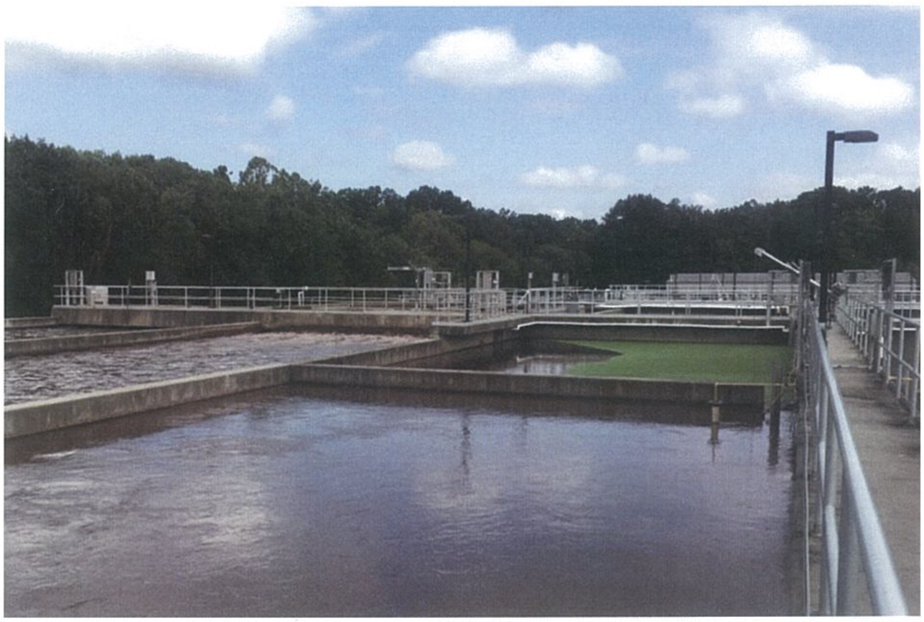
TECHNICAL MEMORANDUM

Triangle WWTP Aeration System Improvements

B&V PROJECT NO. 194729



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PREPARED FOR

Durham County

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Section 1. Background

Durham County owns and operates the 12 million gallon per day (MGD) Triangle Wastewater Treatment Plant (TWWTP), which was constructed in 2001. The plant site is located in the 100-year floodplain. The plant site elevation varies between 2 to 3.5 feet below the 100-year flood elevation, resulting in predominantly above grade construction as shown in Figure 1-1.

Figure 1-1: TWWTP BNR Treatment Trains

The biological treatment system includes three five-stage oxidation ditch biological nutrient removal (BNR) treatment trains featuring common wall construction, each designed for an average daily flow of 4.0 mgd. Each oxidation ditch includes four 75 horsepower (hp) Kruger brush aerators (rotors) for maintaining aerobic conditions. The operation and number of brush aerators placed into service are controlled by a programmable logic control (PLC) based control panel that uses an operator adjustable dissolved oxygen (DO) set-point, which is measured by two DO probes located in the ditch. The brush aerator standard oxygen transfer rate (SOTR) is dictated by the rotor blade submergence, which is controlled by an electric actuated effluent weir in each oxidation ditch. The side water depth in the oxidation ditch is approximately 18 feet, thereby requiring the continuous operation of two 7.4 hp submersible mixers for maintaining the solids in suspension.

The average daily influent flow to the plant is approximately 6.0 mgd, thereby requiring only two treatment trains. Over the past several years, plant staff observed the brush aerators overloading and tripping out at increased rotor blade submergence depths to address peak oxygen demands. Plant staff has noted an increase in maintenance associated with the brush aerators. In 2015, the rotor shaft of one of the brush aerators that serves the middle treatment train (Train No. 2) sheared. Currently, the plant is operating two (Train Nos. 1 and 3) of three treatment trains. The depth of the oxidation ditches, increased maintenance and useful design life (~20 years) of the brush aerators, and Durham County's utilities division desire to improve the efficiency and resiliency of the TWWTP have resulted in the County investigating more efficient alternative aeration systems.

Section 2. Objective

This technical memorandum (TM) investigates alternative diffused aeration and blower type configurations and provides a recommended diffused aeration system, based on the application, site constraints, and life cycle costs of the capital expenditure. In addition, this memorandum provides a recommendation for repairing the cracking and subsequent leaking expansion joint observed by plant staff that spans the length of the treatment train. This TM provides the design basis for developing the contract documents and provides an engineer's estimate of probable construction cost, permit requirements, and schedule for implementing the proposed recommendation.

Section 3. Aeration System Alternatives Evaluation

3.1 BACKGROUND

The aeration system evaluation considers different blower technologies and types of fine bubble diffused aeration (tube versus membrane disc) to determine the most efficient overall system for addressing the brush aerator failure in treatment train No. 2. Diffused aeration was considered in lieu of other types of aeration systems when considering the depth of the oxidation ditch, initial capital costs, aeration efficiency, and site constraints. A key consideration of the alternatives evaluation is determining the most cost-effective long-term solution, when considering the energy savings of the diffused aeration system and remaining useful design life of the brush aerators. The ability to regulate the airflow delivered by the blower(s) and subsequent DO concentration maintained in the oxidation ditch, as well as the location of the diffused aeration grids is critical to avoid upsets in the anoxic zones of the process. Therefore, the blower(s) will be equipped with a manually operated adjustable frequency drive (AFD) to allow adjustment of the airflow delivered by the blower to reduce energy consumption, while reducing the capital cost of the investment by not integrating the improvements into the existing PLC-based control system. The existing brush aerators would remain in service and be controlled by the existing PLC-based control panel, based on the operator adjustable DO set-point and augments the oxygen supplied by the blower(s).

The aeration system alternatives evaluated in this TM include different combinations of blowers and fine bubble diffuser grids to augment the existing brush aerators. Four brush aerators are required in each oxidation ditch to satisfy the oxygen demand required by the process biology. Therefore, the option to "Do Nothing" was not considered a viable alternative since this would compromise the treatment performance and capacity of the plant.

3.2 AERATION REQUIREMENTS

The equivalent actual oxygen requirement (AOR) provided by one of the existing 75 hp brush aerators was calculated, according to the standard oxygen requirement (SOTR) for one brush aerator, as shown in Figure 3-1 based on the maximum rotor blade immersion of 11.5 inches. Adjusting the SOTR for above field conditions, based on a residual DO concentration of 2.0 mg/L and a summer wastewater temperature of 30^{o}C, resulted in an a AOR of 122 pounds of oxygen per hour (lb O_2/hr). This calculated AOR served as the basis used by the diffused aeration system suppliers to determine SOTR, air flowrate (SCFM) and discharge pressure that would serve to size the blower(s) for replacing the brush aerator(s).

- Alternative 1: Equivalent airflow rate required for one blower to provide the oxygen capacity supplied by one brush aerator
- Alternative 2: Airflow rate that would be required by one blower to provide the oxygen capacity supplied by two brush aerators
- Alternative 3: Airflow rate that would be required by two blowers to provide the oxygen capacity supplied by four brush aerators, assuming no stand-by blower units
- Alternative 4: Airflow rate that would be required one blower to provide the installed oxygen capacity of four brush aerators. This option considered a stand-by blower would be furnished in

addition to a duty blower and represents the most conservative and expensive of the alternatives.

- Alternative 5: This option considered the maximum airflow rate that could be furnished by one 75 horsepower blower to determine the number of brush aerators offset by the blower and the corresponding energy savings.

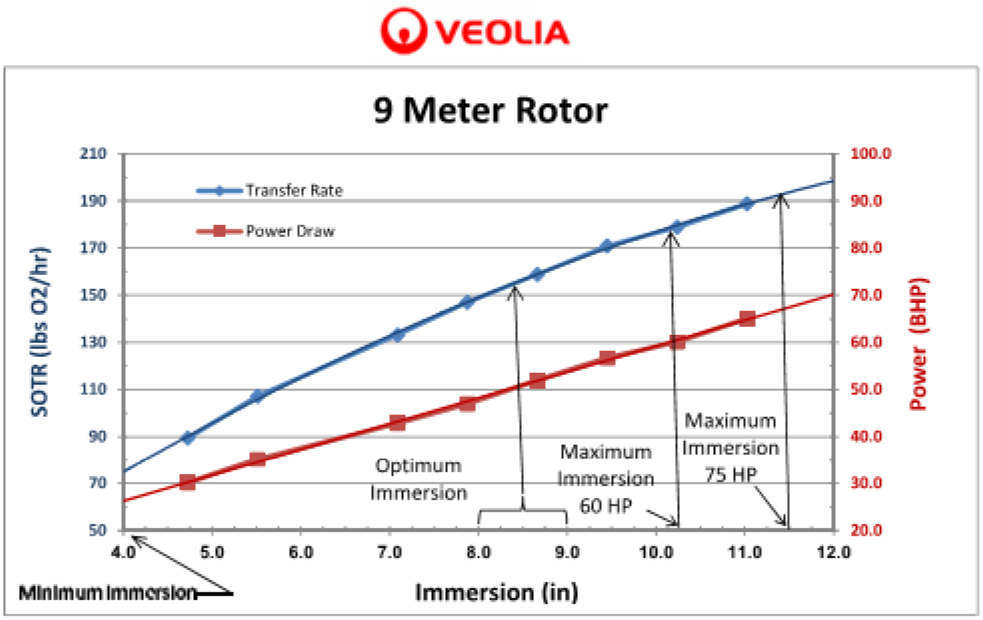

Figure 3-1: SOTR for 9 Meter Rotor Brush Aerator (figure provided by Veolia)

3.3 FINE BUBBLE DIFFUSED AERATION SYSTEM ALTERNATIVES

Two types of fine bubble diffused aeration systems were evaluated for this project; membrane disc and tube diffusers. Figures 3-2 and 3-3 provide a photo of membrane disc and tube diffusers, respectively.

Figure 3-2: Membrane Disc Diffusers

Figure 3-3: Tube Diffusers

Both the membrane disc and tube diffuser suppliers recommended a single diffuser grid arrangement for Alternative Nos. 1, 2, and 5 which are represented as Option No. 1 in Table 3-1. Two diffuser grids were recommended by both suppliers for Alternative Nos. 3 and 4, which is represented as Option No. 2 in the table below.

Common to both types of diffuser arrangements was a 304 stainless steel dropleg pipe transitioning to Schedule 40 PVC to serve a fixed floor diffuser grid anchored to the channel floor of the oxidation ditch. Table 3-1 provides a summary of the membrane disc and tube diffusers systems for each option.

Table 3-1: Fine Bubble Diffuser System Summary

DESIGN PARAMETERS	OPTION 1		OPTION 2	
	Membrane Disc	Tube	Membrane Disc	Tube
Number of grids	1	1	2	2
Number of diffusers per grid	372	72	720	108
Footprint per grid	25’x36’	40’x36’	50’x36’	55’x36’
Dropleg pipe diameter, inches	6	6	8	8
Air flowrate per grid, scfm	713	709	1,440	1,470
Total air flowrate, scfm	713	709	2,888	2,940
Air flowrate per diffuser, scfm	1.92	9.85	2.0	13.6
Transfer efficiency	34.4%	35.2%	34.0%	34.0%

Cost proposals were received for both membrane disc diffusers and the tube diffusers. The costs for tube diffusers were found to be substantial higher than membrane disc diffusers. Therefore, membrane disc diffusers are recommended and used as the basis for the fine bubble diffused aeration grids included the life cycle cost evaluation.

Although fine bubble diffused aeration systems are typically fixed to basin floor, retrievable systems are available, as shown in Figure 3-4. Retrievable systems were investigated, as part of this evaluation and found to be twice the cost of a fixed floor system and is therefore not recommended.

Figure 3-4: Example Installation of a Retrievable Diffuser System

Overtime the manufacturer recommends the diffusers be cleaned. To alleviate the need to drain a basin, the membrane disc manufacturers offera portable liquid cleaning system, which can be used for in-situ cleaning of the diffusers, thereby not requiring the oxidation ditch (basin) to be drained. According to diffuser manufracturer, the estimated cost of the in-situcleaning system is approximately $20,000.

3.4 ALTERNATIVE BLOWER TECHNOLOGIES

A number of blower types and technologies could be considered for diffused aeration systems including positive displacement, single or multi-stage centrifugal, and gearless turbo type blowers. Single stage centrifugal blowers are more cost-effective for larger airflow capacity requirements and were therefore were not considered for this application.

Each of the blower types evaluated considers locating the blower(s) outside on the operating walkway of oxidation ditch for Treatment Train No. 2, as shown in Figure 3-5, to reduce the costs of the aeration piping, minimize construction costs, and simplify the installation when considering the height and location of the treatment train above existing grade in conjunction with the 100-year flood plan elevation.

Figure 3-5: Proposed Blower Location on Oxidation Ditch Operating Walkway

High speed gearless turbo blowers are not recommended for outdoor installations due to the potential maintenance implications of exposing the electronic components within the blower housing to humidity and temperature fluctuations. The option of housing the gearless turbo blower(s) inside a new building on an elevated slab outside the oxidation ditches would not be cost-effective in comparison to alternative blower technologies. In addition, there is not adequate space for a pre-engineered enclosure on the operating walkway of the oxidation ditch. Therefore, high speed gearless turbo blowers were not further considered, as part of the evaluation.

Three types of blower technologies which were considered for the evaluation included the following:

- Rotary Lobe Positive Displacement (LPD)
- Dry Rotary Screw Positive Displacement (SPD)
- Multi-stage Centrifugal (MS)

For the purpose of this TM, the rotary lobe positive displacement blowers are referred to as 'Lobe PD blowers'; the dry rotary screw positive displacement blowers as 'Dry Screw PD blowers'; and the multi-stage centrifugal blowers are referred to as 'Multistage Blowers'.

The following sections provide a description of each of the three blower technology.

3.4.1 Rotary Lobe Positive Displacement Blowers

Rotary lobe PD blowers are variable pressure, constant capacity machines which use two parallel rotary lobes rotating in opposite directions to compress the air to meet the discharge pressure requirements for the application. They are provided with inlet and discharge silencers to reduce pulsations, and can either be operated as constant speed machines or provided with adjustable frequency drives (AFDs) where capacity control and turndown is required. Sound attenuating enclosures are typically recommended for lobe PD blowers in outdoor locations where noise attenuation is warranted.

Figure 3-6: Typical Lobe PD Blower with and without sound enclosure

3.4.2 Dry Rotary Screw Positive Displacement Blowers

Dry screw PD blowers are a newer type of positive displacement blower technology relative to rotary lobe blowers. Unlike the rotary lobe blower, dry screw PD blowers compress the air internally, resulting in lower power requirements and reduced pulsations from the blower.

Sound attenuating enclosures are standard for dry screw PD blowers, as illustrated in Figure 3-7.

Figure 3-7: Typical Dry Screw PD Blower

3.4.3 Multi-stage Centrifugal Blowers

Multi-stage centrifugal blowers are constant pressure, variable capacity machines that consist of a series of impellers used to compress the air to the final discharge pressure. Either an inlet throttling valve or AFD is used for applications with varying airflow requirements. AFDs are generally used to improve efficiency. Typically multi-stage blowers have a higher capital cost and are more efficient when compared to positive displacement blowers.

Figure 3-8: Typical Multi-stage Centrifugal Blower

3.4.4 Qualitative Comparison of Blower Technologies

The following non-economic factors were considered in evaluating the blower technologies:

- Power consumption
- Packaging
- Turndown capability
- Operating speeds
- Space requirements
- Typical noise levels
- Maintenance requirements
- Number of operating installations

The following table presents a qualitative comparison of the three blower technologies.

Table 3-2: Qualitative Comparison of Blower Technologies

PARAMETER	LOBE PD	DRY SCREW PD	MULTISTAGE
Efficiency	Low	Low-Medium	Low-Medium [1]
Noise	Medium-High [2]	Medium [2]	Medium [2]
Pulsations	Medium	Low	None
Footprint	Small-Medium	Medium	Medium (long and narrow)
Moving Parts	Medium	Medium	Few
Voltage Requirement (V)	460	460	460
Capacity Control	AFD	AFD	Combination [3]
Maximum speed (RPM)	3,600	3,600	3,600
Capacity Turndown	~20% of rated	~20% of rated	~60% of rated [3]
Metal to Metal Contact	Yes (bearings only and timing gears)	Yes (bearings only and timing gears)	Yes (bearings only)
Lubrication	Yes	Yes	Yes
Municipal Operating History	High	Low	High
Maintenance	Low-Medium	Low-Medium	Low

Notes:

[1] Efficiency level indicated for multistage blowers is based on blower sizes within the capacity range required for this application.

[2] Noise level indicated is based on lobe PD and multistage blowers being furnished with sound attenuating enclosures. Dry screw PD blowers are furnished standard with sound attenuating enclosures.

[3] Capacity control and turndown for multistage blowers is based on the use of an inlet throttling inlet valve or an AFD.

All three blower technologies are suitable for the application. However, dry screw PD blowers are a relatively newer technology that has been used in the municipal market with fewer applications. A key consideration of the qualitative assessment was the blower footprint and space required around the unit for servicing, when considering the desire to locate the blower on the oxidation ditch walkway to avoid the construction of an elevated equipment pad at grade, minimize air piping, and simplify construction to reduce the capital cost.

3.4.5 Blower Selections

Proposals from blower manufacturers for each of the three blower technologies were requested based on the airflow requirements of the membrane disc diffuser option summarized in Section 3.3.

Blower discharge pressure requirements accounted for the diffuser submergence depth, estimated headloss across the membrane diffusers and distribution piping, as well as the potential for fouling. A blower discharge pressure of 9.2 psig was used in conjunction with the airflow requirements summarized in Section 3.3.

Rated blower capacities, pressure requirements, and site conditions were provided to the blower manufacturers in order for them to provide selections. The following table provides a matrix summary of the design criteria and resulting blower selection information for each alternative and blower technology considered.

Table 3-3: Aeration Blower Design Criteria

ALTERNATIVE	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5
Number of diffuser grids	1	1	2	2	1
Air flowrate per grid	713 scfm	1,440 scfm	1,440 scfm	1,440 scfm	Varies b/t blower type
Number of blowers	1	1	2	2	1
No. of duty/standby	1 Duty	1 Duty	2 Duty	1 Duty	1 Duty
Rated blower capacity, summer conditions, each	750 scfm	1,500 scfm	1,500 scfm	3,000 scfm	Varies b/t blower type [1]
Winter turndown capacity	150 scfm	225 scfm	225 scfm	450 scfm	Varies b/t blower type [2]
Blower discharge pressure	9.2 psig				
Min rise-to-surge at turndown [3]	0.3 psi				
Blower Motor Rating	60 hp	125 hp	125 hp	250 hp	75 hp
Lobe PD Blower footprint	5'-8" x 4'-0"	7'-2" x 5'-2"	7'-2" x 5'-2"	10'-6" x 8'-4"	7'-2" x 4'-6"
Dry Screw PD Blower footprint (with VFD)	8'-8" x 4'-8"	9'-6" x 5'-6"	9'-6" x 5'-6"	13'-0" x 6'-10"	8'-8" x 4'-8"
Multistage Blower footprint	7'-0" x 3'-0"	9'-6" x 3'-6"	9'-6" x 3'-6"	10'-6" x 4'-0"	9'-6" x 3'-6"

Notes:

[1] Alternative 5 rated blower capacity in summer conditions is 1,200 scfm for lobe PD blower; 1,190 scfm for dry screw PD blower; and 1,150 scfm for multistage blower.

[2] Alternative 5 winter turndown capacity is 400 scfm for lobe PD blower, 225 scfm for dry screw PD blower, and 750 scfm for multistage blower.

[3] Rise-to-surge applies to multistage centrifugal blowers.

The blower selections were first evaluated based on their required footprint relative to the available space on the operating walkway of the oxidation ditch. The footprint requirements for each of the 3,000 scfm Alternative 4 blower selections were found to be too large to fit within the available space. Therefore, Alternative 4 was eliminated from further evaluation. Alternatives 1, 2, 3, and 5 were evaluated further based on a life cycle cost comparison discussed in the following section.

3.5 LIFE CYCLE COST EVALUATION

A life cycle cost analysis was performed for Alternatives 1, 2, 3, and 5 as summarized in Section 3.2 to determine the most cost-effective solution. The life cycle cost for each alternative includes the capital cost of the equipment, as well as the annual energy costs. Capital costs for each alternative include the costs of the blower(s), fine bubble diffusers, aeration piping, associated electrical, mobilization, contractor's overhead and profit, engineering, and installation. The capital costs do not include contingency.

In addition, the life cycle cost evaluation includes a baseline alternative to replace the brush aerator that failed with an identical brush aerator, as a basis of comparison for the life cycle costs associated with the aeration system improvement alternatives. This alternative is identified as "Brush Aerator" in the subsequent life cycle cost results.

3.5.1 Assumptions

The life cycle cost evaluation was based on the following assumptions:

- Life cycle cost based on 20-year net present worth
- Discount rate of 4.625% (EPA, 2015)
- Power cost of $0.05618/kWh based on TWWTP power bill for February 2017
- Operational cost based on average design conditions with additional brush aerators not augmented by the blower(s) for each alternative operating continuously

The results of the life cycle cost evaluation are presented graphically in the following Figure 3-9 and in tabular form in Table 3-4. Each alternative and blower technology is listed with the associated capital cost, annual operating cost and a calculated life cycle cost as described above. The blower technology for each alternative is identified as "LPD" for lobe positive displacement blowers, "SPD" for rotary screw positive displacement blowers, and "MS" for multi-stage centrifugal blowers.

In Table 3-4, each alternative is also presented with a percent difference for comparison purposes. The percent difference is based on each alternative's life cycle cost compared to the alternative with the lowest life cycle cost.

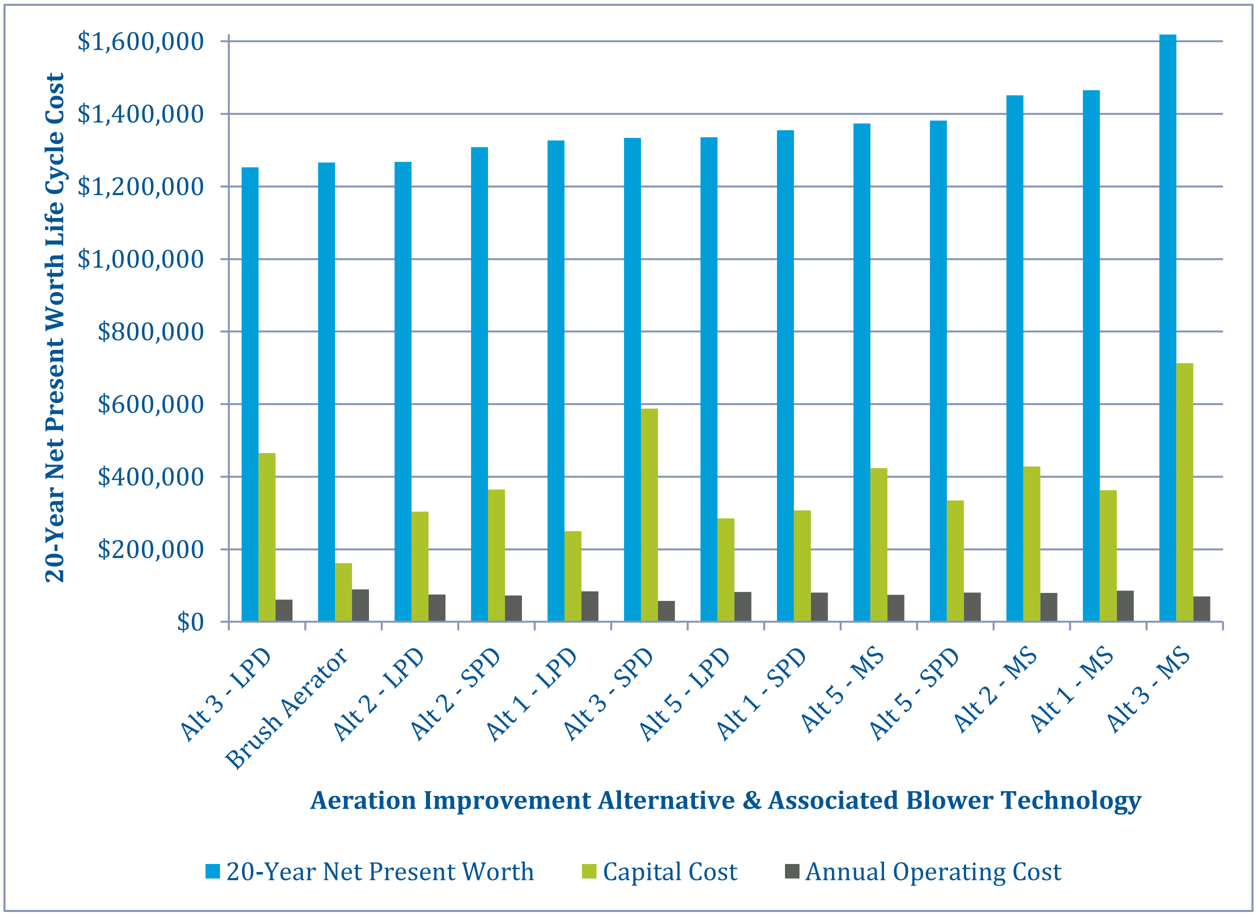

Figure 3-9: Life Cycle Cost Evaluation Results

Table 3-4: Life Cycle Cost Evaluation Results

ALTERNATIVES	INSTALLED BLOWERS	INSTALLED AERATION GRIDS	CAPITAL COST	ANNUAL OPERATING COST	20-YR LIFE CYCLE COST	PERCENT DIFFERENCE
Alt 3 - LPD	2 (125 hp each)	4	$465,000	$61,000	$1,253,000	0%
Brush Aerator	N/A	N/A	$162,000	$89,000	$1,266,000	0%
Alt 2 - LPD	1 (125 hp)	2	$304,000	$75,000	$1,268,000	0%
Alt 2 - SPD	1 (125 hp)	2	$365,000	$73,000	$1,308,000	1%
Alt 1 - LPD	1 (60 hp)	1	$250,000	$84,000	$1,327,000	1%
Alt 3 - SPD	2 (125 hp each)	4	$588,000	$58,000	$1,334,000	2%
Alt 5 - LPD	1 (75 hp)	2	$285,000	$82,000	$1,336,000	2%
Alt 1 - SPD	1 (60 hp)	1	$307,000	$81,000	$1,355,000	2%
Alt 5 - MS	1 (75 hp)	2	$424,000	$74,000	$1,374,000	2%
Alt 5 - SPD	1 (75 hp)	2	$335,000	$81,000	$1,382,000	2%
Alt 2 - MS	1 (125 hp)	2	$428,000	$80,000	$1,451,000	4%
Alt 1 - MS	1 (60 hp)	1	$363,000	$86,000	$1,465,000	4%
Alt 3 - MS	2 (125 hp each)	4	$713,000	$70,000	$1,619,000	6%

3.5.2 Recommendation

The life cycle cost analysis indicates Alternative No. 3 as the most favorable. Alternative No. 3 includes the installation of two 125 hp rotary lobe positive displacement blowers, each with a capacity of 1,500 scfm, in conjunction with two membrane disc diffuser grids to provide the equivalent installed oxygen capacity of four brush aerators.

Alternative No. 2 and the Brush Aerator alternative are essentially equal in terms of life cycle cost due to the lower capital cost associated with in kind replacement of the failed brush aerator. However, long-term use of brush aerator technology does not address the current reliability concerns or provide the operational flexibility for potential future capacity re-rating. Alternative No. 2 consists of one 125 hp rotary lobe positive displacement blower with a capacity of 1,500 scfm and one membrane disc diffused aeration grid. This is the preferred alternative when considering that it provides a return on investment comparable to Alternative 3 with substantially less initial capital, and takes advantage of the useful design life of the existing brush aerators.

Refer to the following Figure 3-10 for an illustration of the recommended Alternative 2. The location of the diffuser grid on the east side of the oxidation ditch was selected to maximize the distance upstream of the nitrate recycle pump while also minimizing the length of piping from the blower.

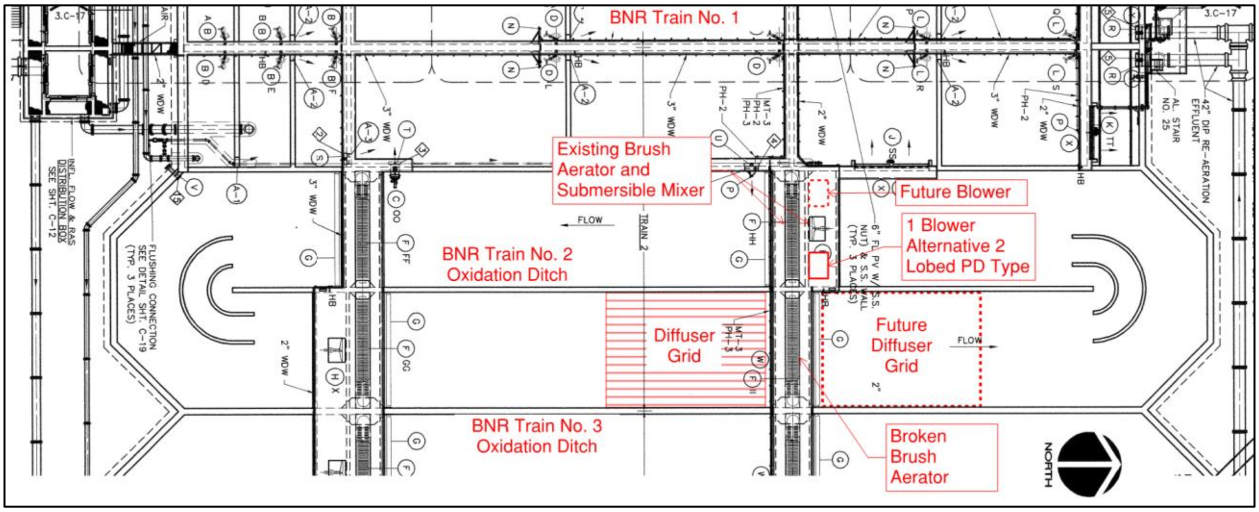

Figure 3-10: Recommended Aeration System Improvements

Section 4. Electrical Considerations

The new blower(s) will be equipped with a manually operated adjustable frequency drive (AFD) to allow adjustment of the airflow delivered by the blower. A local on/off disconnect will be provided on the operating walkway of the oxidation ditch adjacent to the new blower.

Power supply to the existing brush aerators is fed out of Electrical Building No. 2 just north of the BNR Trains. The available spare bucket for the motor control center (MCC) in Electrical Building No. 2 does not provide ample room to accommodate the AFD size required for the blower for any of the alternatives investigated. Furthermore, there is not adequate space required to accommodate a free-standing AFD enclosure while adhering to the space requirements dictated by the National Electrical Code. Therefore, the new AFD should located in the Main Electrical Building. Figure 4-1 below shows the electrical buildings relative to the proposed blower location.

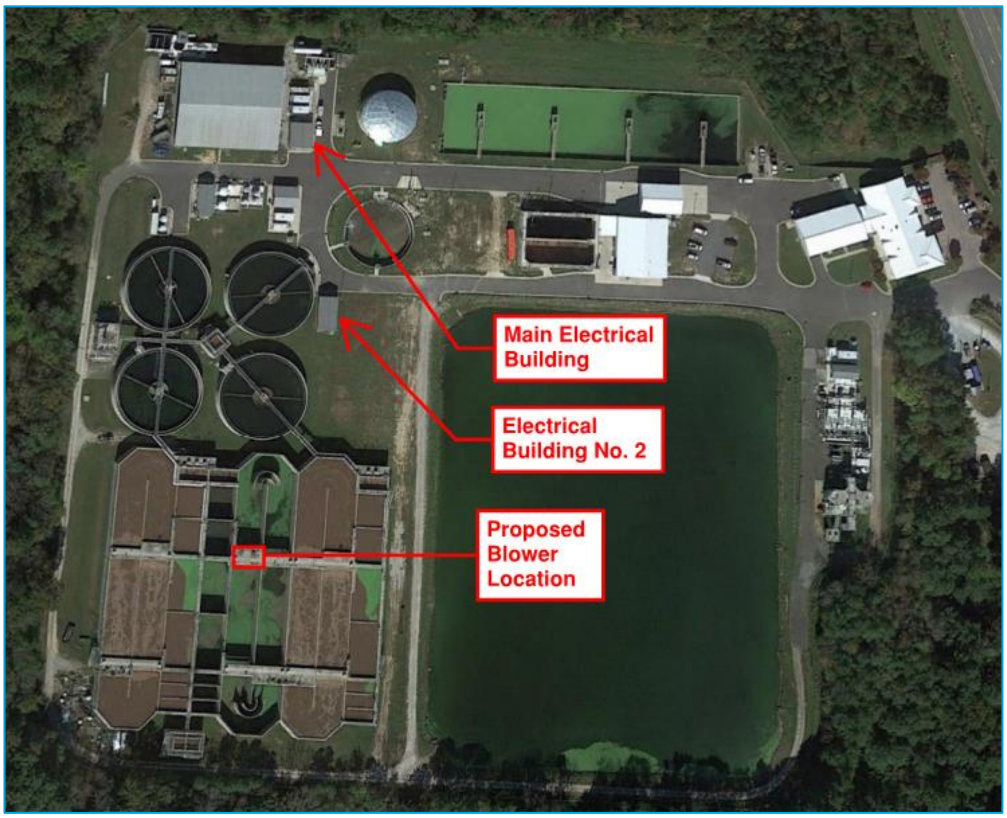

Figure 4-1: Electrical Site Plan

The new AFD will be provided with AFD rated cable, which has a larger outside diameter than standard cable. According to the as-built drawings, the existing conduit used to feed the brush aerator that failed is a 1-1/2 inch diameter conduit fed from Electrical Building No. 2. The existing conduit diameter is not large enough even for the 60 HP AFD blower considered for Alternative 1. Additionally, spare conduits large enough to accommodate the AFD rated cable do not exist. Therefore, new conduit will be required for the recommended alternative.

Cable sizes were determined for each of the blower alternatives. These cable sizes are listed in Table 4-1. The cable sizes were based on values for XHHN cables. Black & Veatch recommends that a cable designed to limit voltage spikes be used for AFDs applications.

The motor for the recommended alternative will include a short-circuit protective device with maximum rating/setting not more than 800% FLA, unless not adequate to allow motor start.

Table 4-1: Motor FLA Requirements

MOTOR HP	FLA @ 460V	REQUIRED CABLE AMPACITY (125%)	CABLE SIZE TABLE B.310.15 B
60	77	96.3	#2
125	156	195.0	#4/0
250	302	377.5	#500mcm (2#4/0)

The following are assumptions associated with the cable sizes indicated in the Table 4-1:

- Motor FLA is based on NEC Table 430.250.
- Cables were sized based on the FLA of the proposed motors, this size will need to be verified and possibly adjusted based on voltage drop, applicable derating factors, manufacture's specifications, and selected AFD input requirements per NEC 300, and 430 Section X.
- RHO of 90 was assumed. Correction factor of 0.9 applied when selecting cable size.
- Cables were assumed to be installed in PVC conduit in concrete encased duct bank.
- Conduit sizing below is based on sample AFD rated cable outside diameter measurements (with allowance for motor unit heater conductors).

Section 5. Structural Considerations

5.1 EXISTING CONDITIONS

On February 8th, 2017, B&V visited the TWWTP. A walkthrough of the BNR basin perimeter and walkways was conducted with the County staff to assess the expansion joint associated with BNR Treatment Train No. 2. Observations noted during the site visit along with repair recommendations, where applicable, are discussed below in the following subsections.

5.2 STRUCTURAL OBSERVATIONS AND REPAIR ACTION ITEMS

There was notable cracking in the walls and walkways observed at the oxidation ditches during the walkthrough. Representative photos of the cracks are illustrated in Figure 5-1. The type of cracking noted is typical for environmental structures of this age and exposure. At this time the cracks do not affect the structural integrity of the tanks. However, the condition of the tanks should be monitored periodically in order to take repair action if necessary in the future.

Figure 5-1: Existing Cracking in Walkway

There were numerous expansion joints throughout the structure. These joints were not actively leaking on the day of the site visit. However, there was significant efflorescence around the joints and some moisture present at the base of one joint at BNR Treatment Train No. 2, as shown in Figure 5-2. The efflorescence is indicative of leakage in the past. The plant staff also indicated that historically these joints have been a significant source of leakage. Long term leakage at the joints could lead to future erosion of the supporting ground at the base of the walls. While the tanks are out of service for the work of this project we recommend these joints be sealed.

Figure 5-2: Efflorescence at Expansion Joint.

We recommend sealing the joints using a surface applied hypalon strip. Below is a sample sketch of the hypalon strip and seal system. The hypalon is a flexible material that is epoxied to the adjacent sides of the joint. The material is allowed to flex over the expansion joint and is adhered on each side of the movement joint to create a watertight bond. This will create a watertight seal and still allow movement during seasonal moisture variations. Batten bars are used when the joints are installed in negative pressure situations such as an adjacent tank being in service. Batten bars are stainless steel plate 2” wide installed on each side of the joint over the length of the joint. The bars provide an active connection to resist negative pressure (water pressure towards the interior of the tank).

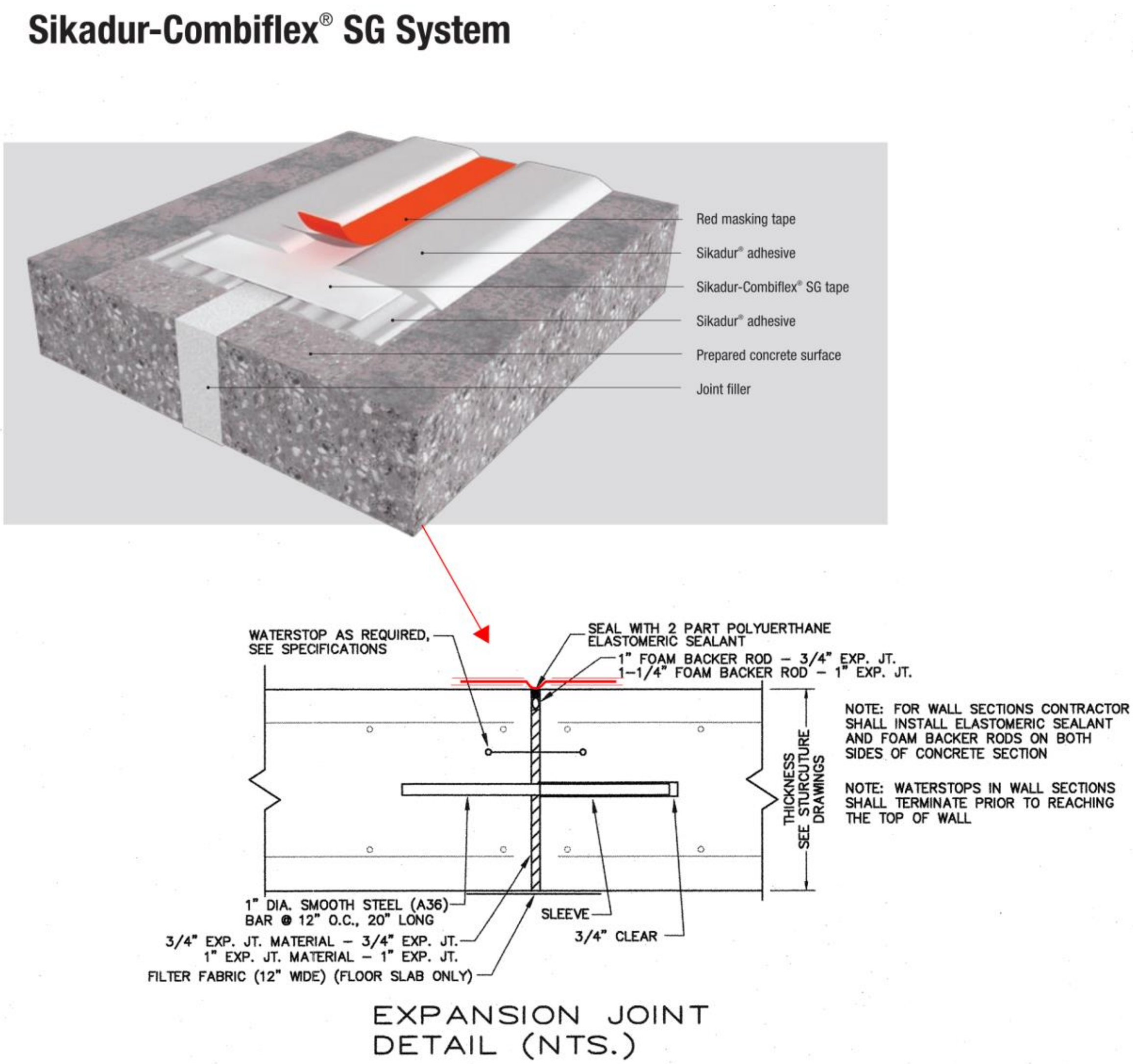

Figure 5-3: Hypalon Strip and Seal System (Batten Bars Not Shown) (Photo Courtesy of Sika Corporation, USA).

5.3 STRUCTURAL REVIEW FOR BLOWER INSTALLATION

Preliminary review of the existing walkway slab and beam system was conducted for the potential blower system installation. Although there is sufficient structural capacity in the slab and beam system there is potential resonant vibration of the slab. We recommend the blowers be located directly above the support beam at the center of the subject walkway. If that location is not possible due to access and space requirements then we recommend installing a stiffening element to the slab. An equipment pad can be used to elevate the equipment and double as a structural stiffening element. This will increase the natural frequency of the slab such that it meets the recommended range of avoidance with the equipment.

Section 6. General Requirements

6.1 MAINTENANCE OF PLANT OPERATIONS (MOPO)

The existing BNR Train No. 2 has been out of service since the brush aerator failure and will remain out of service until the aeration improvements are complete. Therefore, the BNR Train No. 2 cleanout, installation of the blower, diffused aeration grid, and piping will have no impact to plant operations. There will also be no impact to plant operations for the concrete expansion joint repair, including the exterior BNR Train No. 2 walls which are common to Trains 1 and 2. Those repairs can be completed with adjacent Trains 1 and 3 in service and full of water.

Electrical and controls integration and connections will likely require brief shutdowns of certain electrical and controls systems. It is recommended that the following requirements be included in the Contract Documents as a means to balance plant operations with construction activities:

- Permission to interrupt or shutdown any equipment, utility service, or systems shall be requested in writing a minimum of 14 calendar days prior to the desired date of interruption.
- One localized electrical and SCADA system shutdown may be required in order to perform modifications necessary to incorporate wiring and communications required for the new work.
- Duration for shutdown of electrical and SCADA service to any equipment or systems to remain in service shall not exceed three (3) hours.

6.2 PERMITS

The following table provides a summary of permitting requirements anticipated for the recommended aeration improvements.

Table 6-1: List of Permits

PERMIT	AGENCY	APPLICABILITY	CONTACT	EXPECTED REVIEW TIME
Authorization to Construct (ATC)	NCDENR, Division of Water Resources	Required for modification of equipment which has the potential to affect the treatment process	Ron Berry (919) 807-6396 ron.berry@ncdenr.gov	90 days
Level 1 Site Plan Review	Durham City-County Planning Department	Required for projects with no increase in impervious surfaces, new land disturbance or building area, or any changes that would require review by any agency except Planning	Lee Davis (919) 560-4137 x28216 Lee.Davis@DurhamNC.gov	10 days

PERMIT	AGENCY	APPLICABILITY	CONTACT	EXPECTED REVIEW TIME
Building Permit	City-County Inspections Division	To be obtained by Contractor but recommend submitting 90% plans and specs for cursory review prior to bidding	William Bradham gene.bradham@durhamnc.gov 919-560-4144	TBD
Erosion and sediment control	NCDENR, Land Quality Section	Not required due to limits of disturbance less than 1 acre	N/A	N/A
Stormwater	Durham County	Not required due to no change in impervious area	N/A	N/A

6.3 SCHEDULE

The following table provides a summary of the anticipated schedule through design and construction for the recommended aeration improvements. The construction schedule is based on typical lead times provided by the diffused aeration system and blower manufacturers.

Table 6-2: Project Schedule

TASK NAME	DURATION
Preliminary Engineering	2 months
Detailed Design	4 months
Permitting	3 months
Bidding & Award	2 months
Construction	9 months
Submittal Prep	1.5 months
Submittal Review	1.5 months
Fab & Delivery	4 months
Installation & Startup	1 month
Completion	1 month

Section 7. Summary of Recommendations

The list below summarizes the aeration improvement recommendations included in this TM.

- Install one (1) 1,500 scfm, 125 hp rotary lobe positive displacement blower with sound attenuating enclosure on the existing deck of BNR Train No. 2 adjacent to the broken brush aerator.
- Install one (1) membrane disc diffused aeration grid with total footprint of 50'x36'and 720 diffusers.
- Install aeration piping from blower to diffuser drop leg including 12" discharge header with tees and blind flange connections for future blower integration, 8" air supply to new diffuser dropleg, and 8" isolation butterfly valve. All piping to be Schedule 10S 304 Stainless Steel.
- Install one (1) 125 hp AFD inside the Main Electrical Building.
- Install concrete encased duct bank with PVC conduit for cable routing from Main Electrical Building to new aeration blower.
- Repair and seal concrete expansion joint using a surface applied hypalon strip.
- BNR Train No. 2 cleanout including existing solids removal and disposal. The estimated quantity of solids to be removed and hauled to a landfill for disposal is 1,500 cubic yards. It is anticipated that the solids removal will require the use of a crane and bobcat for twelve days, and a crew of four working for two weeks.

An estimate of probable construction cost was developed for the aeration improvement recommendations listed above. The estimate includes markups for mobilization, contractor's overhead and profit, contingency, and engineering. Contractor's overhead and profit was set at 10% and 15%, respectively based on typical values observed for this size project. Contingency was set at 30% to account for the current level of design, uncertainties in the bidding environment, and potential changes in material cost.

The following table summarizes our estimate of probable construction cost for the project. The complete breakdown of the estimate is included in Appendix A.

Table 7-1: Estimate of Probable Construction Cost

DESCRIPTION	COST
Train No. 2 Basin Cleanout	$94,000
Concrete Expansion Joint Repair	$34,000
Fine Bubble Diffused Aeration System	$44,000
Aeration Blower	$45,000
Mechanical Piping & Valves	$12,000
Adjustable Frequency Drive	$17,000
Electrical Conduit and Wiring	$21,000
Subtotal	$267,000
Mobilization (3%)	$9,000
Contractor Profit (15%)	$42,000
Contractor Overhead (10%)	$28,000
Contingency (30%)	$104,000
Subtotal	$450,000
Engineering	$125,000
Total Project Cost	$575,000

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Appendix A Engineer's Estimate of Probable Construction Cost

Triangle WWTP Aeration System Improvements

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5/2/2017

TRIANGLE WWTP AERATION SYSTEM IMPROVEMENTS
ENGINEER'S ESTIMATE OF PROBABLE CONSTRUCTION COST

Project:	Triangle WWTP Aeration System Improvements	**Computed By:**	KBP
Location:	Durham, North Carolina	**Checked By:**	JWB
Owner:	Durham County	**Design Status of Estimate:**	Preliminary
Description:	**Aeration System Improvements**	**Project Number:**	194729

Description	Quantity		Material		Equipment		Labor			Total Cost
	No. Units	Basis	Per Unit	Total	Per Unit	Total	Man Hours	$/Man Hour	Total	
Train No. 2 Basin Cleanout										
Solids Removal & Disposal	1500	CY	$25	$37,500	$0	$0	320.0	$45	$14,400	$52,000
Crane Rental	12	day	$0	$0	$3,100	$37,200	0.0	$45	$0	$37,000
Bob Cat Rental	12	days	$0	$0	$400	$4,800	0.0	$45	$0	$5,000
									Subtotal	**$94,000**
Concrete Expansion Joint Repair										
Hypalon Strip	1415	LF	$15	$21,225	$0	$0	0.1	$45	$6,368	$28,000
Hypalon Strip with Batten Bars	165	LF	$30	$4,950	$0	$0	0.1	$45	$743	$6,000
									Subtotal	**$34,000**
Aeration Equipment										
Fine Bubble Diffusered Aeration System	720	LS	$35	$25,000	$0	$0	0.6	$45	$19,440	$44,000
Aeration Blower	1	LS	$40,000	$40,000	$1,200	$1,200	80.0	$45	$3,600	$45,000
									Subtotal	**$89,000**
Mechanical Piping & Valves										
12" 304SS Sched 10S Aeration Piping	10	LF	$60	$600	$3	$30	0.6	$45	$270	$1,000
8" 304SS Sched 10S Aeration Piping	30	LF	$35	$1,050	$3	$90	0.8	$45	$1,080	$2,000
12"x8" Reducer	2	EA	$150	$300	$60	$120	8.0	$45	$720	$1,000
12" Blind Flange	2	EA	$100	$200	$60	$120	8.0	$45	$720	$1,000
12"x8" Tee	2	EA	$1,135	$2,270	$86	$172	18.0	$45	$1,620	$4,000
8" 90° Elbow	2	EA	$153	$306	$38	$76	8.0	$45	$720	$1,000
Pipe Supports	1	LS	$1,000	$1,000	$0	$0	0.0	$45	$0	$1,000
8" Butterfly Valve	1	EA	$700	$700	$60	$60	12.0	$45	$540	$1,000
									Subtotal	**$12,000**
Electrical:										
Adjustable Frequency Drive	1	EA	$6,200.00	$6,200	$0	$0	240.0	$45	$10,800	$17,000
Electrical Conduit and Wiring	1	LS	$10,090.00	$10,090	$0	$0	240.0	$45	$10,800	$21,000
									Subtotal	**$38,000**
								Subtotal		$267,000
								Mobilization	3%	$9,000
								Subtotal		$276,000
								Contractor Profit	15%	$42,000
								Contractor Overhead	10%	$28,000
								Subtotal		$346,000
								Contingency	30%	$104,000
								Subtotal		$450,000
								Engineering		$125,000
								Total Estimate of Probable Construction Cost		**$575,000**

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Appendix B Diffuser & Blower Information for Recommended Alternative

Triangle WWTP Aeration System Improvements

Black & Veatch
5/2/2017

SANITAIRE

a xylem brand

Diffused Aeration Equipment

for

Durham, NC - Triangle WWTP

Grid to replace 4 Aerators

2 grids proposed to replace 4 aerators. Only 1 of the grids is installed initially to replace 2 aerators for the recommended Alternative 2.

Sanitaire #27689-17s

March 2, 2017

jb K:\OD27689-17\2017-2-17 4 Aertor Design 2scfm-diff.aer

Charlotte, NC

www.sanitaire.com

Sanitaire Aeration Design Inputs for: Durham, NC - Triangle WWTP, Sanitaire #27689-17s

Tank Geometry

2 Trains each Consisting of:

Parameter	Units	Pass 1
Parallel Reactors		1
Pass Process		Aerobic
SWD	ft	18.2
Submergence	ft	17.1
Volume	ft³	32,706.0
Reactor Geometry:		Rect
Length	ft	36.0
Width	ft	50.0

Oxygen/Air Distribution

	Zone	1
	Pass	1
Default		100.0%

Oxygenation

Parameter	Units	AOR 4 Aerators
No. Trains Operating		2
Oxygen Requirement	lb/day	11,712.0-A

Standard Oxygen Correction Factor Parameters

Parameter	Units	AOR 4 Aerators
Alpha		***0.6***
Beta		0.98
Theta		1.024
Dissolved Oxygen	mg/l	***2***
Site Elevation	FASL	250
Ambient Pressure	PSIA	14.58
Water Temperature	°C	***30***

Notes:

Bold, Italicized text indicate assumptions made by Sanitaire

A - Indicates Actual (AOR) Requirement.

S - Indicates Standard Condition (SOR) Oxygen requirement.

If the AOR/SOR parameter is not given, then its value will be evaluated later if suitable alpha, beta, D.O., theta, pressure, and temperature data is supplied.

Round tanks are evaluated as rectangular tanks diameter equal to length and equal surface area.

Annular tanks are evaluated as rectangular tanks of width equal to the annular width and equal surface area.

Sanitaire Project Name: Durham, NC - Triangle WWTP
Sanitaire Project #27689-17s
Design Summary

	Units	AOR 4 Aerators Default	2 grids proposed to replace 4 aerators. Only 1 of the grids is installed initially to replace 2 aerators for the recommended Alternative 2.
No. Trains in Operation		2	1
No. Grids in Operation		2	1
No. Operating Diffusers		1,440	720
SOR	lb/day	24,612	
SOTE	%	34.0	
Total Air Rate	scfm	2,888	1,444
Min.Diffuser Air Rate	scfm/diff.	2.01	
Max. Diffuser Air Rate	scfm/diff.	2.01	
Static Pressure	psig	7.41	
Diffuser DWP @ Min Air	psig	0.56	
Diffuser DWP @ Max Air	psig	0.56	
Pressure @ Top of Dropleg	psig	8.2	
Est. Blower Efficiency		70%	
Est. Motor Efficiency		90%	
Shaft Power	Bhp	129.4	
Est. Motor Electrical Load	kW	107.3	
Est. Standard Aeration Efficiency	#SOR/BHP-hr	7.93	

Notes:

(1) Design air is the maximum of process air or mixing air

(2) Delivered oxygen based on design air

(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss

(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.

(5) Diffuser Air Flow based on Active Valve Modulation

(6) Blower Pressure Capability also requires consideration of:

A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.

B. Potential for increased headloss resulting from diffuser fouling and/or aging. Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other

technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.

C. Increased diffuser submergence during Peak Flow conditions.

(7) Air Flow defined at 30°C

(8) Fine Mixing air based on 0.12 scfm/ft²

Sanitaire Project Name: Durham, NC - Triangle WWTP
Sanitaire Project #27689-17s

Consulting Engineer:
Operating Condition: AOR 4 Aerators
Oxygen Distribution: Default

Aeration System Design

Parameter	Units	Zone 1	Totals/Overall
Pass		1	
SWD	ft	18.17	
Subm	ft	17.12	
Volume	ft³	32,706.0	65,412.0
No. Parallel Tanks		1	
No. Trains in Operation		2	
Grid Count		1	2
Dropleg Diameter	inches	8	
At/Ad		6.09756	
Diffuser Density	% Floor	16.40%	
Diffusers/Grid		720	1,440

Oxygen Transfer

Parameter	Units	Zone 1	Totals/Overall
Diffuser Type		SSII-9	
Alpha		0.6	
Beta		0.98	
Theta		1.024	
D.O.	mg/l	2	
Water Temp	°C	30	
AOR/SOR		0.4759	0.4759
Oxygen Distribution	%/Zone	100.0%	100.0%
AOR	lb/day	11,712.0	11,712.0
SOR	lb/day	24,611.8	24,611.8
Air Rate (7)	scfm		

Performance

Parameter	Units	Zone 1	Totals/Overall
Mixing Criteria	scfm/ft²	0.12	
Safety Factor	%		
Mixing Air (8)	scfm	432.0	
Process Air (for SOR)	scfm	2,887.7	
Design Air (1,7)	scfm	2,887.7	2,887.7
Diffuser Air Rate	scfm/Diff.	2.01	2.01
Delivered SOR	lb/day	24,611.8	24,611.8
Delivered SOTE	%	34.0%	34.0%
Pressure @ Top of Dropleg	psig	8.20	8.20
Shaft Power	Bhp	129.4	129.4

Notes:

(1) Design air is the maximum of process air or mixing air

(2) Delivered oxygen based on design air

(3) Brake Horsepower based on adiabatic compression, 70% mechanical efficiency and 0.30 psi lineloss

(4) Performance based on diffuser density (At/Ad), submergence, and diffuser unit air flow.

(5) Diffuser Air Flow based on Active Valve Modulation

(6) Blower Pressure Capability also requires consideration of:

A. The Air Main headloss (piping, fittings, valves, instrumentation, etc.) between the blower and the aeration assembly dropleg connections.

B. Potential for increased headloss resulting from diffuser fouling and/or aging.

Please refer to the US EPA Fine Pore Design Manual (EPA/625/1-89/023), WEF Manual of Practice FD-13, and other technical publications for a detailed discussion on this subject. Note that this headloss consideration relates to all Fine Pore systems regardless of supplier or type of diffuser element.

C. Increased diffuser submergence during Peak Flow conditions.

(7) Air Flow defined at 30°C

(8) Fine Mixing air based on 0.12 scfm/ft²

Sanitaire Project Name: Durham, NC - Triangle WWTP
Sanitaire Project #27689-17s
Headloss Summary by System Operating Point

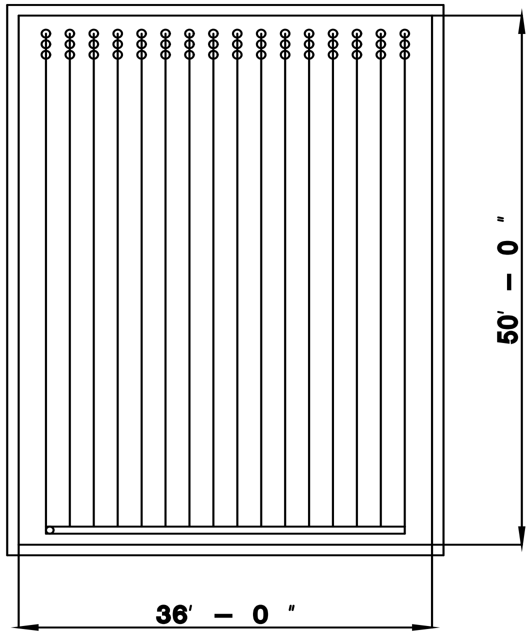
Consulting Engineer:
Operating Condition: AOR 4 Aerators
Oxygen Distribution: Default

Grid Design

	Units	Grid 1
Diffuser Count		720
Dropleg Diameter	inches	8
Line Count		16
Line Spacing	ft	2.08
Manifold Diameter	inches	8
Manifold Length	ft	31.25
Header Length	ft	47.25
Manifold Location		End
Manifold Elevation		Inline
Dropleg Location		End
Header Orientation		Width

Grid Pressure

Grid Air Flow	scfm	1,443.8
Diffuser Air Flow	scfm	2.01
Submergence	ft	17.12
Orifice Diameter	inches	13/64
Static Header Pressure Differential in Assembly	psig	2.66E-02
Average Header Pressure in Assembly	PSI	8.14
A: Average Headloss from Top of Dropleg To Headers	PSI	5.64E-02
B: Diffuser Orifice Headloss	psi	1.70E-01
C: Diffuser Dynamic Wet Pressure	psi	5.61E-01
D: Static Pressure	psig	7.41
Total Pressure Required at Top of Dropleg (A+B+C+D)	psig	8.20
Friction Headloss (A+B)	PSI	2.26E-01



Single Train Information

Grid No	Grid Count	Drop Leg ∅"	Header Count	Header Spc,ft.	Header Len,ft.	Discs/ Grid	At/ Ad	Discs/ Train
1	1	8	16	2.08	47.25	720	6.10	720

Total Discs/Train 720

Note: Some headers may be omitted for clarity

PRELIMINARY - THIS DRAWING IS NOT INTENDED FOR CONTRACT DOCUMENTS, SUBMITTALS, OR CONSTRUCTION

Sanitaire a xylem brand BROWN DEER, WISCONSIN 53223	CUST NO. DWG NO.		Durham, NC – Triangle WWTP 9" Disc Aeration System	DRAWN BY JB CHKD BY APPVD BY	DATE 3/2/17 DATE DATE	JOB 27689–17s SHEET

Excelsior Blower Systems
P.O. Box 15126 - 331 June Avenue
Blandon, PA 19510-5126
Phone: 800-921-0002 Fax: 610-921-9727

Black & Veatch Engineers
201 South Orange Avenue, Suite 500
Orlando, FL 32801

Attn: Steven Scott — March 19, 2017
Re: Durham County, WWTP — Quote# 35306

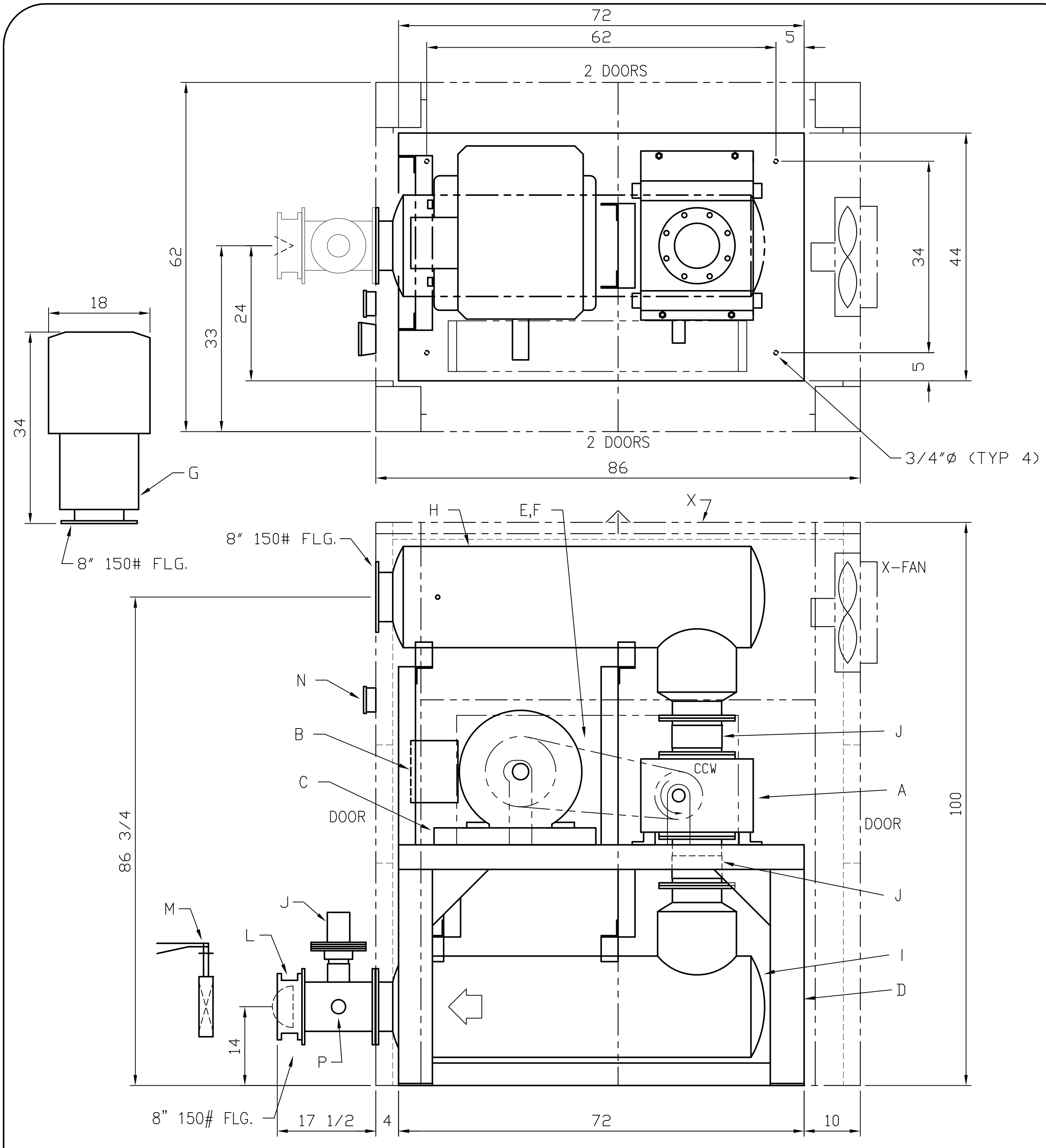
1	Gardner Denver 616 “Heliflow” Series Positive Displacement Blower	
	1500 SCFM / 1691 ICFM	9.8 PSIG
	270’ Elevation	105ºF
	2890 RPM	92.9 BHP
1	Elevated Steel Base	
1	V-Belt Drive	
1	Enclosed OSHA Style Drive Guard	
1	PL-3” Weight Type Relief Valve	
1	Universal CCS-8” Inlet Air Filter with Paper Element	
1	Universal RISY-8” Inlet Silencer with Saddles	
1	Universal SDY-8” Discharge Silencers with Saddles	
1	125 HP – 1800 RPM - TEFC - 444T – 460/3/60 - 1.15 S.F. - Electric Motor	
	Premium Efficient – Certified for VFD Service	
1	Motor Slide Base	
1	Layout & Mount Blower, Motor & Drive	
2	Spool Type Flexible Connector	
1	Protective Crating	
1	Wika 2.5” Pressure Gauge	
1	Dwyer Inlet Vacuum Gauge	
1	Flexi-Hinge 518-8” Check Valve	
1	Deltech Model 52-8” Butterfly Valve	
1	Fully Assemble & Finish Paint All Components	
1	Aluminum Sound Enclosure	
1	Spare V-Belt Set	
1	Spare Filter Element	
1	AEON Synthetic Blower Oil for Initial Start up	
8	Submittals, Shop Drawings & O/M Manuals	
1	Freight to Job Site	
1	Start Up Service	

Total Price for One (1) Blower Package — $ 39,750.00
Approximate Weight is 5800 lbs.

If you have any questions, please contact Gene Franckowiak at 800-921-0002.

Gardner Denver Blowers come off an assembly line in Sedalia, Missouri - Not a BOAT

Gardner Denver – Keeping Americans Working



A BLOWER: G.D. HELIFLOW 616
B MOTOR:
C MOTOR SLIDE BASE:
D ELEVATED STEEL BASE
E V-BELT DRIVE:
  BLOWER SHV:
  MOTOR SHV:
  BELT:
F DRIVE GUARD
G INLET FILTER / SILENCER: UNIVERSAL CCS-8"
H INLET SILENCER: UNIVERSAL RISY-8"
I DISCHARGE SILENCER: UNIVERSAL SDY-8"
J FLEXIBLE PIPE CONNECTOR: FLEX-FAB TYPE I-8"
K PRESSURE RELIEF VALVE:
L CHECK VALVE: F.E. 518-8"
M BUTTERFLY VALVE: 8"
N DIFFERENTIAL PRESSURE GAUGE: DWYER 2020, 0-20" WC
P PRESSURE GAUGE: 0-15 PSI

X NOISE ENCLOSURE: ALUMINUM WITH ACOUSTIC FOAM, PERFORATED GALVANIZED STEEL INNER LINER, 6 LATCHING DOORS, LOUVERS AND EXHAUST FAN (1/15 HP, 115/1/60) WITH THERMOSTAT

ESTIMATED BLOWER PACKAGE WT: 3,650 #
ESTIMATED NOISE ENCLOSURE WT: 800 #
NOISE ENCLOSURE SHIPS KNOCKED DOWN

EXCELSIOR
Blower Systems Inc.
READING, PENNSYLVANIA

DATE: 8/17/11 SCALE: NONE

HF616-A-8x8-E

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Appendix C Hypalon Strip & Seal System

Triangle WWTP Aeration System Improvements

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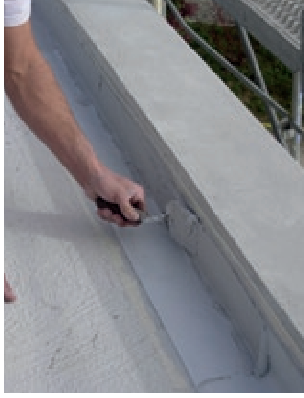
5/2/2017



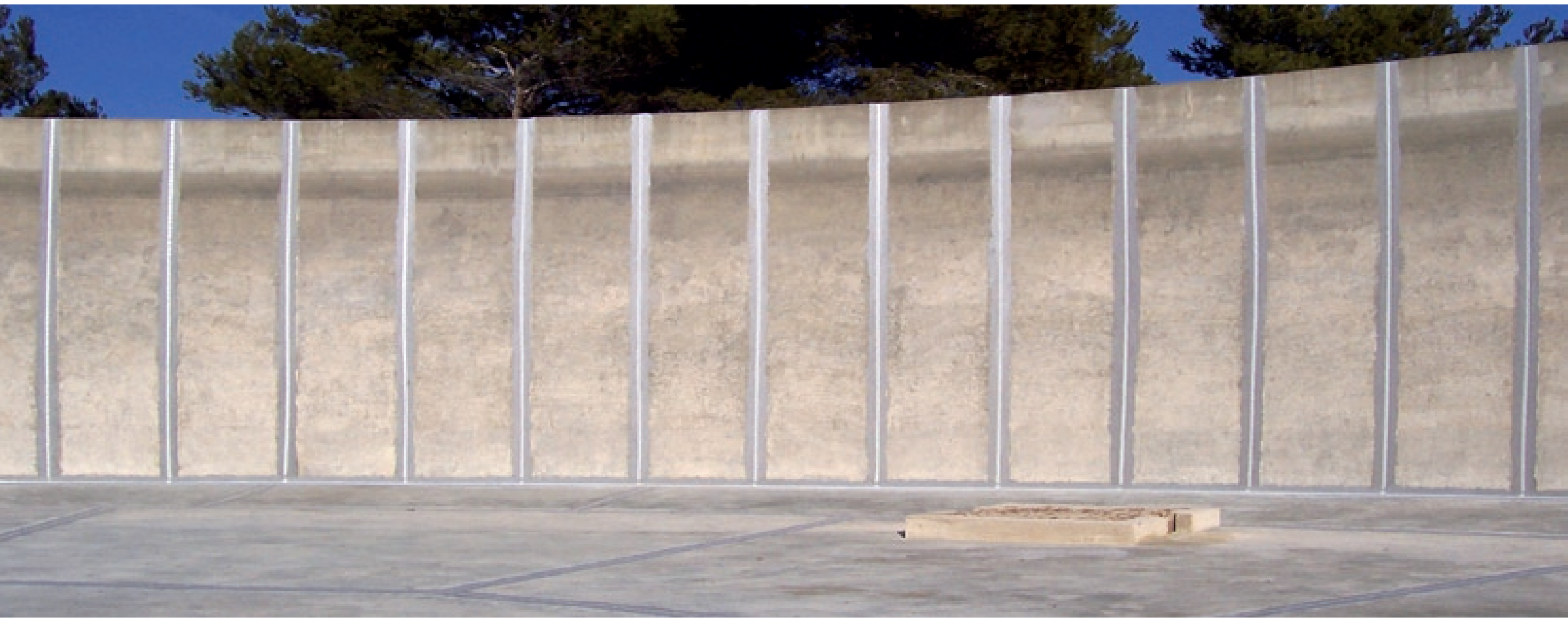
Sikadur-Combiflex® SG System

High Performance Joint and Crack Waterproofing System

Sika®

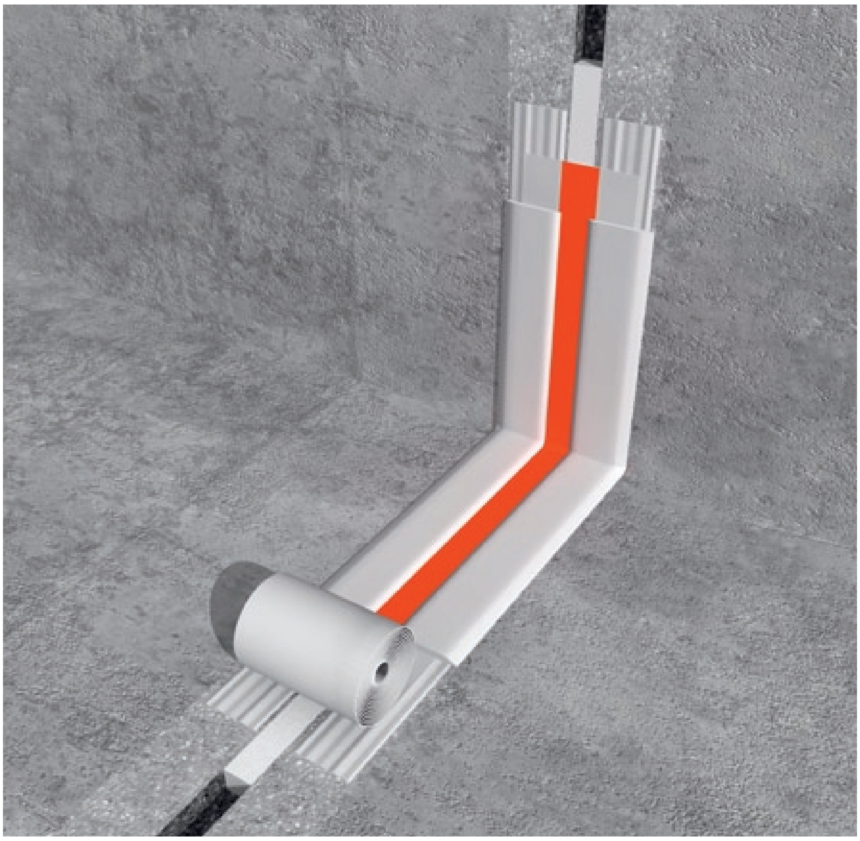
Innovation & Consistency | since 1910

Sikadur-Combiflex® SG System
High Performance Joint and Crack Waterproofing System



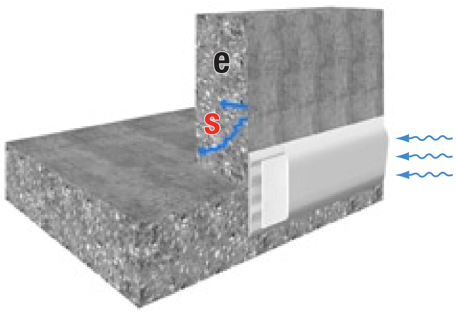
Sikadur-Combiflex® SG System

The **Sikadur-Combiflex® SG** system is the second generation development of the globally proven **Sikadur-Combiflex®** with even improved performance such as advanced adhesion properties and drinking water approval. The unique system consists of the **Sikadur-Combiflex® SG** tape and the **Sikadur®** adhesives. It is widely used as joint waterproofing in watertight concrete structures.



Main Advantages
- Waterproofing of joints with extreme movements
- Easy to install and adjust to complicated construction details
- Excellent adhesion to different substrates
- Resistant to high water pressure
- Crack sealing system
- Easy to control and repair

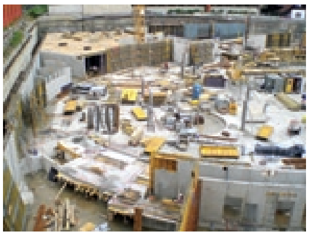
Function:
- Blocking the path of water penetration
- Increased length of water penetration
- Fully bonded to the concrete preventing underflow



s>>e

e = water penetration (EN 206)
s = increassed length for water penetration

Typical Applications



Basements
- High water tightness and durability
- Easy to control / repair
- Independent of concreting steps
- High joint movement capacity

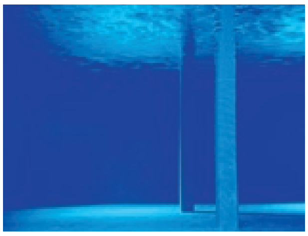
Refurbishment
- Crack sealing
- Resistance to negative water pressure

Infrastructure

Bridges
- De-icing salt resistance
- UV resistant

Tunnel Ventilation Ducts
- Airtight
- Flexible to joint tolerances

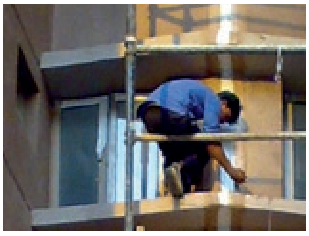
Sewage Treatment Plants
- Resistance to sewage water
- Good abrasion resistance
- Independent of concreting steps
- High joint movement capacity



Drinking Water
- Approved in contact with drinking water
- Long-term water resistance
- Easy to control/repair

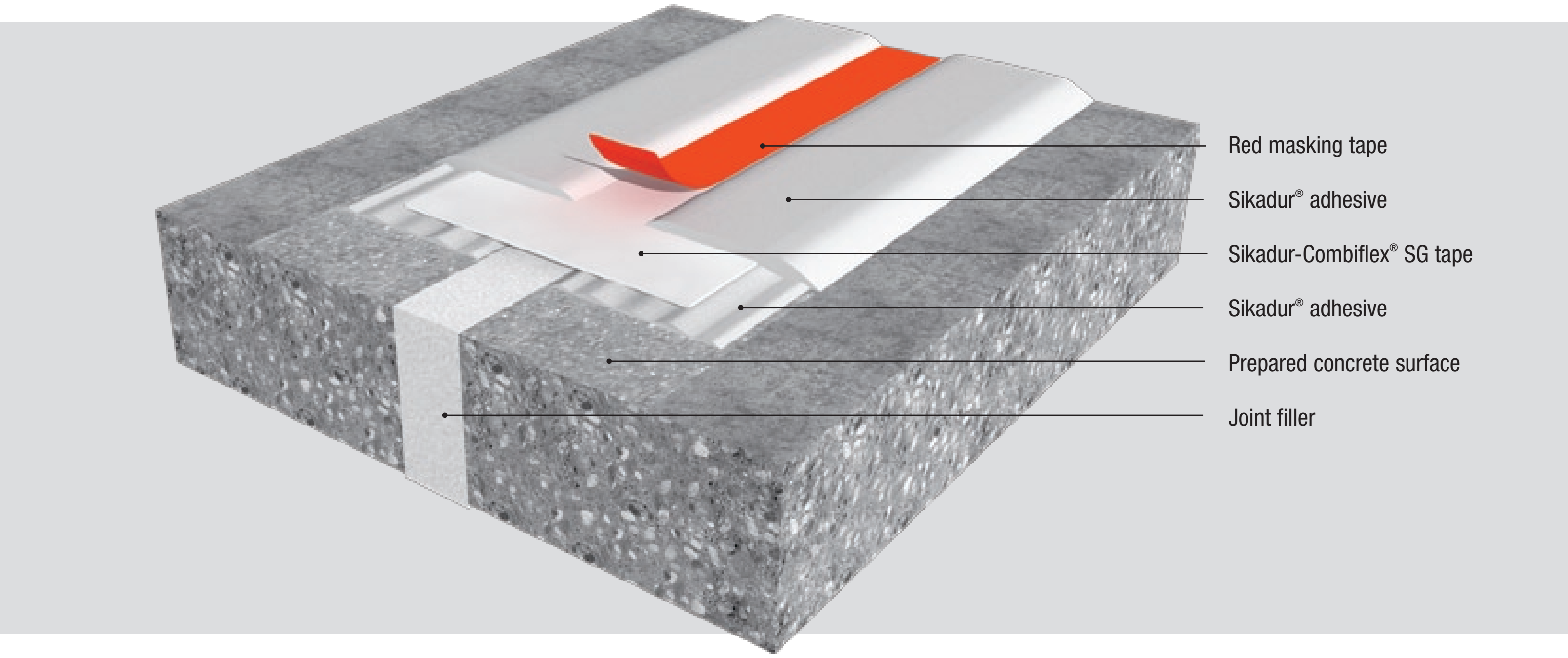
Ground Water Protection
- Chemical resistant
- High safety of environment
- Impermeable

Swimming Pools
- Resistance to ozone, chlorine and UV
- Good cleaning ability
- Non abrasive to skin

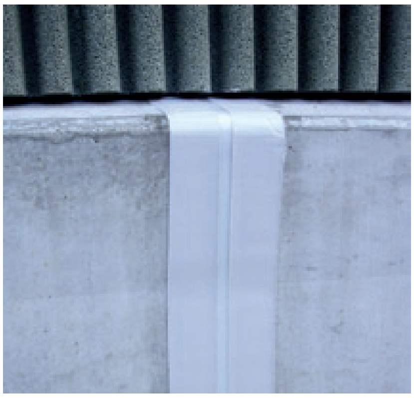


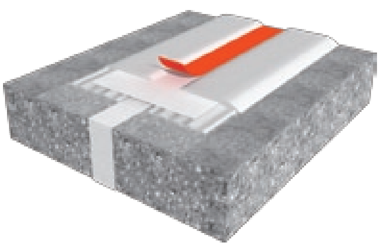
Facade Joints
- High joint movements
- Overpaintable (adhesive)
- Weather resistant

Sikadur-Combiflex® SG System



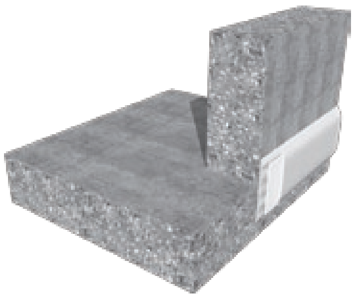
Where to use?





Expansion Joints

- Temperature dilatation
- Construction settlements
- Material connection
- Building connection



Construction Joints

- Connection between concrete steps
- Floor-to-wall Connection
- Different material connection
- Inside-outside application

Cracks Repair

- Construction settlements
- Shrinkage
- Thermal influences
- Structural overload

Sikadur® Adhesives

To achieve a watertight, durable connection between **Sikadur-Combiflex® SG** tape and the substrate **Sikadur®** adhesives are used.

Main Advantages
- Excellent adhesion to many substrates
- Available with normal and rapid hardening grades of adhesive

Sikadur®-Combiflex® CF Adhesive
- Optimum workability and finish
- Provides smooth surface

Sikadur®-31 CF
- Higher layer thickness is required

Sikadur®-31 DW
- Drinking water approval

Sikadur®-33
- Mechanical mixing and dosage with **Sika® CoMix-101**
- Very suitable for high volumes

Sikadur-Combiflex® SG Tape

Sikadur-Combiflex® SG is a flexible prefabricated waterproofing tapes based on modified flexible Polyolefin (FPO) with advanced adhesion.

Main Advantages
- **Advanced adhesion, no activation on site required**
- Can be used in contact with potable/drinking water
- High water pressure resistance
- High durability and chemical resistance
- UV- and weather resistant
- Root resistance
- Plasticizer free

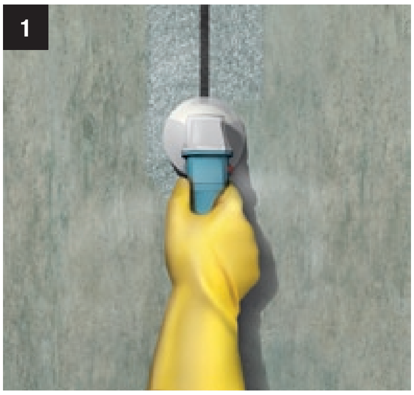
Sikadur-Combiflex® SG type P

	Sikadur-Combiflex® SG-10 P	Sikadur-Combiflex® SG-20 P
Tape thickness [mm]	1.0	2.0
Tape width [mm]	100, 150, 200, 250, 300 400, 500, 1000, 2000	150, 200, 250, 300 400, 500, 1000, 2000
Tape length [m]	25	25

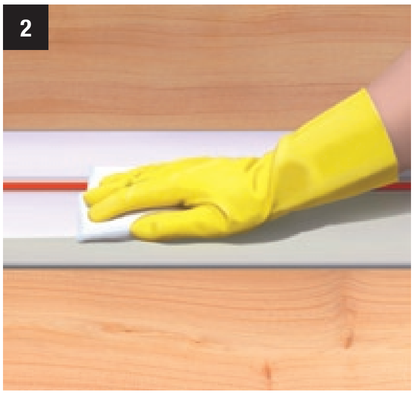
Sikadur-Combiflex® SG type M
(with red masking tape for easier application in expansion joints)

	Sikadur-Combiflex® SG-10 M	Sikadur-Combiflex® SG-20 M
Tape thickness [mm]	1.0	2.0
Tape width [mm]	100, 150, 200, 250, 300	150, 200, 250, 300
Tape length [m]	25	25

Sikadur®-Combiflex® SG System - Application



Substrate preparation by means of sandblasting, grinding etc., followed by vacuuming.

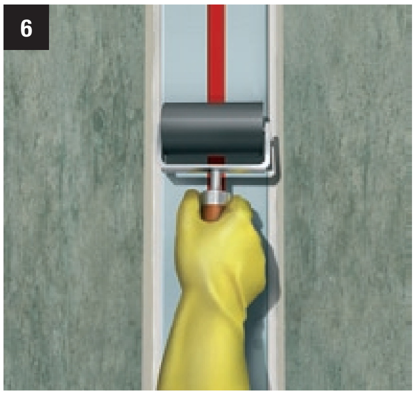


In case of dirt clean the surface of the **Sikadur-Combiflex® SG** tape with a dry or wet cloth. Use water and **no solvent** for cleaning.

Use masking strips to cover the joint.

Mix **Sikadur®-Combiflex® CF** adhesive components A and B for a minimum of 3 minutes until the mix is homogeneous.

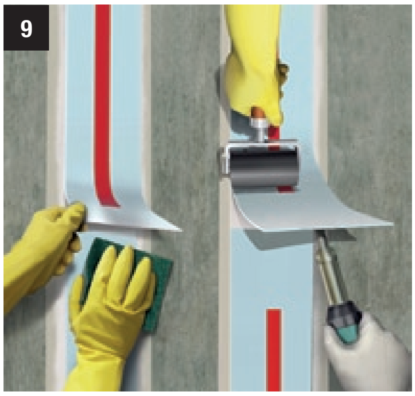
Apply the **Sikadur®-Combiflex® CF** adhesive on the left-hand and the right-hand side of the joint. Then remove masking strip.



Press the **Sikadur-Combiflex® SG** tape without trapping air into the adhesive by using a suitable roller. The adhesive should be squeezed out on both sides by ~ 5 mm.

Apply the **Sikadur®-Combiflex® CF** Adhesive on the tape.

Remove the red middle strip and the masking strips on both sides to ensure a neat and precise detail.



Connect tape ends by hot air welding.
Prepare the welding area by roughing the surface by scotch brite or sand paper.
Overlap 40 - 50 mm.

Sikadur-Combiflex® SG System - Case Studies

Sihlcity-Shopping, Business, Fun and Fitness Centre Zurich, Switzerland

Project Description:
Building complex containing shopping, cinema, office accommodation etc.
Waterproofing of expansion and construction joints in the basement construction

Project Requirements:
Watertight concrete construction
Waterproofing of joints in areas of groundwater pressure

Sika Solution:
Sealing of the expansion and construction joints with the **Sikadur-Combiflex**® system against groundwater pressure

Tunnel du Mont Blanc, France

Project Description:
Extensions of the fraco-italien Tunnel such as technical gallery etc

Project Requirements:
Watertight joint sealing system
Flexibility to joint tolerances

Sika Solution:
Sealing of the joints with the **Sikadur-Combiflex**® system, protection of technical installations from water

Water Tank, Riyadh, Saudi Arabia

Project Description:
Waterproof construction for collection of extra water for emergency purpose

Project Requirements:
Long-term water resistant
High joint movement capacity

Sika Solution:
Sealing of the 25 km joints with the **Sikadur-Combiflex**® system

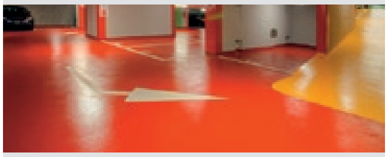
Sika Full Range Solutions for Construction

Concrete Production


Sika® ViscoCrete®
Sika® Retarder®
Sika® SikaAer®

Waterproofing


Sikaplan®, Sikalastic®
Sika® & Tricosal® Water-stops
Sika® Injection Systems

Flooring


Sikafloor®
SikaBond®

Corrosion and Fire Protection


SikaCor®
Sika® Unitherm®

Concrete Repair and Protection


Sika® MonoTop®
Sikagard®
Sikadur®

Structural Strengthening


Sika® CarboDur®
SikaWrap®
Sikadur®

Joint Sealing


Sikaflex®
Sikasil®

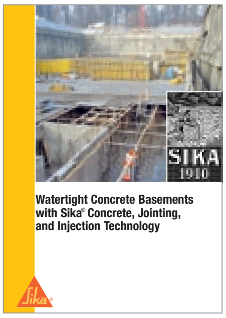
Grouting

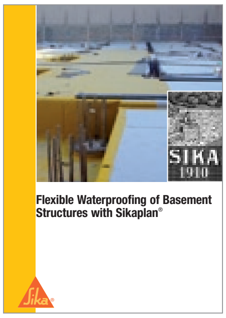

Sikadur®
SikaGrout®
Sika AnchorFix®

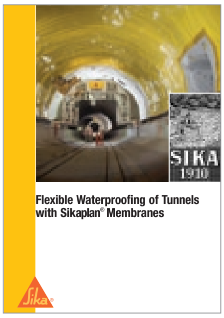
Roofing

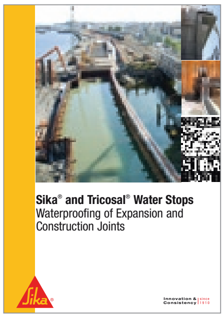

Sarnafil®
Sikaplan®
SikaRoof® MTC®

Also available from Sika









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