation and maintenance costs. The ability to standardize equipment types has the potential to significantly reduce O&M costs by reducing inventories and parts costs and simplifying the procurement process. Additional savings in training and inventory management can result from reducing the number and types of systems and equipment used. However, the procurement laws and policies within which public agencies must operate limit that potential.

All of the agencies must follow state purchasing laws that require competitive bidding and open competition to ensure the lowest possible purchase price. Such laws make efforts to standardize more difficult, even when proven experience suggests certain products have inferior quality or a higher life-cycle cost. In addition, some agencies are clearly more restricted than others by specific local requirements; that is, by requirements imposed by local jurisdictions or economic development programs.

The prequalification process, though it does not allow for sole source purchasing, can provide more avenues to ensure that new equipment can meet reliability and performance standards. Because the successful integration of new equipment or facilities depends on purchasing specific equipment or technology, sole source purchasing can often be justified with the approval of appropriate management, purchasing personnel, or governing body.

Standardization of equipment and systems alone may not reduce overall costs. Specific equipment and systems (that is, brands and manufacturers) must be evaluated within a specific application based on operating and capital costs.

Recommendations include the following:

- **Standardization.** Work within the current purchasing policies and laws to maximize the opportunities to standardize equipment and systems.
- **Asset management**. Implement asset management programs that incorporate life cycle replacement, equipment criticality, spare parts inventory, standardization, and purchasing.
- **Outreach**. Work with other agencies to educate policymakers and lawmakers on the benefits of standardization.

The agencies with the lowest maintenance costs in the study have dedicated staff to plan preventive and corrective maintenance work, and perform the highest percentage of preventive maintenance. Reactive maintenance is more expensive than planned maintenance because it often includes additional costs for overtime and priority shipping of parts, materials, and services; it may also increase the risk of discharge permit violations. Thus an efficient, cost-effective maintenance program should perform more planned maintenance than reactive maintenance. To that end, a dedicated maintenance planning effort should reduce reactive and emergency maintenance work, and increase the amount of planned maintenance that is performed.

The lower-cost participating agencies in the study make use of dedicated maintenance staff to provide job planning and schedule preventive maintenance. They coordinate seasonal or exceptional work with all maintenance disciplines (as well as operations) to provide maximum use of equipment downtime and system outages. In most cases, a craft-level lead staff is responsible for day-to-day activities of individual maintenance personnel and for managing the work order backlog. An effective maintenance planner should have a high degree of technical knowledge or trade experience to adequately serve the needs of the maintenance disciplines. Scheduled maintenance activities should also reduce the costs associated with purchasing and storing inventory. Predictive maintenance technologies or tools, such as vibration analysis and infrared sensors, will further help planning efforts by forecasting failure and identifying causes of failure while equipment is in operation. Best maintenance practices will place the highest priority on preventive maintenance tasks. However, based on established criteria, such as process criticality or safety related concerns, certain corrective maintenance activities will take priority over preventive maintenance activities. Figure 6 shows how the participating agencies distributed their maintenance workload between the various types of maintenance.

Specific recommendations for maintenance practices include the following:

- **Staffing**. Dedicate maintenance staff to plan preventive maintenance and repairs to equipment, using criticality as a measure to establish priorities among equipment.
- **Asset management**. Implement asset management programs that incorporate life cycle replacement, equipment criticality, spare parts inventory, standardization, and purchasing.
- **Preventive maintenance**. Assign the highest priority to preventive maintenance activities.

Optimization efforts should focus on the higher cost processes, such as secondary treatment and biosolids reuse, and the primary cost centers for energy and chemicals. The seven participating agencies are continually trying to improve efficiency and cut costs at their facilities by studying alternative equipment, systems, and operating schemes. These optimization efforts are usually more focused on the higher cost processes because those processes hold the greatest potential for savings. In fact, most of the focus has been on the secondary treatment process, residuals processing and handling, energy, and chemical purchasing. Most of the agencies have significantly reduced secondary aeration costs by installing more energy-efficient equipment, such as fine-bubble diffusers. Many of the agencies have significantly reduced biosolids hauling costs by encouraging multiple hauling contract bidders. In fact, more of the studies or demonstration facilities are focused on solids handling facilities.

For many processes or systems, a benefit analysis can focus primarily on the unit process. However, for most alternatives, optimization efforts should be evaluated based on plantwide impacts. For example, the benefits of enhanced primary sedimentation are truly realized in the secondary treatment process and residuals processing. Another example is dewatering, where performance can have a significant impact on biosolids hauling costs and the other plant facilities due to recycle streams. Any analysis of new equipment, including new facilities, should be based on life cycle costs, including maintenance.

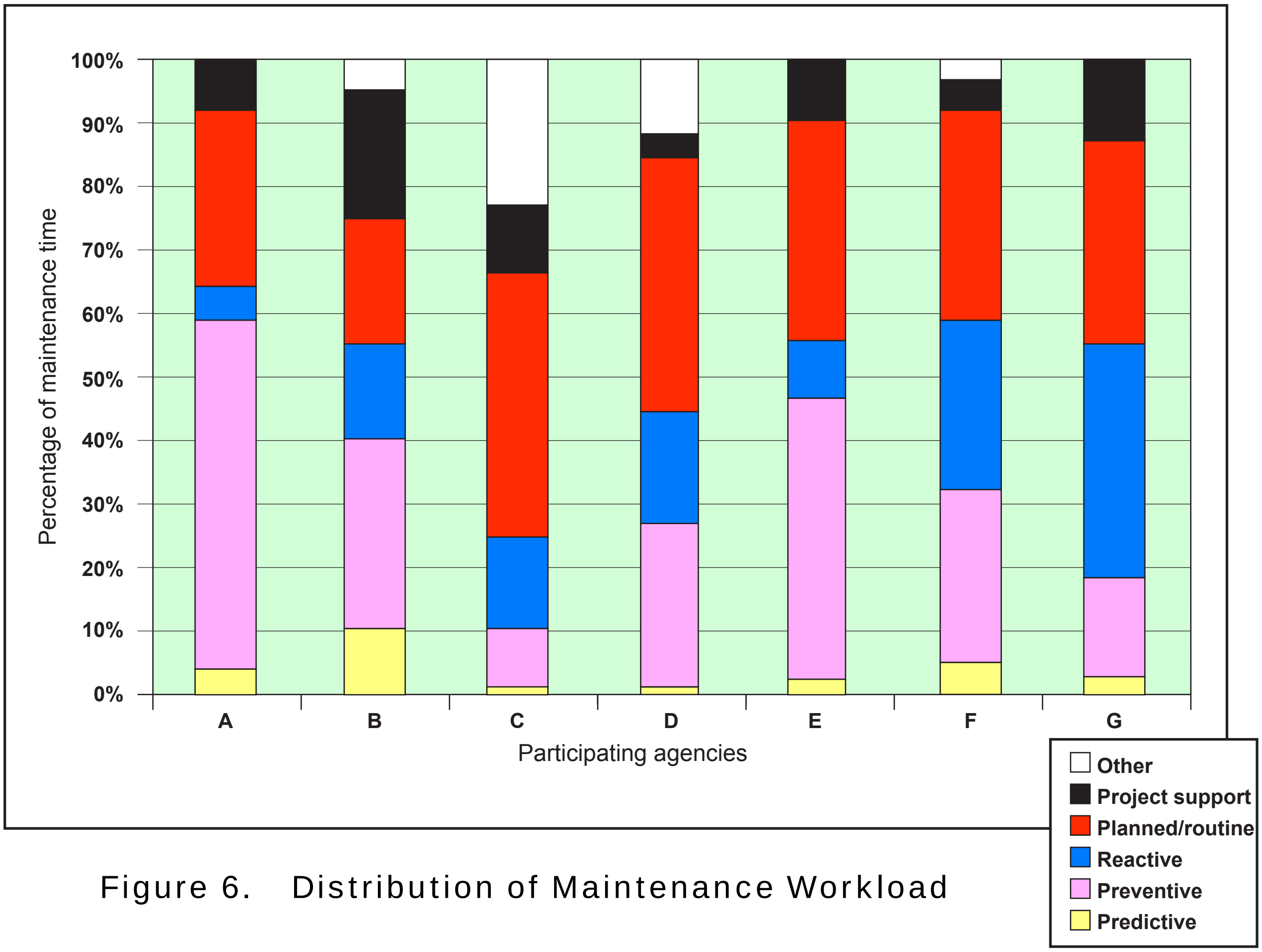


Figure 6. Distribution of Maintenance Workload

Recommendations for Further Study

The O&M Work Group recommends that future phases of the benchmarking project include the following:

- **Annual updates.** Update benchmarking data annually; longer-term trends will provide a stronger database from which to reliably evaluate data and the effectiveness of optimization efforts.
- **Tools.** Continue to refine the benchmarking tools. Refine the process benchmarking surveys and analysis, and develop tools to assess the effects of changes implemented as a result of this study.
- **Templates**. Modify and improve templates for future years to include other areas such as collection systems, water reclamation, and so on.
- **Additional processes.** Commit adequate time to unit processes not fully analyzed in this phase of the study, such as odor control, water reclamation and conservation, tertiary treatment, information technology, labor-management relations, and capital projects and O&M.
- **Definitions.** Develop standard and uniform definitions for maintenance activities among the participants, such as wrench-on-bolt time, planned maintenance, predictive maintenance, reactive maintenance, preventive maintenance, and so on.
- **Standards.** Establish maintenance standards for optimum efficiency, such as ratio of preventive to breakdown work.
- **Financial management.** Implement O&M-friendly financial management systems consistent with O&M templates.
- **Participating agencies.** Expand the number of agencies participating in the Multi-Agency Benchmarking Project by targeting agencies with similar capacities.

Engineering Work Group

The Engineering Work Group selected 72 capital program engineering projects for inclusion in its study.

Methodology

The Work Group divided projects into two types: collection system projects or treatment plant projects. Only projects designed, constructed, and completed within the last 10 years were included.

Surveys were used to collect process benchmarking data in 12 areas, including:

- Capital improvement program development.
- Partnership and dispute resolution.
- Customer identification.
- Document management.
- Authority levels.
- Change order processing.
- Consultant procurement.
- Staffing.
- Construction contract approval.
- Project management.
- Alternative capital project delivery methods.
- Inspection duties.

Some agencies improve efficiency by preparing tight scopes of work within their consultant agreements and aggressively managing projects to prevent changes in the scopes of work.

Challenges in Comparing Engineering Data

When comparing data, the Engineering Work Group tried to account for different labor rates, hiring requirements, decision making practices, and project types among the participating agencies.

- To normalize regional labor rate differences for both in-house staff and consultants, the Work Group compared project construction costs to the total hours spent by both in-house staff and consultants for each of the projects studied.
- The Work Group recognized that some of the participating agencies operate with no minority/woman-owned business enterprise goals and requirements.
- The staff at some participating agencies receive more authority from their umbrella governing board for capital projects than other agencies. These agencies also tend to have a culture that supports timely decision making at relatively low levels in the organization.
- Some agencies tend to have more repetitive projects, which helps lead to lower costs. These agencies also have less formal project management procedures, although the Work Group found consistent filing systems among participants.

Selected Engineering Work Group Findings

- **Change orders.** Change orders in some agencies are regularly deferred to future contracts and only nondiscretionary change orders are completed. The percentage of change orders varies widely for both collection system projects and treatment plant projects as well as within individual agencies, indicating that change order percentages may be affected more by the specifics of a project than by a particular management approach. Some agencies also experience lower markups on change orders because they include a limit on markups in their contract specifications.
- **Consultants**. Some agencies use streamlined processes for consultant procurement, particularly for smaller projects. The Work Group's findings indicate that as construction costs increase, the participating agencies tend to use more outside consultant hours than in-house staff hours. This approach to efficiency may be taken to help an agency avoid major staffing fluctuations.
- **Scope control**. Some agencies improve efficiency by preparing tight scopes of work within their consultant agreements and aggressively managing projects to prevent changes in the scopes of work. This approach also applies to managing changes during construction.
- **Staffing.** Some agencies try to account for staff hours by linking all staff hours directly to assigned capital projects, but also use overhead charge codes for work not attributed directly to projects.
- **Effect of design costs on change orders.** The Work Group studied graphs of design costs versus construction costs as related to change order percentage, and found them relatively flat. This indicates that spending more on design does not necessarily reduce the percentage of change orders. Change orders related only to design issues were not categorized in the Work Group template, so no accurate correlation can be drawn between the design effort expended and the value of design-related changes.

Recommendations for Further Study

The Work Group recommends additional study to determine whether deferral of change orders to future contracts is more efficient in the long run than incorporating changes with work in progress.

Administration Work Group

The Administration Work Group was assigned the task of collecting the administration and general costs not specifically identified in any of the other templates.

Methodology

The Work Group's first task was to develop its template and definitions to ensure the closest possible cost comparisons. The administration template includes the traditional administrative categories of management, human resources, safety, training, legal, security, clerical, accounting, finance, communications, travel, rents and leases, insurance, and general overhead. All benefits including medical, retirement, sick leave, holiday, vacation, and any other kinds of leave were collected in this template. Collecting the benefit time in this template allowed the other Work Groups to include just direct labor in their templates, thereby providing more accurate comparisons between agencies. See Figure 7 for a comparative graph of benefit and administration costs.

Once the administration template was completed, the group performed performance benchmarking by assigning all relevant operating dollars to the template. Three rounds of collecting, comparing, evaluating, and refining data were held. Data was normalized by plant flow. Identifying and assigning the costs to the template proved to be somewhat more difficult for this group than anticipated, due to differences in organizational structure and accounting systems and methods. For this reason, the Administration Work Group, perhaps more than any other Work Group in the study,

Though the participants' administrative departments have similar responsibilities, differences in organizational structure, financial information systems, and business procedures all have a significant impact on the distribution of costs.

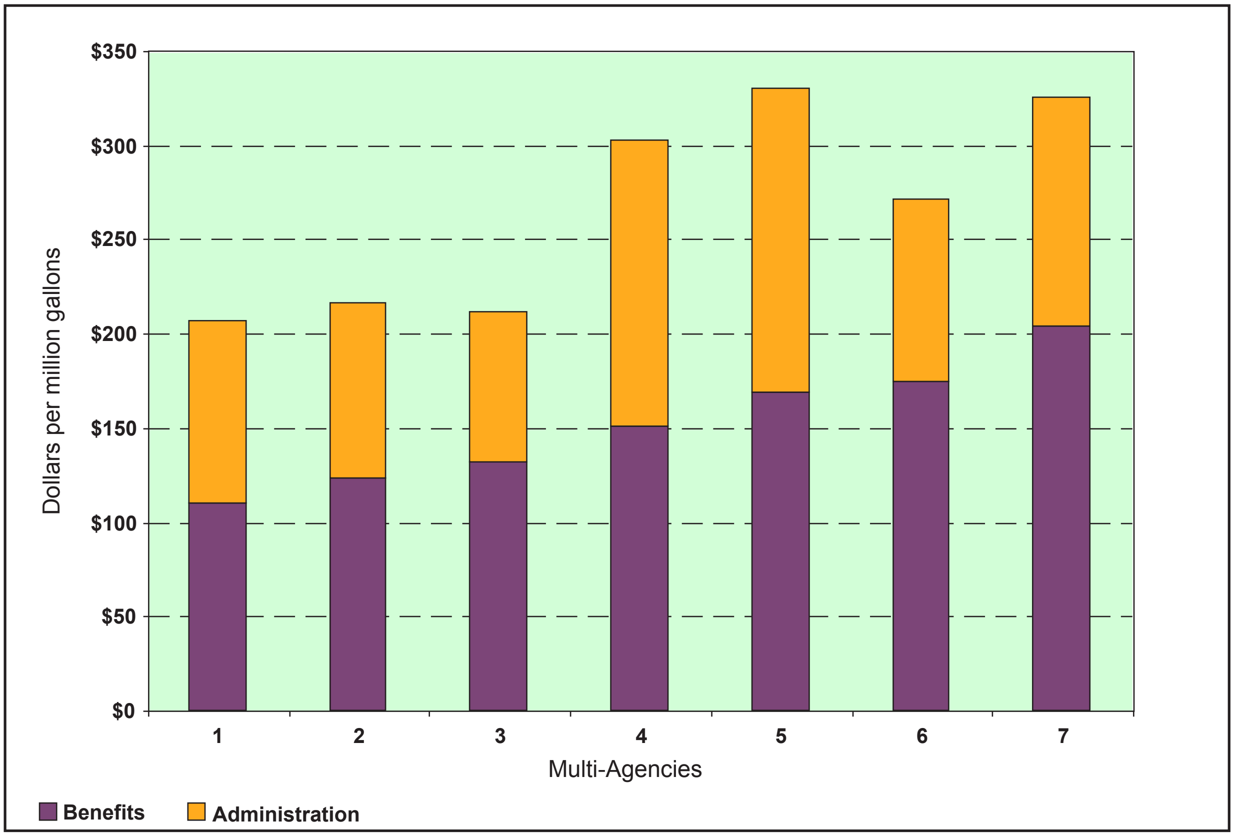


Figure 7. Benefits and General Administrative Expenditures

found the process benchmarking and general discussions significantly more valuable than studying the numbers in the performance benchmarking phase of the project.

While performance benchmarking covered all general administrative areas, process benchmarking efforts focused on the basic support functions common to all agencies that significantly impact the day-to-day wastewater treatment business—the people and financial support systems. Payroll, purchasing, accounts payable, financial information systems, budgeting, training, rates and revenue, bond rating, and reserves were all included. Surveys were developed and information collected to identify some very practical "best practices" that could be adopted by other agencies to improve service and cost effectiveness.

A feature unique to this group is that of control. Unlike other Work Groups whose members are directly in charge of the business being studied, understood, and improved (such as the Operations and Maintenance Work Group), the Administration Work Group members did not possess that kind of authority. As a result, the group focused primarily on documenting costs and practices, providing linkages to the responsible parties in the agencies, and highlighting some practical, potential business improvements.

Findings and Conclusions

The Administration Work Group found the overall normalized administrative costs were fairly similar for the participating agencies, but the cost distribution among the various functional areas differed. Though the participants' administrative departments have similar responsibilities, differences in organizational structure, financial information systems, and business procedures all have a significant impact on the distribution of costs. For example, some agencies reflect more of their costs in "overhead" than others, attributable either to how services are obtained (internal or external) or how costs are collected within their accounting systems.

Factors unique to each of the agencies also contributed to differences in some of the data. One example is the ability of some agencies to bill customers using the tax rolls, a practice that appears to be very cost effective in comparison to agencies that must contract for monthly billing services from within their agencies. Other examples are administrative building ownership versus leasing, and the variance in security requirements at different locations. Evolving business practices resulting from the increasingly widespread use of computers appeared to have an impact by lowering general clerical costs. Also, clerical costs ranked low for some agencies because specialized clerical support costs were collected under the corresponding functional area, such as accounting, maintenance, or training.

The Work Group reached other comparative conclusions. The cost of providing benefits ranked highest for all but one of the agencies. Communications costs ranked fairly high (fourth or above, out of 14 costs compared) for all but one of the agencies. This category included support for management information systems, public information, and internal and external communication. Travel and conference costs ranked low (12th or below, out of 14 compared) for all of the agencies. Though training costs ranked in the top half for all agencies, the Work Group generally felt that greater understanding is needed about how training needs are identified, attendees are selected, and training translates into improved skills or work habits.

Most agencies track staff time very carefully, especially on capital projects, and are researching electronic methods and systems to improve efficiency and accuracy. Nearly every agency was either in the process or preparing to install a new payroll or full financial information system. Tracking staffing costs is clearly an area of major concern, activity, and expenditure for all participants.

Recommendations

Based on its review of administration performance and process benchmarking information, the Administration Work Group recommends these best practices:

Purchasing and accounts payable

- **Use credit cards for routine purchasing**. Three agencies already utilize credit cards, and several others are investigating this possibility. Increased simplicity, efficiency, timeliness, flexibility for purchasers, and reduced accounting costs are realized by eliminating many of the steps and much of the paperwork usually required to purchase items and process payments.
- **Set goals for discounts and, if possible, penalties for not meeting those goals**. Nearly all groups reported problems with timeliness of payments and subsequent problems with vendors. Participants sited establishing goals for the percentage of early payment discounts as the one successful strategy that addressed this problem. Another agency uses a cross team that publishes monthly reports on the discount amounts achieved.
- **Ensure accounting staff dedicated to wastewater are assigned.** For improved access and communication with the purchasing and accounts payable groups, having purchasing and accounting staff dedicated to wastewater proved beneficial for quick troubleshooting as well as addressing ongoing issues.

Payroll

- **One-time entry to feed all information systems.** While no agency participating in the project now has one-time entry, all consider this a goal. All participating agencies are now in the process of implementing, or will soon be implementing, new payroll systems.
- **Strongly consider tying payroll systems to the benchmarking template**. Several participating agencies have already tied their systems to the benchmarking template; others are considering it. Given that all participating agencies are implementing new payroll systems, the opportunity is immediate.

Internal service level agreements

- **Secure written agreement with centralized support services** to spell out the work to be performed, by whom, the expected performance measurements, and important milestones. Not every agency used this technique, but those who did reported improved service and communication and recommend it.

Budgeting

The Administration Work Group's basic concern is that there is too much non-value-added work in the budget process. Some recommendations include:

- **Encourage multi-year rather than annual budgeting.** Most Work Group members felt that there are usually few significant changes from one year to the next, and therefore raised questions about the level of value in annual exercises.

- **Level of budget detail**. Questions were also raised about the level of budget detail and amount of time spent tracking and reporting.

Areas for Further Study

The Work Group considered these areas fruitful to pursue in greater detail in future phases of the project:

Inventory and warehousing

- Geographical and organizational location relative to the plants.
- Staffing levels.
- Inventory levels.
- General business practices.

Billing procedures and costs

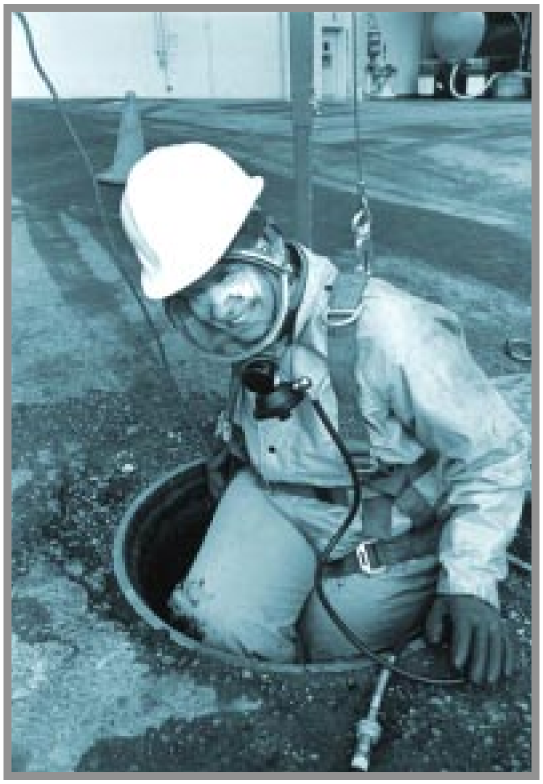
- How to improve service and lower costs.

Training

- Coordinating and tracking.
- Assessment and selection.
- Tying to workplace; personal improvement.

Capital vs. Operating Costs

Every Work Group discussed how to define and assign costs to capital vs. operating budgets. The Administration Work Group was asked to address this during the next phase of the project.



Source Control Work Group

Any publicly owned treatment works with a design flow of 5 mgd that receives pollutants from industrial users is required by federal regulations to develop and implement a pretreatment, or source control, program. Source control programs control discharges of wastewater from nondomestic sources into a public sewer system to protect people, the environment, and the treatment works from harmful discharges.

The minimum requirements for a source control program are detailed in the Code of Federal Regulations and are an enforceable condition of a discharge permit. Minimum requirements include legal authority, sufficient funding, local discharge limits, permits or other control mechanisms, procedures to sample and analyze discharges, an enforcement response plan, and procedures to identify industrial users. The federal government grants some latitude about how each of the program requirements is achieved, but the basic program elements must be in place.

An agency's NPDES permit may contain added requirements such as program reporting, special studies, or development of a pollution prevention program. Once approved, a program must be fully and effectively implemented at all times and cannot be modified without approval from the appropriate oversight agency. A significant change in source control program resources would be considered a modification of the program.

The cost of source control activities may be offset by the avoided costs for repairing damaged sewer lines, adding treatment equipment, increasing the use of treatment chemicals, recycling and disposing of biosolids, or adding air pollution control equipment.

Source control activities represent a small percent of most agencies' budgets (approximately 4 to 5 percent), with most of those costs being for labor. Many source control programs are at least partially funded by user fees assessed on the industrial dischargers. The cost of source control activities may be offset by the avoided costs for repairing damaged sewer lines, adding treatment equipment, increasing the use of treatment chemicals, recycling and disposing of biosolids, or adding air pollution control equipment.

Challenges in Comparing Source Control Data

The cost of a source control program depends on many variables, including the policies of the regional US EPA office and the state oversight agency, the types and number of industries in the service area, the percent of flow from industrial sources, and the agency's NPDES permit requirements. In addition, discretionary activities (such as collection system sampling and pollution prevention) and policy choices (such as the type and vigor of enforcement actions) contribute to a program's cost.

These activities result in programs that are substantially different in scope and emphasis, making performance benchmarking difficult to assess in all but qualitative terms. Therefore, performance benchmarking for source control is best used to measure improvements in an agency's own performance from year to year rather than to assess differences among agencies.

Identifying Non-Traditional vs. Core Program Areas

All the source control programs represented in this study include the traditional elements of a pretreatment program required by federal pretreatment regulations. In addition, some programs have additional responsibilities related to user service charges and implementation of nontraditional source reduction or pollution prevention programs that target commercial or residential sectors. The Source Control Work Group recognized these differences in program scopes among participants and established a separate process to evaluate a subset of the traditional or "core" pretreatment program. This "core" area consisted of permitting, inspection, sampling, enforcement, and septage hauling programs, plus the special studies, administration, data management, reporting, and other activities supporting these elements. The Work Group could discern actual differences in program performance more easily by examining the core pretreatment program data.

Selected Source Control Work Group Findings

Cost of Total Source Control Program vs. Core Pretreatment Program

Figure 8 shows the resources spent by the agencies on both total source control and core pretreatment programs. The Work Group found more variability among the costs for the total source control programs than the costs for the core pretreatment programs. The highest cost agency (C) for the core pretreatment program was not the highest cost agency (A) for total source control. Some of the change in ranking between total source control program and core pretreatment program can be accounted for by policy decisions on whether to regulate small dischargers (non-significant industrial users, or non-SIUs) through the core pretreatment program or through a pollution prevention program. Agency C permits, inspects, and samples non-SIUs through its core pretreatment program, while other agencies control small dischargers through their pollution prevention programs. Agency A, the highest cost source control program in the study, drops to fourth in terms of dollars spent on its core pretreatment program. Agency A administers a large, mandated pollution-prevention program that includes issuing pollution prevention permits, and develops and implements the agency's wastewater rate and charges. Agency B, the second-highest-cost agency for total source control costs, drops to fifth in cost for the core pretreatment program. Agency B's large pollution prevention program is part of its local hazardous waste management program rather than part of its pretreatment program. Agency F, which expends the fewest dollars on core pretreatment, has a program that focuses on large dischargers, has few local limits, and performs limited permitting and inspection of non-SIUs.

Issuing Permits

Two significantly different ways to issue industrial user permits were found among the participating agencies: issuing one permit per industrial facility, resulting in one permit with multiple sampling points; or issuing one permit per sampling site, resulting in multiple permits per facility. This difference complicated interpretation of several benchmarking measurements.

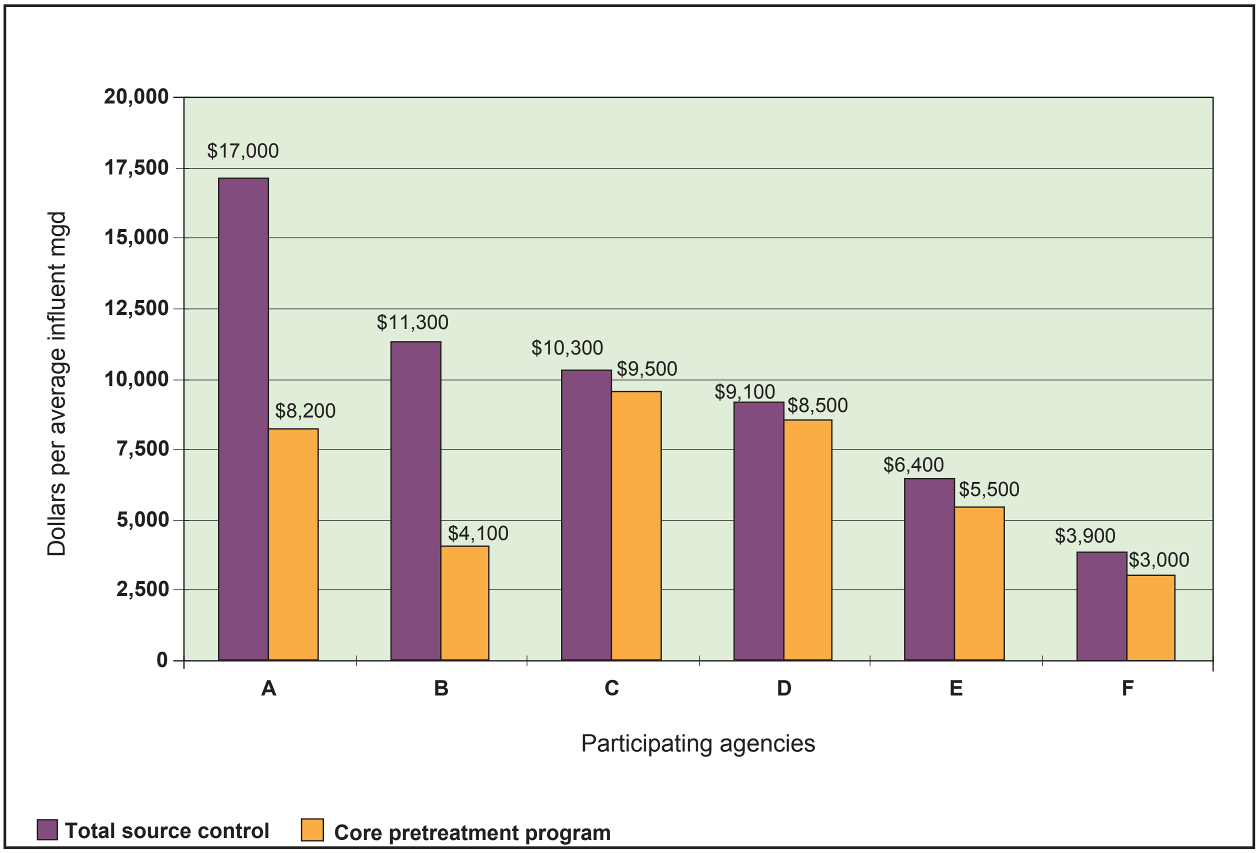


Figure 8. Total Source Control Costs and Core Pretreatment Program Costs per Average Influent mgd

The number of SIU permits and the number of categorical (federally regulated) permits per FTE are shown in Figure 9. Both local and federal categorical permits show a considerable range among the agencies, from a high of 172 local permits per FTE to a low of 32 local permits per FTE, and from a high of 160 categorical permits per FTE to a low of 28 categorical permits per FTE. Agencies C and D issue a permit to each sample site; agencies B, E, and F issue only one permit per facility no matter how many sample sites. Agency A follows a philosophy that lies somewhere in between those two approaches. The situation is further complicated by differing philosophies toward combining wastestreams into single sample sites; some agencies encourage dischargers to combine wastestreams and others discourage combining them.

A large facility with many sampling sites requires more effort to permit than a small facility with a single sample site, regardless of whether or not one permit or multiple permits are issued. Reviewing files and regulations, visiting the site, consulting with the company representatives, making decisions on permit limits, and developing a fact sheet constitute the majority of the work. Producing the permit document is a relatively small portion, especially using an automated process.

Agency F, with 32 local SIU permits and 28 categorical permits per FTE, attributes its low number of permits per FTE to its philosophy of focusing on the large dischargers. Agency D, with 172 local SIU permits per FTE, issues permits to a number of companies for rate implementation purposes only.

Agency A attributes its higher number of categorical permits compared to local permits per FTE (160 compared to 91) to the fact that all its categorical permits are the same category; discharge less than 10,000 gpd; occupy only one building, each with one sample site; and are stable companies. Differences in timekeeping also account for some of the differences in Agency A's numbers for both local SIU and categorical permits. Agency A recorded time spent on pollution prevention and rate implementation under those respective categories in the template rather than the "permit" category. Since time spent on pollution prevention and rate implementation is an integral part of permit processing and helps bring a company into compliance, this appears to reduce the amount of core permitting activities. Agency B, which also has an extensive pollution prevention program, focuses on smaller companies that do not have permits. As a result, the pollution prevention effort does not reduce permit processing time. Agencies C and D include some pollution prevention efforts in their permits and charge that time to permit processing rather than pollution prevention.

Inspection and Sampling

The Work Group found significant differences in how agencies organized the work of inspecting and sampling, but no further comparisons could be made because agencies count inspection and sampling events differently. The Work Group determined that further analysis of these activities could highlight some best practices that could reduce some agencies' labor requirements.

Figure 10 shows the normalized data for the number of inspection and sampling events per FTE. In this graph, these two activities were combined because some agencies could not differentiate between time spent on inspection activities and time spent on sampling events. Two factors were calculated, one for categorical (federally regulated IUs) and one for local SIUs. In analyzing this graph, the Work Group identified differences in a number of areas:

- **Definition of inspection.** The lowest cost agencies, A and B, include all types of field visits as inspections, including visits to verify that IUs under enforcement have installed pretreatment equipment and taken follow-up corrective actions. The remaining four agencies included only field visits that were full and complete inspections.
- **Sites and facilities with multiple discharge points.** Agencies C and D included inspections at a facility with multiple regulated sample points as multiple inspections. Agencies B, E, and F included inspections at a facility with multiple regulated sample points as one inspection. Agency A utilized a combination of both approaches.
- **Inspection teams.** Agency C utilized teams of two inspectors to perform inspection and sam-

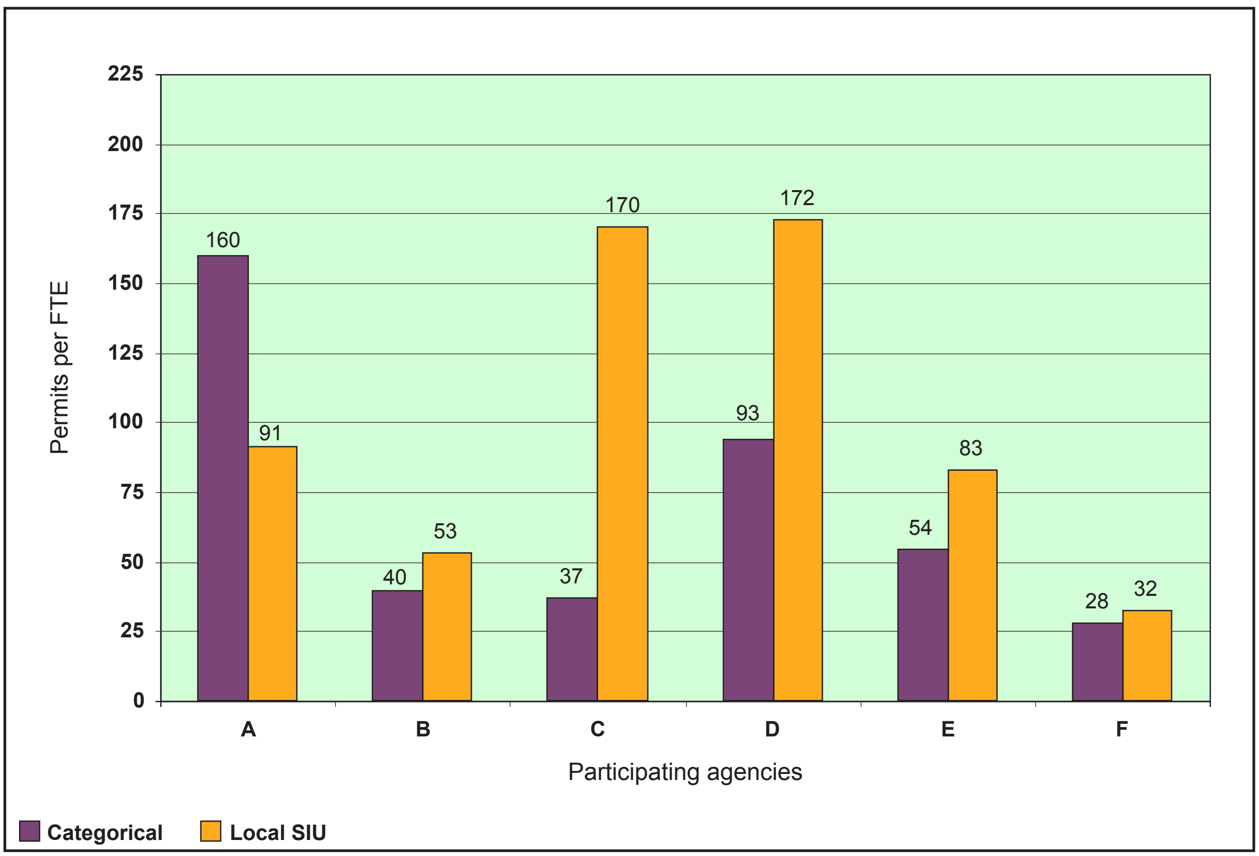


Figure 9. Number of Permits per FTE

pling. Agency E utilized teams for sampling and single individuals for inspections. All other participants generally utilize individuals, not teams, to conduct inspections and sampling. Agency C utilizes teams of two inspectors to perform inspection and sampling.

- **Surcharge sampling.** Agencies C and E perform surcharge sampling separately from compliance sampling. Agencies A, B, and D perform surcharge sampling at the same time as sampling for local and federally regulated pollutants, and consider the visit to be one sampling event. For the other agencies, surcharge sampling and compliance sampling occurred at different times and therefore counts as separate sampling events. Agency F relies on surcharge self-monitoring and does not perform surcharge sampling.
- **Number of grab samples.** Agencies B, D, and F collected four grab samples each for CN and total toxic organics. Agencies A, C and E collected only one grab sample each for CN. Although taking four grab samples to determine compliance is more time consuming, it may be necessary to ensure that violations will be upheld in court.
- **Duration of inspection.** Agencies D and F conduct inspections that may sometimes require an additional day or days to complete, and consider them as one inspection event.
- **Inspection and sampling.** Agencies A and C perform inspections and IU sampling during the same site visit. Agencies B, D, E, and F perform inspections and sampling separately, at different times. Agencies D and F utilize the same staff to perform inspection and sampling; however, inspection and sampling are done at different times. At Agency B, inspections and sampling are performed by different job classes. At Agency E, sampling and inspection activities are performed by different job classes assigned to different divisions.

Because of the many factors affecting normalizing the inspection and sampling results, it was difficult to isolate whether inspections and sampling performed at different times, by different job classes, or by contracting with another division created efficiencies/inefficiencies or cost savings/increases. The

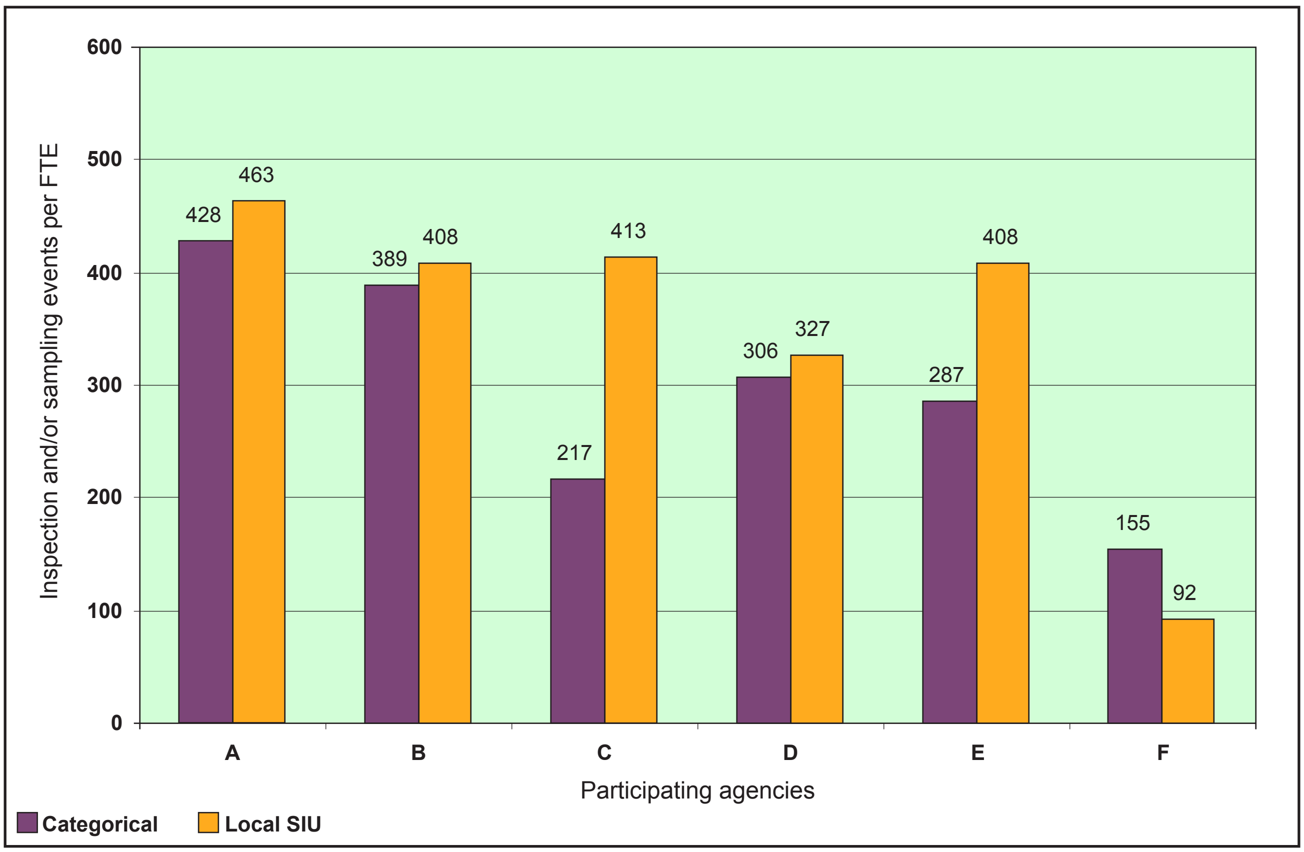


Figure 10. Number of Inspection and/or Sampling Events per FTE

Work Group recommends further evaluating these areas in future benchmarking efforts as part of a more detailed process analysis.

Enforcement Actions

Differences in policies and procedures for pH enforcement, reporting violations, and compounds that do not affect the treatment plant led to significant differences in the number of enforcement actions per permit.

Figure 11 shows the number of enforcement actions per permit for both categorical (federally regulated companies) and local SIUs. The Work Group found that the number varied from 0.3 per permit to 2.1 per permit. The group chose the number of enforcement actions per permit for comparison because the industrial compliance rate can significantly affect effort expended in all areas of a source control program. (The number of enforcement actions is directly related to the number of violations.) Companies out of compliance require more inspections, more sampling, and more time.

With the exception of Agency D, the resources applied to enforcement, when normalized for the number of permits, were nearly identical for categorical and local SIUs. This indicates that the differences can be explained by factors other than industrial classification. Agency D indicated that it directs relatively little enforcement effort towards its local SIUs because they are included in the program primarily for rate purposes.

Several agencies indicated that violation rates, and therefore enforcement actions, have decreased over time. Firm and consistent enforcement was identified as the primary reason for the reduced number of violations. A significant percentage of violations for two of the agencies with the highest number of enforcement actions per permit were for pH violations. Differences in pH monitoring and enforcement procedures rather than actual differences in compliance are probably the cause. Participating agencies have received differing interpretations of the rules about pH enforcement from federal and state EPA contacts. The highest-ranked agency indicated that the majority of its reported enforcement actions were for low-level warning notices; the data does not reflect the resources spent per enforcement action. Another participating agency in-

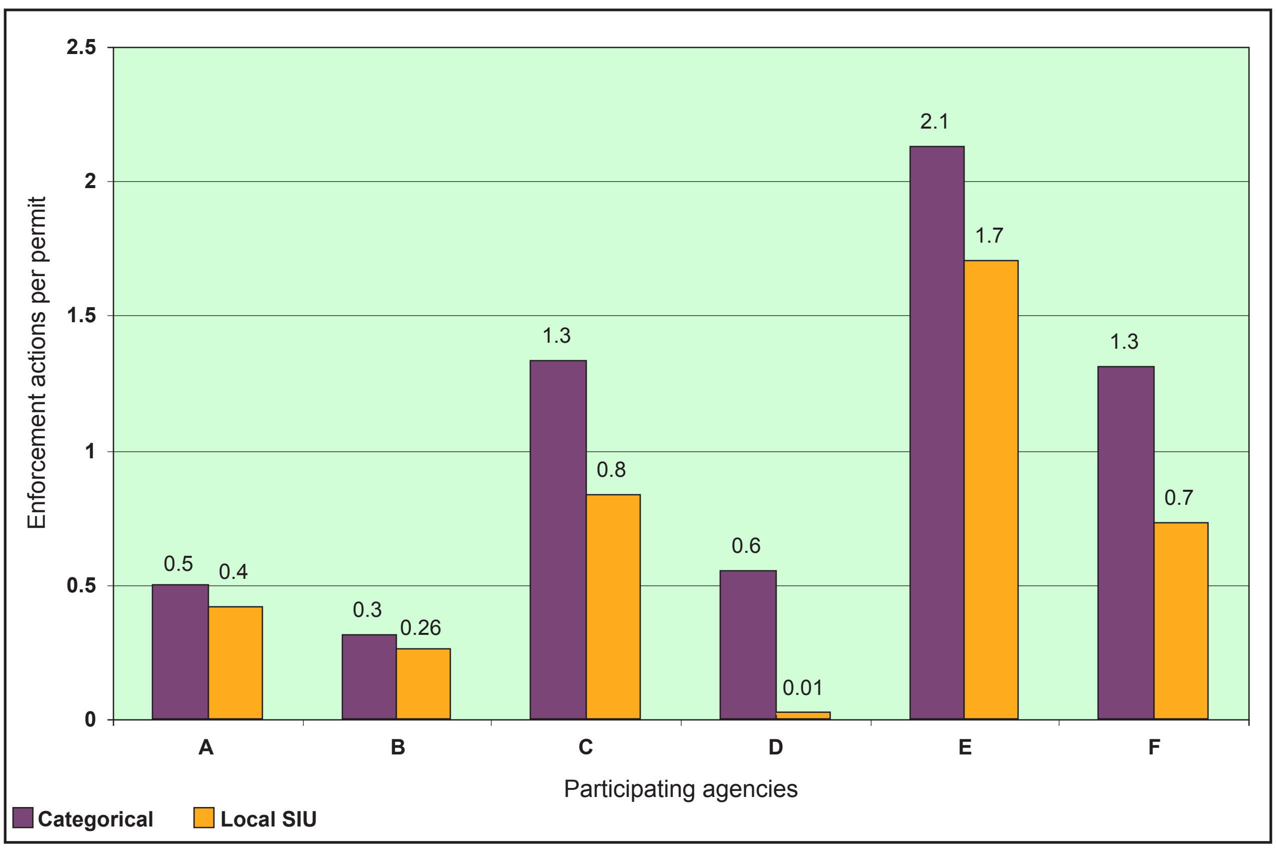


Figure 11. Number of Enforcement Actions per Permit

dicated that it feels reporting violations are reduced by giving IUs telephone reminders of upcoming due dates. Another agency indicated that violations other than exceeding limits were not reflected in their data because that information was not included in their information management system.

One possible source of error in the data is the fundamental difference in definitions of what constitutes a separate facility for the permitting purposes discussed above.

Administration

The percentage of program FTEs spent on administrative activities was similar for all participants but the relative amount of time spent in the different types of administrative activities varied. The percentage of time spent on administrative activities ranged from 30 percent to 44 percent. Administrative activities include program planning and administration, clerical, reporting, data management, and supervision. With the possible exception of data management, differences between agencies may be attributed to organizational structure, amount of employee involvement, oversight of outside jurisdictional service areas, and how accurately time was allocated in the template. Time reported by high-level administrative FTEs (of any type) may reflect a decision to record time as administrative versus distributing it among specific projects. In the area of data management, however, the lowest-cost agency was the only agency with an integrated comprehensive data management system, indicating possible efficiencies.

Conclusions

Given the substantial differences in scope and emphasis among the participating source control programs, the Source Control Work Group did not identify a set of best management practices, during this phase of the study, against which participants could compare their own practices and make improvements. However, a few general conclusions were drawn about possible staffing efficiencies for inspection and sampling procedures. Further assessment by each agency is necessary in order to determine the individual benefits of these practices.

- Some agencies collect samples for surcharge and compliance separately. They may improve efficiency by concurrent sampling so that only one trip meets both needs.
- Some agencies use teams rather than single individuals to perform inspections and/or sampling, and may be able to use their resources more effectively by using individuals instead.
- Some agencies combine sampling and inspection events, which may increase efficiency.
- Some agencies rely more on company self-monitoring and less on agency monitoring, which may lead to reduced costs. In addition to the above general conclusions, each agency was able to identify at least one individual area to evaluate further for program efficiency improvements. During the next year, participating agencies will review the following areas:

Agency A	Upgrade data management systems to include a higher degree of integration and automation.
Agency B	Update IU inventory through a comprehensive survey and finalize a data management system.
Agency C	Evaluate sampling and inspection functions to improve efficiency, revamp the data management system, and evaluate methods to improve the permitting process.
Agency D	Evaluate time-keeping records to determine if under-reporting occurred in enforcement, permitting, batch discharge inspection, and certification areas.
Agency E	Finalize a new data management system, evaluate sampling policies and efficiencies, evaluate the influence of new local limits on violation frequency, and implement a time-keeping system.
Agency F	Evaluate inspection process and data management system to improve efficiency.

Recommendations for Further Study

Based on this year's experience, the Source Control Work Group recommends that future benchmarking efforts focus on process benchmarking and a detailed, task-oriented analysis. Staff should be involved in task-focused workshops to identify the differences in programs and potential labor savings arrangements. In addition to having a smaller budget than other cost centers, the typical Source Control program budget is also more heavily dominated by salaries. A detailed task-oriented approach is necessary to evaluate labor practice efficiencies. The Work Group feels that attention to these work practices and a focus on these tasks are the keys to finding cost reductions and identifying best management practices.

Laboratory Work Group

Optimal, cost-effective use of laboratory resources is a collaborative process between laboratories and their customers.

The Laboratory Work Group included participants from the seven agencies in the Multi-Agency Benchmarking Project, plus the City of San Jose and the Massachusetts Water Resources Authority. (The City of Phoenix, a participant in the early phases of the Laboratory Work Group's efforts, withdrew before contributing any data; however, it is likely they will rejoin during the project's next phase.)

In addition to providing data for the laboratory section in the overall project template, the Laboratory Work Group's goals included:

- Improving functional laboratory operation and identifying best practices;
- Minimizing costs and maximizing efficiencies;
- Developing a model to compare costs for individual analyses and components of the wastewater treatment process; and
- Developing a model to compare and track future changes.

The major work products of the group included:

- A process benchmarking survey;
- A table comparing staffing, salaries, benefits, workload, and lab organization;
- Extensive budget, cost per test, time per test, tests per year, and productivity comparison data; and
- Data for the laboratory portion of the overall project template.

Methodology

The Work Group adopted a two-pronged approach to the performance benchmarking phase: collect data for the overall project template, and develop a cost model to compare cost per test, numbers of tests, and time per test data.

Template

The Work Group focused on expenditures for laboratory analyses of wastewater treatment functions. Expenditures were clearly defined as analytical and related support activities in the template definitions. The Work Group organized the laboratory portion of the template into the following major categories:

- Supervision;
- Clerical support;
- Discretionary laboratory support for treatment plant operations;
- Compliance, regulatory, and required monitoring;
- Source control monitoring;
- Analytical method development;
- Non-required, non-source-control collection-system monitoring; and
- Laboratory Information Management System (LIMS) support for laboratory operations.

Cost Model

The expanded 10-agency Work Group developed a cost model to generate a cost-per-test spreadsheet based on overhead-burdened hourly rates and estimated times per test. A major focus of the cost-per-test effort was to ensure that the laboratories began with comparable budgets by clearly defining which expenditures to include in the model. The cost-per-test model included capital equipment depreciation and laboratory support for non-wastewater programs, whereas the overall project template did not.

Process Benchmarking

Early in the benchmarking process, the Laboratory Work Group established an extensive list of process benchmarking questions in the following categories:

- Human resources;
- Support systems;
- Planning;
- Data management;
- Analytical work;
- Safety and waste management; and
- Quality improvement.

The results were summarized in a table format to facilitate comparison, and this information helped laboratory managers identify best practices at each of the laboratories. The best practices fell into the following four categories:

- Workload management;
- Customer service;
- Employee development and morale; and
- Staffing strategies.

General Findings

When costs are compared, two components appear to contribute to differences in data among agencies: 1) the scope of work requested, and 2) laboratory efficiency when performing the work. The number and type of analyses requested by customers have the most impact on the analytical cost, and cost is influenced to a lesser extent by the cost of an individual analysis. Therefore, only a small percentage of the cost differences among agencies for a given template category can be explained on the basis of cost-per-test differences.

The Work Group performed one interlaboratory comparison on total laboratory expenditures versus flow-normalized laboratory expenditures, as shown in Figure 12. The bars in Figure 12 represent the total annual laboratory expenditure for each agency and expenditures normalized by annual flow. In general, the gap between total expenditures and flow-normalized expenditures narrows as annual flow increases. These data demonstrate the economy-of-scale factor that is achieved by larger systems.

Cost Model Findings

The Work Group calculated a “productivity metric” for each analytical area (biology, microbiology, or-

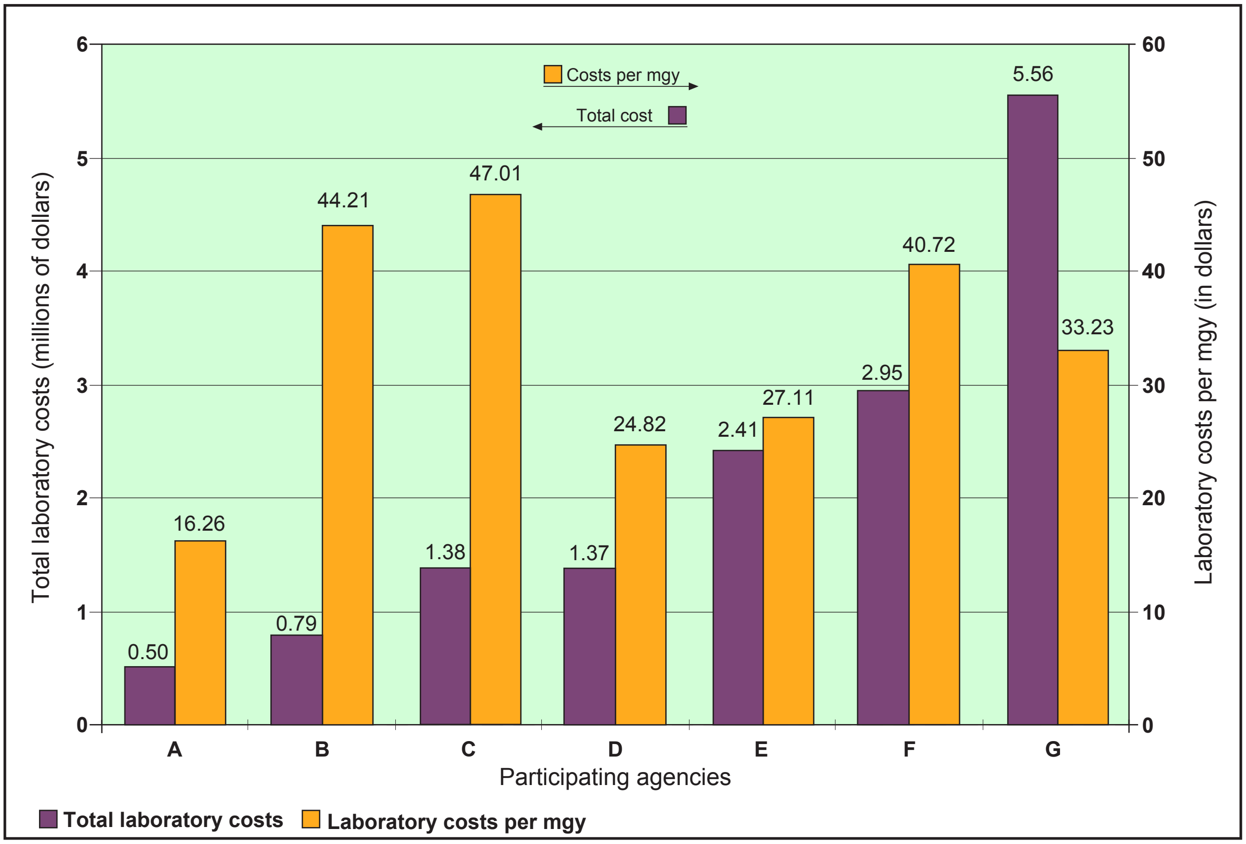


Figure 12. Total Laboratory Costs vs. Costs per mgy

ganic chemistry, metals chemistry, and conventional chemistry). The comparison of these numbers formed the basis of a discussion about factors that either positively or negatively affect productivity. Laboratory managers also shared information about those best practices that, in their experience, successfully addressed efficiency, customer service, data quality, and cost effectiveness. The following list of key findings were identified in these discussions:

- **Keeping the cost per test to a minimum is mostly a function of optimizing batch size and efficiently using laboratory capacity.** Batch size affects the cost per test because a predefined number of quality control (QC) samples are required at a fixed rate per analytical batch. For example, if there are 20 samples in an analytical batch and the QC rate is 5 percent, then one set of QC samples is required for those 20 samples. Depending on the analytical method used, the QC set may include several different samples such as matrix spikes, duplicates, blanks, and standard reference materials. The same set of QC samples is required whether the batch size is one sample or 20 samples, so the cost per individual test is lowest when batch sizes are at the maximum.
- The Work Group identified several fixed costs associated with maintaining instrumentation and other aspects of the laboratory in analyzing utilization of lab capacity. If laboratory capacity is under utilized, costs are spread across fewer samples and the cost per analysis increases. Conversely, the cost per analysis decreases as the percent of laboratory capacity utilization increases.
- Laboratory analysts can streamline analytical procedures by using the most efficient methods and instrumentation, using process flow analysis to improve sample processing, and investigating ways to reduce reruns associated with problems such as QC failure. Minimizing the cost per test, however, is mostly a function of optimizing batch size and efficiently utilizing laboratory capacity.
- **It is critical for laboratories to work closely to schedule workloads efficiently**. The best way for laboratories to achieve the cost reductions

associated with optimizing batch size and efficiently using laboratory capacity is to work closely with customers on scheduling. This is particularly important for samples with short holding times that provide less flexibility for batching. One example of a scheduling best practice is the agency that established a policy giving its laboratory the right of first refusal for all agency lab work.

- **It is critical for laboratories to work closely with their customers to develop cost-effective sampling and analysis plans that address data quality objectives**. In addition to doing things right, it is important that laboratories do the right things. The wise use of laboratory resources requires that laboratories work closely with customers to ensure the labs are doing the appropriate analyses that best meet their customers' project needs and data quality objectives.
- **Flexible staffing strategies help laboratories respond to workload fluctuations**. Once workflow has been leveled as much as possible by improving scheduling with customers, the laboratory can work internally to improve its ability to deal efficiently with peaks and valleys in the workload. A laboratory with cross-trained staff, who can shift from areas with less work to areas with workload peaks, provides greatest flexibility.
- **Laboratories that appeared more efficient from the data often were those with higher levels of automation**. In addition to faster throughput and higher levels of productivity, laboratory automation can improve laboratory accuracy and precision.
- **The variety of analyses offered, complexity of analyses and matrices, extent of QC and reporting requirements, and detection limit requirements affect laboratory efficiency and productivity**. Lab managers reported that productivity and efficiency decreased as analytical complexity and the variety of services offered increased. The most efficient laboratory for organic chemistry analyses, for example, conducts only three different analyses (the highest number of analyses among participants was 39). The Work Group observed that other complexities, such as very low detection-limit requirements or difficult matrices, also lowered productivity.
- **Tools such as customer surveys, customer advisory committees, staff surveys, project management systems, and job progression help laboratories improve customer service and employee morale.** Labs with customer advisory committees, for example, reported that they help customers work with the lab to balance workloads and set priorities. They also found it beneficial for customers to hear other customers' perspectives, recognize conflicting interests, and increase their understanding of lab decisions. Some participants reported that customer surveys helped identify and focus on issues that are important to their customers. Project management systems help improve coordination between the laboratory and its customers, which is important in optimizing utilization of laboratory capacity and developing good sampling and analysis plans. In addition to improving employee retention and morale, participants reported that job progression systems helped laboratories improve their flexibility to respond to workload fluctuations by increasing cross-training.

Areas for Further Study

Participating laboratory managers agreed it is important to continue to collect data in future years to monitor trends, evaluate the success of efficiency measures, and periodically share information with each other. They also agreed it is important to work with customers to explain agency differences in analyzing costs associated with wastewater treatment operations and monitoring programs. Laboratories also need to continue to strengthen their relationships with customers; optimal, cost-effective use of laboratory resources is a collaborative process between laboratories and their customers.

Recommendations for Future Phases of This Project

With the completion of this phase of the project, participants in the original Tri-Agency Benchmarking Project now have several years of data from which to draw in making comparisons that lead to improved practices. All participants will need to collect data over several years to reap the full benefits of the Multi-Agency Benchmarking Project and to begin tracking changes implemented as a result of this effort.

Participants will need to collect data over several years to reap the full benefits of the Multi-Agency Benchmarking Project and to begin tracking changes implemented as a result of this effort.

The Multi-Agency Benchmarking Project Steering Committee recommends the following actions in the next phase of this project:

- **Continue the work of the four new work groups.** The Work Groups that were formed this year (Engineering, Administration, Source Control, and Laboratory) should continue with their work next year. Newly formed Work Groups required about a one-year learning curve before the full benefit of their work was realized.
- **Consider creating additional work groups.** Additional Work Groups might include:
  - **Capital projects and O&M.** This group's mission would be to concentrate on the effects of capital improvements

on facility operating costs and determine ways to incorporate life-cycle cost analysis in capital planning. The group could also examine the costs of capital improvement (planning, predesign, design, construction, and asset replacement) and ways to contain those costs. Finally, the group could look at ways to promote closer working relationships between engineering and operations.

  - **Labor-management relations.** A Work Group could be formed to address labor-management relations as an issue that affects the entire organization, rather than solely as an O&M issue.
  - **Odor control and air quality issues.** Odor control and air quality are complicated issues because their source cannot be traced to a single process (that is, treatment takes place at different locations throughout the plant). In addition, other processes are affected by odor control processes.
  - **Environmental compliance.**
  - **Information technology.**
  - **Training.**
  - **Research and development.**
- **Discuss potential new revenue streams.** The Steering Committee recommends researching how other municipal agencies generate revenue and whether any of those methods could be used by participants in the Multi-Agency Benchmarking Study.
- **Consider tracking costs by plant.** Participants at agencies with more than one treatment plant could benefit by determining whether it is beneficial to track costs by plant. If the indications are that it is indeed beneficial to do so, participants could then establish an accurate method of allocating shared overhead costs between the plants.
- **Continue to refine benchmarking tools.** The Multi-Agencies should work together to improve existing benchmarking tools and create new ones to make accurate comparisons.
  - **Modify existing tools.** Refine the process benchmarking surveys and analysis to reflect "lessons learned" from this phase of the project.
  - **Develop new tools.** Develop tools to assess the effects of decisions made by participating agencies to change or modify business practices based on findings from this project.
- **Begin tracking trends.** The next phase of the project will allow the participants to compare data between fiscal years and track the effects of recently implemented changes.
- **Conduct benchmarking with privately operated utilities**. Comparisons with privately owned utilities may reveal additional ways that participants could cut costs and operate more efficiently.
- **Conduct benchmarking with non-wastewater businesses**. Many functions such as information systems, telecommunications, fleet maintenance, accounting, training, and building maintenance can be benchmarked with non-wastewater businesses, both public and private. The Multi-Agency Benchmarking Project participants should identify, compare, and potentially emulate those companies recognized for superior performance in these areas.
- **Standardize reporting methods.** This phase of the project underestimated the amount of time and effort required to document and present findings. Establishing a standard report structure and production model will help participants in future phases compile and present their findings.

Appendix A

Benchmarking Project Methodology

This appendix provides information about the approaches and methods used in the Multi-Agency Benchmarking Project.

- For information about the project's history, goals, and objectives, see the Introduction.
- For details about the participating agencies, see Appendix B.

Managing the Project

Organization

Participants in the Multi-Agency Benchmarking Project included a Lead Agency, a Steering Committee, a Project Coordinator, five Work Groups, contributing staff from each of the seven participating agencies, and an outside consultant. At the outset of the project, all seven agencies collaborated on and agreed to a Memorandum of Understanding (MOU) that outlined the roles and responsibilities for participants.

"I've learned more about our business from this project than I have from any other work during my career."

— Bill Burwell, East Section Manager, KCDNR

The **Lead Agency** was responsible for managing the overall project, resolving issues related to the MOU and the consultant's contract, coordinating information flow among participants, facilitating meetings, tracking decisions, and maintaining the project's master database. The role of lead agency rotates among the participating agencies, alternating with each successive phase of the project. EBMUD was the lead agency during this phase of the project.

The 12-member **Steering Committee** consisted of one lead from each agency who was responsible for that agency's timely cooperation throughout the project, and the leads from each of the five Work Groups. The Steering Committee assisted the lead agency by overseeing and directing the project and ensuring that the needs of each participating agency were met. The committee managed budget issues and provided direction to contributors from each participating agency. Steering Committee members met regularly to discuss the status and direction of the project.

The **Project Coordinator** facilitated meetings and communication among agencies, tracked decisions, and maintained the master database.

The **Work Groups** met regularly to develop and refine the template; collect, organize, and analyze the process and performance data associated with each cost center; and determine best practices when possible. In some cases (such as the Operations and Maintenance Work Group), a work group analyzed more than one cost center. In other cases, the Steering Committee created auxiliary Work Groups to examine specific areas within more complex cost centers so that more meaningful comparisons could be made. Participants in the Work Groups were organized so that those most familiar with a specific business or treatment processes were asked to define the process and then collect and analyze information about it. This helped ensure that the proper individuals received the most benefit from information gained during the collection process and subsequent discussions.

An **outside consultant** assisted the project by providing project management, developing the database, collating and analyzing data collected by individual agencies, overseeing project subconsultants, and assisting with the production of a Technical Memorandum (published January 1999) and the O&M and Engineering reports.

Approach

The participants in the Multi-Agency Benchmarking Project recognized the inherent challenges of a project to collect and analyze information from disparate agencies. Their first step was to develop and agree to a set of tools that would allow the participants to collect and compare cost and process information in a meaningful way. To accomplish this step, many discussions took place about which specific costs should be selected for comparison and what basis for comparison would be used.

From those discussions, four distinct project elements emerged:

- **Resolve to communicate openly** throughout the data collection and analysis process.
- **Develop a template for data collection and management.** Using a basic template developed during an earlier phase of the project, the agencies refined the template they would use to collect data. With this new template, participants gathered data to form a database, performed data analysis, and developed a plan for data presentation.
- **Conduct performance benchmarking.** (Performance benchmarking is the development of cost data for across-the-board comparisons.) Each agency collected and analyzed its costs for providing wastewater treatment operations during FY 1997.
- **Conduct process benchmarking.** (Process benchmarking is a more subjective, analytical analysis of how each agency does business.) Each agency provided a description of the methodology it used to run all aspects of its operations.

A more detailed discussion of these elements follows.

Developing the Tools

Communication

Participants identified early in the project that open, honest, and candid communication would be critical to its success. They agreed to meet regularly to discuss data collection methods, differences in business operations, and areas for improvements identified by each agency. Discussions about how to distribute costs helped identify alternative ways to account for all costs, perform work, and optimize systems.

Data Collection Template

One of the first and most important objectives for the project participants was to develop a common framework for comparing the many facets of managing and operating a wastewater treatment agency. To help define and categorize the processes that drive costs, participants agreed to use a common data collection template.

During the development of the template, participants borrowed heavily from work done on a template during the first phase of the project by participants in the Tri-Agency Benchmarking Project. With the template in place, participants collected data, compiled a database, and began to organize the data in a meaningful way.

Template. The template divided all costs into nine major categories. During this phase of the project, only costs in the following categories were collected and compared:

- Operations.
- Maintenance.
- Technical support (including laboratory and source control).

- Administration/general.
- Capital program.

The template was designed to visually represent all the functional areas that comprise a wastewater treatment agency. Each item was strictly defined so that multiple users could assign costs consistently among the categories. The template is provided in *Exhibit A-1,* which begins on page A-7.

Database. A database, developed using Microsoft Access software, was designed as both a data collection tool and for data presentation after analysis. The structure of the cost collection database was based on the data collection template described above. Each agency received a blank database and was responsible for providing data at an appropriate level of detail for their agency.

The database provided for seven levels of detail. (Not all cost centers, however, required that level of detail.) Costs were subdivided as far as each agency's accounting system would allow, with some agencies able to provide very detailed information on a specific area or a specific unit process. The database allows participants to generate bar graphs that compare an agency's performance for a specific parameter against the other participating agencies' performances.

The Engineering Work Group developed a separate database to account for its cost collection and analysis. That database used scatter-plot graphs with trend lines to show average costs for each agency and the average of all agencies for capital projects from $100,000 to $100,000,000. The scatter plots allowed the participating agencies to compare costs for a wide range of projects without requiring the agencies to submit costs for projects of any specific or predetermined size.

Data Analysis. Raw data was entered into a project master database (except for the Engineering data). The master database was designed to accept sets of raw data from individual agencies, normalize them, and then provide comparative tables and graphs. The master database was capable of accepting many normalization factors to accommodate the many kinds of analyses participants wanted from the data.

Normalization factors are a necessary component of the benchmarking process. Such factors help provide meaningful data comparisons by reconciling or "normalizing" differences among agencies, primarily by providing a common basis of measurement for comparison purposes.

An example is recalculating data based on a common unit of measurement such as cost per mgd of treated wastewater, rather than using unqualified, raw cost figures. Cost is affected by many factors, including size of a facility. Dividing the amount of wastewater treated normalizes the data to allow straight comparisons between figures.

Appropriate normalization values vary with the type of analysis and type of data desired. Many of the treatment plant processes, for example, can be normalized based on flow. Laboratory costs, however, may be more meaningful if normalized by the number of analyses performed. Influent characteristics may make some processes more or less effective at one plant than another. See *Constraints* for more information about why data must be normalized.

Data Presentation. In keeping with a generally accepted benchmarking practice, the reports in this Executive Summary do not link comparative cost data to agencies by name. Letters are used to represent each agency whenever cost information is presented.

The bar graphs in this report generated by the Work Groups generally present cost data for a given parameter from lowest-cost agency to highest-cost agency (Agency A through Agency G). Because the lowest- and highest-cost agency changes from one graph to another, no single agency is represented consistently by a single letter.

Performance Benchmarking

All agencies agreed to provide data for FY 1997. Each agency gathered data on its expenditures and allocated all costs according to the categories in the template. Despite the inevitable discrepancies that arose from sharing a common tool to account for all costs, each agency made every effort to account for all ratepayer dollars spent.

Work Groups then began meeting regularly to determine how to analyze the cost data to produce the most accurate comparisons. When the template did not truly capture or reflect the reality of participants' cost allocations, it was revised accordingly.

To verify the accuracy of their data, the agencies compared the cost data submitted with actual expenditures. Verification of data also occurred when individual Work Groups met to compare costs, which promoted more discussion about different ways that participating agencies performed work or allocated costs. All data submitted was examined to determine performance "trouble spots" and to identify those areas best suited for process benchmarking and discussions about best practices.

Process Benchmarking

Examining data gathered in the performance benchmarking effort within the context of information gathered in the process benchmarking effort helps illuminate why one agency appears more cost-effective than another in a particular area. This, in turn, helps participants determine best management practices.

To collect process benchmarking information, each Work Group designed a detailed process area survey, concentrating on the most important aspects of its cost centers. An agency representative from each Work Group collected information about their agency, usually by assigning specific questions to knowledgeable and appropriate colleagues, and reported back to the group.

Survey results were summarized in tabular format to make it easier to compare agency responses to survey questions. The compiled responses were extensively analyzed and discussed where cost performance data indicated wide variations in costs to better understand those differences and to develop best practices. *Exhibit A-2,* which begins on page A-19, presents a sample compilation of participant responses to survey questions developed by the Administration Work Group about payroll practices.

Understanding the Data

Constraints

The Multi-Agency Benchmarking Project database allows for quick, progressively more detailed comparisons between agencies' cost center data. However, data alone cannot adequately account for the differences in treatment processes, regulatory requirements, political environments, and discretionary programs among the participating agencies. Care must be taken not to draw conclusions without considering the myriad underlying factors.

To illustrate this point, compare the participating agencies' permit requirements in *Appendix B, Table B-2.* Differences in permit requirements will impact the level of treatment an agency provides and its overall treatment cost. Other factors that may render generalizations about costs include influent characteristics (which may make some processes more or less effective at one plant than another), the type and age of equipment installed at each facility, and regional differences in the cost of living.

Similarly, long-range benefits are not immediately apparent from raw data. The data for an agency with an active public involvement program to mitigate dissent on planned projects might only reflect that the program increases the overall cost of treatment, while failing to account for the potential savings such a program might recover later. Likewise, an agency's approach to reclaiming wastewater or recycling biosolids will vary depending on local and state politics and regulations. These programs undoubtedly contribute to the overall cost of treatment, but may deliver long-term benefits to a community (such as reducing potable water needs) or an agency (in the form of research and development for future endeavors).

Benefits

In addition to the ability to compare normalized data among the seven participating agencies, the collection and analysis of the data yielded further benefits to the participants. As a result of this study:

- Regular Steering Committee and Work Group meetings provided a venue to discuss differences in cost allocations, business operations, and data collection methods. These discussions helped participants identify alternative ways to distribute costs, perform work, optimize systems, and pursue areas for improvement.
- Future research efforts among participants can be more feasible and cost-effective because the costs as well as the benefits can be distributed among participants. Subsets of participants can collaborate in evaluating potential treatment and practice options of mutual interest.
- Participants now have the data and, perhaps more importantly, the appropriate interagency contacts to explore a proposed treatment or organizational alternative in use at another participating agency.
- The database allows an agency to make multiple-year comparisons, track its own cost trends, and evaluate cost-saving measures.
- The tools developed, particularly the database, will allow more agencies to be added to the project in the future and comparisons of normalized cost data to be performed more rapidly.

Exhibits

- Exhibit A-1: Multi-Agency Benchmarking Data Collection Template
- Exhibit A-2: Administration Work Group—Sample Process Benchmarking Survey Questions (Payroll Function)

Exhibit A-1. Multi-Agency Benchmarking Data Collection Template

NOTE

See the full Work Group reports for template category definitions.

Multi-Agency Benchmarking Study

TEMPLATE
SUMMARY BREAKDOWN OF FUNCTIONAL AREAS IN A WASTEWATER TREATMENT PLANT

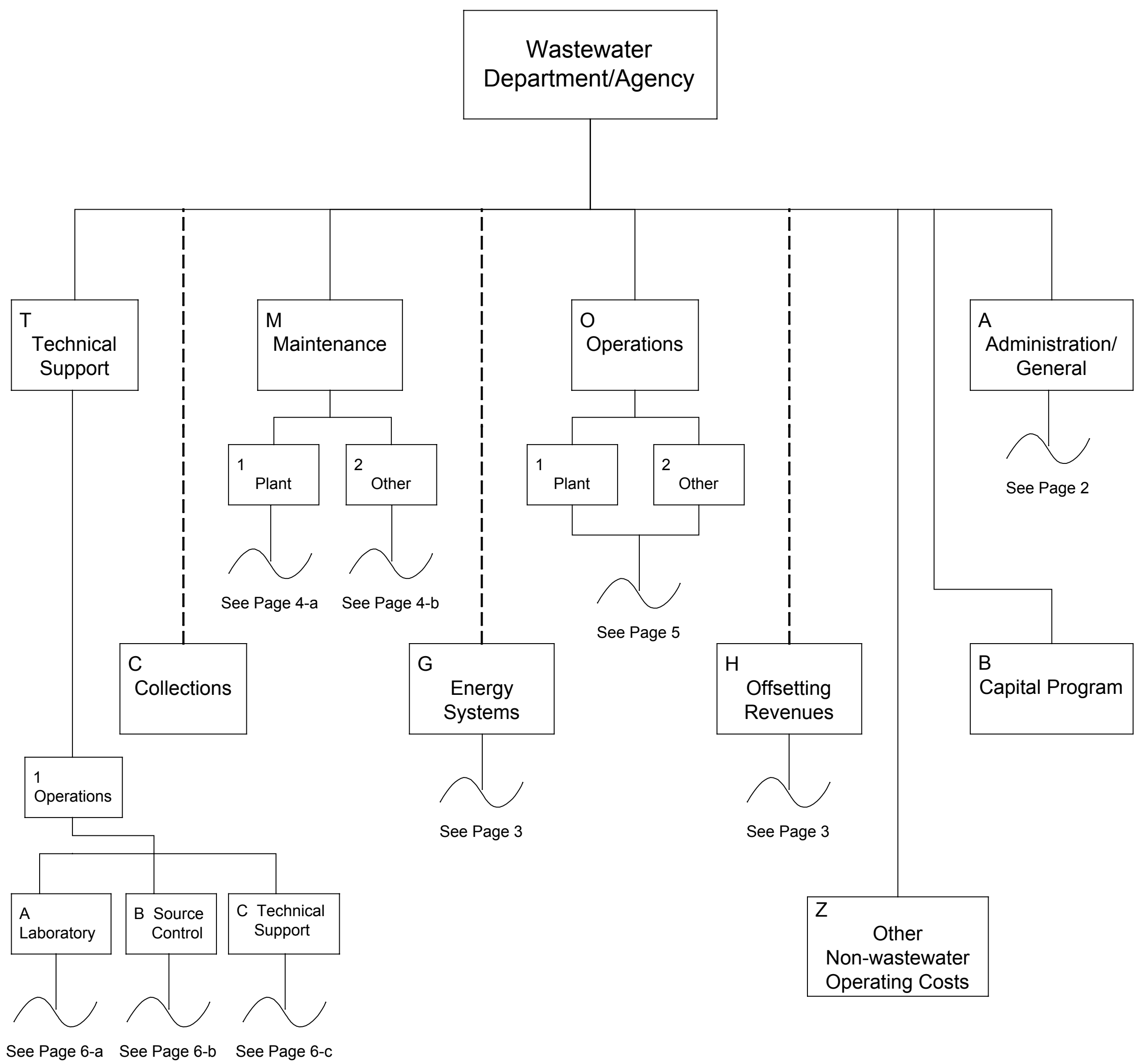
Phase II FY 1997

REV 8.0 3/25/98

Final

FY97

Multi-Agency Template
Summary Breakdown of Functional Areas
in a Wastewater Treatment Plant



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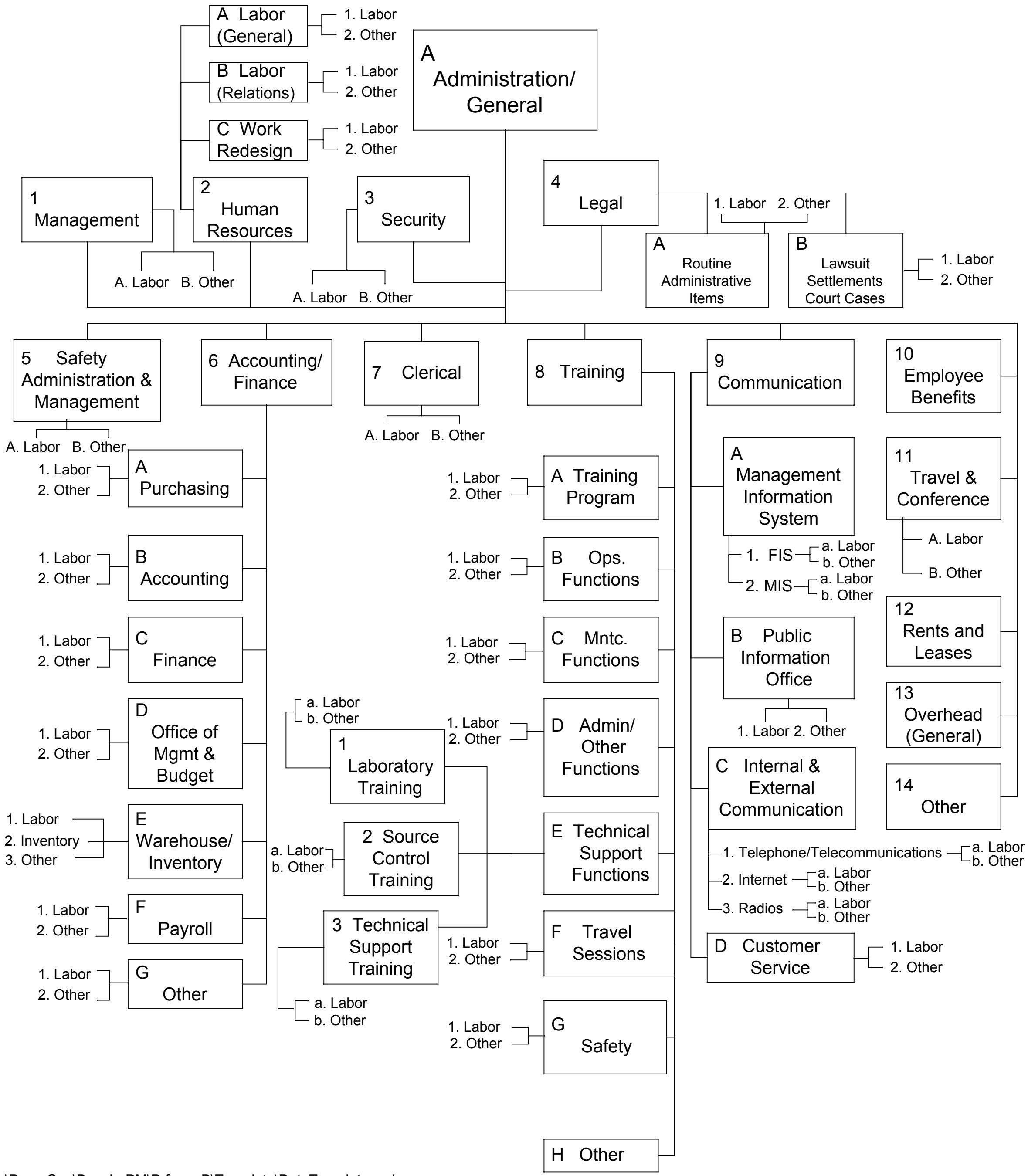
Revision 8.0 3/25/99

Page 1

Multi-Agency Template
Administration/General Section Breakdown of Functional Areas

Final

FY97



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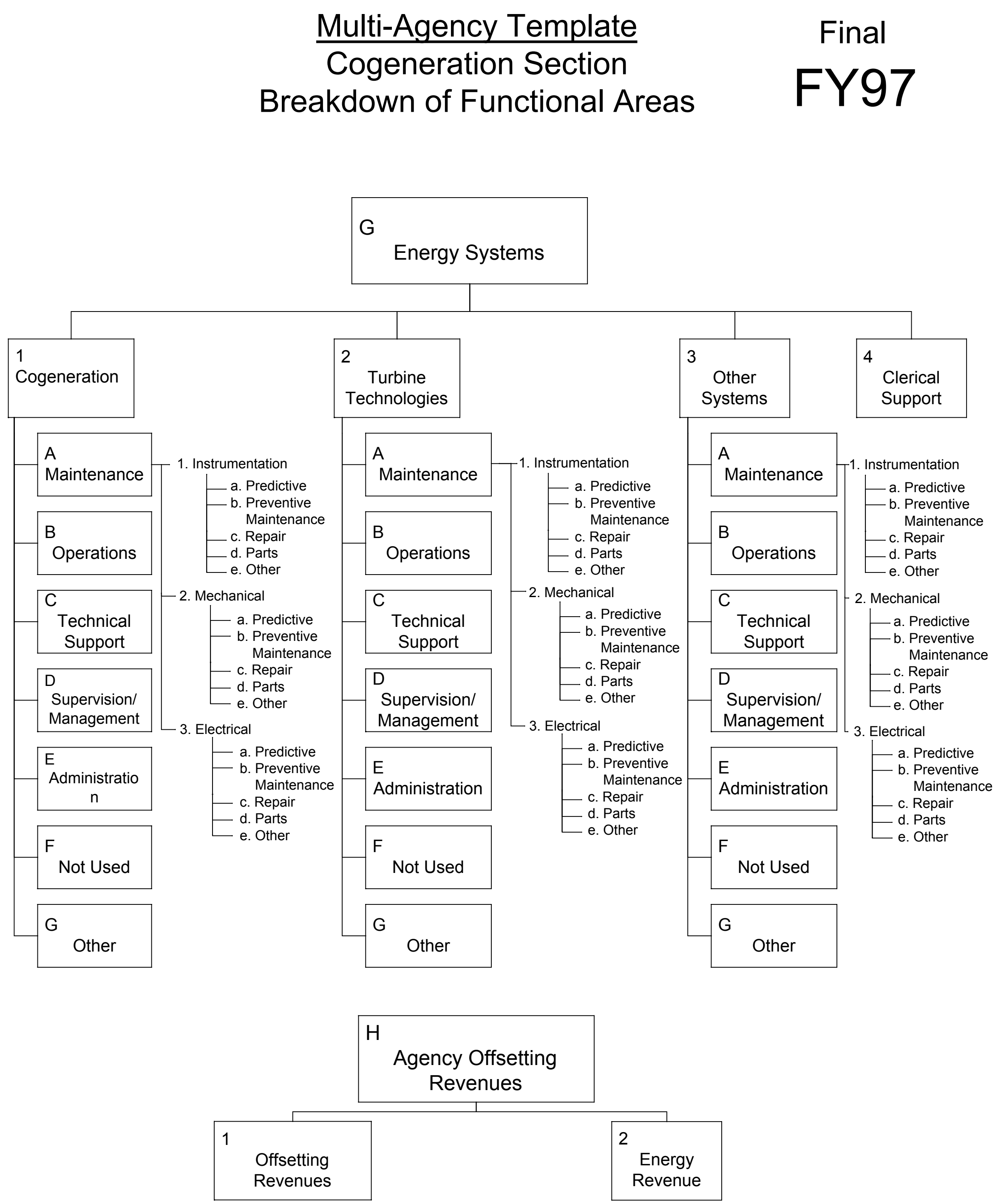

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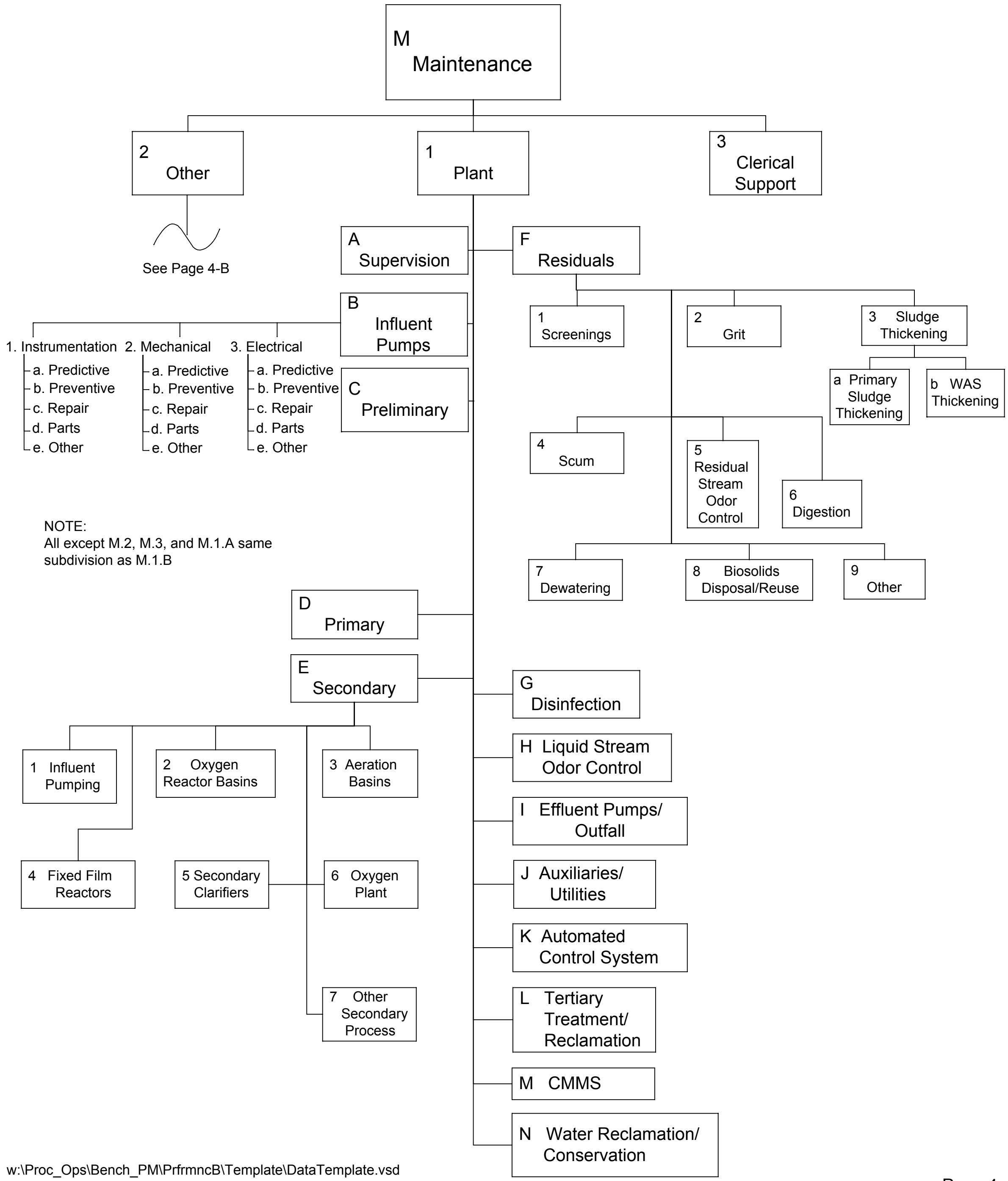
Revision 8.0 3/25/99

Page 3

Multi-Agency Template
Maintenance Section
Breakdown of Functional Areas

Final

FY97



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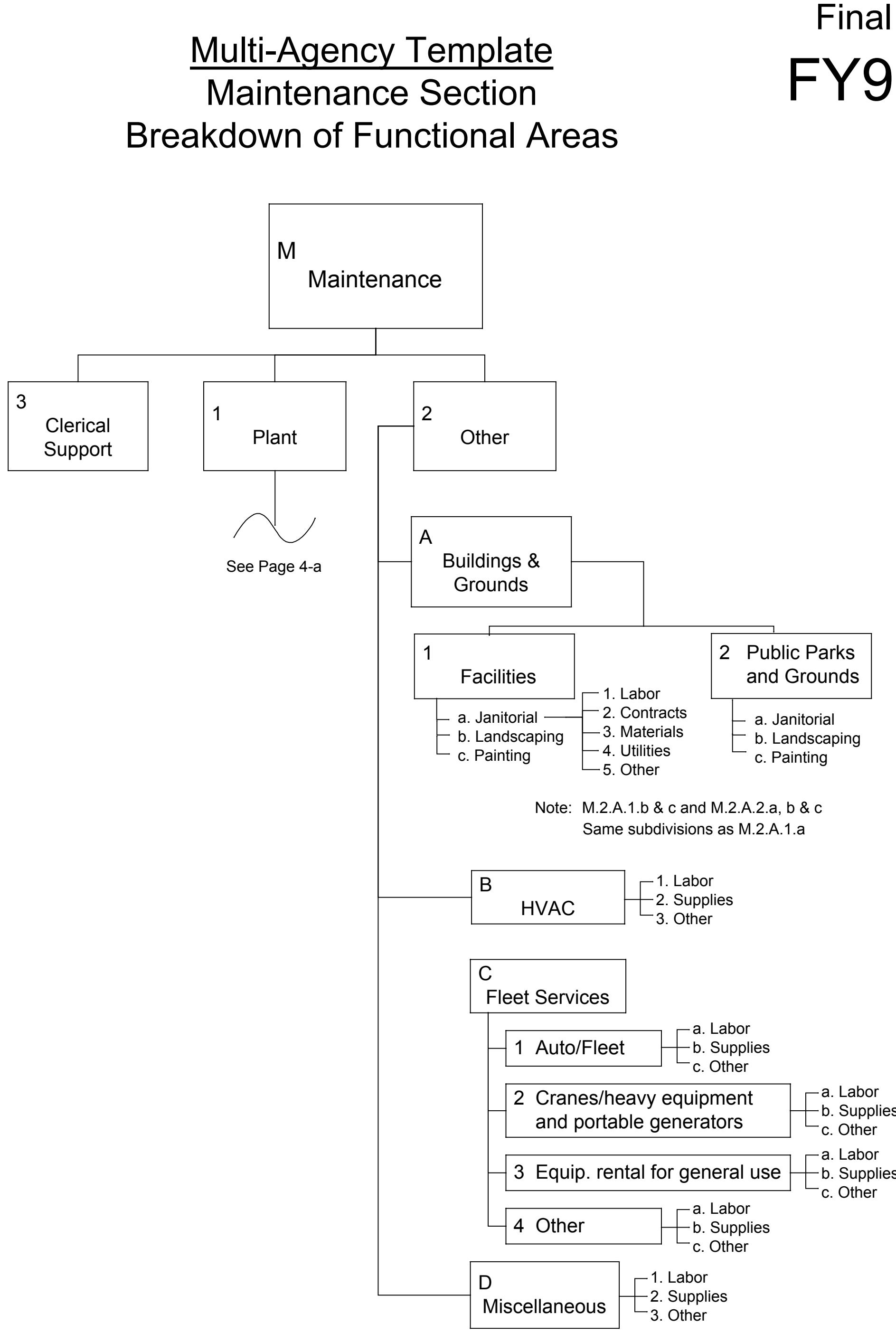

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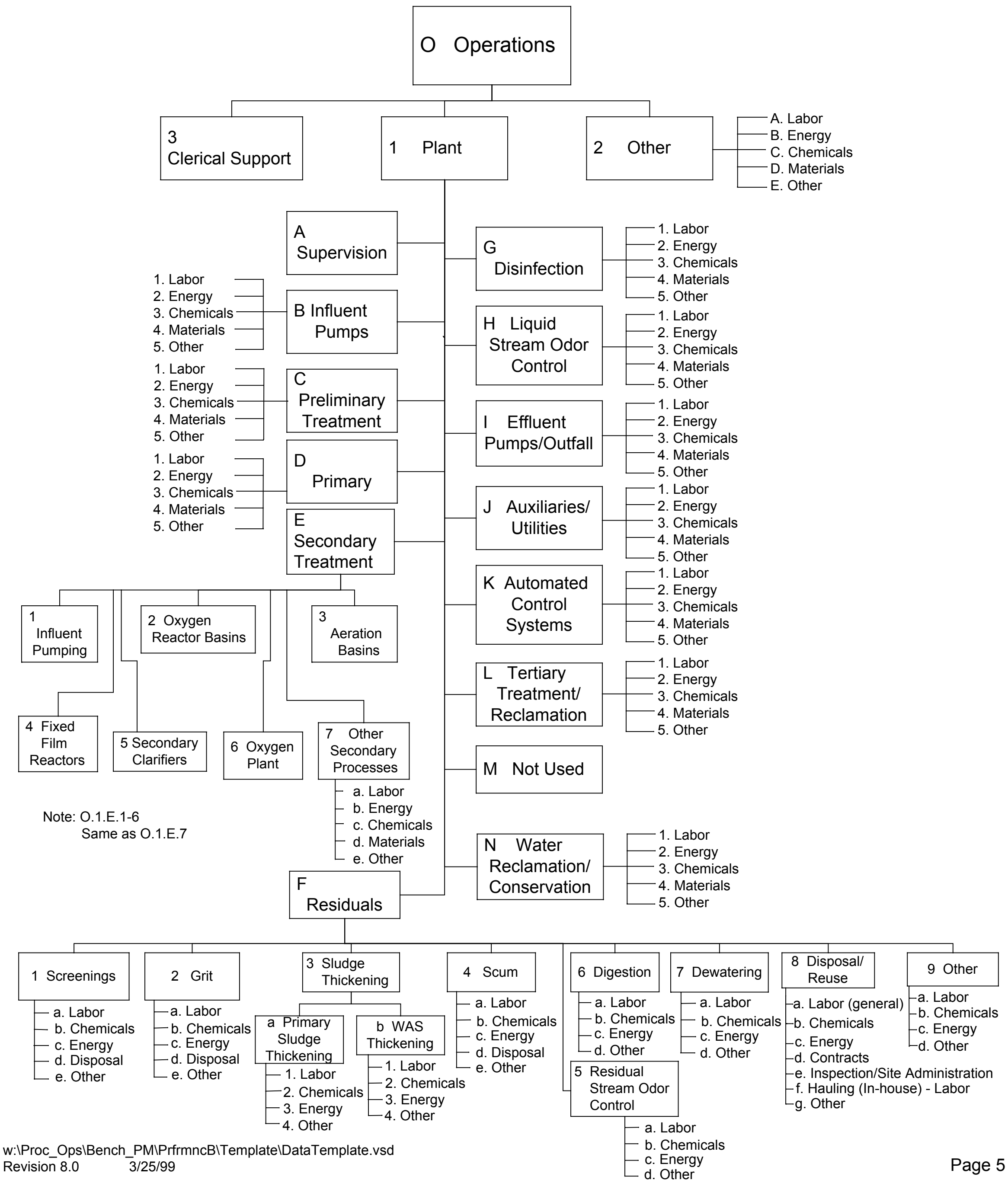
Multi-Agency Template
Operations Section
Breakdown of Functional Areas

Final
FY97



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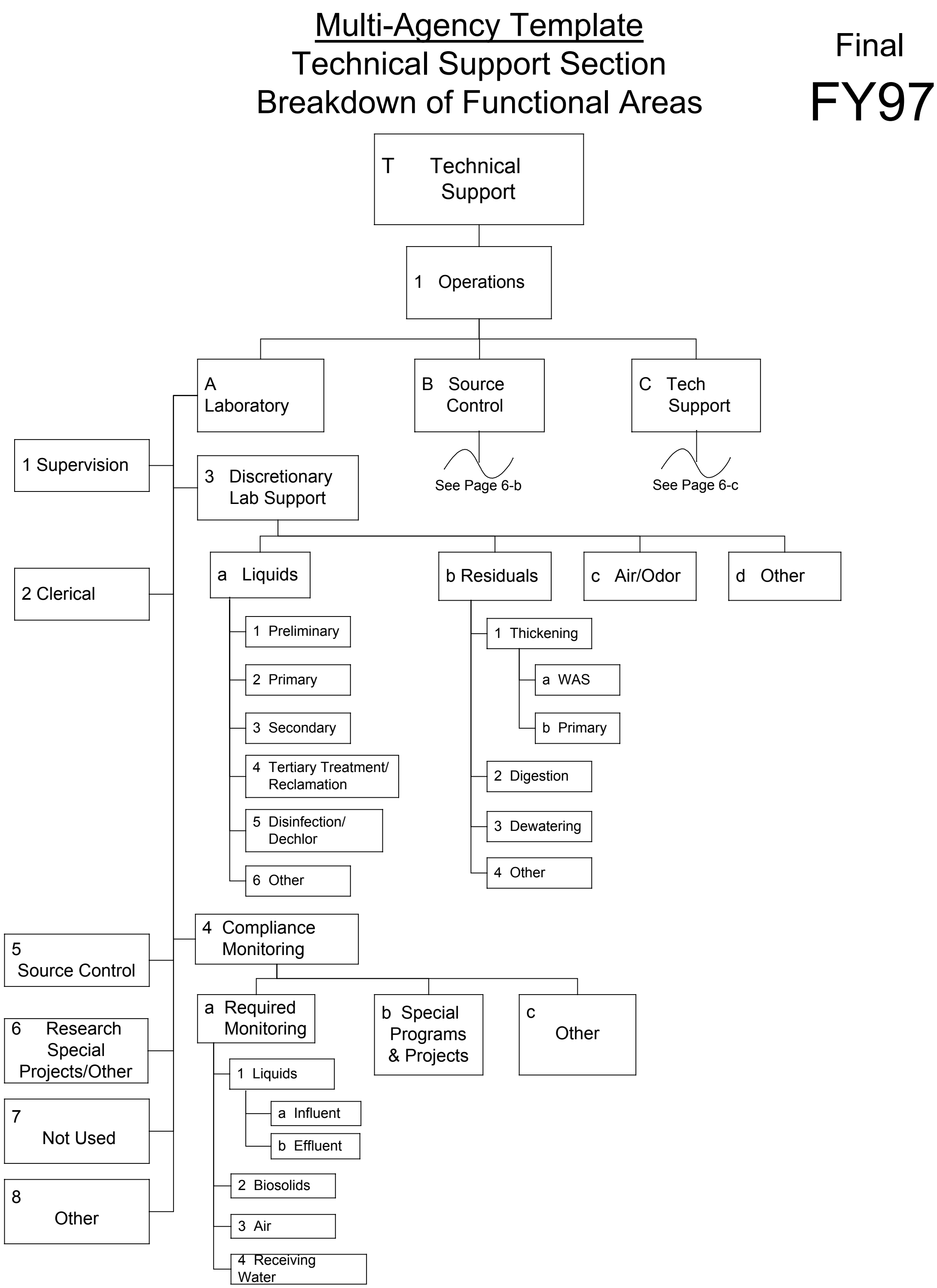

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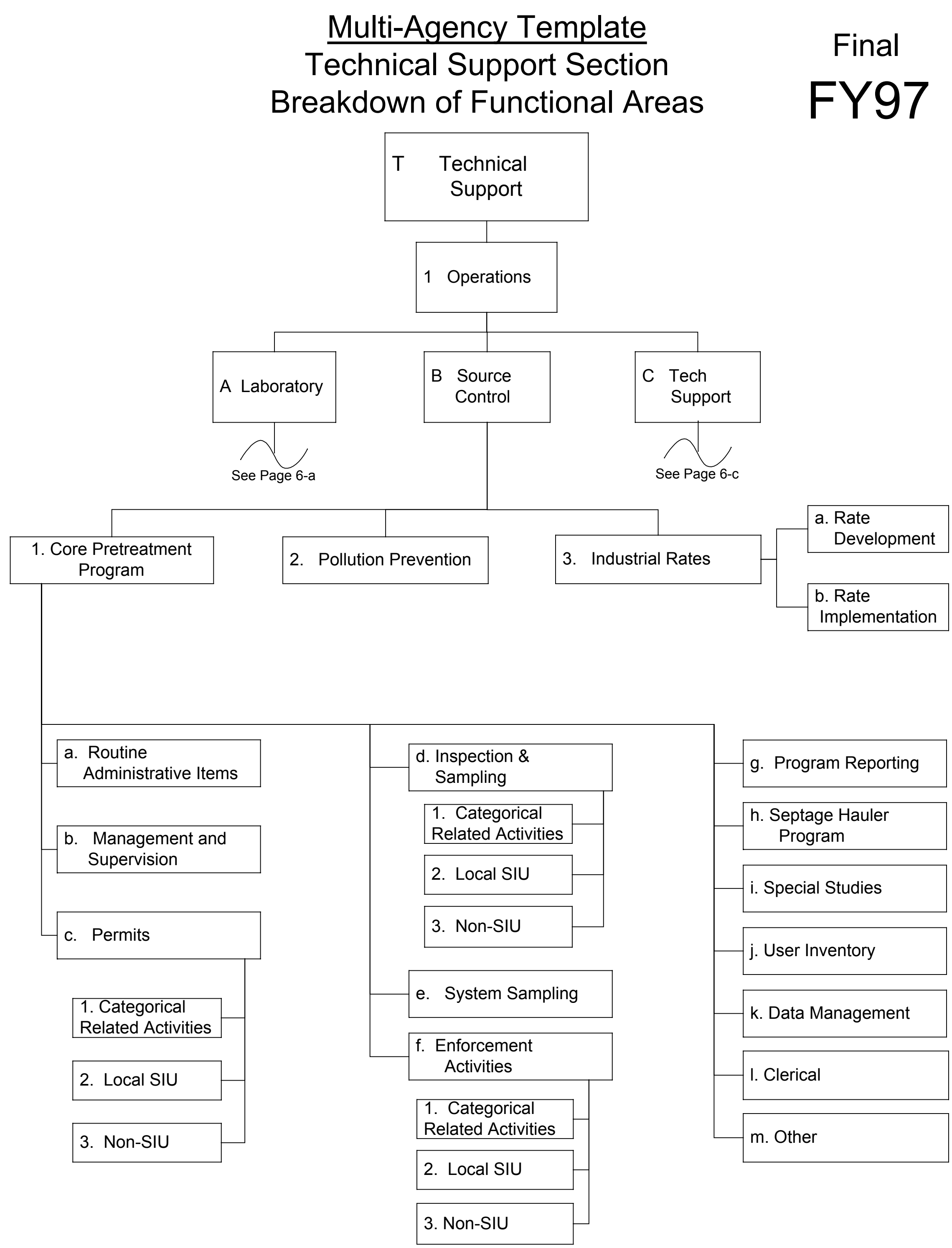

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Multi-Agency Template
Technical Support Section
Breakdown of Functional Areas

Final

FY97

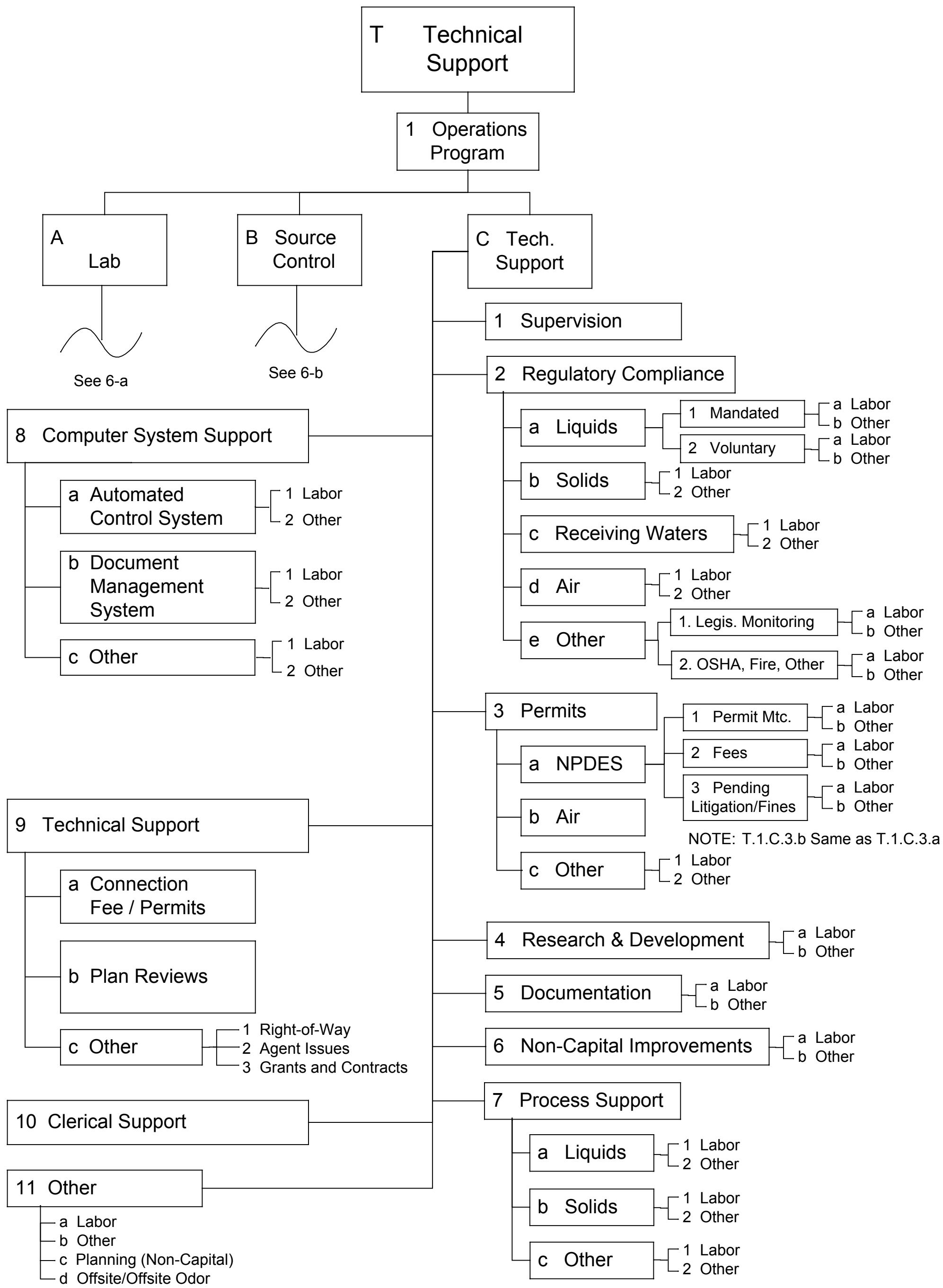

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Exhibit A-2. Example of Table Used to Summarize Participant Responses to Process Benchmarking Survey Questions

(Payroll Function)

NOTE

See the full Work Group reports for complete process surveys and responses.

Administration Work Group Process Benchmarking Survey: Payroll Summary

Topic	CCCSD	CLABS	CPBES	EBMUD	KCDNR	OCSD	SRCSD
1. Is payroll function contracted out?	No	No	No	No	No	No	No
2. Number of checks issued monthly	295*	*5,000+/-*	326	628	600	570	640
Number of Employees	295*	*2,500+/-*	163	314	300	285	320
Pay cycle	Monthly	Biweekly	Biweekly	Biweekly	Biweekly	Biweekly	Biweekly
Number of payroll staff	1.25	*16*	1.5	1	1.5	2	2
3. Software system	In-house integrated HR-payroll system	Automated timeslip data entry system, Faxmasters/ Teleform	Portland's own pc-based system that is d-base program.	PeopleSoft Human Resources Management System	Currently converting to PeopleSoft	Separate payroll system soon to integrate with JD Edwards FIS	Had separate system, have since implemented SAP
4. Time and labor info single or double entry	Double	Double	1/99 new system to allow direct employee input into system	Double	Varies—Mainsaver to payroll direct for maintenance staff on work orders only	Double	Double
5. Timekeeping: manual or electronic?	Employee manual; payroll tech keys	Manual by employees; central payroll enters data	Employees manual; pay-roll clerk keys in color-coded timeslips	Manual by employee; IS clerk enters data into system	Employee manual; data tech enters into system	Employees manual; tech enters into system.	Electronic at plant; manual in county.
6. Other payroll services charged to employee?	No	No	No	No	No, but contemplating	No	No
7. How are employee pay status changes entered into and monitored in system?	HR generates and enters into system; payroll reviews each check for obvious errors.	Entry by Personnel section to controller. Monitor written notice from controller to Bur. payroll	Extensive cross-checking; please see survey for complete info.	Internal program controls, plus significant manual oversight; please see survey for complete info.	Written notice sent, but no monitoring reports.	Written notice; HR makes changes; employees check own.	Written notice; clerk enters status changes; not on check; must ask payroll clerk.

*CCCSD has shown whole agency, while others have shown treatment plants only.

Administration Work Group Process Benchmarking Survey: Purchasing/Accounts Payable

Topic	CCCSD	CLABS	CPBES	EBMUD	KCDNR	OCSD
1. Type of financial software	HTE, an integrated system of key modules: accounting, purchasing, inventory, personnel and permits.	SNIMS, CLAMMS,FMIS, MMS and TSO -- all are mainframe based program systems. Currently moving to centralized city system.	IBIS (Integrated Business Info Systems)	MMIS (Materials Management & Invoicing System) In process of Implementing PeopleSoft FIS.	IBIS currently. SAP to be implemented by 2000.	JD Edwards
2. Purchasing/ receiving authority centralized or decentralized	Single purpose district; centralized at head-quarters building next to plant.	Decentralized at plant to capture discounts and to negotiate lower prices.	Centralized downtown with a plant node. Requisitions are linked to line item budgets.	Centralized policy, some decentralized items, e.g. Credit Card Program.	Mixture of centralized and decentralized—buy ers at plants for some items; large contracts downtown. AP centralized downtown.	Special district. Resources located at plants.
3. Authority signing levels	Supes: $10K Mgrs: $100K	Supes: $10K ***Mgrs: $30K***	Varies by Work Group— $5K as general limit??	Plant Supes: $7.5K Div mgrs: $25K GM staff Dirs: $50K GM: $100K	Supe/author signers: $10K Plant Mgr: $25K WTD Mgr: $100K	Div Mgr: $25K Dept Mgr-$50K GM: $100K
4. Discount policy; streamlining efforts; dollars saved	Blanket PO's, credit cards, direct office supply purchasing, take discounts when possible.	Cross team meets regularly, publish monthly discount reports.	Credit cards used, internet research and CD-ROM catalogues, 5 day turn on invoices.	PeopleSoft will use automated vendor \ catalogue, save 39 in- house process days. Credit cards.	Implementing credit cards; on-line purchasing, receiving, and approving.	On-line order approval
5. Inventory control: Recorded/ charged with barcode or other electronic system	Items issued through MIS system with barcode scan to charge to approp. O & M accounts	***Not included on survey***	In a barcode Beta test, integrate with IBIS for vendor payment	Survey says "nothing brief here!" Call Les Martin (510) 987-7700		Future=bar code to process area of plant.
6. Inventory size	$925,000	***Not included on survey***	$550,000; $330,000 yr turnover 3300+ line items		$3.9M	

Appendix B

Benchmarking Project Participants

Appendix B provides "at a glance" comparisons and complete narrative descriptions of the agencies participating in this phase of the Multi-Agency Benchmarking Project. This information may be useful in understanding underlying factors that influence each agency's processes and performance, particularly since each agency conducts its business with its own set of local conditions, regulations, politics, organizational strategies, and natural resource constraints.

To quickly compare the agencies, refer to Tables B-1, B-2, and B-3, beginning on page B-2. These tables list general agency information, effluent permit limits, and installed treatment processes, respectively, for each agency. Complete narrative descriptions begin on page B-5. All information applies to FY 1997, unless otherwise noted.

Each agency conducts its business with its own set of local conditions, regulations, politics, organizational strategies, and natural resource constraints.

Table B-1. General Agency Information

Agency	Number of Wastewater Plants	FY-1997 Avg Annual Influent Flow Rate (mgd)	Governing Organization
CCCSD	1	49	Special District
CLABS	4	444	City of Los Angeles
CPBES	2[1]	85[2]	City of Portland
EBMUD	1	77	Special District
KCDNR	2	200	King County
OCSD	2	244	Special District
SRCSD	1	152	Special District

1 Although CPBES operates two treatment plants, the Benchmarking Project focused on the larger of the two, Columbia Boulevard.
2 Reflects 1997 influent flow for Columbia Boulevard Wastewater Treatment Plant only.

Table B-2. FY 1997 Effluent Permit Limits

Agency	Plant	BOD[1] (mg/L)	TSS[2] (mg/L)	Cl_2 Residual (mg/L)	Coliform (MPN/100 ml)[3]	
					Total	Fecal
CCCSD		25[4]	30	0.0[5]	N/A[6]	200
CLABS	Hyperion	30	30	0.84[5]	1,000	200
	Tillman	20	15	0.1[7]	2.2[8]	N/A
	Terminal Island	15	15	0.1[7]	1,000	200
	LA-Glendale	20	15	0.1[7]	2.2[8]	N/A
CPBES	Columbia Boulevard	30	30	1.0[5]	N/A	200
EBMUD		30	30	0.0[5]	240[9]	N/A
KCDNR	East Treatment Plant	30	30	0.66[10]	N/A	200
	West Treatment Plant	30	30	0.216[10]	N/A	200
OCSD	Plant 1	100	60	0.001	N/A	N/A
	Plant 2	100	60	0.001	N/A	N/A
SRCSD		30	30	0.018[11]	23[12]	N/A

1 Biochemical oxygen demand (5-day), milligrams per liter – monthly average
2 Total suspended solids, milligrams per liter – monthly average
3 Coliform count, most probable number (MPN) per 100 milliliters – monthly average
4 Value is for carbonaceous biochemical oxygen demand, milligrams per liter – monthly average
5 Instantaneous maximum
6 Not applicable
7 Daily maximum
8 7–day moving median
9 Most recent permit limitation is 500 fecal coliform
10 Monthly average
11 Daily average (monthly average is 0.011 mg/L)
12 Monthly median

Table B-3. Treatment Processes Installed at Participating Agencies

		Preliminary /Primary Treatment			Secondary Treatment							Residuals Handling									Other Plant Processes								Misc.		
Agency	**Flow**[1]	Influent pumping	Preliminary treatment	Primary treatment	Pumping to secondary	Aeration basins	Oxygen reactor basins	Oxygen plant	Fixed film reactors	Secondary clarifiers	Other secondary processes	Screenings	Grit	Scum	Sludge thickening	Digestion	Dewatering	Biosolids disposal/reuse	Other residuals handling	Residuals stream odor control	Disinfection	Liquid stream odor control	Effluent pumping/outfall	Auxiliaries/utilities	Automated control systems	Tertiary treatment/reclamation	Computerized Maintenance Management Software (CMMS)	Water reclamation/conservation	Other O&M functions	Plant supervision	Clerical support
CCCSD	49	•	•	•	•	•				•	•	•	•	•	•		•	•	•	•	•	•	•	•	•		•	•	•	•	•
CLABS, Hyperion	355[2]		•	•	•		•	•		•	•	•	•	•	•	•	•	•	•	•		•	•	•	•		•		•	•	•
CLABS, Tillman	67	•	•	•		•				•	•										•	•		•	•	•	•	•	•	•	•
CLABS, Terminal Is.	16		•	•		•				•		•	•	•	•	•	•	•		•		•	•	•	•	•			•	•	•
CLABS, LA-Glendale	20	•	•	•		•				•											•	•		•	•	•	•	•	•	•	•
CPBES, Col. Blvd.	85	•	•	•		•				•		•	•	•	•	•	•	•		•	•	•	•	•	•	•	•		•	•	•
EBMUD	77	•	•	•	•		•	•		•	•	•	•	•	•	•	•	•	•		•	•	•	•	•				•	•	•
KCDNR, East	79	•	•	•		•				•		•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•
KCDNR, West	121	•	•	•	•		•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
OCSD, Plant 1	89	•	•	•	•	•			•	•	•	•	•		•	•	•	•	•			•	•	•	•		•		•	•	•
OCSD, Plant 2	155	•	•	•	•		•	•		•	•	•	•		•	•	•	•	•			•	•	•	•		•		•	•	•
SRCSD	152	•	•	•			•	•		•		•	•		•	•		•		•	•	•	•	•	•		•		•	•	•

1 Average annual flow in mgd for FY 1997

2 Wastewater flows through the CLABS Hyperion Plant include 14 mgd residual flows discharged from the Tillman and L.A.-Glendale plants. These discharge flows are reflected in the flow listed here for Hyperion. Thus, although the total of all CLABS flows in this table is 458 mgd, actual flow through the system net of residuals is 444 mgd (458 mgd – 14 mgd = 444 mgd), as indicated in Table B-1. Likewise, the net flow for Hyperion is 341 mgd (355 mgd – 14 mgd = 341 mgd).

Central Contra Costa Sanitary District (CCCSD)

Central Contra Costa Sanitary District (CCCSD) is an independent special district that collects, treats, disposes, and reclaims wastewater for nearly half of Contra Costa County's population. The District owns and maintains almost 1,400 miles of sewer pipeline, ranging in size from 6 inches to 120 inches in diameter, and 20 sewage pumping stations. The treatment plant, located in unincorporated Martinez, is permitted to treat and discharge 45 million gallons of wastewater to Suisun Bay (average dry-weather limit). The average annual influent flow for FY 1997 was 49 mgd and the average dry-weather flow was 38.5 mgd. Central San currently produces 1 to 2 mgd of high-quality recycled water for treatment plant landscaping and processes as well as for landscape irrigation customers located adjacent to its treatment plant and in Pleasant Hill.

Agency History

In the early 1940s, central Contra Costa County was predominantly a community of farms and orchards. The post-war growth of San Francisco and East Bay communities spilled over into Contra Costa County. At the time, most of the County depended on individually owned septic tanks. That situation, plus the area's impervious adobe soils, combined to produce polluted conditions considered by state health authorities to be among the worst in California. Public support for a sewage collection and disposal system was overwhelming, as demonstrated by the successful general election in 1946 that created the Central Contra Costa Sanitary District. The District's first action, selling $2.4 million in general obligation bonds, financed construction of trunk sewers, pumping stations, and a treatment plant. By 1948, the 4.5-mgd primary treatment plant with 150 acres of oxidation ponds was operational.

The District completed construction of an 11-mgd treatment plant in 1959. The District expanded the primary treatment facilities and replaced the oxidation ponds with digesters for biosolids processing and a 72-inch-diameter, four-mile-long outfall pipeline to Suisun Bay. Two additional treatment plant expansions increased the plant capacity to 21 mgd in 1965 and 30 mgd in 1968. By 1986, the treatment plant was upgraded with secondary treatment capabilities and a capacity of 45 mgd. The District also constructed a water recycling facility as part of a joint project with the Contra Costa Water District. More recent treatment plant improvements include the 1995 headworks expansion to boost the plant's intake capacity to 260 mgd during peak wet-weather events, the 1995 start-up of a cogeneration facility that saves the District about $1 million a year in energy costs, and the 1996 construction of the largest ultraviolet disinfection facility in the US.

CCCSD has been frequently recognized by organizations such as the US EPA and the Association of Metropolitan Sewerage Agencies for outstanding operations, maintenance, and pretreatment accomplishments.

Service Area Description

As shown in Figure B-1, CCCSD serves a 135-square-mile area generally located about 30 miles east of San Francisco. The District includes about 291,000 residents of the communities of Alamo, Danville, Lafayette, Martinez, Moraga, Orinda, Pacheco, Pleasant Hill, San Ramon, and Walnut Creek. The District also treats wastewater for an additional 126,000 residents of the Concord-Clayton area under a 1974 contract with the City of Concord. About 82 percent of the District's customers are residential. The remaining 18 percent are primarily commercial, office, and institutional customers, with less than 1 percent industrial.

The topography of the District ranges from steep hillsides to flat valleys. On the hillsides, the soils are often shallow and prone to sliding. Clay soils are common in the valleys. Several active faults are located in or near the District

Organizational Overview

CCCSD is governed by a five-member, publicly elected Board of Directors. The District has about 255 regular employees, all under the administrative direction of an appointed General Manager and management staff. Figure B-2 presents an organizational chart for the district.

Permit Information

The treatment plant's NPDES permit limits for FY 1997 are indicated in Table B-4.

Table B-4. CCCSD Permit Limits

Parameter	Limit
Total BOD and TSS	85% removal
BOD	25 mg/L, monthly avg. 40 mg/L, weekly avg.
TSS	30 mg/L, monthly avg. 45 mg/L, weekly avg.
pH	6 to 9
Fecal	200 mpn/100 ml, 30 day log mean 400 mpn/100 ml, 10% of samples
Settleable matter	0.1 ml/L/hr, monthly average 0.2 ml/L/hr, maximum
Oil and grease	10 mg/L, monthly avg. 20 mg/L, daily max.
Chlorine residual	0.0 mg/L
Acute toxicity	90% survival in 11 samples
The permit also limits six selected organics and 11 metals/inorganics.	

Source Control

The District's Source Control program began in the mid-1970s and was enhanced in 1981 to provide CCCSD with enforcement authority. CCCSD's service area includes about 4,500 commercial and industrial accounts. These accounts include a wide variety of facility types. Acme Landfill, a solid and hazardous waste landfill undergoing closure and discharging leachate, is the District's most significant industrial user in terms of discharge volume

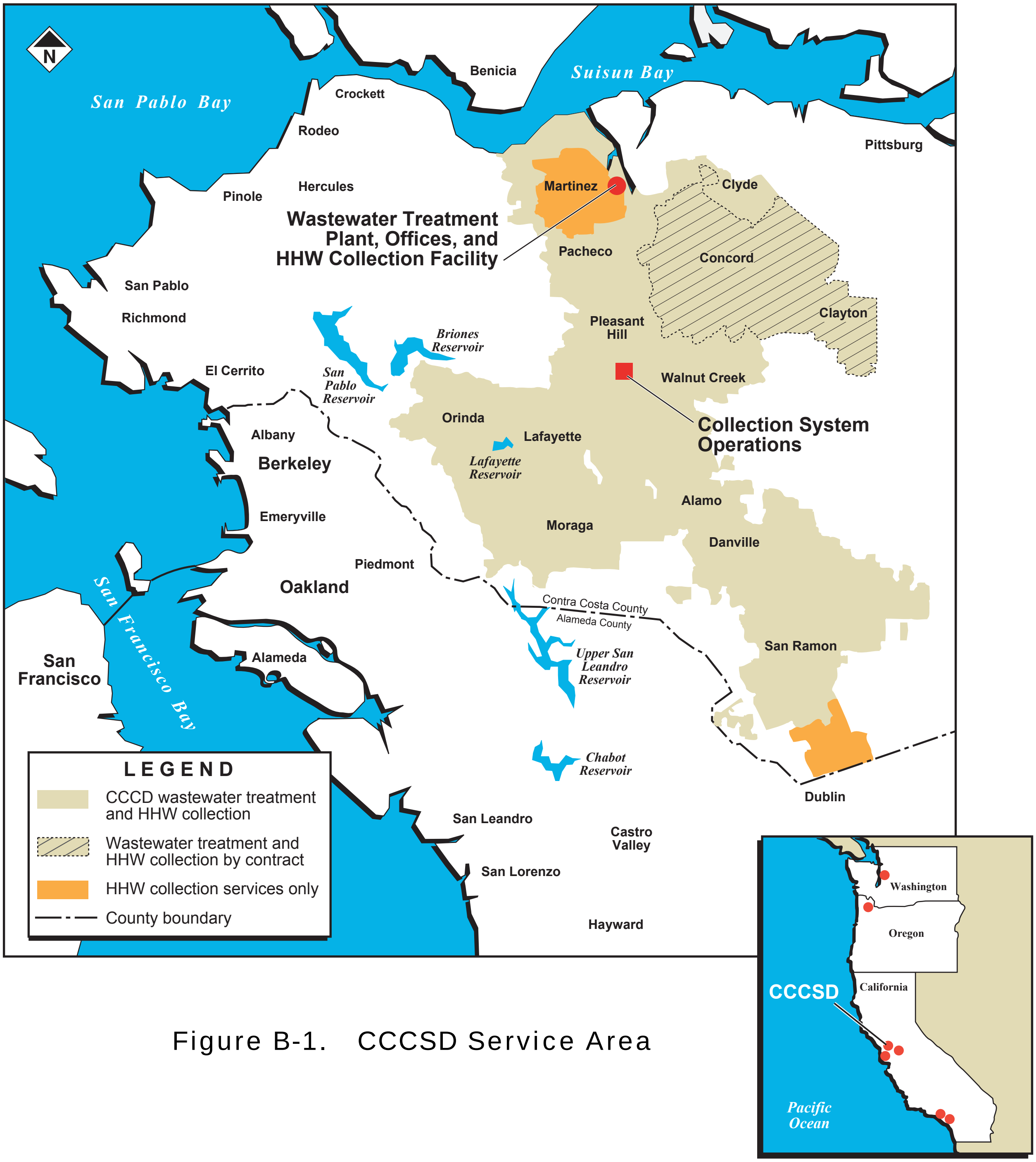

Figure B-1. CCCSD Service Area

and potential pollutant loading. This industrial facility operates under a permit contract. Other facilities under permit include manufacturers, research and development labs, hospitals, large newspaper publishers, radiator shops, and a variety of other industrial and commercial facilities. Other groups of commercial users are not under permit but are significant in terms of number of facilities and types of pollutants generated and potentially discharged to the District's collection system. These include vehicle service facilities, restaurants, dry cleaners, photo processors, and medical, dental, and veterinary offices.

Source Control also administers the treatment plant's trucked-in waste program. Types of trucked waste approved for disposal at the District include septic tank pumpings, portable toilet waste, restaurant grease interceptor waste, and a variety of wastes

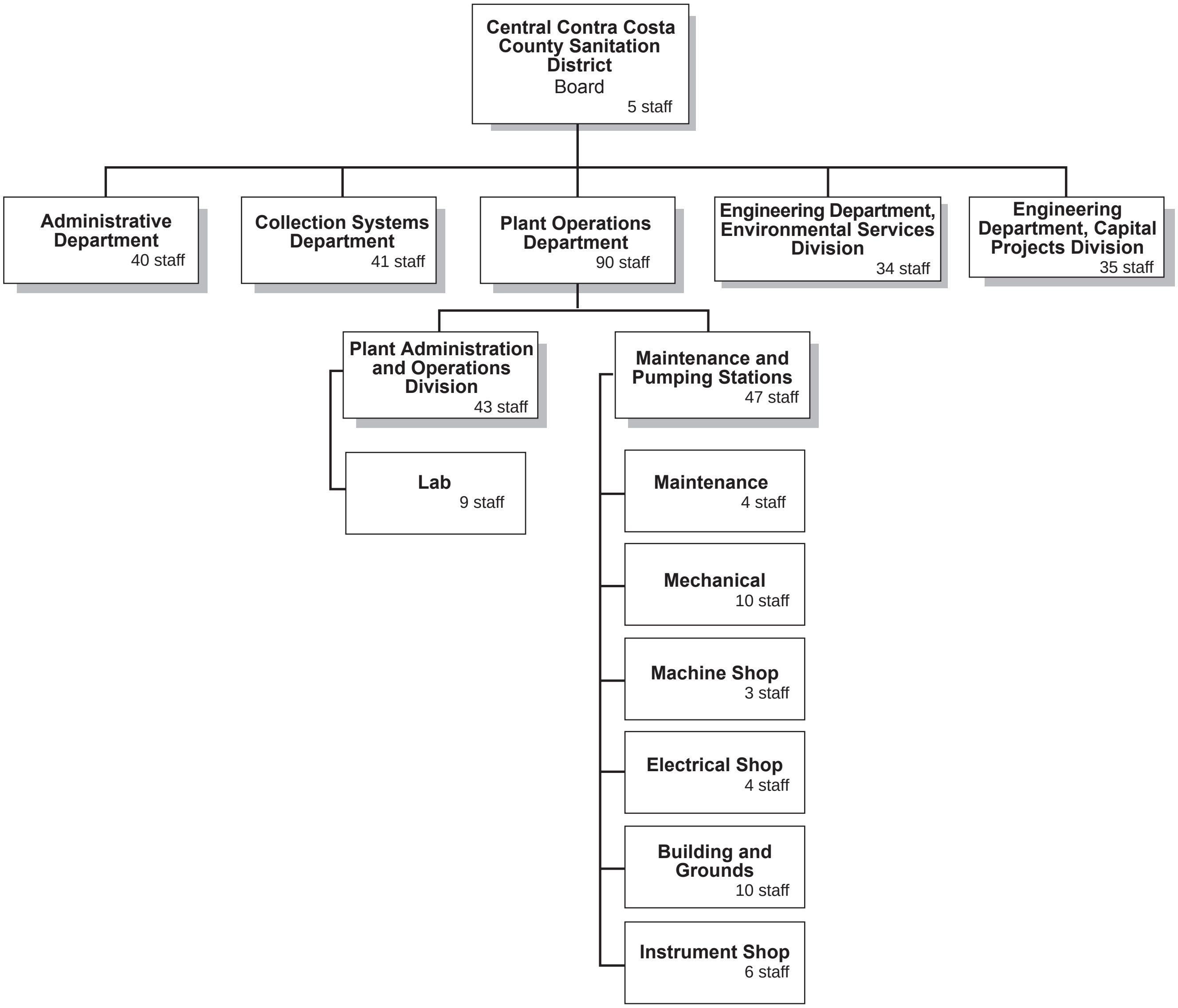

Figure B-2. Organization of Wastewater Treatment Functions at CCCSD

allowed under Special Discharge Permits.

The District relies on a comprehensive pollution prevention program to complement the diligent implementation of the traditional pretreatment program and to achieve cost-effective control of pollutant sources from both domestic and nondomestic users. The District focuses its pollution prevention program efforts by identifying pollutants of concern so that priorities can be set. The District is not in violation of any standard regarding these pollutants but wants to be proactive to avoid any potential problems in the future. The following are current “Priority A” pollutants of concern:

- **Copper.** Copper has been tentatively identified as a possible cause of episodic chronic toxicity to *Echinoderm* and if copper sources are not controlled it may impact biosolids ash quality (in terms of the California hazardous waste criteria/waste extraction test).
- **Pesticides.** Periodic acute toxicity of the District’s effluent to *Ceriodaphnia dubia* has been linked to the presence of two organophosphate pesticides (diazinon and chlorpyrifos) at low concentrations in the plant effluent.
- **Cyanide**. Plant effluent quality intermittently exceeds 10 mg/L, due to production of cyanide

by the biosolids incineration process. The 10 mg/L effluent quality standard is a possible future standard. The present plant effluent limit is 25 mg/L and has not been exceeded.

Significant elements of the pollution prevention program include development of best management practices for commercial users; an Integrated Pest Management (IPM) Partnership Pilot Program with the University of California Cooperative Extension Master Gardeners and the City of Palo Alto; an IPM demonstration garden; successful implementation of an areawide ban on the sale of copper sulfate root killer; participation in the Bay Area Pollution Prevention Group; and an extensive public education program for students, the general public, and businesses to inform them about how to reduce toxic discharges.

The District also teamed with the adjacent Mountain View Sanitary District to build and operate a permanent household hazardous waste (HHW) collection facility adjacent to CCCSD's treatment plant. The HHW Collection Facility functions as an integral component of the source control program by providing a viable solution for residents and small businesses to properly handle HHW so that it is not being dumped down drains, into creeks, or in the garbage. The facility opened to the public on October 25, 1997. This facility also serves the residents and eligible small businesses in the central Contra Costa County area by providing a reliable and economical option to properly manage hazardous wastes. The facility's first 14 months of operation have been very successful, based on participation by residential customers, volume of waste processed, and stakeholder feedback received. Additionally, the facility received statewide recognition by earning Cal EPA's "Best New HHW Collection Program" award in March 1998.

In 1998, CCCSD entered into a contractual agreement with the Contra Costa Clean Water Program to combine inspections for both pretreatment and illicit discharge (stormwater) programs. The focus of these inspections was permitted industries, vehicle service facilities, and restaurants, and in response to complaints. CCCSD performs comprehensive inspections covering pretreatment, stormwater, and pollution prevention program elements whenever feasible.

The District's Source Control and Pollution Prevention Groups are staffed by a Source Control Program superintendent and a Pollution Prevention Program superintendent who report to the Engineering Department's Environmental Services Division manager. These two groups are staffed with one senior Source Control inspector, four Source Control inspectors, a Source Control coordinator for administrative support, a HHW supervisor, senior HHW technician, and a HHW technician. In recognition of its outstanding Source Control program, CCCSD received a 1998 US EPA Pretreatment Program Excellence Award (21-50 SIU category).

Process Control/Laboratory Operations

A 6,400-square-foot, full-service laboratory is located at the District's treatment plant. The laboratory is certified by the California Departments of Health and Fish and Game for various types of water and wastewater analyses. Major laboratory instrumentation includes graphite furnace and flame AAs, GC/MS, a cold-vapor-mercury analyzer, HPLC, gel permeation chromatography, and an automated organic extraction and concentration system. All laboratory data handling is automated through a Laboratory Information Management System (LIMS).

Staffing includes a laboratory superintendent, one senior chemist, six chemists, and one co-op student. Clerical support is provided by the administrative section of the Plant Operations Department. The laboratory has six discrete work groups that include Microbiology, Wet Chemistry, Metals, Organic Chemistry, Toxicology (Bioassay), and Quality Assurance/Quality Control (QA/QC). The laboratory facility includes a superintendent's office, a senior chemist's office, analytical testing areas (biology, conventional chemistry, metals, and organics), a sample receiving area, a common preparation room, chemical storage, and office space for the chemists.

The laboratory's workload can be divided into the following areas:

- Wastewater operations support accounts for 72 percent of the overall laboratory workload. Of that amount, 20 percent is for special studies and 52 percent is related to compliance monitoring.
- Source Control, Collection System Operations, and Engineering support account for about 8 percent of the overall laboratory workload.
- Supervision and data management account for 20 percent of the laboratory workload.

About 9 percent of the FY 1997 laboratory budget covered analytical costs for work subcontracted to outside laboratories.

Financial Information

In FY 1997, the District's operating budget was $28,339,406 and its capital budget was $44,894,000. Plant and equipment assets totaled $452,213,294 ($344,640,746 net of depreciation).

Sources of FY 1997 operating revenues, in descending order, were sewer service charges (in-District and City of Concord), interest income, other service charges, stormwater program, lease rental income, side sewer inspections, industrial permit fees, and septic tank dumping. The annual residential sewer service charge was (and continues to be) $188, of which $153 went to operating revenues.

Sources of FY 1997 capital revenues, in descending order, were ad valorem property taxes, sewer service charges ($35 per residential unit), facilities capacity fee (connection fee), reimbursements from other agencies (such as the City of Concord), interest on investments, miscellaneous income, annexation charges, and pumped zone fee. The facilities capacity fee was (and continues to be) $2,572 per residential unit.

Treatment System and Process Descriptions

CCCSD's treatment plant site encompasses about 324 acres of land near the intersection of State Highway 4 and Interstate 680 in unincorporated Martinez. Included in that acreage are about 95 acres of buffer zone land located east and west of the treatment facilities and the District's headquarters building. North of the plant is a now-closed liquid-toxic-waste evaporation pond site and Acme Landfill. To the east is a Tosco oil refinery. To the south is State Highway 4, Buchanan Field Airport, and several mobile home parks. To the west is the County Animal Shelter (being purchased by the District for additional buffer land), County Public Works corporation yard, a cemetery, and a residential neighborhood.

Treatment processes utilized at the CCCSD plant consist of screening, primary sedimentation, biological activated sludge, secondary clarification, and disinfection.

Wastewater entering the treatment plant headworks is dosed with hydrogen peroxide for odor control. The wastewater then passes through bar screens to remove rags, branches, and large floating debris. This debris is ground and returned to the wastewater treatment process. The wastewater continues to the preaeration tanks where sand and silt (grit) that have infiltrated the collection system are removed. In primary treatment, about 50 percent of the solids and 35 percent of the organics are removed from the wastewater and pumped to a centrifuge for dewatering. The primary sedimentation tanks also remove floatable scum, which is then thickened. Both the thickened scum and the primary solids are then incinerated (see section on Biosolids Management).

Primary treated wastewater is pumped to secondary aeration tanks where bacteria biologically break down and feed off organic matter in the wastewater. The wastewater then travels to clarifiers where the bacteria (activated sludge) sinks to the bottom of the tank. A portion of the settled activated sludge is thickened via flotation thickeners, then is combined with primary solids and lime to assist in dewatering with centrifuges before being incinerated (see section on Biosolids Management). The remaining portion returns through the aeration process to maintain a proper balance of bacteria. The secondary effluent decanted from the clarifiers has 95 percent of the impurities removed. Ultraviolet light is then used to disinfect the clarified effluent by disabling the reproductive capabilities of the remaining pathogens. This completes the secondary treatment process.

Heat recovered from the burning biosolids is used to produce steam in a waste-heat boiler. The steam is piped to a turbine which drives the blower that produces air for the secondary aeration tanks. Augmenting the waste-heat boiler is steam from an on-site cogeneration facility. This facility consists of one 3,300 kilowatt gas-fueled turbine electrical generator and a heat recovery steam boiler. In addition to producing process steam, the natural-gas-burning cogeneration facility provides 90 percent of the electricity needed to run the treatment plant.

Most of the treated effluent is discharged to Suisun Bay through a 72-inch-diameter submerged diffuser located about 1,600 feet offshore at a depth of about 24 feet below mean low water. The rest undergoes more treatment at a filter plant so it can be recycled and reused.

The treatment plant includes a series of holding basins for temporary storage of wet-weather flows in excess of the plant's capacity. These basins are used when necessary to store influent flows in excess of the treatment plant capacity. Excess wastewater is routed from these basins to the plant when capacity becomes available in the treatment units. The combined volume of these holding basins is 140 million gallons. For extremely rare, severe wet-weather events, the basins can become full and excess wastewater may then be discharged via Pacheco Slough and Walnut Creek to Suisun Bay.

Given the proximity of residential and commercial development to the treatment plant, odor control is a high priority. In addition to adding hydrogen peroxide to the influent before it enters the headworks, numerous scrubbing towers clean foul air collected at the plant during primary treatment, biosolids thickening, and dewatering.

Biosolids Management

The primary scum, solids, and secondary-thickened waste-activated biosolids are combined and incinerated in one of two 11-hearth furnaces (one operating, one on standby). The furnaces are fueled by methane gas from the nearby Acme Landfill or natural gas. Incineration reduces 200 tons of wet biosolids to 10 tons of dry ash each day. The ash is disposed of at a landfill or reused as a soil amendment or building material.

City of Los Angeles Bureau of Sanitation (CLABS)

The City of Los Angeles is the second largest city in the US, with a population of more than 3.6 million (1997). Los Angeles is the principal city of a metropolitan region stretching from the City of San Buenaventura to the north, the City of San Clemente to the south, and the City of San Bernardino to the east.

The City of Los Angeles owns and operates a regional wastewater collection, treatment, and disposal system that serves an area of about 600 square miles. The system has two distinct service areas: the Hyperion System and the Terminal Island System. The total average daily flow during FY 1997 was 450 mgd with a system capacity of 550 mgd. The system consists of more than 6,500 miles of sewers and interceptors, four treatment plants, and various other facilities.

Table B-5 on the next page shows the average flows and treatment capacities for the four plants and two service areas during FY 1997.)

Table B-5. CLABS System Flows and Treatment Capacities

Facility	Year Commissioned	Current Capacity (mgd)	Average Flow (mgd)	Future Design Capacity (mgd)
Hyperion System				
Hyperion Treatment Plant	1923	420	348	450
LA-Glendale Treatment Plant	1976	20	20	20
Tillman Treatment Plant	1984	80	65	80
Hyperion System Totals		520	433	550
Terminal Is System				
Terminal Is. Treatment Plant	1935	30	17	30
Combined System Totals		550	450	580

Agency History

In 1980, a consent decree was negotiated with federal, state, and City officials that established a compliance schedule for systematically upgrading the degree of treatment provided at the Hyperion Treatment Plant (HTP). The consent decree was subsequently modified and approved in 1985 and again in 1987. Milestones in the amended consent decree included terminating sludge discharge to the Pacific Ocean by the end of 1987, operating the Hyperion Energy Recovery System (HERS) by mid-1989, and establishing several interim effluent limits that coincided with phased treatment improvements at HTP.

On the basis of a performance evaluation conducted in 1990, the EPA determined that the City was not in complete technical compliance with the federal pretreatment program regarding industrial waste discharges, and was therefore in violation of its NPDES permits. In 1990, the EPA issued an administrative order requiring the City to modify the structure of its pretreatment program for City dischargers and the agencies receiving City services by contract. The administrative order established a compliance schedule that extended from August 1990 to August 1993. The program was restructured to meet all federal requirements, but EPA has not yet lifted the administrative order. (It is expected to be lifted by September 1999.

Service Area Description

The City operates four wastewater treatment plants that receive flows from two service areas (Figure B-3). The central, western, eastern, and northern areas of the City are tributary to a coastal plant, the Hyperion Treatment Plant, and to two inland plants along the Los Angeles River, the Tillman Water Reclamation Plant and the Los Angeles–Glendale Water Reclamation Plant. The southern harbor area of Los Angeles is tributary to the Terminal Island Treatment Plant. The two service areas are referred to as the Hyperion System and the Terminal Island System.

The City's wastewater service area is determined by natural drainage patterns and does not generally conform to political boundaries. Because of the economics associated with gravity flow, parts of the City are served by other agencies and, likewise, the City provides wastewater services for other communities and adjacent areas. The City serves 28

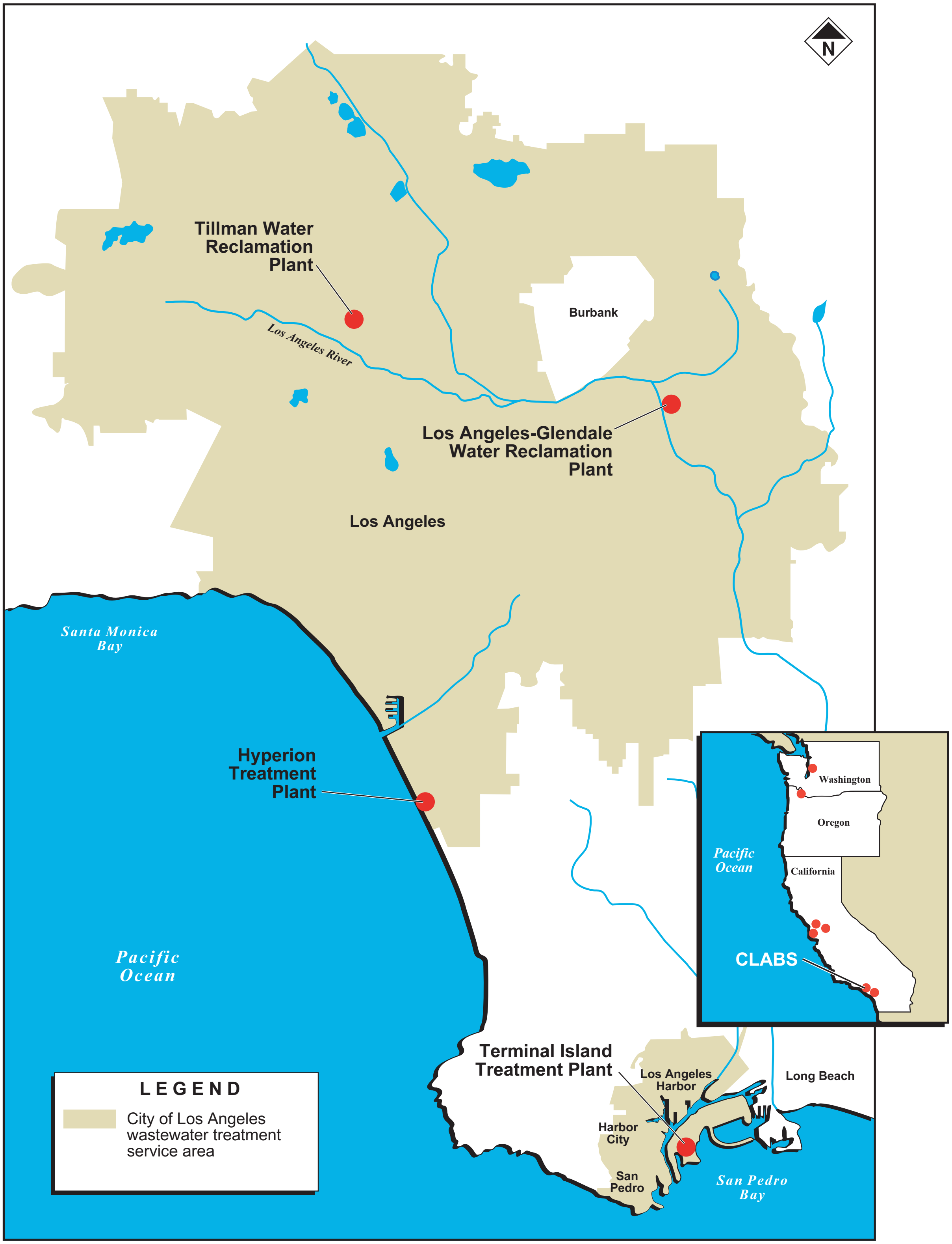

Figure B-3. CLABS Service Area

such adjoining areas by contract. The Los Angeles County Sanitation District serves areas within the City limits that drain towards its Carson Treatment Plant.

The City's wastewater collection and conveyance system consists of more than 6,500 miles of sewers, more than 100,000 maintenance holes, 54 wastewater pumping plants, and other miscellaneous facilities. Forty percent of the sewers have been in service for 50 years or more, with the oldest pipes installed about 100 years ago. The five main interceptor sewers in the Hyperion System are the Central Outfall Sewer (COS), the North Outfall Sewer (NOS), the North Central Outfall Sewer (NCOS), the Coastal Interceptor Sewer (CIS), and the North Outfall Relief Sewer (NORS).

The City has 34 pumping plants in the Hyperion System and 20 pumping plants in the Terminal Island System. The pumping plants are designed with redundancy in the form of standby pumps and power supplies. In case of failure, some plants are provided with storage retention basins or emergency bypass lines.

Organizational Overview

The organization chart for the City of Los Angeles and its Bureau of Sanitation are shown in

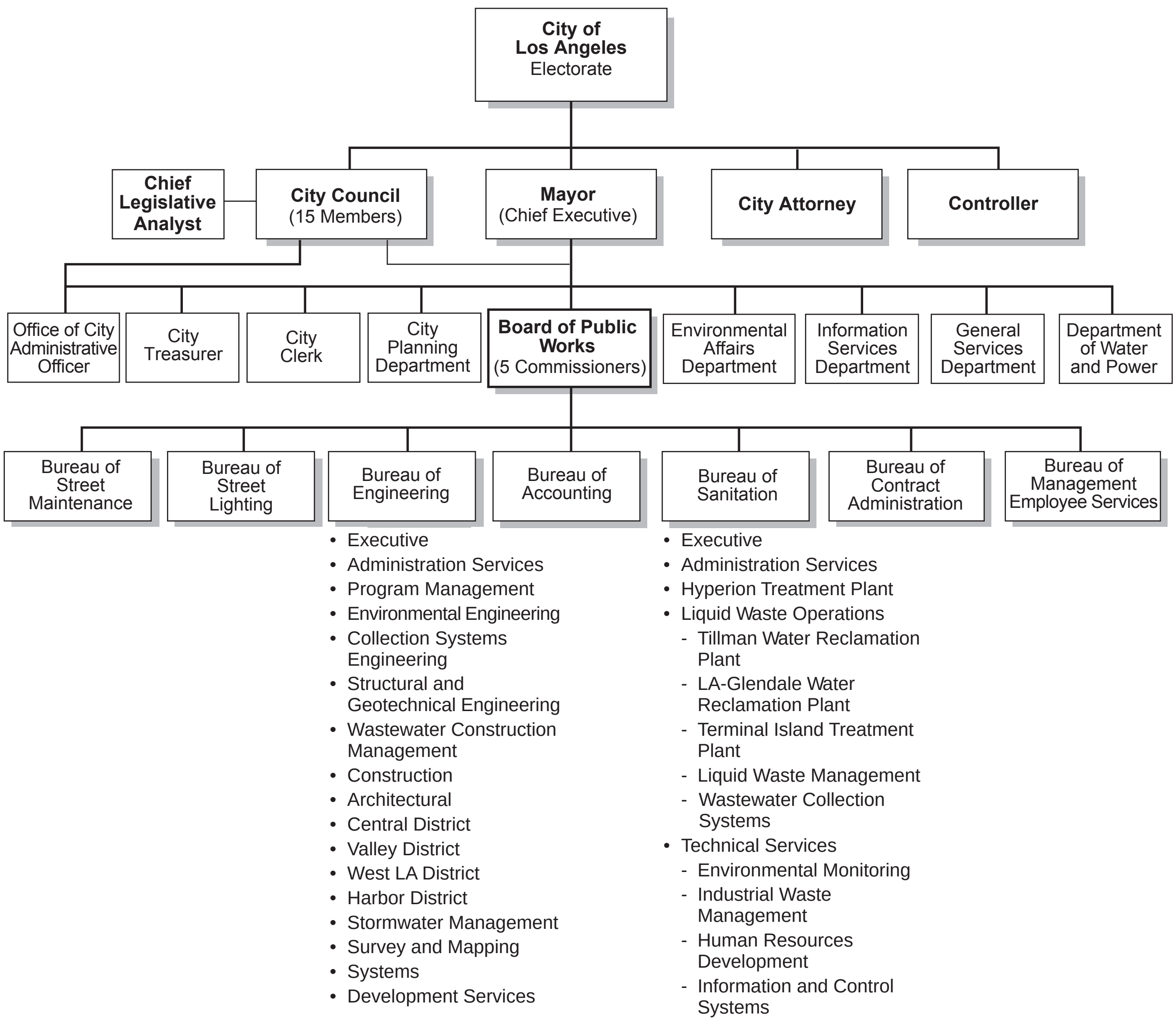

Figure B-4. Organization of the City of Los Angeles Government

Figures B-4 and B-5, respectively. The governing body consists of the Mayor, who is Chief Executive of the City, and a 15-member full-time City Council, which is the legislative body. The Mayor and the City Council, as well as the City Controller and City Attorney, are elected officials.

The Department of Public Works consists of a Board of Public Works, seven Bureaus, and other special offices. The Board of Public Works is a five-member board of commissioners who oversee the operation of these seven bureaus: Accounting, Contract Administration, Engineering, Management-Employee Services, Sanitation, Street Lighting, and Street Maintenance.

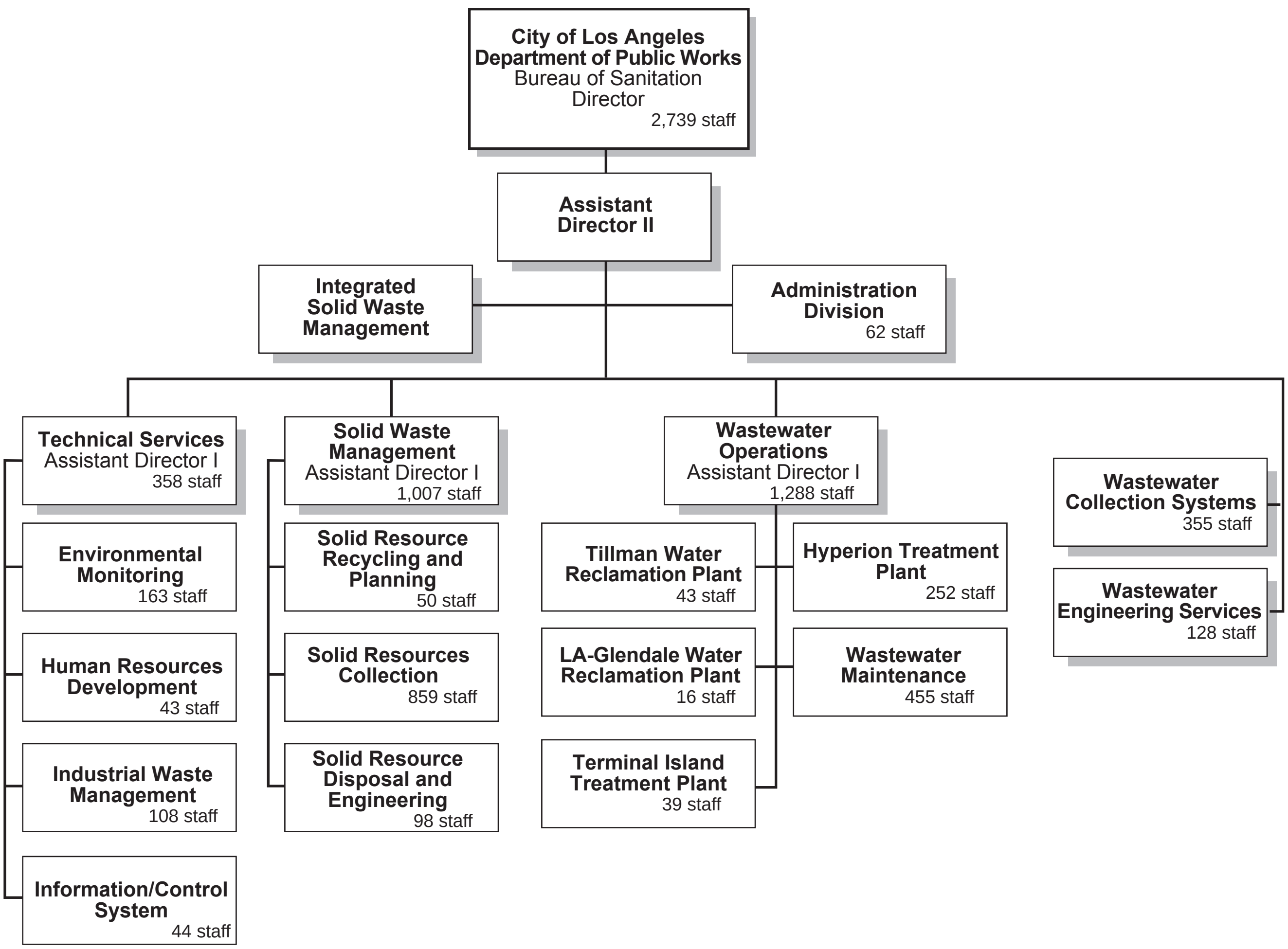

Figure B-5. Organization of the City of Los Angeles Bureau of Sanitation

Permit Information

The City's wastewater operations are subject to regulatory requirements relating to the federal Clean Water Act. To comply with federally mandated effluent quality and disposal criteria, the City must operate its wastewater treatment facilities according to discharge limitations and reporting requirements set forth in its NPDES discharge permits. At the present time, all wastewater treatment plants are substantially meeting the requirements of their individual NPDES permits, which are summarized in Table B-6.

Source Control

To comply with other federal regulations concerning the discharge of waste materials into the sewer system, the City must administer and enforce industrial pretreatment standards on users of the system. The City has had an industrial waste program in place since the early 1940s.

The Industrial Waste Management Division (IWMD) of the Bureau of Sanitation is currently responsible for administration of the City of Los Angeles' pretreatment program. The objectives of the program include protecting the publicly owned treatment works, preventing regulated toxic wastewater constituents from passing through to receiving waters and recovered biosolids, protecting operating and maintenance personnel, and ensuring the health and safety of the public. To meet these objectives, the program focuses on regulating industrial users (IUs) of the publicly owned treatment works. In FY 1997, more than 6,600 IUs were permitted to discharge to the sewer. Of these, 280 were significant industrial users (SIUs), 183 of which were subject to federal categorical standards. The success of the pretreatment program is exemplified by the 88-percent reduction in heavy metals in the treatment plants' influent over the past 20 years and the 100-percent beneficial reuse of recovered biosolids.

The program is managed through many functional elements, including inventory, permitting, inspection and sampling, enforcement, local limits, contracting jurisdictions, information systems development, and reporting. Other IWMD responsibilities include revenue and surcharge billing, hauled septage waste, and pollution prevention. In additional, each contract agency is required to permit and monitor all industries within its service area.

The IWMD staffing level for FY 1997 was 109. The division is organized into three sections: engineering (civil, chemical, mechanical: 28 staff), inspection (industrial waste inspectors: 67 staff), and administration (administrative/clerical: 14 staff).

Process Control/Laboratory Operations

The Environmental Monitoring Division (EMD) of the Bureau of Sanitation provides quality environmental data and assessment in support of the Bureau's activities. The division is organized into five sections (Biology, Chemistry, Industrial Waste, Process Control, and Technical Support) and three groups (QA/QC, Laboratory Information Management System, and Legal Reporting).

The staffing level for the division was about 115 in FY 1997, of which 104 were dedicated to wastewater activities and 11 to non-wastewater activities. The division staff consists of laboratory managers, supervisors, chemists, water biologists, water microbiologists, and laboratory technicians. The division occupies about 53,000 square feet of laboratory

Table B-6. CLABS Permit Limits

Treatment Plant	BOD[1] (mg/L)	TSS[2] (mg/L)	Cl_2 Residual (mg/L)	Coliform (MPN/100 ml)	
				Total	Fecal
Hyperion	30	30	0.84[1]	1,000	200
Tillman	20	15	0.1[2]	2.2[3]	N/A
Terminal Is.	15	15	0.1[2]	1,000	200
LA-Glendale	20	15	0.1[2]	2.2[3]	N/A

1 Instantaneous maximum
2 Daily maximum
3 7-day moving median

space in 10 buildings located at the four treatment plants. The main laboratory is located at the Hyperion Wastewater Treatment Plant. All laboratories within the division, except the air laboratory, are accredited by the California Department of Health Services through its Environmental Laboratory Accreditation Program. The air laboratory is certified by the Air Quality Management District Laboratory Approval Program.

Analytical capabilities of the EMD include conventional chemistry, microbiology, aquatic toxicology, organics, metals, air testing, and marine biology. The EMD provides support for treatment plant processes, NPDES permit compliance, source control, landfill operations, the sewer collection system, receiving water monitoring programs, and capital improvement projects. In addition to providing analytical services, the division is also responsible for preparing plant NPDES permit reports and annual assessment reports on receiving waters, providing consultation on environmental compliance and regulatory issues, and participating in the activities of various engineering project planning teams.

The EMD has an annual operating budget of $9.16 million, which includes salaries, contractual services, laboratory supplies and expenses, and equipment. Most of the division's resources support the wastewater program. Within the wastewater program, 73 percent of laboratory work is dedicated to complying with the NPDES permit requirements for the four treatment plants and source control. The remaining resources of the division are used by the Bureau to provide the best possible waste management services to the public while protecting the air, land, and water of the City of Los Angeles.

Financial Information

The wastewater program's operating budget for FY 1997 was $187,691,876; the capital budget was $289,528,000; and the budget expenditure for debt service was $125,689,000. The total value of wastewater fixed assets in 1997 was $2,811,535,000.

The City recovers the cost of the wastewater system's operations and maintenance and a portion of major capital expenditures through six types of user fees, plus federal Clean Water Grants, interest earnings, and miscellaneous revenues. The six user fees currently imposed by the City are:

- Sewer service charge.
- Industrial waste surcharge, inspection and control fees, and significant industrial user fees.
- Sewerage facilities charge.
- Industrial waste permit application fees.
- Service charges to the contract agencies.
- Miscellaneous fees: bonded sewer fee, cesspool vehicle permits, sewer tap fees, and other miscellaneous revenue sources.

The remaining capital expenditures are funded by wastewater revenue bonds.

All revenues derived from the six user fees are (pursuant to the municipal code of the City) deposited into the Sewer Construction and Maintenance Fund and used only for sewer and sewage related purposes, including but not limited to industrial waste control and water reclamation purposes. All interest earnings on money held in the Sewer Construction and Maintenance Fund are retained in the fund. The methodology for developing the fee schedules for the above charges is governed by the municipal code and conforms with rules set forth by the State Water Resources Control Board (SWRCB), acting on behalf of the US EPA.

Treatment System and Process Descriptions

Hyperion Treatment Plant

The Hyperion Treatment Plant (HTP), designed for an average flow of 450 mgd, treats an average dry-weather flow of about 348 mgd. HTP has a total wet-weather flow capacity of 850 mgd. HTP provides primary treatment for all influent flow and secondary treatment for about 175 mgd, utilizing the activated sludge process.

Most effluent is discharged to the Santa Monica Bay through a five-mile ocean outfall. Nearly 50 mgd of secondary effluent is recycled onsite or pumped to a nearby water reclamation plant owned by a local water district.

Biogas from Hyperion is transported by pipeline to the Department of Water and Power's Scattergood Power Plant.

Tillman and Los Angeles-Glendale Water Reclamation Plants

The Tillman Water Reclamation Plant is designed to provide tertiary treatment for an average dry-weather flow of 80 mgd and a peak wet-weather flow of 160 mgd. Nearly 29 mgd of tertiary effluent from the plant is reused locally. The balance is discharged into the Los Angeles River.

The Los Angeles-Glendale Water Reclamation Plant is designed to provide tertiary treatment for an average dry-weather flow of 20 mgd and a peak wet-weather flow of 30 mgd. The biosolids produced by the two water reclamation plants are returned to the interceptor system for treatment at HTP. About 3.8 mgd of tertiary effluent is reused locally. The remaining effluent is discharged into the Los Angeles River.

Terminal Island Service Area and Treatment Plant

The service area for Terminal Island Treatment Plant consists of the harbor area of the City, located about 20 miles south of downtown Los Angeles. The area includes the communities of Wilmington and San Pedro, Terminal Island, and a portion of Harbor City. Being geographically isolated from the rest of the City, the area requires a separate collection, treatment, and disposal system.

Tertiary effluent from the Terminal Island plant is discharged into Los Angeles Harbor, but is suitable for beneficial reuse. The facility generates electricity onsite from a portion of its biogas.

Biosolids Management

The City stopped discharging sewage sludge into the ocean in November 1987. The Hyperion and Terminal Island treatment plants contain onsite biosolids handling facilities (digesters and centrifuges). Solids from the Tillman and Los Angeles–Glendale Water Reclamation Plants are returned to sewers and processed at Hyperion.

The Bureau of Sanitation has developed a diversified program for disposing and reusing biosolids. Stabilized and dewatered biosolids are recycled as a high-quality soil amendment for landscaping, applied to agricultural land, used as landfill cover, and trucked for disposal in landfills.

City of Portland Bureau of Environmental Services (CPBES)

The City of Portland, the largest city in Oregon, is located on the south shore of the lower Columbia River and straddles the lower Willamette River. The City of Portland Bureau of Environmental Services (CPBES) is a municipal agency that includes programs for stormwater management; wastewater collection and treatment; protection, enhancement and restoration of natural waterways; and solid waste collection and recycling services. CPBES also designs and installs sewers, monitors residential and industrial wastewater discharges to sewers, streams, and rivers, and regulates solid waste collection and recycling services for Portland residents.

CPBES operates two wastewater treatment plants with a combined average dry-weather flow capacity of 108 mgd and average dry-weather flows of 86 mgd.

Agency History

Before 1947, Portland discharged its wastewater and stormwater flows directly into the Willamette River and Columbia Slough, utilizing more than 60 outfalls. Over time, discharge from these outfalls severely impacted the area's waterways. Dissolved oxygen levels of zero were common in the Willamette River during summer months.

In 1947, Portland embarked on an aggressive capital improvement program to restore water quality and allow beneficial uses of the area's water-

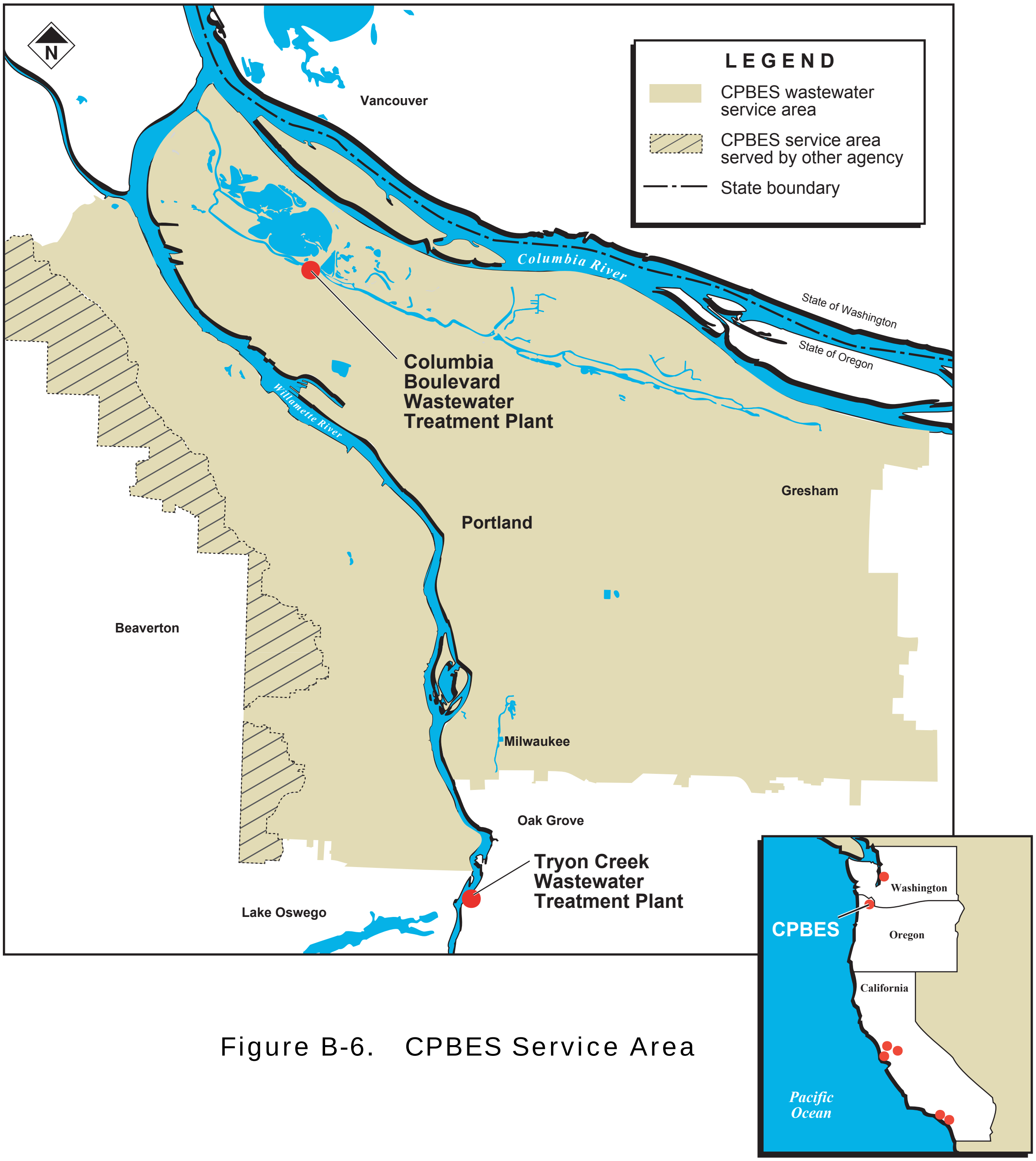

Figure B-6. CPBES Service Area

ways. The program was dedicated to the diversion, collection, and treatment of wastewater in a combined sewer system. Portland designed a system that would intercept the entire sanitary portion of the combined sewage and transport it to a new treatment plant. After constructing these first intercepting lines and a primary treatment plant on Columbia Boulevard in north Portland, the City began treating its wastewater. Today these large interceptors, generally paralleling the Willamette River to the east and west and extending along the south side of the Columbia Slough, are the sewer system's major sewage-carrying conduits.

In 1952, construction of the first phase of the Columbia Boulevard Wastewater Treatment Plant (CBWTP) was completed, a major element of the 1947 program. Other major milestones included construction of the Tryon Creek Wastewater Treatment Plant (TCWTP) in 1965 and expanding the CBWTP to a secondary treatment plant in 1974. Further improvement in water quality should be realized with the construction of wet-weather treatment facilities at CBWTP by the end of 2000.

Service Area Description

The CPBES service area boundary (see Figure B-6, preceding page) covers about 94,000 acres (28,000 acres are served by a combined sewer system and 66,000 acres by a separate sanitary sewer system). The service area is located on both sides of the Willamette River, extending about 20 miles south of its confluence with the Columbia River. The area generally is bounded on the west by low-lying hills paralleling the Willamette River, by other service areas serving the City's metropolitan area to the south, by the City of Gresham to the east, and by the Columbia River to the north.

Water consumption records indicate that 58 percent of the total dry-weather flow originates from combined sewer service areas; the remaining 42 percent originates from separated sewer service areas.

The sewer system serves about 144,787 residential customers and 12,844 commercial customers within Portland, as well as customers served via wholesale contracts with other municipal agencies adjacent to Portland (notably Lake Oswego). The system serves a "population equivalent" of 931,212.

Portland's sewerage system consists of a network of more than 2,280 miles of collection system piping (about 940 miles of sanitary, 850 miles of combined, and 490 miles of storm), ranging in diameter from 4 to 144 inches; 95 pump stations; and the two sewage treatment plants.

CPBES owns, operates, and maintains the sanitary and stormwater collection and transport systems within its boundaries. The drainage area served by these systems encompasses about 85,000 acres. Portland also provides sanitary sewer service to about 9,000 acres outside Portland's corporate limits. CPBES provides sanitary sewer service to about 500,000 people, numerous commercial and industrial facilities, and several wholesale contract customers located adjacent to Portland.

Organizational Overview

The City of Portland is a home-rule charter city that operates under a modified commission form of government. The Charter provides for five nonpartisan elected councilmembers, called Commissioners, including the Mayor.

The Mayor is the formal representative of the City, and is responsible for assigning each of the commissioners to manage one of five departments: Finance and Administration, Public Affairs, Public Safety, Public Utilities, and Public Works. The Mayor traditionally serves as the Commissioner of Finance and Administration and can reassign the other commissioners at any time. Following a recent assignment change by the Mayor, CPBES currently resides in the portfolio of the Commissioner of Public Affairs.

CPBES is organized into five operating groups that report to the Office of the Director (see Figure B-7). The **Office of the Director** provides policy direction to all CPBES programs, coordinates activities of the five CPBES operating groups (see following list), provides CPBES accounting, budgeting, computer, facilities management, financial, and human resources services, and ensures timely and appropriate response to the public, ratepayers, and regulatory agencies. The Office of the Director also includes public information, public involvement, intergovernmental relations, and a business opportunities program for minority/women/emerging businesses.

- **Engineering Services Group**. Consolidates most CPBES engineering activities under the direction of the Chief Engineer. The group provides engineering services to support the CPBES' capital improvement program and City development goals.
- **Systems Development Group**. Keeps the CPBES Public Facilities Plan current, ensures that planning efforts incorporate all applicable regulatory conditions, and evaluates CPBES programs and projects for compliance with environmental regulations.
- **CIP Management Group**. Administers the development and implementation of the CPBES capital improvement program. This group manages the design and construction of capital projects for the sanitary and stormwater collection and treatment systems, and ensures improvements meet all state requirements for Portland's CSO program.

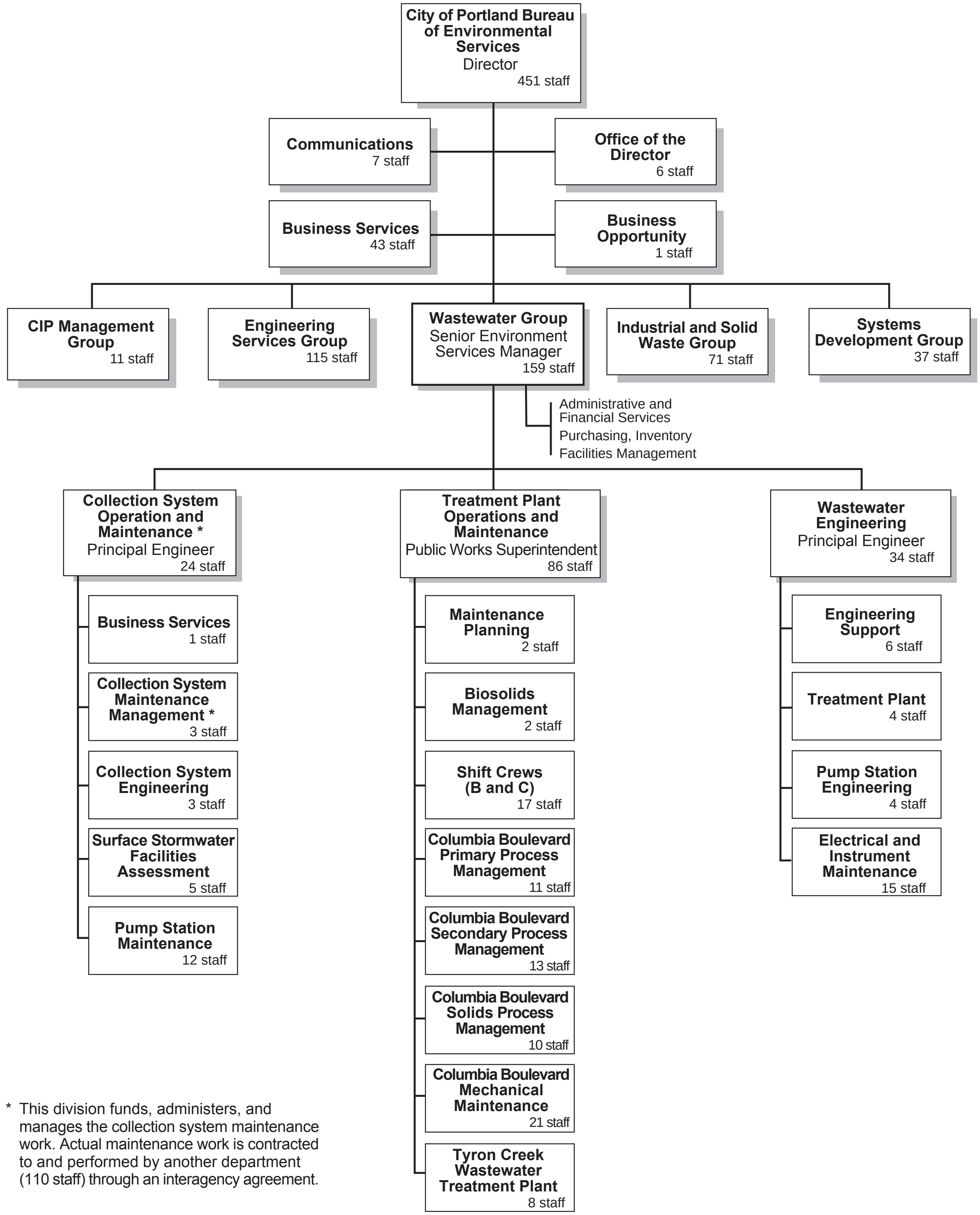

Figure B-7. Organization of Wastewater Treatment Functions at CPBES

- **Industrial and Solid Waste Group**. Has lead responsibility for the source control program and provides environmental investigation, monitoring, environmental compliance, and enforcement support to other CPBES programs. The group manages Portland's commercial recycling programs, franchised residential solid waste systems, and environmental remediation activities.
- **Wastewater Group**. Responsible for the management, operation, and maintenance of the system's two wastewater treatment plants, collection system pipelines for stormwater and wastewater, collection system pump stations, drainage maintenance, and related structures.

Permit Information

CPBES' two treatment plants are activated sludge, secondary treatment plants with capacities to treat 100 mgd (CBWTP) and 8 mgd (TCWTP). Under Oregon state law, a NPDES permit is required to discharge treated effluent from each treatment plant. Oregon's Department of Environmental Quality (DEQ) is delegated to preside over the NPDES permitting program and ensure that CPBES is in compliance with all federal and state provisions pertaining to discharge from the treatment plants. CPBES permit limits are summarized in Table B-7.

Source Control

The CPBES Industrial Source Control Division (ISCD) implements various source control programs to protect the local environment from harmful substances discharged by industrial and commercial users. The ISCD has three operating sections and is staffed by a division manager, three section supervisors, 16 environmental technicians, and one administrative staff.

The Industrial Permitting Section administers the core pretreatment program for 76 significant industrial (Class P-1) users, 57 major (Class P-2) facilities, and 10 minor (Class P-3) dischargers. In addition, permits have been issued to 36 Class P-4 industrial sources that do not discharge to the City's sewerage system; but which, due to their process and category, have potential to discharge industrial wastewater. The work performed by this section is required by CPBES' NPDES permit. Portland has controlled industrial sources by a source control program since 1974 and has reduced harmful pollutants discharged to its facilities from industrial sources by 90 percent.

The Industrial Stormwater Section administers CPBES' NPDES industrial stormwater program. The purpose of the program is to monitor and control stormwater runoff from 150 permitted industrial facilities to CPBES' separate storm sewer system. The program is implemented through a partnership agreement with DEQ.

The Industrial Projects Section implements the alternative discharge control program to reduce pollutant discharges to the CPBES sewer system from nonpermitted commercial and industrial sources. This section also operates the high-strength surcharge program to appropriately assess treatment charges for industrial users, maintains the industrial user survey and building plan review process, and handles batch discharge requests.

The ISCD receives support services from the Environmental Compliance and Environmental Monitoring and Investigations Divisions. The former provides legal assistance for major enforcement actions, responds to pollution complaints and spill episodes, traces slug loads discovered upon entering the treatment plants, and handles the septage hauling and disposal program. The latter provides all sampling and testing services required by the ISCD on a "work order" basis.

Table B-7. CPBES Permit Limits

Treatment Plant	NPDES Permit	Total Residual Chlorine
Tryon Creek Wastewater Treatment Plant (TCWTP)	30/30 wet months; 20/20 dry months	1.7 mg/L daily/0.7 mg/L monthly
Columbia Boulevard Wastewater Treatment Plant (CBWTP)	30/30	Total residual chlorine not to exceed 1.0 mg/L*

*Limit for total residual chlorine is based on continuous monitoring; any excursion beyond 1.0 mg/L requires CPBES to provide written documentation of the excursion in a monthly monitoring report. The written documentation is required to provide a detailed explanation for the excursion. If CPBES can show that the excursion did not result in a stream condition that exceeds the water quality standard for chlorine, then the excursion is not considered a violation of the permit.

Process Control/Laboratory Operations

The City of Portland's Water Pollution Control Laboratory (WPCL) is a full-service analytical laboratory that provides water quality analyses for CPBES' water quality programs. The laboratory is located about three miles from the CBWTP and occupies about 11,000 square feet of a 37,000-square-foot building. Included in the laboratory are analytical areas for general chemistry, nutrient analysis, process control, organics, and metals analysis. In addition it houses storage areas, prep areas, sample receiving/sample custodian areas, and office space for the laboratory staff. The offices for Source Control, Field Operations, Spill Response, Data Acquisition and Management, Investigation and Monitoring, and Industrial Stormwater Management are also located in the building.

The laboratory staffing level in 1999 is 16 people, and includes a laboratory manager, a QA/QC chemist, an inorganics chemist, an organics chemist, a process control chemist, and 11 laboratory technicians. The building receptionist in the Administrative Support Section performs clerical responsibilities. A Laboratory Information Management System assists in managing all laboratory data.

Hours of operation are 6:00 a.m. to 5:30 p.m., Monday through Friday. The laboratory is staffed on weekends for wastewater treatment plant process control and NPDES permit analysis.

Financial Information

CPBES is organized as a governmental enterprise entity, funded entirely from fees and charges levied for services provided. It receives no tax revenues other than federal and state grant funds. CPBES provides revenue to the City of Portland's general fund in the form of a business license fee equivalent to 7.75 percent of user fee revenues. In the current fiscal year, business license fee payments are estimated to total $8.4 million. Total user fee revenues for this fiscal year are currently forecast at $106.1 million.

User fee revenues fund all operating and maintenance expenses, including general fund overhead expenses and debt service on outstanding revenue bonds, and contribute toward the cost of CPBES' capital improvement program. CPBES currently has $650 million in outstanding debt, and the five-year financial forecast includes issuance of an additional $226 million.

All fees and charges are developed according to cost-of-service ratesetting principles. The three primary service fees are the sanitary volume charge (for sanitary sewer service), the stormwater charge (for stormwater services), and the account service charge (for customer service and billing related services). Other fees are collected from industrial customers who discharge "extra-strength" sewage, customers who discharge cooling water to the sewer system, domestic septage haulers who discharge tank truckloads at the sewage treatment plant, and customers of other sewer and stormwater services.

Residential customers pay $2.75 for every 100 cubic feet of water discharged to the sewer system; commercial/industrial customers pay $2.86 for every 100 cubic feet. Usage is calculated based on water use, net of nonsewer uses (such as irrigation). Residential customers are billed based on winter-month water use, when it is assumed that all water used is discharged to the sewer. Stormwater service charges are $2.87 per 1,000 square feet of impervious area on residential property and $3.24 per 1,000 square feet of impervious area for commercial/industrial customers. Single family homes are charged based on the citywide average of 2,400 square feet. Commercial/industrial customers are charged according to the actual amount of impervious areas on their properties.

CPBES imposes a system development charge (SDC) on new construction and on existing development for connecting to the sewer system. There is a SDC for sanitary sewer service ($1,720 per equivalent dwelling unit) and a SDC for stormwater service ($100 per 1,000 square feet of impervious area, plus $.95 per foot for site frontage to the right-of-way, plus $.38 per vehicle trip, as measured by the ITE manual). The current-year SDC revenue forecast is $7.7 million.

The CPBES capital improvement program (CIP) is funded from federal grants, system development charge revenues, net operating income, and the sale of sewer system revenue bonds (which in turn generates additional rate revenue requirements in the form of higher debt service payments). The five-year CIP totals $389 million, of which about 78 percent will be funded from revenue bond proceeds.

Treatment System and Process Descriptions

The system's 95 pump stations provide service where gravity sewers cannot function because of topographic restrictions. All pump stations are monitored remotely through a telemetry system connected to a central computer system at CBWTP.

The TCWTP is located within the City of Lake Oswego's city limits, adjacent to the Willamette River, but is owned and operated by the City of Portland. Treatment services are provided for both Lake Oswego and Portland by an intercity contract. Roughly half of the flow to the TCWTP comes from the City of Portland's Tryon Creek basin which discharges to the 30-inch Tryon Creek Interceptor. The other half originates in the City of Lake Oswego sewer service area and discharges to a 24-inch line. The TCWTP was designed for an average flow of 8.3 mgd with the ability to treat hourly peak flows of 35 mgd for short periods of time.

The CBWTP is a 133-acre site about two miles west of Interstate 5 and five miles north of downtown Portland. Until a permit violation in November 1998, the CBWTP had been in total compliance with its NPDES permit for 55 consecutive months, and routinely achieves effluent quality beyond permit stipulations.

Under normal operating conditions, a two-mile-long, 102-inch-diameter gravity outfall line carries up to 130 mgd from the CBWTP to a 350-foot-long flow diffuser structure in the Columbia River. Flow discharged to the 102-inch diameter pipe is divided into a 54-inch and 72-inch pipe in a siphon box near the south bank of the Columbia Slough and recombined into a 102-inch line in a junction box on the opposite bank. Similar structures divide and recombine flow as it enters and leaves the Oregon Slough. The gravity system discharges to a flow diffusion manifold equipped with multiple discharge outlets via rubber duckbill valves.

Under high river or increased plant flow conditions, effluent pumping is required. Three 78-mgd pumps can be actuated to discharge through the 102-inch gravity line system. Two additional pumps can be engaged to transport excess effluent through a separate 72-inch diameter pressure line which parallels the 102-inch gravity line and connects to the 72-inch gravity line entering the Oregon Slough just beyond a flow splitter box located on the south bank. Flow from the 72-inch line is combined with flow from the 54-inch gravity line on the north bank of the slough and directed to the effluent discharge assembly via the 102-inch gravity pipe.

CBWTP meets chlorine requirements by injecting chlorine solution into outfall lines and utilizing detention time in the lines for chlorine contact. Chlorine, delivered to the plant site in 90-ton railcars, is metered through three evaporators and one 10,000-lb/d and two 2,000-lb/d chlorinators into the outfall lines. There are two 8,000-lb/d chlorine injectors at the effluent pump station. The 102-inch outfall line to the Columbia River provides sufficient detention time to meet chlorine contact requirements if flow rates are within design limits.

The plant has been continually improved and expanded since it was built in 1952. Recent changes include:

1998. The Headworks Project was completed, replacing one of the oldest sections of the CBWTP.

1996. A 6 mgd (expandable to 12 mgd) reuse water reclamation plant was constructed directly north of secondary clarifiers. The plant processes secondary effluent through Envirex™ microscreens prior to ultraviolet light disinfection. It is designed to produce reclaimed water for a variety of CBWTP process uses (such as washdown water, spray nozzles, scum cleaning, and channel cleaning) and includes a water feature immediately southwest of the new headworks. Reclaimed water is also used as an additional water supply for irrigating plant grounds. The wastewater reclamation plant was designed to produce Level III effluent.

1994. Modifications were completed to the secondary treatment system. Selector technology incorporated into the plug flow process mode was added to the secondary phase, making this plant one of the largest in the country to convert to this process. Modifications included reconfiguring the aeration tanks to plug flow selector technology, converting the aeration tanks to fine-bubble diffusion, adding additional low-end blower capacity to take advantage of the energy savings of the new diffusers, and modifying secondary clarifiers to improve performance and hydraulic capacity. The addition eliminated unwanted microorganisms and minimized the need for chlorination, while increasing secondary treatment flow from the maximum of 100 mgd to 160 mgd.

1992. New chlorination facilities were constructed to meet revised Uniform Fire Code requirements for emergency scrubbers.

CPBES recently received approval for its first master plan for the CPBES campus, with an expanded campus boundary. The master plan is a 10-year plan incorporating the results of a long-range (40-year) Facilities Plan, completed in 1995. The CBWTP Master Plan outlines more than 30 projects over a 10-year period, including a substantial program for odor control improvements. This plan provides CPBES with a "road map" for the future, which should result in excellent facility development.

Biosolids Management

The City of Portland generates roughly 15,000 dry tons of freshly digested biosolids annually at the CBWTP. Raw solids captured from primary and secondary clarification processes at the two wastewater treatment works are thickened, anaerobically digested, dewatered, and recycled. A combination of digested primary solids and raw thickened waste-activated solids from the TCWTP are integrated with undigested solids generated at the CBWTP immediately prior to digestion.

For several years, Portland has successfully beneficially recycled all its biosolids. In 1984, the City began operating a Taulman-Weiss invessel-composting system designed to process about 60 dry tons of anaerobically digested biosolids daily. Until recently, the composting system has been used to process about 25 percent of the freshly digested biosolids produced at the CBWTP. The State DEQ has classified compost generated under this operation as "exceptional quality" (Class A). During 1998, Portland produced 20,635 cubic yards of compost. Over the past two years, Portland has marketed 98 percent of this compost to commercial customers on a wholesale, sealed-bid basis. In addition, a small quantity of compost has been sold to retail customers on Saturdays during spring, summer, and fall months. (For economic reasons, retail compost sales were discontinued in spring 1999.)

Since early 1990, Portland has recycled the majority of its biosolids (classified as a bulk, Class B product by state standards) on semi-arid rangeland in north central Oregon. For the past several years, digested biosolids have been integrated with older solids derived from a storage lagoon at the CBWTP and trucked, under contract, about 200 miles from the CBWTP to a DEQ-authorized land application site and distributed on rangeland under a separate contract. Biosolids have effectively halted soil erosion and dramatically increased biomass and forage quality at the rangeland site.

During 1998, 13,308 dry tons of biosolids were surface-applied at agronomic rates under the rangeland program. Portland expects to recycle 100 percent of its biosolids on rangeland sites in the near future. In addition, Portland has initiated the identification of land application sites in the dryland wheat belt bordering the lower Columbia River Plateau (which is 30 to 40 percent closer to Portland) in an attempt to reduce transport costs.

East Bay Municipal Utility District (EBMUD)

Special District No. 1 (SD-1), a separate district within the East Bay Municipal Utility District (EBMUD) and governed by the same Board of Directors, was established in 1944 and is administered by EBMUD's Wastewater Department.

Domestic, commercial, and industrial wastewater is intercepted from city-owned sewers and treated for the California cities of Alameda, Albany, Berkeley, Emeryville, Oakland, and Piedmont, and for the Stege Sanitary District, which includes El Cerrito, Kensington, and part of Richmond. Each of these communities operates sewer collection systems that discharge into one of five EBMUD intercepting sewers.

The Main Wastewater Treatment Plant has a capacity of 415 mgd. Two remote wet-weather treatment plants provide an additional capacity of 258 mgd. In FY 1997, the main plant flow averaged 77 mgd.

Agency History

The following chronology lists important milestones in the evolution of Special District No. 1.

1944: SD-1 established.

1946: General obligation bonds approved for primary treatment plant.

1948: Primary treatment plant construction begins.

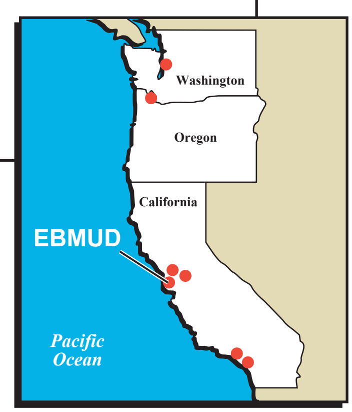

Figure B-8. EBMUD Service Area

1951: Primary treatment plant begins operating.
1970: General obligation bonds approved for secondary treatment.
1972: Source control program initiated.
1973: Secondary treatment construction begins.
1977: Secondary treatment begins operating.
1983: Biosolids composting initiated.
1985: Wastewater power generation begins.
1987: Wet-Weather Capital Improvement Program initiated.
1994: Biosolids composting replaced with land application.
1995: North Richmond Reclamation Plant begins operation.
1995: Wet-Weather Capital Improvement Program completed.

EBMUD's Wastewater Department has received three EPA awards for source control pretreatment excellence, one EPA award for leadership in composting, and one award for air emissions research and development excellence.

Service Area Description

The SD-1 service area (Figure B-8, preceding page) consists of six East Bay cities and one sanitary district that covers 83 square miles. The total number of customers served is about 600,000. The interceptors equal 27 miles of reinforced concrete pipes, ranging from 12 inches to 9 feet in diameter, and collect wastewater from about 1,800 miles of sewers owned and operated by the communities. Fourteen pumping stations, ranging in capacity from 1.5 to 60 mgd, lift wastewater throughout the interceptors as it travels to the Main Wastewater Treatment Plant. SD-1 also operates two remote wet-weather treatment plants.

Organizational Overview

EBMUD is governed by a seven-member, publicly elected Board of Directors representing home wards. The District has about 1,700 permanent, full-time employees, all under the administrative direction of an appointed General Manager and management staff. A Wastewater Department Director reports to the General Manager. Figure B-9 shows the organization of the Wastewater Department, which consists of about 315 staff performing engineering, operations, laboratory, source control, and clerical duties.

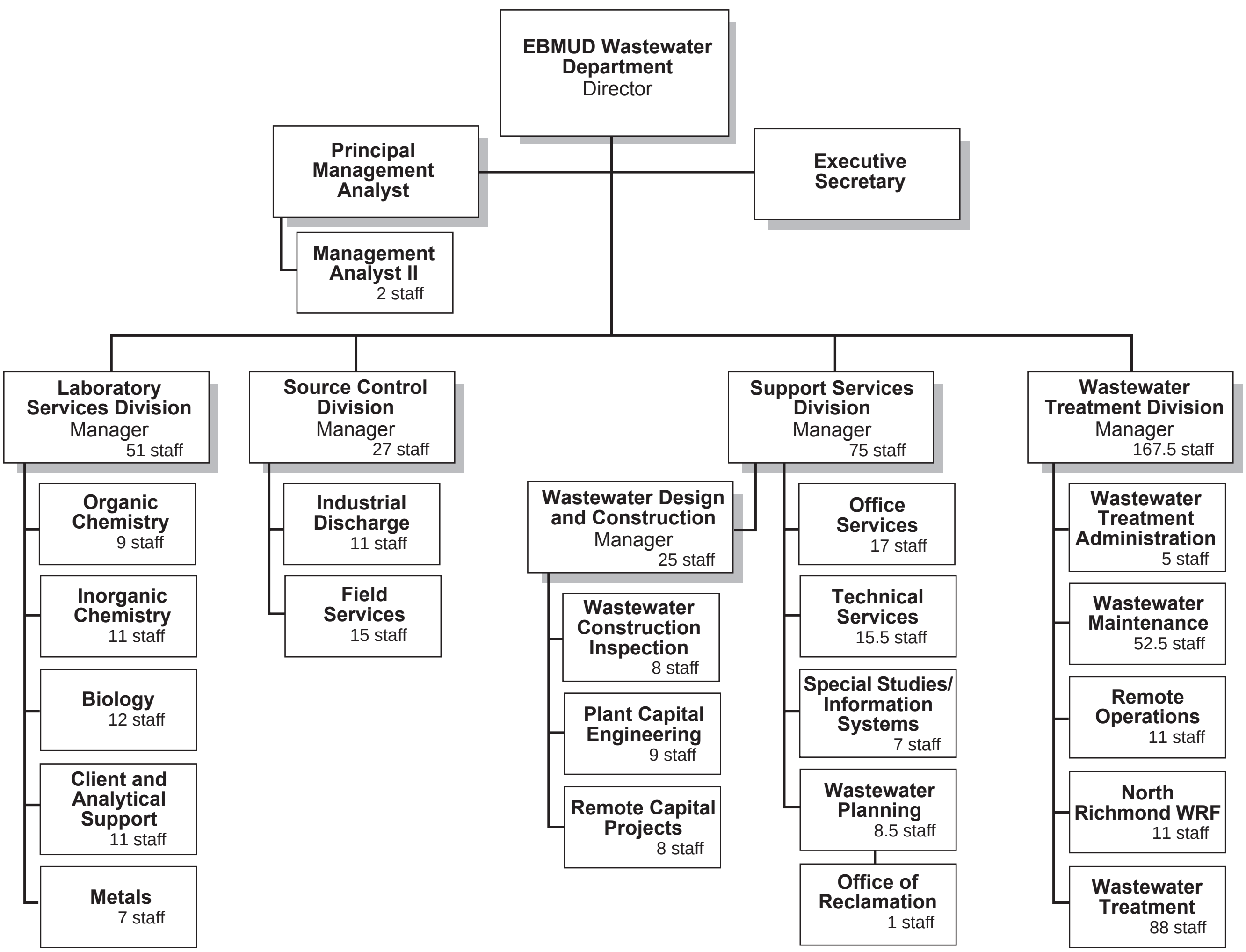

Figure B-9. Organization of Wastewater Treatment Functions at EBMUD

Permit Information

The Main Wastewater Treatment Plant's NPDES permit limits for 1997 are indicated in Table B-8.

Table B-8. EBMUD Permit Limits

Parameter	Limit
Total BOD and TSS	85% removal
BOD	30 mg/L, monthly average 45 mg/L, weekly average
TSS	30mg/L, monthly average 45mg/L, weekly average
pH	6 to 9
Total coliform	240 MPN/100 ml, 5 day average 10,000 MPN/100 ml, per sample
Settleable matter	0.1 ml/L/hr, monthly average 0.2 ml/L/hr, maximum
Oil and grease	10 mg/L, monthly average 20 mg/L, daily average
Chlorine residual	0.0 mg/L
Acute toxicity	90% survival in 11 samples
The permit also limits 10 selected organics and 12 metals/inorganics.	

Source Control

The District's wastewater service area includes more than 20,000 commercial and industrial accounts. In 1972, EBMUD began a local source control program requiring pretreatment of wastes by certain categories of industrial customers. The Wastewater Source Control Program reduced the amount of heavy metals discharged into sewers by 91 percent, and EBMUD's treatment plant reduced the remaining heavy metals by another 75 percent. Together these two steps have reduced the quantity of heavy metals discharged into the San Francisco Bay by 98 percent since 1977.

In 1988, source control efforts expanded into pollution prevention/waste minimization activities by educating commercial customers about how to reduce not only heavy metals, but volatile organics as well. Preventing pollution also eliminates or minimizes many costs for industrial and commercial customers by avoiding permit fees, disposal charges, consultant expenses, and the need to buy more chemicals.

In 1989, 1993, and 1997, EBMUD's Pretreatment Program received the National Pretreatment Excellence Award for large programs from the US EPA. EBMUD is the only agency to win the award more than once. In 1990, the District's air emissions monitoring program/inventory gained national recognition by receiving an award for research and development from the American Academy of Environmental Engineers.

Process Control/Laboratory Operations

The Wastewater Department manages the District's combined laboratory, which operates 10 hours a day, 365 days a year to constantly monitor water quality for drinking water and wastewater systems. The laboratory occupies 30,000 square feet of analytical and office space and offers state-of-the-art instrumentation and laboratory information system for data storage and transfer.

The Laboratory Services Division is a full-service, production-oriented environmental laboratory providing analytical support for EBMUD's water and wastewater systems. The laboratory is certified by the State of California Environmental Laboratory Accreditation Program in 14 separate fields of testing. High-quality analytical data is produced for water, wastewater, reclaimed water, receiving water, air, soil, sludge, biosolids, compost, hazardous waste, and treatment materials.

Quality assurance and quality control (QA/QC) programs dominate every aspect of the laboratory's daily operations. Five work sections comprise the laboratory: Organic Chemistry, Inorganic Chemistry, Biology, Metals, and Client and Analytical Support.

Organic Chemistry. The laboratory's Organic Chemistry Section performs all aspects of instrumental analyses for organic chemistry, using gas chromatography-mass spectrometers and gas chromatography to identify some 300 organic compounds. A high-performance liquid chromatograph tests for nonvolatile organics, and the latest in gel permeation cleanup extraction technology is used to prepare air, water, and solids samples for analysis.

Inorganic Chemistry. This section performs chromatographic, spectrophometric, potentiometric, and physical analyses. Most of the section's workload supports water and wastewater process control operations and regulatory compliance monitoring.

Metals. The Metals Section performs metals analyses using US EPA-approved analytical methods for water and wastewater. Using state-of-the-art instrumental procedures, the staff can simultaneously analyze up to 75 elements with extremely low detection limits. Most heavy metals can be accurately measured in the range of parts or subparts per billion.

Biology. The Biology Section consists of two groups that conduct microbiological and toxicological investigations. The microbiology group uses standard procedures to test for bacteria, parasites, and phytoplankton in water and wastewater. The toxicology group conducts biomonitoring studies to monitor acute and chronic toxicity in wastewater effluent.

Client and Analytical Support. This section manages all client projects; collects, receives, and preserves samples; tracks progress and provides QA/QC support; and reports data. This staff group also manages procurement, shipping, receiving, and storage of inventory; preparation of glassware and sampling kits; and laboratory services contracts.

Financial Information

In 1997, the Wastewater Department's operating budget was about $50 million and the capital budget was about $30 million. Plant and equipment assets total roughly $450 million.

Revenues are generated by a combination of fees and charges, bonds, and taxes.

Treatment System and Process Descriptions

The treatment steps include prechlorination (for odor control), screening (to remove large objects), grit removal, primary sedimentation, secondary treatment using high-purity, oxygen-activated sludge, final clarification, anaerobic sludge digestion, centrifuge/belt press dewatering, and land application of biosolids. The treated effluent is then disinfected, dechlorinated, and discharged through a deep-water outfall into San Francisco Bay, one mile from the East Bay shore.

Methane gas produced during anaerobic digestion is used to generate electric power, supplying about 40 percent of plant power needs.

A 1-mgd reclaimed water plant provides onsite irrigation and sealing water needs.

Biosolids Management

Under a private contractor, 100 percent of biosolids generated are land applied or alternatively used as landfill cover.

King County Department of Natural Resources (KCDNR)

King County is a general-purpose government that provides regional services (roads, transit, law enforcement, parks, etc.) on a countywide basis and contracted services to cities within the County. King County's Department of Natural Resources (KCDNR) provides wholesale wastewater transport, treatment, and disposal service to 17 cities and 18 local sewer and water districts, collectively known as component agencies.

The County owns and operates the major sewer interceptors and pump stations that carry wastewater to its treatment plants. The component agencies individually own, operate, and maintain the pipelines and other conveyance facilities that carry wastewater to the County's interceptors.

The County operates two regional wastewater treatment plants with a combined wet-weather capacity of 248 mgd and a total hydraulic capacity of 540 mgd. In 1997, the combined average flow through these plants was 200 mgd. The County also operates one CSO treatment plant and one primary treatment plant, now undergoing conversion to a CSO treatment facility and scheduled to be online in late 1999.

In 1997, wastewater treatment operating expenditures totaled $68,332,00; capital expenditures totaled $104,162,000. Wastewater treatment staff numbered 545.9.

Agency History

In 1911, the City of Seattle constructed a conveyance tunnel on then-federally held land to discharge untreated wastewater into Puget Sound. By the 1950s, more than 25 small sewage treatment plants served the Seattle metropolitan area, but many communities still discharged their untreated wastewater into surrounding water bodies.

Declining water quality in the largest of these bodies of water, Lake Washington, and concern about the future of other area water bodies led to the formation of the Municipality of Metropolitan Seattle (Metro) by a vote of citizens in 1958. In 1959, Metro assumed responsibility for cleaning up Lake Washington and establishing a regional wastewater conveyance and treatment system. By the end of the 1960s, Metro had constructed two regional treatment plants—the West Point Treatment Plant (West Treatment Plant), on the shore of Puget Sound in Seattle, and the East Section Reclamation Plant (East Treatment Plant) in the City of Renton—and developed plans to consolidate regional wastewater treatment facilities.

Metro spent most of the 1980s and 1990s expanding and improving its conveyance and treatment systems and closing the last of the original community-based plants. In 1986, the agency completed an effluent transfer system—consisting of a pump station, 12-mile force main, and 2-mile-long deep water outfall—to divert East Treatment Plant effluent from the Duwamish River to Puget Sound. In 1988, solids handling facilities were brought online at the East Treatment Plant, eliminating the need to pump solids to the West Treatment Plant for processing. In 1995, in response to a federal consent decree, the West Treatment Plant completed an expansion and upgrade to provide secondary treatment. And in a series of phased expansions that began in 1988 and will continue to 2003, the East Treatment Plant is increasing its capacity and improving its solids handling facilities.

In 1992, citizens voted to consolidate Metro (which also provided regional transit services) with King County government. Effective January 1996, Metro's Water Pollution Control Department joined the County's surface water management and solid waste functions to form a new Department of Natural Resources.

Among the new Department's top priorities was planning for the region's wastewater treatment service needs for the next 30 years. In 1998, King County proposed a $1.1 billion Regional Wastewater Services Plan to:

- Build a third treatment plant in north King County by 2010 to accommodate additional flows from the northern service area.
- Expand the East Treatment Plant from 115 mgd to 135 mgd in 2020.

King County's efforts to preserve the region's water quality have received national recognition over the years, including:

- 1959 to 1989, American Public Works Association. Designation for Project of Historical Significance, for cleanup of Lake Washington.
- 1987, American Consulting Engineers' Council. Award of Engineering Excellence, Renton Effluent Transfer System.
- 1988, EPA. Award for Outstanding Wastewater Treatment Facility, East Treatment Plant.
- 1996, EPA. National First Place Award for Outstanding Project Involving and Enhancing Beneficial Use of Municipal Wastewater Biosolids.
- Multiple Gold and Silver Awards from the Association of Metropolitan Sewerage Agencies, East and West Treatment Plants.

Service Area Description

Figure B-10 shows the KCDNR service area, which covers about 420 square miles and includes most of the urbanized areas within King County and part of southwest Snohomish County. The population within the service area, including commercial and industrial employment, is about 1.3 million. Although the region has a healthy industrial base dominated by aircraft manufacturing and computer technology, only 1.9 percent of the average daily influent is industrial flow, reflecting the large residential makeup of the service area.

The total service area is divided into east and west service areas. The east service area receives wastewater flows from 97,300 acres east and south of Lake Washington. Most of the development within this area was originally constructed with separated conveyance systems for sanitary sewage and stormwater. The west service area receives separated flows from north of Lake Washington and combined sewage from the City of Seattle. Roughly half (46 percent) of the west service area's 66,800 acres is served by combined sewers. Combined flows join separated flows prior to being routed through the West Treatment Plant.

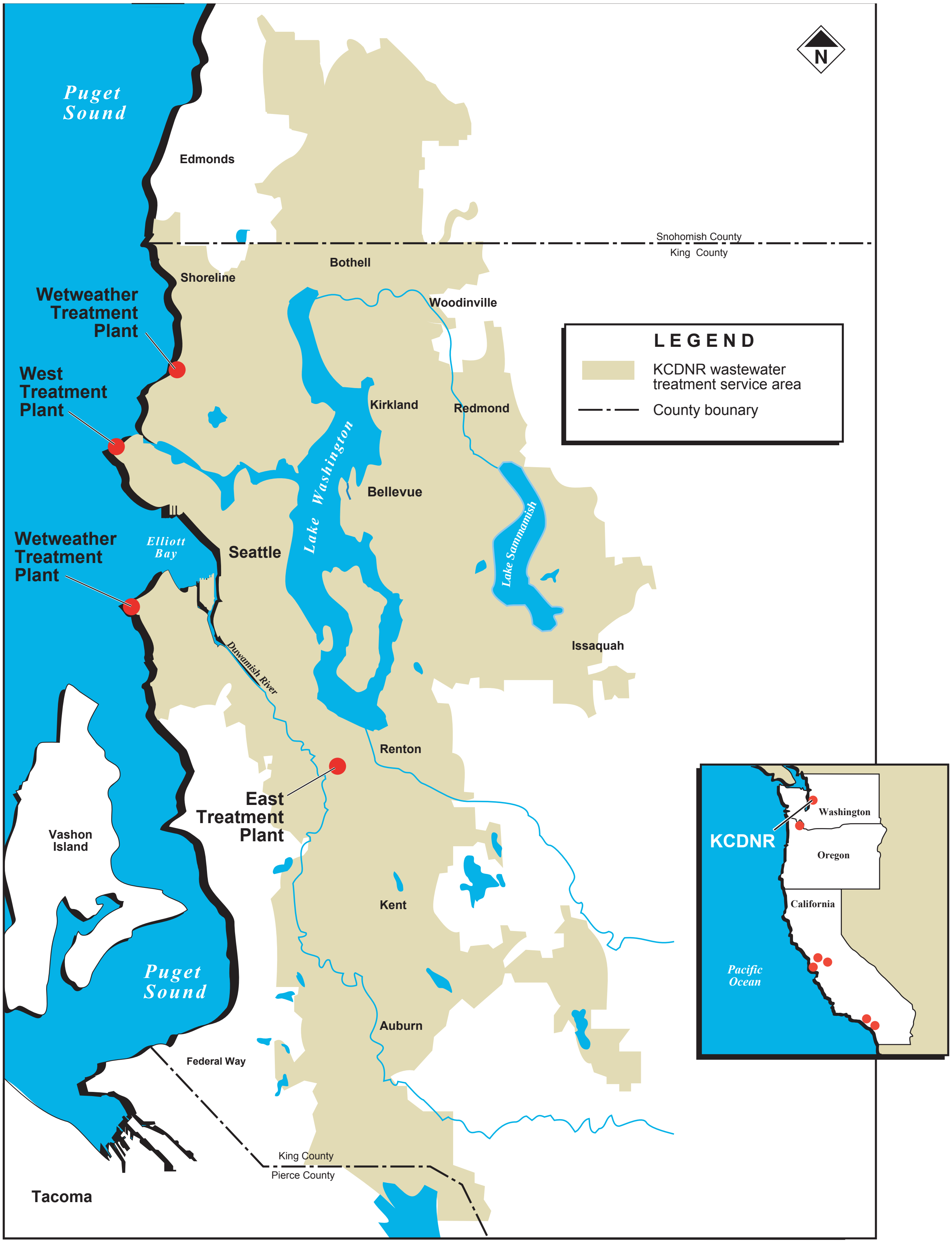

Figure B-10. KCDNR Service Area

Conveyance and treatment structures and facilities include more than 265 miles of pipeline, 42 pump stations, 22 regulator stations, two regional wastewater treatment plants, one primary treatment plant (to be converted to a CSO treatment plant in 1999), one CSO treatment plant, and 34 CSO locations. The north-south orientation of surrounding hills, lakes, and Puget Sound necessitates large high-energy pump stations to convey flows to and from the treatment plants.

Organizational Overview

Figure B-11 shows the organization of wastewater treatment functions within KCDNR, which includes divisions for Wastewater Treatment, Water and Land Resources, and Solid Waste, plus a Commission for Marketing Recyclable Materials. Wastewater treatment operations, maintenance, administration, and capital improvement functions are located within the Wastewater Treatment Division; source control, public outreach, water quality monitoring, and environmental functions are located within the Water and Land Resources Division.

King County is governed by a County Executive and 13-member Council elected by district. A Council committee, the Regional Water Quality Committee (RWQC), meets regularly to make policy recommendations to the Council. In addition to King County Councilmembers, the RWQC includes representatives from the City of Seattle, suburban cities, and sewer and water districts.

Permit Information

King County's two major wastewater treatment plants both discharge into marine water through deep, offshore outfalls. During the dry season (May to October), both plants must meet the technology-based limit of 30 mg/L monthly average for TSS and BOD, or must remove at least 85 percent of these two parameters on average for the month, whichever limit is more stringent. During the wet season (November to April), the 85-percent limit is dropped for the West Treatment Plant.

Both plants provide chlorination to control fecal coliforms to 200 org/100 ml for a monthly geometric mean (400 org/100 ml for the weekly geometric mean). At the West Treatment Plant, chlorine residual is limited to a maximum daily average of 0.546 mg/L and a monthly average of 0.216 mg/L. At the East Treatment Plant, chlorine residual is limited to a maximum daily average of 1.7 mg/L and a monthly average of 0.66 mg/L. Effluent from the West Treatment Plant is dechlorinated using sodium bisulfite. Effluent from the East Treatment Plant is dechlorinated "naturally" during its 12-mile passage through the effluent transfer system.

The permits limit pH to the range of 6 to 9, but do not contain nutrient (N and P) limits. Recently metals limits were dropped from the permit requirements after demonstrating "no reasonable potential to violate water quality standards," but organics limits may be imposed in the future.

Limits for whole effluent toxicity (WET) were not deemed necessary following a year of characterization testing. However, compliance monitoring required by permit includes wet-weather acute and chronic WET testing at the West Treatment Plant, chemistry-based sediment monitoring followed by bioassay testing in the event of chemistry exceedances, and wet and dry-weather intensive studies that include metals and organics monitoring.

The system's two CSO plants, Carkeek and Alki (due online in 1999), both have moderately deep, offshore outfalls. The Carkeek plant must not average more than eight discharges or 14 million gallons per year during the five-year permit cycle. It must achieve at least 50 percent TSS removal averaged over a year, measured by an effluent event average limit of 60 mg/L. Settleable solids must not exceed 1.9 ml/L/hr for each overflow event or 0.3 mg/L/hr on average for the year. Although chlorination is provided, there are no fecal coliform or chlorine residual limits. The Alki permit requirements are in development, but likely will be similar. About 60 treatment events per year are anticipated at the Alki plant, with a permit allowance of 29 treated CSO discharges.

Source Control

King County's Industrial Waste Program was established in 1965 and approved by the EPA as a pretreatment program in 1981. Since the pretreatment program was approved, biosolids quality at both treatment plants has improved to the point that it now meets EPA's most stringent standards for metals, which allows King County to recycle biosolids without tracking the cumulative loading (i.e., pounds per acre, over the years) of metals.

The Industrial Waste Program administers local and federal pretreatment regulations as required by the County's NPDES permit. The program includes waste discharge permits for significant industrial users (SIUs), discharge authorizations for smaller dischargers, technically based local discharge limits, an enforcement response plan, technical assistance, and a "key manhole" program of collection system monitoring and investigations. Permitted companies are monitored at least twice a year and inspected at least once a year. In 1997 KCDNR had 74 federal categorical companies and 69 SIUs under

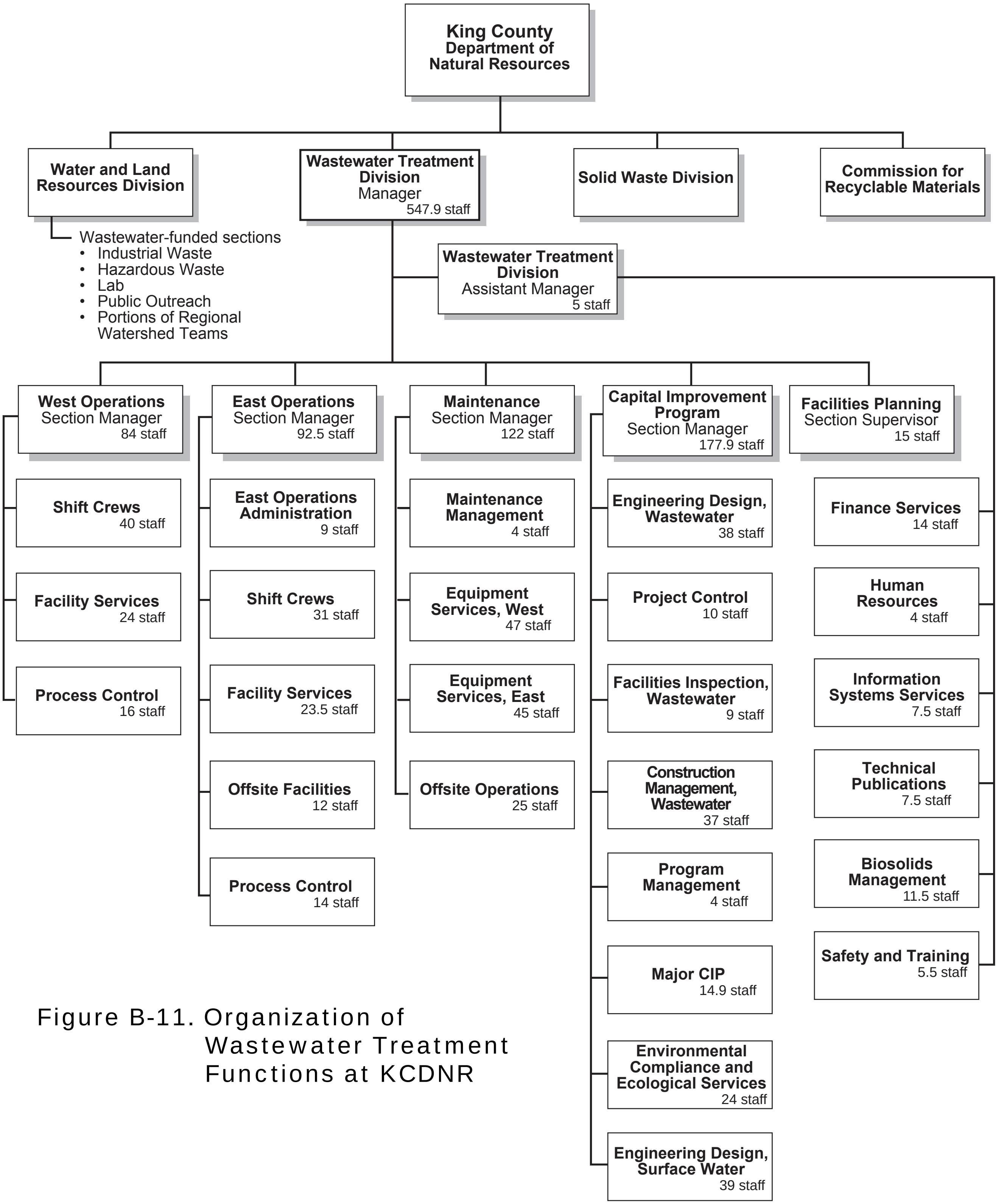

Figure B-11. Organization of Wastewater Treatment Functions at KCDNR permit. An additional 258 non-SIUs were permitted under discharge authorizations.

In addition to the regular sewer rate, industries pay permit fees and monitoring fees. Monitoring fees cover both monitoring and program administration costs and are charged according to the pollutants discharged and the volume of discharge. A surcharge is assessed to companies discharging TSS in excess of 400 milligrams per liter (mg/L) or BOD greater than 300 mg/L, and is intended to recover the additional cost of treating high strength waste.

A Hazardous Waste Program was established in 1991 to help small business owners and residents manage their hazardous waste. The program belongs to King County's Local Hazardous Waste Management Program (LHWMP), an umbrella group consisting of four agencies, 36 suburban cities, and a technical planning and oversight committee. KCDNR's wastewater fees fund 17 percent of the LHWMP; the greater part of the program is funded by solid waste tipping fees. Hazardous Waste Program activities include onsite assistance, an interagency regulatory analysis committee, a voucher assistance program, an EnviroStar incentive program, a hazardous waste reference and research library, an annual hazardous waste trade fair, and a technical assistance team to characterize waste and recommend best management practices and regulatory changes.

Process Control/Laboratory Operations

The King County laboratory system consists of process control laboratories at each of the two major treatment plants, plus a central environmental laboratory. Staff at the process laboratories perform conventional chemistry and microbiology tests to support plant process optimization and NPDES requirements. They also provide support to capital projects such as effluent reuse and the Applied Wastewater Technology (AWT) program. Process laboratory specialists and treatment plant operators share sampling duties at the plants.

The Environmental Laboratory includes five analytical units (aquatic toxicology, microbiology, conventional chemistry, trace metals, and trace organics) plus field sampling, information systems, and client services support groups. They support NPDES permit requirements; the biosolids and source control programs; and receiving water, collection system, CSO, and lakes and streams monitoring programs. The Environmental Laboratory also provides support for wastewater capital projects such as effluent reuse, construction projects, facilities planning, and the AWT program, as well as services to other public agencies, and non-wastewater-funded groups in King County on a reimbursable basis.

All the Laboratory's functional areas use Laboratory Information Management Systems for sample management and data tracking. In addition, the Environmental Laboratory maintains an historical database of all the data it has generated during more than 30 years of wastewater and water quality monitoring.

Financial Information

The King County Wastewater Treatment Enterprise (KCWTE) is an enterprise fund operated and funded by sewer rate payers and managed separately from all other County operations. Revenues, bond proceeds, and grants-in-aid are restricted by purpose. Accordingly, the KCWTE maintains separate accounting records. In accordance with bond covenants, independently audited financial statements are issued annually. The fund is financed primarily by sewer rates, connection fees, investment interest, and borrowing, and is responsible for:

- Operation, maintenance, rehabilitation, and replacement of the County's wastewater treatment system.
- Planning and construction of future wastewater treatment lines and facilities.
- Debt servicing.

In 1997, the sewer rate for each customer equivalent was $19.10. Sewer system billings to the component agencies are based on the number of single family households (residential customers) and on the water consumption of other users such as factories, offices, and apartment complexes. For non-single-family-household customers, the single family rate is levied for each 750 cubic feet of usage (750 cubic feet = one residential customer equivalent, or RCE). Other sources of revenue are industrial waste surcharge fees, septage, and sales of onsite-generated gas (East Treatment Plant) and electricity (West Treatment Plant).

Wastewater treatment operating expenditures in 1997 totaled $68,332,00; capital expenditures totaled $104,162,000. Wastewater treatment staff numbered 545.9.

Treatment System and Process Descriptions

KCDNR's total wastewater treatment service area is divided into east and west service areas. The conveyance system in the west service area transports wastewater to West Treatment Plant; the conveyance system in the east service area transports wastewater to the East Treatment Plant. Both discharge treated effluent deep into Puget Sound through offshore outfalls.

The East Treatment Plant

The East Treatment Plant is a 72-mgd secondary treatment plant now being enlarged to a 115-mgd plant with a hydraulic capacity of 240 mgd. The hydraulic capacity will be increased to 325 mgd in 2001 by upgrading the Effluent Transfer System (ETS) peaking pumps. Flows in excess of the secondary capacity receive primary treatment, are chlorinated, and then blended with secondary effluent for discharge into Puget Sound. In 1997, East Treatment Plant flows averaged 79 mgd.

The influent pumping station (6 pumps with 325-mgd total capacity) lifts raw wastewater from the 120-inch-diameter, 40-feet-deep influent sewer to the treatment plant. Wastewater is screened prior to pumping, and then passes through a conventional treatment sequence: preaeration/grit removal, primary treatment without chemicals, selector air activated sludge, and chlorine disinfection. Final effluent is discharged into Puget Sound via the ETS, which consists of a 240-mgd pumping station (4 duty pumps and 4 peaking pumps), a 12-mile long, 96-inch-diameter force main, and a twin 2-mile-long outfall with 42-inch diameter diffusers located at a depth of 580 feet. In an emergency, final effluent can be dechlorinated and discharged to the nearby Green River (into which the East Treatment Plant discharged before 1988).

Both the primary sludge/scum and waste activated sludge are processed via dissolved air flotation thickening (DAFT), anaerobic digestion (at 97 degrees F), and dewatering with belt filter presses. In 1997, 12,589 dry tons of raw solids were processed and about 59,382 wet tons of dewatered biosolids (averaging 21.2 percent solids) were trucked offsite for reuse. Also, 4,516 wet tons of grit and screenings were hauled to a landfill for disposal in 1997.

Large heat extractors take heat from the final effluent to heat the digesters, which convert 50 percent of solids to methane. This methane is then "scrubbed" and dried to meet a thermal quality standard of 1,000 Btu per cubic feet, then sold to Puget Sound Energy (Washington Energy Services in 1997). King County sold 140 million cubic feet of scrubbed gas in 1997, generating $187,460 in revenue.

Other features of the East Treatment Plant include:

Odor control. The DAFTs and the dewatering building each have an activated carbon odor adsorption system. Another carbon odor control system treats odors from the septage receiving station.

Septage treatment. In 1997, 19 million gallons of domestic septage were received from haulers throughout northwestern Washington, generating $1.5 million in revenue from hauler fees and permits.

Water reuse. Secondary effluent is used to cool a nearby industrial facility (at the Boeing Company) via a closed-loop heat-exchanger. A 1.3-mgd water-reclamation system came online in 1997 that produces Class A reclaimed water for internal process uses and irrigation at a nearby park.

Technology demonstration. As part of an Applied Wastewater Technologies Program, the East Treatment Plant is involved in the development and testing of several new processing technologies, including anoxic gas flotation, pulse power, Centridry (a low-heat, flash drying process for biosolids), and a VERTAD-digestion process.

Waterworks Garden. An eight-acre, public wetland garden collects and treats up to 2.5 mgd of stormwater runoff from the plant.

The West Treatment Plant

The West Treatment Plant is a high-purity oxygen, activated sludge, secondary treatment plant with an average wet-weather flow capacity of 133 mgd, a peak secondary capacity of 300 mgd, and a peak hydraulic capacity of 440 mgd. Flow in excess of the secondary capacity receives primary treatment, is blended with secondary effluent, and is chlorinated and discharged as a treated CSO. The average flow through the West Treatment Plant in 1997 was 120.8 mgd. There is no current plan to expand the plant, which occupies a relatively small 32-acre site.

Raw wastewater enters the plant's influent control structure through 144-inch and 84-inch tunnels. Wastewater is screened and lifted by digester-gas-driven pumps to preaeration/grit removal tanks and primary sedimentation tanks.

An intermediate pump station lifts primary effluent to the secondary treatment facilities. Secondary treatment is accomplished with high-purity oxygen, aeration basins, and secondary clarifiers. Flows are then chlorinated, dechlorinated, and, depending on the magnitude of flow through the plant and the tide level, either pumped or conveyed by gravity to a 250-foot-deep outfall that is about 3,700 feet offshore in Puget Sound.

Solids handling at the plant includes gravity belt co-thickening of primary and secondary solids, anaerobic digestion (at 96 degrees F), and centrifuge dewatering. In 1997, 14,889 dry tons of raw solids were processed and about 68,613 wet tons of dewatered biosolids (averaging 21.7 percent solids) trucked offsite for reuse. Also, in 1997, 4,684 wet tons of grit and screenings were hauled offsite to a landfill.

Major support and reuse systems at the West Treatment Plant include:

- **Odor control system**. A plantwide odor control system removes foul air from the influent, primary treatment, and solids handling areas of the plant, scrubs the foul air in six packed-bed wet scrubbers using a mixture of sodium hydroxide, hydrogen peroxide, and plant effluent, and exhausts the scrubbed air to the atmosphere.
- **Oxygen generation system**. Each of two vacuum swing adsorption (VSA) trains can provide up to 70 tons per day of high-purity oxygen (about 92 percent pure) to the secondary aeration tanks. A liquid oxygen system with a capacity of 200 tons serves as a backup to the VSA system.
- **Methane/cogeneration/heat recovery**. Digester gas is used to run both the 25,000 hp engines that drive the four main raw-sewage pumps and the engines that produce electricity. Heat from these engines is recovered and normally supplies all heat needs for the plant heat loop. The generated electricity is then sold to the City of Seattle. In 1997, revenue from the sale of electricity was $265,458.
- **Mitigation**. To meet an extensive set of mitigation requirements, the plant is surrounded by a landscaped berm planted with native vegetation and includes a public access beach trail and wetland.
- **Water reuse facility**. A 0.75-mgd water reuse system treats secondary effluent and distributes it throughout the plant for such uses as pump packing seal water, polymer dilution water, and irrigation of the extensive vegetation planted on the landscaped berm.

Biosolids Management

In 1997, the East and West Treatment Plants produced about 129,000 wet tons of Class B biosolids, all of which was recycled. An independent contractor trucks the biosolids from each of the treatment plants for use in three major recycling programs:

- **Agriculture**. In Eastern Washington, over 120 dryland grain farms, hops farms, orchards, and managed rangelands use recycled biosolids as a fertilizer and soil conditioner.
- **Composting**. Since 1976, King County has contracted with a local private company to make a compost consisting of one part biosolids to three parts sawdust. The nearly pathogen-free, Class A product is marketed in the greater Seattle area under the name GroCo. GroCo Inc. is responsible for permitting, monitoring, distributing, and marketing its product.
- **Forestry**. The Mountains to Sound Greenway forestry program applies recycled biosolids to enhance forest growth within King County. A regreening program uses GroCo to restore unused logging roads and revegetate harvested mountain slopes. The programs are the result of a collaborative agreement among KCDNR, the Washington State Department of Natural Resources, the University of Washington College of Forest Resources, and the Weyerhaeuser Company.

Since 1973, KCDNR's Biosolids Management Program has worked with local universities to develop and test biosolids recycling methods. Research has studied the effects of biosolids on soils, crops, and water quality, as well as application techniques. Results provide the technical basis for appropriate site management, environmental monitoring, development of regulations, public acceptance, and quality assurance for landowners.

Collaboration with the Northwest Biosolids Management Association, the University of Washington, Washington State University, Oregon State University, the University of Idaho, and the University of British Columbia has led to consistent regional information for biosolids managers, enhanced KCDNR's ability to create cost-effective land application programs, and improved both public awareness and acceptance of biosolids recycling. As a result, the demand for biosolids now exceeds the supply produced by KCDNR's treatment plants.

All biosolids users pay a fee for the product, which is usually equivalent to the cost of alternative fertilizers. In 1997, agriculture, forest, and compost customers paid a total of $123,222 in fertilizer revenue to King County. An additional $86,207 was received from the Washington State Department of Natural Resources, representing King County's share of timber revenue from forestlands acquired and managed under the Mountains to Sound Greenway agreement.

Orange County Sanitation District (OCSD)

The Orange County Sanitation District (OCSD) is a special district that operates two treatment plants. Reclamation Plant 1, in Fountain Valley, receives wastewater flow from six large trunks. Treatment Plant 2, in Huntington Beach, receives flow from five trunks. The District owns and maintains more than 650 miles of major trunk sewers, 200 miles of collection sewers, 22 pumping stations, and two major treatment plants with disposal facilities to discharge the treated effluent. Participating cities and agencies own and operate 97 percent (about 5,500 miles) of the sanitary sewer systems feeding the two treatment plants.

The hydraulic capacity of the combined plants is 480 mgd, limited by the outfall capacity. Plant 1 has a rated capacity of 108 mgd and is operated at 89 mgd. Plant 2 has a rated capacity of 168 mgd and currently treats 155 mgd.

The treated wastewater is either discharged to the Pacific Ocean in strict and consistent compliance with state and federal requirements as set forth in the District's NPDES permit, or reclaimed at facilities operated by the Orange County Water District (OCWD). The reclaimed water (about 6.8 mgd) is made available to the Orange County Water District for the Seawater Intrusion Barrier Project (direct groundwater injection system) and the Green Acres Project (reclamation water plant) for irrigation at parks and golf courses.

Agency History

Orange County was primarily agricultural in the early 1900s, but already recognized the need for an intercity or metropolitan sewerage system. To meet this need, the Joint Outfall Sewer Organization (JOS) was formed in 1921 as a joint powers arrangement among the California cities of Anaheim, Santa Ana, Fullerton, and Orange, and the Sanitary District of Placentia, Buena Park, La Habra, and Garden Grove.

In the early 1920s, the JOS constructed a sewerage system to serve the eight-member organization with a treatment plant located in Fountain Valley at what is now Reclamation Plant 1. The JOS also constructed a 24-inch cast-iron pipe that disposed of screened wastewater a short distance into the surf near the mouth of the Santa Ana River.

In 1954, the District began full operation with a network of trunk sewers, two treatment plants, and a new 7,200-foot-long, 78-inch-diameter ocean outfall terminating at a depth of 60 feet, called Discharge Serial No. 002 in the District's NPDES permit.

The initial flow of wastewater collected by the joint system was about 18 mgd, generated by a population of about 200,000 people. This outfall is now available for use only during emergencies. The 78-inch outfall had an original design capacity of 256 mgd. The present capacity has been increased to an estimated 300 mgd by the replacement of 2,000 feet of 78-inch pipe with 120-inch pipe on the land section of Discharge Serial No. 002.

In 1971, the District began operating a new $10 million outfall pipe that is 120 inches in diameter and about five miles long, the last 6,000 feet of which is a diffuser section.

Service Area Description

The OCSD operates the third largest wastewater management agency west of the Mississippi River. The District serves a population of about 2.2 million people in a 470-square-mile area. All wastewater collection systems in the service area (Figure B-12) are sanitary sewer systems. Stormwater collection and maintenance are provided by the cities and by the County of Orange.

The plants are operated in accordance with regulations established by the federal and state EPA (including the State Water Resources Control Board [SWRCB], the Regional Water Quality Control Board [RWQCB], and the South Coast Air Quality Management District [SCAQMD]).

About 90 percent of the wastewater influent is domestic and commercial; the remaining 10 percent is industrial.

The two OCSD treatment plants jointly use a 120-inch-diameter deep-sea outfall that discharges the treated wastewater five miles off the coast at a depth of 200 feet. The last mile of the pipe is a diffuser with over 500 ports designed to provide an initial dilution level of at least 148:1 seawater-to-wastewater effluent.

Following a 1977 amendment to the Clean Water Act, OCSD applied for and received a NPDES 301(h) waiver. This waiver allows the District to discharge high quality, but less-than-fully-treated secondary effluent into the ocean. OCSD has committed to treat at least 50 percent of influent wastewater to secondary treatment levels prior to ocean discharge. Advanced primary treatment and chemical coagulation of wastewater in the primary treatment process improves removal efficiency and is the primary basis for qualifying for this waiver.

Organizational Overview

OCSD is governed by a Joint Board of Directors, consisting of 29 members representing 23 cities, three sanitary districts, one water district, and the County of Orange government. A District general manager and legal counsel report to the Board. Two assistant general managers oversee eight departments, staffed by 624 full-time staff (including 15 vacancies) in FY 1997 (see Figure B-13).

The District implemented several organizational changes in FY 1997. The Operations and Maintenance Departments were combined into one department. Maintenance staff not directly operating or maintaining the treatment works were reorganized into the General Services Administration Department (GSA). GSA manages and operates the fleet services, buildings and grounds, the rebuild shop, and the sanitary sewer collections divisions. Three divisions comprise the Human Resources Department: Human Resources, Safety and Emergency Response, and Training.

Permit Information

For OCSD, federal and state laws include a unique combination of stringent environmental standards to protect ocean waters. In 1979, the Districts submitted an application for a NPDES Section 301(h) permit modification from the requirements of secondary treatment (30 mg/L monthly average effluent limit for BOD and TSS). After years of technical

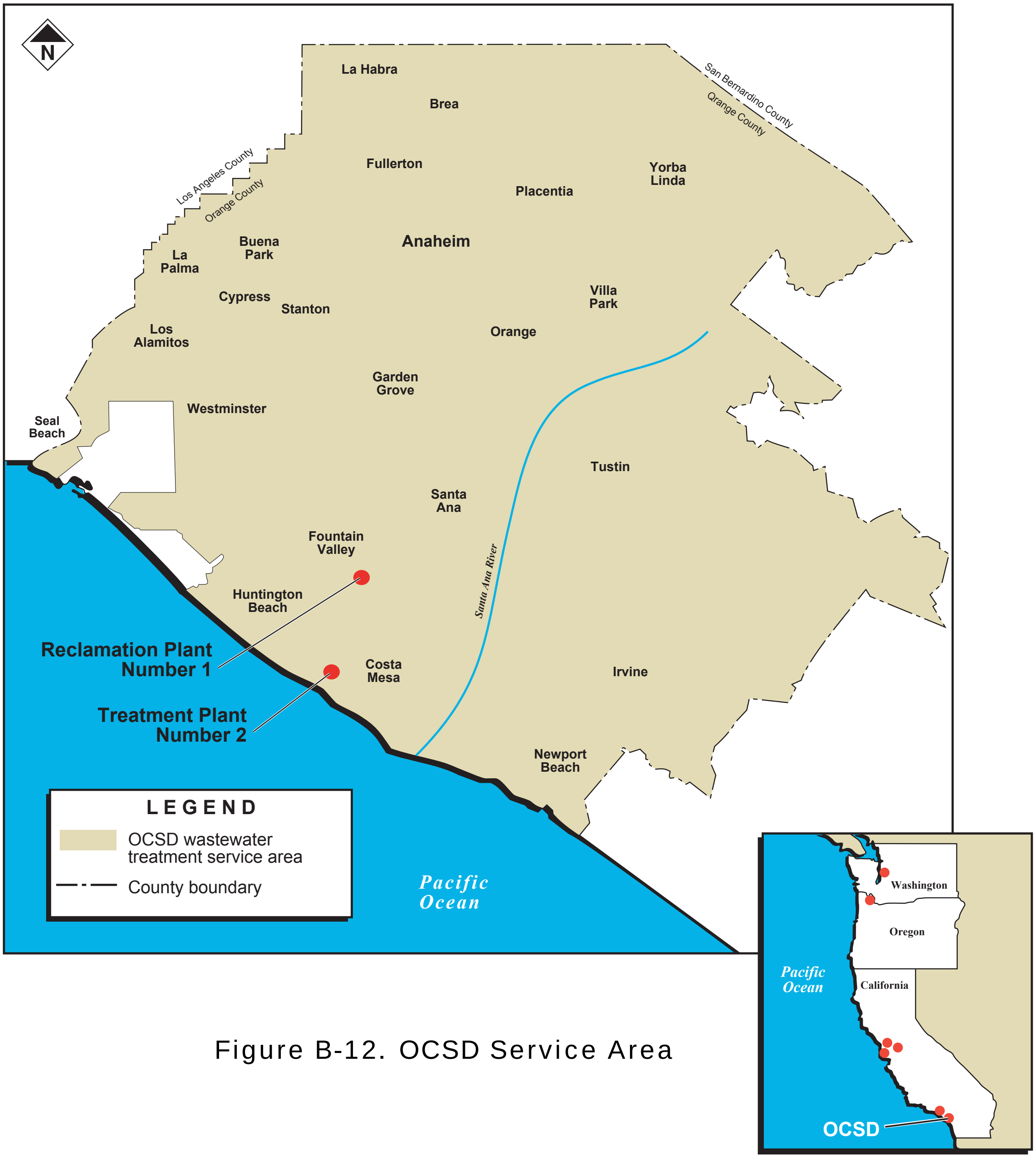

Figure B-12. OCSD Service Area

review by the US EPA and approvals by other regulatory agencies (Fish and Wildlife Service, National Marine Fisheries Services, CRWQCB and the California Coastal Commission) a five-year NPDES permit was issued in 1985. The permit required that all provisions of the California Ocean Plan and federal Clean Water Act be met other than the waiver from the 30 mg/L limits (85 percent removal) for BOD and TSS. The NPDES permit limits allow five-day BOD and TSS levels of 100 mg/L and 60 mg/L respectively. The plants are not required to chlorinate their effluent, and have a 0.001 mg/L limit on chlorine residual. There are no limits for coliform bacteria in the final effluent.

Under the current permit, the District is required to remove 75 percent of the suspended solids and is

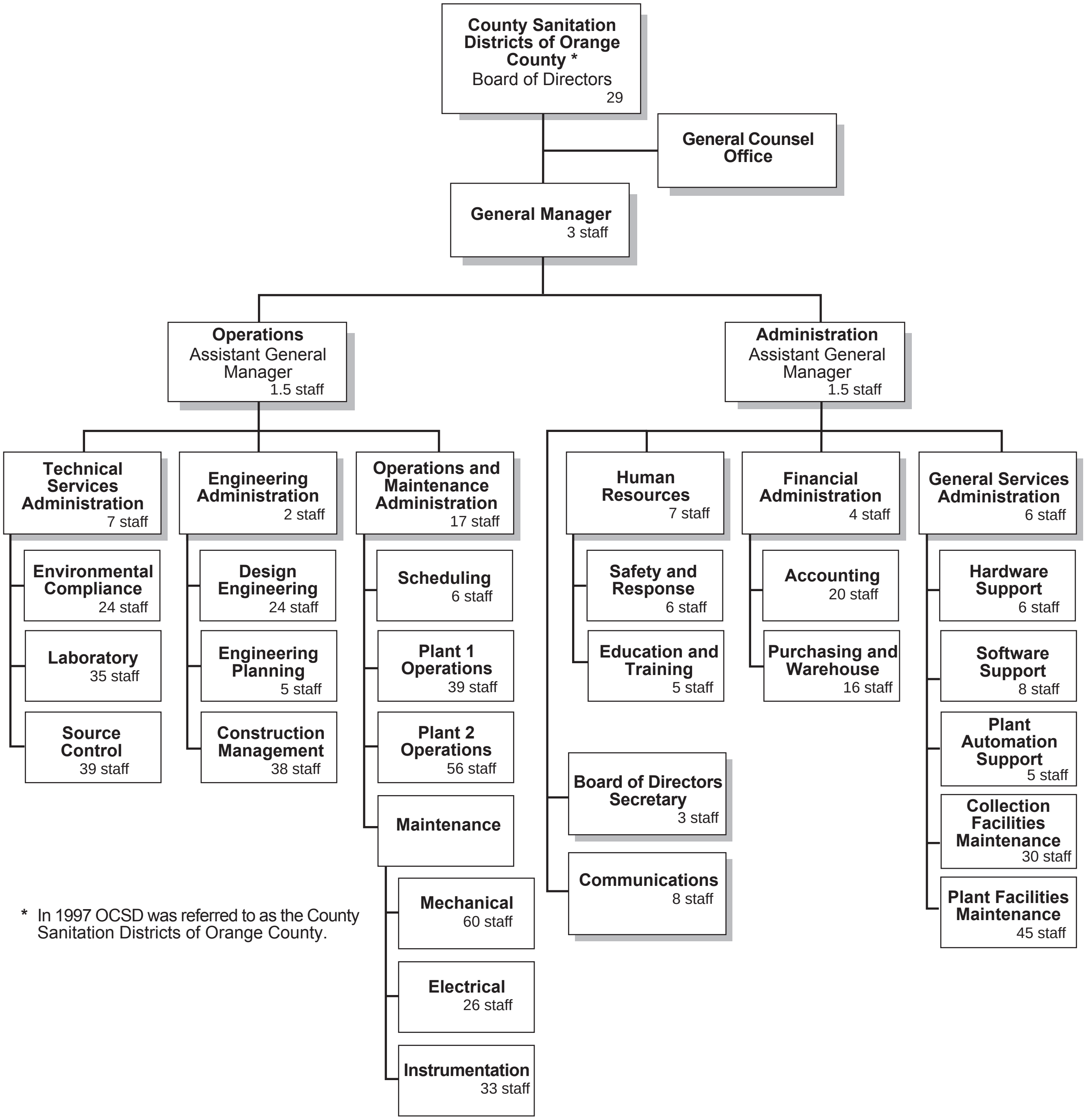

Figure B-13. Organization of Wastewater Treatment Functions at OCSD

limited to 189,000 pounds per day of BOD in the blended final effluent.

One result of the NPDES permit conditions is that the District conducts an extensive ocean monitoring program to measure the condition of the marine environment off Orange County's coast impacted by the outfall discharge. Results of this monitoring program demonstrate that the District is successfully protecting Orange County's public health and its coastal ocean waters. This program operates with a budget of about $2.5 million per year.

Source Control

OCSD's Source Control Program was established in the early 1970s. The goals of the Source Control Program are to:

- Ensure that the quality of water discharged to the ocean meets the NPDES permit requirements at all times.
- Prevent the pass-through of toxic chemicals to the ocean from industrial sources.
- Prevent interference with the District's operations and facilities.
- Prevent municipal biosolids contamination and provide beneficial reuse options.
- Prevent exposure of the District's employees to chemical hazards created by industrial discharges.
- Prevent toxic contamination of the treated wastewater.
- Enforce federal pretreatment standards.
- Ensure the equitable distribution of collection, treatment, and disposal costs to all users of the system.
- Emphasize waste minimization and pollution prevention.

The EPA officially approved the pretreatment program in 1984. In 1976 the District adopted a wastewater discharge ordinance which established limits on heavy metals. Since FY 1976-77, the source control program has been successful in reducing the total mass of metals entering the Districts' system by 81 percent and reducing the metals discharged to the marine environment by 89 percent. Over this time, influent cadmium has been reduced by 97 percent, chromium by 94 percent, copper by 72 percent, lead by 95 percent, nickel by 75 percent, and zinc by 80 percent. The reduction in toxics by the source control program has been so effective that for the last five years the influent heavy metals to the District's treatment plants have met NPDES effluent standards even without benefit of treatment.

The Source Control Manager oversees the work of three supervisors and reports to the Director of Technical Services. Two engineering supervisors oversee the work of eight engineers. The engineers are responsible for issuing and renewing permits, and all formal enforcement actions. Engineers conduct field inspections as necessary to support these functions. Eleven field inspectors conduct sampling and inspection of all assigned industries, including those with categorical, noncategorical, or local permits. The inspectors also conduct area search activities and inspections of unpermitted facilities such as dry cleaners and radiator shops. Three technicians are responsible for sampling equipment maintenance, equipment inventory, and sampling at the Districts' wastehauler station. The administrative support staff is specialized to handle permits/enforcement, self-monitoring, and inspection/lab reports.

As of mid-1997, the Districts administered 892 permits, of which 434 were Class I permits, 199 were Class II permits, 200 were Class III permits, 44 were Wastehauler permits, and 15 were Special Purpose permits. Of the 434 Class I users, 271 were subject to federal categorical pretreatment standards. There were 650 nonpermitted industrial users, including 550 dry cleaners and 100 radiator shops.

Process Control/Laboratory Operations

The District's Laboratory Division (Laboratory) is under the administration of Technical Services and includes sections for general administration (including quality assurance), microbiology, inorganic chemistry (including trace metals), and organic chemistry.

The Laboratory occupies about 20,000 square feet of a two-level steel and concrete building which was designed and built in 1990-91 specifically as a laboratory building.

The mission of the Laboratory is to provide analytical services in support of operations, compliance, and source control activities and to conduct research directed toward improving the effectiveness of the laboratory and furthering the overall mission of the sanitation district. About 100,000 analyses, not including quality assurance, are performed annually.

The Laboratory defines its role in terms of its customers and its ability to provide analytical services in support of their programs. In order to meet the analytical and compliance-related needs of customers, the Laboratory is accredited with the California Department of Health Services Environmental Laboratory Accreditation Program.

The first priority of the Laboratory is to support the various programs and activities associated with wastewater treatment, including NPDES permit compliance, wastewater processing operations, source control pretreatment monitoring, and ocean receiving water monitoring (including surfzone microbiology monitoring).

Laboratory staff also participate in various engineering project teams. Their role is to provide expert advice in chemistry and microbiology and to properly coordinate and conduct analytical work that flows from the projects into the Laboratory.

Financial Information

A general overview of OCSD's accounting and finance functions is as follows:

- Accounting records are maintained on the accrual basis for all funds.
- Internal controls safeguard assets and ensure proper recording of transactions.
- Enterprise funds are used to account for the operation of the District, similar to private business enterprises.
- Despite the Orange County bankruptcy in 1994, the District has maintained an AA rating from Standard and Poor's and an Aa rating from Moody's Investor Services.
- An outside consultant manages the majority of the District's investment portfolio.
- In FY 1997, the District was self-insured for workers' compensation and property damage.
- Annually, an independent team of certified public accountants audits the books, financial records, and transactions of the District.

Revenues

OCSD receives revenues from service and connection fees, property tax revenues, investment interest, and borrowing. In FY 1997, the District's average single family residential sewer service fee per month was $71, plus about $31 of property tax revenue. This $102 fee was slightly more than half (55 percent) of the state average of $184 per year.

In May 1997, the District adopted a new user fee rate schedule that provides for gradual increases over the next five years. The schedule was developed with input from a Rate Advisory Committee, comprised of representatives from industrial, commercial, and residential users.

Table B-9 shows FY 1997 joint operating budgets and expenses.

Table B-9. OCSD Revenue and Expenses

FY 1997	
Revenue	**$**
Service Charges	2,318,676
Power Sales	118,943
Other	903,827
Total Revenue	3,341,446
Expenses	
Salaries and Benefits	27,193,724
Supplies/ Materials	4,435,283
Contractual	7,776,344
Repairs and Maintenance	3,152,171
Utilities	3,073,497
Other	5,827,259
Total Expenses	51,458,278
Net Joint Operating Expenses	47,264,146
Gallonage Charge per MG	530
Collections District Charges*	9,691,070
*Not included in Joint Operating Cost	

Financial Information Systems

Finance/Accounting used two Financial Information Systems during FY 1997. The Work Order System (Delphi software on an SCO-UNIX platform) was accessible to departmental staff only. The new system developed by J. D. Edwards operates on an IBM AS 400 and is accessible to all District staff. This system was implemented in January 1997 for Payroll. All other Finance and Accounting modules were implemented after June 30, 1997.

Treatment System and Process Descriptions

Raw wastewater enters Plant 1 from a metering and diversion structure that receives flow from six influent trunks. Flow, pH, and conductivity are measured in each trunk. The influent and diversion structure also can divert flows to Plant 2.

At the Plant 1 headworks, flow is screened and pumped to the grit removal tanks and primary sedimentation tanks. Primary effluent is then treated by trickling filters or an air-activated sludge secondary treatment facility. Effluent from these two processes is blended and transported to an outfall pumping facility.

Wastewater entering Plant 2 undergoes the same primary treatment processes, but secondary treatment is provided by a 90-mgd, high-purity-oxygen-activated sludge plant.

Solids handling processes consist of dissolved air flotation thickening of waste activated sludge, mesophilic-type anaerobic sludge digestion, belt press dewatering, and biosolids storage and transfer. A total of 179,880 wet tons (39,386 dry tons) of biosolids were produced by the District during FY 1997.

For over 30 years, the District used digester gas as a fuel in its plants to save electricity and provide reliability in the event of a utility company outage. Excess gas was flared. This antiquated system of engine-driven equipment had reached the end of its useful life and needed to be replaced. In the mid-1980s, the District investigated means to more efficiently harness this power source while meeting new air quality regulations. The result of this effort was a co-generation system, called the General Generation System, comprised of eight state-of-the-art, low-emission, engine-driven electric generators that replaced 23 internal combustion engine-driven pumps and blowers.

The District ensures reliability by the availability of three sources of electricity to power the all-electric plants: Southern California Edison, diesel-engine-driven emergency power units, and the Central Generation System (the most beneficial and cost-effective of the three, and the District's primary source of electricity). The heat generated by the Central Generation System is used to produce steam and hot water for digester heating, maintain sludge pipeline maintenance, heat and cool buildings, and power a turbine generator.

Implementation of these facilities has reduced air emissions, improved plant reliability, maximized the use of biogas, and saved ratepayers money by internally producing electricity. Energy savings are about $5,000,000 per year.

Support facilities consist of plant and city water, odor control, chemical addition, and electrical and emergency power generation. A wet-scrubber odor control system uses hydrogen peroxide, caustic soda, and/or bleach scrubbant to treat foul air throughout the plants. Caustic is added upstream in the trunk lines to reduce foul air produced prior to entering the plant. The addition of ferric chloride to the digestion process has eliminated the need for solid stream odor control within the plants.

Biosolids Management

In late 1991, the District's Biosolids Management Program achieved a milestone of 100 percent beneficial reuse of biosolids, allowing the District to lower its management costs and eliminate the need for valuable landfill space. The present program consists of composting, direct land application, and a standby agreement to landfill biosolids in the event of an emergency. Beneficial reuse costs about 50 percent less than landfilling and should become even more cost effective in the future, as the market for compost material grows.

The present program consists of direct land application of the District's biosolids to enhance agricultural solids, reduce the amount of irrigation water needed, and provide a much needed source of organic humus. During FY 1997, the District contracted with three biosolids management firms (Pima Gro Systems, Inc., Bio Gro, Wheelabrator Clean Water Systems, Inc., and Tule Ranch) to haul and apply 179,880 wet tons of biosolids directly to land. All three contractors utilized commercial fertilizer spreaders to distribute the biosolids prior to incorporation into the soil. Two of the three contractors have contracts with farmers for the land application of biosolids. One contractor is a farmer who is using these biosolids for a marginal farmland reclamation project. The contractors apply the biosolids at agronomic rates to farm lands, maintain records, perform additional laboratory analysis, and submit monthly reports to the District and the Regional Board.

Sacramento Regional County Sanitation District (SRCSD)

The Sacramento Regional County Sanitation District (SRCSD) is a special district that provides centralized collection and treatment of wastewater for the urbanized areas of Sacramento County. The District is governed by an eight-member board, consisting of five supervisors from the County of Sacramento and elected city councilmembers from the cities of Sacramento, Folsom, and Citrus Heights. The individual jurisdictions maintain their own wastewater collection systems, and treatment is provided at one regional treatment plant.

The Sacramento Regional Wastewater Treatment Plant (SRWTP) provides full secondary wastewater treatment and discharge to the Sacramento River. The plant has an average dry-weather capacity of 181 mgd, and a peak wet-weather capacity of 400 mgd. Average flow for FY 1997 was 152 mgd.

The District's staff is part of the Water Quality Division of Sacramento County's Public Works Agency. This staff provides operation, maintenance, engineering, and administrative services for the District. In addition to the regional treatment plant, the District also provides staffing for County Sanitation District #1 (CSD #1), a major underlying agency which provides collection system services for the unincorporated areas of the County.

Agency History

In the 1950s and 1960s, significant growth occurred in the unincorporated areas of Sacramento County. To provide wastewater services, developers constructed treatment facilities throughout the area, resulting in 21 separate facilities in operation by the early 1970s. Most of these facilities discharged to either the Sacramento or American Rivers, or to surface streams tributary to those waterways. The passage of the 1972 federal Clean Water Act provided both the mandate and the financing necessary to clean up these surface waterways.

The Sacramento Regional County Sanitation District was formed in 1973. Through a Master Interagency Agreement (MIA), the cities of Sacramento and Folsom, the County of Sacramento, and several sanitation districts agreed to regionalize all wastewater conveyance, treatment, and disposal services. The three underlying agencies would continue to provide wastewater collection in their respective areas. All of the sanitation districts operated by the County of Sacramento were ultimately abolished. The MIA provided for transfer of ownership of all the community's wastewater treatment facilities to the Regional District. In return, the District would assume all outstanding debt on these facilities, and would construct and operate a new grant-financed regional wastewater conveyance and treatment system for the urban area of Sacramento County.

The new regional system went online in late 1982. A major plant expansion was completed in 1993, and several other major construction projects to accommodate continuing growth in the County have either been recently completed or are currently in progress.

Service Area Description

The District provides service for about 1,026,000 Sacramento County residents. The service area covers more than 250 square miles (see Figure B-14), and has more than 3,300 miles of collection system piping, including 90 miles of major interceptors and 70 pump stations. About 70 percent of the service area is maintained by Sacramento County (CSD #1), with the remainder maintained by the cities of Sacramento (26 percent) and Folsom (4 percent).

Some of the older portions of the area served by the City of Sacramento have combined sewers. The remainder of the service area has separate sanitary and storm sewers. Industrial flows represent about 8 percent of treated volume, and about 25 percent of the treatment loading.

Wastewater treatment is provided at one regional treatment facility, the Sacramento Regional Wastewater Treatment Plant (SRWTP), located on 900 acres of a 3,500-acre site south of the city of Sacramento. The balance of the property serves as a buffer against urban encroachment.

Organizational Overview

SRCSD is staffed by employees of the Sacramento County Public Works Agency, Water Quality Division. District managers report to the eight-member board described earlier. About 170 employees work at CSD #1, and about 340 employees work at SRWTP. The accompanying organization chart (Figure B-15) shows the staffing at SRWTP.

The treatment plant is managed by a Wastewater Treatment Superintendent. The Operations and Maintenance sections were managed separately in FY 1997, but are now organized under one O&M Manager since an O&M redesign that occurred in January 1998. There are also managers for the Laboratory, Engineering, and Administration sections.

In FY 1997, the Operations section included Flight Crew, Day Crew, and Operations Support. Flight Crew consisted of five shifts that provide 24-hour coverage for plant operations. Day Crew, which has since been combined with maintenance in process area teams, provided other operations needs and assisted with plant maintenance. Operations Support, which has since been combined with Maintenance Planning, provided support for new construction and assisted with development of monitoring reports.

As part of the O&M redesign, portions of the electrical, instrumentation, and mechanical maintenance crafts have been combined with Operations Day Crew into area process teams. Electrical/control systems and mechanical support teams also provide for plant-wide maintenance needs. A stationary engineering group maintains the plant buildings and HVAC (heating, ventilation, and air conditioning) systems.

The Laboratory, Engineering, and Administration sections are organized as shown on the organization chart. A redesign of these sections is in progress. The Engineering section is largely comprised of staff who support the capital improvement program, and also includes the source control (industrial waste) group. The Administration section includes staff who maintain the bufferlands surrounding the plant.

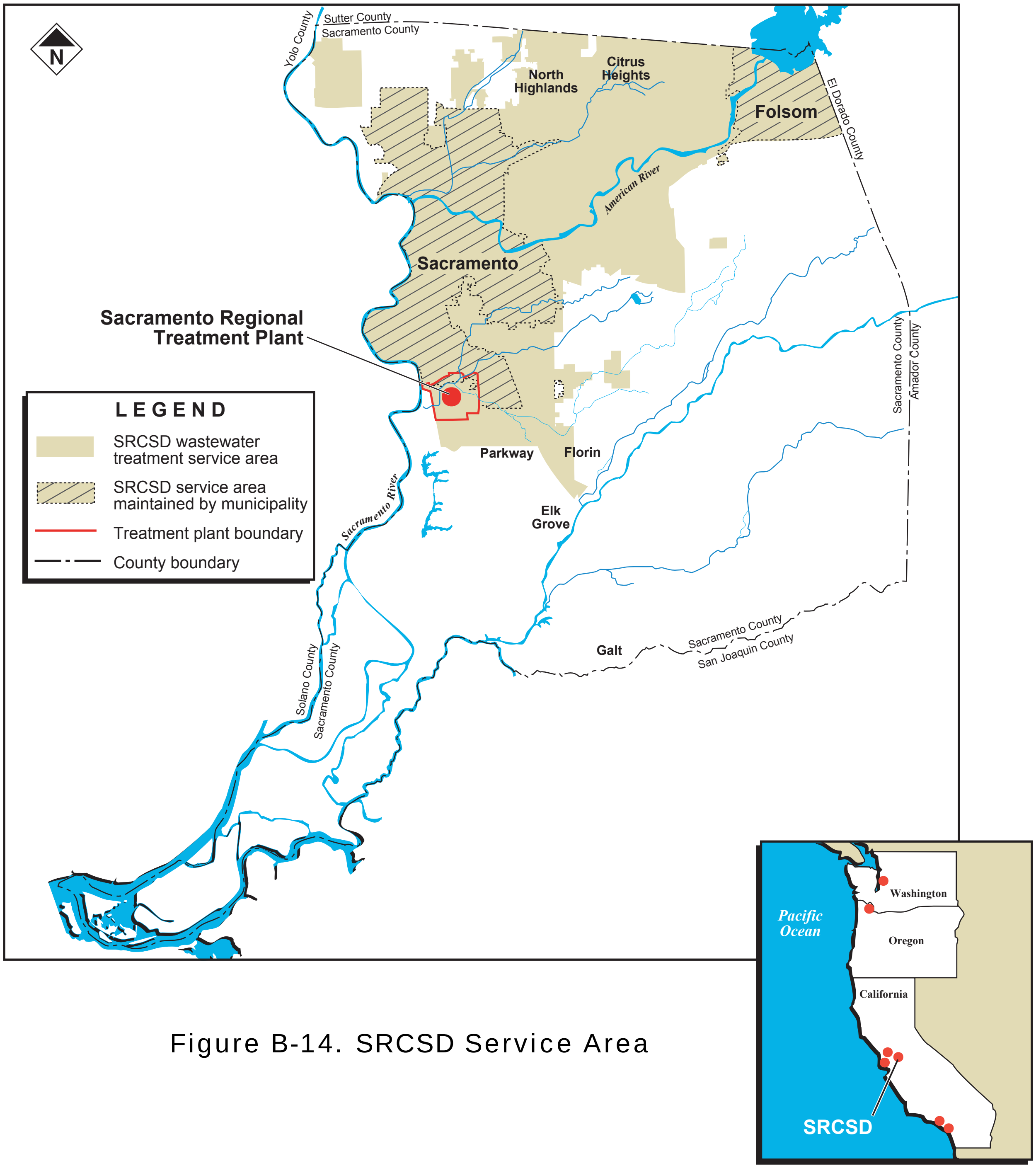

Figure B-14. SRCSD Service Area

Permit Information

SRWTP is required to meet a monthly average effluent discharge of less than 30 mg/L BOD and 30 mg/L TSS. The plant is required to maintain a monthly median for total coliform of 23 mpn/100 ml, which requires a chlorine dose of 8 to 10 mg/L. After the plant effluent travels 1.5 miles, it must then be dechlorinated before discharge to the Sacramento River. The maximum daily average chlorine residual cannot exceed 0.018 mg/L. In practice, excess sulfur dioxide and/or sodium bisulfite is added for dechlorination. The chemical costs for chlorine and sulfur dioxide are significant, and there are also additional costs associated with equipment mainte-

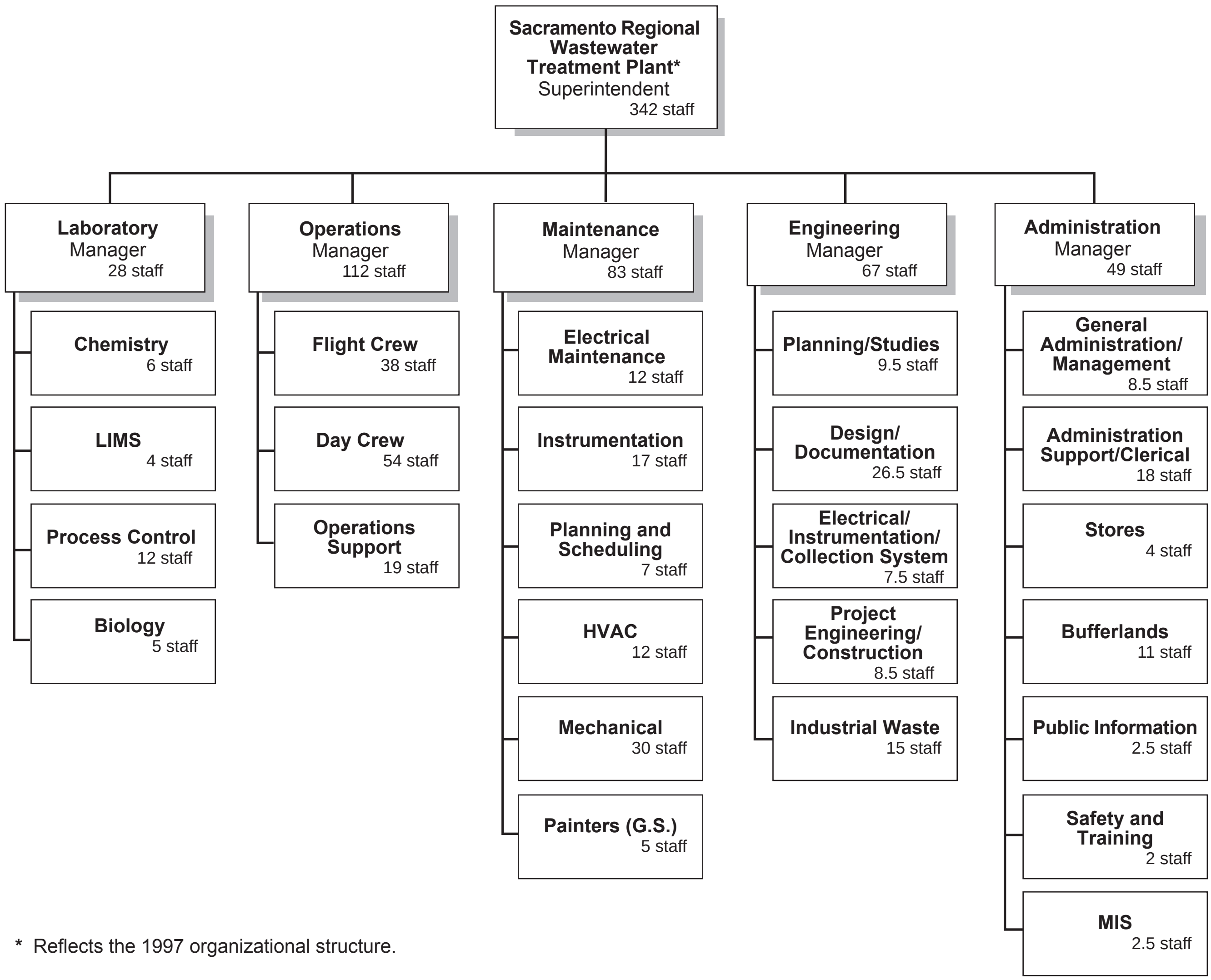

Figure B-15. Organization of Wastewater Treatment Functions at SRCSD

nance and staffing of the remote outfall facility.

The discharge permit also requires the following:

- Routine bioassay monitoring of the dechlorinated effluent at the outfall.
- Temperature restrictions, which limit how much the discharge can increase the temperature of the receiving water body (Sacramento River).
- Monitoring of the receiving water.
- No discharge during times of low river flow.

The Sacramento River is influenced by tides. Flow in the river can slow significantly or at times flow upstream. SRWTP must divert plant effluent to its onsite emergency storage basins (200-million-gallon capacity) when the ratio of river flow to effluent discharge declines below 14:1. This can occur up to twice a day during the summer and fall of dry years. After discharge to the river is resumed, the diverted effluent must then be recycled through the treatment plant, which impacts cost because the wastewater is being treated twice. Another basin, now under construction, will allow for future direct discharge of the diverted effluent.

Source Control

SRCSD's Industrial Waste Pretreatment Program was officially approved by the state and EPA in 1983. The program has undergone intensive changes during the last 10 years. Staffing increased from four to the current level of 15 during this period, with corresponding improvements in permitting, inspection, enforcement, and data management. The District feels that it now has a mature and effective program. Effluent and biosolids pollutant concentrations have decreased significantly since program inception and are typical of well-run treatment plants with effective pretreatment programs.

The District's Industrial Waste Program focuses on the basic pretreatment program. The majority of staff time is spent on regulating categorical and significant industrial users. Industrial rate implementation is also an important component of the program. Industrial Waste Program staff also play an important role in pollutant monitoring and pollutant accounting for the treatment plant and collection system.

With the closure of its only two large seasonal canneries in 1997 and ongoing military base closures, the District's industrial user base has continued its shift from large significant industrial users to smaller light industrial and high tech firms. The trend has been toward greater numbers of permits with more categorical standards. The District expects that additional pollutant limits will be a part of future NPDES permits and its source control program will play an important role in meeting those limits. Development continues in the District at a steady pace. In spite of anticipated growth in the number and complexity of permits and commercial user programs, the District does not anticipate significant increases in staffing. Continuing increases in program efficiency should accommodate the increased workload.

Process Control/Laboratory Operations

The SRCSD's Water Quality Control Laboratory is a California Department of Health Services-certified facility. The laboratory provides environmental analytical and sampling services in support of the Wastewater Treatment Plant's process control monitoring and permit-required waste discharge monitoring programs. The laboratory also provides analytical support services for other programs such as the Sacramento River Coordinated Monitoring Program (CMP); various Industrial Waste Program monitoring activities, including Source Control, Billing, Septage Haulers, and the Priority Pollutant Pretreatment Program (P4); and County Water Resources' drinking water monitoring. It also periodically provides analytical or sampling services for any other county agency that requires certified analytical laboratory services.

The laboratory is organized into four natural work groups:

- **Administrative Section** (6 staff). This section serves to support basic laboratory needs in laboratory management, clerical services, Laboratory Information Management System administration, data management, quality control, and customer relations functions.
- **Biology Section** (4 staff). All biological testing and related field sampling is conducted in this section. The testing includes permit and process monitoring for the SRWTP and other County agencies. Tests in this section can be categorized into bacteriological, microbiological, ecological, and toxicological analytical procedures.
- **Chemistry Section** (8 staff). Low level metals and organics sample analyses are conducted in this section with highly sophisticated instrumentation including atomic absorption spectroscopy by flame and gas furnace methodology, inductively coupled plasma mass spectroscopy, and gas chromatography. In addition, this group is also responsible for digester gas analysis and cyanide testing.
- **Conventional Chemistry Section** (9 staff). All of the physical and standard wet chemistry laboratory testing takes place in this section, as well as field sampling and testing activities.

The laboratory operates daily with an extended workday to allow all critical process analyses to be completed and reported to plant operations on the same day the samples are received. About 30,000 samples and 100,000 tests are processed each year.

Financial Information

The FY 1997 operations budget for SRWTP was $46,173,889.04. The benchmarked total budget, after subtracting capital expenses and other nonrelated expenses (such as debt service and sewer rebates) was $37,271,462.54. The budget also included $82.6 million in expenses for the two capital program budgets.

Operating revenues are collected in sewer service charges and sewer connection fees. Capital programs are financed through revenue bonds, which are also largely paid from sewer service charges and connection fees. District net assets exceed $500 million.

Treatment System and Process Descriptions

Major liquid stream treatment processes at SRWTP include prescreening followed by influent pumping, aerated grit removal, primary sedimentation, pure oxygen activated sludge, secondary sedimentation, chlorination for disinfection, effluent pumping, and dechlorination prior to discharge to the Sacramento River via an 8,000-foot outfall. Primary or secondary effluent can be diverted to three onsite emergency storage basins, with a total capacity of 200 million gallons. Solids handling processes include disposal of grit and screenings, waste activated sludge (WAS) thickening, mixing of thickened WAS and primary sludge, anaerobic digestion, storage of digested sludge in onsite solids storage basins, and disposal of the stored sludge at onsite, dedicated-land-disposal areas. Major onsite support systems include odor control facilities and channel aeration blowers. Digester gas is sent to an adjacent cogeneration plant owned and operated by the local utility company, and SRWTP receives steam from the cogeneration plant.

Average net influent flow for FY 1997 was 152 mgd. Recycle flows from the emergency storage basins or from the onsite sanitary drains are excluded from this total. Flow through the plant is the same in all the treatment processes. Effluent pumping is often not required during periods of low flow and low river elevations. During FY 1997, the effluent pumps were needed about 30 percent of the time, with effluent flow reaching the river by gravity at all other times.

As wastewater enters the plant, it passes through mechanically cleaned barscreens and into the influent pump wet well. Each of the five influent pumps are 1,250 hp, and can pump 125 mgd at a total head of 36 feet. A variable speed drive on each pump provides for automatic regulation of pumping in accordance with influent flow. The pumped wastewater flows to one of four aerated grit tanks and then to one of 12 primary sedimentation basins. The grit tanks and primary basins are covered, and have odor control scrubber facilities. Odor control facilities are also provided for the barscreen area and for the secondary treatment system. Grit is sent to grit classifiers and then to storage hoppers for truck loading and offsite disposal. Screenings are also trucked to the same offsite disposal site. Primary sludge and scum are mixed with thickened WAS prior to being sent to the digesters.

The entire plant flow is routed through secondary treatment. The plant has 12 covered pure-oxygen activated sludge basins and 24 circular clarifiers. Oxygen is supplied by an onsite cryogenic facility. Eight of the activated sludge basins have submerged turbines, with oxygen recycled through recirculation compressors. The other four basins have surface aerators. Activated sludge basins and secondary clarifiers are placed in service or removed from service based on changes in loading and flows.

Secondary effluent is chlorinated with gaseous chlorine at the effluent observation structure. Chlorinated effluent is pumped by effluent pumps (or flows by gravity at low flows and low river elevations) through an 8,000-foot outfall. Each of the four effluent pumps are 1,500 hp, and can pump 25 to 125 mgd at a maximum head of 41 feet. A variable speed drive on each pump provides for automatic regulation of pumping in accordance with effluent flow. The outfall conduit is used as the chlorine contact chamber. Effluent is dechlorinated prior to discharge to the Sacramento River. The primary means of dechlorination is via a sulfur dioxide vacuum line paralleling the outfall conduit. Detention time in this vacuum line is about 20 minutes. At the point of dechlorination, sodium bisulfite can also be added for peaking during rapid flow changes and for backup to the sulfur dioxide. Following dechlorination, effluent is discharged to the Sacramento River through a multiport diffuser.

Waste activated sludge (WAS) is thickened in four dissolved air flotation thickeners. Two gravity belt thickeners are also available, but are not used in normal operations. Thickened WAS is combined with primary sludge in the mixed sludge system, and the mixed sludge is sent to the digesters. The SRWTP digestion system includes three batteries of digesters, with a total of nine conventional mesophilic anaerobic digesters and two blending digesters. Minimum detention time is 15 days. Flow from the conventional digesters is sent to two blending digesters, which provide additional mixing and detention time, and then to facultative lagoons for onsite storage, followed by onsite disposal.

Natural gas generated in the digesters is compressed and sent to an adjacent cogeneration facility operated by the local power utility. Steam from the cogeneration facility is sent to the plant for use in heating the digesters.

A plant channel air aeration (CAA) system provides low-pressure air for the grit tanks, and for mixing of channels in the preliminary, primary, and secondary treatment areas. The system includes three large blowers and an extensive system of channels, pipes, and diffusers for air distribution. For the purpose of benchmarking, a portion of the costs to operate a CAA system were allocated to the preliminary, primary, and secondary treatment processes. This added significantly to these unit processes' costs.

Biosolids Management

Onsite solids storage basins include 20 basins with an area of 125 acres. They provide three to five years of onsite storage and also allow for further decomposition of volatile solids. Stabilized sludge from these basins is dredged and pumped to 200 acres of onsite dedicated land disposal areas (DLDs) during the six dry months from May to October. The stabilized biosolids are injected below the soil surface by means of a tractor-like machine. Biosolids are applied to the DLDs at a high rate (100 to 150 dry tons per acre annually). Crops are not grown on the DLDs. Naturally occurring soil microbes degrade the applied solids. Due to the detection of nitrates in the underlying groundwater, the District is planning to line the DLDs to allow for continuing onsite biosolids disposal.

Appendix C

Project Contacts and Contributors

Appendix C provides contact information for each of the agencies participating in the Multi-Agency Benchmarking Project and recognizes the many individuals who committed their time and expertise to the project.

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