Analysis of MSD Float Control to Prevent Sewer Surcharge in Combined Sewers

University of Cincinnati Environmental Engineering Capstone Project

Environmental Overflow Consultants

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Executive Summary

The project objective is to evaluate recently developed technology to prevent sewer surcharge during storm events for the Metropolitan Sewer District of Greater Cincinnati (MSDGC). During a recent storm event in late 2021, MSDGC collected and provided data on the current float control prototype. From this data, debris buildup showed to be a real concern and an alternative analysis was conducted on different debris prevention options. It was determined that improving the shape of the gate by increasing the arc radius proved to be the best option based on circle-circle interaction calculations. Research was conducted on possible Low Rainfall Intensity Flooding Analysis (LRIFA) sites to place the float control device. An environmental impact analysis on the final system concluded that the implementation of the MSD float control should not negatively impact the surrounding environment. An economic analysis was conducted on several LRIFA sites and the installation of float control devices has the potential to save MSD millions of dollars. Gate installation will resolve 22 LRIFA sites and remove 200 SBU's in the Cincinnati area. This project would cost roughly $303k and generate cost savings in the short term of $541k and in the long-term of $3.8M (assuming MSD installs current prevention measures in each of the problem areas). Our overall recommendation to decrease debris buildup is that the gate needs an increased opening arc radius with sloped corners.

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1. Introduction

1.1 Site Background

MSDGC initiated a pilot study in 2021 to address the ongoing expenses of sewer backups in the Mill Creek, Little Miami, and Muddy Creek watersheds. With the help of Hazen and Sawyer, sewer backup (SBU) problem locations were identified throughout MSDGC's service area and categorized based on solution types given certain parameters unique to each location. Solutions such as operational controls, prevention programs, infiltration wells, and conveyance/separation improvements, among others, were considered for each SBU location. One of the main operational controls identified for this problem is what has been termed a "coverage door," i.e., a small door that remains closed to various degrees preventing full stormwater infiltration into combined sewer lines. The MSD-designed float control prototype is a variation of a coverage door that is dynamically opened and closed with the help of a floatation attachment on the device (see Figure 1.1.1).

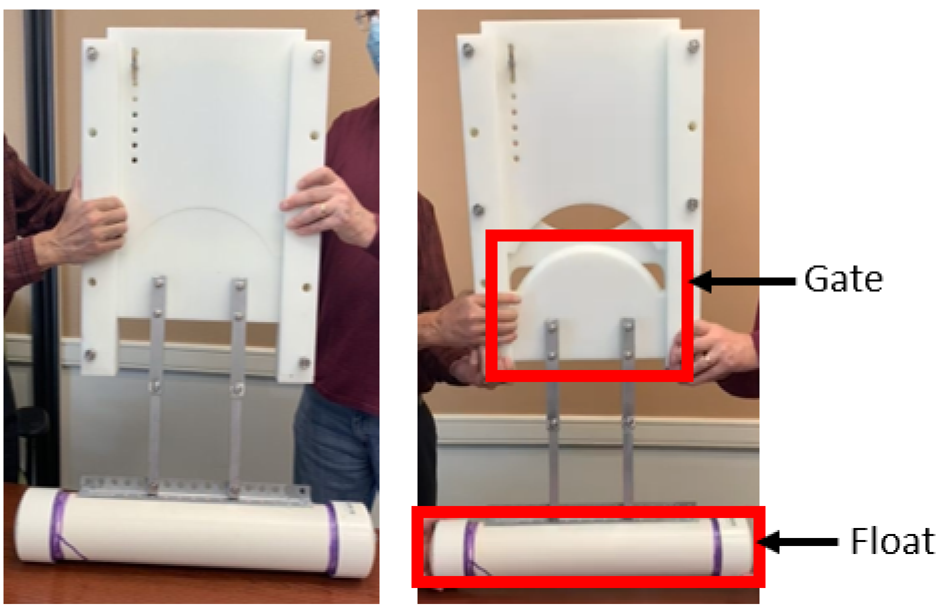

Figure 1.1.1: Float device with components labeled

As expected, preventing stormwater from entering the combined sewer results in the runoff flowing elsewhere, namely along the street. Therefore, this solution is only applicable in neighborhoods and streets whose houses and yards are elevated from the level of the street.

The fully closed coverage door has already been installed in several neighborhoods that meet these criteria. The float-gate prototype has only recently been installed in the Oakley neighborhood of Cincinnati on Eileen Drive. As shown in Figure 1.1.2, many of the houses on Eileen Drive are affected by SBU's during storm events. Return periods of these storms range from a few months to a year with 12 houses on the block regularly affected.

A neighboring street, 33rd Avenue, is a potential location for float-gate installation with similar, even more common SBU incidents (Figure 1.1.3). Like Eileen Drive, coverage doors have been installed blocking storm water from entering combined sewer lines. Three partial-plug coverage doors were installed on February 22nd, 2021 on 33rd Avenue, which were replaced with full plug operational controls after a June 30th-July 1st storm event.

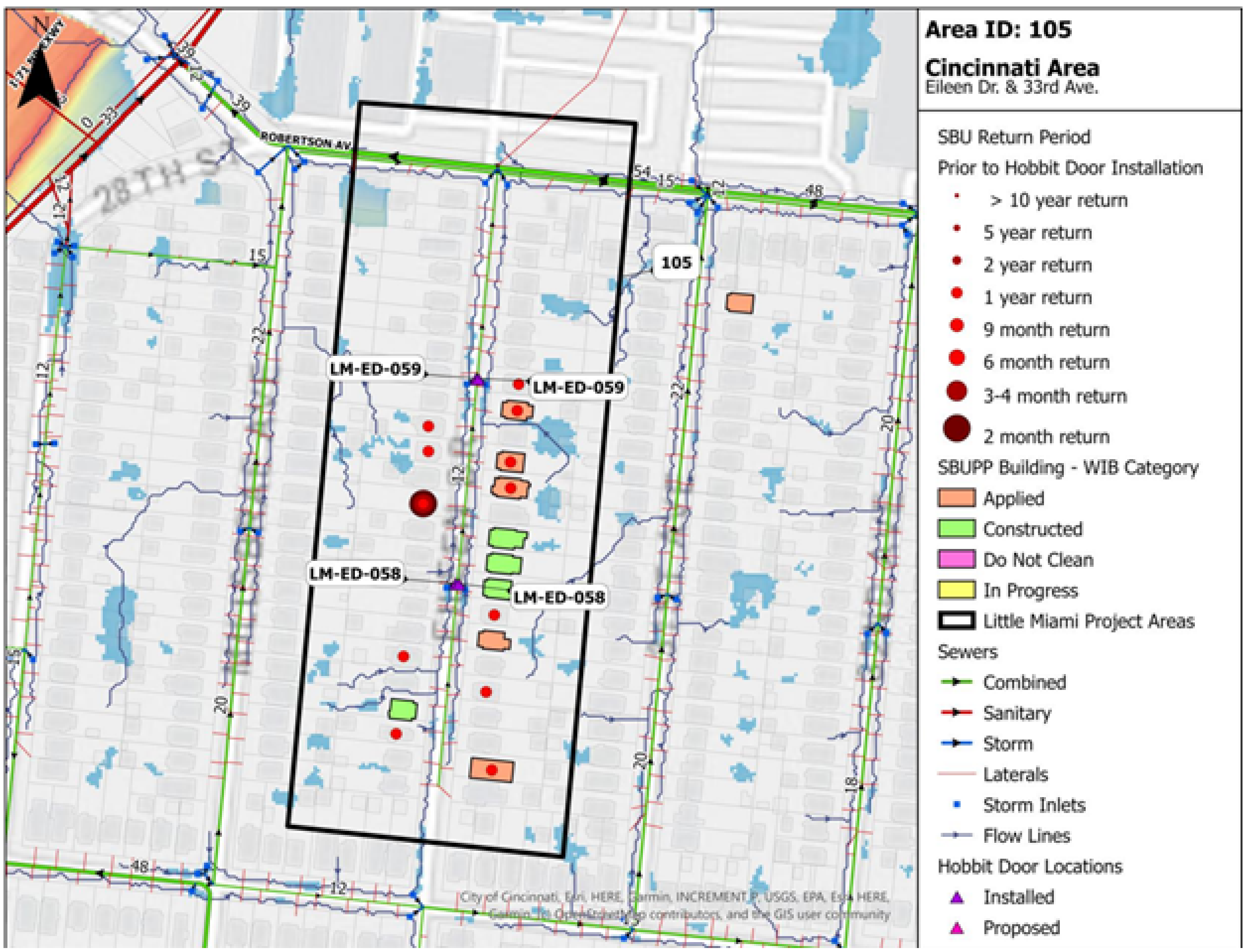

Figure 1.1.2: Eileen Drive

Source: Hazen and Sawyer "Sewer Backups and Operational Controls Performance Evaluation Pilot Study"

Similarly on Eileen Drive, four partial plug coverage doors were installed and replaced with full-plug operational controls over the same timeline. Although these full-plug coverage doors are effective for preventing sewer backups in homes, the buildup of debris and sitting water is detrimental to maintenance and the general health of the sewer lines. The float-gate prototype will ideally alleviate these problems by allowing runoff to flow freely until a large storm event closes the gate.

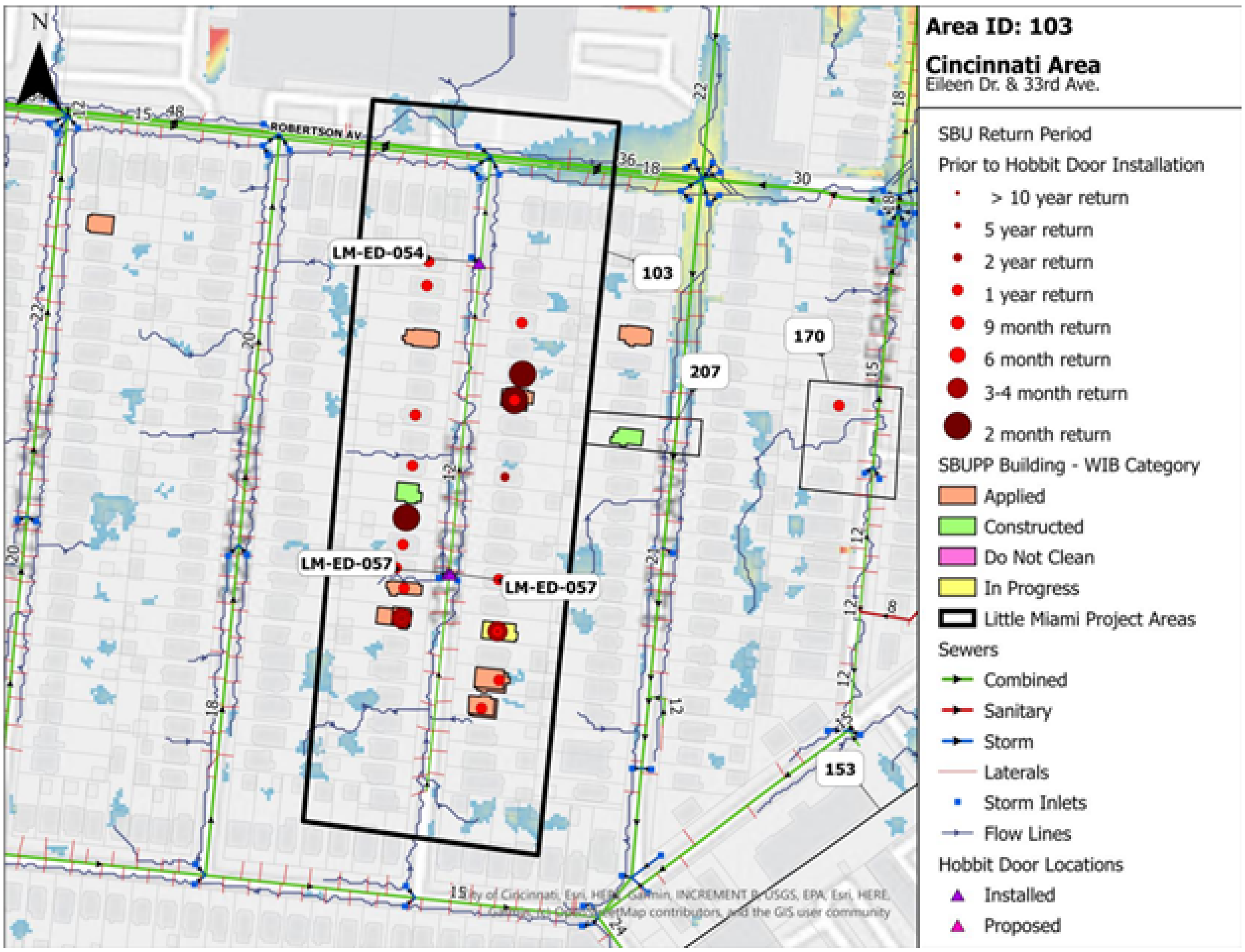

Figure 1.1.3: 33rd Avenue

Source: Hazen and Sawyer "Sewer Backups and Operational Controls Performance Evaluation Pilot Study"

1.2 Scope of Issue

Sewer backups are a regular and costly occurrence throughout Greater Cincinnati. Not only does MSDGC provide costly cleanup and prevention solutions for those affected, but homeowners' lives are disrupted with damaged property and routine maintenance. In the approximately four-month period from February 28th, 2021 to July 1st, 2021, there were a total of 352 district-wide SBU incidents. The majority of these events (334) occurred due to a storm with a return period of 100 years. While storms of this scale may prove difficult to defend against, each event results in costly maintenance for MSDGC. Therefore, each SBU must be evaluated against the efficacy of possible solutions.

1.3 Problem Statement

Environmental Overflow Consultants (EOC) conducted preliminary testing, data analysis, and research on the float control prototype to determine necessary areas of improvement. EOC then conducted an alternative analysis between the MSD float device and other flow regulators as well as a secondary alternative analysis evaluating the most effective enhancements. EOC identified potential LRIFA sites for installation and executed an economic analysis on the cost savings of installing the float gate devices.

2. Performance Analysis

2.1 Alternative Analysis: Flow Regulation

2.1.1 Alternative Devices

1. GNA

   Gabriel Nobac and Associates Ltd. (GNA) offers three solutions. The first two are the “Float-controlled outlet gate type A and B” that stop flow completely based on the level of water below the gate. However, their sizing chart shows that the application would require four and a half feet horizontal distance. Therefore, they are too large for this application. The last option is the “mini Vario” which does not shut off flow until the water level is too high. Refer to Appendix 10.1 for sizing information.

2. Eliquo Hydrok

   The ALPHEUS-VO flow regulator from Eliquo Hydrok uses a float activated mechanism to control flow. It is a cost-effective and passive solution that can maintain a constant discharge for flows of at least 2 liters per second. However, this product would not work for MSD because the lever arms are too long for a manhole. Refer to Appendix 10.2 for a visual of the Eliquo Hydrok ALPHEUS-VO flow regulator.

3. Veolia Electric Gate

   The Veolia electric gate is part of the Hydrovex line of weather control technology. It controls combined, sanitary, and storm runoff flows. There is a floatable screen for debris collection that allows pieces up to 2 mm to pass through. Since Veolia has a line of devices, all products are priced differently based on desired criteria. The gate has in-line, out-line retention and treatment. While this device addresses several issues, the electric gate is not a passive solution and requires electricity to operate. Please refer to Appendix 10.6 for clarification.

4. Duckbill Valve

   The duckbill valve is a one way backflow prevention device. Duckbill valves have a flexible end that pinches together like a beak when backflow occurs, while the other end contains a circular pipe like opening to allow for one directional flow. These valves are manufactured to fit standard pipe sizes, especially small to medium diameter pipes. The TF-1 Tideflex technologies Duckbill valve was quoted at $2200 for a 12” pipe. The Duckbill valve does not require an actuator nor manual force to operate. Please refer to Appendix 10.3 for product data on series TF-1 Tideflex technologies check valve and further technical specifications on the Duckbill valve.

5. Hydrobrake Agile

   The Hydrobrake Agile is designed to allow water to flow unaltered in periods of light rain and low flow. As flow increases, the Hydrobrake Agile is engineered to provide a constant discharge. This is accomplished with a chamber that fills with water during periods of high flow. The rising water level raises a float that in turn closes a gate limiting the flow moving through the pipe opening. The Hydrobrake Agile is not a viable solution for MSD due to its inability to fit in a stormwater pipe. Please refer to Appendix 10.4 for technical specifications.

6. MSD “Float”

   The Cincinnati Metropolitan Sewer District designed a device with a door that rises with water level to block flow when the manhole becomes flooded. The device has three main pieces - the body, sliding door, and float attachment. The body and sliding door are made of HDPE and the float attachment is Schedule 40 PVC. The MSD float device is sized to fit in the MSD combined sewer.

7. 100% Coverage Door (existing)

   This door is currently installed in manholes at several MSD locations. With this device virtually no flow is allowed through the storm pipe. Therefore, all flow from rain events will run down the street. Please refer to Appendix 10.5 for clarification.

2.1.2 Selection Criteria

1. Sized to Fit in Combined Sewer

   The selected flow control device must be entirely contained in the MSD owned combined sewer. The sewer pipe of interest is a 12” pipe with a manhole space of 4’ x 4’ x 9.59’. This criterion was weighted with the highest importance since a solution is unable to be used if it is not sized properly for the sewer collection system.

2. Percentage of flow stopped

   The goal of the flood control device is to stop 95% of flow when the device is activated during a storm event. This criterion was weighted second most important because it is essential that at least 95% of flow is stopped to avoid sewage backup.

3. Passive Solution

   The solution to the combined sewer overflow problem must be passive and function without electricity. Electric hookup is not available in the sewers for the solution. The cost of adding electricity or maintaining an electric device is not reasonable for this project. This criterion was weighted third most important.

4. Potential Future Maintenance Costs

   Once the flow control device is installed and functional, the next most important consideration is its future functionality. It is important to determine the replaceability of broken parts and durability of the device. In order to be a viable option, the chosen device must be easy to replace, able to withstand storm events, and have inexpensive parts in case of failure. This criterion was weighted fourth most important and prioritized over installation and material costs. Installation and material costs are one time and upon replacement, while future maintenance is an ongoing added expense.

5. Material Installation and Cost

   One goal of this project is to keep the material and installation cost as low as possible for the float control device. MSDGC is performing this project in order to reduce the costs of sewage cleanup and overflow events. Effectively, if the overall cost of the flow control device is not less than the annual cost to clean up basements, the flow control devices will not be a priority to install. This criterion was weighted fifth most important.

6. Street Flooding

   Ideally, the street will not be flooded as a result of the flow control device. The flow control device should not prevent stormwater runoff from accessing the sewer system. This criterion was weighted as least important. It is unlikely MSDGC would incur added costs due to temporary street flooding.

2.1.3 Values and Scoring

The alternative analysis for flow control solutions used a zero through two scoring system. Devices were scored zero if they failed to meet the criteria, one if they met the criteria, and two if they exceeded the criteria or were considered a top option.

Table 2.1.3.1: Values and Scoring

Values/Scoring	
Does not meet criteria	0
Meets criteria	1
Exceeds criteria, top option	2

2.1.4 Alternative Analysis Results

Table 2.1.4.1: Alternative analysis matrix displaying weighted and unweighted values of different flow regulation devices

Alternative Analysis: Flow Regulation								
Criteria	Weighting	DuckBill Valve	Hydro -brake	MSD Float	100% Coverage Door	GNA	Eliquo Hydrok	Veolia Electric Gate
Sized to fit in Combined Sewer	6	1 (6)	1 (6)	1 (6)	1 (6)	0 (0)	0 (0)	1 (6)
95% flow stopped	5	0 (0)	0 (0)	**2 (10)**	2 (10)	2 (10)	2 (10)	2 (10)
Passive Solution (electric use)	4	1 (4)	1 (4)	1 (4)	1 (4)	1 (4)	1 (4)	0 (0)
Maintenance Cost	3	2 (6)	1 (3)	2 (6)	2 (6)	2 (6)	1 (3)	0 (0)
Material/Installation Cost	2	1 (2)	1 (2)	2 (4)	2 (4)	1 (2)	1 (2)	0 (0)
Does not Flood Street	1	1 (1)	1 (1)	1 (1)	0 (0)	1 (1)	1 (1)	1 (1)
Total Weighted Score		19	16	31	30	23	20	17
Total Unweighted Score		6	5	9	8	7	6	5

The data displayed in Table 2.1.4.1 confirms the MSD designed float device as the best option to solve the sewage backup problem. The MSD float device scores highest in both the weighted and unweighted analysis, scoring 31 and 9, respectively. The MSD float device exceeded criteria in the material and installation cost, maintenance cost, and percentage of flow stopped categories. The MSD float device met the criteria of a passive solution, correct size to fit in the MSD owned combined sewer, and not flooding the street. Some of these scores, such as the score on street flooding, were determined based on assumptions of the MSD float device working as designed and intended. The percentage of flow stopped was calculated during preliminary testing to exceed the 95% flow stopped minimum criterion.

2.2 Data Collection

A pull test was conducted measuring the horizontal force (Fh) needed to open the gate under different vertical forces (Fv). Using Equation 1 we solved for the coefficient of friction (μ).

$$F_h = \mu F_V \qquad \text{(Equation 1)}$$

Plotting horizontal force against vertical force creates a line (Figure 2.2.1). The equation of the line is used to determine how much buoyancy force is needed when different pressures are applied to the gate, with the slope equal to the coefficient of friction. The coefficient was determined to be 0.3334.

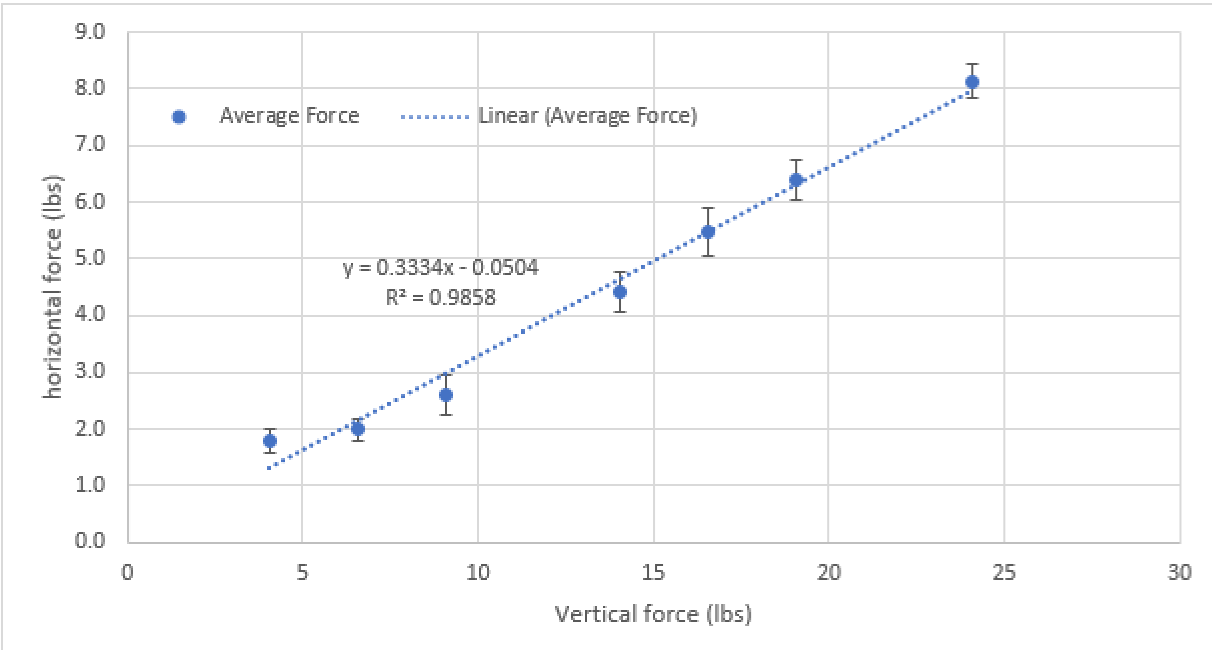

Figure 2.2.1: Comparison of vertical force applied to the gate with the horizontal force required to pull the gate open.

The buoyancy force required to close the gate was also tested in the field with a pull test under simulated storm conditions. To begin, a ratchet strap was attached to the float. The unattached end of the strap was brought to the surface and attached to a force gauge. The force gauge was zeroed out to cancel the force of lifting the strap. The gate was then lifted with no flow through the storm pipe and the force was recorded. To start testing with flow, the hose was aimed at the corner of the catch basin. The hydrant was turned to a low flow rate and the gate was lifted with the force gauge. The force required to close the gate was recorded. This process was repeated for ten trials with low, medium, and high (relative) flow rates through the storm pipe. The results are summarized in Figure 2.2.2. The minimum force required to lift the gate was measured to be 11.6 lbs.

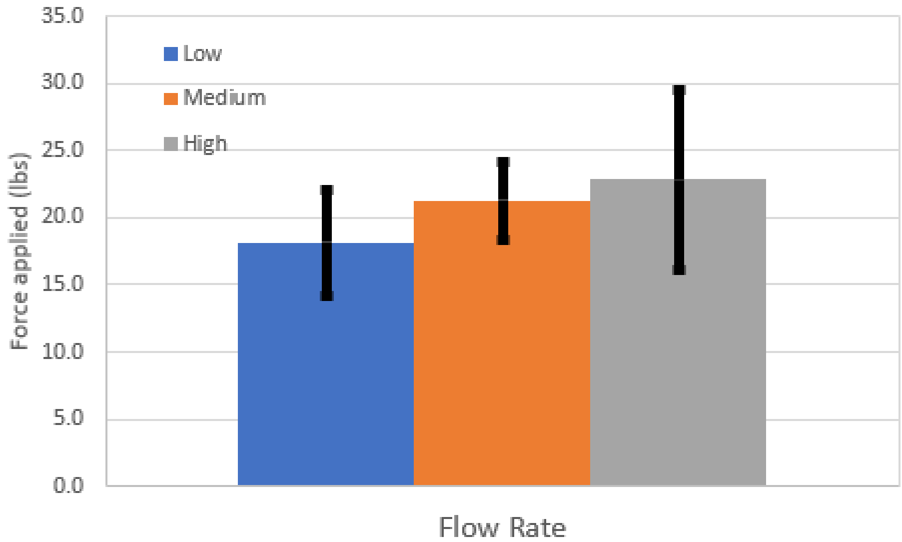

Figure 2.2.2: Force applied to close the gate (lbs) with standard deviations

Additionally, the effective buoyant force of the current prototype was measured using Archimedes principle (Equation 2) and subtracting the weight of the float component. The effective buoyant force was found to be approximately 2.92 lbs. Because this figure is well below the minimum force required to lift the gate (11.6 lbs), it was decided that adjustments must be made to increase the buoyant force of the float component by adding closed cell foam. This change increased the effective buoyant force to 9.82 lbs (see Appendix 10.8 for calculations).

$$F = \boldsymbol{\rho} \cdot g \cdot V \quad \text{(Equation 2)}$$

F - buoyant force **ρ** - density of water g - gravity constant V - volume of the float

In November of 2021, Environmental Overflow Consultants conducted preliminary testing on the float-gate prototype. These tests included a leak test to determine a range of flow to be expected when the gate is closed and the manhole is filled to the top of the storm catchment (approximately 31.5 inches of head). The leak tests were conducted by maintaining a steady level of water in the manhole using a fire hydrant and hose. The flow rate was calculated by measuring the time it takes to fill a five-gallon bucket. Results indicated a leak rate of 1.17±0.51 gal/s.

Bernoulli's equation (Equation 3) was used to determine the total flow possible. Surveyors provided the level of water to the center of the device outlet as 31.5 inches. The friction was assumed to be negligible. Head loss through a pipe entrance (Equation 4) was calculated with a k value of 0.04 while head loss through the gate was calculated with a k value of 2.06 (Finnemore).

The storm pipe is twelve inches in diameter. The flow rate in the basin is considered zero because the water level in the basin remained constant. Both sides have atmospheric pressure. The total flow possible was calculated to be 73.9 gal/s when the gate is fully open. Therefore, a leak percentage of 1.6% was determined by dividing the leak rate found in the field by the total possible flow (see Appendix 10.9 for calculations).

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g h_1 - h_L = P_2 + \tfrac{1}{2}\boldsymbol{\rho} v_2^2 + \boldsymbol{\rho} g h_2 \qquad \text{(Equation 3)}$$

P - pressure $\boldsymbol{\rho}$ - density of water g - gravity constant h - height h_L - head loss

$$h_L = k \cdot \frac{V^2}{2g} \qquad \text{(Equation 4)}$$

h_L - head loss k - minor loss constant V - velocity g - gravity constant

In late 2021, MSD conducted additional testing on the float-gate device. In one of these tests, with the help of Timothy Calder and his team at ADS Environmental Services, the combined sewer was flooded by a fire hydrant flow through the storm drain on Eileen Dr. where the prototype is installed. This test was designed to test the float-gate's closing ability in a simulated rain event. In the initial test, the gate closed as designed, and when the float was pushed down repeatedly with a long pole, the mechanism repeatedly closed and reopened. This indicated that under ideal conditions, the float-gate closes readily and with little resistance.

In other trials, the gate did not close completely and became stuck in a partially closed position. It was determined that debris was caught in the opening of the gate and prevented full closure. Debris prevention is a necessary improvement for the gate.

The performance analysis of the float-gate prototype indicated that a greater buoyancy force is needed to reliably close the gate during a storm event, and that greater debris prevention is needed to improve the resilience of the float-gate mechanism. Closed cell foam was added around the outside of the float to increase the volume, which in turn increased buoyant force.

3. Design Improvements

3.1 Alternative Analysis: Debris Prevention

3.1.1 Debris Prevention Alternatives

1. Mesh Screen at Gate Opening

   A mesh screen would be attached at the gate opening, preventing large debris from reaching the gate and ensuring the gate is able to close. An affixed mesh screen could allow debris to clog the pipe and prevent flow.

2. Gate Opening Shape Change

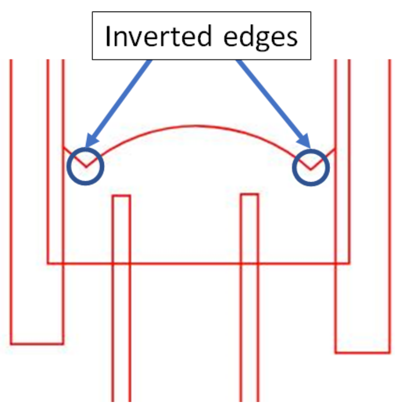

Figure 3.1.1.1: Gate with inverted edges

   A change in the shape of the gate opening has the potential to allow debris to flow through the system without obstructing the gate's functionality. Inverted edges near the device's wall would be included (Figure 3.1.1.1). A shape change would ideally direct debris towards the center of the gate opening and prevent buildup at the wall. Shape changes considered include an increased arc radius at the opening and an inverted arc at the opening following the contour of the pipe.

3. Metal Inlet Cover Change

   A metal inlet cover is a gridded grate on the street leading to the storm drain. A storm water inlet with a finer mesh could be installed at the street level to prevent debris from entering the sewer. This solution is most likely costly as storm sewer inlet covers come standard and would need replaced in many locations. Storm sewer inlet covers are most likely called out in City of Cincinnati specifications and unable to be changed on a wide scale.

4. Temporary Inlet Cover

   The temporary inlet cover is a cloth device that overlays the storm drain and is often used on construction sites. It collects virtually all debris flowing toward the storm drain, but can cause flooding on the street if it is fully covered. Temporary inlet covers need routine cleaning and are not built to withstand frequent traffic. Reference Appendix 10.7 for a visual representation.

5. As-Is

   No changes will be made to the gate. This option incurs the current risk of debris being stuck in the gate.

3.1.2 Selection Criteria

1. Stops debris from affecting gate operation

   The goal of the debris prevention method is to ensure the gate can function at all times. Any solution must reduce or completely stop debris from getting caught at the gate opening, which may prevent complete closure. Since the solution must be effective, this criterion is the most important.

2. Does not cause clogging in pipe

   The solution must not clog the pipe leading to the gate. Water must be able to flow freely to the gate without a potential clogged pipe caused by debris buildup. This criterion is ranked second most important.

3. Maintenance Needs

   The solution must not create additional costly maintenance on the gate. This criterion was ranked third most important.

4. Initial Costs

    The selected debris prevention method should not significantly increase the gate cost. This criterion was ranked least important.

3.1.3 Values and Scoring

The alternative analysis for debris prevention used a one through three scoring system. Devices were scored one if it did not necessarily meet a criterion, two if it met the criterion, and three if it exceeded the criterion or were considered a top option.

Table 3.1.3.1: Values and Scoring

Values/Scoring	
Might not meet criteria	1
Meets criteria	2
Exceeds criteria, top option	3

The criteria were assigned weights that were multiplied by the scores to show importance. The criteria of initial cost, maintenance needs, pipe-clog prevention, and preventing debris from stopping operation were weighted at 5, 7, 9, and 10, respectively. These weights were selected based on the importance of each criteria. The importance of preventing debris from stopping operation was twice as important as the initial cost, 1.43 times more important than maintenance needs, and 1.11 times more important than clog-prevention in the pipe. Likewise, the initial cost is 1.4 times less important than the maintenance needs and 1.8 times less important than preventing pipe clogging.

3.1.4 Alternative Analysis Results

The data displayed in Table 3.1.4.1 indicates that changing the shape of the gate opening will be the most effective debris prevention method. Shape change scores highest in both the weighted and unweighted analysis, scoring 83 and 11, respectively. It surpassed all options in the initial cost, maintenance needs, and stopping debris buildup categories. The initial cost of changing the gate shape is $0, since it will just change cut angles in the manufacturing stage. The shape change will not require any additional maintenance and will not cause any additional debris buildup in the pipe that might cause a clog. Most importantly, changing the gate opening shape will reduce the amount of debris that is caught at the gate opening and prevents complete closure. Some of these scores were determined based on assumptions of the shape change working as designed and intended. If the shape change is not as effective as intended, an additional debris prevention method may be necessary.

Table 3.1.4.1: Alternative analysis matrix displaying weighted and unweighted values

Alternative Analysis: Debris Prevention							
Criteria	Weight	Mesh Screen	Shape Change	Metal Inlet Cover	Temporary Inlet Cover	As-Is
Initial Cost	5	1 (5)	3 (15)	2 (10)	1 (5)	3 (15)
Maintenance Needs	7	1 (7)	3 (21)	3 (21)	1 (7)	2 (14)
Does not cause clogging in pipe	9	1 (9)	3 (27)	2 (18)	3 (27)	2 (18)
Stops debris from affecting operation	10	3 (30)	2 (20)	2 (20)	3 (30)	1 (10)
Totals		6	11	9	8	8
Weighted Totals		51	83	69	69	57

3.2 Shape and Open Distance Change Methods

The original design of the gate was based on previously designed coverage doors. This design was convenient and readily available. However, there was no understanding of how much pressure was applied to the gate or if another shape would be better. Furthermore, a flaw was found where debris would get caught where the gate connects to the wall of the device. A change in the shape and open distance of the gate and a calculation method is proposed to solve these problems.

Circle-circle interaction calculations were used to understand how changing the radius and opening height of the gate affects the area where pressure is applied (Figure 3.2.1). This area is called the overlap in the As Is, Control, and Larger Arc options while the Inverted Arc option uses Lune 2 (Figure 3.2.2). For the As Is, Control, and Larger Arc options distance between each circle's center, d, decreases as the opening increases while the inverse is true for the inverted arc (Figure 3.2.1). For simplification, r1 always remains six inches to match the storm sewer. Therefore, r2 is altered to flatten the gate (Figure 3.2.2).

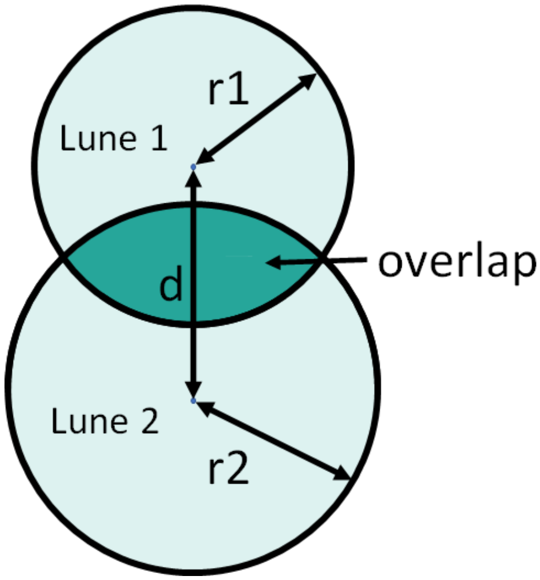

Figure 3.2.1: Circle-circle interaction diagram

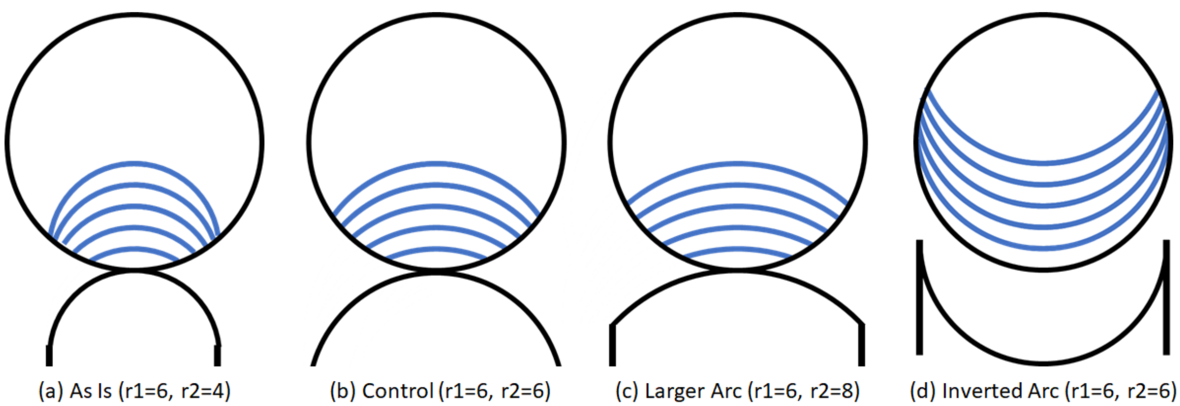

Figure 3.2.2: Four gate shape change options in inches

Hydrostatic pressure is used to find the total pressure on the gate just as it is about to close at different opening sizes. Total pressure refers to the pressure on the gate in the moment before completely closing. Pressure was found at different heights using equation 5. The gate is divided into inch tall sections. Each section uses the larger height to calculate pressure. Therefore, total pressure is calculated by multiplying each section's pressure by the area of the gate in that section (Figures 3.2.3 & 3.2.4).

$$P = \rho \bullet g \bullet h \quad \text{(Equation 5)}$$

P - Pressure ρ - density of water g - gravity constant h - height of water

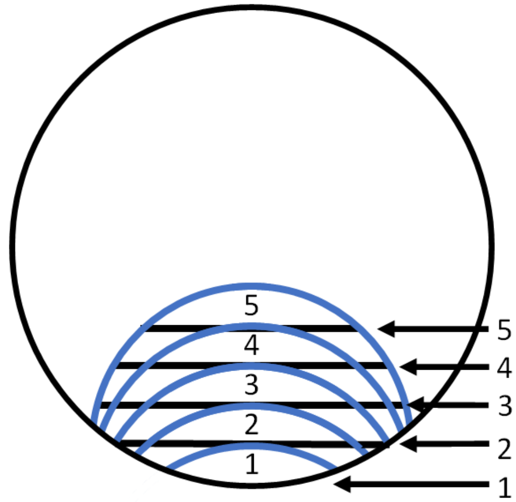

Figure 3.2.3: Pressure and area relationship on As-Is gate option. Arrows point to the height used for pressure at corresponding numbers. Lines represent inch tall segments.

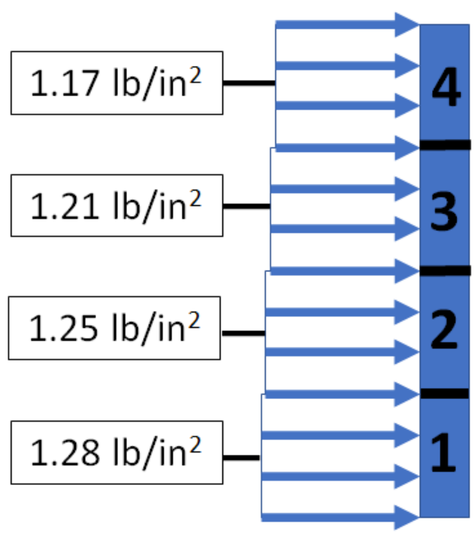

Figure 3.2.4: Side view of pressure and height relationship on gate with four-inch opening size

The following assumptions were made with this method. First, all gates start with 31.5 inches of water or 1.14 lb/in^2 of pressure applied. Next, the height of the water in the catch basin increases by one inch for every inch the gate closes. Also, the total pressure on the gate in the moment before closing is equal to the pressure on the gate in the moment after closing. Lastly, the inverted edges of the gate will not affect the area of the gate significantly, which allows the additional area and pressure applied to be disregarded.

Coefficient of friction is multiplied by total pressure on the gate to find the buoyancy force required to close the gate. Therefore, the maximum opening size of the gate is determined by using the effective buoyancy force of 9.82 lbs as the max amount of force that the float can apply. Any force greater than 9.82 lbs will cause the gate to not close. For a detailed description of how these calculations were completed refer to Appendix 10.10.

3.3 Environmental Impact Analysis

We do not foresee any meaningful negative impacts on surrounding environments with the implementation of float-gate devices in combined sewers. Downstream CSO’s may potentially be mitigated with the decreased flow in the combined sewer. The float-gate device will only be installed in areas where minor street flooding is acceptable over backup into homes, garages, and basements. Because any additional runoff generated will be stormwater, there is minimal risk of increased biohazard.

Ohio regulations 2404 and 2407 give requirements for diverting stormwater. These regulations give criteria pertaining to new storm sewers. In this case, we would not be altering the existing storm sewer, so these conditions do not pertain.

4. Shape and Open Distance Change Results

The intersection of the float’s effective buoyancy (black line) with each gate shape line in Figure 4.1 is the maximum opening size for that gate. The gates will no longer be able to close after this intersection.

Two results were found. First, force required for the Inverted Arc increases faster than all other shapes. Specifically at one inch the float must supply almost four times more buoyancy force than any other shape. Second, the As Is, Larger Arc, and Control options all intersect with the float’s effective buoyancy at almost the same opening distance (see Figure 4.1).

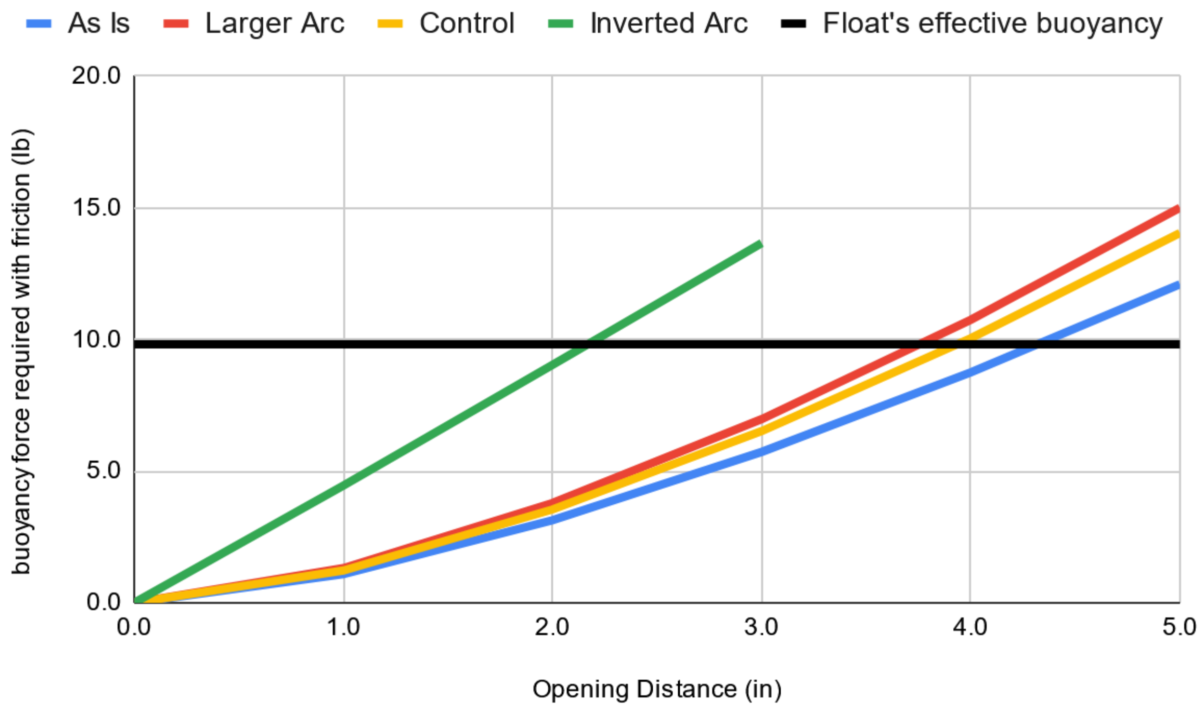

Figure 4.1: Comparison of each size option as opening distance increases with the float's effective buoyancy

4.1 Final Design Recommendation

Environmental Overflow Consultants recommends the gate have a 3.5" maximum opening. To decrease debris buildup, the gate needs an increased opening arc radius with sloped corners. Please reference Figure 4.1.1 for the recommended design.

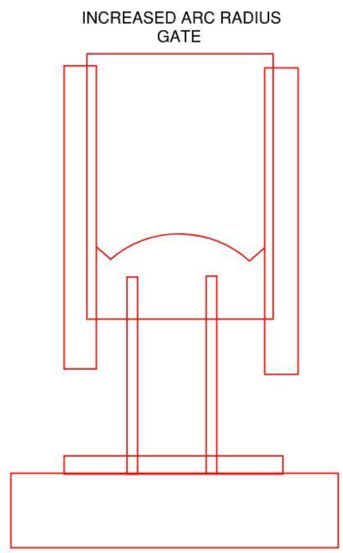

Figure 4.1.1: Draft of Improved Design with Increased Arc Radius

5. LRIFA Sites of Interest

The Low Rainfall Intensity Flooding Analysis (LRIFA) conducted by MSD and Hazen and Sawyer identified 100 problem areas requiring a SBU solution. These sites were evaluated for potential float control installation based on several parameters, including size of sewer line, number of regular sewer backups per site, potential for surface flooding and property damage, and perceived priority. Out of 100 sites, 22 were determined to be suitable locations for a float control device. Twenty-one sites were determined to be possible locations, but these sites will need further review to decide if the device will be worthwhile or helpful. Fifty-seven sites were deemed unsuitable for a float control device because it would cause further flooding and property damage (see Appendix 10.11). EOC has identified the following five LRIFA sites as ideal locations to install a float control without causing further flooding. These sites should be considered priorities for installation.

- Site #160 Cadillac Ave. & Isabella Ave.
- Site #407 Boyd St. & Chambers St.
- Site #434 Lysle Ln. & Bosworth Pl.
- Site #613 Girard Ave.
- Site #916 Glenmore Ave. & Daytona Ave.

6. Economic Analysis

The economic analysis focuses on the cost savings for SBU's with the float control device installed. Only overflow situations where the float control could effectively prevent SBU's were considered. Out of 22 suitable locations, 70 float control devices could be installed. For each site, the following information was recorded: the number of active SBU's, the largest SBU return period, the number of SBU-affected houses that have applied or are a part of the Sewer Backup Prevention Program (SBUPP), and the number of floats that can be installed.

The initial capital cost of the floats was determined to be $176,000. This was calculated by multiplying the number of floats that can be installed by the sum of the material and installation costs. The material cost estimate is $950, provided by ADS Environmental Services. The installation cost estimate is $1,560, assuming three workers are getting paid $130 per hour and installation takes four hours. Next, the annual maintenance cost of all 70 floats was determined to be $127,000. This was calculated by multiplying the number of floats that can be installed by the annual maintenance cost of one float. This estimated annual maintenance cost for each float is $1,811, assuming three workers are getting paid $130 per hour and performing maintenance four times per year. This also assumes that a part must be replaced 20% of the time, which costs half of the sum of the material and installation cost.

Using SBU data provided by MSD for the years 2004 to 2020, the current annual cost of SBU cleanup for the 22 sites was determined to be $844,000. For each site, this was calculated by multiplying the number of active SBU's by the SBU return period and the average cost of fixing one backup ($7,500). The costs for each site were then summed to find the total current annual cost of SBU cleanup. Next, the current cost of SBU prevention for the 22 sites was determined to be $3.25 million. For each site, this was calculated by multiplying the cost of one sewage sump pump used to prevent a backup ($65,000) by the number of active SBU's less the number of SBUPP applied or constructed. The costs for each site were then summed to find the total current cost of SBU prevention.

A cost savings analysis was subsequently conducted. By summing the initial capital cost and the annual maintenance cost of the floats, the project cost was found to be $303,000. The minimum cost savings was found to be $541,000, which only considers the cost savings of SBU cleanup. The maximum cost savings was found to be $3.8 million, which considers the cost savings of both SBU cleanup and prevention. Detailed calculations for the cost savings analysis can be seen in Appendix 10.12 of this report.

7. Conclusion

An alternative analysis determined the MSD designed float surpasses all commercially available flow reduction solutions in affordability and flow stopping efficiency. The coefficient of friction associated with gate movement was found to be 0.3334. The effective buoyant force was found to be approximately 9.82 lbs.

A key problem identified during preliminary testing was the buildup of leaves behind the gate and in the gate opening, preventing closure. An alternative analysis determined a change in the shape of the gate opening was the most effective way to prevent debris buildup. The most effective gate shape and opening size were determined using circle-circle calculations and buoyancy force required to lift the gate.

EOC advises a 3.5" maximum gate opening with an increased arc radius that will reduce debris without having a significant effect on the amount of pressure applied to the gate. This will allow the buoyancy force provided by the float device to remain the same. In addition to an increased arc radius, the final cutout should have sides sloping upward to prevent small debris from getting caught in the wall of the device.

Gate installation will resolve 22 LRIFA sites and remove 200 SBU’s in the Cincinnati area. This project would cost roughly $303k and generate cost savings in the short term of $541k and in the long-term of $3.8M (assuming MSD installs current prevention measures in each of the problem areas).

8. Acknowledgements

Environmental Overflow Consultants would like to thank the following individuals for their involvement and guidance with the project:

- Dr. Drew McAvoy at the University of Cincinnati for providing guidance throughout the year
- John Barton and Robert Schneider at Metropolitan Sewer District of Greater Cincinnati for providing research assistance and organizing the project
- Timothy Calder and team at ADS Environmental Services for installing the float device and helping to collect data
- Jamie Leon at Hajoca Corporation for providing quotes and product data

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10. Appendices

10.1 GNA

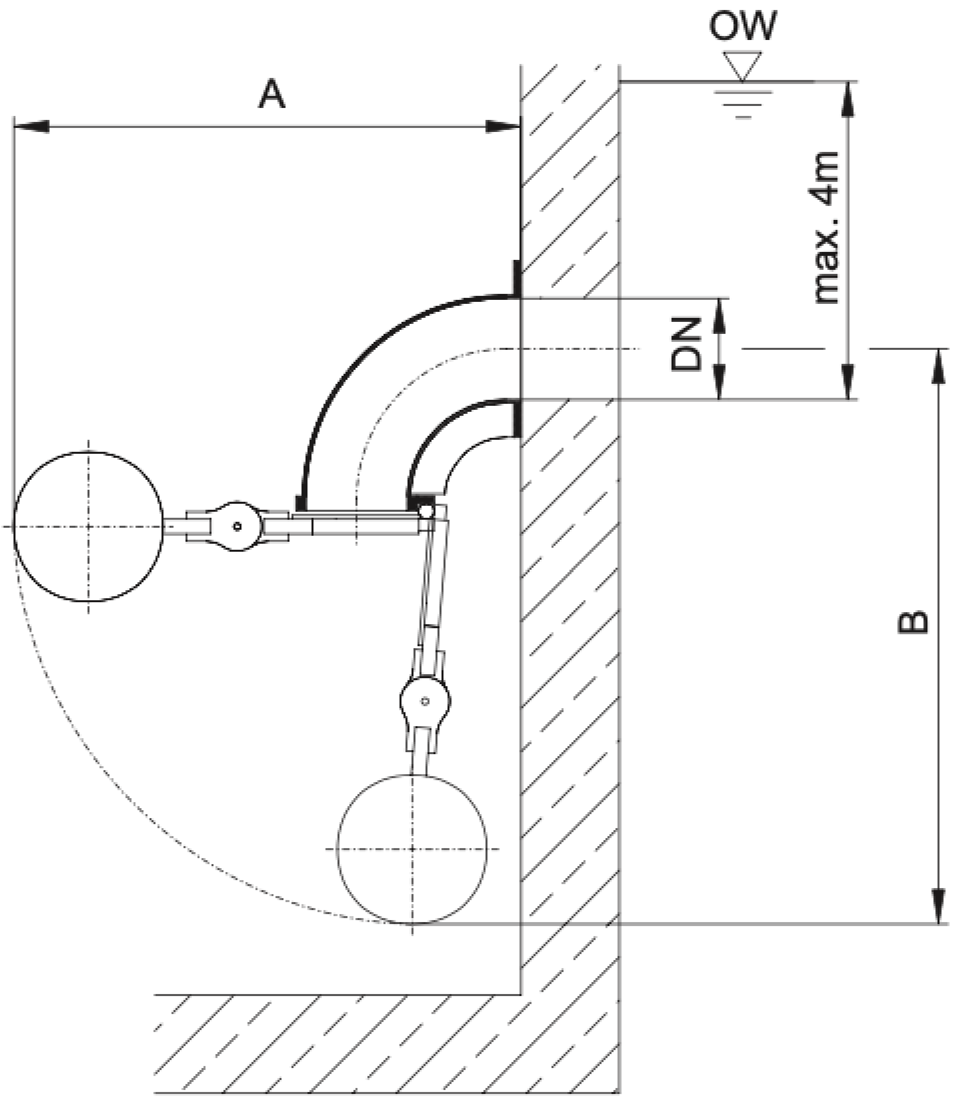


Figure 10.1.1: Diagram of float-controlled outlet gate type A

Table 10.1.1: Measurements for Figure 10.1.1

DN [mm]	A [mm]	B [mm]	C [mm]	Number of floats	Ø floats
100	700	720	450	1	200
150	930	1080	450	1	300
200	1020	1230	650	1	350
250	1240	1410	700	1	400
300	1410	1640	800	1	450
400	2050	2350	800	1	550

10.2 Eliquo Hydrok

Figure 10.2.1: Image of the Eliquo Hydrok flow control device

Tideflex® Technologies

Technical Data

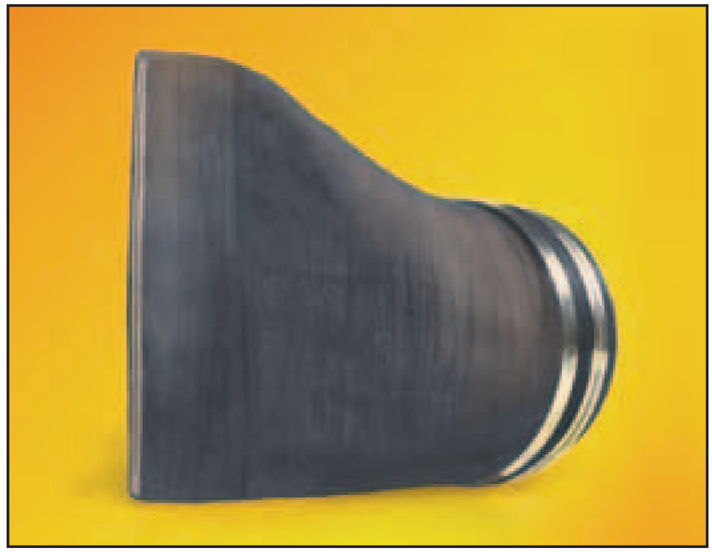
Series TF-1—Tideflex® Check Valve

Features & Benefits

- Ideal for manhole installations
- Lightweight, all-elastomer design
- Seals around entrapped solids
- Cost-effective, maintenance-free design

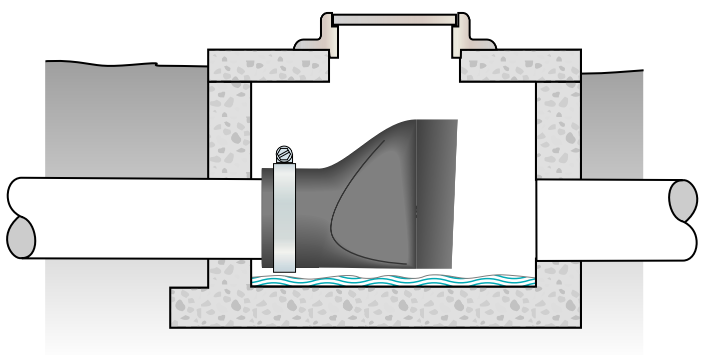
Materials of Construction

- Elastomers available in Pure Gum Rubber, Neoprene, Hypalon®, Chlorobutyl, Buna-N, EPDM, and Viton®

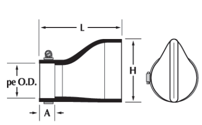


We are pleased to announce the introduction of the revolutionary TF-1 Check Valve. It functions and operates under the same simple principle of operation as the original TF-2 Tideflex®.

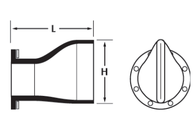
This design is ideal for existing manhole installations where the invert of the pipe is close to the floor of the vault. There are many check valves in interceptors, manholes, and vaults. These vaults are designed so that there would be a maximum gravity head; thus, the invert pipe is as close to the base as possible. The TF-1 allows installations in such applications.



The Tideflex® Technologies Series TF-1 Tideflex® Check Valve is designed for applications in manholes, where the bottom of the manhole is close to the invert of the pipe. The TF-1 configuration allows the valve to be properly installed without manhole modification, ensuring positive backflow prevention and a lifetime of maintenance-free performance.



Tideflex® TF-1



Flanged Style TF-1

Dimensions Series TF-1 Tideflex® Check Valve

The TF-1 slip-on connection is based on the O.D. of the mating Pipe. For in-between sizes, consult factory.

Pipe O.D.	Tideflex® TF-1 Cuff Slip-On Length A	TF-1 Flanged ANSI Flange Size	Maximum Length L	Maximum Height H
6"	2"	6"	14"	12"
8"	2"	8"	17-1/4"	15-1/4"
10"	3"	10"	21-1/2"	18-3/4"
12"	4"	12"	26"	22"
16"	5"	16"	32"	29"
20"	8"	20"	40"	36"
24"	8"	24"	46"	43"
30"	9"	30"	55-1/4"	54-3/4
36"	10"	36"	65"	69"
42"	10"	42"	59-1/2"	70-1/2
48"	10"	48"	71"	91"
60"	13"	60"	80-3/4"	95"

Tideflex Technologies, Inc. • 300 Bilmar Dr., Pittsburgh, PA 15205 USA • 412-919-0919 • Fax 412-919-0918 • www.tideflex.com

10.4 Hydrobrake Agile

Figure 10.4.1: Image of Hydrobreak Agile Flow Control

10.5 100% Coverage Door

Figure 10.5.1: Coverage Door with opening

Figure 10.5.2: Coverage Door with 100% coverage

10.6 Veolia Electric Gate

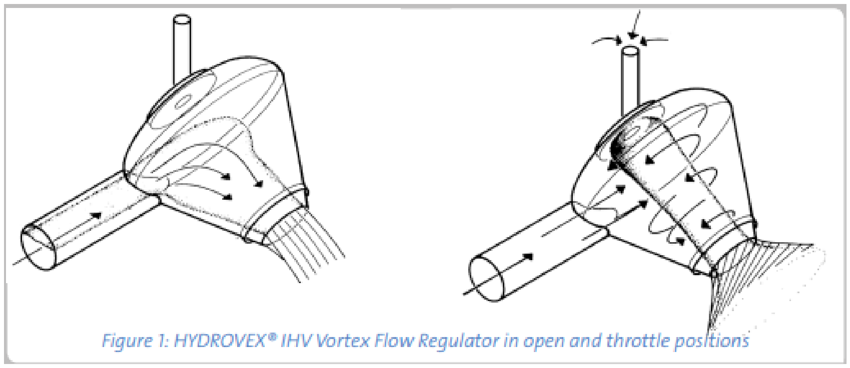


Figure 1: HYDROVEX® IHV Vortex Flow Regulator in open and throttle positions

Figure 10.6.1: Hydrovex IHV Vortex Flow Regulator Open and throttle positions

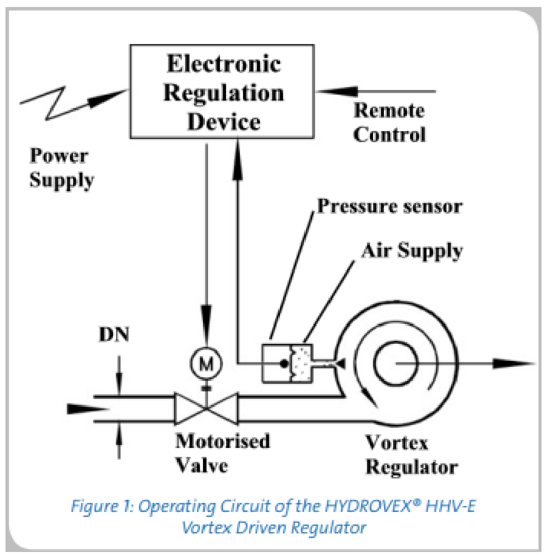


Figure 1: Operating Circuit of the HYDROVEX® HHV-E Vortex Driven Regulator

Figure 10.6.2: Operating Circuit of the Hydrovek HHV-E Vortex Driven Regulator

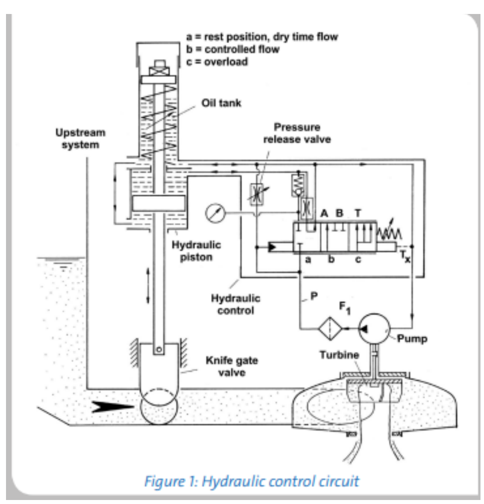


Figure 1: Hydraulic control circuit

Figure 10.6.3: Hydraulic Control Circuit

10.7 Temporary Inlet Cover

Figure 10.7.1: Temporary Inlet Cover collecting debris

10.8 Buoyancy Calculations

$2in = 0.167ft$

$Volume\ of\ cylinder\ (pvc\ pipe) = \pi \cdot (0.167ft)^2 \cdot 2ft = 0.18ft^3$

$Volume\ of\ front\ foam = 2ft \cdot 0.25ft \cdot 0.167ft = 0.084ft^3$

$Volume\ of\ back\ foam = \frac{10}{12}ft \cdot 0.25ft \cdot 0.167ft = 0.035ft^3$

$Volume\ of\ float\ (all) = 0.18ft^3 + 0.084ft^3 + 0.035ft^3 = 0.293ft^3$

$Buoyancy\ force\ ,\ F_b = 62.4\frac{lb}{ft^3} \cdot 0.293ft^3 = 18.3lb$

$Weight,\ W = weight\ of\ cylinder\ and\ gate + weight\ of\ foam = 8lb + 0.5lb = 8.5lb$

$Effective\ buoyancy\ force,\ F_{be} = F_b - W = 18.3lb - 8.5lb = 9.8lb$

10.9 Leak Percentage Calculations

10.9.1 Total Flow Calculation

$2.625ft = 31.5in$

$2.625ft \cdot 32.17\frac{ft}{sec^2} = 0.5 \cdot v^2 + 0.04 \cdot \frac{v^2}{2 \cdot 32.17\frac{ft}{sec^2}} + 2.06 \cdot \frac{v^2}{2 \cdot 32.17\frac{ft}{sec^2}}$

$v = 12.6\frac{ft}{sec}$

$12.6\frac{ft}{sec} \cdot \pi \cdot 0.5ft^2 \cdot \frac{7.48gal}{1ft^3} = 73.9\frac{gal}{sec}$

10.9.2 Leak Percentage of Total Flow

$\frac{1.17\frac{gal}{sec}}{73.9\frac{gal}{sec}} = 1.6\%$

10.10 Shape options with detailed calculations and tables

Table 10.10.1: As Is full calculation table with all values used for buoyancy force required

As Is (r1 6in, r2 4in)																	
height of water (in)	d (in)	open distance (in) /section number	pressure (lb/in²)	lune 1 area (in²)	overlap area (in²)	circular segment area of circle 1 (in²)	circular segment area of circle 2 (in²)	semi-perimeter of triangle, P (in)	circle 1 arc length, a (in)	Half Chord Length circle 1, l (in)	Small Sagitta circle 1, s_1 (in)	Small Sagitta circle 2, s_2 (in)	Small Sagitta Area of Circle 1 (in²)	Small Sagitta Area of Circle 2 (in²)	Total Pressure (lb)	buoyancy force required with friction (lb)	total area used (in²)
31.5	10.0	0.0	1.1	113.1	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32.5	9.0	1.0	1.2	110.2	2.8	4.5	3.6	9.5	4.3	2.1	0.4	0.6	1.1	1.8	3.3	1.1	2.8
33.5	8.0	2.0	1.2	105.1	7.9	12.4	9.8	9.0	6.1	2.9	0.8	1.3	2.9	5.0	9.5	3.1	8.0
34.5	7.0	3.0	1.2	98.8	14.3	22.1	17.2	8.5	7.3	3.4	1.1	1.9	5.0	9.3	17.4	5.7	14.3
35.5	6.0	4.0	1.3	91.6	21.5	33.0	25.1	8.0	8.2	3.8	1.3	2.7	6.9	14.7	26.5	8.8	21.5
36.5	5.0	5.0	1.3	83.8	29.2	44.6	33.0	7.5	8.7	4.0	1.5	3.5	8.2	21.1	36.6	12.1	29.3

Table 10.10.2: Control full calculation table with all values used for buoyancy force required

Control (r1 6in, r2 6in)																	
height of water (in)	d (in)	open distance (in) /section number	pressure (lb/in²)	lune 1 area (in²)	overlap area (in²)	circular segment area of circle 1 (in²)	circular segment area of circle 2 (in²)	semi-perimeter of triangle, P (in)	circle 1 arc length, a (in)	Half Chord Length circle 1, l (in)	Small Sagitta circle 1, s_1 (in)	Small Sagitta circle 2, s_2 (in)	Small Sagitta Area of Circle 1 (in²)	Small Sagitta Area of Circle 2 (in²)	Total Pressure (lb)	buoyancy force required with friction (lb)	total area used (in²)
31.5	12.0	0.0	1.1	113.1	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32.5	11.0	1.0	1.2	109.9	3.2	4.5	4.5	11.5	4.9	2.4	0.5	0.5	1.6	1.6	3.7	1.2	3.2
33.5	10.0	2.0	1.2	104.1	8.9	12.4	12.4	11.0	7.0	3.3	1.0	1.0	4.5	4.5	10.7	3.5	9.0
34.5	9.0	3.0	1.2	96.8	16.3	22.1	22.1	10.5	8.7	4.0	1.5	1.5	8.2	8.2	19.8	6.5	16.3
35.5	8.0	4.0	1.3	88.3	24.7	33.0	33.0	10.0	10.1	4.5	2.0	2.0	12.4	12.4	30.4	10.0	24.8
36.5	7.0	5.0	1.3	79.0	34.1	44.6	44.6	9.5	11.4	4.9	2.5	2.5	17.1	17.1	42.6	14.0	34.1

Table 10.10.3: Larger Arc full calculation table with all values used for buoyancy force required

Larger Arc (r1 6in, r2 8in)																	
height of water (in)	d (in)	open distance (in) /section number	pressure (lb/in²)	lune 1 area (in²)	overlap area (in²)	circular segment area of circle 1 (in²)	circular segment area of circle 2 (in²)	semi-perimeter of triangle, P (in)	circle 1 arc length, a (in)	Half Chord Length circle 1, l (in)	Small Sagitta circle 1, s_1 (in)	Small Sagitta circle 2, s_2 (in)	Small Sagitta Area of Circle 1 (in²)	Small Sagitta Area of Circle 2 (in²)	Total Pressure (lb)	buoyancy force required with friction (lb)	total area used (in²)
31.5	14.0	0.0	1.1	113.1	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32.5	13.0	1.0	1.2	109.6	3.4	4.5	5.2	13.5	5.3	2.6	0.6	0.4	2.0	1.5	4.0	1.3	3.4
33.5	12.0	2.0	1.2	103.5	9.6	12.4	14.5	13.0	7.6	3.6	1.2	0.8	5.6	4.0	11.5	3.8	9.6
34.5	11.0	3.0	1.2	95.6	17.4	22.1	26.1	12.5	9.5	4.3	1.8	1.2	10.4	7.1	21.1	7.0	17.5
35.5	10.0	4.0	1.3	86.5	26.5	33.0	39.3	12.0	11.1	4.8	2.4	1.6	16.1	10.5	32.6	10.7	26.6
36.5	9.0	5.0	1.3	76.5	36.6	44.6	53.7	11.5	12.7	5.2	3.1	1.9	22.7	13.9	45.5	15.0	36.6

Table 10.10.4: Inverted Arc full calculation table with all values used for buoyancy force required

Inverted Arc (r1 6in, r2 6in)										
height of water (in)	d (in)	open distance (in) /section number	pressure (lb/in²)	lune 1 area (in²)	overlap area (in²)	circular segment area of circle 1 (in²)	circular segment area of circle 2 (in²)	Total Pressure (lb)	buoyancy force required with friction (lb)	total area used (in²)
38.5	7.0	7.0	1.4	79.0	34.1	79.0	68.5	N/A	N/A	N/A
37.5	6.0	6.0	1.4	68.9	44.2	68.9	56.5	N/A	N/A	N/A
36.5	5.0	5.0	1.3	58.2	54.8	58.2	44.6	N/A	N/A	N/A
35.5	4.0	4.0	1.3	47.1	65.9	47.1	33.0	N/A	N/A	N/A
34.5	3.0	3.0	1.2	35.6	77.4	35.6	22.1	41.4	13.7	35.5
33.5	2.0	2.0	1.2	23.9	89.2	23.9	12.4	27.4	9.0	23.9
32.5	1.0	1.0	1.2	12.0	101.1	12.0	4.5	13.5	4.4	11.9
31.5	0.0	0.0	1.1	0.0	113.0	0.0	0.0	0.0	0.0	0.0
30.5	-1.0	-1.0	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
29.5	-2.0	-2.0	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
28.5	-3.0	-3.0	1.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
27.5	-4.0	-4.0	1.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A

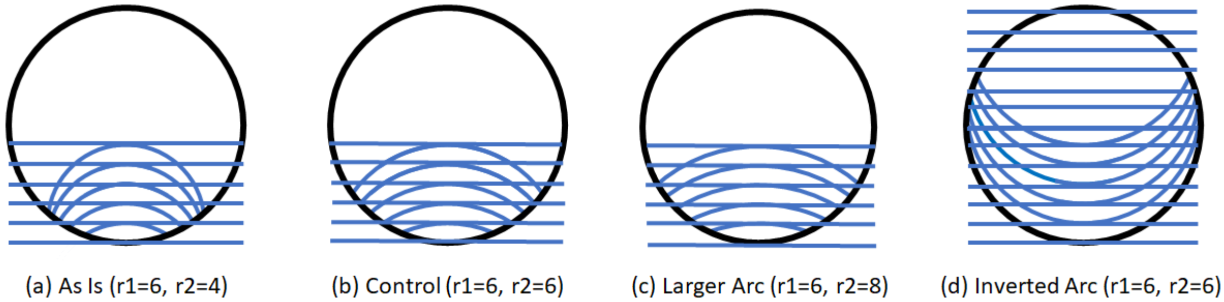


Figure 10.10.1: Areas utilized for each shape option with inch segments

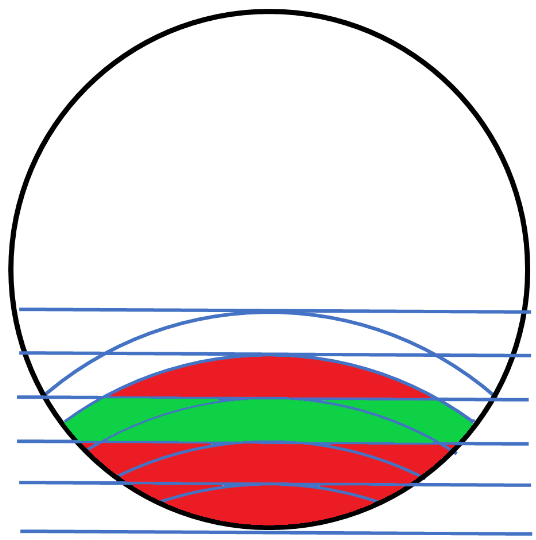


Figure 10.10.2: Example of how areas are summed and subtracted to calculate only the area of that section (Larger Arc, third section, four-inch opening)

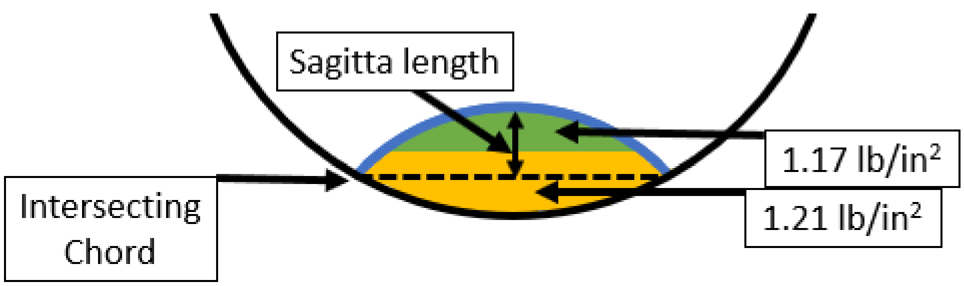


Figure 10.10.3: two inch opening As Is gate with pressure, area of each pressure, Intersecting Chord, and Sagitta length marked

$$lune\ 1\ area\ =\ 2\cdot\frac{\sqrt{(r1+r2+d)\cdot(r2+d-r1)\cdot(d+r1-r2)\cdot(r1+r2-d)}}{4}+r1^2\cdot arccos(\frac{r2^2-r1^2-d^2}{2*r1*d})-r2^2\cdot arccos(\frac{r2^2-r1^2+d^2}{2*r2*d})$$ (Equation 10.10.1)

$$overlap\ area\ =\ \pi\cdot r1^2-lune\ 1\ area$$ (Equation 10.10.2)

$$lune\ 2\ area\ =\ \pi\cdot r2^2-overlap\ area$$ (Equation 10.10.3)

$$area\ of\ circular\ segment\ =r^2\cdot arccos(\frac{r-h}{r})\ -\ (r\ -\ h)\cdot\sqrt{2\cdot r\cdot h-h^2}$$ (Equation 10.10.4)

$$semi\ -\ perimeter\ of\ triangle\ (P)\ =\frac{r1+d+r2}{2}$$ (Equation 10.10.5)

$$Circle\ 1\ arc\ length\ (a)\ =\ 2\cdot r1\cdot arcsin\frac{2\cdot\sqrt{P\cdot(P-r1)\cdot(P-r2)\cdot(P-d)}}{d\cdot r1}$$ (Equation 10.10.6)

$$half\ chord\ length\ of\ circle\ 1\ (l)\ =\ r1\cdot sin(\frac{a}{2\cdot r1})$$ (Equation 10.10.7)

$$sagitta\ of\ circle\ 1\ (s_1)\ =\ r1-\sqrt{r1^2-l^2}$$ (Equation 10.10.8)

$$sagitta\ of\ circle\ 2\ (s_2)\ =\ open\ distance\ -s_1$$ (Equation 10.10.9)

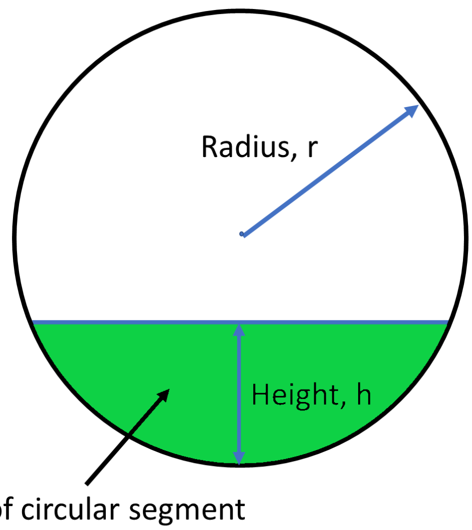


Figure 10.10.4: area of circular segment used in equation 10.10.4

Equation 10.10.4 is used to calculate area in each section (Figure 10.10.4). Sagittas are needed because as the circles move intersecting points change and fall between sections (Figure 10.10.3). Therefore, the height of the sagitta is inputted in equation 10.10.4 when calculating that section's area. Areas are added and subtracted until only the area in the section is included (Figures 10.10.1 & 10.10.2). Areas are confirmed by comparing the total area used column with the overlap area column which uses equations 10.10.1 and 10.10.2. The sum of the pressures is then multiplied by each section's area is the total pressure applied. This process is repeated for all gate heights and all gate shapes (Tables 10.10.1-4).

10.11 LRIFA Sites Table

Potential LRIFA Locations To Place Gate													
Site #	Street	Operational Controls Feasible	Basin	Complies with Hazen and Sawyer	Quantity Active SBU's	Return Period (in months)	# of SBUPP Applied/Constructed	Number of Floats That Can Be Installed	Inital Capital Cost of Floats	Maintenance and Replacement Cost of Floats	Current Annual Cost of SBU Cleanup	Cost of Installing SBU Prevention Measures	Comments
109	Wasson Rd. & Michigan Ave.	No	Little Miami	Yes	6								Line runs under under house? SBUPP applied
113	Madison Rd. & Hyde Park Ave.	Yes	Little Miami	Yes	5	6	0	6	$15,060.00	$10,866.00	$75,000.00	$325,000.00	
117	Dawes Ln. & Mears Ave.	No	Little Miami	No	3								Attached to larger pipe, control might flood other houses
118	Brotherton Rd. & Cavour St.	Maybe	Little Miami	No	3								has hobbit doors, not enough upstream flow, Feasible
119	Bayard Dr. & Erie Ave.	Yes	Little Miami	Yes	3	6	2	3	$7,530.00	$5,433.00	$45,000.00	$65,000.00	
121	Linwood Ave. & Herschel Ave.	Maybe	Little Miami	No	2								Only one house, backflow preventer, house purchased?
122	Ault Park Ave.	No	Little Miami	No	2								Downstream impacts.
124	Erie Ave. & Brenwood Ave.	No	Little Miami	Yes	1								Depressed driveways
125	Montgomery Rd. & Grand Vista	No	Little Miami	No	3								Attached to larger pipe
126	Woodlark Dr. & Mayland Dr.	Maybe	Little Miami	No	2								Hobbit door? all houses have SBUPP, 2 houses still have SBU issues?
127	Ault View Ave. & Uright Pl.	Maybe	Little Miami	No	2								1 house with SBUPP
129	Madison Rd. & Woodland Ave.	No	Little Miami	No	2								No upstream basins, wont have enough for activation
130	Markbeit Ave. & Gilmore Ave.	No	Little Miami	No	2								No upstream basins to activate, sink downstream
141	Lawndale Ave. & Glengate Ln.	Yes	Little Miami	Yes	1	6	0	2	$5,020.00	$3,622.00	$15,000.00	$65,000.00	
143	Perkins Ln. & Edwards Rd.	Maybe	Little Miami	Yes	1								Kindof a mess, hard to determine
149	Madison Rd. & Drake Ave.	Yes	Little Miami	Yes	5	9	0	3	$7,530.00	$5,433.00	$50,000.00	$325,000.00	
150	Desmond St. & Conway St.	No	Little Miami	No	3								No nearby storm basins to block
151	Dalzell St. & Winona Ter.	Yes	Little Miami	No	3	12	0	8	$20,080.00	$14,488.00	$22,500.00	$195,000.00	Plenty of storm drains for float gate to possibly prevent 2 downstream SBUs
153	Markbreit Ave. & Madison Rd.	Yes	Little Miami	Yes	3	9	2	5	$12,550.00	$9,055.00	$30,000.00	$65,000.00	mulitple downstream SBU incidents, several upstream storm basins to install
156	Nitram Ct. & Burney Ln.	No	Little Miami	Yes	0								not necessary, no current SBU's
157	Paxton Ave. & Marburg Ave.	Yes	Little Miami	No	4	5	2	1	$2,510.00	$1,811.00	$72,000.00	$130,000.00	houses built on sinks, but worth a shot with multiple upstream catch basins
160	Cadillac Ave. & Isabella Ave.	Yes	Little Miami	Yes	2	10	1	3	$7,530.00	$5,433.00	$18,000.00	$65,000.00	multiple upstream catch basins to install float-gate, would likely prevent both
161	Wasson Rd. & Drake Ave.	Yes	Little Miami	Yes	2	9	0	4	$10,040.00	$7,244.00	$20,000.00	$130,000.00	upstream catch basins to block, tributaries for surface water to flow into
169	Erie Ave. & Burch Ave.	No	Little Miami	No	1								
185	Williams Ave. & Elsmere Ave.	No	Little Miami	Yes	4								big sink already, surface water may flood houses
186	Harrow Ave. & Camberwell Rd.	No	Little Miami	Yes	2								very high return period on SBU's, big combined sewer pipe
194	Observatory Ave. & Berry Ave.	Maybe	Little Miami	Yes	1								could be a lot of pooling, houses on observatory have raised front yards
203	Tusculum Ave.	Maybe	Little Miami	Yes	0								Feasible, but not necessary, no current SBU problems
215	Aikenside Ave. & Pointer Ln.	No	Little Miami	No	0								No active SBU, depressed driveways nearby
217	Grand Ave. & Plainfield Rd.	No	Little Miami	Yes	0								just sanitary line, no active SBU
221	Erie Ave. & Zumstein Ave.	Maybe	Little Miami	Yes	0								No active SBU
223	Moundview Dr. & Indian Mound	No	Little Miami	Yes	0								No combined sewer
227	Tempkins Ave.	Maybe	Little Miami	No	0								No active SBU's
236	Observatory Ave. & Mooney Ave.	No	Little Miami	Yes	0								Depression at inlets
248	Bancroft St. & South Whetzel St.	Maybe	Little Miami	No	0								No active SBU
407	Boyd St. & Chambers St.	Yes	Mill Creek	No	7	27	0	4	$10,040.00	$7,244.00	$23,333.33	$455,000.00	
409	Sedam St. & Lodwick St.	No	Mill Creek	Yes	6								144" sewer line
410	Avonlea Ave. & Phantom Ave.	Yes	Mill Creek	No	15	12	10	8	$20,080.00	$14,488.00	$112,500.00	$325,000.00	
413	Geert St. & Jeffersone Ave.	Maybe	Mill Creek	No	6								Lots of SBU, unsure if gate will help
416	Joselin Ave. & Joselin Aly	Yes	Mill Creek	Yes	6	120	0	1	$2,510.00	$1,811.00	$4,500.00	$390,000.00	Large hill, UC Campus
421	Lysle Ln. & Homer Ave.	No	Mill Creek	Yes	4								SBU on seperate sanitary only line
422	Wess Park Dr.	No	Mill Creek	Yes	4								60" line
423	Ridgecliffe Ave. & Fernview Ave.	No	Mill Creek	No	3								
424	Alter Pl.	No	Mill Creek	No	4								Sink at inlet
425	Cortelyou Pl. & Lisbon Ave.	Maybe	Mill Creek	Yes	3								Downstream impacts, maybe hobbit door?
426	Elizabeth Pl. & Matlock Ave.	Yes	Mill Creek	Yes	3	3	3	3	$7,530.00	$5,433.00	$90,000.00	$0.00	
430	Wilke Dr.	Maybe	Mill Creek	No	2								Feasible, would only help 1 house, 10 yr return
433	Section Rd. & Ross Ave.	Yes	Mill Creek	Yes	2	24	1	1	$2,510.00	$1,811.00	$7,500.00	$65,000.00	
434	Lysle Ln. & Bosworth Pl.	Yes	Mill Creek	Yes	3	168	3	1	$2,510.00	$1,811.00	$1,607.14	$0.00	Ideal
436	Briarcliff Ave. & Fernview Ave.	Yes	Mill Creek	No	5	24	4	6	$15,060.00	$10,866.00	$18,750.00	$65,000.00	
455	Vinecrest Pl. & Vine St.	No	Mill Creek	Yes	1								72 in pipe, only one SBU, return period 5 years
457	Debonair Ct. & Stillwell Rd.	No	Mill Creek	Yes									only one SBU, >10 year return period
462	Addice Way & Argus Rd.	No	Mill Creek	Yes	2								Depressed driveways, big pipe
465	Park Pl. & Church St.	No	Mill Creek	Yes	0								No SBU's
474	Robinson Cir. & Hamilton Ave.	Maybe	Mill Creek	No	4								large 30 inch pipe, but several SBUs with multiple upstream catch basins
475	Granville Ln. & Brushwood Ave.	No	Mill Creek	Yes	4								surface water would flood houses, depressed driveways
476	Glenside Ave. & Carthage Ave.	No	Mill Creek	Yes	5								surface water may flood homes on border of sink
483	Barvac Ave. & Howard Ave.	Yes	Mill Creek	Yes	3	24	1	1	$2,510.00	$1,811.00	$11,250.00	$130,000.00	couple storm basins to plug upstream, many houses elevated from street level
486	Souh Oak Knoll Dr. & Highcliff Ct.	No	Mill Creek	Yes	4								96 inch pipe, wow!
488	West North Bend Rd. & Aspen	No	Mill Creek	Yes									lot of houses near sink, surface water may flood homes
512	Boyd St. & Mad Anthony St.	No	Mill Creek	Yes	2								60 inch pipe
517	Mehmert Ave. & Kirby Ave.	No	Mill Creek	Yes									96 inch pipe
518	Bruce Ave. & Virginia	No	Mill Creek	Yes	2								two 2-year return periods, runoff could potentially cause flooding
520	Greenfield Dr. & Springbrook Dr.	Maybe	Mill Creek	No	2								only one SBU, multiple installations required
521	South Oak Knoll Dr.	No	Mill Creek	Yes	2								96 inch pipe, sink downstream
522	Wittekind Ter. & Devonwood Dr.	Maybe	Mill Creek	Yes	2								large pipe, surface flow would likely run into sink away from houses
523	Elkton Pl.	No	Mill Creek	No	2								Depressed driveways
525	Andina Ave. & Hermit Ave.	Yes	Mill Creek	Yes	8	42	6	2	$5,020.00	$3,622.00	$17,142.86	$130,000.00	7 or 8 SBUs, unlikely to flood houses with surface water
532	West 15th St. & Race St.	No	Mill Creek	Yes	2								Low priority 10-year return periods, could flood surrounding area
533	8th St. & Overlook Ave.	Yes	Mill Creek	Yes	2	6	2	1	$2,510.00	$1,811.00	$30,000.00	$0.00	6 month return period SBU, surface flooding should not be a problem
549	Blair Ave. & Fernside Pl.	Maybe	Mill Creek	No	1								2 year return period SBU, surface flooding may flood downstream houses
564	North Hill Ln. & Glenbrook Ct.	Maybe	Mill Creek	Yes	1								low chance of flooding downstream houses, 2 houses with SBU
604	Towanda Ter. & Cheyenne Dr.	No	Mill Creek	No	2								drainage at large basin nearby
613	Girard Ave.	Yes	Mill Creek	Yes	4	9	2	2	$5,020.00	$3,622.00	$40,000.00	$130,000.00	Ideal

616	Clinton Springs Ln. & Vine St.	No	Mill Creek	Yes	1								Sink at inlet and houses
669	Hartwell Ct.	No	Mill Creek	Yes	0								Sink at inlet and houses, no active SBU
684	Paddock Hills Ave. & Paddock Ln.	No	Mill Creek	Yes	0								Sanitary sewer only, top off hill not enough flow
694	Glenwood Ave. & Vine St.	No	Mill Creek	Yes	0								No active SBU, giant line
697	Ardmore Ave.	No	Mill Creek	Yes	0								Downstream impacts, no active SBU
700	Canyon Dr.	No	Mill Creek	No	0								Sink at inlet, no active SBU
703	Intervine Pl. & Vine St.	No	Mill Creek	Yes	0								72" pipe, no active SBU
712	Brushwood Ave. & Cherrywood	No	Mill Creek	No	0								No active SBU, not enough upstream flow
714	Greenfringe Dr. & Singbrook Dr.	No	Mill Creek	No	0								No active SBU, not enough upstream flow
715	Greenfarms Dr.	Yes	Mill Creek	No	3	60	3	2	$5,020.00	$3,622.00	$4,500.00	$0.00	
716	Archland Dr.	No	Mill Creek	Yes	0								Depressed driveways
741	West Fork Rd.	No	Mill Creek	No	0								Depressed houses
757	Mardon Pl. & Rosemont Ave.	No	Mill Creek	No	0								Depressedd driveways, no active SBU
759	8th St.& Schiff Ave.	Maybe	Mill Creek	No	0								No active SBU
764	Clearview Ave. & St. Lawrence	No	Mill Creek	Yes	0								Inlet in ink, no active SBU
766	Highridge Ave. & Lockman Ave.	Maybe	Mill Creek	Yes	0								No active SBU
767	Loeta Ave. & Olivia Ln.	No	Mill Creek	No	0								No active SBU, sink at inlet
903	Werk Rd. & Werkcastle Ln.	No	Muddy Creek	No	3								Depressed Driveway
916	Glenmore Ave. & Daytona Ave.	Yes	Muddy Creek	Yes	3	2	0	3	$7,530.00	$5,433.00	$135,000.00	$195,000.00	Ideal
918	Muddy Creek Rd. & Rosebud Dr.	Maybe	Muddy Creek	Yes	0								No active SBU's
929	Vittmer Ave.	No	Muddy Creek	Yes	1								Depressed driveways
944	King Ave. & Mignon Ave.	No	Muddy Creek	Yes	0								No active SBU
959	Julmar Dr. & Sylved Ln.	No	Muddy Creek	No	0								No active SBU
961	Cleander Dr. & Cimarron Trl.	No	Muddy Creek	No	0								No active SBU, sink would collect surface water
964	Casa Loma Blvd & Glenway Ave.	No	Muddy Creek	Yes	0								No current SBU
988	Meadow Ave.	No	Muddy Creek	Yes	0								No current SBU

10.12 Cost Savings Calculations

Installation Cost: 3 * 130 * 4 = $1,560

Material and Installation Cost: 950 + 1,560 = $2,510

Initial Capital Cost of Floats: 70 floats * 2,510 = $176,000

Annual Maintenance Cost of One Float: (3 * 130 * 4) + 0.20*($2,510/2) = $1,811

Annual Maintenance Cost of Floats: 70 floats * 1,811 = $127,000

Project Cost: 176,000 + 127,000 = $303,000

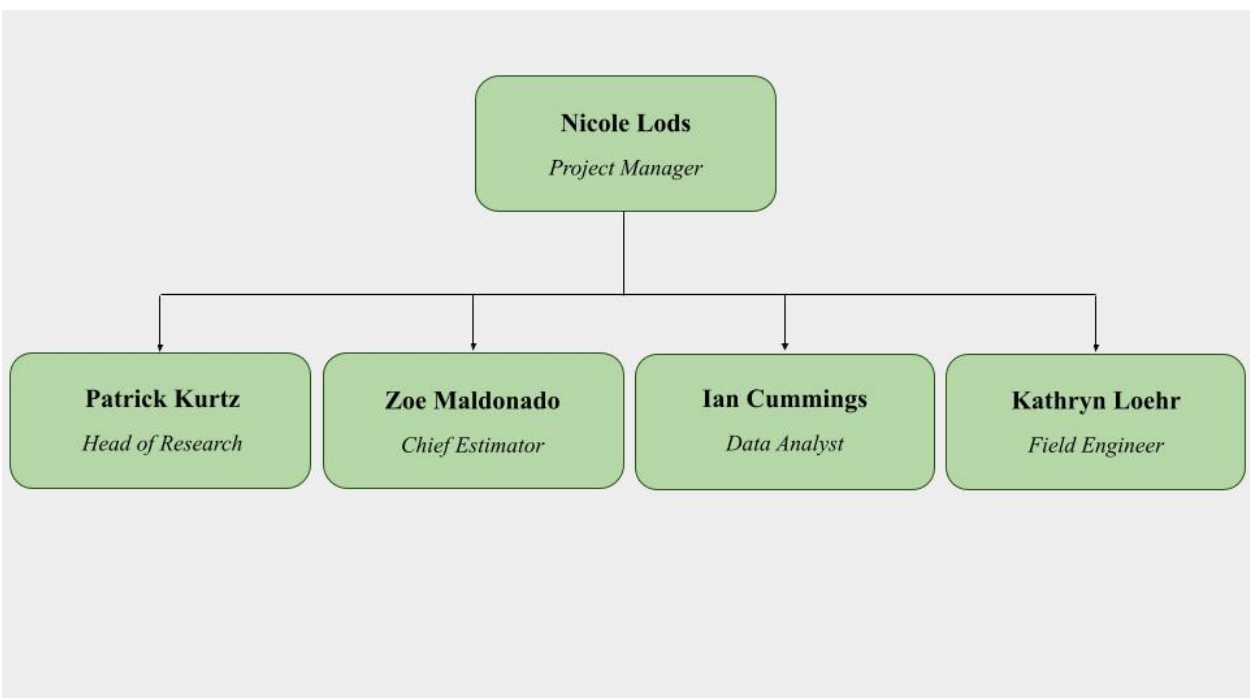
Minimum Cost Savings: 844,000 – 303,000 = $541,000

Maximum Cost Savings: 3,250,000 + 541,000 = $3,791,000

10.13 Vision Statement

Designing innovative solutions to storm and wastewater challenges to create cleaner communities.

10.14 Organizational Chart



10.15 Engineer Bios

Ian Cummings - Data Analyst

Ian Cummings is a fifth-year environmental engineering student at the University of Cincinnati. He completed two co-ops at the Metropolitan Sewer District of Greater Cincinnati (MSDGC) and Kroger. At MSDGC he worked on the organization's surveying crew. Currently he is working at Kroger in their Facilities Engineering Department. After graduation, he plans on continuing to work for Kroger.

Patrick Kurtz - Head of Research

Patrick Kurtz is a fifth-year environmental engineering student at the University of Cincinnati. Patrick's first two co-op rotations with Pixelle Specialty Solutions provided a background in environmental compliance. His co-op rotations with the Metropolitan Sewer District's Division of Industrial Waste granted him experience in water sampling and preservation techniques. Patrick is currently working in the lab of Dr. David Wendell on a project concerning estrogen detection in water using a bioluminescent indicator.

Nicole Lods - Project Manager

Nicole Lods is a fifth year Environmental Engineering student at the University of Cincinnati. She completed two co-op rotations with the Shepherd Color Company focusing on air pollution permitting and EPA compliance and three co-op rotations at Ulliman Schutte Construction as a project engineer co-op in the water/wastewater construction industry. Following Graduation, Nicole will be moving to Raleigh, North Carolina to pursue a career in water resources with RS&H.

Kathryn Loehr - Field Engineer

Kathryn Loehr is a fifth year Environmental Engineering student at the University of Cincinnati. She has experience working at the Metropolitan Sewer District of Greater Cincinnati as a safety co-op in 2019. Currently, she works for Gresham Smith as a water resources intern. Following graduation, Kathryn will be traveling to Europe for a few months and then begin working full-time at Gresham Smith.

Zoe Maldonado - Chief Estimator

Zoe Maldonado is a fifth year Environmental Engineering student at the University of Cincinnati. She co-oped as a lab assistant to a graduate student researching ‘How hormone levels will affect water fleas in the Ohio River’. She has built an aquaponics system for the Independent Explore Program and has completed a co-op rotation at the Ohio Department of Transportation in the environmental department in 2021. Following graduation, Zoe will raise a puppy, spend time with family, and apply for jobs along the way.

10.16 Engineer Resumes

Ian Cummings

3212 Buell Street, Cincinnati, OH 45211 • (513)-969-7569 • cumminid@mail.uc.edu

Education:

Bachelor of Science, Environmental Engineering *Class of 2022*
University of Cincinnati, Cincinnati, OH *GPA: 3.7*

- Minor: Horticulture
- Awards and Honors: Dean's List (8 semesters)

Experience:

Student Intern (Surveying) *February 2019 – January 2020*
Metropolitan Sewer District of Greater Cincinnati, Cincinnati, OH

- Captured points using the Leica total and complete stations in order to obtain accurate locations of sewer apparatuses
- Produced over 25 comprehensible AutoCAD 2D drawings of sewer apparatuses for public records
- Trained a new employee for three weeks on how to use AutoCAD 2D

Cincinnati Reds Food Vendor *April 2014 – September 2019*
Delaware North, Cincinnati, OH

- Carried food products throughout stands for three hours per event
- Averaged $600 in sales per event (50 events per year)
- Developed relationships with customers to improve the fan experience

Student Worker *February 2015 – February 2019*
University of Cincinnati Parking Services, Cincinnati, OH

- Created an online accountability system which tracks employee tasks through Google forms
- Received the Prestige Award for developing protocols on how to maintain new software
- Maintained parking facilities by picking up garbage and sanitizing public areas

Greenhouse Worker *September 2016 – December 2016*
Diefenbacher Greenhouses, Cincinnati, OH

- Assisted in the production of hundreds of poinsettias during the holiday season
- Mentored by growers about common greenhouse practices such as scheduling orders, watering, planting, and fertilizing
- Maintained greenhouse quality by sweeping, weeding, and winterizing

Leadership & Extracurricular Activities:

Volunteer *November 2001 – November 2019*
People Working Cooperatively, Cincinnati, OH

- Assisted in raking leaves and other outdoor maintenance for the elderly and disabled in the Cincinnati area for the annual Prepare Affair

Volunteer Chair *August 2018 – May 2019*
Society of Environmental Engineers, University of Cincinnati

- Obtained position by election
- Recruited individuals to assist in helping with volunteering events in the community
- Headed five volunteering events with local groups such as People Working Cooperatively, Cincinnati Zoo, and Mill Creek Alliance

Skills:

Relevant Courses: Materials and Energy Balances, Statics, Physics
Computer Programs: AutoCAD 2D, Microsoft Excel, Word, PowerPoint, Matlab

Available for Co-Op Position Spring 2021

Patrick Kurtz

(502) 552-0185 – kurtzpg@mail.uc.edu

EDUCATION

BS, Environmental Engineering

University of Cincinnati, Cincinnati, OH Graduation: May 2022

- Minor: Mathematics
- GPA: 3.45
- Focus: Water treatment & Hydro-systems
- Relevant Coursework: Hydraulic Systems, Applied Biology for Engineers (Lab), Water Treatment, Hydrology, Organic Chemistry (Lab)

EXPERIENCE

Full-time Industrial Waste Co-op

Metropolitan Sewer District of Greater Cincinnati 1/21 – 8/21

- Worked alongside a pretreatment specialist sampling various water sources:
    - Business and manufacturers' wastewater streams
    - Rivers and creeks (e. coli, organic nitrogen, hardness)
    - Wastewater treatment plant low-level Hg, NPDES required sampling
- Completed chain of custody paperwork, as well as field-log paperwork noting procedures taken
- Gained proficiency in online database iPACs managing sampling events, analyzing flow data, altering flow-based studies as needed
- Operated flow meters and automatic samplers requiring calibration, maintenance, and varied onsite troubleshooting for each sampling location
- Assisted in training a new co-op within the department

Full-time Environmental Co-op

Pixelle Specialty Solutions, Chillicothe, Ohio 8/19-12/19, 5/20-8/20

- Prepared and submitted monthly water discharge monitoring reports to Ohio EPA as well as monthly energy generation reports to the Department of Energy
- Collected, analyzed, and organized continuous emission monitoring data on 4 emission sources throughout the mill
- Led 2 annual projects for chemical inventory of entire mill [three paper machines, pulp mill, utilities (4 boilers operating 24/7, 2 supplementary boilers), woodyard]:
    - Toxics Release Inventory
    - SARA 312
- Completed Quarterly Reports to Ohio EPA for 4 emission sources (boilers and lime kiln)
- Assisted contractors performing maintenance on ambient air monitoring devices throughout the mill

SKILLS

Computer: C++, MATLAB, Microsoft Excel, ArcGIS, CEMs, Process Book, iPACS

EXTRACURRICULAR ACTIVITIES

Volunteer

Civic Garden Center of Greater Cincinnati 2019-2021

- Monthly or weekly volunteering at various community gardens throughout the city, focus on sustainability and resource management

Member

UC Students for Burnett Woods, Cincinnati, OH 2019-2021

- Student organization supporting Burnett Woods and other local parks through voluntary invasive species removal and educational outreach

lodsne@mail.uc.edu
502-523-7720

Nicole Lods

Education

Environmental Engineering, Bachelor of Science — Class of 2022
University of Cincinnati, Cincinnati, OH

Experience

Project Engineer Co-op, Ulliman Schutte Construction - Raleigh, NC — Spring 2021, Summer 2021

- Assisted in material procurement on Dewatering and Steam supply operations at Neuse River Bioenergy Recovery Project
- Coordinated with subcontractors to write electrical submittals and job safety analyses
- Supervised quality control tests on structural and slab concrete pours
- Tracked material from point of order and supervised installation
- Wrote subcontracts, Purchase orders, RFI's, and change orders
- Managed certified payroll for 10 subcontractors weekly

Project Engineer Co-op, Ulliman Schutte Construction - Baltimore, MD — Summer 2020

- Assisted in equipment start-up on the Mechanical Self-Perform Team at Back River Wastewater Treatment Plant Headworks Project
- Coordinated with vendors to write submittals including Operation and Maintenance Manuals and Training plans
- Completed pipe layouts using AutoCAD Software
- Conducted Quality Control Tests on completed systems including Hydraulic Pressure Pipe Leak Tests and Slide Gate Leak Tests
- Wrote demolition plans for existing grit removal facilities
- Completed Purchase Orders, Change Orders, and Pay Applications

EH & S Co-op, The Shepherd Color Company - Cincinnati, OH — Spring 2019, Fall 2019

- Interpreted environmental regulations and permits to ensure compliance with the US EPA Clean Air Act
- Developed and utilized data analysis tools for ventilation systems
- Performed air, noise, and stack testing in a manufacturing environment to meet OSHA Permissible Exposure Limits
- Maintained an environmental data collection, analysis, and reporting system to meet NESHAP
- Collaborated with Contractors and Consultants to solve problems safely and effectively

Skills and Training

- OSHA 10-hour training, Six Sigma Yellow Belt training, AutoCAD
- Proficient in Microsoft Office, MATLAB, and Microsoft VBA

Leadership and Affiliations

Phi Sigma Rho Sorority — Fall 2017-Present
- Vice President of Finance- Managed $40,000 budget semesterly
- National Housing board- Developed Housing management system for 45 chapters

Girl Scouts Series Facilitator — Fall 2021-Present
Rho Lambda Honorary — Fall 2020 - Present

KATHRYN LOEHR

513-805-6736 | kathrynloehr1@gmail.com | linkedin.com/in/kathryn-loehr

EDUCATION

Bachelor of Science, Environmental Engineering — May 2022

University of Cincinnati, Cincinnati, OH

- GPA: 3.8/4.0

EXPERIENCE

Water Resources Intern — June 2021-Present

Gresham Smith, Cincinnati, OH

- Assist with the design of multiple water main replacement projects using Civil 3D by drafting proposed alignments, water line taps, fire hydrants, valves, and profiles
- Prepare a design summary for a 9,000 lineal feet water main replacement project by gathering existing utility and site condition information
- Deliver quality projects to clients by being detail-oriented and adhering to deadlines

Upskill Experiential Exploration Program (EEP) — Spring 2021

University of Cincinnati, Cincinnati, OH

- Designed learning plan to further professional development and career goals
- Managed time effectively to complete self-paced, online courses
- Gained experience in AutoCAD, Civil 3D, and Storm Water Management Model (SWMM)
- Volunteered with the Mill Creek Alliance and developed Manning Equation worksheet for educational purposes

Safety Co-Op — January 2019-December 2019

Metropolitan Sewer District, Cincinnati, OH

- Assisted with the development of lockout/tagout program by improving swim lane for Energy Control Procedure (ECP) and creating a user-friendly guide for completing ECPs
- Conducted annually required fire extinguisher training for over 600 employees and created a map and list of fire extinguishers located on the Mill Creek Treatment Plant campus
- Completed regular inspections of fall protection equipment and calibration gas cylinders and gas detectors in order to ensure worker safety
- Job shadowed an environmental engineer and learned more about green infrastructure in the wastewater treatment industry
- Collaborated with people from other departments, such as treatment, engineering, and collection, on various customer specific projects

SKILLS

Computer: Microsoft Office, AutoCAD, Civil 3D, SWMM, ArcGIS, MATLAB

EXTRACURRICULAR ACTIVITIES

Member, UC Society of Environmental Engineers, 2019-2021

Member, UC Running Club, 2018-2020

Sabrina Z. Maldonado

6513 Sunny Drive
Mason, OH 45040
Phone: (210)421-5816
maldonsz@mail.uc.edu

EDUCATION

University of Cincinnati *Cincinnati, Ohio* Class of 2022

- Bachelor Degree of Science, Environmental Engineering GPA 3.0/4.0

EXPERIENCE

Upskill Experiential Exploration Program (EEP) Summer 2020
University of Cincinnati*, Cincinnati, Ohio*

- Designed learning path and individual projects
- Managed to schedule self-paced online learning modules
- Gained experience in Python, Safety Protocols, Leadership Skills
- Ensured that PPE was available and supplied
- Implemented COVID-19 regulations for volunteer work

Lab Assistant Fall 2019
University of Cincinnati, *Cincinnati, OH*

- Filled beakers with concentrated water for water-fleas
- Observed the reproduction of water-fleas through 9 generations
- Applied hormones to water to see if they affect the growth of water-fleas

ACTIVITIES

Volunteer November 2016 – Present
Matthew 25 Ministries, Blue Ash, Ohio

- Assembled hygiene products
- Inspected clothing for donations

Chairperson January 2016 – May 2017
Health Occupation Students of America, Mason, Ohio

- Communicated ideas between advisor and members
- Arranged The Southwest Regionals for 16,000 people
- Motivated 90 members at The State level

Chapter Member – Chair of Decorations and Food January 2019- Present
Zeta Tau Alpha, Cincinnati, Ohio

- Raised money for Beast Cancer Education and Awareness
- Hosted fundraiser events with our National Partners

SKILLS

Microsoft Office

- *Certified in Excel, Word, Access, PowerPoint, Outlook*

MATLAB
Python

10.17 Request for Proposal

UC Environmental Engineering Senior Capstone Project RFP
"Stormwater Inlet Control Float Performance Testing"
Sponsor: Metropolitan Sewer District of Greater Cincinnati

Date of RFP Issuance: August 23, 2021

Introduction

The Metropolitan Sewer District of Greater Cincinnati (MSDGC) is currently developing a new technology for preventing sewer surcharge in combined sewers. The purpose of the flow control, or "float control," is to restrict flow from incoming storm pipes to a combined sewer pipe during storm events to avoid surcharging MSDGC's sewer and flooding the surrounding houses. The concept is not new and other types of models are available commercially, but a few unique challenges led MSDGC to construct a custom float control (*e.g.*, incoming storm pipe is too low, cannot fit two float controls in one manhole, *etc*.) MSDGC wants a solution that (i) is low cost, (ii) is housed entirely in the MSDGC manhole, (iii) eliminates flooding in MSDGC's sewer, (iv) is automated and immediate, (v) maximizes the flow MSDGC's sewer can take, and (vi) requires no ongoing catch basin cleaning. The float control prototype is on track to be installed by the end of Summer 2021 (Fig. 1). MSDGC is seeking student consultants to develop a plan for testing performance of the float control, analyzing the results of the performance tests, and delivering a report and recommendations to improve performance.

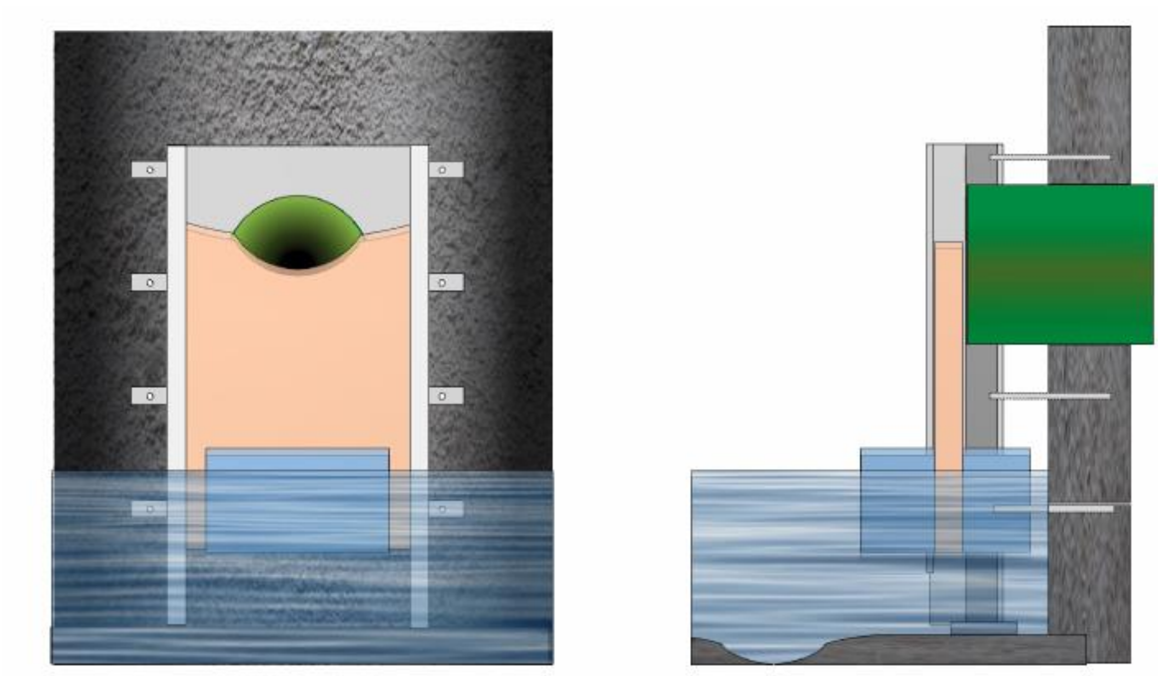


Fig. 1. Model of float control partially restricting flow from storm pipe (green).

Description of the Project

MSDGC will install the float control prototype and work with the consultant team to develop a plan for testing performance (Fig. 2). Two questions that must be addressed are:

1) What is the buoyant force to lift the gate?

   To design an effective float, it is necessary to know how much force is required to lift the gate when the manhole is flooded with water. MSDGC assumes that the deformation of the gate's plastic surface during a storm event will change the coefficient of friction. To determine the effective friction and required buoyant force, we can mount a gate in a manhole, flood with water, and measure how much force is required to lift the gate with water pressing on its surface.

2) Does the float control work as needed to restrict flow during storm events?

   Sensors on the gate will measure pressure and there are flow monitors in the surrounding area. The consultant team will be responsible for analyzing field data to determine whether the float control works as designed, *i.e.*, when the combined sewer pipe surcharges, the gate shuts to restrict incoming stormwater.

Fig. 2. Beginning of construction of the float control in manhole.

Description of Services Required

MSDGC will coordinate closely with the consultant team throughout this project. A project kickoff meeting will be scheduled in mid-September where MSDGC representatives will provide presentations on the technology and respond to any questions from the consultant team. The purpose of this initial meeting is to ensure the consultant team understands the goals and objectives of the project. Additional meetings will be scheduled on an as needed basis.

For this project the team will need to evaluate the float control prototype devise for its functionality and cost, as well as make recommendations on improving its performance. These evaluations will include analysis of field data collected from the installed float control prototype. Any recommended changes in the prototype design should be provided in CAD drawings. An economic and environmental impact analysis is also required.

Deliverables

The consultant team shall submit a project proposal and give a formal presentation to MSDGC at the end of the Fall Semester, which outlines the recommended performance tests and analysis. At the end of the Spring Semester, the consultant team shall submit a final project report and give a formal presentation to MSDGC on key findings of the project.

Fall Semester

Specific tasks include, but are not limited to, the following:

1. Conduct research on existing flow control technologies for restricting flow from incoming stormwater pipes.
2. Evaluate how existing flow control technologies compare to the float control prototype.
3. Assist in installing the monitoring equipment (i.e., pressure and flow sensors), if needed, which will be used to assess the performance of the float control prototype.
4. Evaluate any preliminary data on system performance (e.g., buoyant forces to lift the gate and how much flow is restricted during storm events) on the monitoring equipment is installed.
5. Develop a plan for testing performance of the float control prototype devise based on preliminary monitoring data.
6. Conduct a preliminary economical evaluation of the float control prototype devise.
7. Prepare a proposal report on key findings and the recommended performance test.
8. Provide a presentation to the Sponsor that covers the key findings and recommended performance testing approach.

Spring Semester

Specific tasks include, but are not limited to, the following:

1. Evaluate performance of the float control prototype using data collected from the performance testing trials (e.g., maximum flow in sewer, minimum amount of basin cleaning).
2. Make recommendations and develop design specifications on modifications to the float control prototype.
3. Evaluate possible locations in MSD's identified Low Recurrence Interval Flooding Areas (LRIFA Areas) where float control devices could be placed in MSDGC's sewer network.
4. Conduct an economic cost and environmental impact analysis of the final system. This analysis should include capital and maintenance costs, as well as potential cost savings of reduced flooding.
5. Prepare a final report that includes a performance evaluation of the float control prototype, design specifications of any modifications to the prototype devise, an economic analysis, and an environmental impact analysis.
6. Provide an oral presentation on key findings at the end of the semester.