Market Research Report

Pacific Northwest Water and Wastewater Market Assessment

prepared by

Quantum Consulting Inc. with Adolfson Associates

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May 2001

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PACIFIC NORTHWEST WATER AND WASTEWATER MARKET ASSESSMENT

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1. EXECUTIVE SUMMARY

The water and wastewater industry is a significant consumer of energy in the Pacific Northwest where it consumed 2910 GWh, or approximately two percent of total energy consumed in the region last year.[1] Water supply facilities consume 661 GWh regionally, of which municipal facilities consume 332 GWh and non-municipal facilities consume 329 GWh. Total energy consumption attributed to wastewater is 2249 GWh of which municipal and non-municipal facilities consume 997 GWh and 1252 GWh, respectively.

The focus of this summary, and report, is on the municipal facilities due to limited publicly available information about flow rates and system design at non-municipal facilities.[2]

Distribution of energy consumption at municipal wastewater facilities is shown below. Excluding unknown/other facilities, activated sludge facilities' energy consumption dominates every other category. Relative to other treatment processes, activated sludge facilities tend to be more energy intensive, and are more likely to serve populous urban areas – thus contributing to greater energy consumption.

Exhibit 1-1
Distribution of Energy Consumption (GWh) at Municipal Wastewater Treatment Facilities by Size and Treatment Type

	Large	Medium	Small	Total
Activated Sludge	247	338	36	621
Lagoon	12	39	19	70
Oxidation Ditch	16	6	0	22
Trickling Filter	0	30	4	34
Unknown/Other	125	84	41	250
Grand Total	400	497	100	997

Movement towards energy conservation continues to be obstructed by a focus on meeting permit, particularly in the wastewater industry. This is not to say that the industry ignores energy efficiency, only that amongst the list of priorities energy efficiency is dwarfed by the focus on meeting permit – for good reason, the costs of not meeting permit can be a fine, job loss, or worse.

In spite of this focus on permit, energy efficiency does make it into facilities. Design and engineering firms make it part of their specs and operators look for opportunities when they implement changes. In fact, energy efficiency (through VSDs) is frequently considered in

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[1] Based upon 171,000 GWH for the region.

[2] Non-municipal facilities include industries such as pulp and paper, fish hatcheries and aluminum production. Excluded from the non-municipal category are agricultural uses and mining uses.

designs and retrofits, and is often pursued outside of utility programs. Further investigation of energy efficiency wants and needs were probed through a series of interviews with operators from both water and wastewater facilities. In addition design and engineering firms, equipment purveyors, and industry "gurus" were surveyed about trends, opportunities and issues. Secondary sources from EPRI, the California Energy Commission, DOE and others were used to provide history, technological insights, energy intensities and industry scope. Analysis of these resources produced the following insights.

- **For the wastewater industry, energy efficiency is a low priority relative to meeting permit.** Meeting permit continues to drive most activities in the wastewater industry. Penalties and the potential loss of job make this focus consistent. Water markets are also concerned with permit, however energy costs represent a relatively larger percentage of operating costs. This focus on permit compliance fosters an environment where facility reliability is the predominant concern. This, in turn, translates into redundancy and over-specialization – and ultimately, more energy consumption.

- **Wastewater energy consumption is nearly three times that in the water treatment/supply market.** The 2910 GWh of energy consumed in the water and wastewater industry – 23 percent for water and 77 percent for wastewater. Relative to other regions the energy consumption for the water supply market is limited given the reliance on gravity to transport water and the lack of chlorination required.

- **Twenty large wastewater treatment facilities consume approximately 40 percent of total municipal energy consumption.** Concentrated in urban areas, large facilities (defined as 20 million gallons per day or more) are huge energy consumers. Average flow at these twenty facilities is approximately 50 million gallons per day (MGD) each. These facilities collectively require approximately 400 GWh per year. While large facilities are significant consumers of energy, they are more likely to have invested in energy-efficient equipment – some even have full-time energy managers. By contrast, small facilities (defined as facilities capable of treating 0-1 MGD) make up 75 percent of the municipal plants, yet consume only 10 percent of the energy.

- **Activated sludge wastewater facilities consume over 60 percent of total industry energy consumption.** Wastewater plants that rely on activated sludge treatment consume far more energy than comparatively sized lagoon or trickling filter systems. Activated sludge facilities annually consume approximately 621 GWh. They are able to process waste more quickly, with lower detention times, than other alternatives of a similar footprint. This makes them well suited for urban areas.

- **Adoption of VSDs and control systems occurs without program interventions.** Rebates and incentives are not drivers for measure adoption; most respondents adopted VSDs and/or control systems (SCADA) outside of the programs. In only a few instances did operators adopt measures as part of a program. In many cases the adoption of VSDs and control systems was related to non-energy benefits such as greater control and reliability. Design/engineering firms also stated that nearly all of their facility designs make use of both measures.

- **Operators in small and medium sized facilities want training and technical assistance.** Primarily due to lack of resources, operators overwhelming stated that their greatest need was in the area of training and technical assistance. Many design & engineering firms were reluctant to provide these services as they thought operators were not capable of dealing with "complicated" systems. The view on the part of design / engineering firms stems from a larger rift between operators and firms. Basically firms feel they have to design systems that are easy to operate, or are "operator friendly." Operators stated they would be interested in energy management and monitoring techniques.

- **Regulatory issues for water and wastewater have the potential to drive up energy consumption for the industry.** For wastewater, salmon listing could force higher quality standards that may increase filtration levels, a significant consumer of energy. For the water industry, more constant river levels will likely force suppliers to find sources that are either deeper, further or both.

Based on the assessment findings, we believe the following opportunities exist:

- **Broaden the criteria for Continuing Education Units to include energy efficiency related training.** Continuing education presents an ideal mechanism for addressing the technology constraint identified by facility operators and design / engineering firms in both industries. The educational infrastructure and the requirements are already in place; what's lacking is a curriculum that is broad enough to meet the needs of operators who must keep pace with the industry's rapidly developing technology. Expanding the scope of classes that fulfill certification requirements would lead to a wider range of classes offered and a greater preparedness on the part of facility managers to adopt energy-efficient technologies.

- **Many facilities are aging and will need to be expanded and upgraded.** Smaller municipalities are particularly strapped for upgrade resources. Many wastewater facilities were built with funding from the federal government as part of the Clean Water Act; similar funding for upgrades is not available, at present – at least not at the levels that are required by the industry. As upgrades and expansion take place, opportunities to incorporate energy efficient design will become available.

- **Operators want training and technical assistance more than anything, including demonstration facilities.** Operators, particularly those from smaller facilities cited a lack of resources for technical assistance, and advanced training. Assistance focused on energy savings techniques would certainly be valued.

- **Equipment with energy savings potential may be in facilities but not used.** Some operators stated they had control systems and monitoring equipment, but have chosen to shut down such equipment. Reasons included lack of technical expertise to maintain and operate equipment. At this time it is not known how many facilities are in a similar situation. There may be a significant opportunity to save energy by providing limited training on existing equipment.

2. STUDY METHODOLOGY

2.1 STUDY OBJECTIVES

This study examines the current state of the water and wastewater markets in the Pacific Northwest. The primary objective of this examination is to identify opportunities to introduce energy-efficient technologies and practices into these industries.

2.2 STUDY APPROACH OVERVIEW

Project staff utilized both primary and secondary sources in preparing this report. Dozens of water and wastewater professionals were interviewed as part of primary data collection. Secondary sources were consulted to provide background information critical to an understanding of these industries.

Exhibit 2-1
Distribution of Interviewed Facilities

	Wastewater Treatment Facilities	Water Supply Facilities	Design / Engineering Firms	**Total**
Idaho	4	4	2	**10**
Montana	0	3	0	**3**
Eastern Oregon	1	3	3	**7**
Western Oregon	1	6	3	**10**
Eastern Washington	5	2	3	**10**
Western Washington	2	4	3	**9**
Total	**13**	**22**	**14**	**49**

Project staff interviewed a total of thirty-five operators, managers and supervisors of water distribution and wastewater treatment facilities across the Pacific Northwest. The distribution of these facilities is listed in Exhibit 2-1. They range from tiny, two-person operations to huge urban complexes. Smaller facilities tend to be located in rural areas of Idaho, Montana, and eastern Oregon and Washington. Larger facilities are more common near population centers along the Pacific Coast.

Representatives of design & engineering firms were also consulted in preparing these materials. Fourteen firm representatives were interviewed for this report. These companies range from smaller firms operating exclusively in the Pacific Northwest to national corporations.

In addition, project staff members attended Water Environment Federation's WEFTEC Conference in Anaheim (October, 2000), and spoke to representatives of ten selected manufacturing and engineering firms in attendance. These firms were targeted because they specifically offer energy-efficient products and services, from pumps and motors to process controls and monitoring equipment. Staff also attended several technical sessions presenting energy-saving innovations in wastewater treatment.

Specialists at the Electric Power Research Institute's Community Environmental Center (EPRI) and Waterworld Magazine were also consulted for technical data and clarification. This information was analyzed and used to discern the general attitudes of wastewater treatment and water distribution professionals. Self-reported wants, needs, and concerns of industry professionals provide the substantive thrust of this analysis.

Secondary sources were also employed to prepare technical components of this report which were unavailable by other means. These materials were supplied by a variety of sources including federal, state and local governments and various government agencies, industry organizations, and academic institutions.

2.3 REPORT OVERVIEW

An overview of the wastewater treatment industry is presented in Section 3. Included in Section 3 is the technical assessment, where different treatment types are explained and a variety of problems associated with wastewater treatment are discussed. An overview of data collection and market characterization methodology is presented in Section 4. This section presents the self-reported needs and concerns of wastewater facility operators. Section 5 is an overview of water market mechanisms in the Pacific Northwest, while Section 6 contains an evaluation of primary data collected in interviews with water distribution facility operators. In Section 7, this report discusses energy use within the water and wastewater markets. Existing energy-efficiency measures are discussed and energy-efficient technologies and practices are identified and explained.

3. WASTEWATER TREATMENT INDUSTRY OVERVIEW

3.1 INDUSTRY OVERVIEW

Wastewater collection, treatment and disposal in the Northwest are provided by either publicly owned and operated wastewater utilities or by private entities such as industrial or agricultural enterprises. There is a tremendous range in terms of the types of wastewater facilities, service area characteristics, and operational factors associated with each individual facility or system.

The focus of this section is on municipal wastewater treatment facilities due to limited publicly available information available about non-municipal facilities.

Municipal wastewater treatment facilities in the Northwest are summarized below.

Exhibit 3-1
Number of Wastewater Treatment Facilities by Size and Treatment Type

	Large	Medium	Small	Total
Activated Sludge	11	95	207	313
Lagoon	3	49	279	331
Trickling Filter	0	13	29	42
Oxidation Ditch	1	3	2	6
Unknown/ Other	4	37	109	150
Total	19	197	626	842

There are 842 municipal wastewater treatment facilities in the Pacific Northwest. Facilities are considered small if they treat fewer than 1 million gallons per day (MGD), medium if between 1-20 MGD, and large if greater than 20 MGD. Most Pacific Northwest municipal wastewater treatment systems, 74 percent, are small facilities located in less populated areas. This is due to 1) the prohibitive cost of constructing the conveyance mechanisms required to transport raw sewage to larger, centralized facilities, 2) the desire to retain local control of wastewater treatment processes, and 3) problems associated with sewage leakage and possible contamination of near-surface aquifers. Treatment type definitions and distinctions will be outlined in a later section.

Nationally, activated sludge facilities are more common than other types. Their small footprint makes them especially appropriate for wastewater treatment near population centers. Activated sludge facilities can be found across the Pacific Northwest, but are most common in the more densely populated western regions of Oregon and Washington. Lagoons, on the other hand, require a large footprint and are usually located where inexpensive land is readily available. For this reason, in the Pacific Northwest, lagoon systems are most common in rural parts of Idaho, Montana, and eastern Oregon and Washington. Trickling filters are generally not as popular as activated sludge or lagoon systems. 'Other' treatment types include such methods as oxidation ditches and rotating biological contactors and are less common than other types.

Wastewater management systems generally include three major components:

- Collection / conveyance (pipes, pumping stations, etc.)
- Treatment (primary, secondary, or advanced treatment)
- Disposal / discharge (outfall / outflow, land application, or re-use)

Following is a brief summary of the major components within the wastewater treatment process. This overview is primarily relevant to municipal wastewater facilities; industrial and agricultural facilities are not considered due to limited information. Estimates of energy consumption at non-municipal facilities are discussed in a later section.

3.1.1 Collection System

The collection system conveys untreated, or raw, sewage to the treatment facility where it is treated to comply with the facility's permit. Tributary flows (flows coming into a facility) can range from thousands of gallons of untreated sewage daily to more than 150 MGD. Wastewater may include one, or a combination of, the following components: human or animal waste from households or businesses, other wastewater such as that from kitchens, industrial sources, and storm water. In most cases industrial and agricultural waste streams must be "pretreated" before they are delivered to a municipal facility. Depending on the waste stream content, industrial and agricultural facilities may choose to (or be required to) treat their waste entirely.

3.1.2 Treatment System

Contaminants in wastewater may be removed by physical, chemical, and biological means. Most treatment plants include a combination of two or more of these operations and processes. Physical unit operations include screening, mixing, sedimentation and filtration operations, among others. Precipitation, gas transfer, absorption and dis-infection are common examples of chemical processes. Biological treatment is used primarily to remove biodegradable organic substances, by converting these substances into gases or into solids that can be removed by settling. Biological treatment is also used to remove nitrogen from wastewater.

Treatment systems vary depending upon the permitted quality of effluent, space limitations, and other considerations. The level of treatment received ranges from primary, which is largely a physical process removing settleable solids, to secondary treatment where biological and chemical processes remove the bulk of the organic matter.[1] Depending on the jurisdiction and receiving stream, tertiary treatment may be required to remove other items such as nitrogen, or chlorine, which was added in the clarifying stage. In some cases, depending on the level of tertiary treatment, the effluent may become "drinking water" quality.

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[1] Metcalf & Eddy, Inc., 1991

When determining the most effective facility type for an area, many factors come into play including regional population, the cost of land, and the capital associated with the machinery. Common treatment processes at wastewater facilities include aerated lagoons, activated sludge, trickling filters, and oxidation ditches; some plants combine components to achieve a higher quality effluent.

3.1.3 Disposal/Discharge System

Following treatment of the wastewater, the effluent is discharged from the plant. Methods for discharging treated wastewater include land application, recharge or injection, re-use for agricultural or industrial purposes, or direct discharge into a receiving surface water body. The chosen method depends on factors such as plant location, climate, and receiving water characteristics.

3.2 DEFINITIONS OF WASTEWATER STREAMS

Wastewater is a generic term for discarded water-based effluents that are contaminated with various pollutants. These pollutants can range from human and animal wastes to chemicals, to residues from food processing such as sugars and starches. Regulatory agencies classify different types of wastewater into various categories depending upon what the effluent contains. As different pollutants require different treatment technologies and/or processes, regulators must know the components of a waste stream in order to write effective guidelines for a facility's effluent discharge into receiving waters.

3.2.1 Domestic/Municipal Wastewater Streams

Municipal, or domestic, wastewater streams are generated by cities and towns with wastewater collection systems that direct sewage and other waste streams to a centralized treatment plant. Domestic wastewater streams may include household, commercial, institutional, and recreational sewage sources, and in some cases industrial sources.[2]

3.2.2 Industrial Wastewater Streams

Industrial wastewater streams include those generated by food processing plants (e.g., canneries), heavy industry (e.g., pulp and paper mills), and animal operations.[3] Industrial wastewater streams tend to be highly concentrated (as opposed to municipal wastewater streams that are comparatively more dilute) and can contain industrial pollutants such as organic byproducts, chemicals, pesticides, or heavy metals.

3.2.3 Agricultural Wastewater Streams

Agricultural wastewater streams are generated primarily by farms and ranches and are often treated onsite. In particular, animal feeding operations (AFO's), where animals are kept and

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[2] Metcalf & Eddy, Inc., 1991; Chapter 173-216-030 WAC

[3] For example, see *Chapter 173-216-030 WAC*

raised in confined situations (as opposed to open grazing),[4] generate large amounts of liquid waste that must be treated prior to release into receiving streams. AFOs may contribute pollutants such as nitrogen, phosphorous, organic matter, sediments, pathogens, heavy metals, hormones, antibiotics, and ammonia to the environment and typically have a high biological oxygen demand (BOD) on receiving waters.[5] Agricultural wastewater from animal operations is generally included as an industrial wastewater.[6]

3.3 GOALS AND OBJECTIVES OF WASTEWATER TREATMENT PLANTS

Operators and Supervisors of wastewater treatment plants strive to discharge the cleanest and safest effluent possible into the receiving waters; primarily because they are concerned with permit compliance issues, but also because they take pride in their facilities and operations when they are operating well. However, they also strive to process the wastewater stream in the most efficient manner possible – in part because many treatment plants must work within a tight budget and with a small staff.

Because of these limitations, many plants do not explore treatment alternatives once construction is completed unless expansion is required or a problem arises that cannot be solved by manipulating the existing system. When a problem does arise, operators rarely conduct a systematic evaluation of all treatment options. Instead, they often adopt the first potential solution to present itself, as long as the potential benefits of the treatment outweigh the costs of continuing to try to solve the problem without intervention. Furthermore, wastewater treatment facility operators and engineers want the technologies they adopt to be proven in "real-life" situations and be documented by independent and credible sources. They do not want 'lab only' products. This requirement presents significant barriers to the permanent adoption of new treatment technologies.

3.4 ISSUES FACING THE WASTEWATER INDUSTRY

Relative to water, wastewater facilities face a more dynamic environment where problems can arise. These problems are most frequently associated with aesthetic byproducts of the treatment process (e.g., odor/air quality, water quality) but also involve permit compliance issues and physical constraints of the treatment plant's location that prohibit expansion to increase plant capacity. Problems associated with the process itself can be exacerbated by certain weather conditions (e.g., cold temperatures) and changes in the influent following heavy precipitation.

The following discussion presents some of the most pressing issues facing the wastewater treatment industry and some potential solutions. This is not a comprehensive list, but it reflects the range of treatment options available and ramifications for energy consumption.

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[4] EPA, 1999

[5] EPA, 1999

[6] Chapter 173-216-030 WAC

3.4.1 Permit Compliance/Stringent Discharge Requirements

A major issue facing wastewater treatment plants is maintaining permit compliance in the face of increasingly stringent discharge regulations. Meeting permit requirements is becoming more challenging as regional populations increase while water quality standards are tightened. Depending upon the discharge location/receiving water, many treatment plants are facing severe discharge limitations. Permit violations may involve elevated levels of fecal coliform bacteria, BOD, TSS, nitrogen, phosphorus, or ammonia—the latter two having particularly low limits. Levels of phosphorus, nitrogen and ammonia are being severely restricted in a number of river receiving water systems. New and more stringent Total Maximum Daily Loads (TMDLs) for effluent components pose significant challenges to plant operators while non-water quality decisions, such as the listing of the Chinook salmon as a threatened species under the Endangered Species Act, require regulators to comply with additional issues when writing permits.

Many wastewater treatment plants (WWTPs), when faced with impending permit violations, will attempt to manipulate their system—for example, by altering the aeration system or modifying other treatment components — before considering other solutions. Facility operators may use additives when a treatment system is not functioning at an optimal level, if they are confident that the additives will not significantly disrupt their overall treatment process. Some additives exist that improve digestion of organic constituents, thereby reducing the BOD and other constituents in the effluent. If simple solutions appear unworkable, facility operators may evaluate other options, including modifications to equipment. For example increased filtration may be used, which can considerably increase energy requirements as more pumps are required to push waste through the filters. Restrictions are forcing some facility managers to evaluate advanced wastewater treatment options, which are expensive, complex to construct and manage, and more energy intensive. These solutions require significant evaluation prior to implementation.

3.4.2 Widely Varying Flow Ranges

Many wastewater treatment facilities must deal with widely varying flow ranges, particularly in regions with combined sewer/stormwater systems. Treatment systems rely on bacterial digestion of the various pollutants in the wastewater. However, when the influent is diluted with large volumes of stormwater, the necessary bacteria populations can die off due to a lack of sufficient nutrients.

3.4.3 Expansion/Capacity

A significant concern for wastewater treatment plants is finding ways to treat higher volumes of wastewater while still achieving the same quality of effluent -- without expanding existing facilities or building new facilities. This is of particular concern to small municipalities that lack funds for large construction projects. Insufficient capacity is often the result of population growth, which puts a greater demand on wastewater treatment facilities and their receiving waters.

Faced with the need to expand capacity, facility managers attempt to optimize existing system performance to the greatest degree possible. Methods of optimization include reducing extraneous inflows and enhancing the existing treatment process. Enhanced treatment options can include operational changes, equipment modifications, and additives. In most cases equipment modifications or additions will result in increased energy consumption for the facility.

To accomplish a capacity expansion without expanding the actual footprint of the facility, treatment plant supervisors and operators will not only adjust their operational procedures, but may consider implementing new technologies. Some new equipment alternatives are available to reduce solids build-up, resulting in increased plant capacity. Some newer equipment technologies require a smaller amount of space relative to their treatment capacities. Many operators at smaller facilities, however, report resource constraints in their operations and maintenance budgets that can restrict their access to, and adoption of, emerging technologies.

Not much specific information is available about changes in the quality, volume, or content of these waste streams. Economic growth and industrial expansion have added to the waste stream in recent years, straining the capacity of many wastewater facilities. At the same time, new environmental regulations have placed greater emphasis on the effluent quality. This often requires longer detention times for wastewater within the treatment system, slowing total flow and further stressing the facility.

3.4.4 Odor

Another problem facing wastewater treatment plants is odors. Odors are the result of aerobic and anaerobic breakdown of wastewater components. The dominant wastewater treatment odor is hydrogen sulfide (H_2S), (the “rotten egg” smell) that results from anaerobic decomposition. Ammonia gases are also produced through anaerobic digestion.[7] Odors can originate from various sources, such as open lagoons, when sludge blankets in lagoons turn over and float on the surface, and also at intake points where raw sewage enters the plant.

Historically, odor control was achieved by locating treatment plants in remote areas, minimizing flow turbulence, and adding chlorine. A typical response involves adjusting the process (e.g., adding aeration). They then may consider additives to enhance the process or considering adding odor-removing devices. At present, a large number of odor-control options are available.

Engineered equipment solutions to odor control are also available – but tend to be energy intensive. For instance, airtight covers installed over lagoons trap polluted air. The polluted air can then be sent through a scrubbing or bio-filtration system that removes odor-causing molecules before release to the atmosphere. Numerous options for the bio-filtration of bio-gases exist; these generally scrub sulfide from bio-gas by utilizing chemical reactions in the bio-filtration reactor.

3.4.5 Training in Technology

Several operators interviewed indicated that unfamiliarity with new technologies kept them from considering or implementing energy-efficient equipment and processes. While training is

[7] King County Wastewater Treatment Division, 1999

offered in the form of Continuing Education Units, the courses offered have not kept pace with the changes in technology.

Even those operators most inclined to educate themselves about new technologies often have difficulty finding courses with updated curricula. One operator noted that he makes an attempt to send his staff to training sessions dealing with controls technologies and variable speed drives, only to discover that sessions billed as training seminars instead resemble vendors' fairs. This operator reported that he has had difficulty finding training that dealt with even the most rudimentary computer applications, to say nothing of the more sophisticated optimization technologies that are currently standard in the industry.

This raises concern that facility managers who are apprehensive about new technologies are effectively forestalling their adoption by the industry as a whole, since an effective demand cannot be demonstrated. A need exists to expand the range of continuing education courses that are offered.

3.4.6 Privatization

Another pressing issue facing an increasing number of municipal wastewater treatment plants is the national movement towards privatization. While only a few facilities in the Northwest region have adopted privatization, market factors could cause the numbers to increase. Privatization involves the transfer of operations to a private corporation. Threat of privatization has caused publicly-owned facilities to feel increased pressure to optimize their operations in order to maintain long-term control of their facilities. For instance, one design firm representative indicated that wastewater treatment facility managers often approach his firm seeking assistance in increasing cost (and energy) efficiency and reliability in order to resist and privatization.

3.5 ENERGY CONSUMPTION

Wastewater treatment facilities in the Pacific Northwest annually consume 2249 GWh. Municipal facilities and non-municipal facilities consume approximately 997 GWh and 1252 GWh, respectively. Estimates of energy consumption at non-municipal facilities were calculated using flow data supplied by the U.S. Geological Survey. A detailed explanation of this calculation is in the methodology section.

Energy is an important wastewater treatment operation cost. Wastewater treatment plants are generally among the community's largest energy consumers, accounting for 1 to as much as 3 percent of a community's energy usage, and 0.1 to 0.3 percent of the nation's total energy usage.[8] Assuming annual energy consumption of 171,000 GWH for the Pacific Northwest region, municipal and industrial wastewater account for more than one percent of the total. Energy costs consume 15 to 30 percent of a large WWTF's and 30 to 40 percent of a small WWTF's operation and maintenance budgets – the difference is due largely to economies of scale that can not be achieved by the smaller facilities. On a regional basis smaller facilities consumed less power than medium or large facilities, even though they account for three times

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[8] Water Environment Federation, 1997

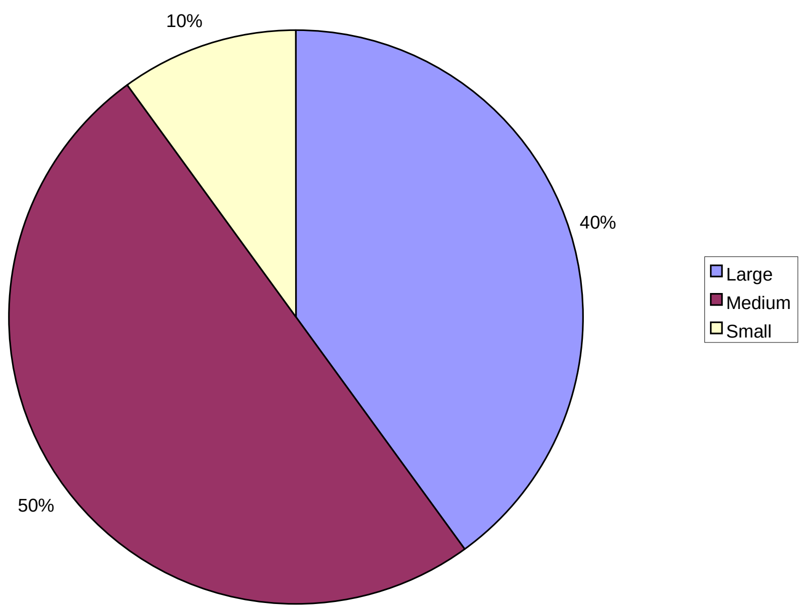
as many sites. Exhibit 3-2 presents a breakdown of energy consumption by treatment type and size/flow.

Exhibit 3-2
Municipal Wastewater Energy Consumption in GWh by Treatment Type and Size/Flow

	Large	Medium	Small	Total
Activated Sludge	247	338	36	621
Lagoon	12	39	19	70
Oxidation Ditch	16	6	0	22
Trickling Filter	0	30	4	34
Unknown/Other	125	84	41	250
Grand Total	400	497	100	997

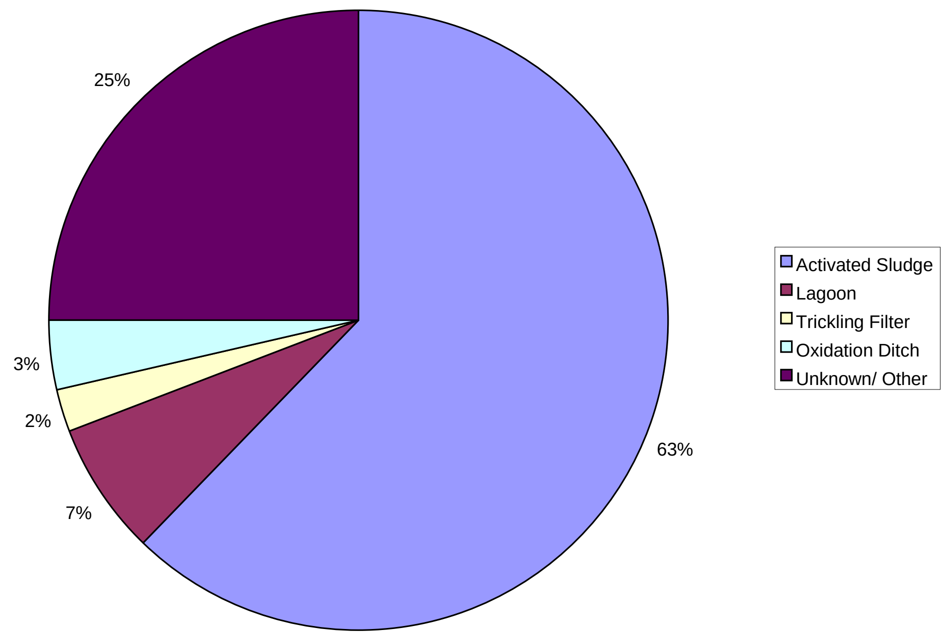
Municipal wastewater facilities in the Pacific Northwest treat about 547,778 million gallons and consume approximately 997 GWh each year. Small wastewater treatment plants (defined as those capable of treating between 0-1 MGD) comprise nearly three quarters of the 842 Pacific Northwest facilities. However, these plants consume only 10 percent of total energy. About one half of all energy consumption within the wastewater industry is used at medium sized facilities (1-20 MGD). Large facilities are relatively uncommon in the region; only 2 percent of Pacific Northwest wastewater plants can treat more than 20 MGD. However, as shown in Exhibit 3-3, the 2 percent consume 40 percent of total industry energy.

Exhibit 3-3
Energy Consumption by Facility Size



The difference in energy consumption is attributable, in part, to different treatment types commonly utilized by different sized facilities. Large wastewater plants are generally located near population centers which generate large waste streams. To treat large volumes of wastewater at a rapid flow rate, a treatment known as activated sludge is usually employed. Activated sludge facilities can treat high volume waste streams with minimal detention time. They are, however, very energy intensive. The high flow rates at large facilities, combined with relatively high energy intensity required per unit of treated wastewater, results in disproportionate energy consumption at large plants. Small wastewater plants, on the other hand, are typically located in rural areas with relatively low flow rates. For this reason, lagoon systems are often employed at these plants. Lagoons require a much longer detention time for wastewater, making them well-suited to slow flows. Natural processes are allowed to do more treatment at lagoon facilities; consequently, they are relatively efficient users of energy. Slow flows and efficient treatment processes result in low energy consumption at small facilities.

Exhibit 3-4
Municipal Wastewater Energy Consumption
by Treatment Type



Source: BacGen Database

Exhibit 3-4 shows that activated sludge facilities consume approximately 63 percent of total energy required by wastewater treatment plants in the Pacific Northwest. Despite the large number of lagoon systems in the region, they account for only 7 percent of total consumption. 'Unknown/other' facilities, which comprise 25 percent of total energy consumption, are wastewater plants for which limited information is available.

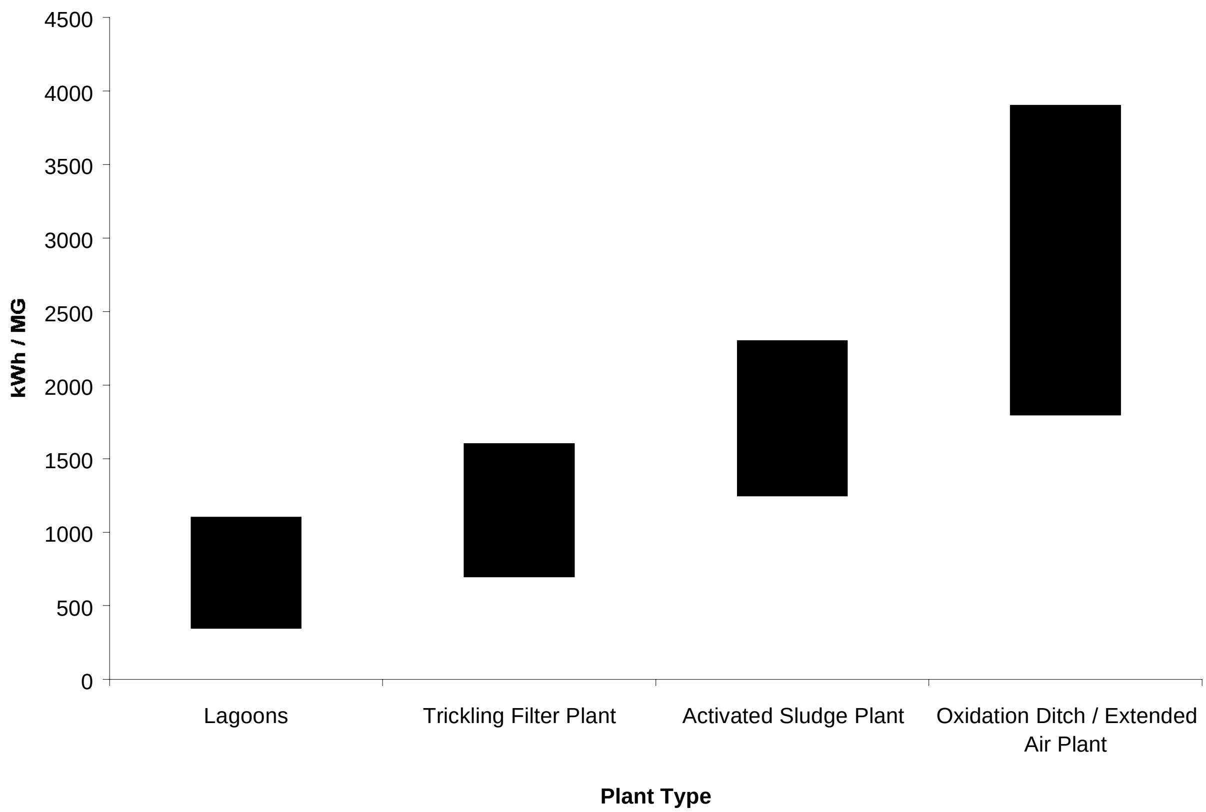
3.5.1 Relative Energy Consumption

Lagoons and trickling filters are the most energy efficient treatment systems, with activated sludge processes and oxidation ditches being relatively larger energy consumers. Average energy consumption for lagoons in the Western United States ranges from approximately 300 to 1,200 kWh/MGD treated.[9] An oxidation ditch or extended aeration facility typically consumes from 1,600 to 3,700 kWh/MGD of wastewater treated. Exhibit 3-5 presents the various components of the wastewater treatment process and characterizes them according to

[9] Water Environment Federation, 1997

electricity consumption. Aeration emerges as a significant energy consumer, and is the greatest single source of consumption in lagoon systems.

Exhibit 3-5
Distribution of Unit Energy Consumption for Secondary Wastewater Treatment Plants by Treatment Type



Source: EPRI CEC Report CR-104300, July, 1994, Figure 3-1

Unit energy consumption data has been assembled to compare the energy-efficiency of these treatment types. That is, how much energy is required by each method to treat one million gallons of wastewater. The large range in energy consumption among wastewater facilities of different sizes is attributable to economies of scale. Large facilities generally are more energy efficient than smaller facilities. Therefore, on a MGD basis, large facilities are more cost efficient. Oxidation ditches and extended air facilities typically require the most energy per unit of treated wastewater, while lagoons offer the most energy-efficient treatment process.

3.5.2 Energy Consumption by Treatment Type

This report explores energy use at four types of treatment facilities: 1) activated sludge plants, 2) lagoons, 3) trickling filter plants, and 4) oxidation ditches /extended-air plants. Primary treatment methods at these facilities may be very similar. All wastewater plants, for example, need to filter and remove solid matter from incoming streams. Energy costs at different plant types will not vary significantly at this early stage. Typically, pumps are the most prominent energy consumers.

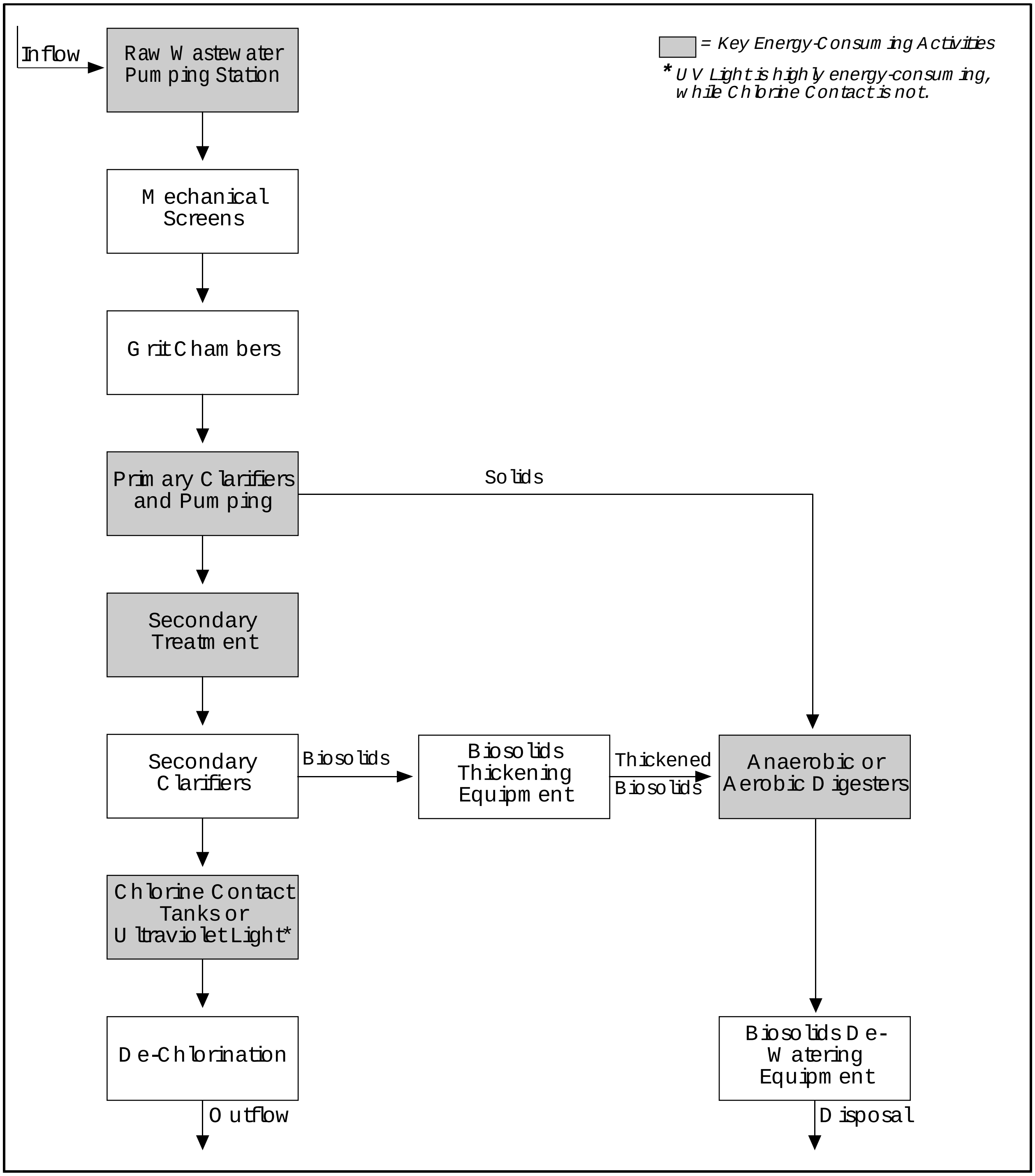
Secondary treatment types vary widely, although most employ bacterial cultures to remove organic materials still remaining after primary treatment. These bacterial cultures require oxygen to function. Aeration may be defined as the introduction of air into secondary treatment tanks to facilitate the decomposition of organic matter in wastewater.

There are two basic methods of aeration: 1) the injection of air into wastewater via submerged diffusers, and 2) the agitation of wastewater to promote aeration through contact with the atmosphere. Both of these methods consume large amounts of energy. In fact, aeration (powered by fans/blowers) constitutes the largest energy expense at most wastewater treatment facilities.

3.5.2.1 Activated Sludge Plants

Activated sludge plants rely on the activated sludge secondary treatment process. This is the most common form of secondary treatment. Activated sludge facilities are usually located near urban centers, and are typically larger and more energy intensive than other systems. A schematic of a sample activated sludge facility is presented below in Exhibit 3-6.

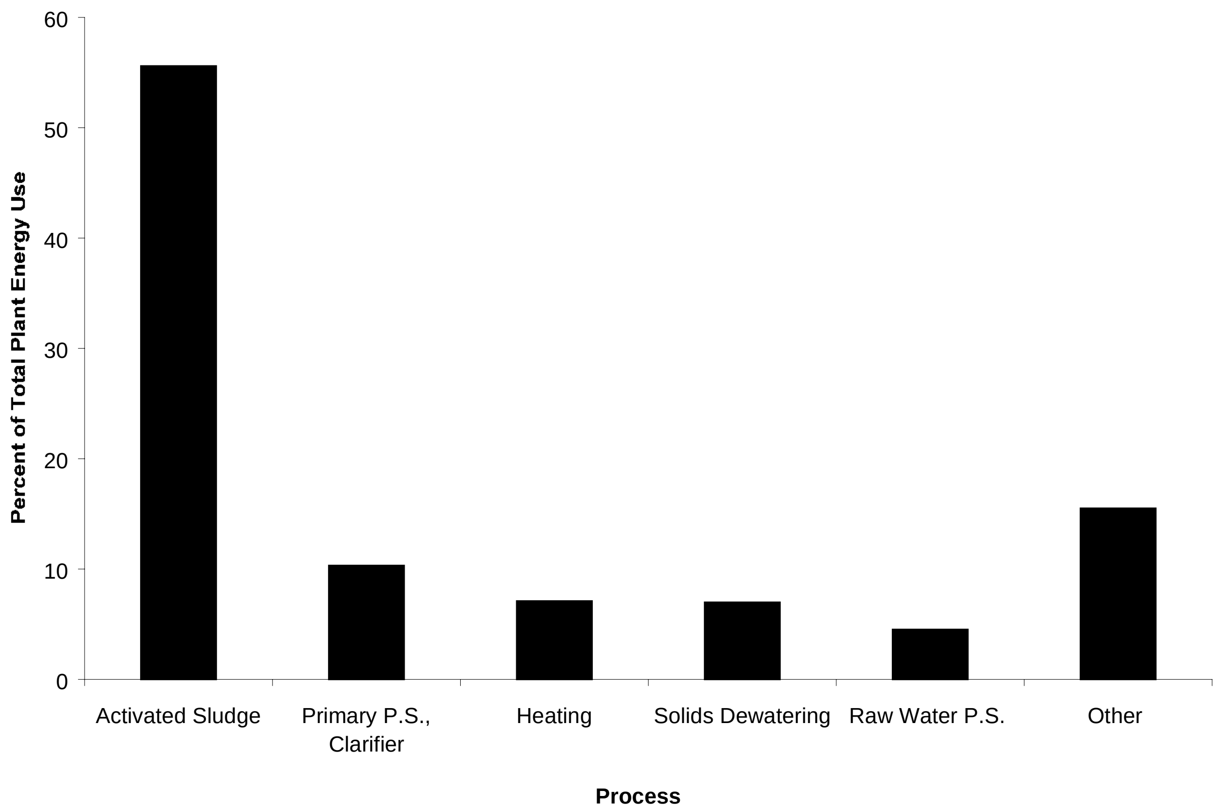
Exhibit 3-6
General Schematic for Activated Sludge Wastewater Treatment Facility



Activated sludge processes involve two components: biological conversion and solids separation. Biological conversion entails the decomposition of organic matter within the wastewater stream. Solids are then 'settled' and removed before the water is discharged for release or further treatment.

Although pumps are energy-intensive, energy use at activated sludge plants is concentrated in the activated sludge process itself. Aeration equipment is the major energy consumer. Energy efficiency in activated sludge treatment varies depending on the fineness of the diffused-air system. Diffusion of smaller air bubbles produces more surface area per volume of air released. This results in more efficient wastewater treatment and less energy use. At some activated sludge facilities, furthermore, ultraviolet light may be used as an additional purifier – one with a much greater energy use than that of chlorine contact.

Exhibit 3-7
Energy Consumption by Activated Sludge Facility Component
for a 7.5 MGD Secondary Wastewater Treatment Plant



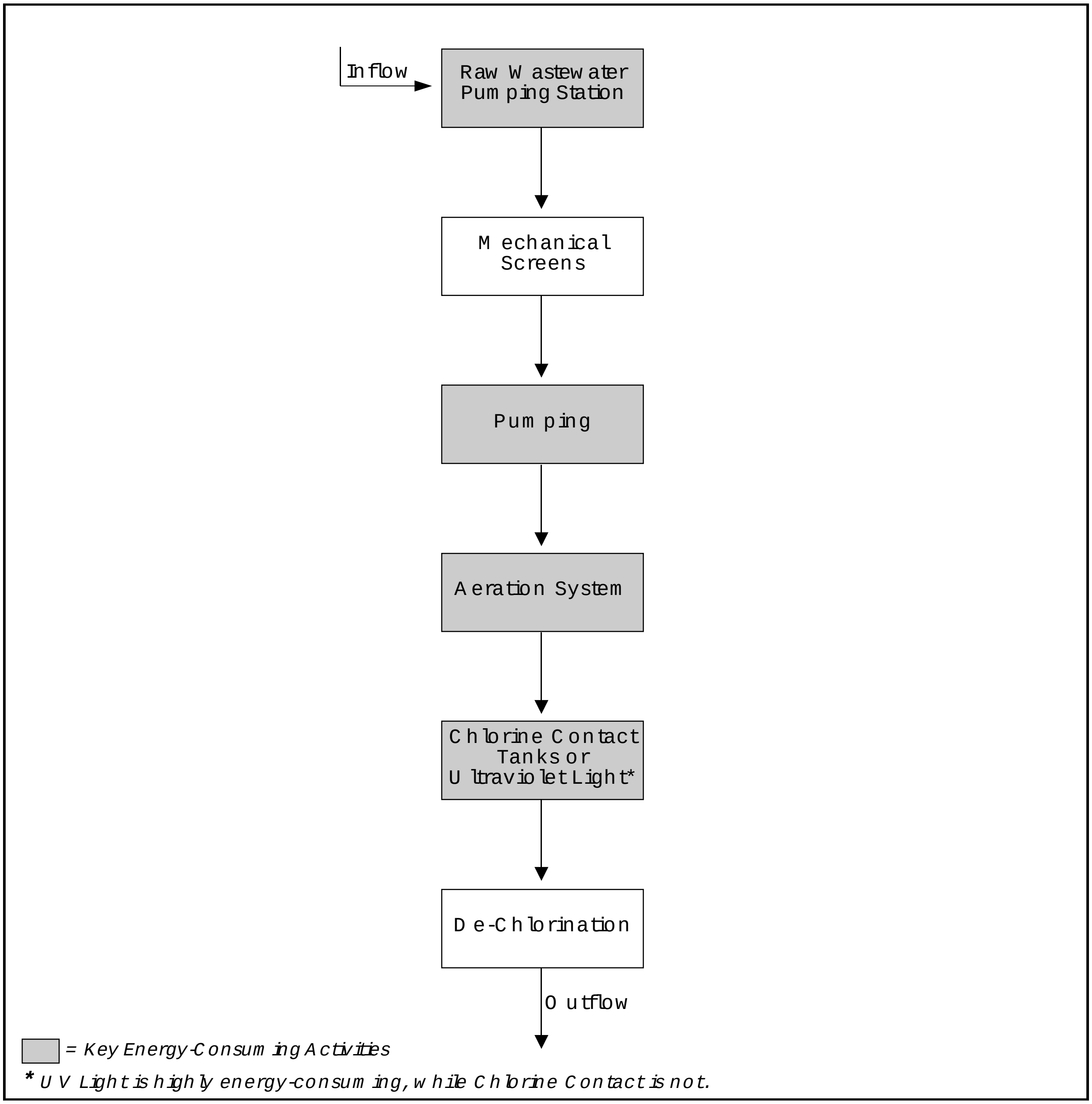
Source: EPRI CEC Report CR-104300, July, 1994, Figure 3-4

Activated sludge processes (fans/blowers) account for more than one half of energy consumption at typical wastewater treatment facilities – as shown in Exhibit 3-7. Pumps also consume a large share of energy, generally requiring about fifteen percent of total plant use. Heating and solids dewatering are processes sometimes employed to treat solid waste matter that has been removed from wastewater streams. Other processes such as chlorine mixing and effluent filtering each use less than four percent of consumed energy.

3.5.2.2 Aerated Lagoons

Aerated lagoons are large basins where wastewater is stored and treated before its release. They are similar to activated sludge plants, but typically require much more land area. For this reason, lagoons are less common in western Pacific Northwest regions where land is less available. They typically operate at a lower inflow rate than do other secondary treatment processes. Lagoons are most common in rural areas with plenty of available land and small wastewater streams. A schematic of a typical lagoon wastewater system is presented below in Exhibit 3-8.

Exhibit 3-8
General Schematic for Lagoon Wastewater Treatment Facility



At lagoon treatment facilities, on-site processing of solids is not an integral part of usual operations. After screening, wastewater is pumped directly into the lagoons, where the aeration system operates. This component supplants the clarifying and digester stages observed in the activated sludge system.

Aeration and pumping constitute the most significant energy uses at lagoons. Many lagoons save energy through the use of surface agitators rather than diffusers for aeration. Low inflow rates, furthermore, place fewer demands on pumping equipment. Lagoons generally use less energy than other secondary treatment methods.

3.5.2.3 Trickling Filter Plants

Trickling filters are an alternative to activated sludge treatment. These systems rely on gravity to move water through a series of 'filters.' Each filter is coated with bacterial colonies that consume organic matter in the water. Wastewater is recirculated through the filters until the water quality has reached a desired level.

Pumps are the primary energy consumers at trickling filter plants. Wastewater recirculation is a significant part of the trickling filter process. Although pumping is energy-intensive, aeration is unnecessary because the filters allow for suitable oxygen flow through the mechanism.

Trickling filter plants are not as common as other types in the Pacific Northwest. Maintenance restrictions and difficulty of cleaning have limited their popularity.

3.5.2.4 Oxidation Ditch /Extended Air Plants

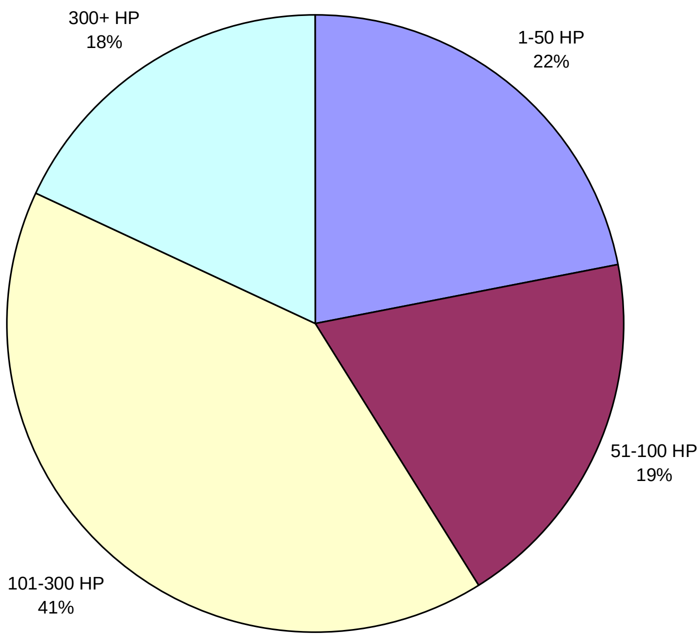
Oxidation ditch plants are types of activated sludge plants. Screened wastewater enters a large, ring-shaped channel and is aerated as it circulates. Most oxidation ditch plants operate in extended-air mode, which lengthens the time of exposure to the open air. This treatment method is usually associated with slow wastewater flows and long solids-retention times.

Oxidation ditch plants typically use more energy than other secondary-treatment methods. Most of this energy is consumed in aeration and pumping.

3.6 MOTOR AND PUMPS IN WASTEWATER

Most energy consumed at wastewater treatment facilities is used by pumps and fans/blowers. Pumps convey wastewater through successive stages of the treatment system, while fans/blowers supply the oxygen necessary for aerobic treatment. Distribution of energy consumed by pumping systems at Pacific Northwest water & wastewater facilities is shown below:

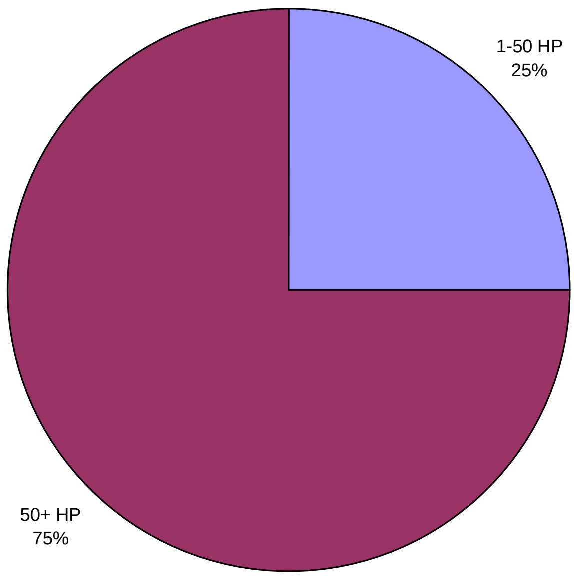
Exhibit 3-9
Energy Consumed by Water & Wastewater Pumps



Source: Energy Efficiency within the Pulp & Paper, Waste & Wastewater, and Irrigation Markets in the Pacific Northwest, Ducker Worldwide, 1999.

Pumps of greater than 100 horsepower consume the majority of energy required by water & wastewater pumping systems. However, small pumping systems (50 horsepower or less) comprise a significant (22 percent) share of total energy consumption. This trend is also evident in fans/blowers; distribution of horsepower consumed by these systems is shown below in Exhibit 3-9.

Exhibit 3-10
Energy Consumed by Water/Wastewater Fans/Blowers



Source: Energy Efficiency within the Pulp & Paper, Waste & Wastewater, and Irrigation Markets in the Pacific Northwest, Ducker Worldwide, 1999.

Fans/blowers greater than 50 horsepower consume three quarters of energy used by these systems. Small fans/blowers, however, are significant contributors to total energy consumption.

4. WASTEWATER WANTS AND NEEDS ASSESSMENT

4.1 OVERVIEW

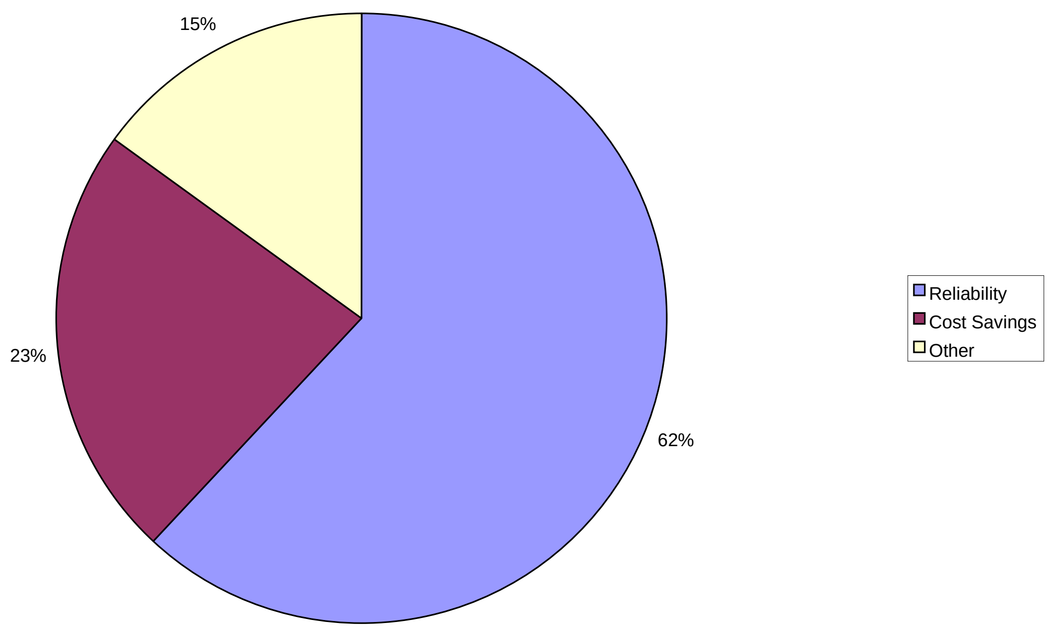
Meeting permit continues to drive all wants and needs for the industry, from operators in the smallest facilities to those on the largest urban utilities, from international engineering firms to three-person shops. The industry clearly has a unified focus and purpose. The general desire amongst both operators and design / engineering firms is to maintain or improve reliability of their facilities – this desire is constant and clear. Underlying this desire is obviously the permit, therefore energy efficiency opportunities must be framed with this in mind.

Opportunities do exist. For example, many facilities have installed VSDs or are planning to. All design firms now include VSDs as part of their specifications. The market however is not saturated though it seems that some level of market transformation has occurred as facilities are choosing the VSDs outside of utility programs. Energy reducing process changes are another area of interest for operators, however design / engineering firms do not generally share this interest. A more specific discussion of needs and wants in the wastewater industry is presented below. Section 4.2 describes the benefits most operators look for in technologies. Section 4.3 presents the criteria used in making purchase decisions, for example initial costs or reliability of equipment under consideration. Existing and planned retrofits / modifications are discussed in Section 4.4. Section 4.5 describes potential intervention strategies for wastewater facilities.

4.2 BENEFITS

When asked to consider the benefits of new technologies or processes in the wastewater industry, facility managers stated that reliability and cost controls were their primary areas of concern. Wastewater professionals seeking new technologies or processes may be addressing problems specific to their facility or region. Regardless of the benefits to be derived from such changes, however, they will not be implemented at the cost of reliability or financial stability.

Exhibit 4-1
Most Important Benefits of New Products and Services



Wastewater facility operators and managers consistently reported that reliability was a top consideration when examining new products and services. Ease of operation, reduced operating costs, and permit compliance were also considered very important by a large majority of interviewed wastewater professionals.

These preferences reflect most operators' preoccupation with permit compliance. Reliability concerns were mentioned constantly when discussing sought-after benefits of new equipment or processes because unreliable treatment systems could pose the greatest threat to permit compliance. Generally, operators are willing to consider benefits such as cost-reduction and design simplification when researching new products and services *if and only if* they are convinced that these benefits will not jeopardize their compliant status. One facility operator, when asked whether he would consider installing a new monitoring system designed to optimize dissolved oxygen levels and cut energy costs, replied that he 'would consider it when compliance becomes an issue.'

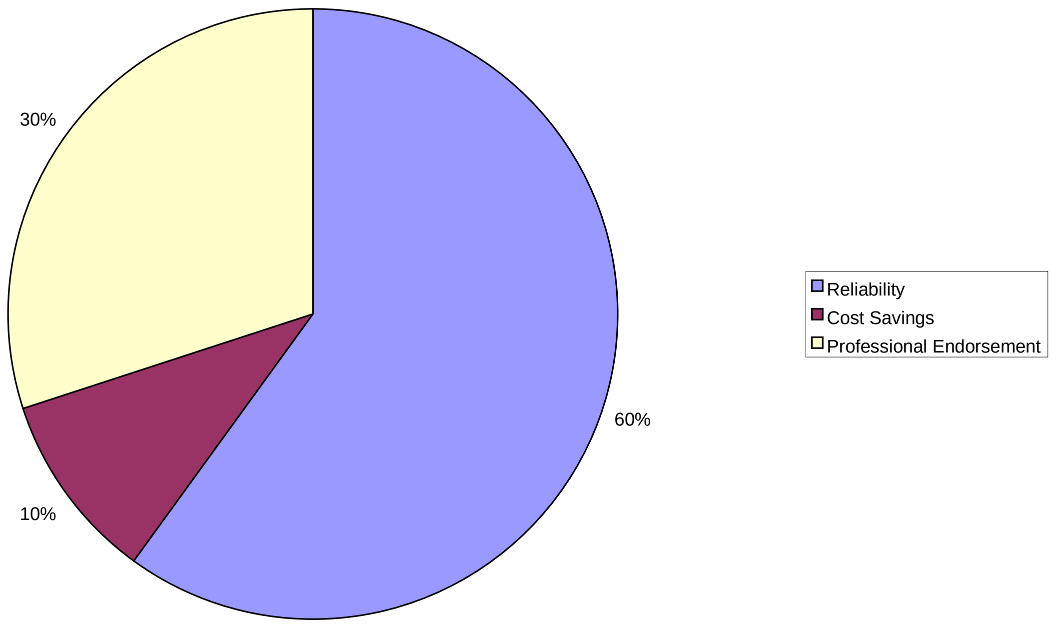
Exhibit 4-2
Important Benefits of New Products and Services

Very Important	• Improved Compliance • Ability to Handle Greater Flow • Easier Operation • Reduced Operating Costs • More Precise Control / Monitoring • Greater Reliability • Less Downtime for Maintenance
Somewhat Important	• Fewer Odor Problems • Ability to Handle Weather Changes • Reduced Energy Usage • Reduced Chemical Costs • Simpler Design

4.3 PURCHASE DECISION CRITERIA

When considering equipment purchases or procedural changes, wastewater facility operators are most concerned with reliability. This underscores a fundamental reality of wastewater facility management: permit compliance may be threatened without consistent, reliable treatment practices.

Exhibit 4-3
Most Important Purchase Decision Criteria



Almost 100 percent of respondents stated that ‘reliability’ would be a very important factor in decision-making. Ease of operation, operating costs, and increased flow capacity were also considered very important by most operators and managers.

Most wastewater operators look to other facilities for information when considering new equipment purchases or procedural changes. A large majority of respondents stated that recommendations of other facility operators would be a very important factor in any decision. Wastewater professionals are a close group; operators are usually aware of treatment practices at nearby facilities. They often rely on each other for information, and generally are unwilling to consider new practices until they have been proven elsewhere.

Exhibit 4-4
Important Purchase Decision Criteria

Very Important	• Operating Costs • Ease of Operation • Ability to Handle Increased Flow • Reliability • Regulator – Approved • Used at Other Regional Facilities • Payback Period
Somewhat Important	• Initial Cost • Energy – Efficiency • Ability to Handle Weather Changes • Supported by PNPCA • Recommended by Engineering Firm • Supported by Community Groups • Endorsed by Technical Research Group

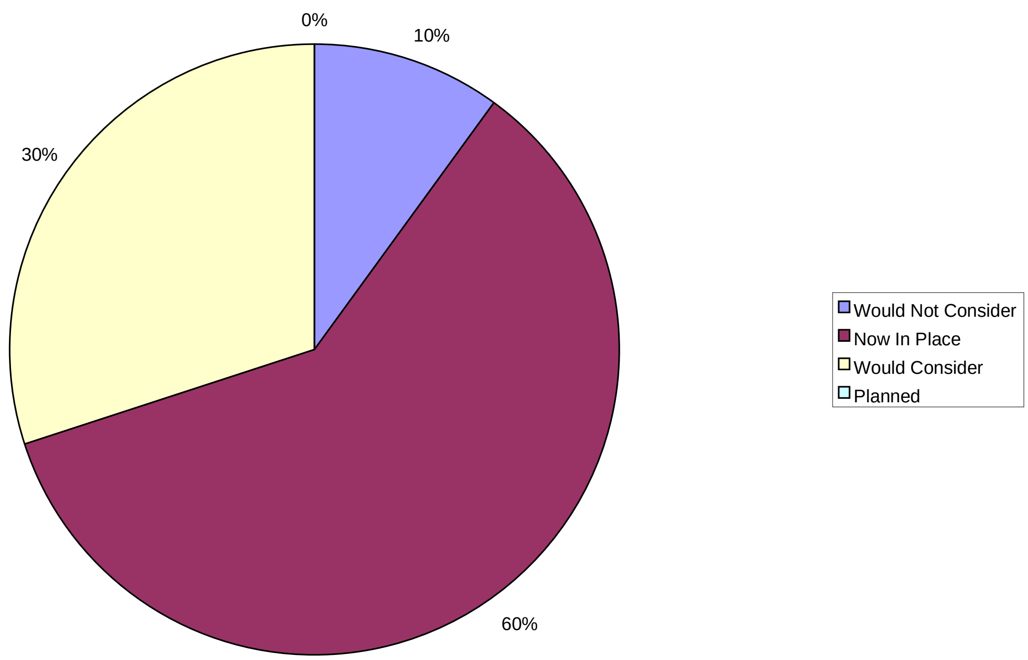
4.4 PROGRAM PARTICIPATION AND INTEREST

When asked if they had any systematic programs in place to conserve energy, most respondents stated that they did not. In fact, previous research has shown that systematic conservation programs are found in larger facilities (50 MGD or higher), but rarely in smaller facilities. This is not to say that energy efficiency does not occur, only that it takes place in a less systematic and structured environment. For example, a majority of operators stated that they have or plan to install VSDs – primarily outside of any utility sponsored programs.

Operators were asked whether they would consider undertaking a series of energy efficient equipment change-outs/retrofits, process modifications, and training in energy efficient best practices. Generally operators were interested in most offerings as long as they were consistent with their facility type. In fact, it was rare that an operator said they would absolutely not consider an energy efficient measure or practice. This suggests that while conservative in their approach, operators are not closed minded.[1]

Nearly all respondents stated that they have installed VSDs, are planning to install or would consider installing them. Exhibit 4-5 shows that only 10 percent would not consider installation of VSDs. When asked why they would not consider VSDs, operators stated VSDs were not appropriate for their facilities. Given the market progress borne out in the interviews as well other sources, there may not be a need for initiatives focused on increasing penetration.[2]

Exhibit 4-5
Would You Consider Installing Variable Speed Drives in Your Facility?



In addition to VSDs, operators are interested in process improvements generally and aeration improvements specifically. As shown in Exhibit 4-6 majority of operators would consider or plan to make use of process modification. Note that most of the facilities interviewed are

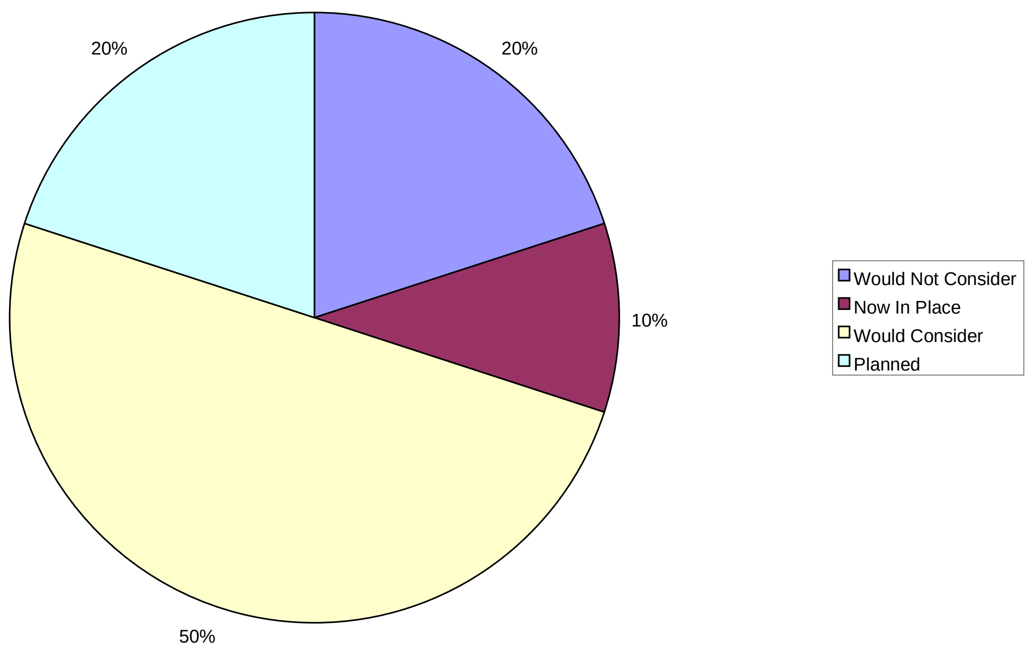
[1] Biological additives and micro-nutrients being the only change that will not receive consideration.

[2] *Energy Efficiency within the Pulp & Paper, Water & Wastewater and Irrigation Markets in the Pacific Northwest,* Ducker Worldwide.

smaller (staff of 2 to 5 and flow of less than 5 MGD) and as such are unlikely to have the resources for process controls and monitoring that are necessary for a process modification.[3]

While there was interest in process modification for aeration systems, there was not much interest nitrification processes, sulfur dioxide mixing, or pumping. In many cases the lack of interest was related lack of need, i.e. the processes are not needed in their systems.

Exhibit 4-6
Would You Consider Process Modification At Your Facility?



Training was another area that was of interest to operators. Nearly all operators were interested in learning how to optimize systems and make better use of controls. There was some interest in learning to rewind motors as well. The interest in training may be a function of the resource constraints that smaller facilities face. With larger facilities consulting engineers can be brought in to educate staff in the best practices; in smaller facilities this is not financially feasible.

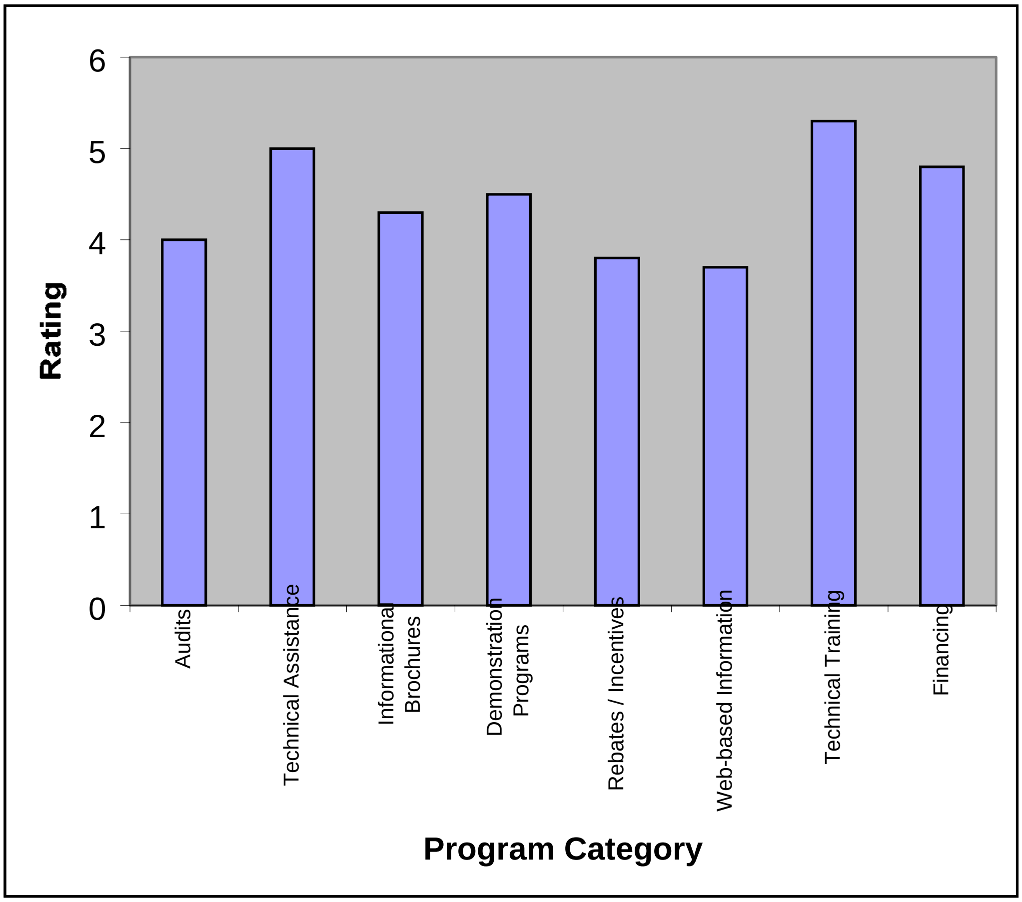
[3] Generally larger facilities, 5 MGD or more, do have controls and monitoring equipment that helps optimize wastewater systems.

A few facility managers reported that existing process control and monitoring equipment was underutilized. Due to lack of adequate training and the complexity of these systems, some operators are unable to fully realize their benefits. When maintenance is required or problems occur, the equipment is disconnected and discarded. "We've got monitoring equipment installed," one operator stated, "but we've had problems with it. We leave it off and do things manually." This scenario was not encountered frequently. However, if widespread, this problem certainly presents opportunities for energy-efficiency improvements and warrants further investigation.

4.5 INTERVENTION STRATEGIES

Wastewater facility operators stated that 'technical assistance' and 'training programs for technical staff' would be most helpful when implementing new technologies or practices. In many cases, technical assistance is necessary to ensure proper plant operation. This poses a problem at smaller facilities with limited financial resources. Large urban facilities may have greater access to consulting firms and engineers unavailable to smaller firms. Without this support, implementing new technologies and practices is unfeasible for small facilities in the long term.

Exhibit 4-7
Intervention Strategies



It is understandable that, due to resource limitations, technical assistance and training are very important to small facilities. Many facility operators stated their desire for financing programs to help allay the costs of equipment modifications. Wastewater facilities would certainly be more receptive to new equipment or practices with additional resources at their disposal.

Demonstration programs ranked high among those measures which would affect decision-making at wastewater facilities. Obviously, facility managers want to be certain that proposed changes to equipment or procedures can deliver as promised. If it can be demonstrated to the manager's satisfaction that equipment modifications or procedural changes will result in significant energy savings *and* not affect permit status then adoption is much more likely.

5. WATER SUPPLY INDUSTRY OVERVIEW

5.1 INDUSTRY OVERVIEW

Water is essential to many of humankind's most basic activities – agriculture, forestry, industry, power generation, and recreation. In the U.S., the ready availability of a supply of good quality water is expected. However, events of recent decades conspire to jeopardize that supply. Groundwater levels in certain areas have fallen dramatically since the 1940s, leading to higher pumping costs. Other surface and subsurface water sources are becoming increasingly polluted by urban, agricultural, and industrial wastes in spite of increased expenditure on wastewater treatment and legislation of minimum quality standards.

Human use of water involves its extraction from the hydrologic cycle, the continuous circulation of water in the Earth's atmosphere. Once freshwater is removed from surface or groundwater supplies, some means of conveyance is necessary to get the water from source to user. Conveyance mechanisms vary depending on geographic, economic, and political circumstances. In general, however, water conveyance systems include three major components:

- Suppliers (collection + storage + conveyance)
- Purveyors (filtration + purification)
- Distributors

Following is a brief summary of the major factors within the water industry:

5.1.1 Suppliers (collection + storage + conveyance)

During the mid-twentieth century, the Bureau of Reclamation and the Army Corps of Engineers erected dozens of dams throughout the American West. These projects, at considerable environmental cost (and federal expense), made the West's great waterways accessible to farmers and policymakers.

In the Pacific Northwest, states themselves are suppliers of water. All surface or groundwater within a state's boundaries is property of that state. Streams and springs flow into reservoirs or seep into groundwater aquifers, where water is collected and stored.

Water conveyance systems in the Pacific Northwest usually rely on gravity. For example, Tacoma's primary conveyance system is a gravity pipeline approximately thirty miles long. Relatively short conveyance distances and favorable topography lend themselves to this mechanism. Of course, gravity-conveyance systems are much less expensive and energy-intensive than pump-driven systems.

5.1.2 Purveyors (filtration + purification)

Purveyors are wholesalers who purchase water from suppliers and sell it to distributors. They are usually responsible for filtration and purification of their water before it is sold.

Water is treated in order to make it appropriate for municipal, industrial or agricultural use. Treatment methods vary depending on the eventual water application, for example, domestic drinking water must be filtered more thoroughly than industrial or irrigation water.

In Pacific Northwest states, there is little distinction between suppliers and purveyors. Several major cities, including Seattle and Portland, function as suppliers, purveyors, and distributors. Rural conveyance systems may be constructed by private firms or by the state itself. In some cases, individuals may contract directly with their respective states to secure rights to use water.

5.1.3 Distributors

Distributors deliver water to end-users. In many cases, distributors are cities or local water districts who purchase water from nearby purveyors and sell it to their citizens.

There exists a wide variety of water distribution systems in the Pacific Northwest. Distributors may be end-users themselves. In some rural areas, individuals or associations of individuals may contract directly with the state to divert water for personal use.

States have the responsibility of dispensing water within their borders. Most states, however, have failed to implement an equitable, sustainable water distribution policy. Lack of coordination in water policy has led to a multitude of agencies and districts with specific priorities and limited jurisdictions.

Recent collaborative efforts have explored basin-wide management strategies as a way to alleviate potential conflicts. The Watershed Management Act, for example, passed by the Washington State legislature in 1998, allows local citizens and local governments to join with state agencies and tribes to formulate watershed management plans.

5.1.4 Urban v. Rural Distinctions

State laws in the Pacific Northwest encourage relatively small water districts in rural areas. Large-scale infrastructure and centralized administration may be appropriate for water distribution near urban centers. However, these programs are often unfeasible in less populated regions.

Large water districts usually have greater resources at their disposal to fund infrastructure improvement projects. Smaller districts, however, generally lack the access to capital required for such projects. Montana law provides public funds for water distribution projects, but only if projected revenues are sufficient to pay for the project's operation and maintenance. The state of Oregon provides funds for water projects serving communities of less than 30,000 residents, but only if the district's financial resources 'are adequate to provide the working capital needed to operate and maintain the project.'[1] Many rural districts lack the resources to be eligible for this funding.

It is often more convenient for rural residents to simply raise groundwater for personal use. In Oregon, no permit is required to pump groundwater for domestic use if the diversion is less than 15,000 gallons per day. Groundwater in Washington State may be withdrawn without permit for residential or industrial use not exceeding 5,000 gallons per day. Idaho residents who rely on self-supplied groundwater are exempted from permit regulations.

Limited access to funds, state water laws, and fewer administrative restrictions have conspired to create a multitude of small, independent water districts throughout the rural Pacific Northwest. The scope and scale of these operations may be quite limited compared to municipal city systems. Their basic function, however, is the same – supplying water to homes, farms, and businesses.

5.2 DEFINITIONS OF WATER SOURCES

5.2.1 Groundwater

Most groundwater comes from precipitation. Precipitation infiltrates below the ground surface into the soil zone. When the soil zone becomes saturated, water percolates downward, saturating the soil. Groundwater continues to descend until, at some depth, it merges into a zone of dense rock and is trapped there. The process of precipitation replenishing the groundwater supply is known as recharge.

Underground layers of permeable rock allow considerable storage of water and act as major sources of water supply; these are known as aquifers. Groundwater is water drawn from these aquifers, wells, underground springs, or other non-surface sources. Continued drawing of water from ground sources can cause a reduction in surface water levels or stream base flows.

The process of precipitation replenishing the groundwater supply is known as recharge. In general, recharge occurs only during the rainy season in tropical climates or during winter in temperate climates. Typically, 10 to 20 percent of the precipitation that falls to the Earth enters water-bearing strata (aquifers).

Groundwater plays a vital role in the development of arid and semiarid zones, sometimes supporting vast agricultural and industrial enterprises that could not otherwise exist. However, continued withdrawal will deplete even the largest of groundwater basins so that development based on the existence of aquifers can be only temporary at best.

5.2.2 Surface Water

Surface water is water from streams, creeks, lakes, reservoirs, and rivers. Surface water also includes groundwater that is discharged into streams. The total runoff is equal to the total precipitation less the losses from evaporation from soil surfaces and plant leaves, storage (as in

[1] ORS 541.720

temporary ponds), and other such diversions. Surface water provides the majority of the water used by humans.

5.3 PURPOSE AND OBJECTIVES OF THE WATER MARKET MECHANISM

Usable freshwater is a scarce commodity. The ever-widening utilization of water for agricultural, industrial, and recreational purposes has given rise to growing concern over the availability of adequate water supplies to accommodate competing end-uses. The water market mechanism is charged with delivering water to end-users according to priorities established by economic, political and logistical circumstances.

The most obvious function of the water market mechanism is to provide safe water to the people who use it, and to do it cheaply and efficiently. Conflicting interests and priorities lie at the center of disputes over water use. Organizational structures have been established to forestall conflicts and resolve disputes within this charged industry. Administration and policymaking have become critical cogs in the water market mechanism, responsible for solving questions of competing claims to a scarce resource. The water rights described in section 5.6 detail each state's response to this challenge.

Once water rights have been established, the next task is to treat it to the degree necessary for its eventual end-user. Laws enacted at the national and state level determine the standards for water quality for municipal drinking water, water used in various forms of agriculture, and water used in industry. Furthermore, the recent growth of the conservation and environmental movements has led to national legislation protecting certain water sources and the wildlife that depend on them. These issues are taken up in more detail in section 5.4, while figures for water use by sector are given in section 5.7.

5.4 ISSUES FACING THE WATER SUPPLY INDUSTRY

Compared to facilities in the wastewater treatment industry, the routine operation of water supply facilities encounters relatively few serious problems. Facility managers' concerns run more to the upcoming regulatory changes than to current problems of permit compliance or capacity.

Water supply facility managers readily identify the Safe Water Drinking Act as the most important issue in the industry today. Particularly crucial will be upcoming decisions on the implementation of such portions as arsenic and radon control, required filtration, and groundwater disinfection.

There is much concern that complying with the new regulations will be prohibitively expensive, and that regulators are ignoring important differences between supply facilities' adaptability in the face of such sweeping changes. The mandatory disinfectant component, for instance, has a proposed 20-minute contact rule that will be impossible for small groundwater facilities to comply with, according to one facility operator. The arsenic regulations call for additional water testing that another operator called "excessive," and that will require major procedural changes in filtration and disinfection in some facilities, and structural changes in others.

Several operators cited supply issues as a major concern. Imminent legislation protecting salmon – with direct implications for drawing water from ground sources – makes it more difficult to determine how water supply facilities will satisfy ever-increasing demand. Quality is also an issue at the source; wellhead protection is a growing concern as standards have intensified with recent legislation.

Facility operators' viewpoints regarding the industry are further detailed in Chapter 6.

5.5 ENERGY CONSUMPTION

This section lays out the water supply process, highlighting the most energy-intensive steps. It is worth mentioning that groundwater generally requires less treatment than surface water, often involving only inflow pumping, possible chlorination, and pumping through the distribution system. As a result, facilities supplying groundwater tend to be less energy-intensive than those dealing with surface water. Water supply facilities in the Pacific Northwest consume an estimated 661 GWh per year, 332 GWh at municipal facilities and 329 GWh at non-municipal facilities. A discussion of this estimate is in the methodology section.

Surface water from reservoirs, lakes, rivers, canals, tunnels, and pipelines is delivered by means of gravity in some cases, but usually some method of pressurization is used. After the water reaches collection points, a raw water pumping station sends it through the treatment process.

Water supply facilities employ a variety of treatment processes, used in varying combinations, depending primarily on the characteristics of the water but also on its intended use. The first step in treatment is often a series of flocculation tanks. In a rapid mix tank, chemical additives such as aluminum sulfate (alum) cause particles to coagulate and then to settle. Settled particulates collect in the sedimentation tanks and are removed as residuals. Filtration through beds of fine sand or through crushed anthracite coal can trap finer suspended matter.

The purification process destroys harmful bacteria and deactivates viruses. Liquid chlorine is the most common chemical used in modern treatment plants and is usually applied before other treatment and as a final treatment before distribution. In some plants, ozone and ultraviolet light are used as disinfectants.

After treatment, water is pumped either directly into the distribution system or to an elevated storage location, such as a water tank. For adequate distribution, water systems must operate under pressure. In some cases, the gravity drop of water from its elevated storage location provides enough pressure; otherwise, it is supplied by a pumping station.

Exhibit 5-1
General Schematic of Water Treatment Plant

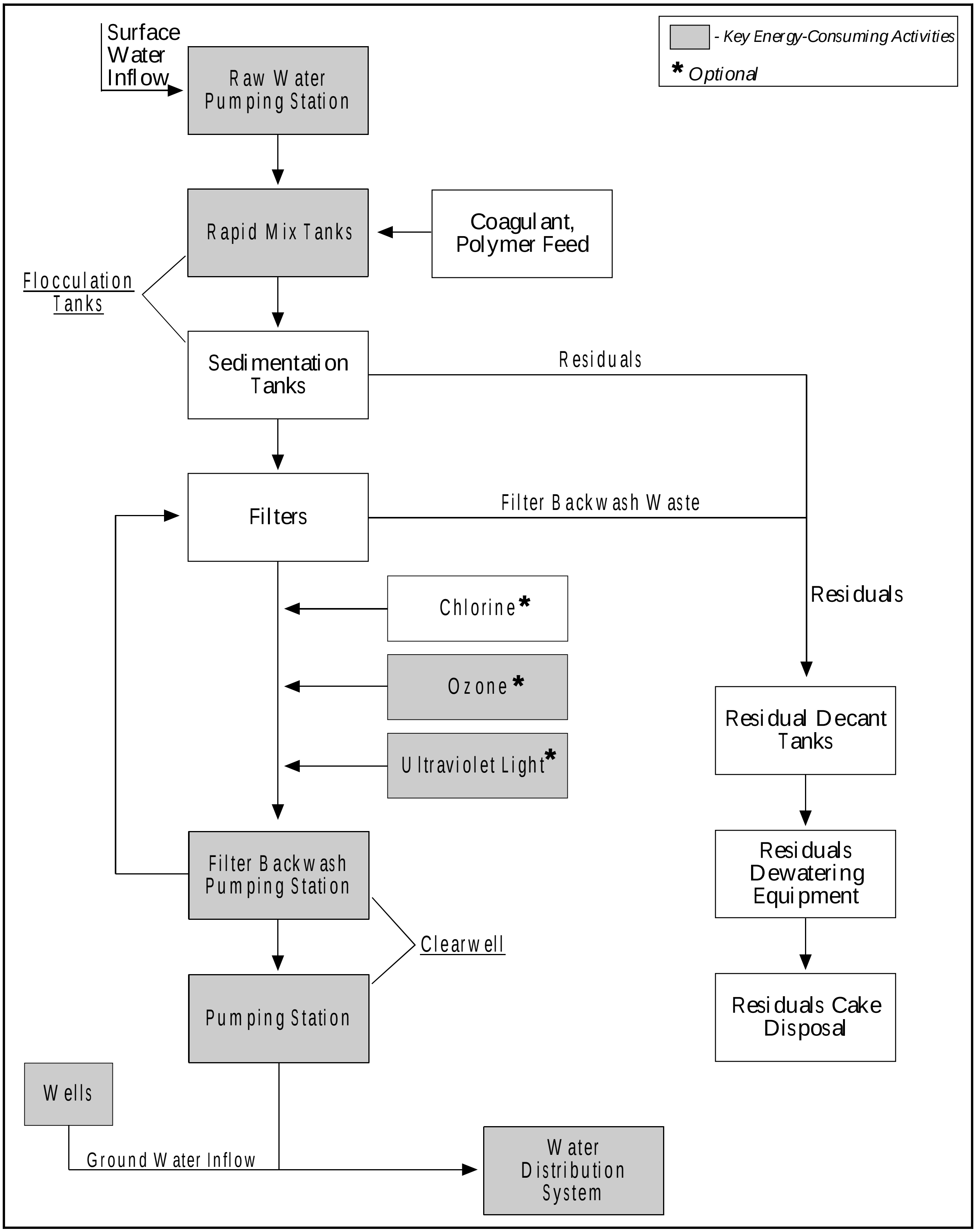
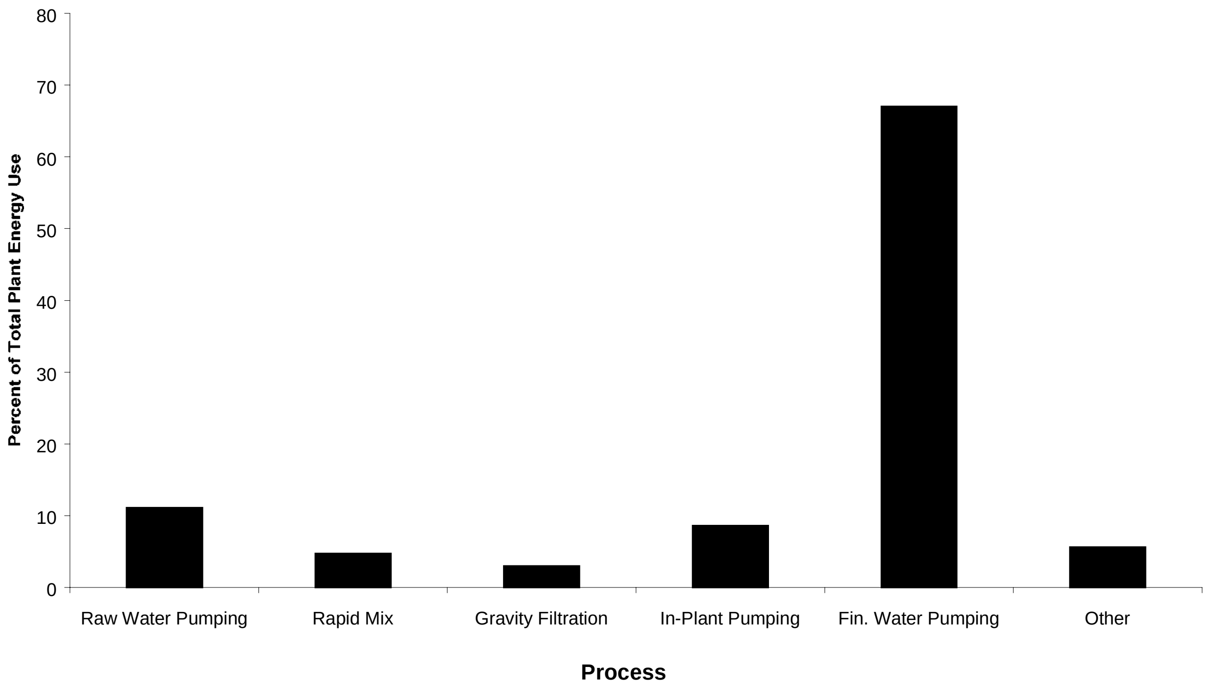


Exhibit 5-2
Energy Consumption per Facility Component
For a 10-MGD Surface Water Treatment Plant



Source: EPRI CEC Report CR-104300, July, 1994, Figure 3-3

5.6 THE PROCESS/POLITICS OF WATER DISTRIBUTION

A 'water right' legitimizes and protects one's ability to divert and use a given quantity of water. Water rights are subject to certain conditions. Withdrawn water must be put to a publicly defined beneficial use in order to maintain a water right. 'Use it or lose it' rules penalize speculation, non-use or misuse by forfeiture of water rights.

For most of U.S. history, water rights were established through the doctrine of riparian use. This method of appropriation is still widely used in states east of the Mississippi River. Riparian water rights are granted to only those landowners with water flowing within or across their lands. Most western states honored riparian water rights until the early twentieth century, when states asserted their sole authority to grant water rights. Today, when determining water rights, many western states honor the principle of prior appropriation. That is, the first to divert public water and put it to productive use will have priority over newer appropriations.

In almost all cases, the allocation of water rights is left to the discretion of individual states. All western states have an official or entity with the responsibility of administering water rights. These responsibilities are governed by specific statutory and case law.

5.6.1 Idaho

The Idaho Department of Water Resources manages the state's water according to the direction and policies of the Idaho Water Resource Board. All water within Idaho's borders belongs to the state. The right to use water is granted on the basis of priority; the first user to divert water and put it to productive use obtains priority. Water rights are real property under Idaho law, and therefore can be leased or sold.

The director of the Idaho Department of Water Resources is responsible for the issuance of all permits to divert and use water. If no public protest is filed, the director may approve a permit application if it conforms to the requirements imposed by law. Successful applicants have five years to successfully satisfy the terms of their permit. If these conditions are met, the Department may issue a water right license.

5.6.2 Montana

The Montana Department of Natural Resources and Conservation manages and allocates the state's water resources. As in Idaho, water use rights are honored on the basis of priority. Water rights exist in perpetuity in Montana, and are attached to the land or other end use for which the water was intended.

The state of Montana retains all ownership rights to water within its borders. The Montana Water Use Act (1979) governs the permitting and licensing procedures required in order to secure rights to appropriate state waters.

5.6.3 Oregon

The Oregon Water Resources Department manages Oregon's water resources according to the direction and policies of the Water Resources Commission. The WRC is a seven-member body, appointed by the governor, comprised of one representative from each of the five regional river basin management areas as well as one member from each side of the Cascade Range.

All water within Oregon's borders is property of the state. The doctrine of prior appropriation governs the right to divert surface waters. The use of any surface or groundwater requires, with some exceptions, a permit from the Water Resources Department. The Department's management authority is vested in its Director, appointed by the governor to a four-year term and ratified by the State Senate. The Director is required to administer and enforce Oregon's water policies in compliance with the WRC as well as Oregon law.

5.6.4 Washington

The Washington Department of Ecology manages the state's water resources. Water within state borders is property of the people of Washington. State water code requires that any diversion from public supply must be used for a 'beneficial purpose.' Violation of this principle could result in forfeiture of water rights.

The responsibility for administering Washington's water policies is vested in the Director of the Department. The Director is appointed by the governor and confirmed by the Senate. The Department's primary duties are: 1) supervising the diversion and allocation of public waters, 2) issuing water rights and providing a framework for the sale and purchase of water rights, 3) establishing minimum flow levels for streams and rivers in compliance with environmental law, and 4) water rights adjudication.

5.6.5 The Federal Role

Congress traditionally has not interfered with states' rights to allocate water. However, the Federal government still has an active role in western water management.

Federal programs provided funds for the construction of large dams throughout the West. One-fifth of all water consumed in the West flows through these facilities; their operation is a federal responsibility.

The federal government establishes national water quality standards in the interests of responsible environmental stewardship. The Clean Water Act, passed in 1972, requires states to establish appropriate water quality criteria and develop pollution control programs to meet them. It regulates the quantity and toxicity of chemicals earmarked for aquatic disposal. The Endangered Species Act establishes minimum streamflow requirements for aquatic creatures protected under its jurisdiction. Water diversions that disregard this required minimum flow may be illegal and subject to federal prosecution.

Usually, these federal measures do not infringe on states' rights to allocate water as they see fit. However, states must employ water distribution practices that are consistent with federal law.

5.7 WATER USE BY SECTOR[2]

Most end-use water applications require freshwater; for others, saline water is acceptable. Most saline water applications are in industry. For example, over 30 percent of water used in the production of thermoelectric power is considered saline.

In 1995 the U.S. Geological Survey estimated total U.S. freshwater use at 341,000 MGD. Irrigation and thermoelectric power together consume almost 80 percent of this total, or about 266,000 MGD. Withdrawal into public supply accounts for about 12 percent, followed by industrial use (6 percent). Livestock, residential use, commercial use, and mining each account for approximately 1 percent of total freshwater use.

By themselves, these statistics are somewhat deceiving. Although almost 40 percent of U.S. freshwater resources are 'consumed' in the production of thermoelectric power, most of this water is just used to cool equipment and may be returned to the environment for use elsewhere. The following sections detail water use by sector.

[2] Unless noted, figures from U.S. Geological Survey

5.7.1 Municipal

Municipal water use includes water for daily household purposes, such as bathing, drinking, and food preparation. Municipal applications also include water for hotels, restaurants, golf courses, and other commercial facilities.

Nationally, most municipal water is taken from public sources. 70 percent of commercial water is public-supply water. (Of the rest, two-thirds is from private surface-water sources.) Only 13 percent of residential water is not drawn from public supply.

In the Pacific Northwest, municipal water use is much less dependent on public water resources. More than half of municipal water is self-supplied. Commercial interests in the region, in fact, relied on private water sources for over 80 percent of total water use. Almost all of this self-supplied water is drawn from surface –water resources. Groundwater withdrawals, on the other hand, account for 97 percent of residential non-public water use in the region.

Total municipal water use in the Pacific Northwest is estimated at 547,778 million gallons per year, or roughly 1,500 MGD.[3]

5.7.2 Industrial

Industrial water use includes water for manufacturing processes, washing, and mining. Heavy industrial users of water include the chemical industry, the paper industry, the steel industry, and petroleum refineries.

Over 80 percent of industrial water is drawn from non-public sources. Of this private water, almost three-quarters is surface-drawn and the rest pumped from underground aquifiers. In many industrial applications, especially mining, saltwater may be preferable or more cost-effective than freshwater. About 9 percent of total industrial water applications utilize saline water sources.

In 1995 total industrial water use was estimated at 30,870 MGD nationally. Mining water accounts for nearly 14 percent of this figure. Total industrial use, excluding mining, declined by 2 percent between 1990-1995.

Total industrial water use in the Pacific Northwest was estimated at 1,490 MGD. This is approximately 5 percent of total U.S. industrial water use and 4.8 percent of total regional water use.

In the Pacific Northwest, industry relies on public sources for about 27 percent of water use. This is slightly higher than the national average, about 19 percent. Industrial interests in the region correspondingly rely upon less groundwater (215 MGD, 14 percent of total use) than others across the nation (16 percent of total industrial use). The reported use of reclaimed water by Pacific Northwest industry was negligible between 1990-1995.

[3] Calculated using flow information supplied by BacGen Technologies and the EPA

5.7.3 Agricultural

Agricultural water use includes water for irrigation and livestock.

Most agricultural water, about 63 percent, is drawn from surface water resources. The rest is supplied by groundwater aquifiers. Reclaimed water use in agriculture constitutes a tiny fraction of total use.

In 1995 national agricultural water use was estimated at 139,490 MGD. This represents a 1 percent decline in total use between 1990-1995. Despite this decline, 1 percent more acreage was cultivated nationally in 1995 than in 1990.

The Pacific Northwest uses more surface water for agricultural purposes than any watershed in the country. About 85 percent of its agricultural water is drawn from surface sources. Livestock in the region, in fact, rely on surface sources for over 97 percent of their water.

Agriculture is, by far, the Pacific Northwest's greatest water consumer. Agricultural water use in the region is estimated at 27,210 MGD. This represents approximately 19.5 percent of total U.S. agricultural water use, and 86.8 percent of total regional water use.

6. WATER SUPPLY FACILITY WANTS AND NEEDS ASSESSMENT

6.1 OVERVIEW

Twenty-two water supply facility operators from throughout the Pacific Northwest were interviewed in order to elicit viewpoints on industry issues, identify operator concerns, and evaluate opportunities for energy-saving measures. Their responses indicate that energy efficiency is a definite concern, although not the most pressing one, and that the chief obstacle to furthering the adoption of energy efficient technologies and processes is a lack of information and technical training.

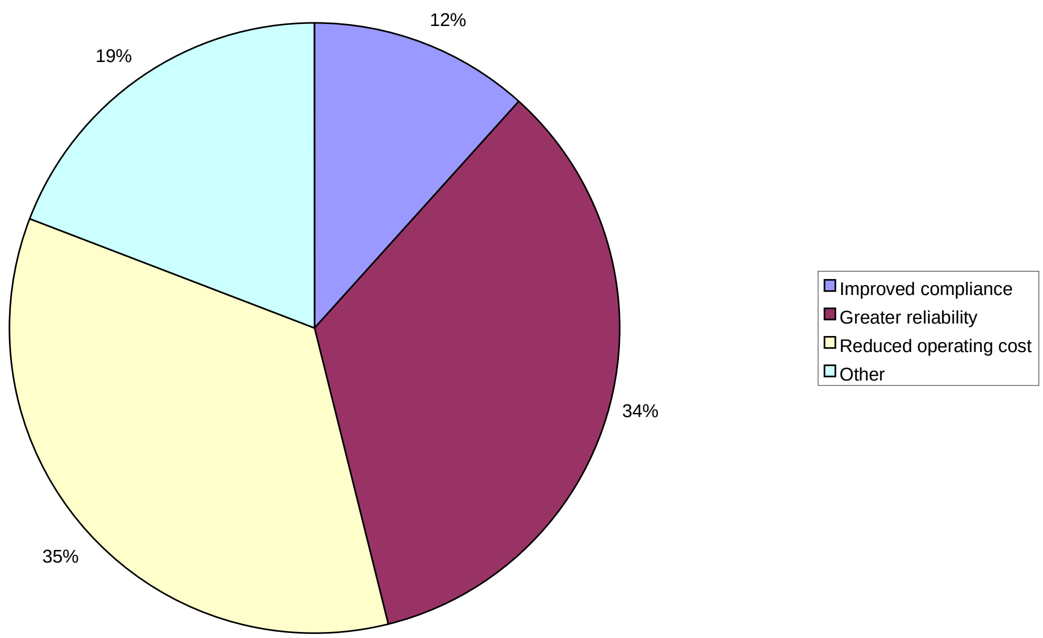
Equipment reliability emerged as the most important concern among facility operators. Ensuring that no trade-off exists between reliability and energy efficiency will be key to introducing innovations in the latter. Currently, operators are attentive to the need for energy efficient technologies, but remain hesitant to adopt technologies about which their information is still incomplete.

6.2 BENEFITS

When facility managers were asked to consider the benefits of new technologies or processes in the water supply industry, greater reliability emerged as the single most important factor, identified by 34 percent of respondents. Nineteen percent identified “reduced operating costs,” 12 percent said “reduced energy costs,” and 4 percent chose reduced chemical costs, totaling 35 percent for this group taken together.

As displayed in Exhibit 6-1, another 12 percent said that improved compliance was their greatest concern when considering a new technology. The rest of the responses were scattered among several categories, including simpler design, more precise control/monitoring, smaller footprint, and easier operation.

Exhibit 6-1
Most Important Benefits of New Products and Services



Facility managers were also asked to rate a list of possible benefits of any new technology or process under consideration. Respondents rated each benefit as “Not at all important,” “Somewhat important,” or “Very Important.” The aggregate results, displayed in Exhibit 6-2, corroborate the above responses – greater reliability, reduced operating costs, and improved compliance appear among the most important concerns.

Reduced chemical costs were deemed only “Somewhat Important” overall. Many of the facilities referred to here were groundwater treatment facilities, which involve less chemical treatment, in general, than their surface water treatment counterparts. Groundwater treatment facilities downplayed the importance of reduced chemical costs, so that on average, they emerge as only a secondary concern.

A similar story pertains to more precise control/monitoring. A number of the facilities interviewed were very small-scale, involving only a few motors. These facilities’ operators, predictably, were not as concerned with automated control or monitoring as were the larger operations, and this influence appears in the lower overall importance given to this feature.

Exhibit 6-2
Important Benefits of New Products and Services

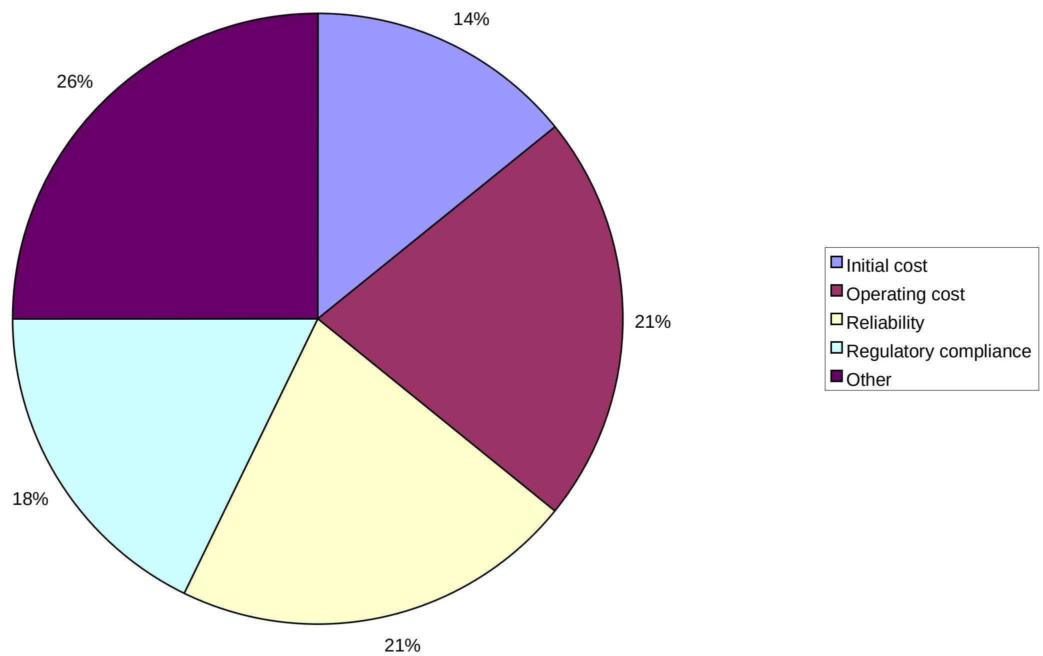
Very Important	• Reduced Operating Costs • Greater Reliability • Improved Compliance • Reduced Energy Costs • Simpler Design
Somewhat Important	• More Precise Control / Monitoring • Reduced Chemical Costs

6.3 PURCHASE DECISION CRITERIA

When considering equipment purchases or procedural changes, water supply facility operators' concerns are more diverse. As seen in Exhibit 6-3, reliability appears as the most frequently identified major purchase criterion (21 percent of respondents), tied with operating cost (including energy cost). Regulatory compliance (18 percent) and initial cost (14 percent) also appear as major concerns.

The remainder of the responses cover a wide range. One respondent indicated that payback (incorporating initial and operating costs) was his main concern, while several others agreed that a technology's endorsement by design / engineering firms, community groups, or other plants in the region was the most important consideration.

Exhibit 6-3
Most Important Purchase Decision Criteria



Over 90 percent of respondents classified reliability as a "Very Important" factor in decision-making. Not surprisingly, operating cost and regulatory compliance were also commonly identified as "Very Important," as were energy efficiency, ease of operation, and regulator approval of the technology in question.

Perhaps surprisingly, initial cost was considered only "Somewhat Important" overall. A number of the facilities whose operators were interviewed have a yearly budget approved in advance of any major purchases, and the acquisition of large equipment does not pose undue hardship. Therefore, while several managers identified initial cost as their most important concern (see Exhibit 6-3), this consideration receives only secondary importance over the group as a whole.

Facility managers as a group were ambivalent about the role of endorsements in their decision-making. A few of them put paramount importance on the seal of approval by regulators, neighboring facilities, or the community, while others put little stock in the opinions of these groups and more confidence in their own judgment.

Exhibit 6-4
Important Purchase Decision Criteria

Very Important	• Reliability • Operating Costs • Regulatory Compliance • Energy Efficiency • Regulator-approved Technologies • Payback • Ease of Operation
Somewhat Important	• Initial Cost • Technology Used at Other Regional Plants • Endorsed by Technical Research Group • Recommended by Design/Engineering Firm • Availability of Financing • Supported by Community Groups

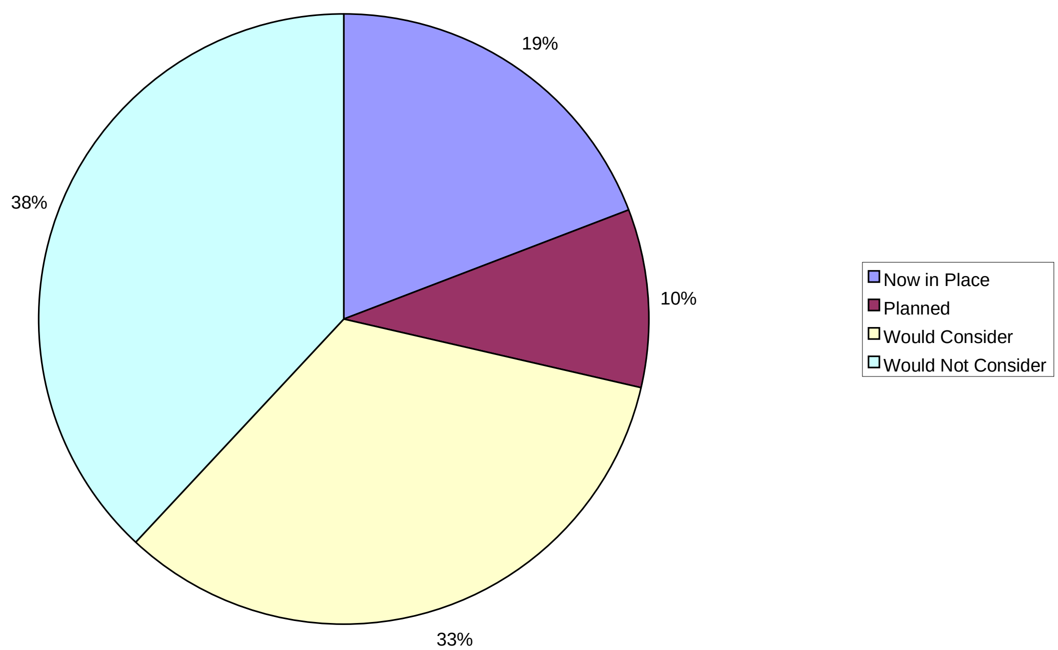
6.4 MEASURE IMPLEMENTATION AND INTEREST

When asked whether they had any systematic programs in place to conserve energy, most respondents stated that they did not. Upon further questioning, it came to light that a majority of facilities had Supervisory Control and Data Acquisition (SCADA) systems in place, and that several more had installed Variable Speed Drives (VSDs) or energy efficient motors. SCADA systems may be seen more as a labor-saving investment than an energy-saving one, or may have been installed as part of a general modernization, rather than as a specifically energy-conscious measure.

Operators were asked about their views towards a host of energy efficient technologies – whether they had implemented any of them, whether they had any plans to do so, and whether they would consider such a change. The example of VSDs is instructive.

Nineteen percent of operators stated that they had installed VSDs, and several more indicated that they had put in slow-start motors for some of their pumps, which they viewed as a mutually exclusive measure. Another 10 percent had plans to install VSDs, and 33 percent said they would consider such a move.

Exhibit 6-5
Would You Consider Installing Variable Speed Drives in Your Facility?



Of the remaining 38 percent who would not consider installing VSDs, the majority explained that it was unnecessary. Some operators had recently installed high-efficiency or slow-start pump motors and felt that adding VSDs would not be worth the expense. Another explained that he does not experience varying pressure – when the pumps are on, they need to be running at full capacity, so he would have no use for VSDs. The remainder of those not considering VSDs said that they lacked information or capital, or had had a bad experience with the technology.

Generally, operators would consider implementation of most technologies or process modifications, provided that they were appropriate for their facility type, and that significant savings could be demonstrated. A payback threshold was not solicited for each technology, but a few respondents volunteered figures, specifying a payback of 3-4 years for maximization of natural gas as a prime mover fuel source, and 5-10 years for high-efficiency motors.

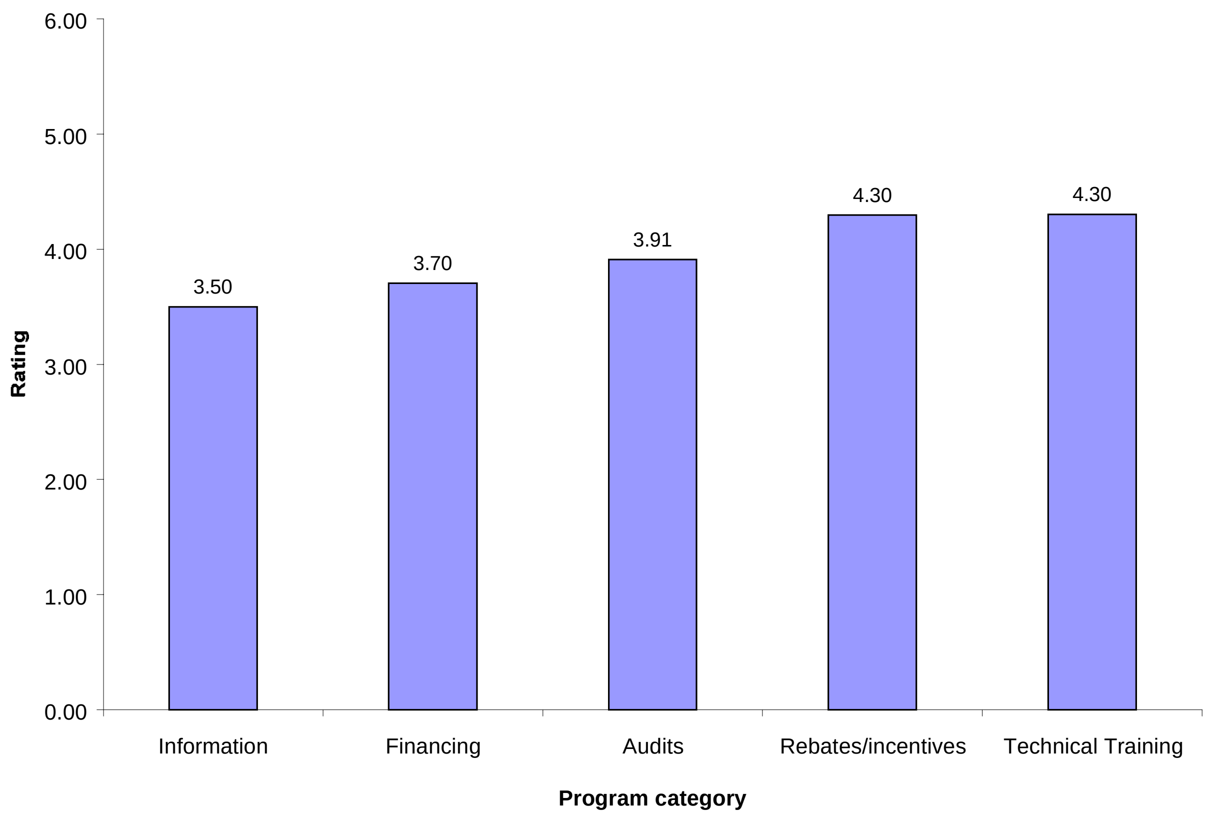
The technologies enjoying the highest rates of implementation include SCADA systems, high-efficiency motors, VSDs, optimization of motor systems, controls strategies, and programmable logic control, either for electrical load management or for metering rate schedules.

6.5 INTERVENTION STRATEGIES

Water supply facility operators were asked to consider several types of programs and rate them for their helpfulness in promoting energy efficient technologies. In most cases, these were hypothetical considerations, as few of the operators interviewed had participated in any programs designed to promote energy efficiency. However, many of the operators had attended equipment demonstrations or technical training sessions.

Exhibit 6-6 lists the aggregated responses to these questions. Respondents rated each program on a scale of 1 to 6, where 1 was "not at all helpful" and 6 was "extremely helpful" for promoting energy efficient technologies.

Exhibit 6-6
Intervention Strategies



Survey respondents rated information programs (informational brochures and Web-based information) lowest, at 3.50 out of 6. (Within this category, informational brochures scored 3.00, while Web-based information was rated at 4.00.) Provision of financing rated only slightly higher – most facility operators expressed little enthusiasm for financing programs for new equipment, and noted that public facilities used cash or bonds for equipment purchases.

Facility operators gave slightly more credence to energy audits as a way of motivating the adoption of energy efficient measures, rating them at 3.91 on average. Several respondents remarked that demonstrating actual current energy use, and opportunities to reduce it, is the most important catalyst for EE technology adoption.

Rebates and financial incentives were deemed helpful, rating at 4.30. Again, this appraisal is largely conjecture, since only one of the operators interviewed reported having participated in a rebate program, but discounts on equipment are always attractive. Perhaps the only surprising result is that rebates were not rated higher. Recall from Exhibit 6-4 that facility operators identified the initial cost of a new technology as only “somewhat important,” suggesting that a capital constraint is not their main concern. Rather, operators often explained that a budget is drawn up and approved every year, and that necessary equipment purchases are made out of that budget, usually without further contention.

Familiarity with the equipment, its relevance to their operations, and its potential benefits, seemed to be the most pressing concern. The “Technical Training” category, comprising the three programs identified as “Technical Assistance,” “Demonstration Programs,” and “Training for You or Technical Staff,” was rated at 4.30 overall. Of these, “Training for You or Technical Staff” received the highest rating, 4.66 out of 6.

One operator explained that training classes are well attended, especially because continuing education is required for certification. However, federal regulations as to what is an applicable class are narrow, and since few classes are offered locally, technicians end up going to the same classes over and over again. He stated that expanding the list of applicable classes – for instance, to include classes on electricity use – would be helpful to his staff.

This emphasis on training and education jibes with the responses given during earlier questioning about specific energy efficiency measures. When operators stated that they would not consider implementing a certain technology, the most common reasons given were “not needed yet” and “not enough information.” The first of these sometimes refers to a situation in which the technology in question is not appropriate for the type of facility under consideration, but it may also indicate an instance in which the operator is unaware of the energy savings to be realized by implementing such a measure. In general, operators were seemingly receptive to the idea of adopting energy efficient technologies, but were wary of unproven products.

7. ENERGY EFFICIENCY IN THE WATER & WASTEWATER INDUSTRIES

7.1 ENERGY EFFICIENCY INITIATIVES FOR THE REGION AND INDUSTRY TRENDS

This section will focus primarily on initiatives geared toward wastewater treatment facilities. Energy-efficiency programs applicable to water distribution facilities are also included, but are given less focus in this discussion. We have decided to consolidate energy-efficiency measures pertaining to these two industries into one section because:

- All energy-using components at water distribution facilities (pumps and motors) are also found in wastewater treatment facilities. Energy-efficiency programs pertaining to these components will be discussed in the context of wastewater treatment; however, these programs are certainly applicable to both industries.

- Although some water treatment processes are energy-intensive (e.g. denitrification), in the Pacific Northwest these processes are used relatively infrequently. Many water distribution facilities in the region do not treat their water for much of the year. Even when treatment processes are used, these usually involve merely adding chlorine (which is not energy-intensive) to otherwise untreated water. Energy used for water treatment in the Pacific Northwest is negligible and not within the scope of this section.

Opportunities for energy-efficiency programs in the wastewater industry are varied. Energy-use patterns and problems at wastewater facilities have prompted a number of initiatives designed to promote energy-efficient practices and wise energy management.

7.1.1 Current National and Regional Initiatives

California Energy Commission Initiatives

The California Energy Commission (CEC) has developed several energy conservation initiatives and programs. These programs include energy efficiency and energy saving programs for schools, agricultural facilities, and utilities such as water and wastewater, along with programs to develop energy-efficient technologies. The Energy-Water Connection is CEC's energy conservation program targeted specifically to water supply and wastewater treatment facilities[1].

The Energy-Water Connection is the result of CEC's response to water and wastewater professionals who wanted reliable information on energy management opportunities. The Energy-Water Connection has developed a Web site that supplies a centralized information source on proven methods and technologies for eliminating unnecessary waste of energy and money (www.energy.ca.gov/water/index.html). Topics include how to increase the efficiency of motors, pumps, and blowers; improve control of processes and equipment; and many other cost saving strategies. Case studies are also provided and describe in detail the methods

[1] Energy-Water Connection, 2000

adopted by selected facilities and the energy and cost savings realized following implementation of new processes and / or technologies.

Department of Energy Motor Challenge

The main goal of the US Department of Energy's Motor Challenge is "to increase the market penetration of energy-efficient industrial electric motor-driven systems by helping industry adopt the systems approach in designing, purchasing, installing, and managing motors, drives, and motor-driven equipment such as pumps, fans, and compressors[2]."

The Motor Challenge program is designed to provide information, tools, case histories, model corporate management plans, awareness, and education regarding energy-efficient motors, their various applications, and benefits associated with their use. The program's offerings are designed to fulfill the strategies described above and include the Information Clearinghouse; design decision tools; Showcase Demonstrations; and workshops, conferences, and training sessions. Participation in the Motor Challenge program beings with becoming a Motor Challenge Partner. Motor Challenge Partners collaborate with the US Department of Energy to "encourage increased market penetration of energy efficient motor systems." Industry response has been "overwhelmingly favorable"[3].

NYSERDA (New York State Energy Research and Development Authority)

NYSERDA has made available $1.2 million this year for projects that evaluate or demonstrate 1) innovative and / or energy-efficient technologies for public water and wastewater treatment or processing, 2) water distribution or wastewater collection, 3) sludge or biosolids management, 4) highway runoff pollution control, 5) watershed or reservoir management, 6) decentralized wastewater treatment, 7) air pollution and odor control related to wastewater processes, and 8) energy management.

7.1.2 Current Alliance Initiatives

Comparison of Alliance Initiatives to national trends

Magna-Drive

Preliminary tests of the Magna-Drive adjustable speed coupling have shown impressive results. More research will be conducted into the promotion and adoption of this technology.

Drive Power

The Northwest Energy Efficiency Alliance has teamed up with the Electric League of the Pacific Northwest on a two-year motor management project. As one of the Alliance's Drive Power Initiative's goal is to increase the overall efficiency of in-service electric motors in our region by helping to establish effective practices among companies that have substantial motor loads. The

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[2] Scheihing, 2000

[3] Scheihing, 2000

Electric League and Alliance strategy will center on motor-management practices for industry, which offer the benefits of lowered operating costs, greater reliability and reduced production downtime.

BacGen

In this unique project, the Alliance is funding the development and demonstration of a micro-nutrient assisted digestion technology that will greatly enhance a wastewater treatment facility's ability to process effluent. The project targets municipal, industrial and agricultural wastewater facilities. As part of the project, a business plan will be developed and implemented along with dissemination of demonstration site results.

7.2 PRODUCTS AND TECHNOLOGY

Electricity requirements in the wastewater treatment industry are expected to increase to nearly 25 billion kilowatt-hours (kWh) per year by 2010.[4] Opportunities for energy conservation will focus on equipment needed for pumping, aeration, and sludge processing, as they are the greatest consumers of electricity. The regulatory environment will continue to impose more stringent standards for wastewater treatment effluent, resulting in higher overall energy consumption.[5] Primary energy management techniques include:

- Improving management of existing facilities and equipment
- Installing energy-efficient equipment
- Applying new energy-efficient technologies
- Using available electric utility programs

Improving Management of Existing Utilities

Various opportunities exist for energy conservation through energy management improvements at existing wastewater treatment plants. Electricity is typically billed by the quantity of energy used over a period of time as well as by demand.[6] Electrical utilities will often structure their rate schedule to encourage customers to shift electrical use to off-peak hours to minimize overall electrical system demand during peak hours. These time-of-use (TOU) rates vary with time of day as well as time of year. Interruptible rates are also offered by some utilities. Interruptible rates offer users discounts in exchange for a commitment to reduce demand upon request.[7]

Cogeneration optimization is another energy management strategy that takes advantage of a system byproduct. This technology utilizes gas produced by anaerobic digesters for use in

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[4] EPRI, 1993

[5] EPRI, 1993

[6] Energy-Water Connection, 1999a; EPRI, 1993

[7] Energy-Water Connection, 1999a

cogeneration engines and generators to produce electricity and thermal energy for plant use or for sale.[8]

Installing Energy-Efficient Equipment

Energy consumption at wastewater treatment plants can also be reduced through conversion from standard to energy-efficient equipment. Two types of frequently used energy-efficient equipment are adjustable-speed drives (ASDs) or variable-frequency drives (VFDs) and high- or premium-efficiency motors.[9]

ASDs / VFDs are used to vary the frequency of motors in response to fluctuating demand. ASDs / VFDs can be used to offer more precise control of pumping and aeration systems by coupling them with sensors that determine demand at a given time. For example, an ASD/VFD that controls aeration blowers can be linked to dissolved oxygen (DO) sensors, providing more consistent DO concentrations over a wide range of flow and biological loading conditions.[10] Payback periods for these drives range from a few months to less than three years for drives ranging in size from 25 to 250 horsepower.[11]

Pump and blower motors account for 80 to 90 percent of energy costs at wastewater treatment plants. Energy-efficient motors (also known as premium or high-efficiency motors) are 28 percent more efficient than standard motors. In addition, energy-efficient motors tend to have lower failure rates as compared to standard motors.[12] Selecting an appropriately sized motor for a given task is also important when selecting an energy-efficient model. It is estimated that approximately 90 percent of motors in the U.S. are oversized. Motor efficiency drops rapidly when operation falls below 50 percent of full load capacity.[13]

Selecting an appropriately sized pump for use in wastewater treatment plants can also enhance energy-efficiency. Use of oversized pumps often requires throttling to meet actual system needs. Energy losses due to this throttling can be significant. Consideration must be given to variable loads, speed control, motor selection, and impeller selection when selecting or modifying a pump system to maximize its energy efficiency.[14]

Applying New Energy-efficient Technologies

Energy-efficient technologies commonly implemented at wastewater treatment plants include fine pore (fine bubble) diffusers, probes for measuring dissolved oxygen (DO) concentrations,

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[8] Energy-Water Connection, 1999b; EPRI, 1993

[9] EPRI, 1993

[10] Energy-Water Connection, 1999c; EPRI, 1993

[11] Energy-Water Connection, 1999c; EPRI, 1993

[12] Energy-Water Connection, 1999d

[13] US Dept. of Energy, 1998

[14] US Dept. of Energy, 2000

and DO control systems. Fine bubble diffusers provide better oxygen transfer in wastewater; less air is required for biological treatment with no reduction in treatment performance. Less air means less power is required for aeration operations.[15]

DO control systems maintain pre-set DO concentrations in aeration tanks. As the treatment plant load varies throughout the day, the DO control system adjusts the airflow rate by regulating the blower speed to meet the DO demand. These systems prevent under-aeration that may cause odors or process upsets and over-aeration that wastes energy and increases equipment wear.[16]

Programmable logic controls (PLCs) are another technology that allows a treatment plant to exploit off-peak electricity rates. PLCs can automatically sequence and activate motors that drive pumps or aeration units. PLCs can be programmed to take advantage of off-peak electricity rates that often occur during nighttime hours when staff are not present.[17]

Using Available Electric Utility Programs

Electric utility programs may include energy audits, rebates, or special rates. Audits may examine end-use assessment of electricity, annual costs, system modifications and their costs, payback estimates for recommended changes, and a comparison of electricity use to rate structure.[18]

Electric utilities may also offer financial assistance to encourage implementation of energy-efficient measures. Financial assistance may involve incentives such as purchase subsidies/ rebates, low- or no-interest loans, guaranteed payback periods, or direct assistance.[19] Special rate programs are common types of financial incentives and offer time-of-use (TOU) and interruptible rate structures as described above.

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[15] EPRI, 1993

[16] EPRI, 1993

[17] Energy-Water Connection, 1999e

[18] EPRI, 1993

[19] EPRI, 1993

APPENDIX A:

METHODOLOGY

A. METHODOLOGY

Water and wastewater energy estimates for the Pacific Northwest were developed from a number of sources using multiple methods.

For purposes of clarity, this methodology will be divided into a discussion of 1) municipal wastewater treatment facilities (WWTFs), 2) non-municipal WWTFs, 3) municipal water supply facilities, and 4) non-municipal water supply facilities.

A.1 Municipal Wastewater Treatment Facilities

Energy estimates for municipal WWTFs in the Pacific Northwest were derived using a bottom-up approach based upon two databases; the EPA Wastewater Treatment Facility Permit Database (DB) and BacGen Technologies Treatment Database. Initial review of the databases revealed that EPA DB was incomplete, i.e. there were facilities in the BacGen DB that were not in the EPA DB. Inconsistencies between the DBs were resolved and a new more complete DB was developed to estimate municipal wastewater energy consumption in the region.

There are 842 municipal WWTFs in the Pacific Northwest. Two databases, supplied by the EPA and BacGen Technologies, were used to determine the total number of facilities in the region. Flow and treatment type information was not available for all facilities on the unified DB. Of these, facilities in the ten largest Pacific Northwest counties were identified and plant specifications gathered for each. 273 facilities (32 percent) remained without flow and/or treatment type information. QC assumes that these facilities are generally smaller operations located in rural communities.

Capacity flow information, rather than current flow information, was used to estimate energy consumption. This is justified because: 1) in several instances, current flow at individual facilities exceeded their design capacity. Considering this, QC believes that discrepancies between design flow and current flow are negligible and will not substantively alter the conclusions of our estimates. Furthermore, 2) the available information for capacity flow was more complete and useful for purposes of aggregating total flow.

Of the remaining 569 facilities (842-273), reliable wastewater flow-volume information was available for 432 facilities (76 percent). Reliable treatment type information was available for 459 facilities (81 percent). Energy consumption estimates for the remaining 569 facilities are based on calculations derived from these subsets of facilities.

Of those 459 facilities for which treatment type information is available, there exist 219 lagoon systems, 208 activated sludge systems, 27 trickling filters, and 5 oxidation ditches. These treatment types differ widely in energy intensity. Flow-volume information for each of these facilities was multiplied by a conversion factor in order to determine the amount of energy required by each facility.

Economies of scale apply to the wastewater treatment industry. Smaller facilities generally require more energy per unit of output than do larger facilities. This assumption is validated in

Water and Wastewater Industries: Characteristics and DSM Opportunities, by Electric Power Research Institute's Community Environmental Center, Washington University of St. Louis (EPRI). Facilities have been sub-classified into each of the four above treatment types (lagoons, activated sludge, trickling filters, & oxidation ditches) by size. Those facilities with flow capacity between 0-1 million gallons per day (MGD) are considered small. Facilities with flow capacity between 1-20 MGD are considered medium-sized and those with flow capacities greater than 20 MGD are considered large. To attain the best possible estimate of total energy use, different conversion rates have been applied to the twelve categories (small, medium and large facilities of each of the four treatment types) of wastewater plants. These conversion rates are summarized below.

Exhibit A-1
Ranges of Unit Energy Consumption for Secondary Wastewater Treatment Facilities

	Activated Sludge	**Lagoons**	**Trickling Filters**	**Oxidation Ditches**
Small	2300 kWh/MGD	1075 kWh/MGD	1600 kWh/MGD	3900 kWh/MGD
Medium	1700 kWh/MGD	725 kWh/MGD	1150 kWh/MGD	2900 kWh/MGD
Large	1250 kWh/MGD	375 kWh/MGD	700 kWh/MGD	1800 kWh/MGD

These conversion rates are from EPRI's Energy Audit Manual for Water/Wastewater Facilities. This exhibit charts the distribution of required energy consumption for several types of secondary wastewater treatment. For purposes of this analysis, QC has applied the high bound of this spectrum to smaller facilities, the midpoint to medium-sized facilities, and the lower bound to large facilities. Total consumed energy for each facility was calculated and these totals were summed.

For those 137 facilities without flow-volume information, and those 110 facilities without treatment type information, flow rate and treatment type information has been estimated based on relative percentages of known wastewater facilities. For example, if 20 percent of those 459 facilities for which treatment type is known are activated sludge plants, then 20 percent of the unknown 110 facilities are presumed to use activated sludge.

Since all 273 unknown facilities are located in sparsely populated rural counties, we assume them to be small facilities (between 0-1 MGD). Lacking treatment type information for these 273, QC projected the distribution of known small facilities' treatment type onto the unknown group. Of those known small facilities, activated sludge plants represent 39 percent, lagoons represent 41 percent, trickling filters 6 percent, and unknown/other treatment types 15 percent, while the number of small oxidation ditch plants is less than one percent. This breakdown was applied to the group of 273, yielding an estimated 106 activated sludge systems, 111 lagoons, 14 trickling filters, 40 plants with unknown/other treatment types, and one oxidation ditch plant.

In a similar fashion, the flow rate distribution among known facilities was projected onto the group with unknown flow rates. Of those known small facilities, 51 percent ranged from 0.1-0.25 MGD flow, 27 percent ranged from 0.26-0.5 MGD flow, 14 percent ranged from 0.51-0.75 MGD flow, and 8 percent ranged from 0.76-0.99 MGD flow. This distribution was projected onto the estimated numbers of unknown small facilities of each treatment type. For example, 51 percent of those estimated 134 unknown small lagoons are considered to have a flow between 0.1-0.25 MGD.

Using the midpoints of each of these four flow subcategories (.125, .375, .625. .875) and an approximate number of facilities of each considered treatment type (activated sludge, lagoons, trickling filters), approximate flow rates can now be calculated and used to estimate energy consumption. Aggregate flow rates were multiplied by the upper bound (because they are small facilities, and therefore not beneficiaries of economies of scale) of EPRI's kWh/MGD spectrum for each treatment type. These aggregate kWh totals were summed to provide estimated energy consumption for all 273 unknown wastewater facilities.

Summing energy consumption estimates for all 842 municipal WWTFs yields an estimated total consumption of 997 GWh/year.

A.2 Non-Municipal Wastewater Treatment Facilities

Estimating energy consumption at non-municipal WWTFs, for which there is relatively little information available, requires a different, top-down approach. Aggregate flow through these facilities was multiplied by a conversion factor to approximate total consumed energy.

The U.S. Geological Survey estimates annual water consumption in the Pacific Northwest industrial sector at 544,223 million gallons, or 1,490 MGD. Water is consumed if it is diverted from its river or aquifier and 'used' for an industrial or intensive agricultural purpose. For example, water required in pulp & paper manufacturing and at animal feeding operations is considered 'used,' while water that generates hydroelectric power (but is not diverted from its stream or river) is not.

QC assumes that water 'consumed' in the Northwest industrial sector represents the aggregate flow through non-municipal WWTFs, excluding agriculture and mining. We believe this is justified because 1) independent QC research suggests that wastewater originating from intensive industrial applications is seldom, if ever, treated by municipal facilities, and 2) strict federal and state environmental regulations govern the quality of water released into any receiving body. If industrially-applied water is polluted through its use, and if this polluted water is not treated at municipal WWTFs, and if it must be treated before discharge, then this volume of water must flow through non-municipal facilities.

In order to calculate energy consumed at non-municipal WWTFs, QC multiplied total flow through these facilities (1,490 MGD) by a conversion factor previously used to determine energy consumption at small activated sludge plants (2300 kWh/MGD). This is justified because the waste stream through these non-municipal plants is likely richer than municipal wastewater stream, and therefore requires more energy for treatment. Multiplying total agricultural/industrial flow by 2300 kWh/MGD yields a rough estimate of energy required daily by non-municipal WWTFs (approximately 3.48 GWh). Projected over an entire year, this yields an estimated 1252 GWh annual energy consumption.

A.3 Municipal & Non-Municipal Water Supply Facilities

QC multiplied approximate total municipal and non-municipal water consumption by a conversion factor in order to estimate total energy consumed at Pacific Northwest water supply facilities.

Total residential water consumption was supplied by the U.S. Geological Survey & validated through independent QC research. Aggregate flow through municipal water facilities is estimated at 547,778 million gallons, or approximately 1,500 MGD. Non-municipal water consumption is estimated at 544,223 million gallons, or 1,490 MGD (see above).

Aggregate flow information (1,500 MGD municipal, 1,490 MGD non-municipal) was multiplied by a conversion factor of 605 kWh / MGD to yield approximate total consumed energy. This conversion factor was supplied by EPRI report TR-102015, entitled Water and Wastewater Industries: Characteristics and DSM Opportunities. It accounts for the average energy required to pump 1 MGD of water.

Multiplying this conversion factor by daily municipal and non-municipal flow information, and projecting this consumption over an entire year, yields total municipal and non-municipal energy consumption of 332 GWh and 329 GWh, respectively. Total consumed energy at all Pacific Northwest water supply facilities is approximately 661 GWh.

APPENDIX B:

SURVEY INSTRUMENTS

B. SURVEY INSTRUMENTS

B.1 DESIGN AND ENGINEERING FIRMS - WATER

Hello. I'm calling from Quantum Consulting on behalf of the Northwest Energy Efficiency Alliance regarding your organization's use of water supply technologies and practices. The Alliance is a non-profit organization funded by the electric utilities in the Pacific Northwest to deliver cost-effective products and services to a variety of industries, such as water supply.

ASK : DO OTHERS WITHIN YOUR FIRM WORK IN THE WASTEWATER INDUSTRY. IF YES, PLEASE GET NAME.

We're trying to get a better understanding of the way the market for water supply technologies currently functions -- that is, the process by which decisions are made and budgets are allocated -- so that we can help the Alliance determine how its programs to save energy in the Northwest might most effectively influence this market.

Company:	
Name:	
Title:	
Phone:	

1. Could you describe your responsibilities with your company?

To start with, I'd like to get some indication of the scope and nature of your company's activities.

2. Does your company provide consulting services for water supply plants in the Northwest?

[Check ONLY ONE category]

[ ] Yes

[ ] No (T&T)

3. What types of systems and equipment does your company recommend for water supply plants?

   [Read list-Check all that apply]

[ ] Entire plant

[ ] Process and equipment

[ ] Equipment only

4. In the past two years, for how many facilities have you provided design/engineering services to in the Pacific Northwest? _________ (number) What's the distribution across the four states?

   WA:____ OR:____

   ID:____ MT:____

5. What is the size distribution of these facilities? How many of them are:

Small (0-1 MGD)__________

Medium (1-20 MGD)__________

Large (20+ MGD)_________

6. How would you define your organization's overall mission as it relates to your clients? (If appropriate, how would you differentiate yourself from other associations serving all or part of that same group?)

7. How would you define your role in helping to promote efficient and environmentally sound operation of water supply plants in the Northwest (or the national market, as appropriate)? (For example, setting certification standards and testing protocols, providing information to clients and/or end users) (Can they provide materials describing these?)

8. What do you see as the most important issues/trends currently facing the water supply industry in the Northwest? How do those issues affect your role as a supplier to the industry?

Next I would like to talk about your organization's role in specifying certain technologies, processes, or types of equipment used in water supply plants by your clients.

9. Does your firm have or promote a specific set of specifications, standards, or good practices for plant operation? Y_____ N _____

10. If yes, what are those specifications and what aspects of facility operation do they cover?

11. How are changes made to the specifications or list of practices that your organization specifies? Is there a formal review process for evaluating new technologies?

12. In looking at new technologies that your company might evaluate and recommend to your clients, what are the most important characteristics that would determine whether you would support a new technology, assuming those characteristics could be demonstrated to your satisfaction?

    [Check VERY IMPORTANT for all mentioned. Note first and second responses as such]]

    And how important are these other criteria that I'm going to read to you; are they not at all important, somewhat important, or very important in determining whether you would support a new technology?

    [Read remaining factors and check rating]

(ROTATE ORDER)	Not at all Important	Somewhat Important	Very Important
Improved compliance			
Easier operation			
Reduced implementation cost			
Reduced operating cost			
Reduced energy usage			
More precise control / monitoring			
Reduced chemical cost			
Simpler design			
Greater reliability			
Less downtime for maintenance			
Other ______________________________			
Other ______________________________			

13. Among the facilities that you have as clients, approximately what percentage in each size category have each of the following energy-saving technologies in place?

MEASURE TYPE AND NAME	**Small**	**Medium**	**Large**
Energy Efficient Motors			
Fuel Cells			
Cogeneration Optimization			
Others:____________________			
PROCESS MODIFICATIONS:			
Elimination of Backwash Pumping			
Process Improvements			
Ozone optimization			
Ultraviolet light for disinfection			
Continuous wave UV			
Pulsed UV			
Electrically enhanced denitrification			
Membrane filtration			
Energy and Water Quality Management System (EWQMS)			
Supervisory Control and Data Acquisition (SCADA) systems			
TRAINING IN PRACTICES:			
Optimizing Motor Systems			

Controls Strategies			
Ozone System Optimization			
Others:____________________			
MISCELLANEOUS/OTHER:			
Hydro Electric Generation			
Programmable Logic Control for Metering Rate Schedule			
Programmable Logic Control for Electrical Load Management			
Utilizing Time-of-Use			
Maximization of Natural Gas as Prime Mover Fuel Source			
Redesigned Booster Pump Configurations			
Others:____________________			

14. Can you give me the name of several national or regional organizations or institutions that you rely on to keep up with trends in facility operations and management?

15. Similarly, can you give me the name of several publications that you rely on for information on trends in facility operations and management?

Those are all the questions I have for you today. Thank you for your time.

B.2 MUNICIPAL WATER SUPPLY FACILITIES

Hello. I'm calling from Quantum Consulting (Adolfson and Associates) on behalf of the Northwest Energy Efficiency Alliance regarding your organization's use of water supply technologies and practices. This is not a sales call, and your responses will be kept confidential. We are conducting a research project aimed at developing a better understanding of the water supply industry in the Pacific Northwest. We are primarily investigating industry response to new and emerging technologies that have the potential to improve energy efficiency. This interview should take approximately 30 minutes.

Organization:	
Name:	
Title:	
Phone:	
Type of Facility:	
Number of Staff:	
Public or Private	
Size of Facility (MGD):	
Percent Surface Water	
Percent Groundwater	
Percent Purchased Water	

1. Could you describe your responsibilities with regard to the ____________________ facility?

What we would like to talk about today is the process by which your organization makes decisions regarding the energy using technologies and equipment that are used in this facility and the criteria that are used when making those decisions.

2. What percentage of your monthly operating costs is accounted for by energy?

3. Can you tell me approximately how many kWh this facility uses per month?

4. Approximately how many motors do you have at this facility?

5. And what is their average horsepower? ASK RANGE <20, 20-50, 50-100, 100+ IF 100+, ASK AGE OF MOTORS

6. What percentage of those motors are controlled by adjustable speed/variable frequency drives? (percent of total hp)

7. Who makes operational decisions regarding the day-to-day functioning of the plant? What is (are) their job title(s) and job function(s)?

8. Is there an individual with specific energy management responsibility?

9. Considering the water supply industry as a whole, what would you consider to be the most important issues/trends in the field today?

10. Next I would like you to consider the benefits that are sometimes attributed to new technologies and processes in your field. What would be the most important benefits that you would look for in a new technology, assuming that they could be demonstrated to your satisfaction?

[Check VERY IMPORTANT for all mentioned]

I'm going to read some other benefits. Please let me know whether these are not at all important, somewhat important, or very important.

[Read remaining benefits and check rating]

(ROTATE ORDER)	**Not at all Important**	**Somewhat Important**	**Very Important**
Easier operation			
Reduced operating cost			

Reduced energy usage			
More precise control / monitoring			
Reduced chemical cost			
Simpler design			
Greater reliability			
Less downtime for maintenance			
Other ______________________________			
Other ______________________________			

Of the items we have discussed, which would you consider to be most important when looking into new technologies? **(CIRCLE most important)**

11. When decisions are made to either purchase equipment or change the operational procedures at your facility, what are the most important criteria that influence your decision?

[Check VERY IMPORTANT for all mentioned – note which was first and which was second]

And how important are these other criteria that I'm going to read to you; are they not at all important, somewhat important, or very important?

[Read remaining factors and check rating]

	Not at all Important	Somewhat Important	Very Important
Initial cost			
Operating cost			
Payback			
Ease of operation			
Availability of financing			
Reliability			

Energy efficiency			
Regulator-approved technologies			
Regulatory compliance			
Recommended by design / engineering firm			
Used at other plants in the region			
Endorsed by technical research groups			
Other___________________________________			

Which of the above would you consider most important when deciding to make changes to your facility? **(CIRCLE most important)**

12. Could you describe the process by which investment and purchase decisions are made? That is, who initiates purchase decisions of various amounts, and by whom must those decisions be approved? (Probe for the size of investment that can be made at the plant level and the process by which larger investments are routed to higher levels. Determine whether there is a financial threshold after which greater authorization is required.)

13. At what point in the decision making process is DOE / DEQ / EPA contacted about any compliance issues? How often do you use DOE / DEQ / EPA in your decision?

14. A) Can you name any systematic programs currently in place at this facility to reduce energy usage?

    B) Do you have future plans to make energy-savings-related changes?

	A)	**B)**	**C)**	**D)**
MEASURE TYPE AND NAME	**Now in place**	**Planned**	**Would consider ?**	**If NO, why not?**
				1. Too expensive 2. Technology as yet unproven

				3. Don't know enough about it 4. Not needed yet 5. Unavailable
Energy Efficient Motors				
Fuel Cells				
Cogeneration Optimization				
Others:____________________				
PROCESS MODIFICATIONS:				
Elimination of Backwash Pumping				
Process Improvements				
Ozone optimization				
Ultraviolet light for disinfection				
Continuous wave UV				
Pulsed UV				
Electrically enhanced denitrification				
Membrane filtration				
Supervisory Control and Data Acquisition (SCADA) systems				
Others:____________________				
TRAINING IN PRACTICES:				
Optimizing Motor Systems				
Controls Strategies				

Ozone System Optimization				
Others:____________________				
MISCELLANEOUS/OTHER:				
Hydro Electric Generation				
Programmable Logic Control for Metering Rate Schedule				
Programmable Logic Control for Electrical Load Management				
Utilizing Time-of-Use				
Maximization of Natural Gas as Prime Mover Fuel Source				
Redesigned Booster Pump Configurations				
Others:____________________				

C) I'm going to read a list of other measures that could have an impact on your energy usage. Please indicate whether you would consider implementing each of these at your facility. [Read those not voluntarily given by respondent.]

D)Why would you not consider implementing each of the following measures? [Read those with "No" in column C.]

E) [IF any negative responses in D) involve a cost constraint]: What kind of assistance would be necessary to overcome the cost constraint(s) you mentioned?

15. (ASK THE FOLLOWING QUESTION ABOUT THE MEASURES BEING CONSIDERED FROM THE PREVIOUS QUESTION, PART C. IF NONE ARE BEING CONSIDERED, ASK ABOUT PLANNED MEASURES, PART B)

On a scale of 1 to 6, where 1 is not at all helpful and 6 is very helpful, please rate each of the following kinds of programs in helping you to promote the adoption of energy-saving technologies or processes at this facility:

	Rating
Informational Brochures	
Demonstration Programs	
Rebates / incentives	
Web-based information	
Training for you or technical staff	
Financing	
Other ____________________	
(More to be added as info. Solicited)	

16. [ASK ABOUT THREE MEASURES REPORTED AS BEING IN PLACE AT THE FACILITY IN QUESTION 15A]

You mentioned that you have ________, ________, and ________ now in place at your facility. Were these measures adopted as part of a program operated by a utility or another second party?

___________________________ Y / N

______________________________ Y / N

______________________________ Y / N

17. With increasingly stringent water regulations as a result of the Safe Drinking Water Act, what changes do you expect will be needed at your facility over the next several years?

18. Given the regulatory trends described above, as well as population growth, would you expect your facility's electricity usage in two years to be: 1) more than 5 percent lower than at present 2) 1-5 percent lower 3) about the same 4) 1-5 percent higher 5) more than 5 percent higher 6) IF DON'T KNOW ASK - increase, decrease or stay the same

19. Can you give me the names of several state or regional organizations that you rely on for information on trends in facility operations and management?

20. Similarly, can you give me the names of several publications that you rely on for information on trends in facility operations and management?

21. Can you give me the names of some engineering firms with whom you consult regarding your operations?

Those are all the questions I have for you today. Thank you for your time.

B.3 DESIGN AND ENGINEERING FIRMS – WASTEWATER

Hello. I'm calling from Quantum Consulting on behalf of the Northwest Energy Efficiency Alliance regarding your organization's use of wastewater treatment technologies and practices. The Alliance is a non-profit organization funded by the electric utilities in the Pacific Northwest to deliver cost-effective energy reduction products and services to a variety of industries, such as wastewater treatment.

ASK : DO OTHERS WITHIN YOUR FIRM WORK IN THE WASTEWATER INDUSTRY. IF YES, PLEASE GET NAME.

We're trying to get a better understanding of the way the market for wastewater treatment technologies currently functions -- that is, the process by which decisions are made and budgets are allocated -- so that we can help the Alliance determine how its programs to save energy in the Northwest might most effectively influence this market.

Company:	
Name:	
Title:	
Phone:	

1. Could you describe your responsibilities with your company?

To start with, I'd like to get some indication of the scope and nature of your company's activities.

2. Does your company provide consulting services for wastewater treatment plants in the Northwest?
 [Check ONLY ONE category]

[ ] Yes

[ ] No (T&T)

3. What types of systems and equipment does your company recommend for wastewater treatment plants?

   [Read list-Check all that apply]

[ ] Entire plant

[ ] Process and equipment

[ ] Equipment only

4. In the past two years, for how many facilities have you provided design/engineering services to in the Pacific Northwest? _________ (number) What's the distribution across the four states?

   WA:____ OR:____

   ID:____ MT:____

5. What is the size distribution of these facilities? How many of them are:

   Small (0-1 MGD) __________

   Medium (1-20 MGD) __________

   Large (20+MGD) ___________

6. How would you define your organization's overall mission as it relates to your clients? (If appropriate, how would you differentiate yourself from other associations serving all or part of that same group?)

7. What do you see as the most important issues/trends currently facing the wastewater treatment industry in the Northwest? How do those issues affect your role as a supplier to the industry?

8. How are changes made to the specifications or list of practices that your organization specifies? Is there a formal review process for evaluating new technologies?

9. In looking at new technologies that your company might evaluate and recommend to your clients, what are the most important characteristics that would determine whether you would support a new treatment technology, assuming those characteristics could be demonstrated to your satisfaction?

[Check VERY IMPORTANT for all mentioned. Note first and second responses as such]]

And how important are these other criteria that I'm going to read to you; are they not at all important, somewhat important, or very important in determining whether you would support a new treatment technology?

[Read remaining factors and check rating]

(ROTATE ORDER)	Not at all	Somewhat	Very

	Important	Important	Important
Improved compliance			
Ability to handle greater flow			
Easier operation			
Reduced implementation cost			
Reduced operating cost			
Fewer odor problems			
Reduced energy usage			
Ability to handle significant weather pattern changes			
More precise control / monitoring			
Reduced chemical cost			
Simpler design			
Greater reliability			
Less downtime for maintenance			
Other ______________________________			
Other ______________________________			

10. Among the facilities that you have as clients, approximately what percentage in each size category have each of the following energy-saving technologies in place?

MEASURE TYPE AND NAME	**Small**	**Medium**	**Large**
Energy Efficient Motors			

Fuel Cells			
Cogeneration Optimization			
Ultraviolet Disinfection System Optimization			
Fine-Bubble Aeration System			
In-Situ Oxygenator			
Others:____________________			
PROCESS MODIFICATIONS:			
Aeration Efficiency			
Process Improvements			
Sulfur Dioxide Mixing Improvements			
Nitrification Process Improvements			
Lowered Dissolved Oxygen Targets in Activated Sludge			
Minimized Return Activated Sludge Pumping			
Others:____________________			
TRAINING IN PRACTICES:			
Optimizing Motor Systems			
Controls Strategies			
Rewinding Pump Motors			
Others:____________________			

MISCELLANEOUS/OTHER:			
Time of Use Meters for Effluent Pumping			
Gravity Feed Pumps			
Automated Dissolved Oxygen Control Sys.			
Programmable Timers for Aeration Equip.			
Dissolved Oxygen Sensors			
Others:___________________			

11. I'm going to describe a service that you may or may not be familiar with. After I have described it, I would like to know whether you have heard of this service, would consider using the service, or are currently using the service.

SERVICE DESCRIPTION
The installation of real-time monitoring equipment that measures DO, and biological parameters and uses this data in a system / facility modeling software to optimize system performance while reducing energy consumption and facility energy costs. Simply described as maintaining permit while minimizing energy requirements.

11 A. What would you call the service I have just described?

11 B. Are you currently offering this specific service to your clients? **Y/N/Explain:**

[IF YES:]

11 B1. How many clients have purchased this service?

11 B2. What is the breakdown, by size, of the clients who have purchased this service?

S___________

M__________

L___________

11 B3. What are some reasons your clients give for their decision to purchase – or not purchase – this service?

[IF 11 = NO]

12. Why have you not offered this service?

Can you give me the name of several national or regional organizations or institutions that you rely on to keep up with trends in facility operations and management?

13. Similarly, can you give me the name of several publications that you rely on for information on trends in facility operations and management?

Those are all the questions I have for you today. Thank you for your time.

B.4 MUNICIPAL WASTEWATER TREATMENT FACILITIES

Hello. I'm calling from Quantum Consulting (Adolfson and Associates) on behalf of the Northwest Energy Efficiency Alliance regarding your organization's use of wastewater treatment technologies and practices. This is not a sales call, and your responses will be kept confidential.

We are conducting a research project aimed at developing a better understanding of the wastewater treatment industry in the Pacific Northwest. We are primarily investigating industry response to new and emerging technologies. This interview should take approximately 30 minutes.

Organization:	
Name:	
Title:	
Phone:	
Type of Facility:	
Number of Staff:	
Average Daily Flow	
Size of Treatment Plant (MGD)	
Municipal	

1. Could you describe your responsibilities with regard to the ____________________ facility?

What we would like to talk about today is the process by which your organization makes decisions regarding the technologies and equipment that are used in this facility and the criteria that are used when making those decisions.

2. What percentage of your monthly operation and maintenance costs is due to energy?

3. Can you tell me approximately how many kWh this facility uses per month?

4. Approximately how many motors do you have at this facility?

5. And what is their average horsepower? ASK RANGE <20, 20-50, 50-100, 100+ IF 100+, ASK AGE OF MOTORS

6. What percentage of those motors are controlled by adjustable speed / variable frequency drives? (percent of total hp)

7. Who makes operational decisions regarding the day-to-day functioning of the plant? What is(are) their job title(s) and job function(s) ?

8. Is there an individual with specific energy management responsibility?

9. Considering the wastewater treatment industry as a whole, what would you consider to be the most important issues / trends in the field today?

10. Next I would like you to consider the benefits that are sometimes attributed to new treatment technologies and processes. What would be the most important benefits that you would look for in a new technology, assuming that they could be demonstrated to your satisfaction?

[Check VERY IMPORTANT for all mentioned]

I'm going to read some other benefits. Please let me know whether these are not at all important, somewhat important, or very important.

[Read remaining benefits and check rating]

(ROTATE ORDER)	**Not at all Important**	**Somewhat Important**	**Very Important**
Ability to handle greater flow			
Easier operation			
Reduced operating cost			
Fewer odor problems			
Reduced energy usage			
More precise control / monitoring			
Reduced chemical cost			
Simpler design			
Greater reliability			
Less downtime for maintenance			
Other ______________________________			
Other ______________________________			

Of the items we have discussed, which would you consider to be most important when looking into new technologies? **(CIRCLE most important)**

11. When decisions are made to either purchase equipment or change the treatment process at your facility, what are the most important criteria that influence your decision?

[Check VERY IMPORTANT for all mentioned – note which was first and which was second]

And how important are these other criteria that I'm going to read to you; are they not at all important, somewhat important, or very important?

[Read remaining factors and check rating]

	Not at all Important	**Somewhat Important**	**Very Important**
Initial cost			
Operating cost			
Payback			
Ease of operation			
Ability to handle increased flow			
Reliability			
Energy efficiency			
Regulator-approved technologies			
Ability to handle significant weather pattern changes			
Supported by PNPCA or other association			
Recommended by design / engineering firm			
Used at other plants in the region			
Endorsed by technical research groups			
Other________________________________			

Other_______________________________			

Which of the above would you consider most important when deciding to make changes to your facility? **(CIRCLE most important)**

12. Could you describe the process by which investment and purchase decisions are made? That is, who initiates purchase decisions of various amounts, and by whom must those decisions be approved? (Probe for the size of investment that can be made at the plant level and the process by which larger investments are routed to higher levels. Determine whether there is a financial threshold after which greater authorization is required.)

13. At what point in the decision making process is DOE/DEQ/EPA contacted about any compliance issues?

- A) Does any kind of retrofit require approval by the DOE/DEQ/EPA? **Y/N/Explain:**

- B) Does any sort of process change (i.e. non-capital improvements) require approval by the DOE/DEQ/EPA? **Y/N/Explain (get clarification on process changes):**

14. A) Can you name any systematic programs currently in place at this facility to reduce energy usage? B) Do you have a future plans to make energy-savings-related changes?

	A)	B)	C)	D)
MEASURE TYPE AND NAME	**Now in place**	**Planned**	**Would consider ?**	**If NO, why not?**
Energy Efficient Motors				
Cogeneration Optimization				
Ultraviolet Disinfection System Optimization				
Fine-Bubble Aeration System				
In-Situ Oxygenator				
Others:____________________				
PROCESS MODIFICATIONS:	**Now in place**	**Planned**	**Would consider ?**	**If NO, why not?**
Aeration Efficiency				
Process Improvements				
Sulfur Dioxide Mixing Improvements				
Nitrification Process Improvements				
Lowered Dissolved Oxygen Targets in Activated Sludge				
Minimized Return Activated Sludge Pumping				
Others:____________________				

TRAINING IN PRACTICES:	**Now in place**	**Planned**	**Would consider ?**	**If NO, why not?**
Optimizing Motor Systems				
Controls Strategies				
Rewinding Motors				
Others:____________________				
MISCELLANEOUS/OTHER:	**Now in place**	**Planned**	**Would consider ?**	**If NO, why not?**
SCADA				
Automated Dissolved Oxygen Control Sys.				
Programmable Timers for Aeration Equip.				
Dissolved Oxygen Sensors				
Gravity Feed Pumps				
Others:____________________				

C) I'm going to read a list of other energy efficiency measures. Please indicate whether you would consider implementing each of these at your facility. [Read those not voluntarily given by respondent.]

D) Why would you not consider implementing each of the following measures? [Read those with "No" in Column C.]

E) [IF any responses in D) involve a cost constraint]: What kind of assistance would be necessary to overcome the cost constraint(s) you mentioned?

15. [ASK THE FOLLOWING QUESTION ABOUT THREE MEASURES BEING CONSIDERED FROM THE PREVIOUS QUESTION, PART C). IF NONE ARE BEING CONSIDERED, ASK ABOUT PLANNED MEASURES (PART B).]

- A) On a scale of 1 to 6, where 1 is not at all helpful and 6 is very helpful, please rate each of the following kinds of assistance in helping you to promote the adoption of ______________________ at this facility:

	Rating
Informational Brochures	
Demonstration Programs	
Rebates / incentives	
Web-based information	
Training for you or your technicians	
Financing	
Other _____________________	
(More to be added as info. Solicited)	

- B) On a scale of 1 to 6, where 1 is not at all helpful and 6 is very helpful, please rate each of the following kinds of assistance in helping you to promote the adoption of ______________________ at this facility:

	Rating
Informational Brochures	
Demonstration Programs	
Rebates / incentives	
Web-based information	
Training for you or your technicians	

Financing	
Other ____________________	
(More to be added as info. Solicited)	

- C) On a scale of 1 to 6, where 1 is not at all helpful and 6 is very helpful, please rate each of the following kinds of assistance in helping you to promote the adoption of _____________________ at this facility:

	Rating
Informational Brochures	
Demonstration Programs	
Rebates / incentives	
Web-based information	
Training for you or your technicians	
Financing	
Other ____________________	
(More to be added as info. Solicited)	

16. [ASK ABOUT THREE MEASURES REPORTED AS BEING IN PLACE AT THE FACILITY IN QUESTION 14A).]:

You mentioned that you have ___________, _____________, and _____________ now in place at your facility. Were these measures adopted as part of a program operated by a utility or another second party?

____________________________________ Y / N

____________________________________ Y / N

____________________________________ Y / N

17. I'm going to describe a service that you may or may not be familiar with. After I have described it, I would like to know whether you have heard of this service, would consider using the service, or are currently using the service.

    SERVICE DESCRIPTION
    The installation of real-time monitoring equipment that measures DO, and biological parameters and uses this data in a system / facility modeling software to reduce aeration with the ultimate goal reducing energy consumption and facility energy costs, while maintaining permit levels.

Does the service I have described sound familiar to you? **Y/N/Explain:**

[IF YES:]

Are you planning to implement this service at your facility or are you currently receiving this service? **Y/N/Explain:**

Would you consider implementing this service at your facility? **Y/N/Explain:**

18. Can you give me the names of several state or regional organizations that you rely on for information on trends in facility operations and management?

19. Similarly, can you give me the names of several publications that you rely on for information on trends in facility operations and management?

20. Can you give me the names of some engineering firms with whom you consult regarding your operations?

Those are all the questions I have for you today. Thank you for your time.

APPENDIX C:

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C. BIBLIOGRAPHY

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