MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

10-2
PENDING

June 18, 1998

To: Board of Directors (Special Committee on Water Quality, Desalination, and Environmental Compliance--Action)
(Engineering and Operations Committee--Action)
(Budget and Finance Committee--Action)

From: for General Manager

Submitted by: Mark D. Beuhler
Director of Water Quality

for Gary M. Snyder
Chief Engineer

Subject: Decision on Acceleration of the Oxidation Retrofit Program at the Skinner, Weymouth and Diemer Filtration Plants

RECOMMENDATION(S)

It is recommended that your Board select one of the following options as requested by your Board:

Option 1, Current Schedule—That the Oxidation Retrofit Program at the Skinner, Weymouth and Diemer plants maintain the current Capital Improvement Program schedule, with on-line dates of 2006 (Skinner), 2009 and 2012 (Weymouth and Diemer).

Option 2, Accelerate Ozone—That your Board direct staff to accelerate the Oxidation Retrofit Program at the Skinner, Weymouth and Diemer plants to achieve an on-line date of 2005 for each plant.

Option 3, Accelerate Ozone, Alternative Financing—That your Board direct staff to accelerate the Oxidation Retrofit Program at the Skinner, Weymouth and Diemer plants to achieve an on-line date of 2005 for each plant and develop alternative financial strategies to mitigate treatment surcharge impacts of the Oxidation Retrofit Program.

EXECUTIVE SUMMARY

Ozone is needed at the Mills and Jensen filtration plants by the year 2003 to comply with regulations. Ozone will provide significant water quality benefits. The other three filtration plants (Skinner, Weymouth and Diemer) are scheduled to implement ozone in stages over the following nine years (although there is a significant chance that additional new regulations will force an

acceleration of that schedule). Rate impacts of implementing ozone are unavoidable, although the timing of those impacts is partly dependent on the timing of the implementation. At the Board's request, staff has prepared additional information on current health effects studies, the advantages and disadvantages of ozone and alternative treatment technologies, the Capital Improvement Program projects deferred through the rate refinement process, and alternative financing options. An acceleration of the Oxidation Retrofit Program, which will implement ozone at the Skinner, Weymouth and Diemer filtration plants, would result in an on-line date of 2005. The Mills and Jensen filtration plants would continue with their scheduled on-line dates of 2002 and 2003, respectively.

DETAILED REPORT

Water is disinfected to eliminate microbes that cause disease. Chlorination, the most common form of disinfection, is effective but creates disinfection by-products such as trihalomethanes. Ozone is an alternative, more powerful disinfectant that does not create trihalomethanes and provides other water quality benefits.

Ozone is needed at Metropolitan's Jensen and Mills plants to comply with the proposed Stage 1 Disinfectants and Disinfection By-products Rule (D/DBP Rule). Final design of ozonation facilities at these two State Project Water plants is currently underway. (State Project Water produces significantly higher levels of disinfection by-products as compared to Colorado River Water.) Ozone implementation is currently on schedule with on-line dates of 2002 and 2003 for Mills and Jensen, respectively, ensuring that Metropolitan and its member agencies receiving water from these plants will be in compliance with Stage 1 of the D/DBP Rule. Promulgation of Stage 1 is scheduled for November, 1998, and utilities will have to comply between the years 2002 and 2004, depending on the need for capital improvements.

Metropolitan's other three filtration plants currently treating predominantly Colorado River Water, Skinner, Weymouth and Diemer, produce water that meets the existing trihalomethane standard and the proposed Stage 1 standards because Colorado River Water produces lower levels of disinfection by-products when disinfected. These three plants will not meet the proposed Stage 2 standard for total trihalomethanes (40 μg/l). Stage 2 of the D/DBP Rule will be negotiated and is scheduled to be promulgated in the year 2002. Metropolitan would have 3-5 years maximum to comply from that point if the 40 μg/l level is promulgated. There is a significant possibility that Metropolitan will have to have ozone implemented at all five filtration plants by 2005-2007, depending on our success at getting an extension, i.e., three years plus a two-year extension (see Figure 1).

The Board has requested an assessment of options to accelerate ozone implementation at these three plants. To comply with this request and to ensure that the Board is fully informed, additional information has been prepared in the four attached appendices.

Health Effects and Risk Tradeoffs

Appendix 1 on Disinfection By-Products Health Effects and Risk/Risk Tradeoffs provides information on recent health effects studies. Trends in research are indicating that the suspected adverse health effects of disinfection by-products may include cancer and reproductive and developmental impacts in humans. This may lead to stricter regulations such as lower levels of

total trihalomethanes, haloacetic acids and bromate, new regulations on individual disinfection by-products of health concern, and compliance with disinfection by-product regulations at all times at all sample sites versus continued use of a running annual average for compliance. The specifics of Stage 2 have yet to be negotiated with the U.S. Environmental Protection Agency.

History and Chronology

Appendix 2 describes the regulatory history and the chronology of Metropolitan's actions which led to the Oxidation Retrofit Program. Although Metropolitan's system can meet the proposed Stage 1 D/DBP Rule when water quality in the Bay/Delta is good, our member agencies that receive all or most of their water from either the Mills or Jensen filtration plants would have difficulty complying with the trihalomethane regulation even under normal circumstances. For more than 10 years, Metropolitan has conducted exhaustive studies on ozone, granular activated carbon, enhanced coagulation, and membranes to identify cost-effective treatment technologies. Appendix 2 describes the advantages and disadvantages of these technologies and estimates the treatment costs. Other options, including the exchange of source water between Metropolitan and the Los Angeles Department of Water and Power and the "do nothing" approach, were analyzed. Appendix 2 also discusses the treatment impacts of higher blends of State Project Water and Colorado River Water and the benefits of a Bay-Delta solution.

The advantages and disadvantages of the alternative treatment technologies are shown in Figure 2. The costs of various treatment technologies if implemented at all five treatment plants in the year 2002 are shown in Figure 3 (these costs per acre foot are greater than the resulting rate impacts because they do not account for increasing water sales). The overall costs for ozone and enhanced coagulation are comparable (Figure 3); however, ozone provides greater disinfection protection, the flexibility to meet future regulatory requirements, and control of taste and odor producing compounds and does not present sludge disposal problems. Membranes and granular activated carbon are five to ten times more expensive than ozone to implement.

CIP Projects Eliminated or Deferred

Appendix 3 lists the projects that have been eliminated or deferred within Metropolitan's Ten-Year Capital Improvement Program (CIP) through the Integrated Resources Plan and rate refinement process. New programs added to the CIP are also included. The on-line dates for the oxidation retrofit of the Skinner, Diemer and Weymouth plants were deferred beyond the Ten-Year CIP window (1995/96 - 2004/05).

Financing Alternatives

Appendix 4 describes five potential financing alternatives to mitigate the impact of the Oxidation Retrofit Program on the water treatment surcharge. Under Alternative 1, Metropolitan could issue General Obligation Bonds for the capital costs of water treatment facilities, subject to obtaining voter approval of the bonds. The water treatment surcharge would continue to collect the operation and maintenance costs of ozonation. For Alternative 2, a portion of the Oxidation Retrofit Program capital costs could be recovered from the Readiness-to-Serve charge if it was determined that a portion of the costs are attributable to system reliability. Similarly, under Alternative 3, a portion of the Oxidation Retrofit Program capital costs may be assessed to the New Demand Charge or a similar charge. With Alternative 4, the Board may consider establishing a minimum purchase charge to all treated water users. Through this rate

develop the long-term ESWTR and Stage 2 of the D/DBP Rule—is scheduled to commence in December 1998.

In the proposed D/DBP Rule [1], it was agreed upon by all of the stakeholders that "If data prior to this second rulemaking [i.e., the reg neg for the Stage 2 Rule] warrants earlier action on acute health effects, a meeting shall be convened to review the results of these data and to develop recommendations." Although compliance with the current THM rule is based on a running annual average—based on long-term exposure to cancer-causing DBPs—a regulation based on acute effects (e.g., adverse reproductive/developmental health effects, estrogen disruptors) would require compliance all the time in all parts of the distribution system, where calculation of a running annual average would no longer be allowed.

In addition, the USEPA has been developing data analysis plans for assessing data from the ICR to be used in the reg neg process. These include examining the formation and control of individual DBPs of health and regulatory concern (e.g., BDCM), compliance with DBP MCLs all of the time at all sample sites versus continued use of a running annual average for compliance, and simultaneous compliance with a long-term ESWTR (with requirements for the inactivation of *Cryptosporidium*) and Stage 2 of the D/DBP Rule (with a more stringent MCL for bromate).

In considering the regulatory options for the upcoming reg neg, it is likely we may move from a treatment-based/feasibility set of rules (i.e., Stage 1 of the D/DBP Rule) to a risk-based set of rules (i.e., the long-term ESWTR and Stage 2 of the D/DBP Rule). Conceptually, the Stage 1 regulation set MCLs of 80 μg/L TTHMs, 60 μg/L HAA5, and TOC removal requirements to control the risks associated with known and unknown DBPs. Moreover, these were levels that were deemed achievable through the enhancement of existing water treatment processes.

Alternatively, it has been predicted that compliance with the proposed Stage 2 set of MCLs [i.e., 40 μg/L TTHMs, 30 μg/L HAA5] would require significant and costly treatment modifications. With a risk-based Stage 2 Rule, utilities that treat water low in bromide may not be required to lower TTHMs and HAAs to 40 and 30 μg/L, respectively, if the major source of their THMs and HAAs are DBPs with non-zero MCLGs [i.e., chloroform and TCAA], especially if there is no scientific basis for demonstrating a cost/benefit. Alternatively, systems that have relatively high concentrations of DBPs of health concern [i.e., BDCM, DCAA, and BDCAA] may be required to reduce those concentrations. This is because certain bromine-containing DBPs are of higher health concern than some of the chlorinated species.

The USEPA and AWWA Research Foundation jointly participate in a Microbial/DBP (M/DBP) Research Council to fund research in support of the ESWTR and D/DBP Rule development. At the May 1998 meeting of the Technical Advisory Group (TAG) for the M/DBP Research Council, a research agenda for 1998 funding was developed. The number-one priority project that the TAG has recommended for funding is a "Study on Spontaneous Abortion and Disinfection By-Product Exposures." The overall goal of this study will be to evaluate if the results reported in the Waller et al. study [10] can be replicated in another part of the country. More specifically, the objective is to investigate whether exposure to THMs (especially BDCM), HAAs or other DBPs may be associated with increased risk of spontaneous abortion.

In addition, another study is being considered on the "Effects of DBPs on Sperm Quality." Two reasons why this study was suggested are (1) there is a geographic difference in sperm counts and (2) the rodent data suggest a possible connection between HAA exposure (in particular, the bromine-containing HAA DBAA) and sperm effects. Thus, we are entering an era in which adverse health effects that may be associated with DBPs are not being limited to cancer effects.

References

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16. USEPA. National Primary Drinking Water Regulations; Enhanced Surface Water Treatment Requirements; Proposed Rule. *Fed. Reg.*, 40 CFR Parts 141 and 142 (Jul. 29, 1994).

17. USEPA. National Primary Drinking Water Regulations; Interim Enhanced Surface Water Treatment Rule; Notice of Data Availability; Proposed Rule. *Fed. Reg.*, 40 CFR Parts 141 and 142 (Nov. 3, 1997).
18. U.S. Congress. Safe Drinking Water Act Amendments of 1996. Washington, D.C. (Aug. 1, 1996).

Appendix 2

OZONE TECHNICAL INFORMATION DOCUMENT

June, 1998

EXECUTIVE SUMMARY

Metropolitan must modify its Jensen and Mills treatment plants, which treat 100 percent State project water, in order to ensure that Metropolitan and its member agencies comply with both components of Stage 1 of the proposed Disinfectants/Disinfection By-Products Rule. Specifically, the two components of the proposed rule are (1) a treatment requirement for controlling disinfection by-product precursors, and (2) maximum contaminant levels for particular disinfection by-products. The treatment component requires utilities to practice enhanced coagulation or commit to installing alternative treatment processes, such as ozone, granular activated carbon, or membranes.

Promulgation of Stage 1 of the proposed Disinfectants/Disinfection By-Products Rule is scheduled for November 1998. Under the previous Safe Drinking Water Act amendments, utilities would have been required to comply within 18 months of promulgation. However, reauthorization of the Safe Drinking Water Act, which was signed into law by President Clinton on August 6, 1996, extends the compliance period following promulgation to 3-5 years. At present, the most likely scenario is that utilities would have to comply with Stage 1 between 2002 and 2004, depending upon the need for capital improvements. Negotiations for Stage 2 of the Disinfectants/Disinfection By-Products Rule are expected to begin in December 1998, following promulgation of Stage 1.

During the past 10 years, Metropolitan has conducted numerous evaluations, with input from member agencies, to compare treatment technologies for compliance with proposed and future water quality regulations. Ozone/PEROXONE, enhanced coagulation, granular activated carbon, and membranes were compared in terms of disinfection, formation of chlorinated disinfection by-products, bromate formation, control of taste-and-odor compounds, arsenic removal, and cost. The most cost effective option for complying with the proposed Disinfectants/Disinfection By-Products Rule, while providing the greatest number of benefits, is switching the primary disinfectant from chlorine to ozone. In addition to reducing disinfection by-product formation, ozone is the most effective disinfectant against pathogens, such as *Cryptosporidium*, and can improve earthy/musty tastes and odors associated with periodic algae growth in source-water reservoirs.

Implementation of ozone, or an alternative treatment technology, at the remaining three plants (Skinner, Weymouth, and Diemer) is not required under Stage I of the Disinfectants/Disinfection By-Products Rule, as long as these plants treat primarily Colorado River water. <u>However, should these three plants treat a significantly greater percentage of State Project Water (e.g., more than</u>

25 percent) for extended periods of time, or if disinfection by-product maximum contaminant levels are further reduced in Stage 2 of the proposed Disinfectants/Disinfection By-Products Rule, the implementation of ozone, granular activated carbon, or membranes would be required at these plants.

REGULATORY BACKGROUND

Early Developments

The 1986 amendments to the Safe Drinking Water Act (SDWA) directed the U.S. Environmental Protection Agency (USEPA) to set drinking water standards for an initial 83 contaminants, followed by standards for an additional 25 contaminants every three years thereafter. These standards included trihalomethanes (THMs) and other disinfection by-products (DBPs) which form when chlorine used for disinfection reacts with naturally-occurring organic matter in the water. In October 1989, the USEPA released a "Strawman," or working draft regulation, indicating that it would reduce the THM standard from 100 μg/L to 25 or 50 μg/L, as well as set maximum contaminant levels (MCLs) for the individual THMs and other DBPs. Also, the USEPA planned to define granular activated carbon (GAC) as "Best Available Technology" (BAT) for THM control. Promulgation of this "Strawman" regulation would have resulted in serious financial consequences for Metropolitan and its member agencies.

1994 Proposal

In September 1992--in lieu of proceeding with the "Strawman" regulation--the USEPA began negotiating with members of the drinking water industry, the environmental community, consumer-advocacy groups, and other regulatory agencies, in an effort to balance microbial and DBP risks. Metropolitan provided technical assistance to the American Water Works Association (AWWA) and also directly represented the National Water Resources Association during the negotiations. As such, Metropolitan favorably influenced the negotiations, which resulted in a group of proposed regulations that included the Information Collection Rule (ICR), a two-stage Disinfectants/Disinfection By-Products (D/DBP) Rule, and the Enhanced Surface Water Treatment Rule (ESWTR). These three regulations were proposed in the *Federal Register* in 1994. A brief description of each of these regulations is presented below.

Information Collection Rule (ICR)

The ICR was proposed in February 1994 but not promulgated until May 1996, two years behind schedule. This regulation required utilities to collect microbial and DBP occurrence data in their treatment plants and distribution systems over an 18-month period beginning in July 1997. In addition, some utilities were required to perform treatment studies, using either GAC or membrane processes, to evaluate DBP precursor removal. Metropolitan was exempt from the treatment studies because of the relatively low levels of total organic carbon (TOC) present in its source waters.

The ICR was originally intended to collect data which would allow negotiators to develop Stage 2 of the D/DBP Rule and the ESWTR in an effort to balance microbial and DBP risks. However, because of delays in promulgating the ICR and technical difficulties in initiating the sampling,

most ICR monitoring data will not be available to support these rules. Instead, the USEPA intends to use only the first 6 months of ICR data or other independent data currently available.

Stage 1 of Proposed D/DBP Rule

The USEPA proposed the two-stage D/DBP Rule, resulting from the negotiations, in the *Federal Register* in June 1994. Based upon the negotiated agreement, Stage 1 of the D/DBP Rule included two components: (1) a treatment requirement; and, (2) MCLs for specific DBPs.

The treatment component of the rule requires that utilities employ enhanced coagulation, a process that removes precursors (as measured by TOC) of THMs and other DBPs. Enhanced coagulation involves the addition of substantially higher dosages of coagulants, such as alum or ferric chloride, to reduce TOC levels, and hence, the formation of DBPs. Specific TOC removal requirements depend on source water influent TOC and alkalinity. The rationale for the treatment component of the rule was that reducing TOC levels also reduces potential or unknown health risks from unidentified DBPs. MCLs, the second component of the D/DBP Rule, include 80 μg/L for total trihalomethanes (TTHMs), 60 μg/L for total haloacetic acids (HAAs), and 10 μg/L for bromate.

Utilities must comply with both components of the proposed D/DBP Rule. If a utility fails to comply with either component, it will be required to notify the public of its noncompliance, using language that refers to cancer, reproductive, and developmental effects that have been associated with DBPs.

Metropolitan negotiated a clause in the rule that allows utilities to avoid enhanced coagulation under certain circumstances if they make a "clear and irrevocable commitment" to an alternative technology--such as ozone, GAC, or membranes--that will meet one-half of the Stage 1 MCLs (i.e., 40 μg/L for THMs and 30 μg/L for HAAs). These levels, as well as a bromate standard of 5 μg/L, were also proposed as the MCLs for Stage 2 of the D/DBP Rule, pending a second series of negotiations.

Enhanced Surface Water Treatment Rule

In addition to the D/DBP Rule, the USEPA proposed to amend the Surface Water Treatment Rule (SWTR) to provide additional protection against disease causing organisms in drinking water. This proposed rule--the ESWTR--primarily focused on treatment requirements for the removal and/or inactivation of the waterborne pathogens *Cryptosporidium, Giardia,* and viruses. *Cryptosporidium,* a pathogenic protozoan commonly found in surface waters, has caused several waterborne disease outbreaks, most notably in Milwaukee, Wisconsin where over 400,000 people became ill in 1993.

1996 Safe Drinking Water Act Amendments

In 1996, Congress reauthorized the SDWA, which was signed into law by President Clinton on August 6. The Amendments directed the USEPA to promulgate Stage 1 of the proposed D/DBP Rule and an Interim Enhanced Surface Water Treatment Rule (Interim ESWTR) by November

1998. In addition, the Amendments required the USEPA to promulgate a Final ESWTR and a Stage 2 D/DBP Rule by November 2000 and May 2002, respectively.

1997 Proposal

In November 1997, the USEPA published revised proposals for the D/DBP Rule and the IESWTR to tighten limits on DBPs and improve control of microbial contaminants. The two regulations were developed jointly and iteratively because USEPA realized that to reduce DBPs alone might cause utilities to decrease necessary disinfection of drinking water. Adequate disinfection is essential to destroy pathogens in drinking water, which are by far the greatest source of human health risk in drinking water.

The USEPA formalized the process to develop revisions to the D/DBP Rule and the IESWTR using the Federal Advisory Committee Act in February 1997. A newly appointed committee--the Microbial and Disinfectants/Disinfection By-Products Advisory Committee--met five times in March through July 1997 to discuss issues related to the IESWTR and Stage 1 D/DBP Rule. After revisions, these rules became collectively known as the Microbial and Disinfectants/Disinfection By-Products (M/DBP) Rule.

The Committee reached agreement on the following major issues: (1) maintaining the proposed MCLs for TTHMs, HAA5, and bromate; (2) modifying the enhanced coagulation requirements as part of DBP control; (3) including a microbial bench marking/profiling to ensure that there will be no significant reduction in microbial protection as the result of modifying disinfection practices; (4) continued credit for pre-disinfection; (5) modification of the turbidity performance requirements and requirements for individual filters; (6) issues related to the maximum contaminant level goal (MCLG) for *Cryptosporidium*; (7) requirements for the removal of *Cryptosporidium*; and, (8) provision for conducting sanitary surveys.

The most substantial changes from the 1994 proposal include a reduction in the allowable maximum turbidity levels from 5 NTU to 1 NTU and a reduction in the average monthly limit for combined filter effluent from 0.5 NTU to 0.3 NTU. Treatment systems will be required to achieve 99 percent removal of *Cryptosporidium*, install individual turbidimeters for monitoring purposes, and undertake periodic sanitary surveys.

M/DBP Rule Cluster Schedule

Promulgation of the M/DBP Rule cluster is scheduled for November 1998. The 1996 SDWA Amendments extended the period allowed for compliance from the current 18 months to 3-5 years, giving utilities undertaking major construction projects additional time to comply. It now appears that compliance will be required between November 2002-2004.

Negotiations for Stage 2 of the D/DBP Rule are expected to begin in December 1998, following promulgation of the M/DBP Rule cluster. It is hoped that the first six months of ICR data will be available for the negotiators at that time.

IMPACT OF REGULATIONS ON METROPOLITAN

Figure 1 presents the running annual average for total THMs in Metropolitan's distribution system. These data demonstrate that Metropolitan's overall system can meet the proposed Stage 1 DBP MCL requirement with its current treatment practices (chlorine through the treatment plants, followed by chloramines in the distribution system) and with reasonably good quality water out of the Delta. However, Metropolitan will not comply with the DBP precursor removal requirement of the rule unless it modifies its treatment processes (implementing either enhanced coagulation or an alternative treatment technology) at its two plants treating 100 percent State project water (SPW), Jensen and Mills. SPW contains higher concentrations of DBP precursors than Colorado River water (CRW), and leads to the formation of greater levels of DBPs. Also, the nature of the organic material in SPW is different from that found in CRW. While enhanced coagulation removes organic matter in SPW, it removes much less in CRW. For this reason, Metropolitan's other three plants (Skinner, Weymouth, and Diemer), which treat primarily CRW, are exempt from the treatment component of Stage 1. <u>However, should these three plants treat a significantly greater percentage of SPW (e.g., more than 25 percent) on a regular basis in the future, or should the DBP MCLs be further reduced in Stage 2 of the D/DBP Rule, the implementation of ozone, GAC, or membranes would be required at these plants.</u> The implications of blending will be discussed in more detail in subsequent sections.

IMPACT OF REGULATIONS ON MEMBER AGENCIES

Metropolitan's member agencies that receive all or most of their water from either the Jensen or Mills filtration plants (100 percent SPW) would have difficulties complying with the proposed THM MCL of 80 μg/L, without treatment modifications at those two plants. The TTHM levels leaving these plants are generally less than 80 μg/L; however, by the time the water reaches the member agencies, levels greater than 80 μg/L often occur. Implementation of enhanced coagulation or ozone at the Jensen and Mills plants to ensure Metropolitan compliance with both the treatment and MCL requirements of the D/DBP Rule, would also ensure downstream member agency compliance with the THM and HAAs MCLs. However, downstream member agencies receiving ozonated water may no longer be able to use free chlorine in their distribution systems, since ozone does not remove DBP precursors.

Member agencies that operate their own treatment plants that treat either SPW or local supplies with high levels of TOC, will be required to implement enhanced coagulation or an alternative treatment technology in order to comply with both components of Stage 1 of the proposed D/DBP Rule.

METROPOLITAN'S THM ACTION PLAN

In 1986, Metropolitan initiated its THM Action Plan in an effort to identify cost effective treatment technologies that would allow Metropolitan to meet new and more stringent standards for THMs and other DBPs, while maintaining control over taste-and-odor (T&O) compounds and microorganisms. This action plan has included an exhaustive series of bench-, pilot-, and demonstration-scale studies that initially focused on the use of GAC and oxidants (primarily

ozone and PEROXONE--the addition of hydrogen peroxide to the ozone process) and later investigated enhanced coagulation and membranes, as well as ozone.

Based on the results of these studies under the THM Action Plan, enhanced coagulation, GAC, and membranes were found to be either extremely expensive alternatives to control DBPs or serious environmental and siting problems were identified. In contrast, the ozone/PEROXONE process, followed by chloramines, was found to be very effective for controlling DBPs in low bromide waters (THMs from 20-30 μg/L), tastes and odors (>75 percent removal compared to no removal for chlorine), and microorganisms (an order of magnitude more effective than chlorine for *Cryptosporidium* inactivation). In 1993, Metropolitan initiated its Oxidation Retrofit Program (ORP) which will implement ozone/PEROXONE facilities at the Jensen and Mills plants, and possibly at the Weymouth, Diemer, and Skinner plants at a later time. The chronological events for the ORP are outlined in Attachment A. The pertinent Board letters covering this period are listed in Attachment B (copies of individual Board letters are available upon request).

ALTERNATIVE TREATMENT TECHNOLOGIES

During the past 10 years, Metropolitan has conducted numerous evaluations to compare treatment technologies for compliance with proposed and future water quality regulations. Ozone/PEROXONE, enhanced coagulation, GAC, and membranes where compared in terms of disinfection, formation of chlorination DBPs (THMs and HAAs), bromate formation, control of T&O compounds, arsenic removal, and cost. Each of these technologies are assumed to be implemented as part of a conventional treatment train. A discussion of each technology follows. For comparative purposes and consistency, all cost estimates are presented in the year 2002 dollars. This year was chosen since the Mills plant is scheduled to be on-line with ozone facilities in the year 2002. It should be noted that these cost estimates for ozone ($47/acre foot) are higher than the projected rate impact of ozone ($36/acre foot) because the rate impact calculation includes increasing water sales. The assumptions used for the following cost estimates are shown in Attachment C.

Ozone

Pros and Cons

Historically, chlorine has been the most widely used disinfectant in the water industry throughout the United States. However, due to public health concerns over chlorine-based DBPs, water utilities have re-examined the use of other disinfectants, such as ozone. Ozone, though short lived in water, is a very strong disinfectant that oxidizes microorganisms and many organic materials. Unlike chlorine, ozone does not react with humic materials and certain natural organic materials to produce chlorinated DBPs.

Ozone disinfection would allow Metropolitan to comply with both Stages of the D/DBP Rule (as currently proposed), as well as the existing SWTR. In addition, the USEPA will regulate *Cryptosporidium* under the proposed ESWTR, and ozone is much more effective than chlorine or chloramines for inactivating this organism. Pilot- and demonstration-scale studies have shown that ozone/PEROXONE can effectively oxidize the T&O compounds found in Metropolitan's

source waters that cause earthy/musty odors. These compounds are not removed by conventional technologies. Therefore, ozone/PEROXONE facilities will improve customer satisfaction and provide an additional T&O control strategy. Finally, ozone/PEROXONE facilities would provide Metropolitan with a tool to handle water quality uncertainties such as future regulations (e.g., disinfection and DBPs) and potential pollutants (e.g., pesticides and solvents).

During the ozonation of waters containing bromide, bromate may be formed. Bromate is a potential carcinogen, and it will also be regulated as part of the D/DBP Rule. The Stage 1 MCL for bromate is 10 μg/L and the Stage 2 MCL may be lowered to 5 μg/L. Controlling the pH of ozonation has been shown to limit the formation of bromate in SPW and CRW. pH adjustment is generally achieved by adding sulfuric acid at the contactor influent and caustic soda (or lime) at the contactor effluent. When ozonating SPW, a pH from 6 to 7 may be required depending on the bromate MCL, the bromide concentration, and the applied ozone dose. The amount of bromate formed when ozonating CRW is generally less due to the lower levels of bromide found in CRW. At a pH of 7, bromate formation is usually less than 5 μg/L, regardless of the applied ozone dose. One negative aspect of controlling the pH of ozonation, other than the modest cost increase, is the increase in total dissolved solids (TDS) (an additional 20 to 70 mg/L).

Treatment Costs

In general, installing ozone/PEROXONE facilities at Metropolitan's plant will require the addition of oxygen separation facilities, ozone generators, ozone contactor basins, new chemical feed systems, and associated appurtenances. Due to site constraints at the plants, in many cases existing facilities such as maintenance and service center buildings and chemical storage facilities will need to be relocated to accommodate new construction. The cost for ozone at Jensen and Mills (both capital and O&M) is about $58 per acre-feet of treated water based on an ozone design dosage of 2 mg/L, as shown in Table 1. The cost for ozone treatment at the other plants is estimated at $41 per acre-feet of treated water, as shown in Table 2. The cost difference is due to the relatively low flow projections for the Jensen and Mills plants (305 million-gallons-per-day [MGD] and 122 MGD, respectively, for the year 2010). If the bromate standard is reduced to 5 μg/L in Stage 2 of the D/DBP Rule, costs may increase by about 10 percent at the Jensen and Mills plants due to additional chemical usage.

Enhanced Coagulation

Pros and Cons

Enhanced coagulation is a process in which elevated coagulant dosages (30 to 50 mg/L of alum or ferric chloride) are added at the conventional treatment train to remove dissolved organic material from the process stream and hence; reduce the amount of DBPs formed. Many plants throughout the US were designed to remove dissolved organic matter and can accommodate elevated coagulant dosages. However, for a number of reasons Metropolitan's plants where designed for turbidity and particle removal only, which requires significantly less coagulant. Major modifications would be required at Metropolitan's plants before they could be operated in the enhanced coagulation mode on a routine basis.

Facilities associated with enhanced coagulation require major capital investments such as (1) additional chemical feed and storage; (2) additional sludge processing equipment; (3) corrosion control mitigation; and (4) additional chlorine disinfection facilities. In addition to increased chemical useage and sludge handling (which have numerous environmental consequences), disinfection is a concern associated with implementing enhanced coagulation. When employing enhanced coagulation, Metropolitan would not add free chlorine until after the filters, thus decreasing the margin of safety for disinfection. In order to ensure compliance with the disinfection requirements of the SWTR, the MCLs in the D/DBP Rule, and the additional constraints of microbial benchmarking in the M/DBP Rule cluster, Metropolitan would either modify its existing clearwell reservoirs to operate in series or construct a separate chlorine contact basin. Furthermore, enhanced coagulation would not be effective for removing T&O compounds and the TDS of the water would increase (an additional 40 to 70 mg/L).

Enhanced coagulation is a viable alternative to comply with Stage 1 of the D/DBP Rule at the Jensen and Mills plants. However, compliance with the proposed MCLs in Stage 2 could not be achieved using enhanced coagulation, and ozone, GAC, or membranes would still be necessary. For the Weymouth, Diemer, and Skinner plants, enhanced coagulation could be employed to comply with both Stages of the D/DBP Rule, as long as the SPW blend is restricted. In order for no blend restrictions to be imposed, ozone, GAC, or membranes would be required (a more detailed discussion of blending impacts follows).

Treatment Costs

The capital costs for enhanced coagulation include tank farm and feed system upgrades, sludge processing equipment, corrosion control measures, chlorine contactors, and sedimentation basins for the Skinner plant. Additional O&M costs are due to chemical usage, energy consumption, personnel, equipment replacement, and sludge hauling and disposal. The cost for enhanced coagulation at the Jensen and Mills plants is estimated at $52.8 per acre-feet of treated water, as indicated in Table 3. At Weymouth, Diemer, and Skinner, the cost for enhanced coagulation is estimated at $51.5 per acre-feet of treated water, as shown in Table 4.

Granular Activated Carbon

Pros and Cons

Another treatment alternative available for controlling DBPs is GAC. GAC adsorbers reduce the amount of DBPs formed in the treatment process by removing the DBP precursors prior to disinfection with chlorine. The GAC adsorbs the organic precursors on the abundant microscopic fractured surfaces of the carbon. After the GAC becomes exhausted, the adsorption process no longer occurs and the carbon needs to be thermally regenerated in a furnace operating at temperatures in excess of 1,700° F. The thermal regeneration process clears the fractured GAC surfaces by driving the precursors off and into the furnace exhaust gases. Other benefits of using GAC include the reduction of volatile organic chemicals such as pesticides and herbicides, and GAC's ability to improve the T&O of the treated water by adsorbing such compounds as MIB and Geosmin. Compliance with the proposed MCLs in Stage 2 of the D/DBP Rule could be achieved using GAC.

Previous Studies

Metropolitan was involved in two major research projects to further evaluate GAC as a treatment alternative to minimize THM formation. The first study, *Optimization and Economic Evaluation of Granular Activated Carbon for Organic Removal,* was completed in 1989. This study was partially funded by the American Water Works Association Research Foundation (AWWARF) and was conducted by Metropolitan, James M. Montgomery, Consulting Engineers, and Michigan Technological University. The primary objectives of this study, which were directed towards the needs of Metropolitan and the water industry as a whole, were: optimization of GAC for meeting lower THM standards and estimation of the costs associated with optimized GAC treatment for both Metropolitan and six other water utilities across the country. In order to accomplish these objectives, six post-filtration GAC contactors, with varying empty bed contact times (EBCT), were evaluated. The results from this evaluation were then used to develop cost estimates (for Metropolitan's two source waters) associated with GAC treatment.

The second study, performed by Malcolm Pirnie, entitled, *Granular Activated Carbon Regeneration Study,* was completed in March of 1992 specifically for Metropolitan's facilities. This study built on Malcolm Pirnie's experiences in designing the largest post GAC water treatment facility in the world, a 175 MGD water treatment plant in Cincinnati, Ohio. This study also used information developed in Metropolitan's first study and further refined the data to more closely simulate the conditions at Metropolitan's plants.

Treatment Costs

The installation of GAC facilities would require major capital expenditures along with approximately 100 acres of site space for GAC contactors and regeneration facilities. Two options exist for GAC regeneration: on-site regeneration facilities at each of the five plants or a single regeneration facility. For on-site regeneration facilities, a total of 23 multiple-hearth furnaces, each ranging in capacity from 100,000 to 500,000 lbs/day, would be required. For a regional GAC regeneration facility, 13 furnaces, each at a capacity of 500,000 lbs/day, would be required. Extremely stringent air pollution controls would govern the regeneration process in the Los Angeles basin. Metropolitan would likely petition for an exemption from mitigation requirements. If Metropolitan was unsuccessful in receiving an exemption, emission reduction credits would need to be purchased on the open market.

The GAC adsorbers would be located immediately after the filters and the EBCT would be sized to achieve a THM concentration of 30 μg/L. A chorine contactor would be required after the GAC adsorbers. It is assumed that enough open acreage is available at the plants to install GAC adsorbers and chlorine contactors. Carbon regeneration would be the primary O&M cost component. The total cost for GAC at Jensen and Mills is $262 per acre-feet of treated water, as presented in Table 5. The cost for GAC at the CRW plants is estimated at $218 per acre-feet of treated water, as shown in Table 6. Installation of GAC at Metropolitan would result in five of the world's largest GAC treatment facilities.

Reverse Osmosis Membranes

Pros and Cons

During the reverse osmosis (RO) process, pretreated water is pushed through semi-permeable membranes that filter out dissolved materials generating a purified process stream and brine (a waste product). RO processes are extremely effective in removing organic and inorganic contaminants, microorganisms, salts, ions, and DBP precursors from water. As such, installation of RO membranes at Metropolitan's plants would ensure compliance with the proposed MCLs in Stage 2 of the D/DBP Rule. However, the high cost of large-scale membrane facilities makes this treatment alternative prohibitive at this time.

Although Metropolitan has only conducted a limited number of bench- and pilot-scale membrane studies, numerous paper studies have been conducted on the feasibility of implementing RO membrane technology at Metropolitan. The RO process requires a pretreatment step to condition the water prior to membrane treatment. Metropolitan's treatment plants would be used to provide high-quality pretreated water (although this still needs to be verified through experimentation). Current membrane technology only allows for about 90 percent of the process water to be treated. In other words, 10 percent of the process stream must be discharged as waste. A dedicated brine line to the ocean would be required to handle this amount of water. Of course, "wasting" large volumes of water in the arid southwest is not a realistic option. The operating pressures of RO membranes are still relatively high, so a significant amount of energy would be required to drive the treatment process. Membranes are also sensitive to oxidants such as chlorine, so a dechlorination step would also be required prior to treatment.

Treatment Costs

The membrane modules would be located after the filters and before a dechlorination basin. Capital costs include pumps, membranes, pressure vessels, and ancillary equipment. The major O&M cost components include energy, membrane cleaning, and membrane replacement. The additional costs to employ RO at Jensen and Mills are shown in Table 7. The annualized overall cost is about $408 per acre-feet of treated water. The cost for RO at Weymouth, Diemer, and Skinner is $356 per acre-feet of treated water, as indicated in Table 8. Note that the design capacity at each plant would be reduce by about 10 percent (e.g. from 520 to 468 MGD at Weymouth).

LADWP/Metropolitan Water Exchange

Under this compliance strategy, Metropolitan and the Los Angeles Department of Water and Power (LADWP) would exchange source waters; the Jensen plant would treat Owens River water and the Los Angeles Aqueduct Filtration Plant (LAAFP) would treat SPW. With ozone as the primary disinfectant, the LAAFP could treat SPW and successfully meet both the treatment and MCL components of Stage 1 of the D/DBP Rule. While Owens River water is not amenable to enhanced coagulation, enhanced coagulation facilities would still be required at the Jensen plant to treat SPW when sufficient Owens River water is not available to meet demands within the Jensen service area. In addition, higher coagulant dosages would be required to reduce the

elevated arsenic concentrations commonly found in Owens River water (greater than 25 μg/L compared to 2-5 μg/L in SPW). Special sludge handling and disposal techniques would be required to deal with the resulting arsenic-laden sludge, which would be considered a hazardous waste. Finally, a raw water pipeline would be necessary to make the water exchange possible.

Obviously, the water exchange strategy would only accommodate the Jensen plant and additional treatment would still be required at Metropolitan's other plants. The additional cost incurred at the Jensen plant for the water exchange is presented in Table 9. The total cost is $52 per acre-feet which is comparable to the cost of ozone or enhanced coagulation.

Do Nothing Approach

Although doing nothing is not considered a viable alternative, it is still included in this analysis for informational purposes. Doing nothing means discontinuing all ORP design efforts currently underway and making the decision to not pursue any other treatment alternatives. By doing nothing, neither Metropolitan nor its member agencies would comply with Stage 1 of the D/DBP Rule, and public notification would be mandated by the USEPA. Public notification would be required in the form of news media announcements (television, radio, and/or newspaper) and would indicate that the water delivered to the consumer does not meet MCLs for certain DBPs. The public notification would contain language similar to the following excerpt:

> "The U.S. EPA sets drinking water standards and requires the disinfection of drinking water. The Safe Drinking Water Act also requires disinfection for all public water systems. However, when used in the treatment of drinking water, disinfectants combine with organic and inorganic matter present in water to form chemicals called disinfection by-products (DBPs). EPA has determined that a number of DBPs are a health concern at certain levels of exposure. Certain DBPs, including some trihalomethanes (THMs), and some haloacetic acids (HAAs), have been shown to cause cancer in rats. Other DBPs have been shown to damage the liver and the nervous system, and cause reproductive or developmental effects in laboratory animals. There is also some evidence that exposure to certain DBPs may produce adverse health effects in people. EPA has set standards to limit exposure to THMs, HAAs, and other DBPs".

Treatment Technology Summary

The costs to implement the alternative treatment technologies at Metropolitan's plants are summarized in Table 10. The overall costs for ozone and enhanced coagulation are comparable. The advantages and disadvantages of the alternative treatment technologies are summarized in Figure 2. The numerous evaluations conducted during the last ten years have identified ozone as the most cost effective treatment technology that would ensure both Metropolitan and member agencies compliance with Stage 1 of the proposed D/DBP Rule, as well as having the greatest number of benefits (e.g. disinfection protection against *Cryptosporidium* and other microorganisms, and taste-and-odor control). It is also anticipated that ozonation would help meet any future lower DBP regulations to be developed in Stage 2 of the D/DBP Rule, at a reasonable cost.

BLENDING IMPLICATIONS

The Stage 1 D/DBP Rule requires enhanced coagulation for the removal of TOC in water that is amenable to enhanced coagulation. SPW is amenable to enhanced coagulation and, as a result, Jensen and Mills must comply with the treatment provision of the D/DBP Rule. Enhanced coagulation could be avoided by implementing an alternative technology that reduces DBPs, such as ozone, GAC, or membranes. CRW is not amenable to enhanced coagulation due to the high alkalinity in the water, and compliance with the treatment requirement of the Stage 1 D/DBP Rule is not required. Depending on the portion of SPW and CRW in blended supplies, enhanced coagulation (or an alternative treatment technology) may be required at the Weymouth, Diemer, and Skinner plants which treat a blend of CRW and SPW. Preliminary bench-scale work conducted in 1994 and 1995 showed that SPW blends of 50 percent or more were considered amenable to enhanced coagulation. Blends from 25 to 50 percent appeared to be amenable sometimes (depending on the water quality at the time), and blends less than 25 percent were not amenable to enhanced coagulation.

Metropolitan's Board has adopted a TDS salinity goal of 500 to 550 mg/L from April through September at the Weymouth, Diemer, and Skinner plants. In order to achieve this goal, SPW is blended with CRW to reduce the salinity. However, higher blends may trigger additional treatment at these plants. Table 11 summarizes possible treatment alternatives required under different blend scenarios and expected DBP MCLs, and Figure 3 shows the resultant TTHM levels expected after treatment. This analysis only includes ozone and enhanced coagulation, as the other treatment technologies are prohibitively expensive.

BAY-DELTA FIX

Board members and member agency managers also asked for information regarding the need for new facilities to comply with Stage 1 of the D/DBP Rule in light of current efforts underway to find a Bay-Delta solution to improve water quality to drinking water utilities. A preliminary assessment of water quality data indicates that the level of TOC and bromide expected as a result of any Bay-Delta alternative would still require that Metropolitan implement either enhanced coagulation or ozonation at its SPW plants to comply with the Stage 1 treatment requirements. Furthermore, compliance with Stage 1 of the proposed D/DBP Rule will be required at least 10-20 years before a final Bay-Delta solution may be in place.

CALIFORNIA SPW PLANTS

As DBP and disinfection regulations have become increasingly stringent, more than 140 plants in the U.S. have switched to ozone in the past ten years. Approximately 22 California plants are implementing ozone, including 15 plants that treat some portion of SPW (see Figure 4). Figure 5 illustrates the results of an informal telephone survey of 32 plants that treat more than 50 percent SPW. The plants were asked about their current treatment processes and future treatment processes that they would implement for Stage 1 compliance. All of the SPW plants implemented ozone primarily for DBP control; secondary reasons cited include disinfection, taste-and-odor control, and oxidation.

TABLE 1

ADDITIONAL COSTS TO EMPLOY OZONE
AT JENSEN AND MILLS
(year 2002 dollars)

Plant	Capital Cost ($M)	O&M Cost ($M/yr)	Annualized Cost*	
			($M/yr)	($/ac-ft)
Jensen	157.4	4.2	17.9	52.5
Mills	95.0	1.7	10.0	73.1
total	252.4	5.9	27.9	58.4

* Sum of capital costs, amortized at 6% interest for 20 years, and O&M costs

Note, annualized costs would increase by about 10 percent to meet a bromate MCL of 5 ug/ (proposed in the Stage II D/DBP rule).

TABLE 2

ADDITIONAL COSTS TO EMPLOY OZONE
AT WEYMOUTH, DIEMER, AND SKINNER
(year 2002 dollars)

Plant	Capital Cost ($M)	O&M Cost ($M/yr)	Annualized Cost*	
			($M/yr)	($/ac-ft)
Weymouth	102.9	1.9	10.9	36.6
Diemer	132.0	3.0	14.5	42.1
Skinner	125.5	2.9	13.8	44.6
total	360.4	7.8	39.2	41.2

* Sum of capital costs, amortized at 6% interest for 20 years, and O&M costs

TABLE 3

ADDITIONAL COSTS TO EMPLOY ENHANCED COAGULATION
AT JENSEN AND MILLS
(year 2002 dollars)

Plant	Capital Cost ($M)	O&M Cost ($M/yr)	Annualized Cost* ($M/yr)	Annualized Cost* ($/ac-ft)
Jensen	61.2	12.1	17.4	51.0
Mills	37.1	4.6	7.8	57.3
total	98.3	16.7	25.3	52.8

* Sum of capital costs, amortized at 6% interest for 20 years, and O&M costs

Note, enhanced coagulation cannot be used for Stage II D/DBP rule compliance

TABLE 4

ADDITIONAL COSTS TO EMPLOY ENHANCED COAGULATION
AT WEYMOUTH, DIEMER, AND SKINNER
(year 2002 dollars)

Plant	Capital Cost ($M)	O&M Cost ($M/yr)	Annualized Cost* ($M/yr)	Annualized Cost* ($/ac-ft)
Weymouth	32.2	12.6	15.4	51.9
Diemer	32.2	12.6	15.4	44.7
Skinner	63.9	12.6	18.2	58.6
total	128.3	37.8	49.0	51.5

* Sum of capital costs, amortized at 6% interest for 20 years, and O&M costs

Note, enhanced coagulation cannot be used for Stage II D/DBP rule compliance unless chlorine contactors are provided (not included in cost estimate) and severe blend restrictio are implemented.

TABLE 5

ADDITIONAL COSTS TO EMPLOY GRANULAR ACTIVATED CARBON
AT JENSEN AND MILLS
(year 2002 dollars)

Plant	Capital Cost ($M)	O&M Cost ($M/yr)	Annualized Cost*	
			($M/yr)	($/ac-ft)
Jensen	709.7	24.8	86.7	253.7
Mills	330.8	9.9	38.7	283.5
total	1040.5	34.7	125.4	262.2

* Sum of capital costs, amortized at 6% interest for 20 years, and O&M costs

TABLE 6

ADDITIONAL COSTS TO EMPLOY GRANULAR ACTIVATED CARBON
AT WEYMOUTH, DIEMER, AND SKINNER
(year 2002 dollars)

Plant	Capital Cost ($M)	O&M Cost ($M/yr)	Annualized Cost*	
			($M/yr)	($/ac-ft)
Weymouth	527.9	21.5	67.5	227.5
Diemer	527.9	25.0	71.0	205.9
Skinner	527.9	22.5	68.5	220.9
total	1583.7	69.0	207.1	217.5

* Sum of capital costs, amortized at 6% interest for 20 years, and O&M costs

TABLE 7

ADDITIONAL COSTS TO EMPLOY REVERSE OSMOSIS
AT JENSEN AND MILLS
(year 2002 dollars)

Plant	Capital Cost ($M)	O&M Cost ($M/yr)	Annualized Cost*	
			($M/yr)	($/ac-ft)
Jensen	697.7	73	133.8	391.8
Mills	369.4	29.2	61.4	449.4
total	1067.1	102.2	195.3	408.2

* Sum of capital costs, amortized at 6% interest for 20 years, and O&M costs

TABLE 8

ADDITIONAL COSTS TO EMPLOY REVERSE OSMOSIS
AT WEYMOUTH, DIEMER, AND SKINNER
(year 2002 dollars)

Plant	Capital Cost ($M)	O&M Cost ($M/yr)	Annualized Cost*	
			($M/yr)	($/ac-ft)
Weymouth	519.8	63.4	108.7	366.3
Diemer	519.8	73.7	119.0	345.0
Skinner	519.8	66.3	111.6	359.8
total	1559.4	203.4	339.4	356.4

* Sum of capital costs, amortized at 6% interest for 20 years, and O&M costs

TABLE 9

ADDITIONAL COSTS FOR LADWP/MWD WATER EXCHANGE
(year 2002 dollars)

Plant	Capital Cost ($M)	O&M Cost ($M/yr)	Annualized Cost*	
			($M/yr)	($/ac-ft)
Jensen	96.0	9.4	17.8	52.0

* Sum of capital costs, amortized at 6% interest for 20 years, and O&M costs

TABLE 10

COMPARATIVE COSTS FOR VARIOUS TREATMENT TECHNOLOGIES
AT METROPOLITAN'S PLANTS
($/acre-ft in the year 2002)

Plant	Treatment Technology				
	Ozone	Enhanced Coagulation	Granular Activated Carbon	Membranes (RO)	DWP/MWD Water Exchange
Jensen	52.5	51.0	253.7	391.8	52.0
Mills	73.1	57.3	283.5	449.4	---
(SPW plant avg)	(58.4)	(52.8)	(262.2)	(408.2)	---
Weymouth	36.6	51.9	227.5	366.3	---
Diemer	42.1	44.7	205.9	345.0	---
Skinner	44.6	58.6	220.9	359.8	---
(CRW plant avg)	(41.2)	(51.5)	(217.5)	(356.4)	---
District-Wide Average	47.0	51.9	241.9	373.8	---

Table 11. Anticipated D/DBP Rule Treatment Requirements for Metropolitan Filtration Plants*

Percent State Project Water	Current Regulations	Stage 1 Regulations (effective 2003)**	Stage 2 Regulations (effective 2007)**
0	A	A	A
10	A	A	C or E
20	A	A	C or E
30	A	B or D	C or E
40	A	B or D	C or E
50	A	C or E	E
60 or more	A	C or E	E

A: existing post-filtration chloramination
B: part-time enhanced coagulation
C: full-time enhanced coagulation
D: ozone (replaces chlorine as primary oxidant and disinfectant)
E: ozone with acid addition to control bromate formation
* The treatment requirements presented here are only estimates and are subject to change as the regulations continue to develop and as more water quality data become available.

** Effective dates are tentative.

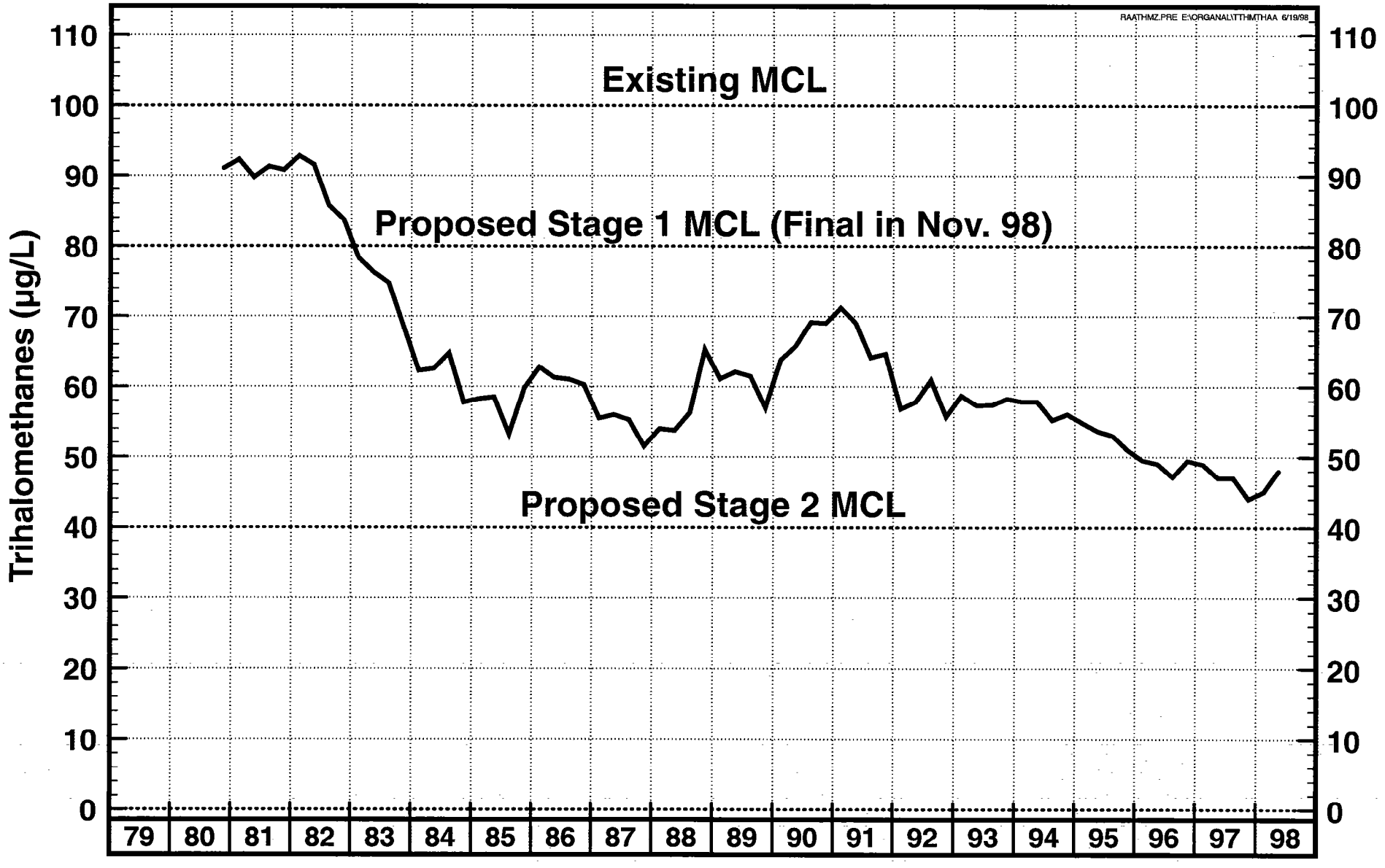

Figure 1. Metropolitan Distribution System Running Annual Average for Quarterly TTHMs

Figure 2. Pros and Cons of Various Treatment Technologies

Issue	Ozone/ PEROXONE	Enhanced Coagulation	Granular Activated Carbon	Reverse Osmosis Membranes
Disinfection	Effective	Ineffective	Ineffective	Effective
Trihalomethanes/ Haloacetic Acids Control	Effective	Effective **	Effective	Effective
Bromate Control	Effective *	Effective	Effective	Effective
Taste and Odor Control	Effective	Ineffective	Effective	Ineffective
Cost	$	$	$$$$$	$$$$$$$

* Effective when acid is used to control pH and reduce bromate levels
** Effective for Stage 1 of the Disinfectants/Disinfection By-Products Rule. Ineffective for Stage 2

restructuring, fixed revenues would be generated to cover the fixed capital costs of the Oxidation Retrofit Program. With the establishment of a peaking charge for treated water under Alternative 5, the member agencies would be encouraged to use the treated water more regularly thus allowing more cost-effective operation of the treatment plants. These five alternatives are summarized in Table 1. In addition to these alternatives, staff continues to pursue other funding sources such as state and/or federal grants to offset the Oxidation Retrofit Program costs.

Schedule

Ozonation facilities at the Skinner plant are currently scheduled to be on-line by 2006, while the Diemer and Weymouth plants are scheduled for 2009 and 2012 (the sequencing of the Diemer and Weymouth plants has not been established). If implementation of ozone at the Skinner, Weymouth and Diemer plants were to proceed aggressively, the three plants could be on-line by 2005. Figure 1 shows the current and accelerated schedules (detailed schedules for design and construction are shown in Appendix 3).

Program Estimates

The program estimate in the CIP for the Oxidation Retrofit Program at the Jensen and Mills plants is $263,000,000 (Program 15173W). The program estimate for the Oxidation Retrofit Program at Skinner, Weymouth and Diemer (Program 95620W) based on the current CIP schedule is $507,000,000 **(Option 1)**. However, by accelerating the Oxidation Retrofit Program schedule, the latter program estimate would be reduced to $437,000,000 **(Options 2 and 3)** due to reduced escalation. In summary, the program estimate for the Oxidation Retrofit Program at all five filtration plants is $770,000,000 under **Option 1** and $700,000,000 under **Options 2 and 3**. The dollar difference is related to the effects of escalation.

The total increase in the treatment surcharge due to the Oxidation Retrofit Program is estimated to be about $36 per acre foot based on the estimated cash flows associated with the accelerated construction schedule and direct operations and maintenance costs at the Skinner, Weymouth and Diemer filtration plants. This rate impact amounts to an eight percent increase in treated water rates over a ten-year period. A treatment surcharge rate comparison of the current construction schedule versus the accelerated schedule shows that a larger rate increase, two years sooner than the current schedule, is needed because the accelerated schedule requires higher capital outlays sooner. The treatment surcharge rate would increase by $5 per acre foot in 2002. This revised rate impact reflects more up-to-date estimates of operating and maintenance expenses and an appropriate split of capital costs between treated and untreated water rates. This analysis also assumes that all ozone costs continue to be collected through the treatment surcharge and treated water sales increase by 20,000 acre-feet per year over the next ten years.

The rate impact analysis also shows that due to the reduced total capital cost for the accelerated schedule, the treatment surcharge is the same on both schedules by year 2009. Beyond 2009, the accelerated schedule results in a lower charge of $5 per acre foot. Figure 4 illustrates the difference in the projected treatment surcharge attributed to the accelerated construction schedule. From the year 2002 to 2009, an estimated $63.5 million in additional debt service is projected to be paid as a result of the accelerated construction schedule.

Option 3 was developed to respond to concerns expressed by some member agencies that accelerating ozone would severely impact their ability to market treated water from Metropolitan.

Option 3 would direct staff to develop, for the Board's consideration, alternative financing strategies, such as those discussed in Appendix 4, to minimize treatment surcharge increases associated with the Oxidation Retrofit Program while proceeding aggressively with the design of ozonation facilities at the Skinner, Weymouth and Diemer plants. Staff would fold this analysis into the fundamental review of Metropolitan's rate structure that will occur over the next 12 months. Hence, Figure 4 can be viewed as showing the maximum potential impact on the treatment surcharge; alternative financing may reduce those impacts.

JMB/MDB/EGM/mi
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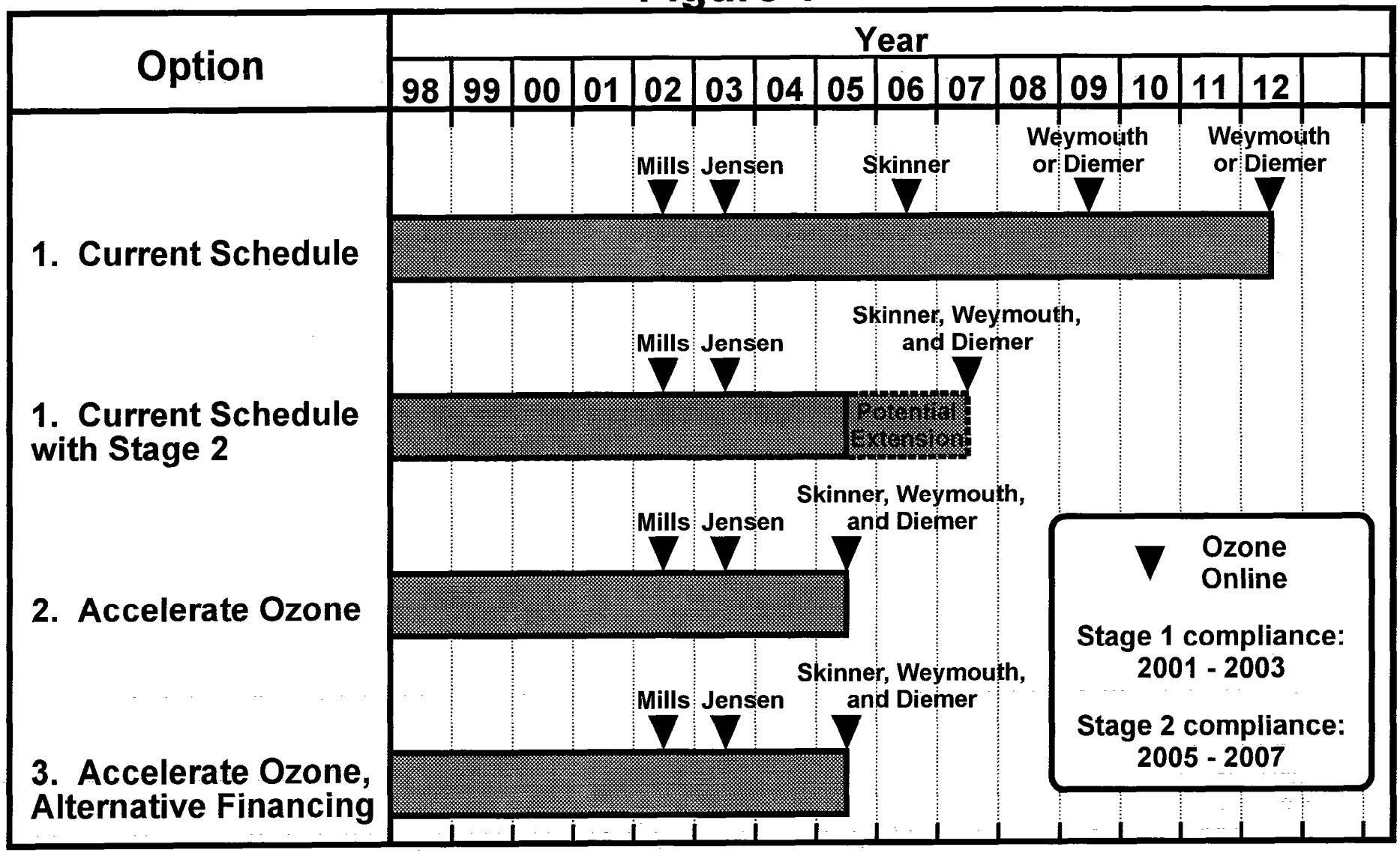
Attachments

Figure 1



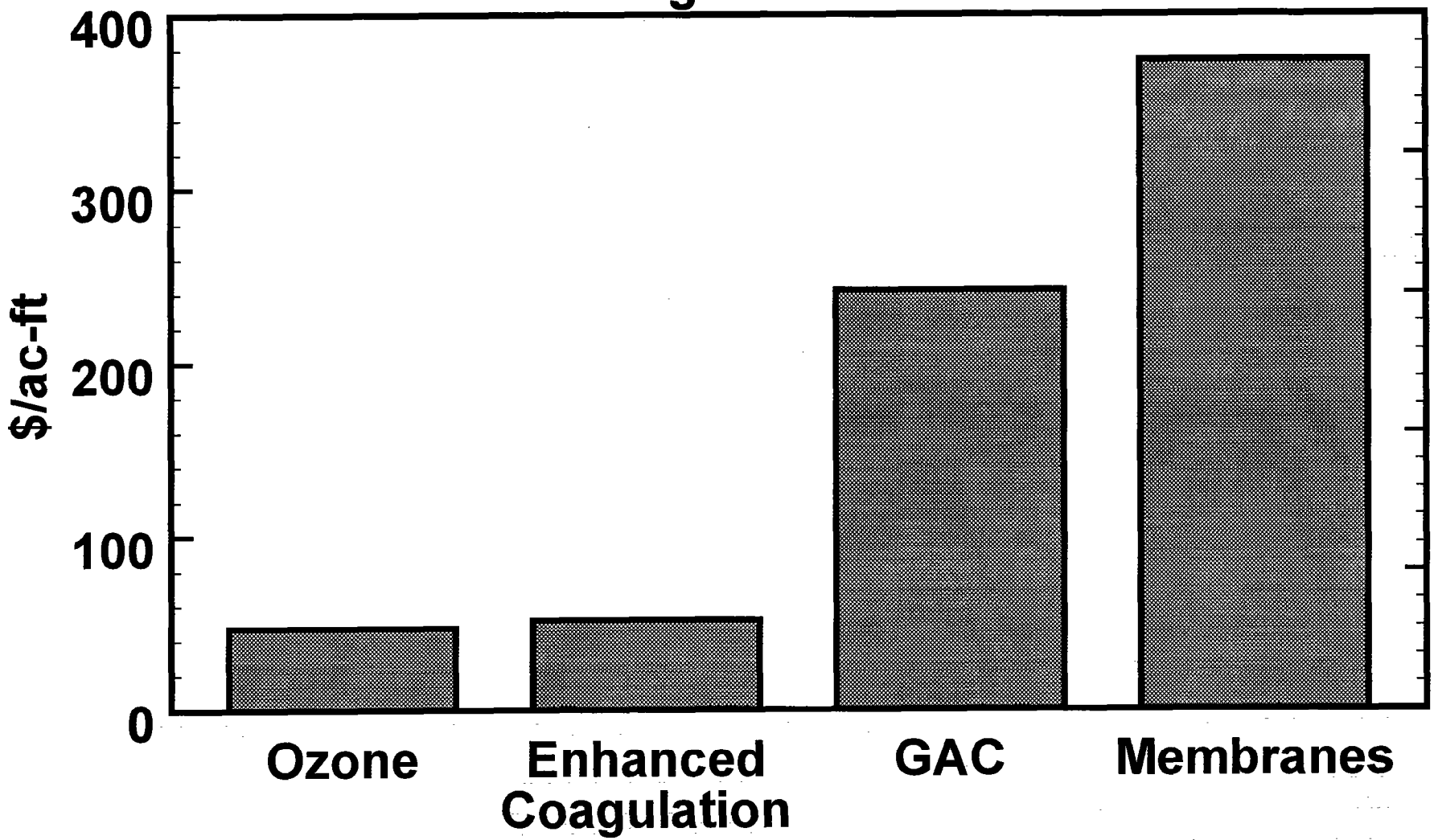
Ozone Implementation Schedule Options

Figure 2. Pros and Cons of Various Treatment Technologies

Issue	Ozone/ PEROXONE	Enhanced Coagulation	Granular Activated Carbon	Reverse Osmosis Membranes
Disinfection	Effective	Ineffective	Ineffective	Effective
Trihalomethanes/ Haloacetic Acids Control	Effective	Effective **	Effective	Effective
Bromate Control	Effective *	Effective	Effective	Effective
Taste and Odor Control	Effective	Ineffective	Effective	Ineffective
Cost	$	$	$$$$$	$$$$$$$

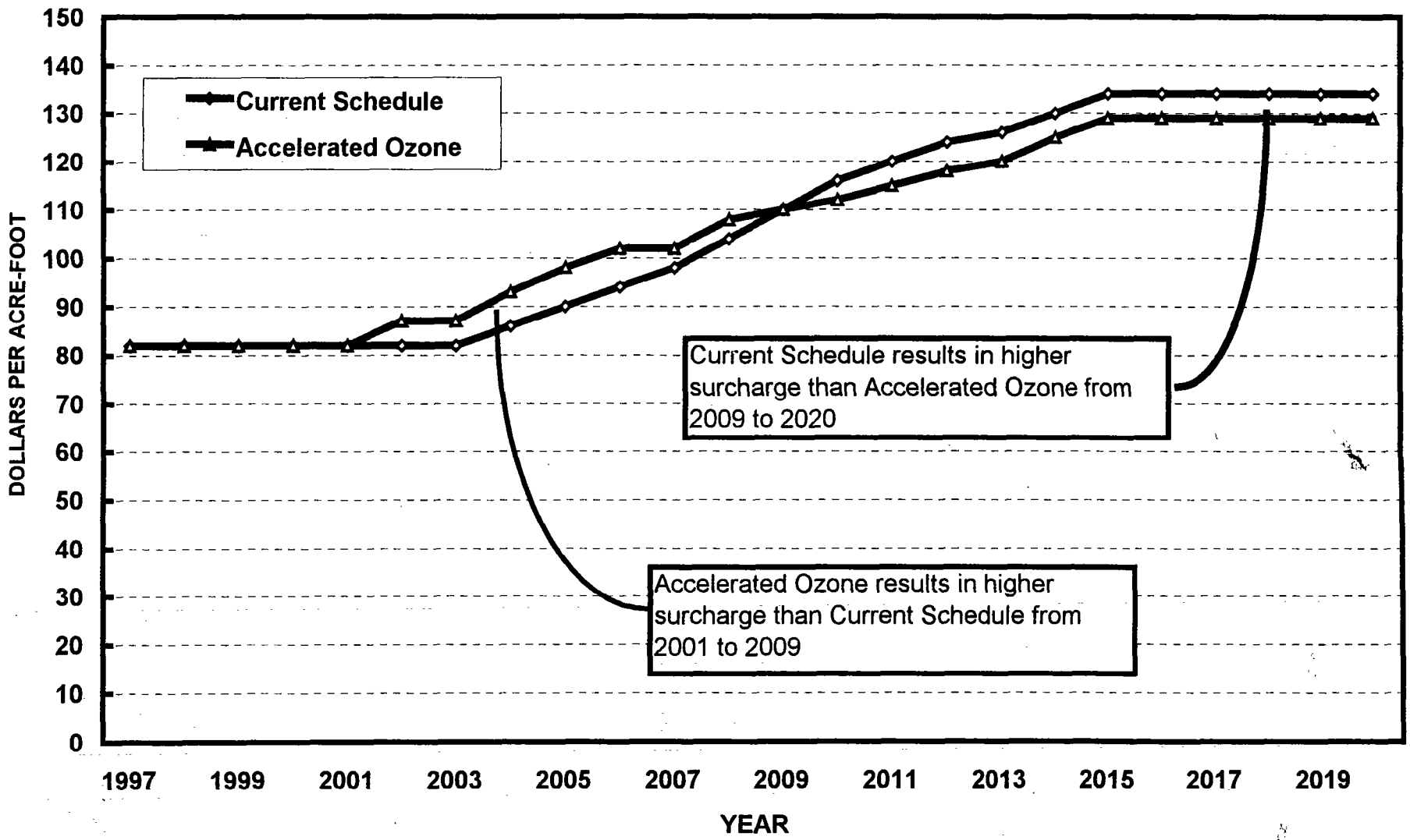
* Effective when acid is used to control pH and reduce bromate levels
** Effective for Stage 1 of the Disinfectants/Disinfection By-Products Rule. Ineffective for Stage 2

Figure 3



Comparative Costs for Various Treatment Technologies at Metropolitan's Plants ($/ac-ft; year 2002)

Figure 4.
TREATMENT SURCHARGE
UNDER ALTERNATIVE ORP CONSTRUCTION SCHEDULES ($/AF)



Attachment to 10-2
Planning & Resources Division
June 18, 1998

TABLE 1: ALTERNATIVE REVENUE SOURCES FOR THE ORP

DESCRIPTION OF ALTERNATIVE	IMPACT ON WATER TREATMENT SURCHARGE	IMPACT ON OTHER CLASSES OF CUSTOMERS	ADDITIONAL REMARKS
1. General Obligation Bonds	Significant reduction in surcharge	No direct impact on other Metropolitan rates	• Tax levy increase • Requires voter approval
2. Apply to Readiness-to-Serve (RTS) charge	Small reduction in surcharge	Small increase in RTS charge	• Applies cost to larger base of customers • Moves revenue from variable to fixed
3. Apply to New Demand Charge (NDC)	Small reduction in surcharge	Small increase in NDC	• Same as #2
4. Minimum Purchase Charge	Same total cost, may have some redistribution between customers	None	• Requires contracts • Promotes stability • Moves revenue from variable to fixed
5. Peaking Charge	Same total cost, but a redistribution between customers	None	• Promotes stability • Moves revenue from variable to fixed

Attachment to 10-2
Water Quality Division
June 18, 1998

Appendix 1

DISINFECTION BY-PRODUCTS HEALTH EFFECTS AND RISK/RISK TRADEOFFS

EXECUTIVE SUMMARY

Research is underway on the occurrence, health effects, and treatability of disinfection by-products and microbial pathogens. Trends in research are indicating that the potential adverse health effects of disinfection by-products may include cancer effects, and reproductive and developmental impacts in humans. This information will be used in Stage 2 Disinfection By-Products (DBP) negotiations to evaluate different regulatory options for controlling microbial contaminants while minimizing disinfection by-products.

Update on Health Effects Information

Carcinogenic Endpoint. There are four "species" of trihalomethanes that make up "total trihalomethanes". They are chloroform, chlorodibromomethane, bromodichloromethane, and bromoform. Current toxicological studies indicate that chloroform, the primary trihalomethane in low-bromide waters, is probably not carcinogenic (causes cancer) to humans at environmental concentrations. The United States Environmental Protection Agency (USEPA) currently sets the maximum contaminant level goal (MCLG) for carcinogens at zero. USEPA is proposing to raise the chloroform MCLG to 300 microgram per liter, the first non-zero MCLG for a previously suspected human carcinogen.

Bromodichloromethane (a bromine-containing trihalomethane), however, does appear to be carcinogenic and could be the trihalomethane responsible for suspected carcinogenic activity in drinking water. In addition, certain haloacetic acids (in particular, the bromine-containing species) are suspected carcinogens. Furthermore, bromate—a by-product formed during the ozonation of bromide-containing waters—has been shown to be a carcinogenic disinfection by-product. In short, all disinfectants can produce by-products of human health concern. During the Stage 1 negotiations, all signatories to the agreement (including AMWA, AWWA, NWRA, NAWC, etc.), in effect, agreed that DBPs were enough of a concern (in the absence of certainty) to take steps to reduce them.

Adverse Reproductive/Developmental Health Effects. Waller and co-workers at the California Department of Health Services published a paper on "Trihalomethanes in Drinking Water and Spontaneous Abortion." These researchers found an association between high exposure to total trihalomethanes and spontaneous abortion. Of the four individual trihalomethanes, only high bromodichloromethane exposure was associated with spontaneous abortions. Several volatile

halocarbons—including bromodichloromethane and certain synthetic organic chemicals (e.g., trichloroethylene)—were found to result in pregnancy loss in a rat study. Bromodichloromethane was found to be the most potent of the disinfection by-products and synthetic organic chemicals that were tested.

Likewise, certain haloacetic acids have produced reproductive health effects in animal studies. For example, using neural tube defects as the morphological endpoint, the bromine-containing haloacetic acids are of higher health concern than the chlorinated haloacetic acids. Neural tube defects was one of the birth defects found to be associated with exposure to chlorinated drinking water in an epidemiology study conducted in New Jersey.

The bottom line is that while the weight of evidence is being hotly debated and all agree that additional studies are needed, the Stage 1 negotiators were concerned enough to agree to significantly more stringent regulations. The Stage 2 negotiations (which could drive ozone at Skinner, Diemer and Weymouth) will occur under a backdrop of new studies linking DBPs to miscarriages.

Risk/Risk Tradeoffs

There is a conflicting need for greater disinfection of drinking water, which may result in higher levels of disinfection by-products. Disease-causing organisms may exist even in pristine waters. *Cryptosporidium* outbreaks have been documented in many places throughout the world. In addition to *Cryptosporidium*, there are many other disease-causing viruses, bacteria, and protozoans which are of concern. The proposed Enhanced Surface Water Treatment Rule would require more rigorous disinfection, including filtration and high level disinfection, or both, to inactivate or remove viruses and protozoan oocysts such as *Cryptosporidium*. The challenge will be that utilities will have to find a way to simultaneously control pathogens and disinfection by-product formation. USEPA has been struggling mightily with setting the proper risk balance including considerations of affordability.

DISINFECTION BY-PRODUCTS HEALTH EFFECTS AND RISK/RISK TRADEOFFS

Negotiated Rule-Making

The U.S. Environmental Protection Agency (USEPA) conducted a regulatory negotiation ("reg neg") in 1992-93 and 1996-97 in order to develop a consensus-based regulation for disinfectants and disinfection by-products (D/DBPs). Although the reg neg was initiated to develop one rule, three rules actually came out of the negotiations: (1) a D/DBP Rule, (2) an Enhanced Surface Water Treatment Rule (ESWTR), and (3) an Information Collection Rule (ICR).

Because of the limited scientific data available on the occurrence, health effects, and treatability of DBPs and microbial pathogens, the reg neg Advisory Committee decided to develop a two-stage D/DBP Rule, with linkage to an ESWTR to prevent potential increases in microbial risk. Furthermore, the cost impacts of the long-term ESWTR and Stage 2 of the D/DBP Rule are substantial. Consequently, the reg neg negotiators decided to have utilities collect data (via the ICR) for use in characterizing occurrence and treatment data that could be used to evaluate different regulatory options for controlling microbial and DBP contaminants. Data collected under the ICR will be used in developing the long-term ESWTR and Stage 2 of the D/DBP Rule in the next negotiated rule-making process.

The proposed D/DBP Rule includes Stage 1 maximum contaminant levels (MCLs) of 80 μg/L for total trihalomethanes (TTHMs), 60 μg/L for the sum of five haloacetic acids (HAA5), and 10 μg/L for bromate [1]. In addition, utilities treating either surface water or groundwater under the direct influence of surface water that use conventional treatment (i.e., coagulation, sedimentation, and filtration) will be required to remove DBP precursors by enhanced coagulation or softening. The removal of total organic carbon (TOC) will be used as a performance indicator for DBP precursor control. The Rule will require 15-50 percent TOC removal, depending on influent water quality [2].

The Stage 2 proposal—which will be reevaluated in the next negotiated rule-making process—currently includes lower MCLs of 40 μg/L for TTHMs, 30 μg/L for HAA5, and 5 μg/L for bromate as "placeholders" to ensure all the parties return to the negotiating table. USEPA could, in theory, proceed directly to Stage 2 promulgation. In addition, the best available technology (BAT) proposed for Stage 2 is treatment with granular activated carbon (GAC) for the removal of DBP precursors, with chlorination for primary and residual disinfection.

Update on Health Effects Information

Carcinogenic Endpoint. Current toxicological studies indicate that chloroform (the primary THM in low-bromide waters) is cytotoxic (toxic to cells; a high-dose phenomenon) and probably not carcinogenic to humans at environmental concentrations [3]. Bromodichloromethane (BDCM) (a bromine-containing THM), however, does appear to be genotoxic (toxic to genes;

therefore, may be manifested at low doses) and could be the THM responsible for suspected carcinogenic activity in drinking water [4].

In addition, certain HAAs (in particular, the bromine-containing HAAs) are of carcinogenic concern [5]. Furthermore, bromate—a by-product formed during the ozonation of bromide-containing waters—has been shown to be a carcinogenic DBP [1].

The USEPA currently sets the MCL goal (MCLG) for carcinogens at zero and then attempts to set MCLs in the range of the 10^{-4} to the 10^{-6} risk level (i.e., 1-in-10,000 to 1-in-1-million excess cancer risk level). Since the USEPA first proposed the D/DBP Rule in 1994, new cancer studies and mechanisms of action have been investigated. New toxicological data indicate that chloroform is not carcinogenic, and the EPA is proposing to raise the MCLG for chloroform to 300 μg/L [6].

In addition to rodent bioassays, other animal models are being studied by the National Toxicology Program (NTP). Although these new studies are preliminary and will require additional verification and peer review, they support the findings that have been observed with rodent bioassays of DBPs. For example, bioassays have been conducted with Medaka fish for chloroform and BDCM [7]. For chloroform, tests were conducted with 0, 15, 150, and 1500 μg/L. Nationwide, the median and 90th-percentile occurrence of chloroform is 25 and 60 μg/L, respectively. Thus, the Medaka study used chloroform doses—in the lower range of doses studied—that bracket the actual concentrations for which humans are exposed, unlike the rodent studies that have been conducted at concentrations that are orders of magnitude higher than human exposure levels.

In the chloroform/Medaka study, the high-dose tests resulted in biliary and gall bladder concretions, which were ascribed to a cell proliferation mechanism. This is a similar mechanism to what was found in the rodent studies (in other words, this was a high-dose phenomena). Thus, these studies combined suggest that chloroform is not a carcinogen at drinking-water concentrations, which supports the USEPA in setting a non-zero MCLG (i.e., 300 μg/L) for chloroform. In contrast, preliminary bioassays of BDCM with the Medaka fish suggest that BDCM is a carcinogen, as has been demonstrated by the rodent studies. Thus, the weight of evidence suggests that chloroform is not a carcinogen, whereas the bromine-containing THM BDCM is a carcinogen.

As for the HAAs, dichloroacetic acid (DCAA) has a MCLG of zero [1,6], whereas trichloroacetic acid (TCAA) has an MCLG of 300 μg/L [1]. NTP is initiating new short- and long-term rodent studies for bromine-containing HAAs of health and regulatory concern (bromochloroacetic acid [BCAA] and bromodichloroacetic acid [BDCAA]). "From a scientific standpoint, bromodichloromethane causes colon cancer in our rats (when given by corn oil gavage) and bromodichloroacetic acid should have bromodichloromethane as an intermediate [8]."

This supposition is consistent with Richard Bull's findings [5] that "Bromine substitution considerably increases the extent of trihaloacetate metabolism in both mice and rats. The more rapid rate of metabolism of brominated haloacetates appear to be associated with significant

evidence of oxidative damage to DNA (i.e., formation of 8-OH-deoxyguanosine), an effect that was only marginally apparent with either TCA or DCA." Again, we have a chlorinated DBP (i.e., TCAA) that has a non-zero MCLG (i.e., 300 μg/L), which upon bromine substitution (i.e., BDCAA) appears preliminarily to be genotoxic and of carcinogenic concern.

In addition to the animal toxicity studies, numerous epidemiology studies have been conducted to determine if there were any associations between chlorination of drinking water with the risk of cancer in humans. The results of these studies have suggested associations with a wide range of cancer sites, including gall bladder, esophagus, kidney, breast, liver, pancreas, prostate, stomach, bladder, colon, and rectum [1]. The most suggestive associations were with bladder cancer. The degree of resolution in epidemiological studies on the consumption of chlorinated drinking water conducted to date has been insufficient for providing definitive information for regulation.

Finally, in performing feasibility analyses for conducting studies for assessing the health effects of exposure to mixtures of DBPs, a common theme has been developed by the different expert panels charged with this effort. For example, in a report prepared by the ILSI Risk Science Institute [9], it was noted that "Several brominated DBPs appear to be toxic, some more so than their chlorinated analogs. Existing epidemiologic studies should be reviewed and new studies should be planned to determine if humans consuming source water with high levels of bromide have higher disease risks, particularly cancer risk, than those consuming water with low bromide but similar levels of DBPs."

Adverse Reproductive/Developmental Health Effects. Certain DBPs have been shown to cause reproductive or developmental effects in laboratory animals. In addition, some epidemiology studies have shown an association between the consumption of chlorinated drinking water and THMs with adverse reproductive/development health effects.

Waller and co-workers [10] at the California Department of Health Services published a paper on "Trihalomethanes in Drinking Water and Spontaneous Abortion." These researchers found an association between high exposure to TTHMs and spontaneous abortion. High exposure was defined as drinking ≥5 glasses/day of cold tap water and containing ≥75 μg/L TTHMs. Exposure was based on the TTHM concentration in the women's first trimester for 90 percent of the database.

This study was conducted in three regions in California. When examined separately, the overall TTHM effect was much more pronounced in Region I (i.e., Santa Clara) than in the other two regions. Women in Region I consumed water—from the Sacramento/San Joaquin Delta—containing proportionately more BDCM and dibromochloromethane than did women in Regions II (Walnut Creek) and III (Fontana). Of the four individual THMs, only high BDCM exposure (≥18 μg/L and ≥5 glasses/day of cold tap water) was associated with spontaneous abortions.

This study—as well as other recent epidemiology studies (published since 1993) on the association between possible reproductive and developmental effects of exposure to disinfected drinking water—was reviewed by an expert scientific panel for the USEPA [11]. The panel reviewed a pre-publication copy of the article by Waller and co-workers. The panel concluded

that this was a well-designed and conducted study, which is the first such study to report an adverse reproductive effect associated with a brominated by-product. The panel recommended to the USEPA that an additional study with a similar comprehensive evaluation of DBP exposure be conducted in another geographical area in an attempt to replicate the findings of the California study.

As part of the panel review, the USEPA presented a summary of the latest information on toxicological studies on the potential of DBPs to affect reproduction and development in experimental animals. Several volatile halocarbons—including BDCM and certain synthetic organic chemicals (SOCs) (e.g., trichloroethylene)—were found to result in pregnancy loss in a rat study. BDCM was found to be the most potent of the DBPs and SOCs that were tested.

In addition to using Medaka fish as an alternative animal model for the assessment of the carcinogenicity of DBPs, a frog embryo teratogenesis assay - *Xenopus* (FETAX) assay uses the South African clawed frog (*Xenopus laevis*) to determine lethality (LC50), effective concentration to produce malformations (EC50), minimum concentration to inhibit growth (MCIG), and teratogenicity index (TI) (which equals LC50/EC50) [7]. Although these new studies are preliminary and will require additional verification and peer review, they support the findings that have been observed with rodent bioassays of DBPs. In addition, the FETAX assay is an ASTM-approved (E 1439-91) *in vivo* 96-hour test [12]. When compared to mammalian developmental toxicity systems, the predictive accuracy of the FETAX assay is ≥90 percent. Moreover, thalidomide—the drug that was found to cause malformations of infants born to mothers using it during pregnancy—was not shown to be a teratogen in rodent testing, whereas it was shown to be a powerful teratogen in the FETAX assay.

Chloroform was found to not be teratogenic in the FETAX assay; its teratogenicity index, TI, was 0.98 (in other words, the dose of chloroform that produced malformations was approximately equal to the lethal dose). BDCM was found to be teratogenic; its TI was 5.6. Thus, the weight of evidence—epidemiology, rodent, FETAX studies—suggests that there is more risk of adverse reproductive/developmental effects when consuming water with BDCM than water with chloroform.

Certain HAAs have also produced reproductive health effects in animal studies. For example, using neural tube defects (NTDs) as the morphological endpoint, the ranking of the HAAs in order of increasing potency is DCAA < tribromoacetic acid (TBAA) < TCAA < dibromoacetic acid (DBAA) < BCAA < monochloroacetic acid (MCAA) < monobromoacetic acid (MBAA) [13]. TBAA appears to be unstable in water and MCAA and MBAA are typically present at very low μg/L (or sub μg/L) levels. Thus, the bromine-containing HAAs, BCAA and DBAA, are of higher health concern for NTDs than the chlorinated HAAs DCAA and TCAA. NTDs was one of the birth defects found to be associated with exposure to chlorinated drinking water in an epidemiology study conducted in New Jersey [14].

Other Health Effects. The USEPA is completing a series of meetings as part of the Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC). EDSTAC is developing recommendations to the USEPA for a screening and testing program required under the Safe

Drinking Water Act (SDWA). EDSTAC is concerned about the potential health effects from chemical mixtures. EDSTAC is recommending that the USEPA begin work immediately on six mixtures, and one of these mixtures is DBPs.

Risk/Risk Tradeoffs

There is a conflicting need for greater disinfection of drinking water, which may result in higher levels of disinfection by-products. Disease-causing organisms may exist even in pristine waters. Protozoa are microscopic organisms; some types of protozoa live in the bodies of warm-blooded animals and can cause disease in humans who drink water contaminated with these organisms. *Giardia lamblia* is common in mountain-dwelling mammals. Giardiasis is a disease in humans which comes from this organism. *Cryptosporidium* is another pathogenic organism found in drinking water supplies as a result of contamination by mammals.

Cryptosporidium outbreaks have been documented in many places throughout the world. The following table lists some of the most significant outbreaks documented in the recent past:

Significant *Cryptosporidium* Outbreaks

Year	Location	Approximate Number of Reported Cases
1984	Braun Station, Texas	2,000 cases
1987	Carrollton, Georgia	13,000 cases
1989	Thames River area, England	100,000 cases
1992	Jackson County, Oregon	15,000 cases
1993	Milwaukee, Wisconsin	403,000 cases, 100 deaths
1994	Las Vegas, Nevada	78 cases, 16 deaths

In April 1993, approximately 403,000 persons in Milwaukee, Wisconsin became ill of cryptosporidiosis, the disease resulting from the presence of *Cryptosporidium* in their water supply. Approximately 100 deaths resulted from this outbreak. The suspected sources of *Cryptosporidium* were cattle wastes, slaughterhouse wastes, and sewage carried by rivers tributary to Lake Michigan, the water body used as the source of drinking water. This outbreak was associated with operational deficiencies in the water treatment plant, and presents a striking example of the importance of maintaining the quality of source waters.

More significantly, the *Cryptosporidium* outbreak in Las Vegas, Nevada in May 1994 was the first documented epidemiologically confirmed waterborne outbreak from a water system with no associated treatment deficiencies or breakdowns. During this outbreak, 78 immunocompromised persons became ill of cryptosporidiosis, even though no *Cryptosporidium* oocysts were detected in the finished drinking water. This outbreak clearly suggests that *Cryptosporidium* is a potential health threat in all drinking water systems, particularly to immunocompromised persons.

In addition to *Giardia* and *Cryptosporidium*, there are many other disease-causing viruses, bacteria, and protozoans which are of concern. The following table lists some of the waterborne diseases of concern in the United States [15]:

Disease	Microbial Agent	General Symptoms
Amebiasis	Protozoan (*Entamoeba histolytica*)	Abdominal discomfort, fatigue, diarrhea, flatulence, weight loss
Campylobacteriosis	Bacterium (*Campylobacter jejuni*)	Fever, abdominal pain, diarrhea
Cholera	Bacterium (*Vibrio cholerae*)	Watery diarrhea, vomiting, occasional muscle cramps
Cryptosporidiosis	Protozoan (*Cryptosporidium parvum*)	Diarrhea, abdominal discomfort
Giardiasis	Protozoan (*Giardia lamblia*)	Diarrhea, abdominal discomfort
Hepatitis	Virus (hepatitis A)	Fever, chills, abdominal discomfort, jaundice, dark urine
Shigellosis	Bacterium (*Shigella* species)	Fever, diarrhea, bloody stool
Typhoid Fever	Bacterium (*Salmonella typhi*)	Fever, headache, constipation, appetite loss, nausea, diarrhea, vomiting, appearance of an abdominal rash
Viral Gastroenteritis	Viruses (Norwalk, rotavirus, and other types)	Fever, headache, gastrointestinal discomfort, vomiting, diarrhea

In response to the 1993 *Cryptosporidium* outbreak in Milwaukee, the USEPA proposed to amend the current SWTR to provide additional protection against disease-causing organisms in drinking water [16]. The proposed ESWTR would require more rigorous treatment, including filtration and high level disinfection, or both, to inactivate or remove viruses and protozoan cysts and oocysts such as *Giardia* and *Cryptosporidium*. The challenge will be to simultaneously control DBP formation and yet minimize exposure to disease-causing microorganisms.

Results of studies have shown that *Giardia* cysts can be inactivated by high levels of chlorine. However, chlorine concentrations necessary to inactivate *Cryptosporidium* oocysts are not practical under typical water treatment processes. More recent studies have shown that *Cryptosporidium* oocysts may be inactivated by ozone [17].

The MCLG for both *Giardia* cysts and *Cryptosporidium* oocysts in drinking water is zero. As a result, removal/inactivation rates for these pathogenic organisms is dependent on the densities of these organisms found in the source water (see Appendix 2 for a discussion of the effectiveness of ozone in controlling these pathogens).

Status of the Rule-Making

Stage 1 and Stage 2 of the D/DBP Rule will be promulgated November 1998 and May 2002, respectively, as required under recent amendments to the SDWA [18]. The next reg neg—to

develop the long-term ESWTR and Stage 2 of the D/DBP Rule—is scheduled to commence in December 1998.

In the proposed D/DBP Rule [1], it was agreed upon by all of the stakeholders that "If data prior to this second rulemaking [i.e., the reg neg for the Stage 2 Rule] warrants earlier action on acute health effects, a meeting shall be convened to review the results of these data and to develop recommendations." Although compliance with the current THM rule is based on a running annual average—based on long-term exposure to cancer-causing DBPs—a regulation based on acute effects (e.g., adverse reproductive/developmental health effects, estrogen disruptors) would require compliance all the time in all parts of the distribution system, where calculation of a running annual average would no longer be allowed.

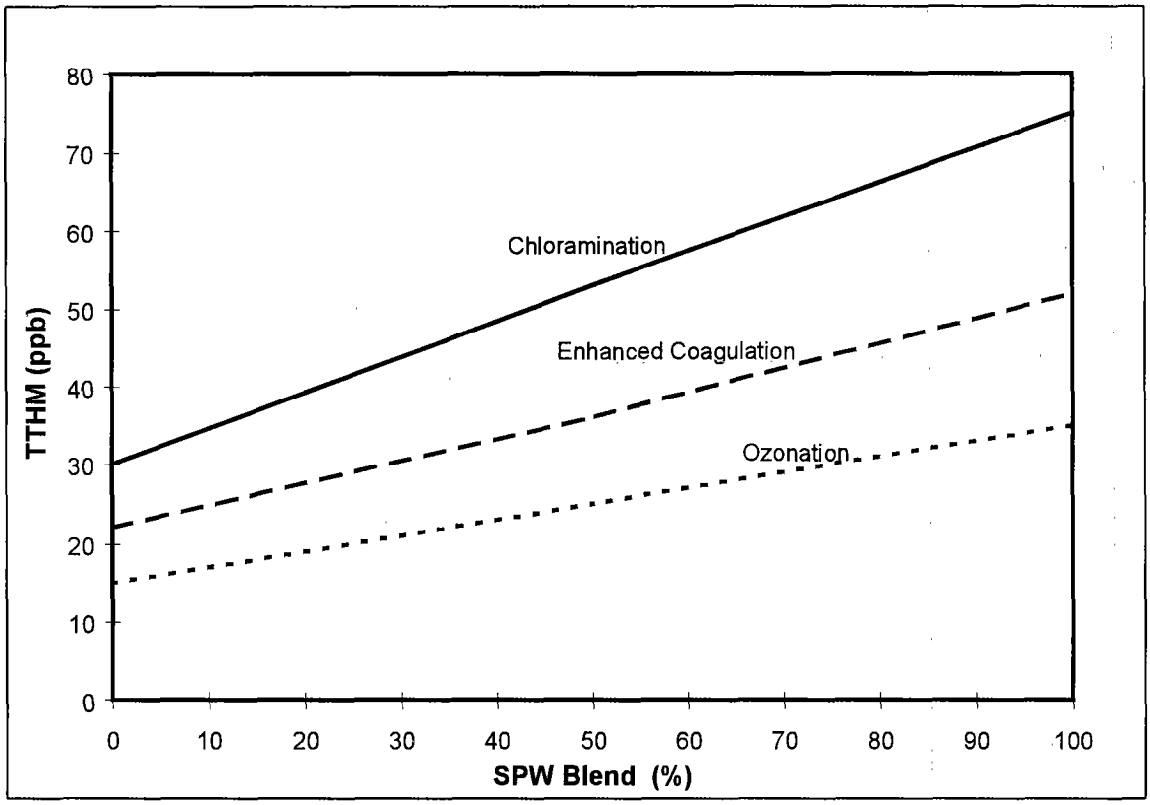
In addition, the USEPA has been developing data analysis plans for assessing data from the ICR to be used in the reg neg process. These include examining the formation and control of individual DBPs of health and regulatory concern (e.g., BDCM), compliance with DBP MCLs all of the time at all sample sites versus continued use of a running annual average for compliance, and simultaneous compliance with a long-term ESWTR (with requirements for the inactivation of *Cryptosporidium*) and Stage 2 of the D/DBP Rule (with a more stringent MCL for bromate).

In considering the regulatory options for the upcoming reg neg, it is likely we may move from a treatment-based/feasibility set of rules (i.e., Stage 1 of the D/DBP Rule) to a risk-based set of rules (i.e., the long-term ESWTR and Stage 2 of the D/DBP Rule). Conceptually, the Stage 1 regulation set MCLs of 80 μg/L TTHMs, 60 μg/L HAA5, and TOC removal requirements to control the risks associated with known and unknown DBPs. Moreover, these were levels that were deemed achievable through the enhancement of existing water treatment processes.

Alternatively, it has been predicted that compliance with the proposed Stage 2 set of MCLs [i.e., 40 μg/L TTHMs, 30 μg/L HAA5] would require significant and costly treatment modifications. With a risk-based Stage 2 Rule, utilities that treat water low in bromide may not be required to lower TTHMs and HAAs to 40 and 30 μg/L, respectively, if the major source of their THMs and HAAs are DBPs with non-zero MCLGs [i.e., chloroform and TCAA], especially if there is no scientific basis for demonstrating a cost/benefit. Alternatively, systems that have relatively high concentrations of DBPs of health concern [i.e., BDCM, DCAA, and BDCAA] may be required to reduce those concentrations. This is because certain bromine-containing DBPs are of higher health concern than some of the chlorinated species.

The USEPA and AWWA Research Foundation jointly participate in a Microbial/DBP (M/DBP) Research Council to fund research in support of the ESWTR and D/DBP Rule development. At the May 1998 meeting of the Technical Advisory Group (TAG) for the M/DBP Research Council, a research agenda for 1998 funding was developed. The number-one priority project that the TAG has recommended for funding is a "Study on Spontaneous Abortion and Disinfection By-Product Exposures." The overall goal of this study will be to evaluate if the results reported in the Waller et al. study [10] can be replicated in another part of the country. More specifically, the objective is to investigate whether exposure to THMs (especially BDCM), HAAs or other DBPs may be associated with increased risk of spontaneous abortion.

Figure 3. Estimated Total Trihalomethane Levels for Different Treatment Alternatives



Note: Values represented in this graph are estimates only and are subject to change with water quality conditions

Figure 4. California Ozone Plants

(In Design, Construction, or Operation)

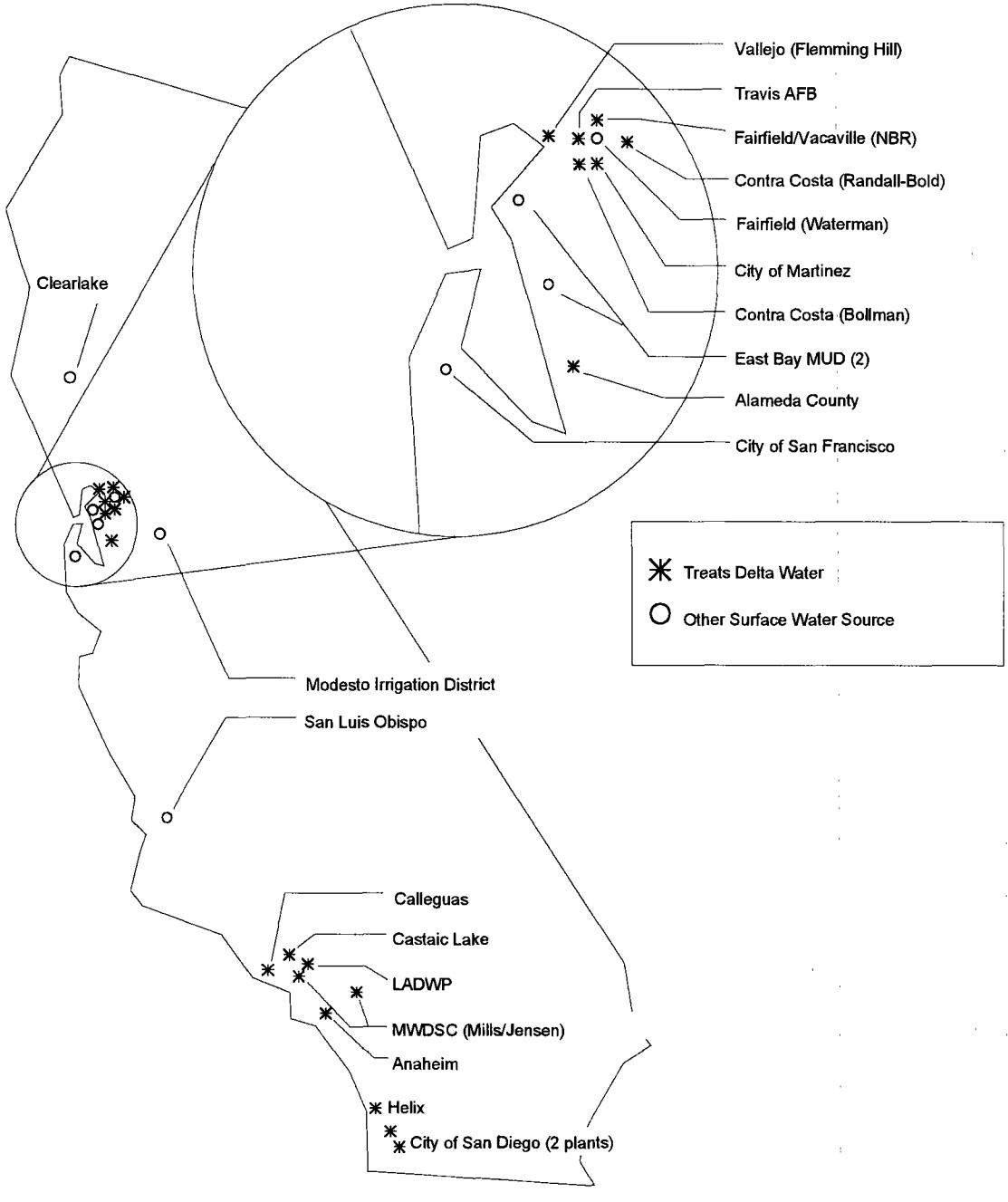
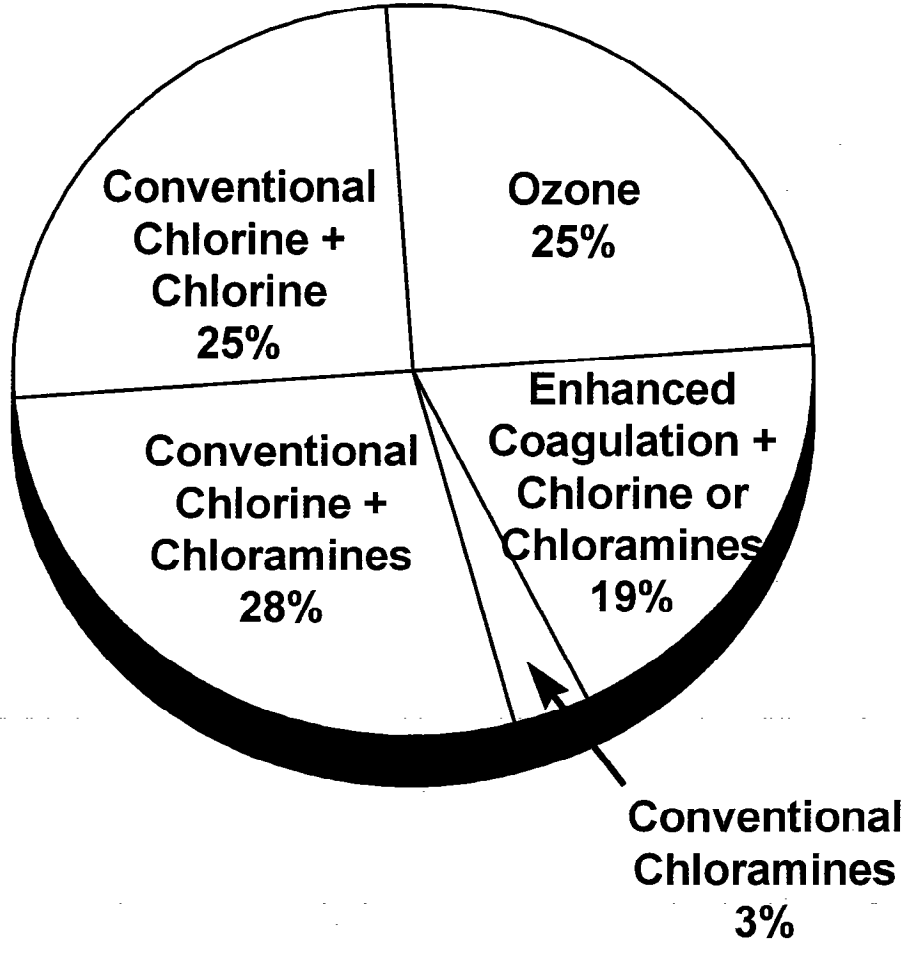
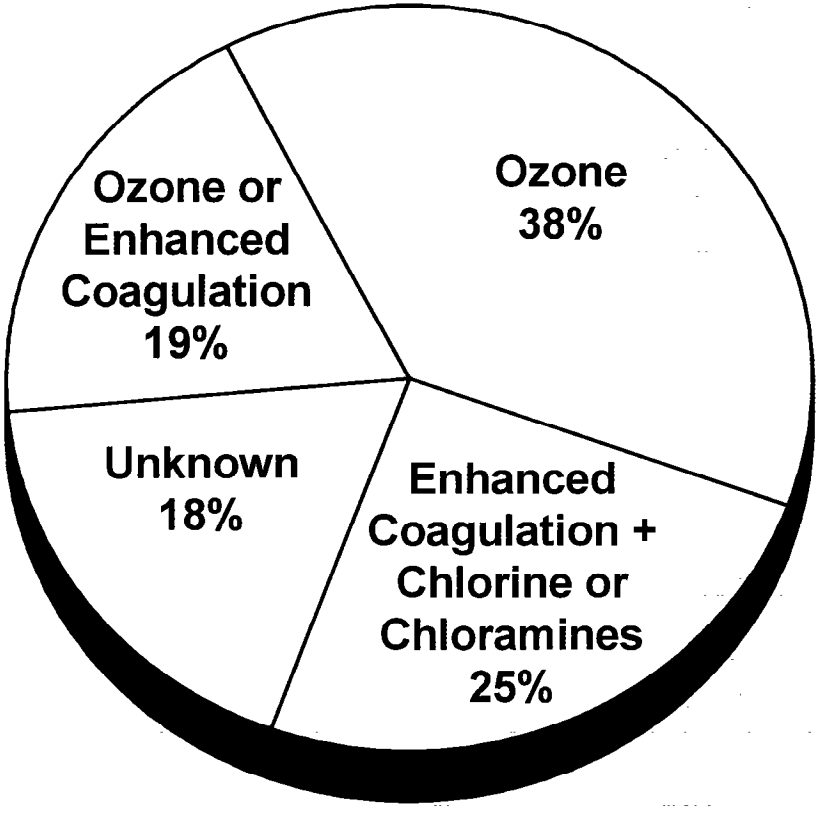


Figure 5

Current Treatment Processes



Future Treatment Processes



Plants Treating >50% SPW (32 Plants)

ATTACHMENT A

JENSEN AND MILLS OXIDATION RETROFIT PROGRAM (ORP)
CHRONOLOGY
(1979-1998)

DATE	ACTIVITY
1979	Trihalomethane (THM) standard set at 100 μg/L.
July 1984	Metropolitan switched secondary disinfectant from free chlorine to chloramines to reduce THM formation.
April 1986	Metropolitan THM Action Plan presented to Board.
June 1986	President Reagan signed the Safe Drinking Water Act (SDWA) Amendments of 1986 into law. USEPA announced plans to significantly lower the THM standard.
July 1987	Board approved $2.9 million (Appropriation No. 536) to fund bench- and pilot-scale studies on granular activated carbon and oxidants (including ozone) under the THM Action Plan.
June 1988	Board approved first increase in Appropriation No. 536 of $800,000 to finance an evaluation of the feasibility of the Oxidation Demonstration Project (ODP) as the next step of the THM Action Plan.
January 1989	Board approved second increase in Appropriation No. 536 of $4.2 million to finance the design of the ODP.
October 1989	USEPA released "Strawman" (or draft) THM standard of either 25 or 50 μg/L.
March 1990	Board approved third increase in Appropriation No. 536 of $13.3 million to finance the construction of the ODP.
September 1990	Board approved fourth increase in Appropriation No. 536 of $100,000 to fund bromide/brominated disinfection by-product (DBP) bench-scale studies.
September 1990	Board approved $5 million (Appropriation No. 610) for Oxidation Retrofit Program (ORP) preliminary investigations at all five plants.
January 1991	Information Board letter on USEPA shift in its regulatory philosophy for developing DBP regulations by seeking to balance DBP and microbial risks.

DATE	ACTIVITY
March 1991	Board approved fifth increase in Appropriation No. 536 of $1.7 million to finance the operations phase of the ODP.
February 1992	Testing began at Metropolitan's ODP to confirm the effectiveness of the ozone and PEROXONE (the combination of hydrogen peroxide and ozone) processes for controlling DBP formation, microorganisms, and taste-and-odor compounds.
September 1992	USEPA initiated negotiations on DBP and microbial regulations with drinking water industry, environmental community, consumer groups, and other regulatory agencies.
May 1993	Tentative agreement on DBP Rule cluster reached between negotiators. The cluster included: Stages 1 and 2 of the Disinfectants/Disinfection By-Products (D/DBP) Rule; the Enhanced Surface Water Treatment Rule (ESWTR); and the Information Collection Rule (ICR). ODP data on enhanced coagulation and bromate formation/control used by negotiators.
June 1993	Board approved $9,265,400 (Appropriation No. 659) to finance an additional three years of ODP operations.
August 1993	Information Board letter , "Overview of Metropolitan's Oxidation Retrofit Program," presented with the Ozone/PEROXONE Decision Document attached. Staff stated need for Board commitment to ORP at all five plants and sedimentation basins at Skinner by September 1993 to ensure compliance by June 1998. ORP preliminary investigations estimated ozone retrofit costs at $725 million for all five plants.
October 1993	Staff from Los Angeles Department of Water and Power (LADWP) suggested a water exchange between the L.A. Aqueduct Filtration Plant (LAAFP) and Jensen as a potential strategy to meet regulations and defer capital costs.
November 1993	Board approved increase in Appropriation No. 610 from $5 to $14.1 million for preliminary design at Jensen and Mills, and environmental documentation at Jensen. Cost estimate of $725 million scaled back to $575 million by considering D/DBP Rule compliance only and reducing the design ozone dosage from 3 to 2 mg/L. Based on Board and member agency comments, as well as the Engineering and Operations Peer Review Group findings regarding ORP capital costs, staff were requested to thoroughly evaluate the proposed water exchange and reevaluate enhanced coagulation.

DATE	ACTIVITY
June 1994	Information Board letter presented on the LADWP/Metropolitan water exchange proposal. A joint LADWP/Metropolitan committee evaluated the water exchange and enhanced coagulation, with input from affected member agencies. The water exchange proposal was not economically feasible, and ozone was confirmed to have a lower overall cost compared to enhanced coagulation. Therefore, staff stated need for Board decision on Jensen and Mills ORP by August 1994 to ensure compliance with Stage 1 of the D/DBP Rule. Decisions on the need for ozone at the plants treating Colorado River water (Skinner, Weymouth, and Diemer) could be deferred at least one year.
June 29, 1994	Proposed DBP Rule cluster (Stages 1 and 2 of the D/DBP Rule, Interim ESWTR, and ICR) published in the Federal Register, with a compliance date of June 1998.
August 1994	Board approved second increase in Appropriation No. 610 of $24 million to finance final design of Jensen and Mills ORP Capital costs estimated at $127 million for Jensen and $73 million for Mills (total of $200 million), with on-line dates of June 1998 for both plants.
April 1995	Board approved third increase in Appropriation No. 610 of $10 million to finance site preparation for Jensen ORP.
November 1995	Process design criteria for Jensen and Mills ORP finalized.
December 1995	Request for bids on the ozone/oxygen equipment package for the Jensen and Mills ORP was advertised.
January 1996	Oral report on Jensen and Mills ORP was given to the Special Committee on Water Quality and Environmental Compliance (Special Committee). Staff were asked to develop additional information and costs on alternative compliance strategies.
February 7,1996	Bids on the ozone/oxygen equipment package were opened.
April 30, 1996	Rate refinement/cost containment review group meeting held with member agency managers. Staff were asked to revise the 1993/94 cost estimates (completed as part of the LADWP/Metropolitan water exchange evaluation) for alternatives to ozone, as well as explore other novel approaches, given draft SDWA language extending the compliance timeframe and reduced demand projections.
June 1996	Draft Board letter for fourth increase in Appropriation No. 610 of $29 million for procurement of ozone/oxygen equipment .

DATE	ACTIVITY
June 1996	USEPA announced further delays in promulgating the DBP Rule cluster from original 1996 date to the year 2000 at the National American Water Works Association (AWWA) Conference, due to delays in the ICR finalization.
July 1996	Temporary employees and consultants working on the ORP were terminated to reduce the program expenditures until Board could make a decision on the ORP implementation schedule.
July 23, 1996	Presentation made to the Special Committee on delaying implementation of ozone at Jensen and Mills to defer costs, based on cost containment efforts. Committee requested that staff bring letter to the Special Committee for action in August 1996, prior to full Board action scheduled for September 1996.
August 6, 1996	President Clinton signed the SDWA amendments of 1996 into law, extending the compliance timeframe from 18-months to 3-5 years. Based on SDWA reauthorization, the USEPA plans to promulgate Stage 1 of the D/DBP Rule and the Interim ESWTR in November 1998.
August 27, 1996	Board letter to Special Committee with Ozone Technical Information Document attached (includes July/August 1996 staff evaluation to look at options to take full advantage of regulatory schedule flexibility afforded by the SDWA reauthorization and reduced demand projections). Requested the committee reaffirm its commitment to ozone and direct staff to proceed with the Extended Schedule/Full Capacity option, which had the lowest present value and the greatest number of benefits, with on-line dates of 2004 for Jensen and Mills. Staff recommendation was approved by the committee.
August 29, 1996	Rate refinement process/cost containment review group meeting with member agency managers, where ORP implementation options were presented. Managers supported shutting the design down because of concerns related to costs and being out front of regulations.
September 1996	ORP pulled from letter to Board on cost containment effort, which also included Inland Feeder and Lake Mathew's Outlet Tower, due controversy concerning continuing the design efforts.
December 2, 1996	Board Workshop on ORP and Body Contact Recreation.
January 1997	Presentation to the Special Committee on questions and answers from the Board Workshop, as well as staff intent to bring recommendation on ORP implementation to March 1997 meeting.

SUMMARY

Based on the results of several comprehensive evaluations, the implementation of ozone at Metropolitan's plants represents the most cost effective strategy for complying with Stage 1 of the proposed D/DBP Rule. Moreover, ozone has the potential for inactivating *Cryptosporidium*, controlling taste-and-odor problems, and for meeting the proposed MCLs in Stage 2 of the D/DBP rule.

The addition of ozone facilities is part of a total water quality program, consisting of: source protection for both the State and Colorado River systems; facility upgrades (including a major water quality laboratory expansion); process optimization (e.g., USEPA/water industry Partnership for Safe Water to improve turbidity and *Cryptosporidium* removal); water quality monitoring (includes partnership with the California Department of Water Resources to monitor SPW for *Cryptosporidium*); and research on emerging issues such as MTBE, *Cryptosporidium*, and Colorado River water salt removal. The goal of the ORP is to improve the region's water quality by applying a new cost-effective treatment strategy that meets the more stringent water quality regulations and anticipates the public perception of health, environment, and drinking water quality.

DATE	ACTIVITY
February 1997	Member agency managers suggested continuing forward with design of Jensen and Mills ORP, as long as no capital expenditures are made in advance of promulgation of Stage 1 of D/DBP Rule and Interim ESWTR in November 1998.
February 21, 1997	Board letter to Engineering and Operations Committee and Special Committee requesting that the Board direct the General Manager to proceed with the final design of the ozone facilities at the Mills and Jensen plants according to the "flexible implementation alternative" with on-line dates of late 2001 for Mills and late 2003 for Jensen (design effort would be reinvigorated, the plants would be designed sequentially, and no equipment would be purchased until after promulgation of Stage 1 of the D/DBP Rule and IESWTR [November 1998]). Board approved Staff recommendation.
February 10, 1998	California Department of Health Services released a study titled "Trihalomethanes in Drinking Water and Spontaneous Abortion" in which there was an association between women with high personal exposure to trihalomethanes (5 or more glasses of water with trihalomethanes greater than 75 micrograms/liter [μg/L]) during their first trimester of pregnancy and miscarriages (15.7 percent compared to a miscarriage rate of 9.5 percent among women with low trihalomethanes exposure). High exposure to one of the four trihalomethanes, bromodichloromethane (BDCM), was associated with miscarriages when the BDCM level was 18 μg/L or more.
February 23, 1998	Information Board letter to the Engineering and Operations and Water Planning and Resources Committees on the potential acceleration of the ORP at the Skinner, Weymouth, and Diemer filtration plants to achieve an on-line date of 2005 for each plant. Indicated that the treatment surcharge would increase at a faster rate with the accelerated schedule, but due to the effects of inflation, the total program cost would be less than with the current Capital Improvement Program schedule.
March 24, 1998	At its March meeting, the Special Committee recommended accelerating the ORP at the Skinner, Weymouth, and Diemer plants to achieve an on-line date of 2005 for each plant and develop alternative financial strategies to seek to mitigate treatment surcharge impacts of the ORP.
March 25, 1998	Board letter on decision to accelerate the ORP at the Skinner, Weymouth, and Diemer filtration plants. Staff presented four options. Board deferred a decision on accelerating the program at these three plants and instructed staff to provide additional information including alternative financial strategies to seek to mitigate treatment surcharge impacts of the ORP.

ATTACHMENT B

OZONE-RELATED BOARD LETTERS

Date	Title
March 27, 1986	Future Trihalomethane Regulation Action Plan
June 24, 1987	Appropriation No. 536 for $2.9 million to Finance the Estimated Costs of the Granular Activated Carbon and Oxidant Studies, and Authorization to Amend the Existing Agreement with James M. Montgomery, Consulting Engineers, Inc.
May 26, 1988	Revision No. 1 in Appropriation No. 536 from $2.9 million to $3.7 million to Finance the Estimated Costs of the Scoping Study Phase of the Oxidation Demonstration Project
September 21, 1988	Changes in the Scoping Study Phase of the Oxidation Demonstration Project
December 22, 1988	Revision No. 2 in Appropriation No. 536 from $3.7 million to $7.9 million to Finance all Estimated Costs in Advance of Award of a Contract for Construction of the Oxidation Demonstration Project and Authorization to Enter into Agreements with James M. Montgomery, Consulting Engineers, Inc.
February 15, 1989	American Water Works Association Research Foundation's Grant for the Oxidation Demonstration Project
October 25, 1989	Oxidation Demonstration Project Update
December 21, 1989	Bromide Levels in State Project Water and Impacts on Control of Disinfection By-Products
February 23, 1990	Revision No. 3 to Appropriation No. 536 to increase funding from $7,900,000 to $21,200,000 to finance all estimated costs and to award a contract for construction of the Oxidation Demonstration Plant and authorization to amend Agreement No. 2132 with James M. Montgomery, Consulting Engineers, Inc.
August 22, 1990	Revision No. 4 to Appropriation No. 536 from $21,200,000 to $21,300,000 to Finance the Estimated Costs of the Bromide/ Brominated-DBP Bench-Scale Experiments and Authorization to Amend Agreement No. 1692 with James M. Montgomery, Consulting Engineers, Inc. (JMM)
August 24, 1990	Appropriation No. 610 for $5,000,000 to finance all estimated costs for preliminary engineering and environmental investigations relating to the retrofit of all filtration plants with oxidation facilities
December 14, 1990	Shift in U.S. Environmental Protection Agency's Regulatory Philosophy
February 20, 1991	Revision No. 5 in Appropriation No. 536 from $21.3 million to $23.0 million to Finance the Operations Phase of the Oxidation Demonstration Project
May 17, 1993	Support for Congressional Appropriation of Funds for Disinfection By-Products Research

Date	Title
June 3, 1993	Appropriation No. 659 for $9,265,400 to Finance an Additional Three years of Demonstration Plant Operations
July 28, 1993	Overview of Metropolitan's Oxidation (Ozone/PEROXONE) Retrofit Program
October 13, 1993	Revision No. 1 to Appropriation No. 610 to Increase Funding from $5 million to $14.1 million to Finance all Estimated Costs of Preliminary Design and Environmental Documentation for Metropolitan's Oxidation Retrofit Program at the Joseph Jensen Filtration Plant
May 23, 1994	Los Angeles Department of Water and Power (LADWP)/Metropolitan Water Exchange
August 5, 1994	Revision No. 2 to Appropriation No. 610 to Increase Funding from $10,000,000 to $34,000,000 to Finance all Estimated Costs in Advance of Award of Contracts for Oxidation Retrofit at the Joseph Jensen and Henry J. Mills Filtration Plants; to Certify the Final Mitigated Negative Declaration for the Jensen Oxidation Retrofit; and to Authorize the General Manager to Amend an Agreement with the Los Angeles Department of Water and Power
March 28, 1995	Authorization No. 3 to Increase Appropriation No. 610 from $34 million to $44 million to Expend Budgeted Funds for Construction of Site Preparation for the Joseph Jensen Filtration Plant Oxidation Retrofit Program and to Finance All Costs in Advance of Construction for Oxidation Retrofit at the Henry J. Mills and Joseph Jensen Filtration Plants and to Award a Contract
June 15, 1995	Impact of Rulemaking Moratorium and Regulatory Reform Legislation on the Oxidation Retrofit Program
August 22, 1996	Oxidation Retrofit Program (ORP) at Joseph Jensen and Henry J. Mills Filtration Plants
August 27, 1996	Scheduling and Implementation of the Inland Feeder Project, Lake Mathews Outlet Facilities Project, and the Ozone Retrofit Project
February 21, 1997	Policy Decision on the Oxidation Retrofit Program (ORP) at the Henry J. Mills and Joseph Jensen Filtration Plants
March 25, 1998	Decision on Acceleration of the Oxidation Retrofit Program at the Skinner, Weymouth and Diemer Filtration Plants

ATTACHMENT C

COST ESTIMATE ASSUMPTIONS

Escalation

All cost estimates were adjusted to 1998 dollars using the Los Angeles Engineering New Record (ENR) construction index. An interest rate of 5 percent was then used to escalate dollars to the year 2002. The total annual cost is equal to the capital cost, amortized at 6 percent for 20 years, plus the yearly O&M cost.

Plant Flows

Capital costs were calculated using plant design capacities and O&M costs were calculated using average plant flow projections for the year 2010. Treatment plant flows are shown below:

Plant	Design Capacity (MGD)	Average Flow (MGD)
Jensen	750	305
Mills	326	122
Weymouth	520	265
Diemer	520	308
Skinner	520	277
Total	2,636	1,277

Ozone

The costs for ozone treatment were extracted from the 1998/99 Capital Improvement Program (CIP) budget. The costs presented in this document will differ slightly from the CIP budget numbers due to differences in escalation and facility on-line dates. The ozone design dosage was 2 mg/L. Bromate formation would be controlled by lowering the pH of ozonation. The pH would be lowered at the contactor influent using sulfuric acid and re-adjusted at the contactor effluent using caustic soda or lime.

Enhanced Coagulation

Jensen - All sludge generated would be processed on-site with mechanical equipment and ultimately hauled to a landfill. Sludge disposal using the existing City of Los Angeles pipeline would no longer occur. Disinfection would be achieved by operating the reservoirs in series and using the first reservoir as a free chlorine contactor.

Mills- Additional sludge processing equipment would not be required at the Mills plant, as adequate capacity already exists. Disinfection would be achieved using a post-filtration chlorine contactor located after the filters and before the first clearwell reservoir. The two finished water reservoirs at Mills cannot be operated in series without major modifications and capital expenditures.

Weymouth/Diemer/Skinner - Sludge processing equipment at each plant would be upgraded and all sludge would be hauled to a local landfill. Sedimentation basins would be required at the Skinner plant No. 2 to accommodate the elevated coagulant dosages. Construction of a free chlorine contactor would not be necessary at these plants to meet a TTHM MCL of 80 μg/L (Stage 1 D/DBP Rule). Therefore, chlorine could continue to be added at the head of the plant and disinfection would be achieved in the flocculation and sedimentation basins. However, in order to achieve a TTHM MCL of 40 μg/L (Stage 2 D/DBP Rule) at these three plants (which would only be possible with severe blending restrictions), a chlorine contactor would need to be employed at each facility. The cost for enhanced coagulation would then increase.

Granular Activated Carbon

The GAC adsorbers would be located immediately after the filters and would be sized to treat the entire plant flow and provide an EBCT of 22 minutes. A chlorine-contact basin would be required immediately after the GAC adsorbers. No chlorine would be added upstream of the GAC units. It is assumed that enough land is available at each plant to accommodate the GAC facilities. Thermal regeneration of the GAC would occur within Southern California and it is assumed that compliance with all state and federal regulations could be achieved (Federal Clean Air Act, California Clean Air Act, and Toxic Air Containment Program).

Membranes

Low pressure reverse osmosis membranes would be installed at the filtration plants. Nanofiltration membranes could also be used to achieve the necessary DBP precursor removal; however, since low pressure RO membranes have other benefits (salinity removal) and the costs are comparable, the ideal choice would be RO membranes. The membrane modules would be sized to treat the entire plant flow (although split-flow treatment may also be a viable option). The conventional treatment plants would be used to provide pretreated water to the RO modules, which would be located after the filters. A dechlorination basin would be constructed to dechlorinate the filter effluent prior to membrane treatment. The membrane elements would operate between 100 and 200 psi and achieve a 90 percent recovery. A brine line would be installed at each plant. These pipelines would transfer RO brine from the plants to the ocean (although construction of 5 ocean outfall brinelines in Southern California would be problematic). At least 10 percent of the flow at each plant would be "wasted". The unit capital cost for all membrane facilities was estimated at $0.68 gallons per day of product water. Energy costs were estimated at $68 per acre-feet of product water.

LADWP/Metropolitan Water Exchange

The LAAFP would treat SPW and the Jensen plant would treat Owens River water and SPW. Both water supplies would be required at the Jensen plant for about 4 months during the year to meet high demands. Therefore, enhanced coagulation facilities would be required at Jensen and the plant would operate in the enhanced coagulation mode for about 4 months. For the remaining eight months of the year, primarily Owens River water would be treated at Jensen. Slightly elevated coagulant dosages (10 mg/L ferric chloride) would still be required due to the high arsenic concentration found in Owens River water. A raw water pipeline would be required to transfer Owens River water to the Jensen plant. A pipeline of adequate size already exists to supply the LAAFP with SPW.

Attachment to 10-2
Engineering Division
June 18, 1998

APPENDIX 3

CIP PROGRAMS DEFERRED THROUGH RATE REFINEMENT PROCESS AND NEW CIP PROGRAMS

During development of Metropolitan's Integrated Resource Plan, and as a result of the Rate Refinement Process, a number of programs within Metropolitan's Ten-Year CIP were eliminated or had their on-line dates shifted back. Table 1 presents a list of these programs along with a summary of the individual action taken, the Total Program Estimate for the program prior to the subject action, and the Total Program Estimate for the program within Metropolitan's FY 1998/99 budget.

During the several-year period since the Rate Refinement Process took place, several programs have been added to the Ten-Year CIP and two programs have become candidates for moving forward in time. Table 2 presents a summary of the new programs added to the CIP. This list excludes the miscellaneous programs included under each fiscal year's $30 million budget item for new unbudgeted projects.

Table 3 contains the two projects which are candidates for moving forward in time: The Oxidation Retrofit Program for the Skinner, Diemer, and Weymouth Plants, and the Lake Mathews Outlet Facilities Construction.

Attachments 1 and 2 show the design and construction schedules for the current Oxidation Retrofit Program and for an accelerated program.

Table 1

PROGRAMS DEFERRED AND ELIMINATED FROM CIP DURING IRP AND RATE REFINEMENT PROCESS

Program	Action Taken	Total Program Estimate at Time of Action	FY 1998/99 Total Program Estimate
Local Ground Water Storage Agreements	Shift of schedules beyond FY 2004/5	210,000,000	210,000,000
Inland Feeder	On-line date shifts to 2003/04	1,027,000,000	1,188,000,000
San Diego Pipeline No. 6	On-line date shifts to 2005/06	325,000,000	368,700,000
Oxidation Retrofit - Skinner, Diemer, Weymouth	On-line date shifts to 2006/09/12	307,000,000	507,000,000
CPA Filtration Plant	On-line date shifts to 2014/15	343,300,000	578,000,000
CPA Tunnels/Pipelines	On-line date shifts to 2014/15	484,500,000	822,000,000
West Valley Project	On-line date shifts to 2006/07	266,300,000	506,000,000
Lake Mathews Outlet Facilities Construction	On-line date shifts to 2009/10	145,000,000	165,000,000
AMP Parallel	On-line date shifts to 2014/15	56,800,000	82,200,000
Skinner Filtration Plant - Modules 4,5,6 Sedimentation Basins	Deferred	39,198,500	72,500,000
Perris Filtration Plant - Study & Land Acquisition	Deferred	20,550,000	35,900,000
Diemer Finished Water Reservoir	Eliminated from CIP	60,000,000	0
Weymouth Sludge Handling	Eliminated from CIP	6,029,800	0
La Verne - Construct a Utility Shop Building	Eliminated from CIP	9,634,000	0
Skinner Monofill	Eliminated from CIP	2,276,600	0
Replace Emergency two-way radio	Eliminated from CIP	1,177,000	0
La Verne Facilities - Hazardous Waste Staging Area	Eliminated from CIP	2,400,000	0
La Verne Construct Office and Warehouse Storage	Eliminated from CIP	7,596,900	0
Lake Mathews Multi Purpose Bldg	Eliminated from CIP	1,265,900	0
Lake Mathews Auto Heavy Equipment Shop	Eliminated from CIP	5,000,000	0
Skinner F. P. - Install Effluent Adjustable Weir Slide Gates	Eliminated from CIP	830,000	0
Lake Mathews Tool Crib Extension	Eliminated from CIP	360,000	0

Table 2

NEW PROGRAMS ADDED TO CIP AFTER THE IRP AND RATE REFINEMENT PROCESS

Program	Added to CIP	FY 1998/99 Total Program Estimate
Jensen Filtration Plant - Finished Water Reservoir #2 Drainage	10/96	2,173,000
La Verne Facilities Expansion of the Sanitary Sewer	10/96	295,000
Weymouth Filtration Plant - WWRP Flocculation Equipment Repair & Replacement	1/97	1,330,000
Soto Street Maintenance Facility - Seismic Upgrade	1/97	354,100
Lower Feeder & Sepulveda Feeder SCI Drain Station	12/97	1,900,000
Black Metal Mountain - Develop Communications	4/98	437,000
Weymouth Filtration Plant - Purchase Real Property	4/98	2,000,000
Bachelor Mountain - Communication Site Acquisition	4/98	1,100,000
Ormond Beach Property Acquisition	4/98	12,200,000

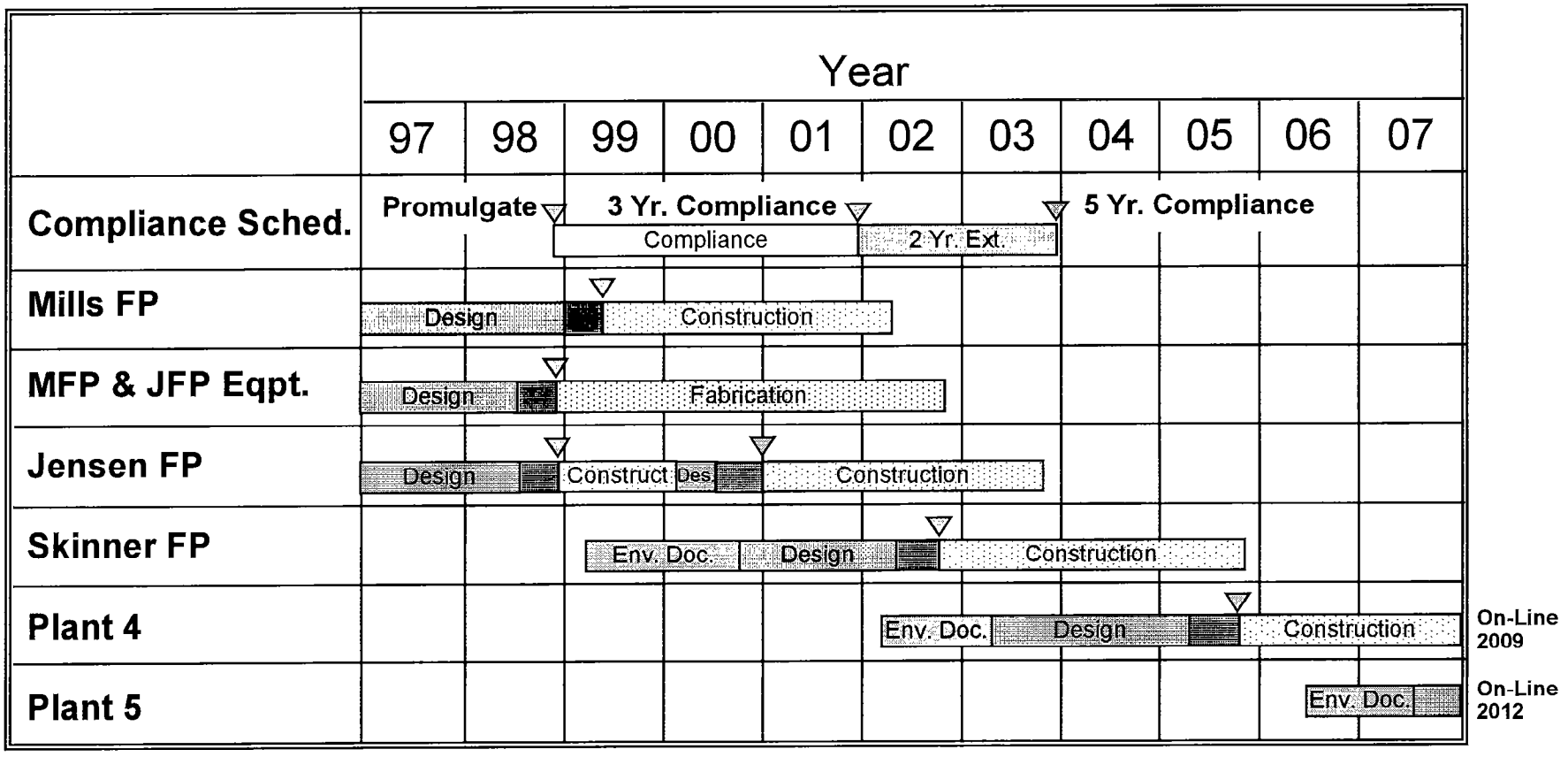
Table 3

CANDIDATE CIP PROGRAMS TO MOVE FORWARD IN TIME

Program	FY 1998/99 Total Program Estimate
Oxidation Retrofit - Skinner, Diemer, Weymouth	507,000,000
Lake Mathews Outlet Facilities Constructions	165,000,000

Attachment 1

ORP Implementation Schedules
Current CIP



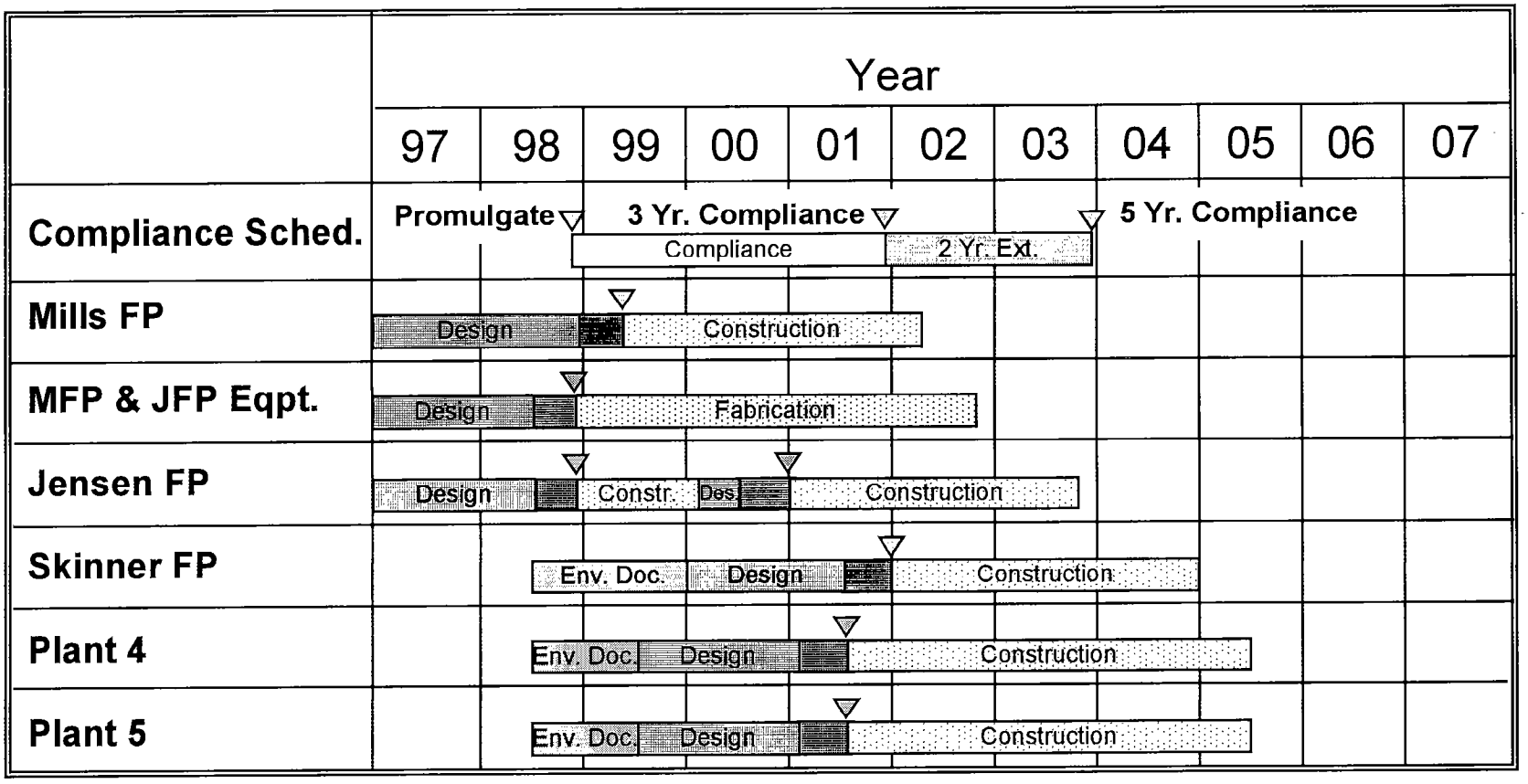
Compliance
Bid Period
Design
Fabrication
Environ. Documentation
Construction

MWD
Metropolitan Water District of Southern California

Attachment 2

Oxidation Retrofit Program

ORP Implementation Schedules
Most Aggressive Approach



Compliance
Bid Period
Design
Fabrication
Environ. Documentation
Construction

MWD
Metropolitan Water District of Southern California

Attachment to 10-2
Planning and Resources Division
June 18, 1998

Appendix 4

FINANCING STRATEGIES TO MITIGATE TREATMENT SURCHARGE INCREASES ASSOCIATED WITH THE OXIDATION RETROFIT PROGRAM

All capital and direct operations and maintenance costs associated with the treatment of water are currently recovered through the water treatment surcharge. Since the Oxidation Retrofit Program (ORP) is a treatment cost, it will impact the water treatment surcharge rates. The impact on the treatment surcharge will be primarily dependent on the capital costs, the timing of capital outlays and the amount of treated water sold contributing payments toward the costs for the treatment facilities.

At its March 24, 1998 meeting, the Special Committee on Water Quality, Desalination, and Environmental Compliance recommended to the full Board to direct staff to accelerate the ORP at Skinner, Weymouth and Diemer plants to achieve an on-line date of 2005 for each plant and develop alternative financial strategies to mitigate treatment surcharge impacts of the ORP.

At the Board's request, staff prepared a schedule and a rate impact analysis on the potential acceleration of the ORP at the Skinner, Weymouth and Diemer filtration plants. With an accelerated schedule, the on-line dates of the Skinner Weymouth and Diemer filtration plants would be 2005. The Mills and Jensen filtration plants would continue with their scheduled on-line dates of 2002 and 2003 respectively. The treatment surcharge would increase at a faster rate with the accelerated schedule, but due to the effects of inflation, the total program cost would be less than with the current Capital Improvement Program (CIP) schedule. The current program estimate in the CIP for the ORP at the Jensen and Mills plants is $263,000,000 (Program 15173W). The program estimate for the ORP at Skinner, Weymouth and Diemer (Program 95620W) based on the current CIP schedule is $507,000,000. However, by accelerating the ORP schedule, the latter program estimate would be reduced to $437,000,000 due to reduced escalation. Total program estimates for all five plants on the accelerated schedule is $700,000,000 with contingencies.

The total increase in the treatment surcharge due to the ORP is estimated to be about $36 per acre foot based on the estimated cash flows associated with the accelerated construction schedule and direct operations and maintenance costs at the Skinner, Weymouth and Diemer filtration plants. This rate impact amounts to an eight percent increase in treated water rates over a ten-year period. A treatment surcharge rate comparison of the current construction schedule versus the accelerated schedule shows that a larger rate increase, two years sooner than the current schedule is needed because the accelerated schedule requires higher capital outlays sooner. The treatment surcharge rate would increase by $5 per acre foot in 2002. This revised rate impact reflects more up-to-date estimates of operating and maintenance expenses and an appropriate split

of capital costs between treated and untreated water rates. This analysis also assumes that all ozone costs continue to be collected through the treatment surcharge and treated water sales increase by 20,000 acre-feet per year over the next ten years.

The rate impact analysis also shows that due to the reduced total capital cost for the accelerated schedule, the treatment surcharge is the same on both schedules by year 2009. Beyond 2009, the accelerated schedule results in a lower charge of $5 per acre foot. Figure 1 illustrates the difference in the projected treatment surcharge attributed to the accelerated construction schedule. From the year 2002 to 2009, an estimated $63.5 million in additional debt service is projected to be paid as a result of the accelerated construction schedule. Figure 2 shows the difference in capital outlays for both the current and accelerated (aggressive) construction schedules for the ORP.

To mitigate the impact of the ORP on the water treatment surcharge, additional revenue from other sources must be found. Several potential alternatives to consider are discussed below.

1. **Issue General Obligation (GO) Bonds for Water Treatment.** Metropolitan could decide to issue GO bonds for water treatment facilities or more specifically, for the ORP. In Board Letter 9-6, dated August 26, 1993, your Board was provided with the procedures necessary to issue GO bonds for water treatment facilities (see Attachment A). This procedure is still valid and is attached to this appendix for your information. If it is assumed that the total capital costs of the ORP in the accelerated time frame were funded from GO bonds, the estimated tax rate needed to pay the annual debt service is 0.005 percent. This estimate is based on capital costs of $595,950,000 (without contingencies), a 30 year term, and a 6% interest rate. The water treatment surcharge would still include the cost of direct operation and maintenance, but if voter approval for the bond issue is obtained, the capital costs would now be collected through the *ad valorem* tax levy.

2. **Recover a portion of ORP capital costs from the Readiness-to-Serve (RTS) charge.** Currently, no water treatment facility costs are recovered through the RTS charge and no RTS revenues are used to offset the water treatment surcharge. The Board could review ORP capital costs to determine if any portion of those costs are attributable to system reliability and if it appropriately meets the intent of the RTS charge. If some portion does qualify, the ORP could be added to the list of qualifying Capital Improvement Projects and RTS funds could be used to offset water treatment surcharge costs. This reduces the surcharge and increases the RTS obligation.

3. **Recover a portion of ORP capital costs from the New Demand Charge (NDC).** Currently the NDC is suspended pending the substitution of an acceptable alternative methodology. Whatever changes are made in this program, the premise that "new growth will pay its share of cost" is the direction the Board has established. Just as the ORP may have a portion of its capital costs that are appropriately assessed to the RTS charge, another portion may be assessed to new demand. The new Nexus Study will include the ORP in its review and if there is a nexus established, the Board could determine that some NDC funds be used to offset the treatment surcharge.

4. **Establish a minimum purchase charge for treated water.** The largest share of cost for the ORP is capital (a fixed cost) while the revenue stream is commodity driven and variable. To change this mismatch, the Board may want to consider establishing a minimum purchase charge to all treated water users. This would best be done through a contracting process. This alternative is not as much a mitigation as it is a restructuring of the rates, however, by the very nature of making firm commitments to Metropolitan, it promotes more efficient use of Metropolitan's treatment plants. Minimum purchases also encourage maintaining or increasing treatment plant use, which helps maintain or decrease the treatment surcharge rate.

5. **Establish a peaking charge for treated water.** The concept of developing a peaking charge for treated water has been discussed several times. In December 1993, your Board approved in concept the creation of such a charge. Analysis of this concept is being done and will be part of the rate structure discussions later this year. Similar to the minimum charge concept, the Board would be establishing a cost to treated water users that encourages a more regular use of the treated water allowing the plants to operate more efficiently and in a cost effective manner.

In addition to the alternatives presented, staff continues to pursue any other sources of funding such as State or Federal grant funds that may become available to offset the ORP costs.

Table 1 summarizes the options discussed.

Figure 1.
TREATMENT SURCHARGE
UNDER ALTERNATIVE ORP CONSTRUCTION SCHEDULES ($/AF)

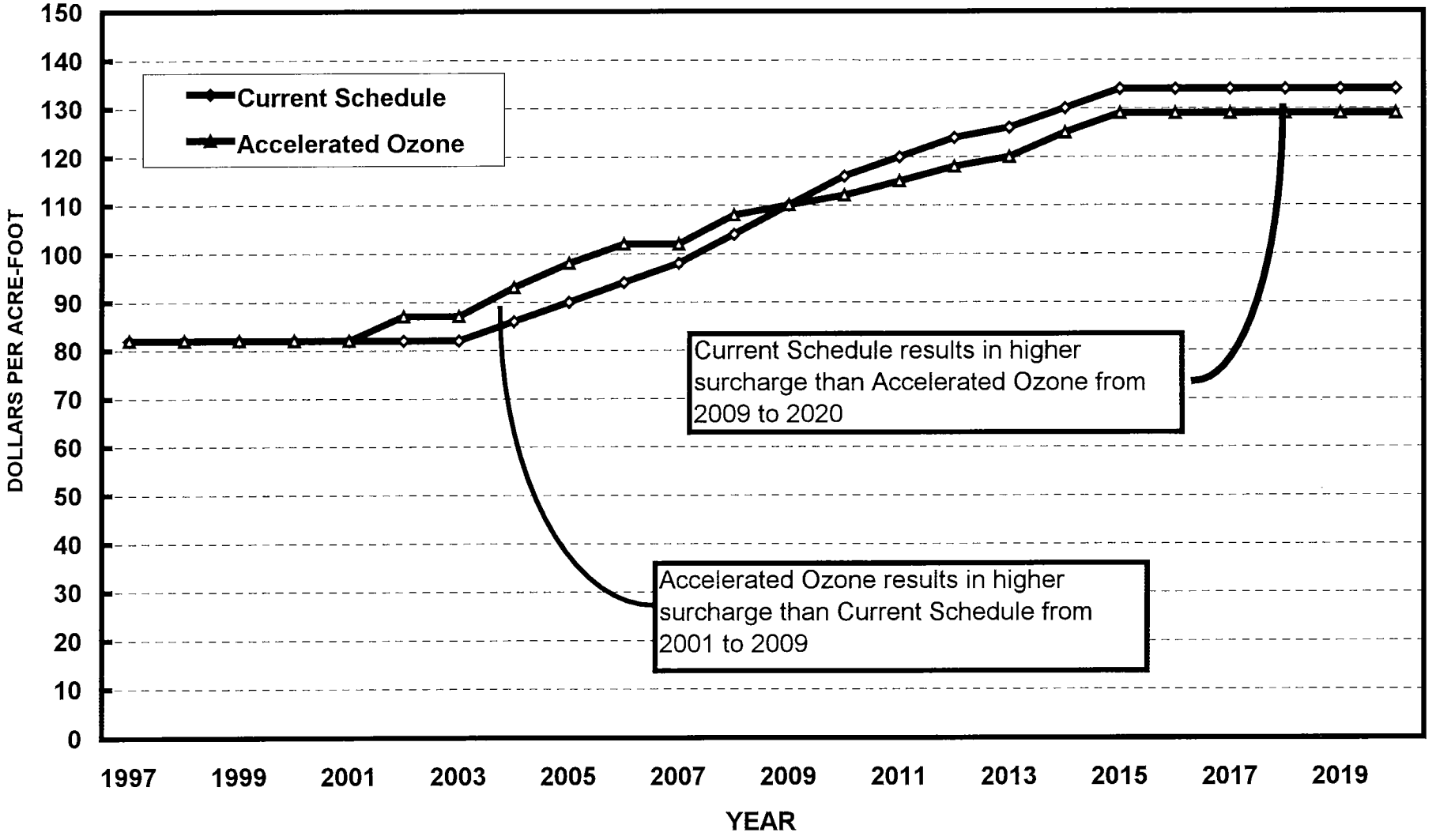


Figure 2.

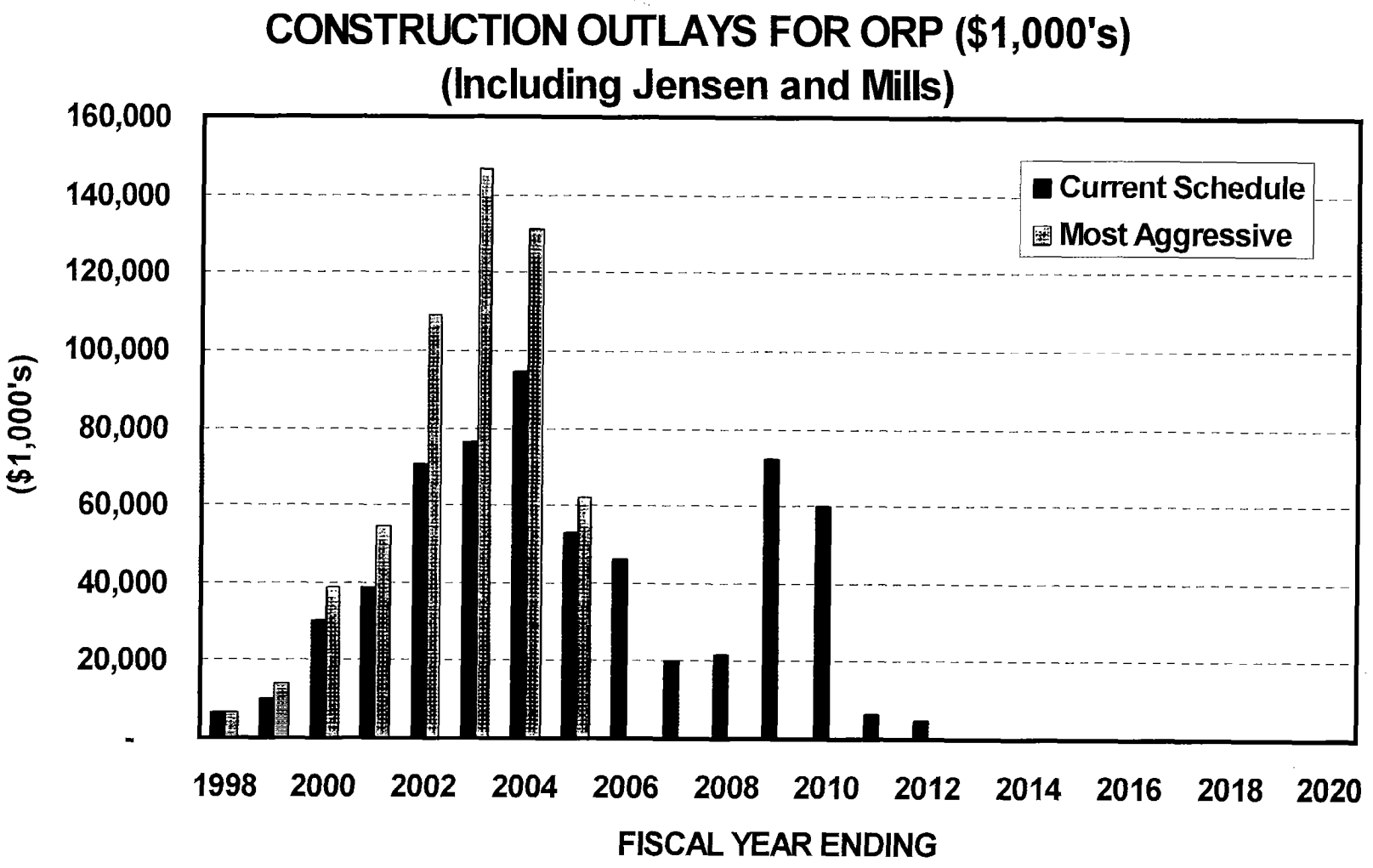

CONSTRUCTION OUTLAYS FOR ORP ($1,000's)
(Including Jensen and Mills)
Current Schedule
Most Aggressive
($1,000's)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
FISCAL YEAR ENDING

TABLE 1: ALTERNATIVE REVENUE SOURCES FOR THE ORP

DESCRIPTION OF ALTERNATIVE	IMPACT ON WATER TREATMENT SURCHARGE	IMPACT ON OTHER CLASSES OF CUSTOMERS	ADDITIONAL REMARKS
1. General Obligation Bonds	Significant reduction in surcharge	No direct impact on other Metropolitan rates	• Tax levy increase • Requires voter approval
2. Apply to Readiness-to-Serve (RTS) charge	Small reduction in surcharge	Small increase in RTS charge	• Applies cost to larger base of customers • Moves revenue from variable to fixed
3. Apply to New Demand Charge (NDC)	Small reduction in surcharge	Small increase in NDC	• Same as #2
4. Minimum Purchase Charge	Same total cost, may have some redistribution between customers	None	• Requires contracts • Promotes stability • Moves revenue from variable to fixed
5. Peaking Charge	Same total cost, but a redistribution between customers	None	• Promotes stability • Moves revenue from variable to fixed

Attachment A

MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

August 26, 1993

Board of Directors (Finance and Insurance Committee--Information)

General Manager

Water Quality Bond Authorization

Report

The General Manager has been requested to provide information relating to procedures for financing Metropolitan's water treatment facilities by way of a general obligation bond issue.

Attached are a timeline showing steps necessary to place this issue on the ballot for the June 1994 statewide election and a report reflecting relevant comments on the proposal.

Board Committee Assignment

This letter is referred for information to the Finance and Insurance Committee because of its authority to study, advise and make recommendations with regard to the sale of bonds, pursuant to Administrative Code Section 2441(b).

Recommendation

For information only.

John R. Wodraska

SBB:gm
bdltr\WQ-Bond.aut

Attachments

MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

August 26, 1993

Board of Directors

General Counsel

Legal Issues Related to a New General Obligation Bond Authorization

Report

The Metropolitan Water District Act (Act), Sections 200 through 216, provides for the authorization of general obligation bonds through a vote of the people within the District and specifies the election procedure. An amendment to article XIIIA of the state Constitution approved in 1986 permits property tax support for general obligation bonds for the acquisition or improvement of real property approved on or after July 1, 1978 by two-thirds of the votes cast by the voters voting on the proposition. Thus, a bond proposition for the purpose of improving water quality through the acquisition or improvement of real property approved by the requisite two-thirds majority would provide the District with authority to incur additional general obligation debt.

Election Requirements

Section 200 of the Act enables the Board to call a special election for the purpose of submitting a bond proposition to the electorate. To do so the Board must adopt by majority vote an ordinance that

> "determines that the interests of the district and the public interest or necessity demand the acquisition, construction or completion of any public improvement or works of the district, or the payment of the funds for any part of the capital costs of any public improvements or works of this state from which service is to be provided to the district, or the incurring of any preliminary expenses, or any combination of such purposes, necessary or convenient to carry out the objects or purposes of the district, the cost of which will be too great to be paid out of the ordinary annual income and revenue of the district . . . ."

Pursuant to Section 201 of the Act, at the time the Board calls the election, it will be necessary for the Board to approve an estimate outlining in broad and general terms the objects and purposes for which the bond proceeds are intended to be used, the amounts estimated to be needed for such purposes, the principal amount of the authorization, and the maximum interest rate payable on the bonds, which shall not exceed seven percent unless the Board determines by a two-thirds vote that a higher rate is required in order to obtain the needed funds. These elements should be furnished to the Board by the General Manager. This information, which must be recited in the ordinance, is necessary in order to advise the voters of the purposes for which the bond proceeds may be utilized and the debt service that may be incurred.

The ordinance must be published at least 10 days before the election, pursuant to Section 212 of the Act.

It also is necessary to adopt a resolution requesting the Boards of Supervisors of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Counties to order the consolidation of Metropolitan's special bond election with the statewide general election to be held June 7, 1994. It would probably also be desirable in that resolution to designate a specific letter such as W or Q for the ballot proposition identification and uniformity throughout the six counties.

The request for a consolidated election must be filed 88 days prior to the election and, therefore, not later than March 11, 1994.

Section 214 of the Act provides that the Board may designate individuals to file with the Secretary of the Board an argument in favor of the proposition and that any member of the Board or other voter or voters of the District may file an argument against the proposition with the Secretary. The Secretary is required to select the arguments for and against the proposition considered to best express the respective views of the proponents and opponents. These arguments will be included with each sample ballot.

Ballot arguments must be filed pursuant to the Act at least 55 days prior to the election. If the Board elects to proceed with this matter, we will verify with the county registrars of the six counties whether this deadline would be timely with their county.

Voter Approval Requirements

As discussed above, authorization of general obligation bonds presently requires the approval of two-thirds of the voters voting on the ballot measure. Several proposed constitutional amendments which would lower the voter approval requirement for various types of general obligation bonds to three-fifths (60%) or a simple majority are pending before the Legislature. Another such amendment (ACA 6) was approved by the Legislature in 1992 and will be before the voters on the November 1993 ballot.

ACA 6 provides for approval of general obligation bonds for financing of school facilities by a simple majority of the voters. It will become law if approved by a majority of the voters voting on the constitutional amendment in November. Proposals for similar constitutional amendments which could lower the voter approval requirement with respect to the District's bonds are largely on hold while their authors wait and see what the voters decide with respect to ACA 6.

These constitutional amendments are proposed because, in the current economic climate, the State and its local government agencies are badly in need of financing for facilities for a variety of purposes. General obligation bonds provide a means of financing those facilities through a voter-approved increase in property taxes for the specific purpose identified in the bond proposition, subject to the difficulty of obtaining voter approval. Any decrease in the percentage required for voter approval increases the possibility of a bond measure's success.

Any general obligation bond proposition from the District is likely to be one of many bond proposals on the ballot. Competition with other state and local bond issues for voter attention and approval could impact the District's ability to obtain the necessary percentage of positive votes. Unlike other local agencies, the District will be required to submit its bond measure to the voters in a number of communities across its six-county service area. Whether or not a constitutional amendment results in lowering the necessary percentage, no assurance can be given that voter approval of a general obligation bond proposition will be obtained.

CEQA Compliance

The submittal of proposals to a vote of the people is not a "project" under CEQA. Placing the bond measure on the ballot will not, in and of itself, commit the District to undertake particular projects having physical environmental effects and compliance with CEQA will not be required.

Use of District Funds

Public funds may not be expended to influence the public in voting on a ballot measure. However, the District is statutorily authorized to expend funds to inform the public regarding its activities and to disseminate information concerning its rights and properties. A public information program to provide information to the public in an even-handed manner respecting a ballot measure and respond to anticipated questions on the ballot measure is anticipated to cost approximately $250,000.

An organization formed by parties interested in the passage of a bond issue but not directly or indirectly supported by District funds could actively campaign in favor of the proposition. The cost of a campaign mounted by such an organization for ninety days is estimated at about $3 million, not including approximately $500,000 for outside polling services.

When the District initiates the dissemination of information, the District and its representatives must present the facts concerning the measure fully and fairly. A fair presentation of the facts includes information on all consequences of the measure. The District may not give a selective presentation which focuses only on the facts it deems favorable to its position.

Information can be distributed to the general public in any form, including, for example, pamphlets, news releases, letters, films or through personal appearances of District representatives. It is also proper for the District to publicize that these materials and speakers are available for various topics, including the topics covered by a ballot measure.

The District is less restricted with regard to the presentation of information where it responds to an inquiry about a ballot measure than when it initiates informational activities. In responding to requests, the District is <u>not</u> obligated to provide a complete presentation of all the

consequences of the measure, but can simply provide the requested information. The District may state its position and all the reasons it believes that position is sound. However, the District cannot urge others to adopt the District's position on the ballot measure or tell people how they should vote.

The previously discussed limitations relate only to activities involving the direct or indirect expenditure of District funds. Where no District funds are involved, neither directors nor staff members are restricted in their activities relating to a ballot measure. Thus, if directors or other District representatives are invited to discuss a ballot measure solely in their personal capacities and at their own expense, they are not limited by the above rules. But if the District is financially sponsoring an activity of an employee or director, that person will be deemed to be acting as a representative of the District and is subject to the limitations discussed above.

In addition to District liability for the improper expenditure of District funds, public officials with authority to direct the expenditure of public funds can be held personally liable for amounts found to be illegally spent if they fail to exercise due care in permitting the expenditure.

Board Committee Assignment

This letter is referred for information to the Finance and Insurance Committee because of its authority to study, advise and make recommendations with regard to the sale of bonds, pursuant to Administrative Code Section 2441(b).

Recommendation

For information only.

N. Gregory Taylor

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Schedule for June 1994
Water Quality General Obligation Bond Election

January	February	March	April	May	June	July
▲ Introduce Election Ordinance at Board Meeting **January 11**	▲ Approve Election Ordinance at Board Meeting **February 8**	▲ Election Consolidation Ordinance to all County Supervisors By **March 11**	▲ Deadline to File Ballot Arguments **April 13**	▲ Publication of Election Ordinance By **May 27**	▲ Statewide Election **June 7**	
January	**February**	**March**	**April**	**May**	**June**	**July**