OZONE SYSTEM FEASIBILITY STUDY
WASHOE PARK TROUT HATCHERY

January 1994

Prepared for:
Montana Department of Fish, Wildlife and Parks
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Washoe Park Trout Hatchery
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EXECUTIVE SUMMARY

Montana Department of Fish, Wildlife and Parks (MDFW&P) has been experiencing a high level of mortality in valuable broodstock trout at its Washoe Park Fish Hatchery. The cause of the mortality problem is a water borne fungus which is entering the hatchery via the Warm Springs Creek water supply. In response, MDFW&P has initiated a study to determine the feasibility and cost of constructing an ozone disinfection water treatment system to eliminate the fungus and other pathogens from the incoming creek water supply. MDFW&P placed a high priority on maintaining gravity flow of water through the entire hatchery water supply system.

The study results indicate that a functional ozone disinfection system is constructable at the Washoe Park facility, with relatively minor modifications to the existing facilities. New infrastructure required includes a 15 lbs/day ozone generation unit, ozone contactor and retention tankage, and an ozone degassing and destruct system. The performance and effectiveness of this system will be influenced by the water temperature and turbidity of the creek. During clean water conditions, ozone dosage can be significantly reduced (an operational cost savings). A new 850 square foot building is recommended to house and protect the ozone system components. There are two available sites for this building. The first site (Option 1) is immediately adjacent to the existing aeration headbox. A second site (Option 2) for these improvements is available along the incoming 24-inch creek water supply pipe approximately 100 feet upstream of the existing aeration building.

Modifications to existing facilities entail cutting in 24-inch pipe fittings at two locations along the creek supply pipe and lowering concrete weirs 1-foot at the self-cleaning screens in the aeration building.

Construction cost in 1993 dollars, is estimated at approximately $226,000 for the Option 2 configuration. Total project costs are estimated to be nearly $300,000. Option 1 would be slightly more expensive to implement because existing valves and flow metering would need to be relocated.

BACKGROUND

The Montana Department of Fish, Wildlife, and Parks (MDFW&P) is experiencing serious fish health problems at its Washoe Park Trout Hatchery. West Slope Cutthroat Trout broodstock held in concrete raceways are developing a fungus infection which results in high mortality rates. The primary water supply to the raceways is diverted from Warm Springs Creek. The creek water supply has been identified as the primary source of the fungal contamination.

As a first step to eliminate the fungus problem, MDFW&P has initiated a study to evaluate the feasibility of constructing an ozone disinfection system on the incoming Warm Springs Creek water supply. The Department entered into a Contract Agreement on April 8, 1993 with KCM, Inc. to investigate the ozone system feasibility, including a conceptual design and cost estimate for budgetary purposes.

Personnel from KCM, Inc. reviewed the existing facilities in the field, studied photographs and "as-constructed" drawings of the existing facilities and communicated with various MDFW&P personnel to form a basis for this study.

EXISTING CONDITIONS

A screened intake structure located on the southeast bank of Warm Springs Creek in Washoe Park directs water from the creek into a 24-inch diameter transmission pipeline. The present water right allows withdrawal of 2,600 gpm through the intake structure. The transmission pipe is sized for up to 5,000 gpm total flow in anticipation of possible future water right increases. The transmission pipeline carries the creek water approximately 2,080 linear feet through Washoe Park and upper portions of the Hatchery (Figure 1) to a newly constructed aeration building. An in-line propeller meter at the pipe entrance to the aeration building measures the creek water flow rate to the hatchery.

After entering the aeration building, the creek water discharges into a concrete sump, from which it overflows a weir and through a sloped, self-cleaning stainless steel screen. An 18-inch pipe carries the screened creek water from the aeration building to two sets of eight concrete raceways. Broodstock trout may be held in the raceways for several years.

The water supply during spring run-off and severe storm events can have high levels of turbidity. Some of this material is colloidal while the bulk of the material is sand, silt and organic matter, such as algae and leaves.

The fungal infection appears to develop during the winter and early spring as fish start to mature sexually. This is also a period when the creek water temperature is the lowest.

PROJECT OBJECTIVES

The Montana Department of Fish, Wildlife, and Parks (MDFW&P) wishes to accomplish the following specific objectives with this study:

- Determine if an ozone disinfection system can be constructed to treat the entire 2,600 gpm creek water supply while maintaining gravity flow through the supply system (no pumping).
- Develop a hydraulic profile and conceptual design for a workable ozone disinfection system.
- Develop a preliminary project cost estimate to construct the ozone disinfection system for budgeting purposes.

These objectives are addressed in detail in the following sections.

OZONE DISINFECTION SYSTEM PARAMETERS

Research by Tipping (1988) has indicated the critical parameter for cold freshwater ozone disinfection effectiveness is a design that results in a contact dosage and time (CT) value of 0.8 or greater.[1] The CT value is a product of the aqueous ozone concentration (C in mg/1) and retention time duration between dosing and degassing (T in minutes). Ozone demand to achieve full disinfection will vary depending on turbidity levels and water temperatures. High levels of turbidity increase ozone demand, as does colder water temperatures. Ozone is still an effective disinfectant under these conditions, in contrast to ultraviolet disinfection which would not be effective unless debris and turbidity were removed by filtration.

For the purpose of this study, the following parameters were used for ozone system sizing:

- Size system for CT value of 1.0.
- Size hydraulic structures for retention time of 5 minutes.
- Use an ozone mass transfer efficiency of 50%. Transfer efficiencies are often much higher, (in the 90—95% range). Using 50% efficiency allows safety factors for high turbidity levels, low water temperatures, some short circuiting through hydraulic structures, and treating higher flow rates in the future.

Based on the above, a dosing rate of 0.4 mg/l, or 15 lbs/day will be needed to achieve full disinfection of the 2,600 gpm (3.744 MGD) creek water supply.

Another critical parameter for the Washoe Park facility is to size the ozone system hydraulic components to minimize headlosses and preserve gravity flow of the creek water supply. Our preliminary calculations indicate that a headloss of six to seven feet through the ozone system is the maximum allowable without having to pump.

[1] J. M. TIPPING. Ozone Control Of Ceratomyxosis: Survival And Growth Benefits To Steelhead And Cutthroat Trout, 1988, Volume 50, No. 4, Progressive Fish Culturist.

To help keep headlosses low, the pipe runs between the existing 24-inch creek water supply and ozone system must be as short as possible. It appears that a good location for the ozone system is an open area approximately 100 feet west of the aeration building (Figure 2), adjacent to the 24-inch creek supply pipe. An equally effective location is immediately adjacent to the existing aeration headbox. We feel it is best to group the system components in a centralized area and protect them from the elements with a new building structure. Electrical power and potable water (for cooling the ozone generator) can be extended to serve this location relatively easily.

HYDRAULIC PROFILE AND CONCEPTUAL DESIGN

According to the drawings provided by MDFW&P, the water level at the creek intake structure is 5313.80. The weir elevation at the screen in the aeration building is at 5,306.5 ±, for a total difference of 7.3 ± feet. About 1.4 to 1.6 feet of head is required to drive 2,600 gpm through the 2,100 feet of 24-inch transmission pipe. This leaves a hydraulic head of approximately 5.5 feet available to move water through the ozone system. At least 5.0 to 5.5 feet of drop through a degassing tower will be needed to effectively strip residual ozone. This results in less than 6-inches of head remaining for gravity flow through the remainder of the ozone system. To ensure gravity flow, we recommend the concrete weirs at the self-cleaning screen be modified as described below. With properly sized piping and hydraulic structure design, a hydraulic profile similar to the illustration in Figure 3 should be achievable.

We recommend the following measures be considered to improve gravity flow hydraulic profile characteristics:

- Remove 1-foot from the tops of the existing concrete weirs at the self-cleaning screen in the aeration building.

- Leave the 24-inch butterfly valve upstream of the meter pit in a full open position.

- Use long radius bends and carefully size baffle openings in the ozone system hydraulic structures.

KCM also investigated the headloss through the existing 24-inch propeller meter and found that less than 1-inch of loss is expected through the meter at peak flow rates. Therefore, no changes in the metering process are recommended.

To meet the ozone system parameters discussed above, we have developed a conceptual design (Figure 4) consisting of the following major components:

- A six foot diameter by 25 foot tall fiberglass contactor tower with center baffle and fine pore diffusers for efficient ozone gas introduction.

- A ten foot diameter by 23 foot tall fiberglass tank to provide 5 minutes retention of ozonated water at 2,600 gpm.

- A six foot by six foot square vented packed column to strip residual ozone from the creek water supply after the retention period.
- A fifteen pound per day air feed ozone generator with air preparation equipment.
- A 25 foot by 34 foot (850 S.F.) building to protect equipment from the elements.

The contactor and retention tanks are shown partially buried (± 6 feet) to reduce building height and floor area requirements. The contactor and retention tanks could, as an alternative, be constructed using baffled cast-in-place concrete. This option should be considered during the design phase if MDFW&P goes ahead with the project.

COST ESTIMATE

Table 1 below includes a summary of probable construction costs and of related project costs for the recommended structural and mechanical improvements necessary to implement the ozone disinfection system. The costs shown herein are for 1993 construction. An escalation factor must be included if construction occurs in 1994 or later. A common method of indexing costs is to use the Engineering News Record (ENR) Construction Cost Index which is at 5,262.02 as of May 3, 1993.

TABLE 1
MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
WASHOE PARK FISH HATCHERY

PROJECT COST SUMMARY

A. PROBABLE CONSTRUCTION COST

24-Inch pipe, fittings and valves	$40,000
6-Foot diameter Contactor	$15,000
10-Foot diameter Retention Tank	$25,000
Packed Column Assembly (including support)	$12,000
15 lbs per day Ozone Generator (with air preparation)	$60,000
Ozone Destruct System	$12,000
Degas Exhaust Fan	$9,000
850 square foot building and paved driveway	$35,000
Electrical, Plumbing and Ventilation	$15,000
Modify concrete weir	$3,000
1993 PROBABLE CONSTRUCTION COST	$226,000

B. PROJECT RELATED COSTS

Contingencies at 15%	$33,000
Survey/Geotech Study (may not be necessary)	$4,000
Engineering Plans and Specifications	$25,000
Construction Management Services	$5,000
Substantial Completion Review	$2,000
Permits	$3,000
SUBTOTAL	$72,000
TOTAL PROJECT COST	**$298,000**

APPENDIX A.
CATALOG CUTS

OZONE SYSTEM FEASIBILITY STUDY
WASHOE PARK TROUT HATCHERY
JANUARY 1994

APPENDIX B.
CALCULATIONS

OZONE SYSTEM FEASIBILITY STUDY
WASHOE PARK TROUT HATCHERY
JANUARY 1994

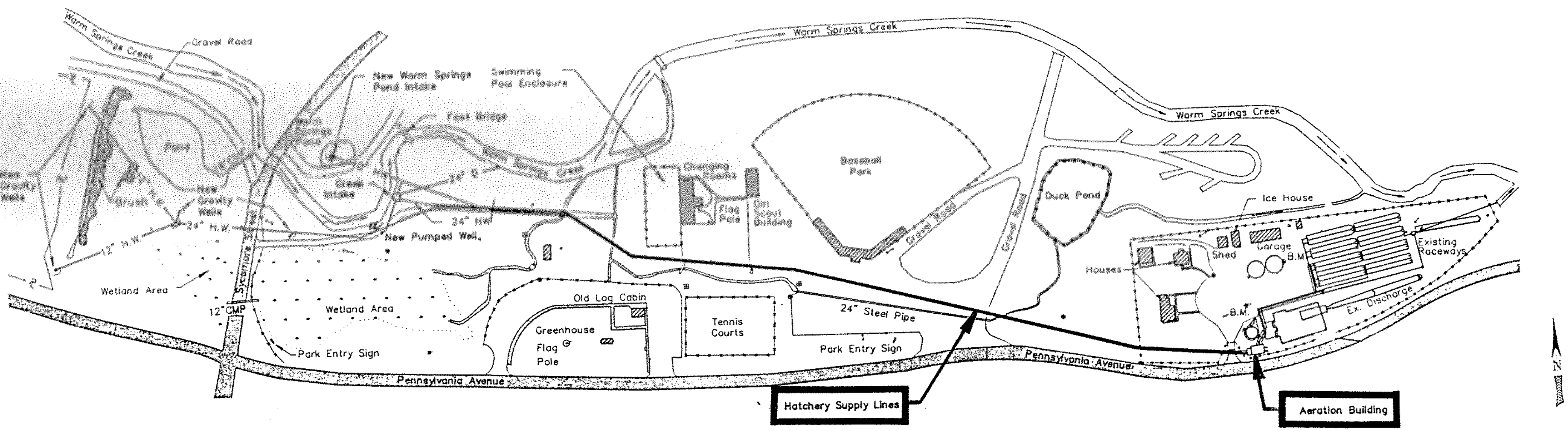

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FIGURE 1

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MONTANA DEPT OF FISH, WILDLIFE AND PARKS
WASHOE PARK TROUT HATCHERY

OZONE SYSTEM FEASIBILTIY STUDY
EXISTING SITE LAYOUT

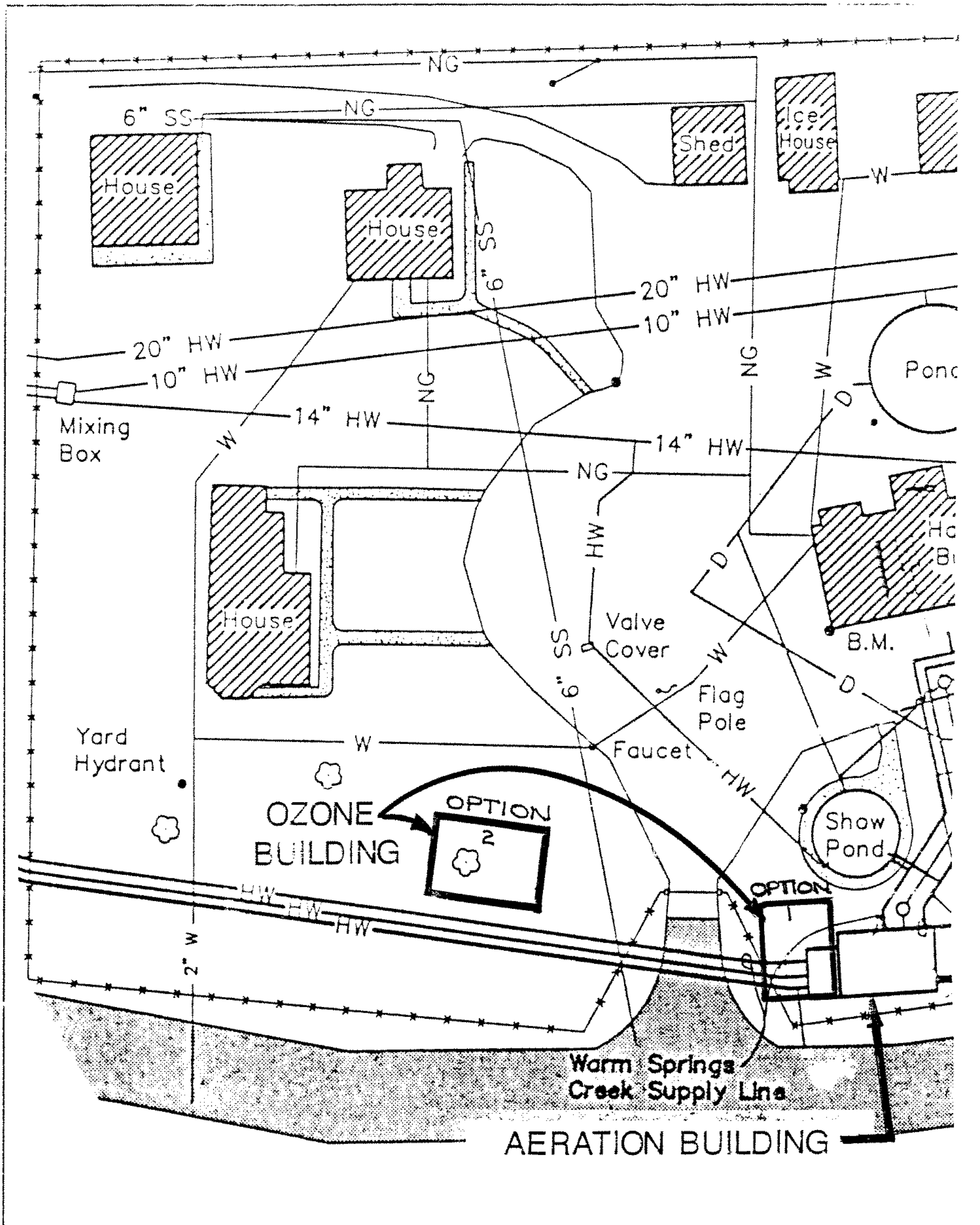

FIGURE 2

KCM

MONTANA DEPT. OF FISH, WILDLIFE AND PARKS	OZONE SYSTEM FEASIBILITY STUDY
WASHOE PARK TROUT HATCHERY	OZONE BUILDING FOOTPRINT

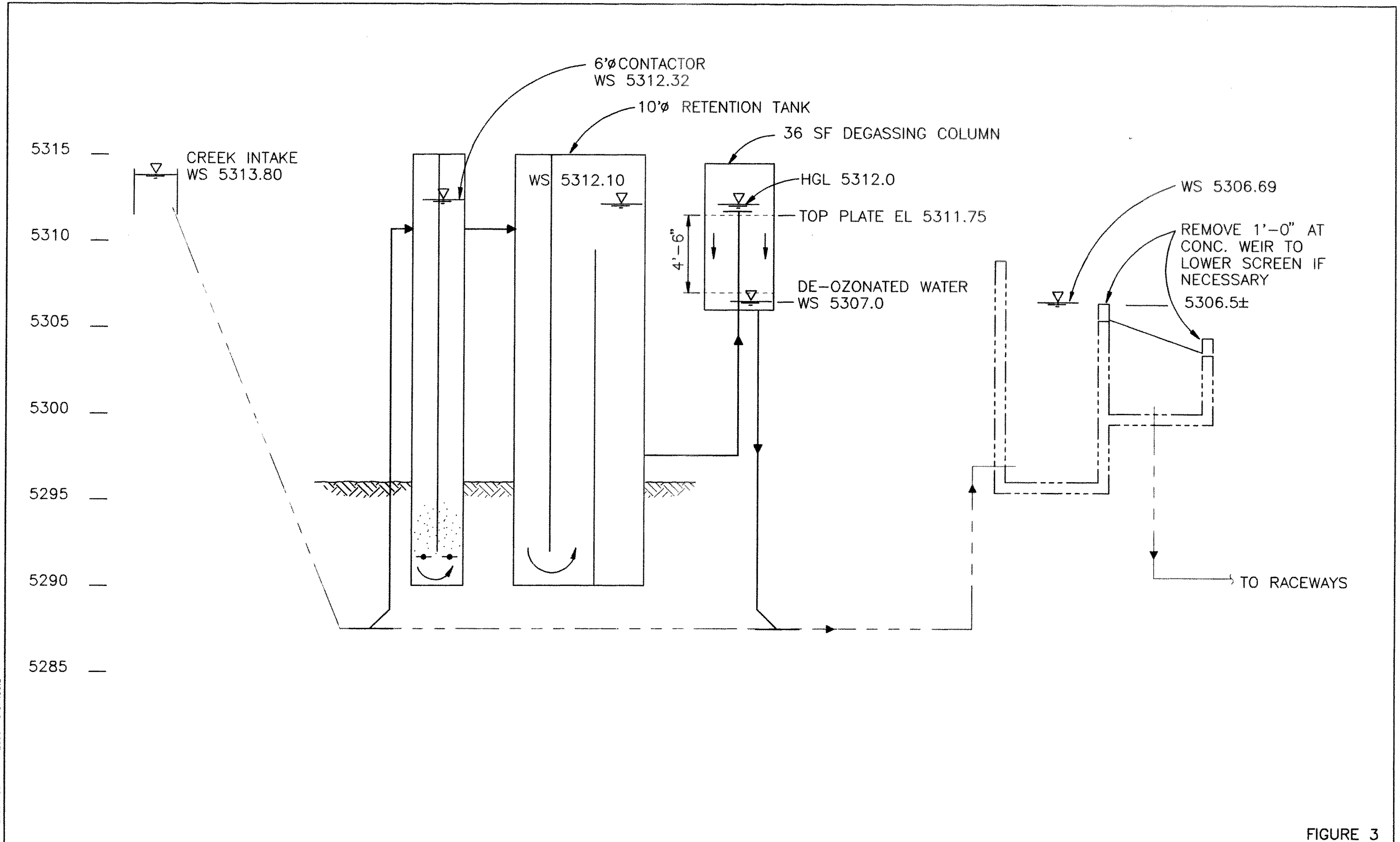

FIGURE 3

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MONTANA DEPT OF FISH, WILDLIFE AND PARKS
WASHOE PARK TROUT HATCHERY

OZONE SYSTEM FEASIBILITY STUDY
HYDRAULIC PROFILE

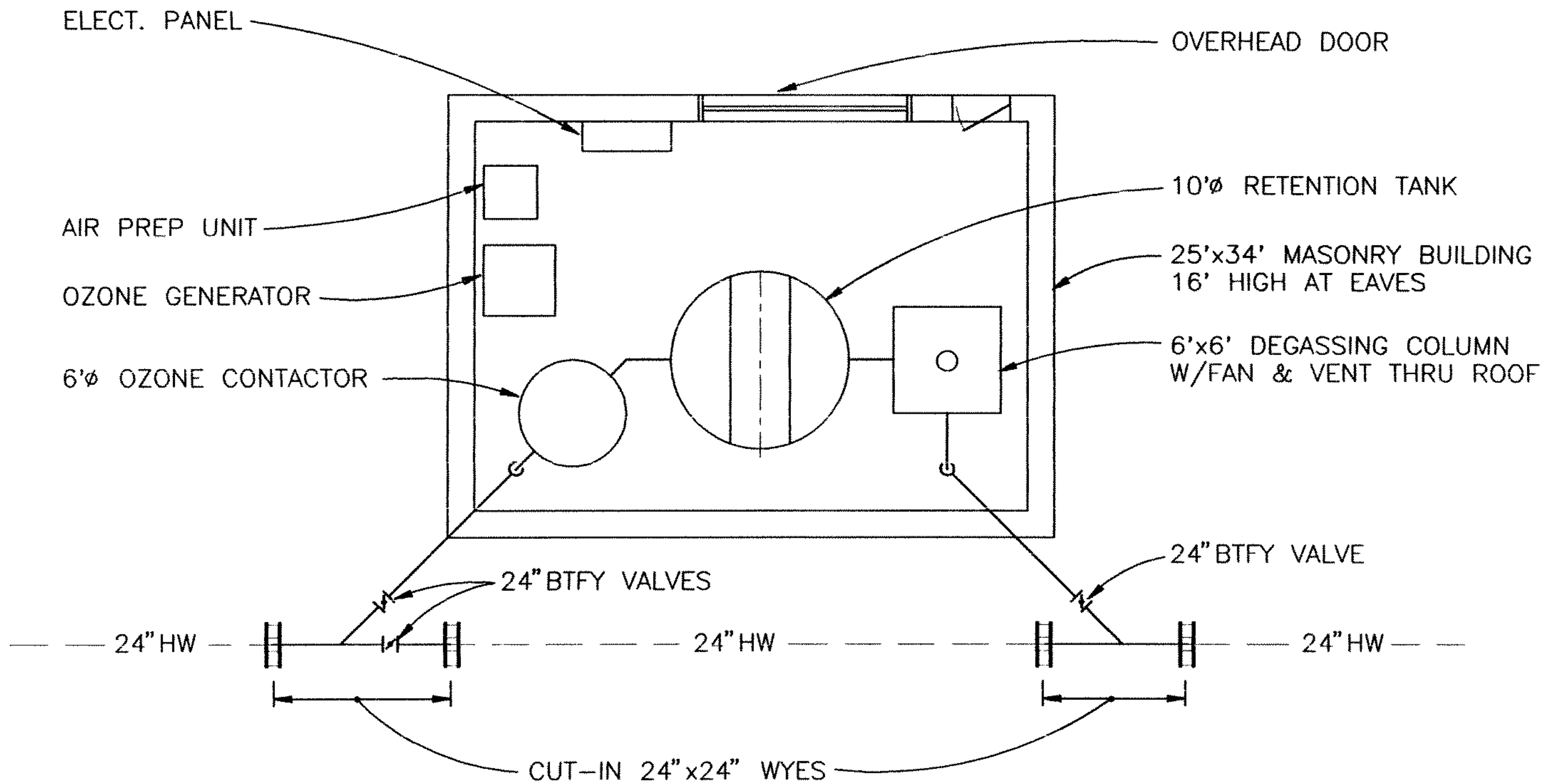

FIGURE 4

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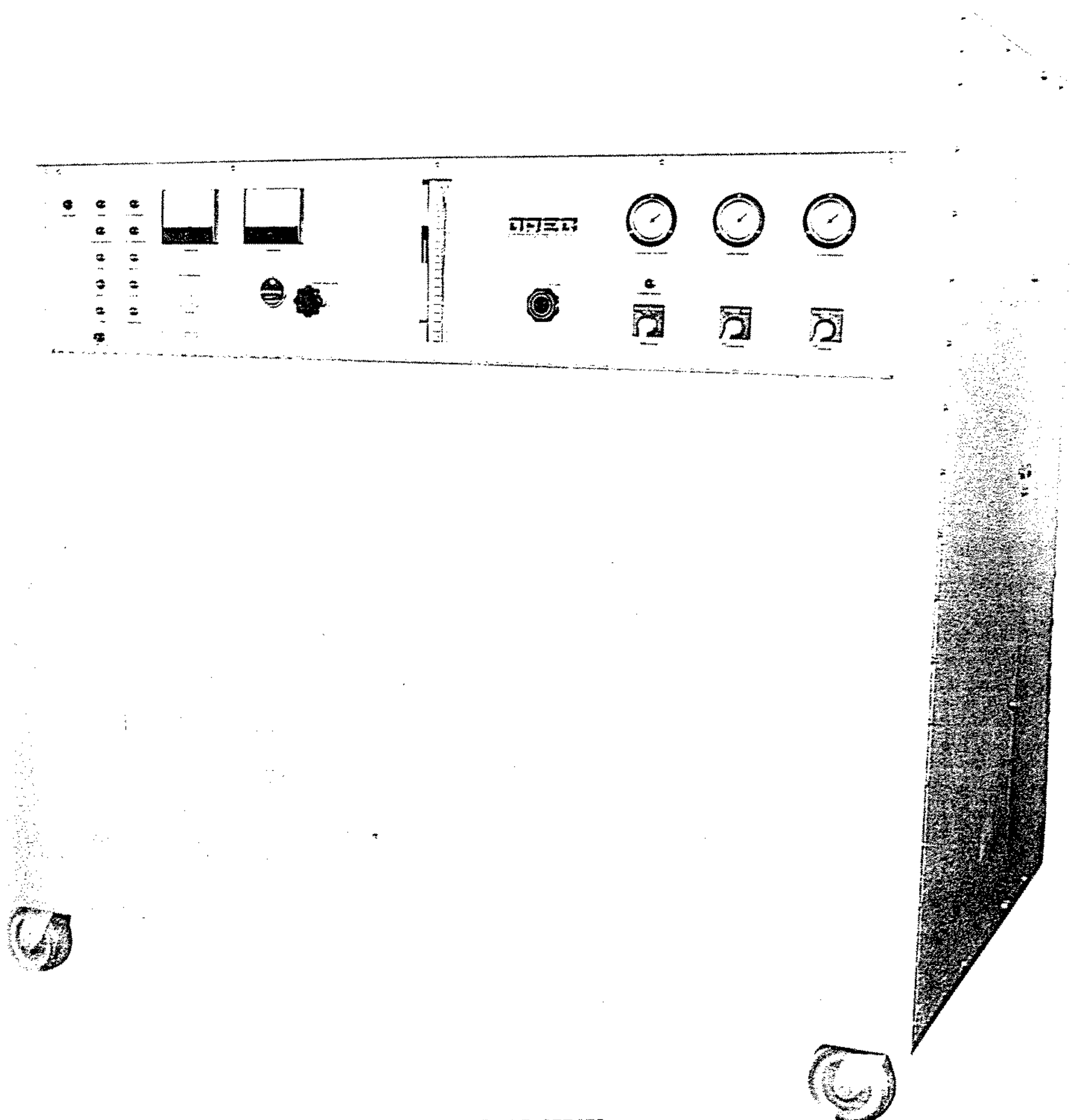
MONTANA DEPT OF FISH, WILDLIFE AND PARKS	OZONE SYSTEM FEASIBILITY STUDY
WASHOE PARK TROUT HATCHERY	SCHEMATIC FLOOR PLAN

APPENDIX A.
CATALOG CUTS

OZONE SYSTEM FEASIBILITY STUDY
WASHOE PARK TROUT HATCHERY
JANUARY 1994



03D-AR SERIES

SPECIFICATIONS
OREC "AR" SERIES OZONATORS
PARENT GAS: AIR

(See footnote explanation of terms)

MODEL	OZONE OUTPUT[a]		AIR FLOW AT 1% WT.		MAX PSIG[b]	DIMENSIONS W"xH"xD"	EST. GROSS WT. LBS.	STD.[d] NOMINAL VOLTAGE	STANDARD EQUIPMENT
	GR/HR	LBS./DAY	L/MIN	CFM					
03V5-AR	2.5	.13	3.1	.11	15	25x14x23	165	120	1-11, 23
03V10-AR	5	.25	6.3	.22	15	25x14x23	175	120	1-11, 23
SP8-AR	9.5	.5	13	.46	30	27x45x15	255	120	1-15
SP19-AR	19	1	26	.92	30	27x45x15	275	120	1-15
SP38-AR		2		1.85	30	39x53x25	600	120	1-19
SP3-AR		3		2.75	30	39x53x25	700	120	1-19
03DV4-AR		4		3.7	30	33x76x49	1200	230-1	1-25
03DV5-AR		5		4.6	30	33x76x49	1250	230-1	1-25
03DV6-AR		6		5.5	30	33x76x49	1300	230-1	1-25
03DV8-AR		8		7.4	30	33x76x49	1400	230-1	1-25
03DV10-AR		10		9.2	30	30x78x80	2000	230-1	1-25
03DV12-AR		12		11.2	30	30x78x80	2300	230-3	1-25, 29
03D15-AR		15		13.9	30	30x78x80	2600	230-3	1-25, 29
03D20-AR		20		18.5	30	72x74x63	3500	230-3	1-25, 29
03DV25-AR		25		23.1	30	72x74x63	4200	460-3	1-25, 29
03H30-AR		30		28	15	90x60x36	2500	460-3	2-18, 20-28
03H50-AR		50		46	15	92x60x45	4300	460-3	2-18, 20-29
02H125-AR		125		115	15	98x100x74	11500	460-3	2-18, 20-29
03H250-AR[f]		250		231	15	100x100x96	20000	460-3	2-18, 20-29
03H500-AR[f]		500		462	15	160x100x96	35000	460-3	2-18, 20-29

NOTE: ALL "AR" OZONATORS ARE PROVIDED WITH COMPLETE AIR PROCESSING EQUIPMENT AND CAN BE PROVIDED FOR OPERATION FROM OXYGEN TO ACHIEVE TWICE THE LISTED OZONE OUTPUT — "AR/O" SERIES.

EXPLANATION OF TERMS

a. Rated output at 60 Hz. Output reduced 16% at 50 Hz. Maximum concentration is 4% wt.

b. Maximum pressure at which ozonator may be operated.

c. GPM cooling water flow is equal to LBS/DAY OZONE x .20 at 70° F cooling water temperature. As water temperature decreases, required flow decreases; e.g. flow is reduced 33% at 50° F cooling water temperature.

d. Price adjustment for ordering other than standard voltage.

e. See equipment listing by code number. 1-7 means 1 through 7 inclusive. Ozonators can be provided with various additional non-standard equipment: automatic controls, measurement instrumentation, interlocks, etc.

f. 60%, 80%, 100% voltage taps in lieu of variable voltage transformer.

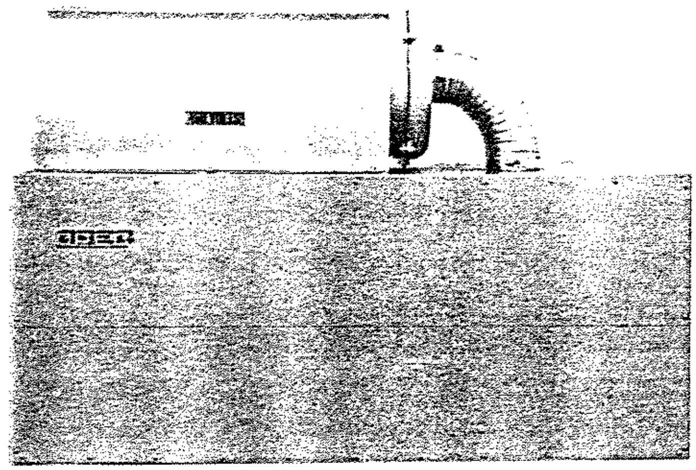
EQUIPMENT LISTING (Code Numbers in Standard Equipment Column)

1. Cabinet enclosed ozonator.
2. Stainless steel ozone generator with dielectrics.
3. Variable voltage control.
4. High voltage transformer.
5. Ammeter, ozone generator.
6. Gas flowmeter.
7. Gas flow valve.
8. Ozone generator pressure gauge.
9. Air compressor with filters.
10. Automatic air drying towers.
11. Gas pressure regulator.
12. Compressor pressure gauge.
13. High temperature limit switch.
14. Gas pressure relief valve.
15. Water flow meter.
16. Humidity limit switch on air dryer system.
17. Horn and signal light indicating cause of auto shutdown.
18. Air pressure limit switch.
19. Water pressure limit switch.
20. Drying towers ammeter.
21. Cooling water pressure gauge.
22. Drying tower cycling signal lights.
23. External compressor.
24. Voltmeter, ozone generator.
25. Running time meter.
26. Tank type ozonator.
27. Water pressure relief valve.
28. Low water flow switch.
29. Phase monitor relay.

OZONE CATALYTIC DESTRUCT MODULES

OREC CDM-OT SERIES

OREC CDM-OT Series Ozone Catalytic Destruct Modules catalytically convert exhaust ozone to oxygen for discharge to the atmosphere. These modules are integral, self-contained units to which the user need only provide an electric power source. Weatherproof, they are designed to operate outdoors in any climate. The user provides ducting of choice from the ozone source, commonly the top of the tank where an ozone process has occurred, to the Ozone Destruct Module inlet which is at negative pressure. The entire catalysis takes place under negative pressure in the system; only at the module exhaust is the pressure positive. The user's ducting need not be air tight: air leakage will be into the system, not out. Ducting materials may be aluminum or 304 SS standard air conditioning tubing, depending upon such factors as flow route, structural requirements, exhaust ozone concentration, etc. Aluminum is an economical and satisfactory option for many exhaust ozone ducting applications. Normally the Catalytic Destruct module is placed above the top of tank level, on a platform at the top of the tank. If the tank top is not covered, it should have a secure, not necessarily air tight, lid attached. There should be a hole in the lid about ¼ inch greater than the 4" OD duct diameter to accept the ducting, assuring the top of the tank to be at atmospheric pressure. Four inch diameter tubing, not pipe, is recommended to match with the Module inlet. High water level should not be less than 1 foot below the duct terminus.



CDM-OT Series Ozone Catalytic Destruct Modules are available in 2 Standard Model Sizes. Model selection is a function of exhaust ozone SCFM and the lowest annual temperature to be encountered. Model CDM50-OT operates at a fixed flow of 50 SCFM. Model CDM100-OT operates at a flow that may be fixed between 50 and 100 SCFM. The user's exhaust ozone enters the fixed flow as a diluent. For example, if the user's exhaust ozone flow is 1 or 49 SCFM, the flow through Model CDM50-OT is 50 SCFM; the balance is makeup air. Each model is designed to treat its specified air flow at air temperatures as low as 0 Deg. C (32 Deg. F). For air temperatures below 0 Deg. C, select Model CDM100-OT and derate the maximum flow of that Model 2 SCFM for every 1 Degree C below 0 Deg. C. Special Order Modules can be provided for SCFM requirement above Standard Models.

PRINCIPLE OF OPERATION:

The motive force for air flow is a high efficiency pressure blower at the outlet end of the Catalyst Destruct Module. Ozonized air flows via ducting to the inlet of the module where it passes through a dust filter and over tubular heating elements which raise the temperature to 190 Deg. F. The heated air then passes through a catalyst chamber which contains beads of a proprietary catalyst, proceeding thence to the inlet side of the blower and discharge to the atmosphere.

DESIGN FEATURES:

OREC CDM-OT series Catalyst Destruct Modules catalytically decompose not less

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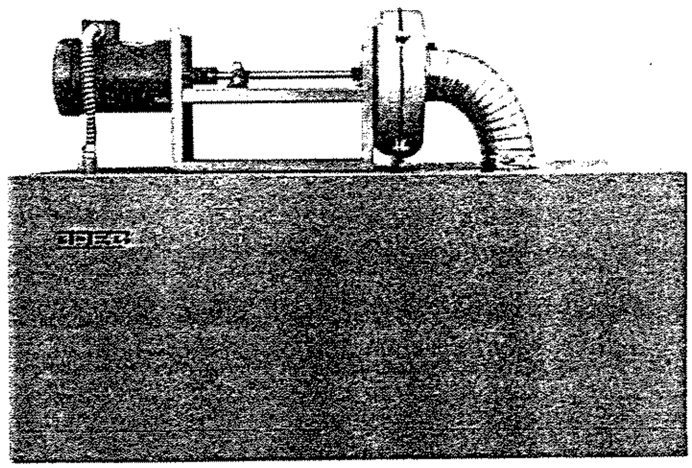

than 99% of the ozone presented in a standard atmospheric air stream independently of varying ambient temperature or humidity. The flowing ozone/air is heated by a 316 SS tubular heater in which is encased 80/20 nickel/chromium resistance wire surrounded by densely packed magnesium oxide insulation. The power conserving temperature control circuit maintains maximum catalyst bed temperature at 190 ± 10 Deg. F, power consumption thus a direct function of inlet ambient air temperature. All materials in contact with ozone are 304/316 SS or ozone resistant polymers. The high efficiency pressure blower, a standard production model featuring cast aluminum construction and teflon seals, is directly driven by a TEFC motor. An extended drive shaft mounted on pillow blocks connects the blower to the motor via a flexible coupling which incorporates an insulating Hytrel spider, thus assuring temperature isolation of the motor from the operating blower. The motor/blower assembly is hood-mounted on the top of the module to facilitate annual lubrication and service. The module cabinet is constructed of 16-gauge paintlock steel, primed and coated with gray acrylic enamel. Removal of the silicone rubber gasketed front panel provides clear access to all internal components, including the control box which houses all electronic components and the catalyst tank assembly. The tank and the internal ducting are enveloped in 3½" of R11 fiberglass insulation. The two connections the user is required to make, electrical and ozone/air inlet, are located on the outside back of the module. The electrical connection is to a ¾" conduit elbow with gasketed cover. The ozone/air inlet is a 4" OD stainless steel tube, which is recommended to be attached to the user's 4" duct via a short length of flexduct and two duct clamps. Again, a significant feature of the OREC Ozone Catalytic Destruct Modules is that the negative pressure ducting system obviates the requirement for leak-tight ducting. Modules are base-mounted using 3/8" anchor bolts through pads located at the base. Branch circuit protection and switching are to be user-provided at a convenient location near ground level. OREC CDM-OT Ozone Catalytic Destruct Modules are no-nonsense, workhorse products designed for remote emplacement with no gauges or valves to monitor or adjust. OREC products are backed by 30 years' experience in Ozone Technology.

*** SPECIFICATIONS:**

MODEL	OZONE/AIR SCFM FLOW	MIN. AMBIENT TEMPERATURE	VOLTAGE	MIN/MAX HEATER KVA	MOTOR KVA	DIMENSIONS	WT. LBS.
CDM50-OT	50	0 C (32 F)	240/480 3 Ph.	.7/3	.6	51Wx33Hx27D	250
CDM100-OT	50-100	0 C (32 F)	240/480 3 pH.	.7/6	.6	51Wx33Hx27D	275

* Specifications subject to change without prior notice.

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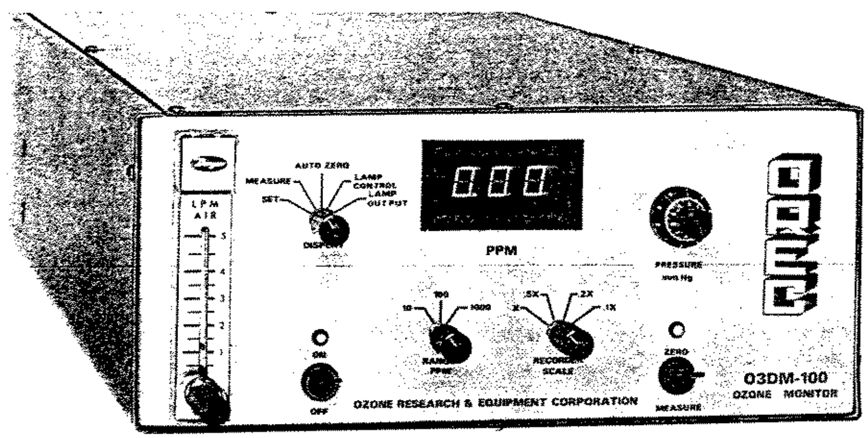
MODEL 03DM-100

OZONE MONITOR

ULTRAVIOLET ABSORPTION OZONE MEASUREMENT

- ABSOLUTE CALIBRATION BASED ON BEER-LAMBERT ABSORPTION LAW
- TWO MINUTE WARM-UP TIME
- NO CHEMICALS REQUIRED
- AUTOMATIC ZEROING
- AUTOMATIC TEMPERATURE COMPENSATION
- CALIBRATED PRESSURE COMPENSATION
- DIRECT READING DIGITAL DISPLAY
- SPECIFIC TO OZONE
- RAPID AND ACCURATE
- 0-1000 PPM MEASUREMENT
- THREE OPERATING RANGES



DESCRIPTION

OREC Model 03DM-100 Ozone Monitor is a continuous ozone measurement instrument for the determination of ozone in air or oxygen. The standard instrument provides the range 0-1000 ppm (parts per million) by volume, displayed on a panel-mounted digital readout meter. Alternate display of ozone concentration in millipascals is included in the OREC 03DM-100 Ozone Monitor.

The principle of ozone measurement is the absorption of ultraviolet light by ozone as determined by the Beer-Lambert Absorption Law, in conjunction with the standard gas laws for temperature and pressure correction:

$$I = I_o \exp \left[-LCX \frac{(273)}{T} \frac{(P)}{760} \right]$$

I = Light intensity with ozone
I_o = Light intensity without ozone
L = Pathlength of absorption cell
C = Ozone concentration
X = Absorption coefficient for ozone at 254 nm
T = Sample temperature, °K
P = Sample pressure, mm Hg

This principle of measurement is recognized by EPA as the method used in the calibration of ambient ozone analyzers.

ASTM D4575-86 states "UV absorption is adopted as the reference method against which other ozone measurement instruments shall be calibrated."

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Coast Products
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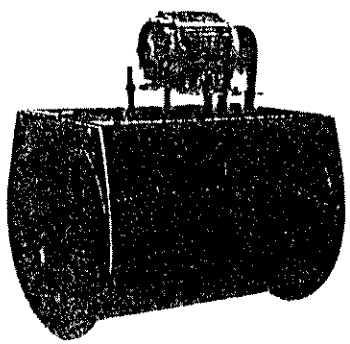
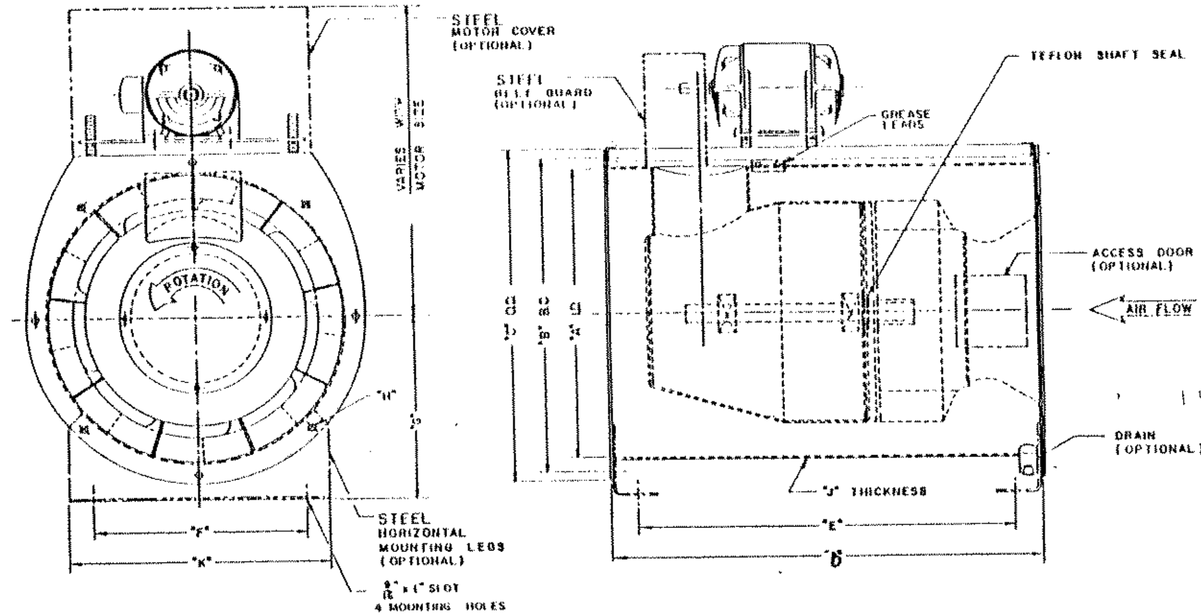
INDUSTRIAL AIR®

MODEL 168 AX·CENT·AIR FANS®

AXIAL FLOW CENTRIFUGAL WHEEL AIR MOVING



- Inline Tubular Centrifugal Fans for static pressure up to 12".
- Solid FRP Backward Inclined Centrifugal wheel with matched inlet cone and stationary guide vanes provide high strength and performance.
- Housings — Solid FRP Construction of Corrosion Resistant Resins.
- Belts, Drive and Heavy Duty Bearings sealed out of the air stream.
- Extended lube lines to outside fan housing are standard.
- Heavy duty steel Adjustable Motor Mount, corrosion, resistant coated, insures ease of Maintenance.
- Optional Accessories include motor cover, belt guard, drain, access doors, special resins, and companion flanges.
- Shaft seals are standard.



FAN SIZE	A	B	C	D	E	F	G	H DIA	H QTY.	J	K	SHAFT DIA.
12	16 7/8	19 1/4	20 1/2	24	18 3/4	11	12	3/8	8	3/16	15	1 7/16
15	20 5/8	23 1/8	24 3/8	30	24 3/4	15	14	1/2	8	3/16	19	1 7/16
18	25 1/8	27 7/8	29 1/8	36	30 3/4	18	16	1/2	8	1/4	22	1 11/16
22	30 5/8	33 3/8	34 5/8	42	36 3/4	21	19	1/2	8	1/4	25	2 3/16
27	37 3/16	40 3/8	42 1/8	49 1/4	43 3/4	27	22	5/8	8	3/8	31	2 7/16
30	41 5/16	44 1/2	46 1/4	54	48 1/2	29	24	5/8	8	3/8	33	2 11/16
36	50 1/4	53 1/2	55 1/4	66 1/4	60 3/4	36	29	5/8	8	3/8	40	2 15/16
44	61 5/16	64 1/2	66 1/4	80 3/4	75	44	34	5/8	8	3/8	48	2 15/16

DEGAS FAN

APPENDIX B.
CALCULATIONS

OZONE SYSTEM FEASIBILITY STUDY
WASHOE PARK TROUT HATCHERY
JANUARY 1994

Kramer, Chin & Mayo, Inc.

Client: MDFW & P

FITTING	K^*	$V^2/2g$	H_L	HGL
				5312.5
24" WYE SPLIT FLOW	.45	0.06	0.027	12.473
24" BTFY VALVE	.18		0.011	12.462
2 - 24" 90° BEND (LR)**	.24		0.0144	12.448
24" EXIT	1.0		0.06	12.388
6' Ø CONTACTOR BAFFLE	1.0		0.06	12.328
24" ENTRANCE	0.5		0.03	12.298
24" 45° BEND	.2		0.012	12.286
24" EXIT	1.0		0.06	12.226
10' Ø TANK BAFFLES	2.0		0.12	12.106
24" ENTRANCE & EXIT	1.5		0.09	12.016
24" 90° BEND (LR)	.12		0.0072	12.009
DEGASSING COLUMN	—		5.0	7.009
24" ENTRANCE	0.5		0.03	6.979
			0.0072	6.972
24" WYE COMBINE	.4		0.024	6.948
24" 90° BEND (LR)	.12	▽		

100' OF EXIST. 24" PIPE, VALVE, BENDS & EXIT LOSSES, H_L = 0.25 = 5306.69

∴ DESIGN LESS DROP THROUGH PACKED COLUMN BY 6" = 5306.373 AT SUMP

* K VALUES FROM "INTERNAL FLOW SYSTEMS" D.S. MILLER

** (LR) = LONG RADIUS

JOB NO.	BY	CHECK	SUBJECT	DATE	SHEET NO.
[illegible]	[illegible]		HYDRAULIC CALCULATIONS	[illegible]	B-1

Kramer, Chin & Mayo, Inc.

Client: MDFW & P

OZONE GENERATOR

$$\frac{O_3 \text{ lb.}}{\text{day}} = \text{flow (gpm)} \times 0.012 \times \text{Mg/L } O_3 \text{ APPLIED}$$

$$= 2{,}600 \times 0.012 \times .4 = 12.48 \text{ lb/day } O_3$$

WITH 50% CONTACT EFFICIENCY, RESIDUAL WILL BE 0.2 mg/l

∴ USE 15 lb/day OZONE GENERATOR TO ALLOW FOR SEASONALLY HIGH TURBIDITY AND COLD WATER

CT VALUE

TO OBTAIN CT OF 1.0, WITH 0.2 mg/l RESIDUAL,

$$\text{RETENTION TIME} = \frac{1.0}{0.2} = 5 \text{ MINUTES}$$

∴ SIZE RETENTION TANK FOR 5 MINUTES @ 2600 GPM.

RETENTION TANK

2600 GPM = 5.8 CFS × 60 × 5 = 1,733 CUBIC FT

1735 ÷ 23' HEIGHT = 75 SF PLAN AREA, $\left(\frac{75}{\pi}\right)^{1/2} = 4.88$ ft radius

∴ USE 10' DIA. TANK, 23' HIGH

JOB NO.	BY	CHECK	SUBJECT	DATE	SHEET NO.
[illegible]	[illegible]		OZONE SYSTEM SIZING	[illegible]	B-2