Des Moines Creek Flow Augmentation Preliminary Design

Seattle-Tacoma International Airport

Port of Seattle

AR 025072

September 2000

K/J 006081.00

Kennedy/Jenks Consultants

FINAL

DES MOINES CREEK FLOW AUGMENTATION PRELIMINARY DESIGN

SEATAC INTERNATIONAL AIRPORT

September 2000

K/J 006081.00

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AR 025073

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1 INTRODUCTION

Kennedy/Jenks Consultants is assisting the Port of Seattle (Port) in the preliminary design of a facility to augment flow in Des Moines Creek. A flow augmentation facility would provide benefits to the aquatic ecosystem during summer periods of stress caused by elevated temperature and low flow.

Potable water from Seattle Public Utilities (SPU) is currently the preferred source of water for creek flow augmentation. An active well, currently used for irrigation of the Tyee Golf Course, may be an alternative water source. Discussions of rights to the well water are underway, and the Port may not be granted the right to water from the well.

Chlorine levels in the potable water supply will be reduced prior to discharge to the creek. A dechlorination system utilizing sodium sulfite tablets will be installed in a contact basin to be constructed near the creek. The dechlorinated water will be aerated prior to discharge to the creek. The augmentation system will be controlled based on downstream flow and temperature conditions.

This report introduces preliminary design concepts for a flow augmentation system including system design, control and selection of dechlorination agents.

2 FACILITY CONFIGURATION

Figure 1 illustrates the proposed location and layout of the flow augmentation system. A process flow diagram is presented in Figure 2. A pipeline for potable water will be connected to an existing water main (used for fire suppression) located at the end of the South Safety Zone of Runway 34R. A dechlorination basin will be constructed just downstream of the confluence of the East and West branches of Des Moines Creek. Sodium sulfite tablets suspended in a basket in the contact basin will be used for dechlorination. A mechanical aerator located near the effluent end of the contact basin will replace dissolved oxygen (DO) consumed by the dechlorination agent. Effluent will be further aerated as it flows through a rock-lined channel to the outfall. The riprap-filled channel will supplement aeration while minimizing erosion of the creek bank.

A monitoring station, located at an existing downstream weir, will allow measurement of flow, temperature, and DO levels. A downstream monitoring station will provide feedback control based on creek flow and temperature conditions. The system will be programmed to maintain creek flows at 1 cubic feet per second (cfs) at the monitoring station. A residual chlorine analyzer, located at the effluent end of the dechlorination basin, will signal an alarm and trigger a controller to close the makeup water valve when residual chlorine reaches a setpoint level.

The preliminary design was checked against wetlands maps (Parametrix 1999). No delineated wetlands will be impacted by the proposed design.

3 PROCESS COMPONENTS

3.1 Backflow Prevention

An approved backflow preventer and flow meter will be installed on the pipeline upstream of the dechlorination basin. The system will be constructed with an air gap of at least two pipe diameters between the potable water source and the contact basin high water level.

3.2 Dechlorination Basin

The preliminary design includes a chlorine contact basin baffled in a serpentine configuration to facilitate contact with the dechlorination agent and minimize short circuiting. A figure for a similar contact basin, currently in design for the City of Portland, is attached. The basin will be constructed of cast-in-place concrete, and the floors of the basin channels will be sloped to drain to the effluent end of the structure. Interior baffle walls will contain holes to allow complete draining of the basin.

Sodium sulfite tablets, contained in mesh cages suspended near the influent of the contact basin, will serve as the dechlorination agent.

As discussed in Section 3.4, a residual chlorine monitor will be located at the effluent end of the contact basin. If chlorine is detected in excess of the setpoint, a controller will close the makeup water valve and alert maintenance personnel to reload the basket with dechlorination tablets. The setpoint for control of residual chlorine concentrations will be established to meet water quality standards for the stream, if possible. More detailed information on control of chlorine residual will be provided in the next submittal to Ecology.

3.3 Aerator

A mechanical aerator/ mixer will be located at the effluent end of the dechlorination basin to help restore DO levels. The aerator will be mounted at the effluent end of the dechlorination basin raceways. A catalog cut of a typical mechanical aerator/mixer is included in Appendix A.

3.4 Aeration Channel and Outfall to Creek

Treated effluent from the dechlorination/aeration basin will flow through an engineered channel prior to entering the creek.

The design of the aeration channel remains to be finalized. However, the channel will provide additional aeration and dissipate the flow energy of the dechlorinated water. The channel will be 50 to 100 feet in length and excavated with a trapezoidal cross section. The channel will have a depth of at least 2 feet, a base dimension of about 3 feet, and a minimum side slope of 3 to 1. The bottom of the channel will be covered with 4 inches of 1.5 inch minus gravel to prevent scouring. The channel will be filled with large hand-placed riprap (WSDOT 9-12.3), which shall be angled and as irregular as possible. Sixty percent of the riprap fill shall have a volume of not less than 1 cubic foot. No stone shall be used which is less than 6 inches thick.

With a channel length of 50 to 100 feet and a maximum flow of 1 cfs, a velocity of about 1 to 1.5 feet per second is anticipated at the point of discharge to the creek. At this velocity, flow energy will be sufficiently dissipated to eliminate the need for an engineered outfall at the creek.

3.5 Process Instrumentation and Controls

The facility will be automated to help supplement creek flow with dechlorinated SPU water. Controls will be housed in a small building to be constructed near the dechlorination basin. The building will also include a storage area for dechlorination agent and spare equipment. Port maintenance staff will be trained to operate the dechlorination facility and associated equipment.

3.5.1 Programmable Logic Controller

The flow augmentation system will be equipped with a programmable logic controller (PLC) to:

- Monitor residual chlorine levels
- Monitor creek flow readings from a meter located at the downstream weir
- Close makeup water valve at elevated residual chlorine levels
- Alarm at high residual chlorine levels
- Regulate position of makeup water valve according to creek flow rate and/or creek temperatures at the downstream monitoring station
- Alarm at low creek flow (less than 1 cfs)
- Alarm at high creek temperature (greater than 16°C).

3.5.2 Residual Chlorine Analyzer

The Operation and Maintenance Plan for the flow augmentation facility will require maintenance personnel to resupply dechlorination tablets before the supply is consumed by makeup water flow. However, as a safeguard, a residual chlorine monitor will be located at the effluent end of the contact basin. The setpoint for control of residual chlorine concentrations will be determined and included in the final design submittal. When residual chlorine levels exceed the setpoint, a controller will close the makeup water valve and alert maintenance personnel to refill the supply of dechlorination tablets. The alarm will be linked by telemetry to the airport Maintenance Duty Officer (MDO). An MDO is continuously on-duty and has direct radio contact to all airport operations and maintenance personnel.

3.5.3 Creek Monitoring Station

Instrumentation will be installed at an existing monitoring station downstream of the flow augmentation facility to allow collection of performance data and a feedback signal for flow control. The monitoring facility will be constructed at an existing weir on the reach of Des Moines Creek between the confluence of the east and west branches and South 200th Street. King County recently modified the weir to achieve more accurate measurements during low flows. It may be possible to install the monitoring station without further modification of the existing weir. A streamflow rating curve will be developed for the modified weir and depths corresponding to a 1 cfs flow rate. More detailed information on the monitoring station design will be provided in the next submittal to Ecology.

Taylor and Associates provides consulting to the Port for water quality monitoring. Taylor and Associates have experience in developing monitoring and control equipment on similar flow augmentation projects. Commercially available probes with 4 to 20 milliamp signals will sense flow and DO. A programmable logic controller such as a Campbell Scientific CR10X or CR500 will monitor the probes, record data, and regulate the position of the makeup water valve. Such units can also be configured to provide remote access, query, and remote programming via cellular phone or hard-wired technology; or alternatively, incorporated into the Port's telemetered maintenance/operation system.

Temperature and flow data will be collected at 15-minute intervals. The final submittal to Ecology will include specific control strategies. For instance, the number of deviations or duration of deviation from the control point necessary to activate the makeup water valve will be established. The inclusion of a programmed delayed start would eliminate false starts due to the system noise inherent in environmental monitoring and control systems.

4 DECHLORINATION CHEMICAL ALTERNATIVES

4.1 General

A number of chemicals can be used as dechlorination agents. Sodium bisulfite, calcium thiosulfate, sulfur dioxide, ascorbic acid, sodium sulfite, and sodium thiosulfate are evaluated below.

4.2 Calcium Thiosulfate

The reaction of calcium thiosulfate is more complex than the sodium bisulfite or sulfur dioxide reactions. The three most common reactions are as follows:

$$CaS_2O_3 + Cl_2 + H_2O \rightarrow CaSO_4 + S + 2HCl$$

$$CaS_2O_3 + 2Cl_2 + 3H_2O \rightarrow Ca(HSO_3)_2 + S + 4HCl$$

$$CaS_2O_3 + 4Cl_2 + 5H_2O \rightarrow CaSO_4 + H_2SO_4 + 8HCl$$

Thirty percent calcium thiosulfate is a clear solution with little odor and a pH of 6.5 to 7.5. It is a NSF 60-approved chemical. Calcium thiosulfate does not break down or crystallize and thus has a long shelf life. Because it is non-toxic, accidental overdosing would not cause water quality problems in the receiving waters. Furthermore, calcium thiosulfate is not an oxygen scavenger.

The chemical is readily available from Best Sulfur Products and would be shipped from Fresno, California. The manufacturer recommends a 1- to 2-minute contact time for chlorine residual limitations near zero. An alternative for this application is to overdose the chemical so that contact times of 1 minute or less will suffice. Continuous overdosing of calcium thiosulfate can lead to thiobacillus growth in the receiving water, but only in continuous dechlorination applications.

4.3 Sodium Bisulfite

Sodium bisulfite reacts with chlorine as follows:

$$NaHSO_3 + Cl_2 + H_2O \rightarrow NaHSO_4 + 2\ HCl$$

Twenty-five percent sodium bisulfite has a pH range of 4.2 to 5.5, is nearly 25 percent heavier than water, and is considered a hazardous chemical. As sodium bisulfite decomposes, it forms sulfur dioxide as an offgas. The reaction time required to complete the dechlorination reaction is estimated at 15 to 20 seconds, which is longer than for sulfur dioxide but shorter than for calcium thiosulfate. The required chlorine-to-sodium-bisulfite ratio is 1 to 1.46. Sodium bisulfite is used for dechlorination in many municipal installations, especially wastewater treatment plants, and is produced at various locations including Tacoma and Salt Lake City. Traditional sodium bisulfite installations use a 38 percent solution. A concentration of 25 percent sodium bisulfite may suffice for this application. Thirty-eight percent sodium bisulfite has significantly greater off-gassing and crystallization problems than 25 percent.

4.4 Sulfur Dioxide

Sulfur dioxide is a toxic, hazardous gas that is stored and fed in a similar manner to chlorine. Historically, it has been the most commonly used method of dechlorination. It can be withdrawn from ton containers in liquid or gas form. Sulfur dioxide is covered by the Risk Management Plan (RMP) Rule, and its use would require a scrubber system. Because of the safety risks associated with gaseous chemicals, sulfur dioxide is not a viable alternative.

4.5 Ascorbic Acid

Ascorbic acid, also known as Vitamin C, is used for dechloramination by kidney dialysis patients and is generally available in powder form in 50-lb. bags. Use of the powdered chemical would require more handling by operators than a liquid product. Two disadvantages of ascorbic acid are that it has a biological oxygen demand component, and it significantly lowers the pH of the water. Because a liquid ascorbic acid solution loses its strength after 1 to 2 days of storage, ascorbic acid must be stored in powdered form. Due to its short shelf life, frequent batching of small volumes of ascorbic acid would be necessary.

4.6 Sodium Thiosulfate

Sodium thiosulfate, which is available in both dry and liquid forms, is commonly used as a dechlorinating agent in the laboratory and in pulp and paper dechlorinating applications. In his *Handbook of Chlorination,* White indicates that while satisfactory for laboratory work, sodium thiosulfate reacts slowly with chlorine and is not amenable to metering control situations. It is significantly more effective at low pH levels.

4.7 Sodium Sulfite

Sodium sulfite, which is used in tablet form, is commonly used to dechlorinate hydrant flushes. It is available with tablet feeders for use with continuous flows. Two significant disadvantages of sodium sulfite are lack of control and its hygroscopic nature. Kennedy/Jenks has participated in projects with large flows in which dechlorination tablets are contained in mesh cages. Mesh cages containing sodium sulfite are also proposed for the Des Moines Creek flow augmentation project. The primary advantage of sodium sulfite is its passive nature (no pumping required).

Kennedy/Jenks conducted dechloramination field tests with sodium sulfite tablets for the San Francisco area's East Bay Municipal Utility District. The study showed that the tablets were effective in removing chloramines in 1 minute or less. The study also showed that increased sodium sulfite concentrations (above stoichiometric quantities) did not have an apparent effect on contact time requirements. Recently Kennedy/Jenks and the Portland Bureau of Water Works conducted additional testing as part of an American Water Works Association Research Foundation (AWWARF) funded study. The AWWARF study, which did not include multiple dosing, confirmed that a contact time of 1 minute would likely be adequate.

4.8 Summary of Dechlorination Alternatives

Sodium sulfite is the most feasible alternative for dechlorination of the Des Moines Creek flow augmentation stream. Sodium sulfite offers the advantage of not requiring any pumps or controls. However, it would be necessary for the sodium sulfite tablets to be installed and/or replaced prior to operation of the dechlorination basin. When the system is not in operation, the tablets will adsorb moisture from the air and need to be replaced periodically. With proper aeration of the effluent stream and instrumentation signaling the need to recharge the supply of tablets, sodium sulfite appears to be the most appropriate dechlorination agent for this application.

5 SUMMARY

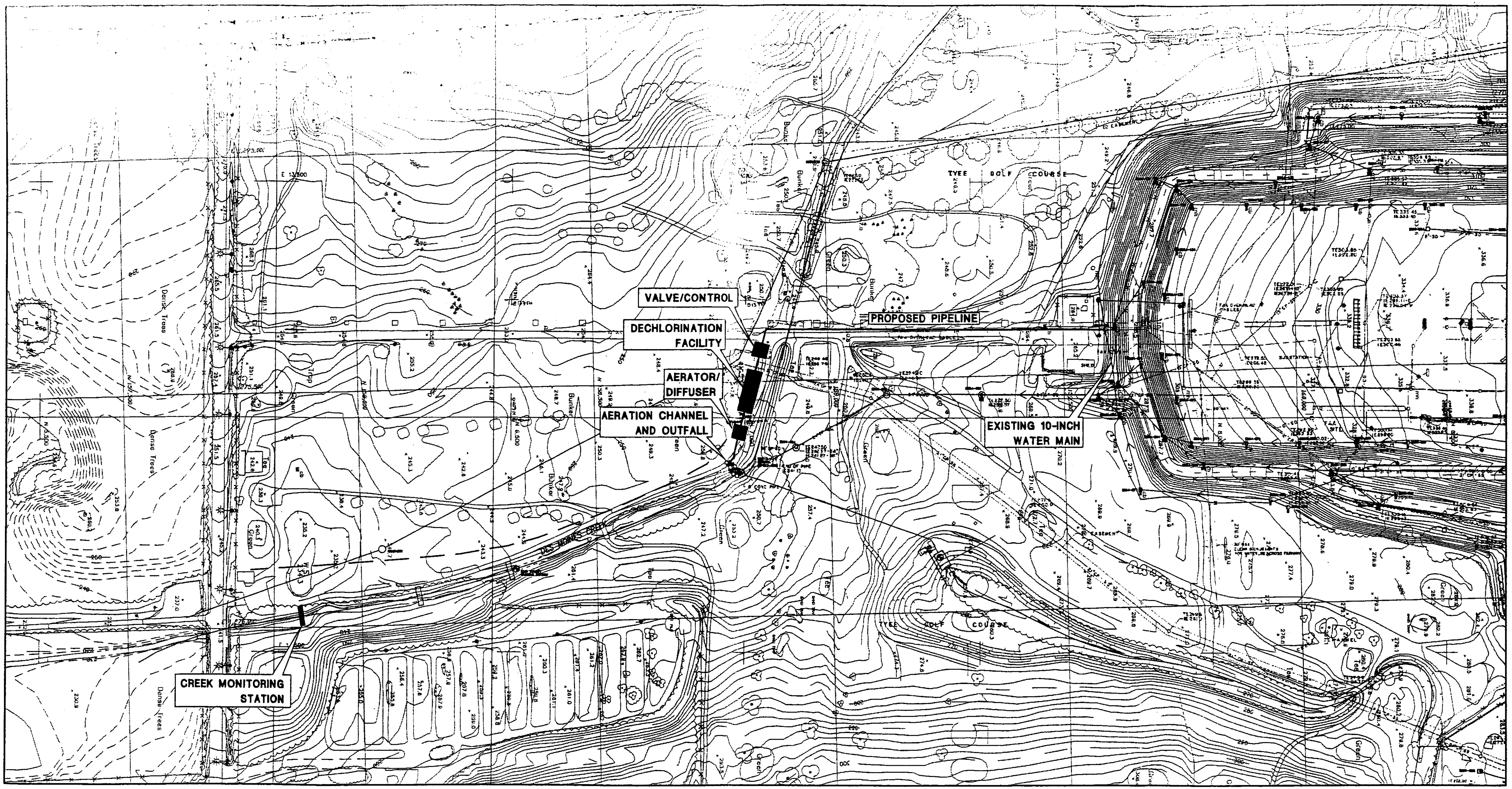
A system for dechlorination of SPU potable water is proposed. A baffled concrete basin will provide contact time for dechlorination. The dechlorination agent, in the form of sodium sulfite tablets, will be contained in mesh cages suspended at the inlet of the contact basin. A mechanical aerator will be placed at the effluent end of the basin to restore the DO sag induced by the dechlorination agent. A riprap-filled channel will provide passive aeration and dissipate the energy of makeup water flow into the creek. A PLC will regulate flow and signal maintenance personnel to recharge the sodium sulfite.

6 REFERENCES

Parametrix, Wetland Delineation Report, Master Plan Update Improvements, Seattle-Tacoma International Airport, August 1999.

White, G.C., Handbook of Chlorination and Alternative Disinfectants, Fourth Edition, Wiley Interscience, 1999.

FIGURES



Kennedy/Jenks Consultants

SEATTLE TACOMA INTERNATIONAL AIRPORT
SEATAC, WA

CONCEPTUAL DESIGN OF DES MOINES CREEK FLOW AUGMENTATION SYSTEM

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FIGURE-1

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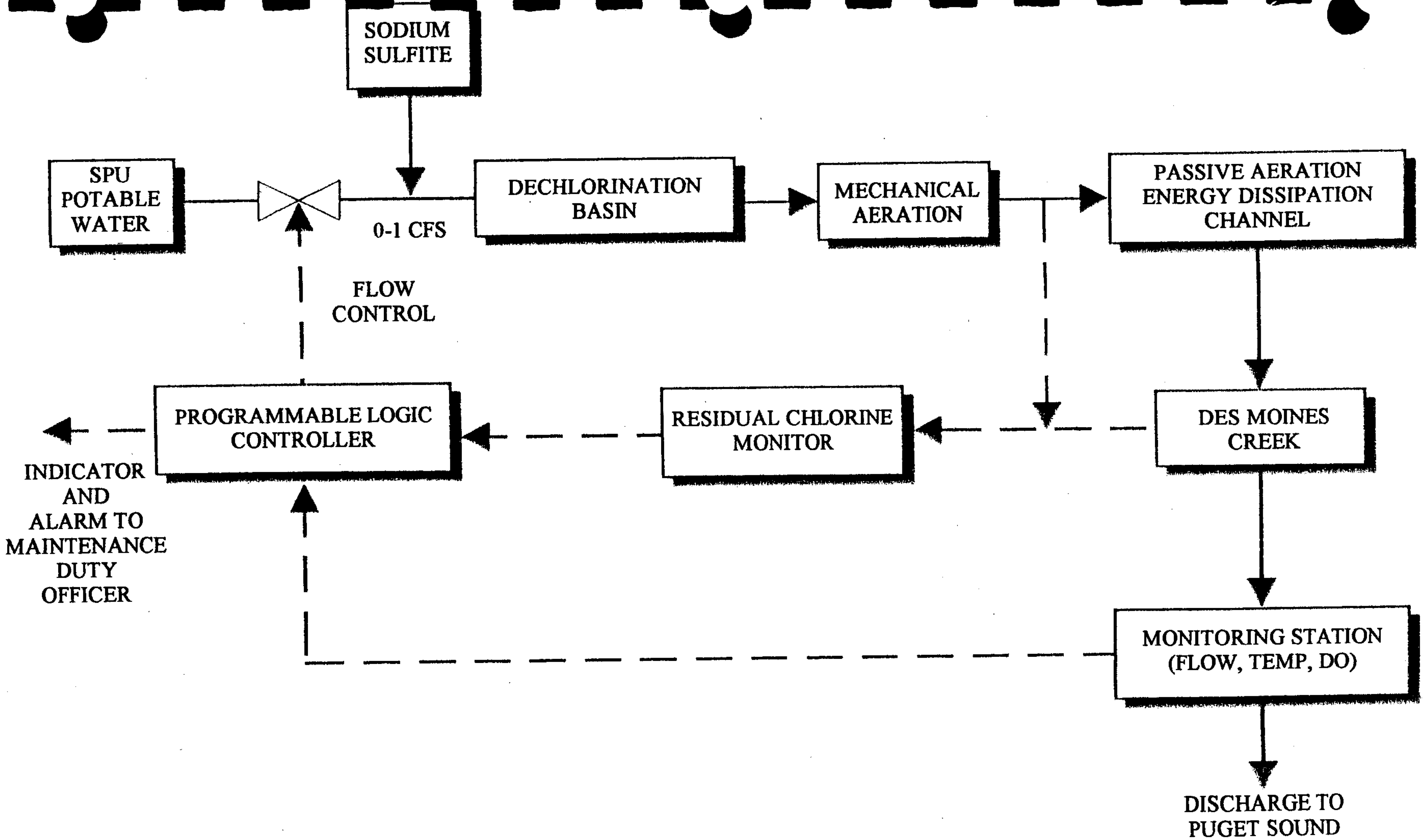

Kennedy/Jenks Consultants

SEATTLE TACOMA INTERNATIONAL AIRPORT
SEATAC, WA

DES MOINES CREEK FLOW AUGMENTATION SYSTEM PROCESS FLOW DIAGRAM

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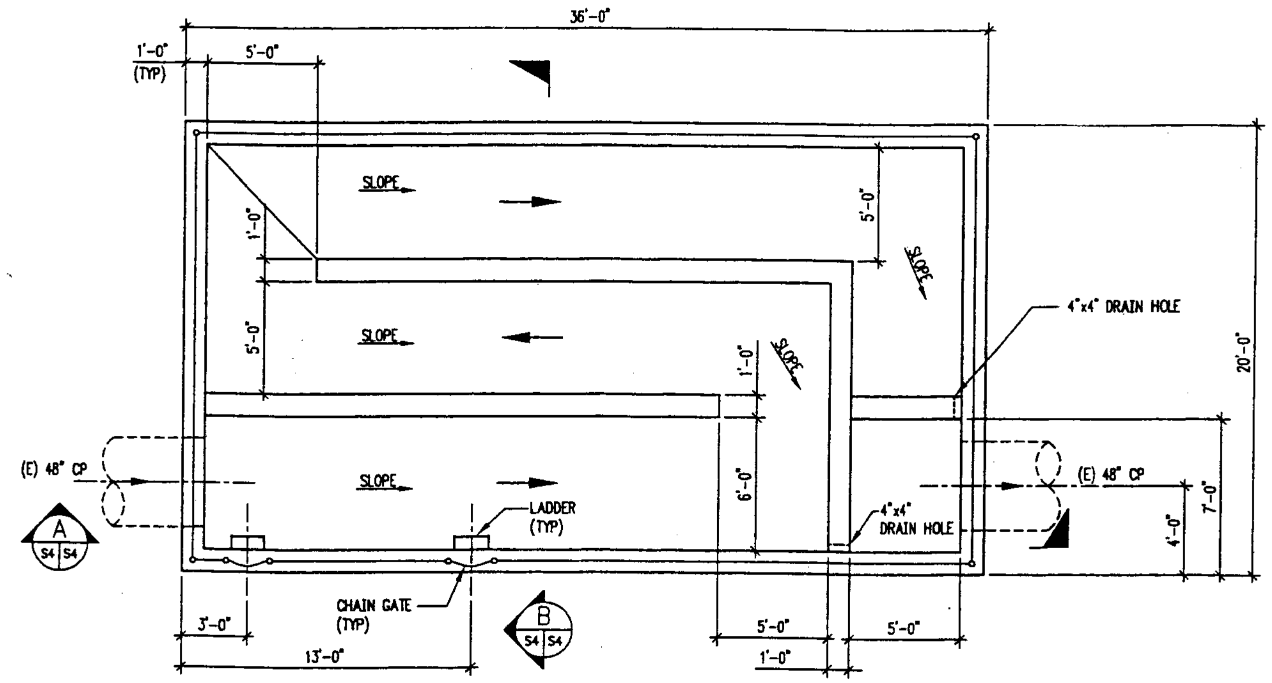
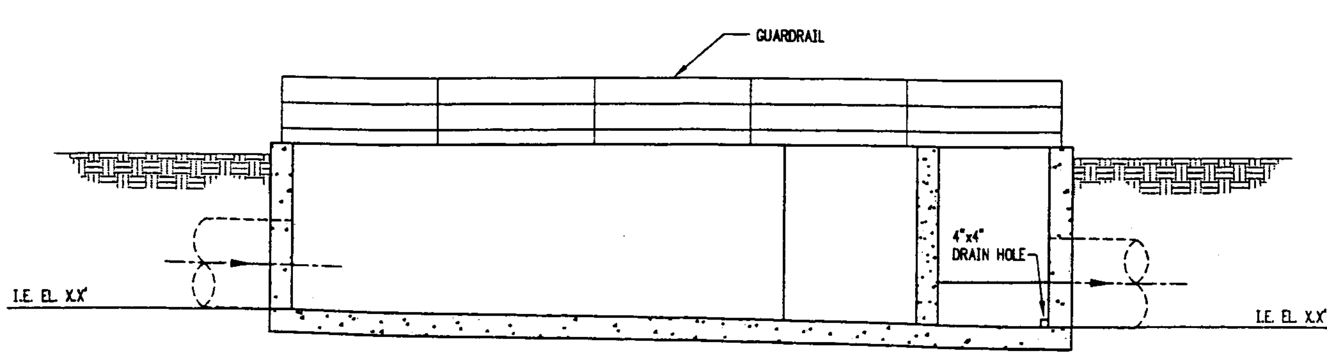
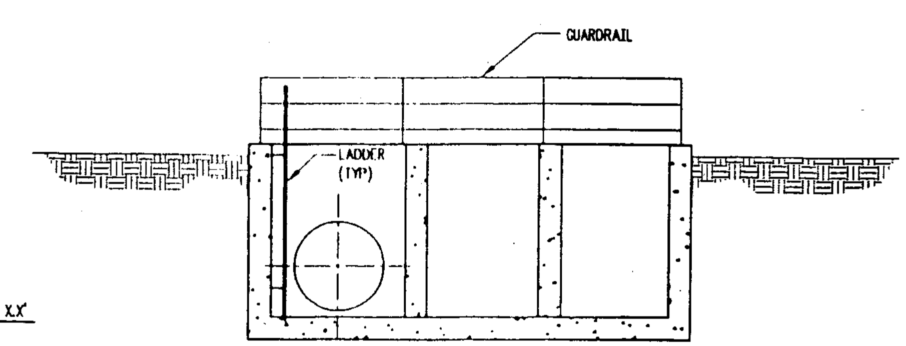
FIGURE-2



PLAN
SCALE: 1/4" = 1'-0"



SECTION
SCALE: 1/4" = 1'-0"
A S4 S4



SECTION
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B S4 S4

SAMPLE

SUBMITTAL

WARNING
IF THIS BAR DOES NOT MEASURE 1" THEN THE DRAWING IS NOT TO SCALE

REVISIONS	BY	DATE

CITY OF PORTLAND
BUREAU OF WATER WORKS

GROUNDWATER PUMP STATION IMPROVEMENTS
RESERVIOR IMPROVEMENTS
CHLORINATION BASIN
PLAN, SECTION AND DETAILS

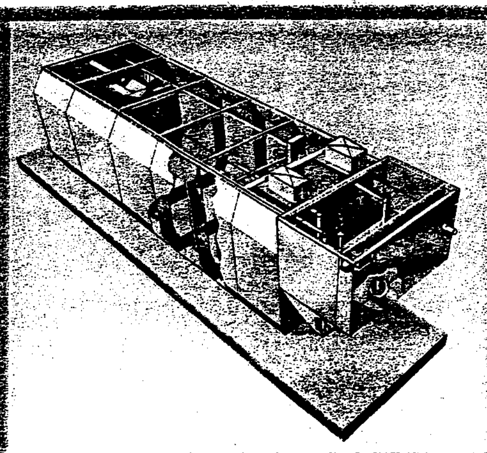
AR 025089

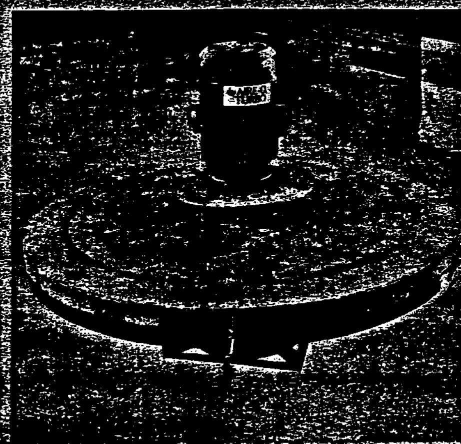
APPENDIX A

CATALOG CUT: AIRE-O_2 TRITON AERATOR/MIXER

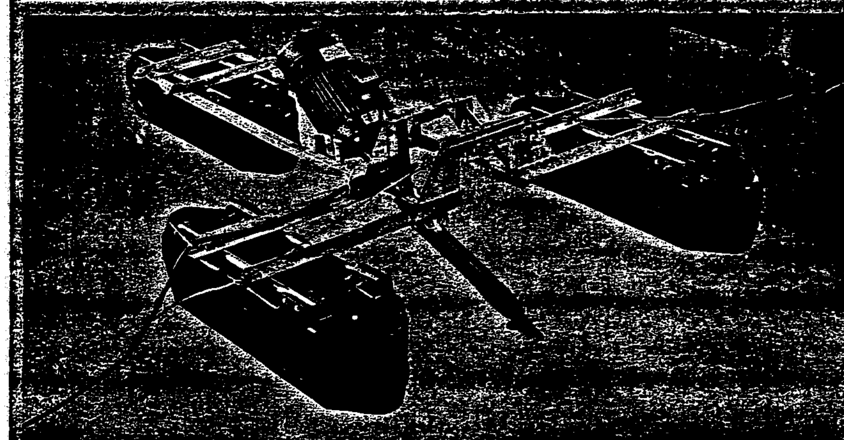
Unlimited Aspirations.

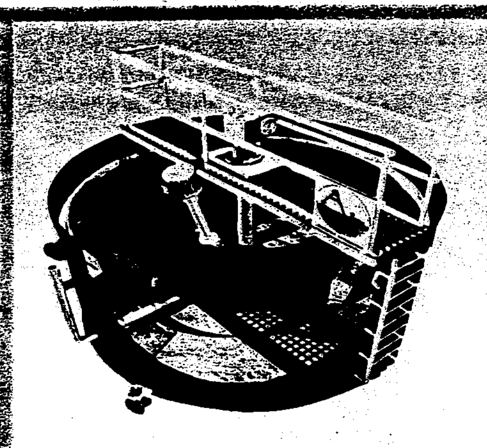
AIRE-O_2® MIXER | **UNISYSTEM®** | **AIRE-O_2® TURBO™**





AIRE-O_2® ASPIRATOR | **MICROFLOAT®**





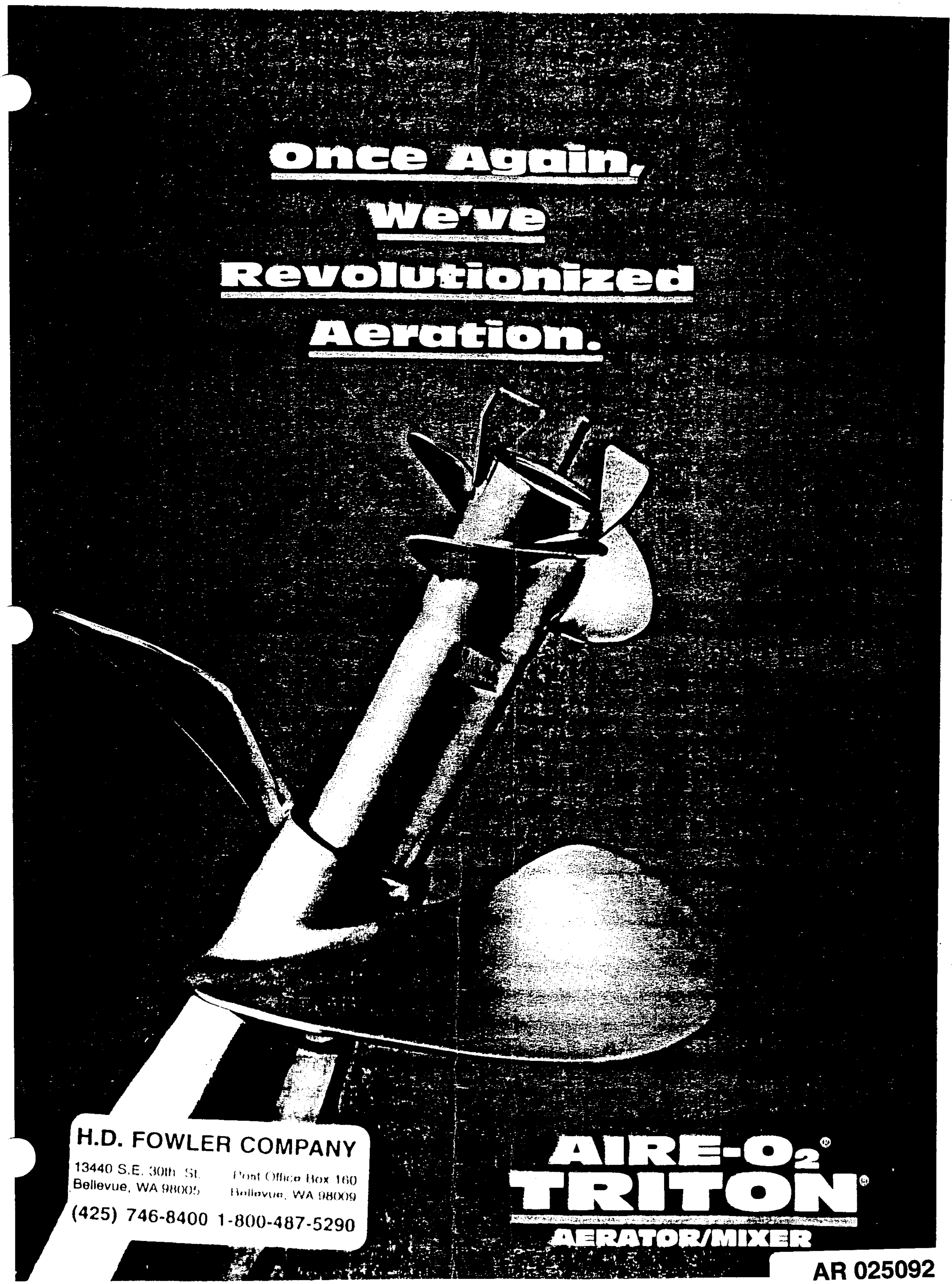
Famous for over 25 years of unequaled performance, Aeration Industries has expanded its line of quality products, some of which are shown here. Clockwise from top left is the new **AIRE-O_2 Slow Speed MIXER**, a powerful unit with a very large, low RPM PowerMix propeller for high-rate, low cost mixing. The **UNISYSTEM** is an expandable, smallfoot print, continuous-flow biological treatment system. The **AIRE-O_2TURBO™** produces a high volume, low spray pattern with less aerosoling and superior O_2 transfer. The compact **MICROFLOAT** system incorporates micron-sized bubbles to achieve 95% FOG removal at half the cost of DAF. And our flagship product - the **AIRE-O_2 Aspirator Aerator**, the industry work horse, delivers high efficiency, reliability, dependability and affordability from 2 to 100 HP sizes. You know us as the leader and the company you can depend on when you need solutions. If you need a custom solution, give us a call.

www.aireo2.com

AERATION INDUSTRIES INTERNATIONAL, INC.

Toll-free: 1-800-328-8287
Phone: 612-448-6789
Fax: 612-448-7293

AR 025091

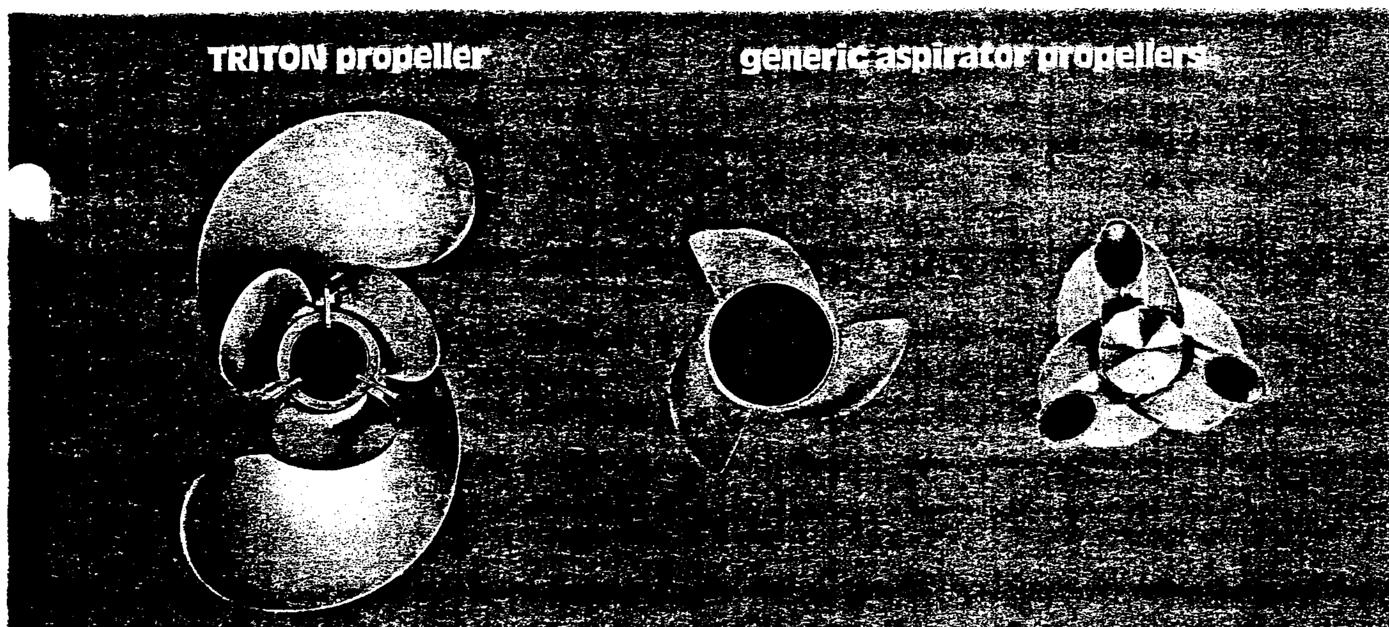

Once Again, We've Revolutionized Aeration.
H.D. FOWLER COMPANY
13440 S.E. 30th St. Bellevue, WA 98005
Post Office Box 160 Bellevue, WA 98009
(425) 746-8400 1-800-487-5290
AIRE-O2®
TRITON®
AERATOR/MIXER

AR 025092

AIRE-O2® TRITON® Redefine

And Mixing. All In One Si

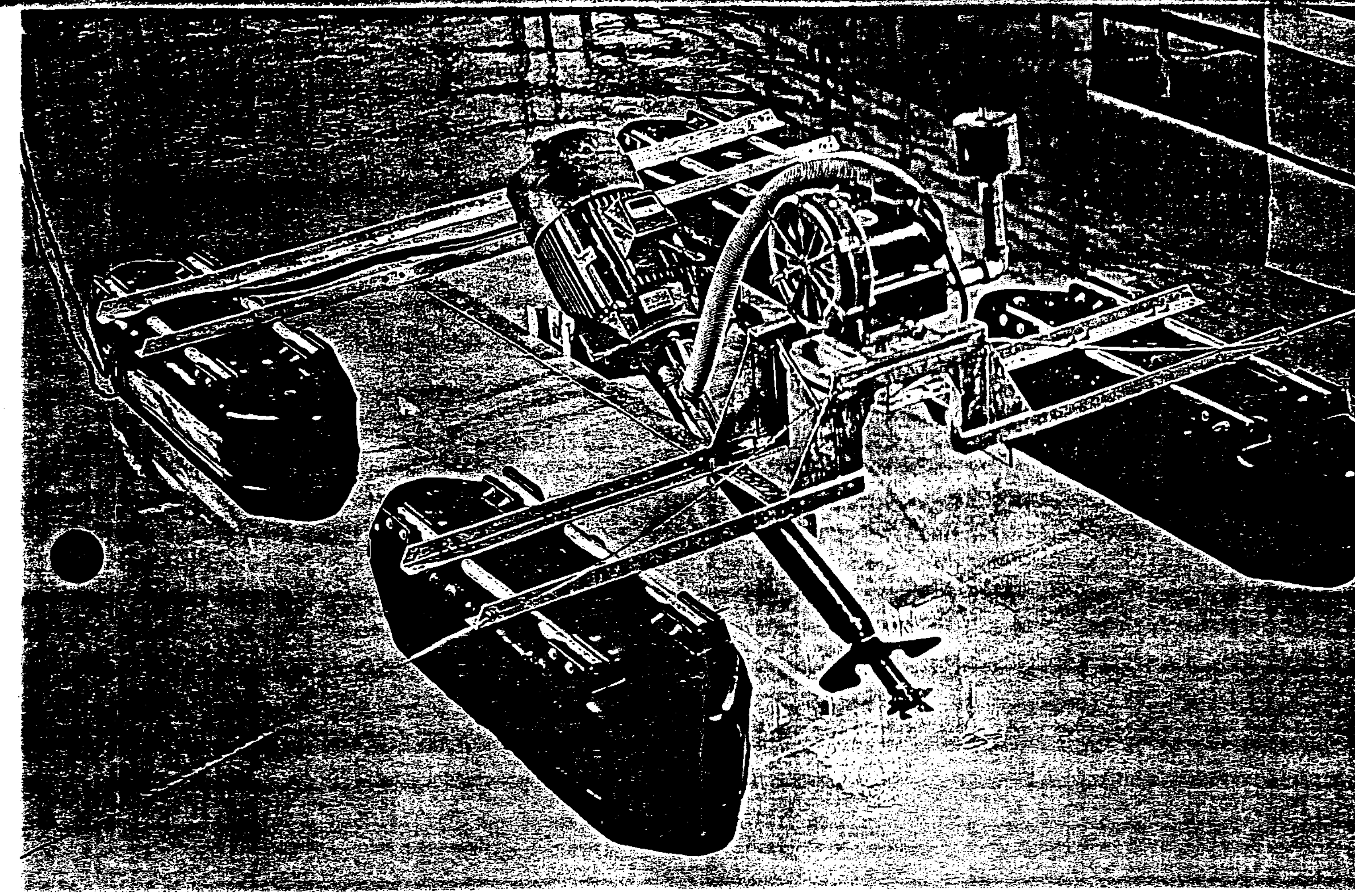
With our huge advance in oxygen dispersion efficiency, we've effectively blown away every other aspirator/aerator in the industry. And that means higher BOD removal rates and no aerosols, odors or sludge build up. It means complete biological nutrient reduction with a single, compact unit. And it means reduced operating costs in every application. Simply put, it's the fastest, most efficient, most effective aerator/mixer available anywhere in the world.

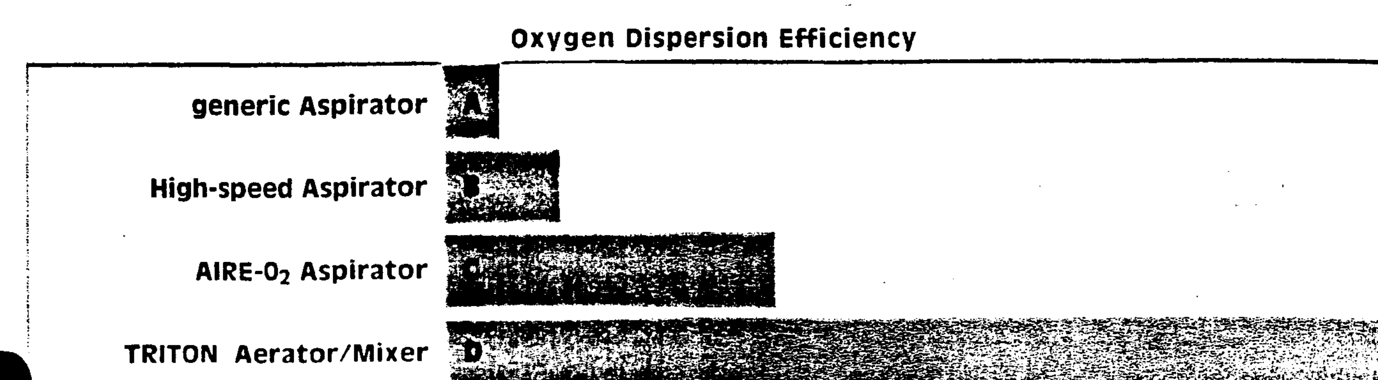


Our PowerMix™ Prop: four times as large as conventional mixer props, quadruples the mixing power while reducing energy costs. In the TRITON, the large mixing prop and smaller aerating prop are used simultaneously, creating excellent synergy.

It's a propeller-driven revolution.

The patented TRITON is the result of a million-dollar effort to develop the optimum combination of hydraulic and aeration efficiency. Our unique PowerShear™ prop creates a plume of ultra fine bubbles and our unique PowerMix™ prop simultaneously drives this plume farther and deeper through the water column extending the contact time and the reach of the bubbles for maximum oxygen dispersion effectiveness .



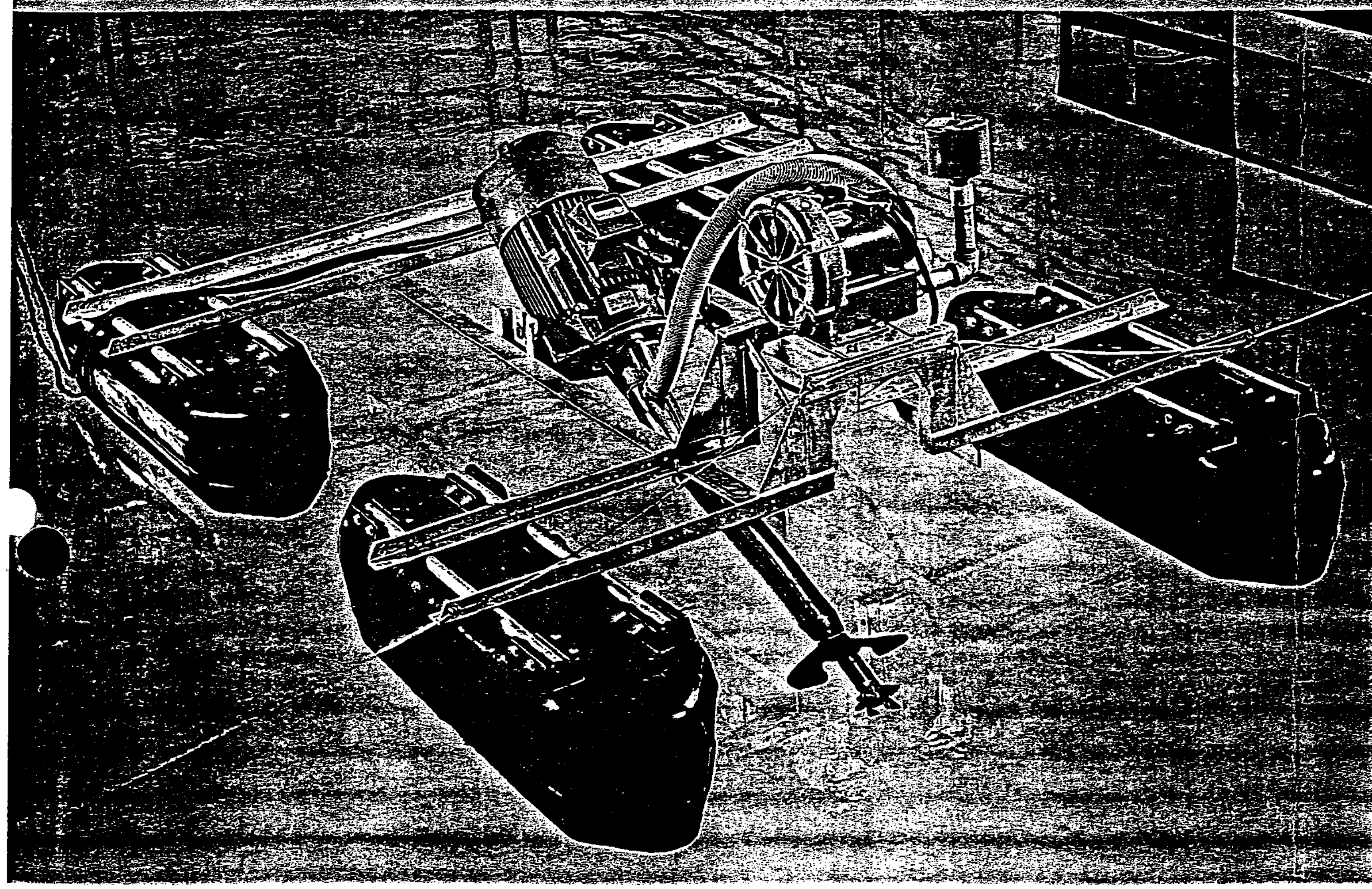


Shown above are relative plume sizes in square feet per horsepower. Aerators A, B and C were tested side-by-side. The TRITON data was developed in a separate test. Aerators A and B both produced large diameter bubbles which rise to the surface more quickly. Aerators C and D produced fine bubbles which extend residence time.

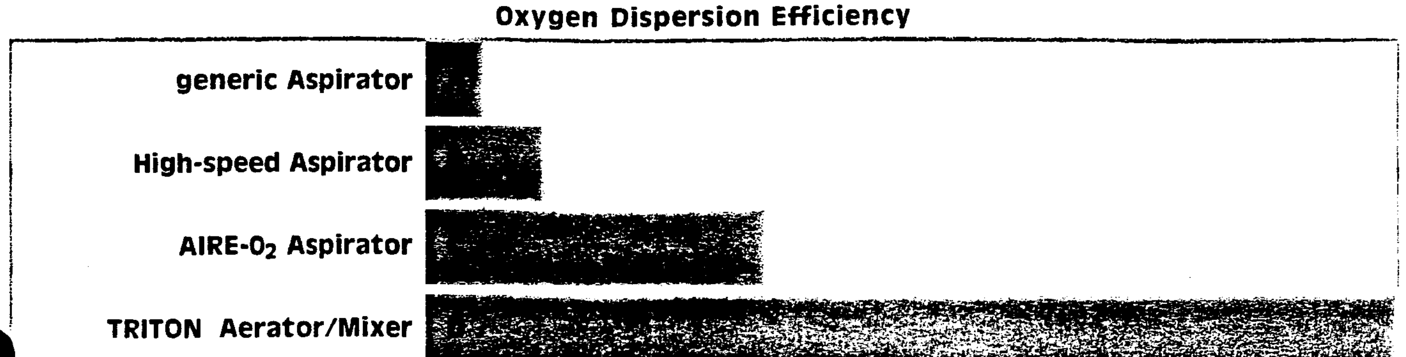
AR 025093

RITON® Redefines Aeration.

g. All In One Simple Unit.



Oxygen Dispersion Efficiency



Shown above are relative plume sizes in square feet per horsepower. Aerators A, B and C were tested side-by-side. The TRITON data was developed in a separate test. Aerators A and B both produced large diameter bubbles which rise to the surface more quickly. Aerators C and D produced fine bubbles which extend residence time.

Nitrify and denitrify with a single unit.

In the nitrification mode, both aeration and mixing are done simultaneously. For denitrifying, mixing is done without air injection. Because TRITON can perform both functions with a single unit, operating modes can change quickly and easily. Other processes are performed with ease by TRITON including extended aeration, post aeration, aerobic digestion, aerosol reduction and phosphorous reduction in all types of climates.

TRITON OUTPERFORMS CONVENTIONAL SYSTEMS IN EVERY IMPORTANT AREA

	AIRE O_2 TRITON	HIGH SPEED AERATORS	OTHER ASPIRATOR/AERATORS
Nitrification	Yes	Yes	Yes
Denitrification	Yes	No	No
Dual-Function Capability	Yes	No	No
Biological Nutrient Removal	Yes	No	No
Aerosol Reduction	Yes	No	Yes
Mixing Rates (O_2 dispersion)	1.0 ft/sec (0.305 m/sec)	<0.25 ft/sec (0.076 m/sec)	<0.35 ft/sec (0.107 m/sec)
Induced Flow	Yes	No	Minimal
Warranty Period	3 years, no pro-rating	1 year pro-rated	1 year pro-rated
On-Site Serviceable	Yes	No	No
Gallons per Minute Pumped (Data is based on 25 HP units)	8000	6000	1700
Motor Speed	Low	High	High

Call for details.

We offer a warranty unlike any other in the industry.

Because TRITON is the industry's best product, we also offer the industry's best warranty. Three years. Non-prorated. No loopholes. When you see the TRITON in action, you'll understand why we can so confidently put this warranty forward. Call us. Let's get you involved in the aeration revolution.

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