FLUIDYNE
CORPORATION
THE EXPERIENCED LEADER IN BIOLOGICAL NUTRIENT REMOVAL TECHNOLOGY

Oostanaula Creek WWTP – City of Athens, TN

Jet MCR

Multi-Channel Orbital BNR Process

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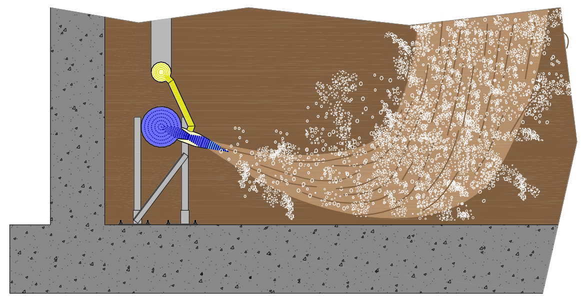
Background The Oostanaula Creek WWTP in the City of Athens, TN was a forty year old conventional activated sludge facility permitted for 2.83 MGD. The facility consisted of two twelve foot deep concrete lined earthen basins with low speed surface aerators, and three very shallow (7 ft. SWD) secondary clarifiers. In spite of the facility's age, and well worn equipment, Chief Operator Greg Hayes and his team consistently achieved effluent quality far better than their permit required. In October of 2003, the facility's NPDES permit was renewed with monitoring requirements for total nitrogen and total phosphorous, and TN and TP limits for the planned 6.0 MGD plant expansion. In the first two years of the permit period, the facility treated an average flow of 2.62 MGD with peak days of 6.5 to 7.0 MGD. The principle industrial contributor to the facility is a large dairy operation. The average influent BOD concentration in 2004 and 2005 was 344 mg/L, with peaks of 700 mg/L. Throughout this period, the operators consistently achieved average effluent BOD and TSS concentrations of less than 10 mg/L.

2.83 MGD CMAS Facility

A Process is Selected. After considering several process options for the expansion, the Athens Utilities Board selected a deep Jet Multi Channel Reactor. Primary factors influencing the selection were the small footprint and high efficiency offered by the twenty foot deep oxidation ditch design. Jet aerator mixers were considered an excellent choice due to their high efficiency, long life, and wide operating range.

Jet Aeration and Mixing Jet aerator mixers are essentially large venturi educators. Recirculated mixed liquor is discharged at a high velocity from an inner nozzle into an outer mixing nozzle. Compressed air from a blower is also introduced in the mixing nozzle. The liquid stream shears the air into very small bubbles and the resulting air/liquid mixture is discharged from the outer nozzle in a jet plume. The horizontal air/liquid flow entrains the surrounding mixed liquor creating a horizontal velocity in the basin of at least 1 fps. When the horizontal momentum is expended, the air in the plume rises creating top to bottom mixing. The horizontal velocity required for the suspension of biological solids can be maintained even when the jets are operated "ungassed" or without air for anoxic mixing.



Jet Aerator/Mixer Operation

Early jet aerator mixers were constructed of fiberglass or PVC, and hundreds of installations worldwide have performed well for as long as forty years without ever dewatering the reactor basins.

Recently, Fluidyne began fabricating jet aeration and mixing headers from type 304 stainless steel.

Stainless Jet Aerator/Mixer

Jet Multi Channel Reactor In the late 1960s and early 1970s, many regulatory agencies in the United State began mandating nutrient limits for POTWs discharging to sensitive streams or wetlands. Of primary concern were nitrogen compounds and phosphorous compounds. Many facilities were being operated to achieve nitrification (conversion of ammonia nitrogen to nitrate) in addition to carbonaceous and solids removal, but removal of nitrates, and/or phosphorous require an anoxic or anaerobic environment in addition to the aerobic environment needed for carbonaceous removal and nitrification.

The multi channel continuous loop reactor was developed to meet the tightening permit requirements. In a conventional design, the basins are less than fourteen feet in depth and utilize surface aeration devices.

In a system utilizing three channels, the outer anoxic channel contains approximately 50% of the total basin volume, and is operated to maintain a dissolved oxygen concentration of zero while meeting 50% of the total oxygen demand. The inner nitrification channel contains approximately 20% of the total basin volume, and is operated to maintain a dissolved oxygen concentration of 2.0 mg/L or more, while meeting 20% of the total oxygen demand. The middle swing channel contains approximately 30% of the total basin volume, and is operated to maintain a dissolved oxygen concentration of 1.0 mg/L while meeting 30% of the total oxygen demand. .

In operation, raw screened and degritted wastewater is fed to the outer channel. As the flow circulates, it passes through several aerated and anoxic zones. In the aerated zones, carbonaceous removal and nitrification occur. In the anoxic reaches between the aerobic zones, denitrification occurs. If the system is properly designed, anaerobic conditions can also be achieved, causing microorganisms to release their molecular phosphorous as an energy source to consume and store carbonaceous material. Then in the aerobic zones energy is produced by the oxidation of stored carbonaceous material and polyphosphate storage within the cells increases. New phosphorous accumulating organisms are also produced.

The flow then passes through transfer ports to the middle, or "swing" channel. The environment in the swing channel varies with the load being received. In periods of high loading, the dissolved oxygen concentration in the "swing" channel falls and the channel operates in the nitrification denitrification mode of the outer channel. In periods of low load, the dissolved oxygen concentration in the "swing" channel increases and the channel serves to accelerate the aerobic processes. The flow then passes through another transfer port to the inner channel. The dissolved oxygen concentration in the inner channel is maintained at 2.0 mg/L or more to complete carbonaceous removal and nitrification.

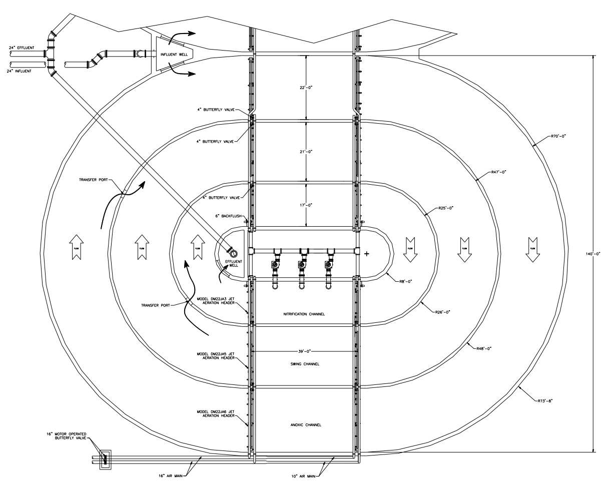
Multi Channel Reactor with Surface Aerators.

Early multichannel BNR processes utilized surface type aeration devices, and therefore had significant process deficiencies. Mixed liquor depth was limited to approximately fourteen feet, so the footprint was quite large; and oxygen delivery could only be controlled by raising or lowering the liquid level. Further, the surface aeration caused significant spray and misting, as well as cooling of the mixed liquor, making nitrification and denitrification difficult in cold weather.

Deep channel designs with submerged medium bubble diffusers plus low speed mixers, or jet aerators represented a distinct improvement in the process. Channel depth is virtually unlimited, providing for much more efficient use of available land; oxygen delivery and mixing are independently controlled, and the liquid level remains constant; less surface area and the lack of spray, mist, and splashing provides much better thermal conservation. Typically, optimum nitrification and denitrification are achievable year round.

The use of horizontal propeller mixers, or drum mixers to provide mixing power is an improvement over surface aerators, but still places constraints on basin configuration; the ratio of the channel width to depth to the mixer diameter is critical to proper operation. Also, medium bubble elastomer membrane diffusers are not only a recurring maintenance problem, having to be replaced every five to seven years, but the lack of turbulence around the air bubbles depresses the oxygen transfer capabilities of the aerator, especially immediately following an anoxic or anaerobic zone.

The Oostanaula Creek WWTP The Jet Multi Channel Reactor process at the Oostanaula Creek WWTP follows a headworks consisting of a fine screen and aerated grit chamber. The Jet MCR consists of two three MGD reactors. Each reactor contains fifty-six aeration/mixing jets in two banks that span the entire treatment basin. The outer channels contain twenty four jets, and are designed to provide half of the process total oxygen requirement. Air flow to the jets in the outer channels is controlled by four butterfly valves in each basin.



3.0 MGD Jet Multi Channel Reactor

The middle channels contain twenty jets, and are designed to provide thirty percent of the process total oxygen requirement. Air flow to the jets in the middle channels is controlled by four butterfly valves in each basin. The inner channels contain twelve jets, and are designed to provide twenty percent of the process total oxygen requirement. Air flow to the jets in the inner channels is controlled by four butterfly valves in each basin.

The total volume of each basin is 3 MG. Basins have an operating side water depth of twenty feet. Motive liquid for the aeration/mixing jets is provided by two vertical dry-pit pumps. There is also a common on-line spare pump. Each pump provides motive liquid to a single bank of twenty-eight jets.

Vertical Dry-Pit Jet Motive Pumps

Use of fixed mount jet aerator mixers and dry-pit pumps provides the advantage of having no mechanical components in the treatment basins. The basins are never dewatered.

Air Delivery Piping – Note Butterfly Valve and DO Sensor in Each Channel

Since the motive pumps draw suction from the inner nitrification channel, the process provides the advantage of an internal recycle system. Fully nitrified mixed liquor is recycled to the anoxic basin for virtually complete denitrification.

The Jet MCR process began receiving influent flow to one train in November of 2005. During the bidding process, an addendum was issued replacing the originally specified multi stage centrifugal blowers with single stage turbine blowers. This was done in the hope of saving power.

Single Stage Turbine Blowers

At startup, it was discovered that the blowers did not provide sufficient turn down to meet the very low air requirements of the highly efficient jet aeration system. This made operation in automatic DO mode impossible; as the system called for less and less air until the blower surged and shut down.

Eventually the blower manufacturer trimmed the impellers, and mitigated the problem, and made automatic operation possible.

The Control Strategy The process was designed to operate in an automatic mode, with the dissolved oxygen concentration in the middle channel of each basin pacing electrically operated butterfly valves in the air mains external to each basin. At startup, the twenty-four manual butterfly valves at the air drops were used to set an operating dissolved oxygen concentration of 0.0 mg/L in the outer channels, 1.0 mg/L in the middle channels, and 3.0 mg/L in the inner channel. The system was then switched to automatic operation. If the dissolved oxygen concentration in the middle channel rises above 1.0 mg/L, the throttling valves reduce the air flow to the entire basin until the DO falls to 1.0 mg/L. If the dissolved oxygen concentration in the middle channel falls below 0.5 mg/L, the throttling valves increase the air flow to the entire basin until the DO rises to 1.0 mg/L. Once the individual channels have been adjusted to the proper aeration ratios in relation to the other channels, the entire system turns up or down together. This operating mode was last adjusted in 2007. For the year 2009, the effluent BOD concentration averaged 1.34 mg/L (99.6% removal); the effluent TSS concentration averaged 0.85 mg/L (99.6% removal), the effluent ammonia nitrogen concentration averaged 0.14 mg/L (98.2% removal), effluent total nitrogen and total phosphorous are only reported in April through October; the effluent TN concentration averaged 2.77 mg/L, and the effluent TP averaged 0.63 mg/L. Monthly reports are included in the appendix.

Effluent from the Jet MCR goes to four center feed clarifiers. Return activated sludge from the clarifiers is fed to Jet MCR influent well.

Center Feed Final Clarifier

Waste sludge is fed to one of the old aeration basins which were converted to a jet aerated aerobic digester.

Settled sludge from the aerobic digester is fed to a two meter belt press where the sludge is dried to approximately a 15% solids concentration.

Jet Aerated Aerobic Digester

The filter cake is conveyed to a gas drying system where 95% of the moisture is removed. The dried sludge is bagged and sold as a slow release 5-5 fertilizer.

Filter Cake on Belt Press

Operators report that by allowing the Jet MCR to operate in automatic mode, they can achieve 60% to 70% biological phosphorous removal, and build the phosphorous concentration in their sludge to a minimum of 5%.

AthenaGro Fertilizer Ready for Sale

Ferric chloride is fed to the clarifier effluent for phosphorous polishing on the final disk filters before discharging the effluent to Oostanaula Creek.

Excellent Floccing Sludge in Jet MCR

Anoxic Channel Improves Settling In addition to providing excellent biological nutrient removal, the anoxic channel also acts as a selector basin, inhibiting the growth of obligate aerobes, including most filaments, and improving solids separation in the clarifiers.

Chief Operator Greg Hayes (right) and members of His Operations Team

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Athens, TN Utilities Board - Oostanaula Creek STP
Fluidyne Jet Multi Channel Reactor

	Flow (MGD)		Temp.	BOD_{INF} (mg/L)		BOD_{EFF} (mg/L)		TSS_{INF}	TSS_{EFF}	NH_3-N_{INF}	NH_3-N_{EFF}	TN	TP
	Avg.	Max.		Avg.	Max.	Avg.	Max.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
January-09	3.77	10.91	14.6° C	188	277	1.10	2.10	124	0.80	11.40	0.139	NS	NS
February-09	2.39	3.17	14.5° C	281	540	0.70	1.70	194	1.00	9.40	0.138	NS	NS
March-09	3.49	5.69	14.6° C	261	592	1.20	3.00	193	0.80	10.00	0.131	NS	NS
April-09	3.42	5.22	15.7° C	299	671	1.20	1.80	191	0.80	9.30	0.139	5.00	BDL
May-09	5.4	9.93	17.2° C	192	310	1.40	4.70	107	0.80	9.30	0.159	1.91	0.11
June-09	2.28	2.8	19.8° C	401	610	1.70	5.30	218	0.90	8.50	0.124	3.36	1.62
July-09	2.15	6.55	21.1° C	440	686	1.90	5.30	325	1.00	8.60	0.144	2.14	0.80
August-09	2.3	3.57	21.6° C	417	655	2.20	4.70	267	0.80	7.90	0.129	2.90	0.40
September-09	3.43	8.91	21.6° C	297	630	1.00	2.00	217	0.80	6.10	0.186	2.60	0.16
October-09	3.31	5.99	19.5° C	284	570	1.50	2.90	251	0.60	4.50	0.138	1.50	BDL
November-09	3.21	7.55	17.8° C	341	580	1.10	2.40	201	0.80	4.70	0.123	NS	NS
December-09	4.95	9.65	15.5° C	244	515	1.10	1.80	195	1.10	4.50	0.109	NS	NS

Notes: Influent NO_3-N, NO_2-N, and P are not monitored. However, nitrates in the wastewater stream from a large dairy operation provide more than sufficient N and P as nutrients.

Effluent TN, and TP are monitored in April through October.

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The Jet Multi-Channel Orbital BNR Process by Fluidyne

The Fluidyne Jet MCCLR offers significant advantages compared to any similar system. The greatest process advantage is that our dry-pit jet motive liquid pumps draw motive liquid (fully nitrified mixed liquor) from the inner channel, and pump it back out to the outer channel at a rate that is approximately 3.0 times the design flow rate. This feature insures virtually complete denitrification. Surface aerated systems have no internal recycle, and rely on simultaneous nitrification/denitrification in the outer channel. Other features include:

- Independent Control of Oxygen Transfer and Mixing. Air flow to the jet aerators can be varied from 10 SCFM per jet to 80 SCFM per jet to control oxygen delivery, without affecting mixing; system can be operated ungassed for anoxic mixing.
- Constant Level Operation. The operating SWD is constant; the level does not have to be varied to control DO. Automatic DO or ORP control (optional) is much simpler.
- Deeper Basins Save Space. Typical MCCLR basins operate at a SWD of twenty feet and require only 60% of the space required for basins with an operating SWD of twelve feet.
- Deeper Basins Increase Overall Efficiency. Most MCCLR deep channel designs will deliver over 4.00 lbs/O_2/BHp/hr at design conditions.
- Subsurface Aeration Eliminates Mist and Spray. Walkways and hand rails stay clean. Odors and airborne VOCs are reduced.
- Thermal Conservation. Less surface area and subsurface aeration reduces heat loss during winter operation. Year round nitrification to levels below 1.0 mg/l NH_3-N is easily achievable.
- No In-basin Mechanical Components. Basins never need to be dewatered. Some competitive systems contain thousands of EPDM diffusers that require replacement every five to seven years.
- Low Maintenance. Simple five minute back flushing operation is the only required maintenance.
- No Shafts to Break or Expensive Gear Drives to Service. The only mechanical equipment is standard pumps, and blowers.
- Long Life. A stainless steel jet aeration system has a life of at least thirty-five years.
- Improved Mixing. Jet aerators impart mixing energy at the bottom of the channel, in the event of a power outage; solids are resuspended much more easily than with any type of surface mixer.
- Anoxic Channel Reduces Oxygen Requirements. 50% of the entire process volume is in the outer anoxic loop. A dissolved oxygen concentration near zero is maintained in the anoxic loop. Standard oxygen requirement and aeration power are reduced by 20% compared to competitive systems.

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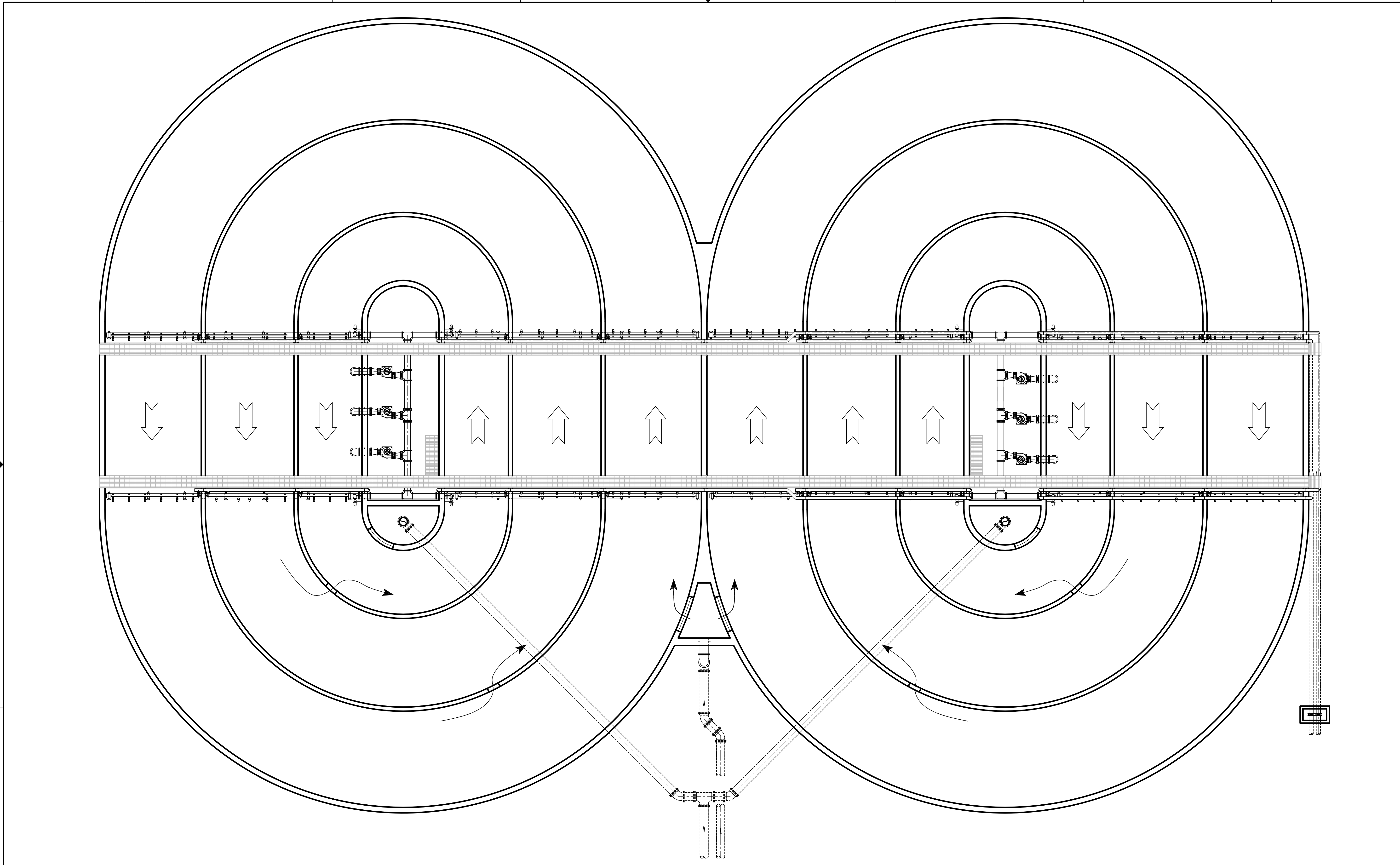

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OOSTANAULA CREEK STP – ATHENS, TN

JET MCR LAYOUT

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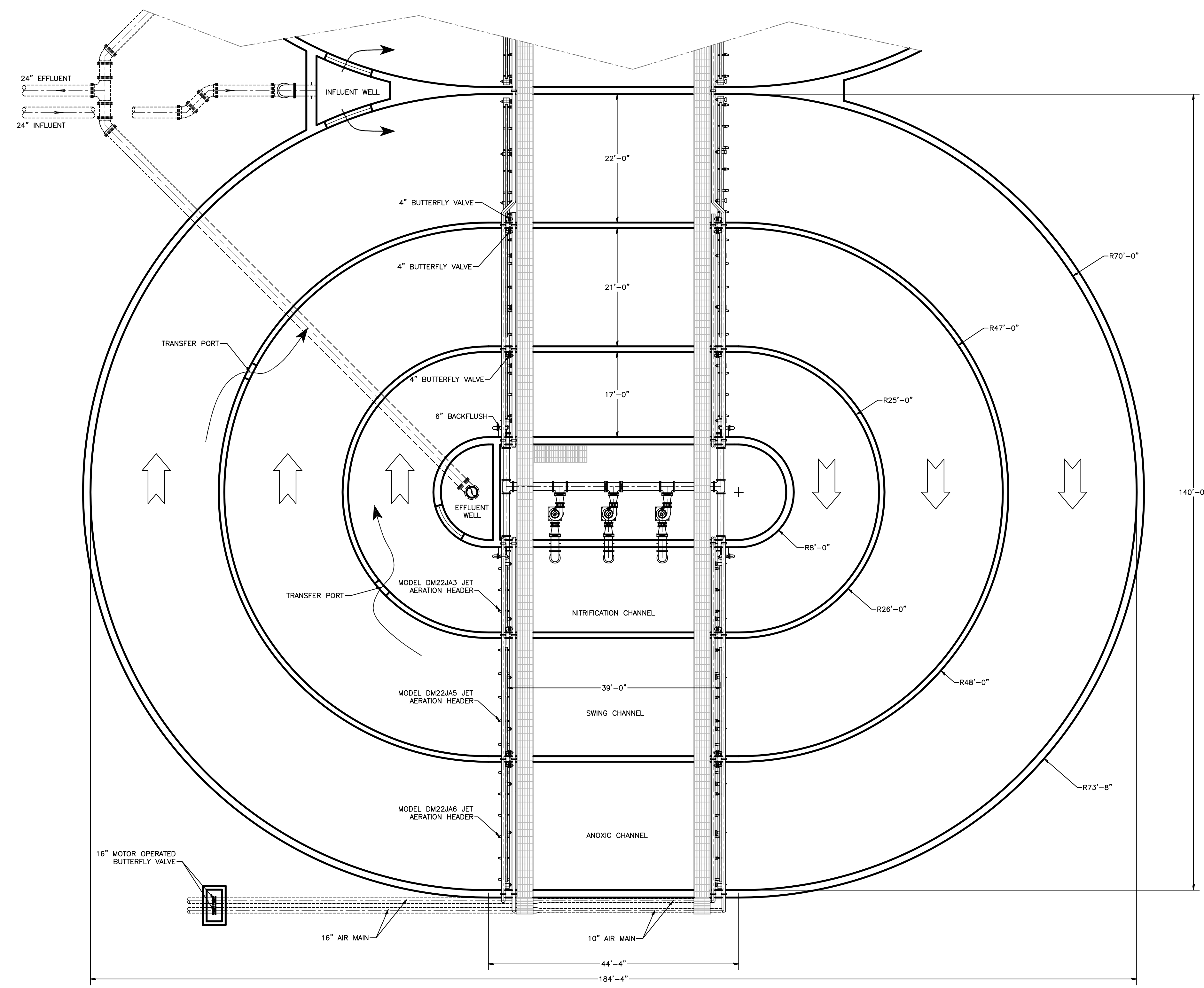

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OOSTANAULA CREEK STP – ATHENS, TN

TOP PLAN

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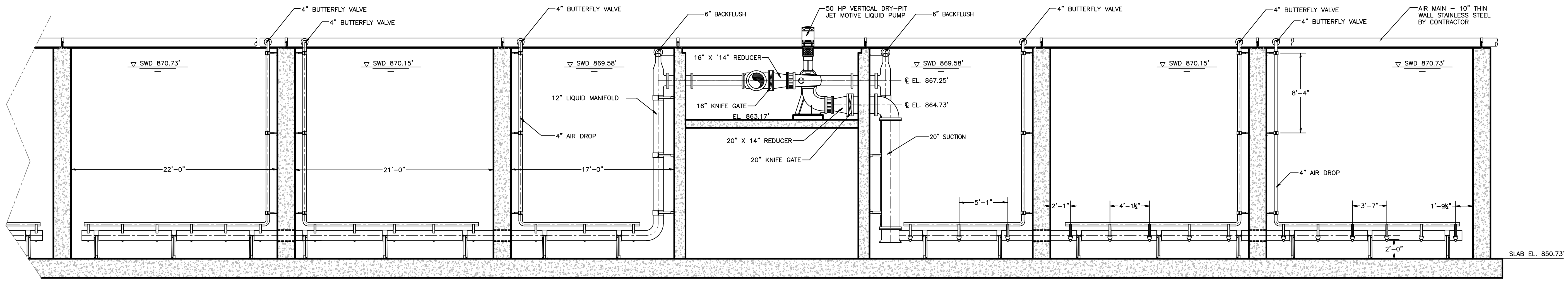
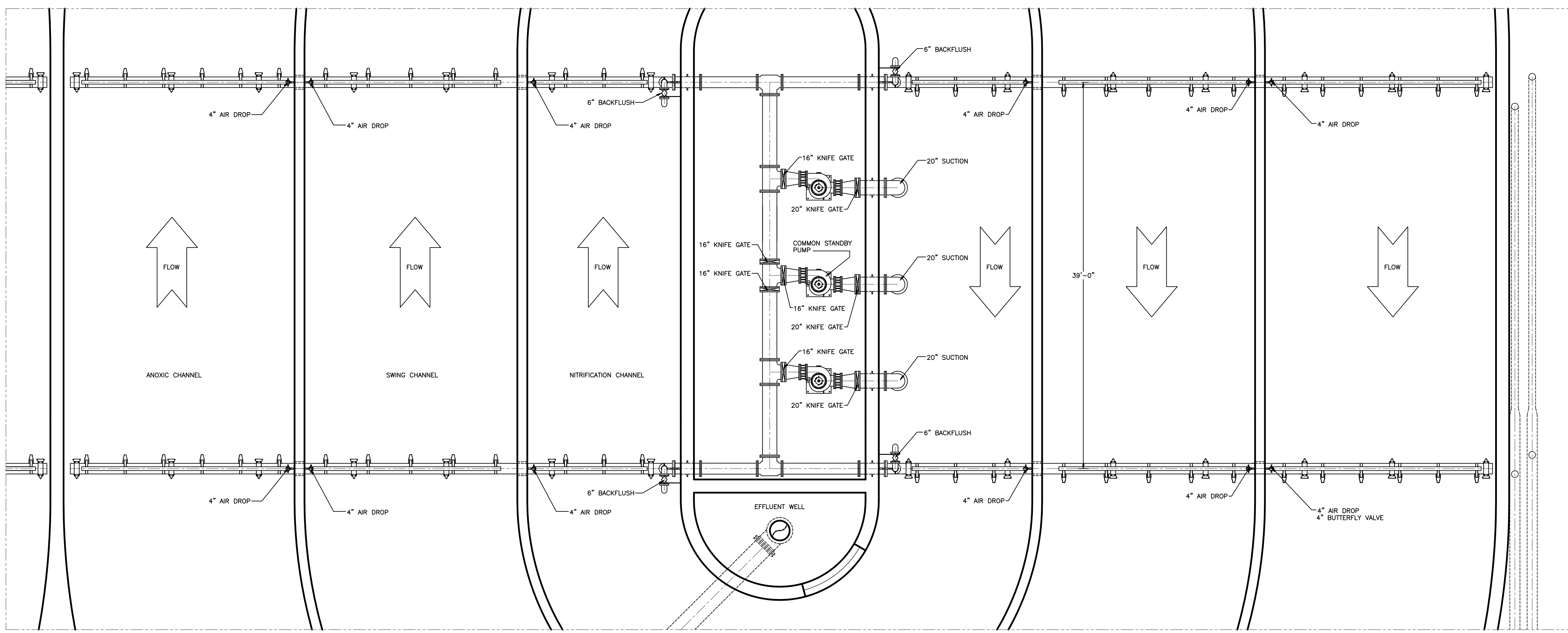


JET AERATOR AND PUMP SECTION



JET AERATOR AND PUMPING DETAILS
ELEVATION 871.00'

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OOSTANAULA CREEK STP – ATHENS, TN

DETAILS AND SECTIONS

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