HydroSynergistic Solutions

To: Mr. Bruce Whitteberry, P.G.
Cc: Dr. Drew McAvoy, P.E.
From: Amy Cristiano, Jared Crosby, Megan Ginn, Catherine Straus, Matt Marotta
RE: Modeling and Design of an Induced Infiltration System to Supplement GCWW's Surface Water Intakes
Date: Friday, April 16th, 2020

Dear Mr. Bruce Whitteberry, P.G.,

HydroSynergistic Solutions respectfully submits the following report on modeling and preliminary engineering design of an induced infiltration system to Greater Cincinnati Water Works.

The following report contains the design proposal, which includes:

- Modeling of the Project Site
- Model Refinements
- Well Design and Placement
- Pump Design and Flow Routing
- Economic Analysis
- Permitting and Compliance
- Final Discussion and Recommendation

Our team is dedicated to finding an induced infiltration solution to fit your needs using quality models. Thank you for considering HydroSynergistic solutions for the completion of this design proposal. Please let us know if we can provide further information or guidance.

Respectfully Submitted,

Amy Cristiano
Jared Crosby
Megan Ginn
Catherine Straus
Matthew Marotta

Modeling and Design of an Induced Infiltration System to Supplement GCWW's Surface Water Intakes

University of Cincinnati Environmental Engineering
Capstone Project

HydroSynergistic Solutions

Amy Cristiano
Jared Crosby
Megan Ginn
Catherine Straus
Matthew Marotta

4/16/2021

Executive Summary

Thorough groundwater modeling has been conducted using MODFLOW with ModelMuse to investigate the feasibility of a riverbank filtration (RBF) system along the Ohio River at GCWW's Richard Miller Treatment Plant (RMTP). Based on the model results, locations for two 50 MGD pumps were identified in the north and south regions of the project area to avoid overlapping drawdown. This would supply the majority of a typical daily intake at the RMTP. The model was also run with both three and four wells in the project area, but these iterations were determined to be infeasible. An alternative scenario is also discussed where two more wells may be placed at Coney Island to provide the remaining water needed to source GCWW's entire intake from RBF. A sensitivity analysis on model parameters identified hydraulic conductivity as being the most influential to the projected water table elevation, indicating that a more thorough investigation should be done to verify the actual value. A preliminary design has been created for the two horizontal collector wells in the project area. These 26-meter deep wells feature two tiers of laterals directed towards the river, and are based on a well with a similar capacity in Kansas City. A pipe routing design has also been developed and verified in EPANET for feasibility. The economic analysis conducted considers savings from chemical use and sludge return in addition to costs from electrical use and construction. From this analysis, the RBF system is not shown to offer significant cost savings, but will reduce chemical use and sludge production. Additionally, a discussion on permitting and compliance measures to be considered has been included. Overall, riverbank filtration is shown to be a feasible method to supplement the water intake at the Richard Miller Treatment Plant.

Contents

1. Introduction

1.1. Site Background

Greater Cincinnati Water Works (GCWW) is an organization that has been supplying potable drinking water to the residents of Cincinnati and Hamilton County for over 200 years. GCWW uses surface water from the Ohio River at the intake in California, Ohio as its main water source for the Richard Miller Treatment Plant (RMTP). This treatment plant produces an average of 110 million gallons per day (MGD), but can produce more when necessary. The facility is rated at 240 MGD. Concerns with harmful algal blooms, oil spills, and other pollution in the Ohio River have motivated a request to create a more secure system or source at GCWW's plant to ensure the health and supply of drinking water to its customers.

1.2. Scope of Issue

GCWW is interested in evaluating the feasibility of using induced infiltration from the Ohio River for up to 100% of their water demand. Water will percolate from the river into the layers of sand and gravel, filtering pollutants before being drawn into a series of wells, and sent to the Richard Miller Treatment Plant for further treatment and distribution. The close proximity of the wells to the Ohio River would create a pressure gradient from the river to groundwater table, effectively forcing the river to recharge the aquifer. Hydrosynergisic Solutions will make a recommendation on the number, size and locations of the wells.

1.3. Problem Statement

In this study, Hydrosynergisic Solutions reviewed existing site information and gathered relevant data to construct a model of the aquifer at the project site. This is done using existing depth to water table data, geographic, geologic, topographic maps, and hydrologic data. A model of the aquifer was created using the data in order to simulate the aquifer response to induced infiltration. The construction of a model will assist in an alternative analysis of different well/pump systems, and the amount of water that can be extracted. An economic analysis of possible savings due to the reduced expenses for flocculation and coagulation and the Operation and Maintenance (O&M) of sandbed filters was conducted.

2. Modeling

2.1. Hydrologic System Under Investigation

The hydrologic system under investigation is GCWW's Richard Miller Treatment Plant, located in California, Ohio. The treatment plant is located near the Ohio River and currently draws surface water that is conveyed under the bedrock to a pump station on the Ohio side, and is then conveyed to two reservoirs, before the treatment process begins (Figure 1).

Figure 1: GCWW Property at the Richard Miller Treatment Plant (source: Google Earth)

2.2. Governing Equation of Aquifer Transport

The governing equation for groundwater transportation is:

$$\frac{\partial}{\partial x}\left[K_{xx}\frac{\partial h}{dx}\right] + \frac{\partial}{\partial y}\left[K_{yy}\frac{\partial h}{dy}\right] + \frac{\partial}{\partial z}\left[K_{zz}\frac{\partial h}{dz}\right] + W = S\frac{\partial h}{dt}$$

- Where K_{xx},K_{yy}, and K_{zz} are the values of hydraulic conductivity in the x, y, and z coordinate axes (L/T)
- h is the potentiometric head (L)
- W is the volumetric flux per unit volume, representing sources/sinks of water. ($L^3/T*L^3$). Negative values are extraction and positive are injections.
- S is the specific storage of the porous material (L^3/L^3-L)
- t is time

This differential equation is difficult to solve by hand, and only a few analytical solutions exist that require specific boundary conditions. The goal of modeling software is to solve this differential equation by numerical techniques.

2.3. Mathematical Methods and Appropriateness to the problem under investigation

Early modeling was done using MODFLOW-2005, with the Layer-Property Flow Package (LPF) and the Pre-conjugated Gradient Package (PCG) solver. The flow package is used in the transport of mass and pressure, whereas the iterative solver is used to complete the water and pressure budgets. The LP Flow package and PCG package are standard for solving various groundwater models, and have been used extensively in research.

In addition to LPF and PCG, and on other recommendations in literature, and Dr. Soltanian, we created a conceptual model of the project area using MODFLOW-NWF (Newton-Formulation), with the Upstream Weighting Gradient Flow package, and NWT solver. This combination of flow package and solver are specifically designed for unconfined aquifer systems.

2.4. Hydrogeologic Character of Boundary Conditions

The most important boundary condition to be considered in this project is the infiltration the Ohio River has on supplying water to the surrounding aquifer. Some of the key parameters in determining how much water is able to be supplied are:

- Hydraulic Conductance of the Riverbed

- River Stage of Ohio and Little Miami rivers
- Hydraulic Conductivity of the surrounding alluvial aquifer
- Little Miami River, it’s close proximity could provide water for extraction
- Bedrock - a detailed map of the bedrock is provided in the Appendix A
- Water Table of the alluvial aquifer

Table 1: Aquifer System Properties

Parameter	Value	Unit
Hydraulic Conductivity of Alluvial Aquifer	322	meters/day
Hydraulic Conductance of Ohio River	100	meters/day
Hydraulic Conductance of Little Miami River	100	meters/day
Saturated Thickness	30	meters
Bedrock Depth	121	meters
Specific Storage	0.2	unitless

2.5. Discretization of Project Domain and Preliminary Modeling

QGIS output a topographical Digital Elevation Model (DEM) obtained from the Ohio Department of Natural Resources (ODNR), was converted into a grd. file type, which ModelMuse uses as the surface elevation of grid cells. (Appendix A, Topographical Data). Figure 2 below shows a map of the project area with the Ohio River and Little Miami River added as objects created in QGIS. The property line and on site pump house road are marked with black lines. Currently, bedrock is set at 121 m, or 400 ft. An improvement to the model would be to set the bedrock layer as a topographic elevation feature, like was done with the top of the model. The model is set to 90 columns by 90 rows. There is 1 aquifer layer with 3 layers of discretization, which allows for greater accuracy but significantly increases computational requirements. The water table surface starting elevation has been set to 5 meters below surface elevation. The Ohio River and the Little Miami River were traced in QGIS and added to the model space as objects.

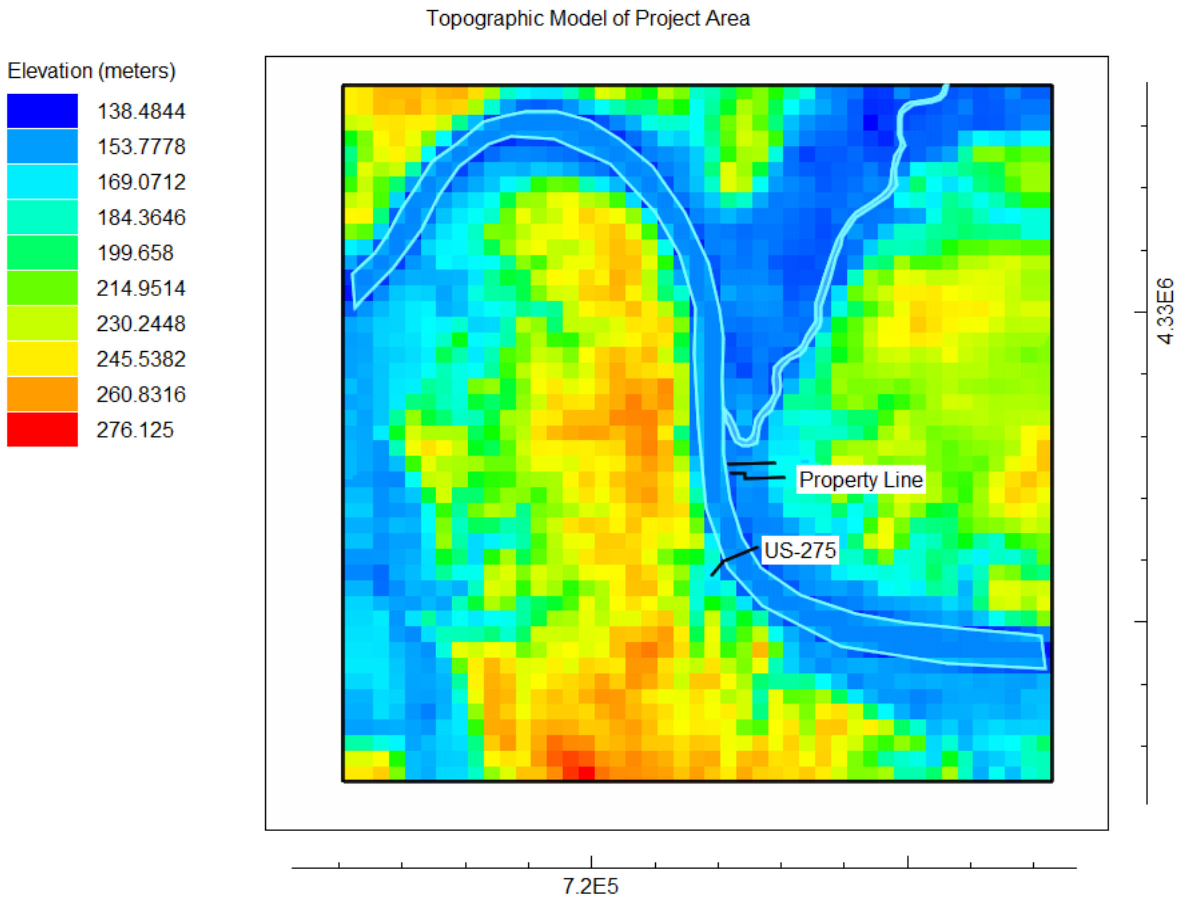


Figure 2: Topographic map of the project area, 30 meter resolution. Source: ODNR

After determining parameter values such as Hydraulic Conductivity, Riverbed Conductance, and River stage, the next step in the modeling process was to run the model without any wells, to verify the model is running properly and to understand the “resting” position of the water table.

ModelMuse provides a water balance and head flux balance so the modeler can check the validity of the model results, and these settings are controlled in the Solver dialog window of ModelMuse. We kept the default solver parameters, which have a water flux tolerance of 0.06 m^3/day and head flux balance tolerance of 0.001 m. After meeting the specified tolerance, the program will finish iterating and save the results of the run.

ModelMuse (which includes MODFLOW) iteratively solves problems of groundwater flow until they converge within a specific threshold. There were multiple moments of troubleshooting in the modeling process, and solver convergence could not be obtained with an evaluation of the entire project area, which was a considerably larger size than was actually needed for an informative model. A smaller area which extended a kilometer north and several kilometers south of the project site was created, and solver convergence was obtained with 0.0015% discrepancy. A low value of discrepancy does not mean that the model is accurate to the real work system, but means that the stressors (the ins-outs of water balance and hydraulic head) are accounted for by the model, and the model isn’t missing values of hydraulic head or volumetric water.

Figure 3 below shows the hydraulic head of the project site without any wells installed. The model is run in a steady state simulation, with the time period of 1 day, though under steady state conditions this isn’t an important setting. The area for installing wells is parallel to the Ohio River, as close as we can get without worries of erosion or flooding. The water table at this location ranges from 143-148 meters, which is 469-485 ft. The surface elevation at the project site is 150 meters (492 ft), which came from the imported DEM model. Improvements and refinements that could be made to our model will be discussed in Section 3: Model Calibration, but it is worth mentioning that the project area elevation will deviate from some of the values used in the creation of the model, and accuracy could be increased with more site-specific parameters.

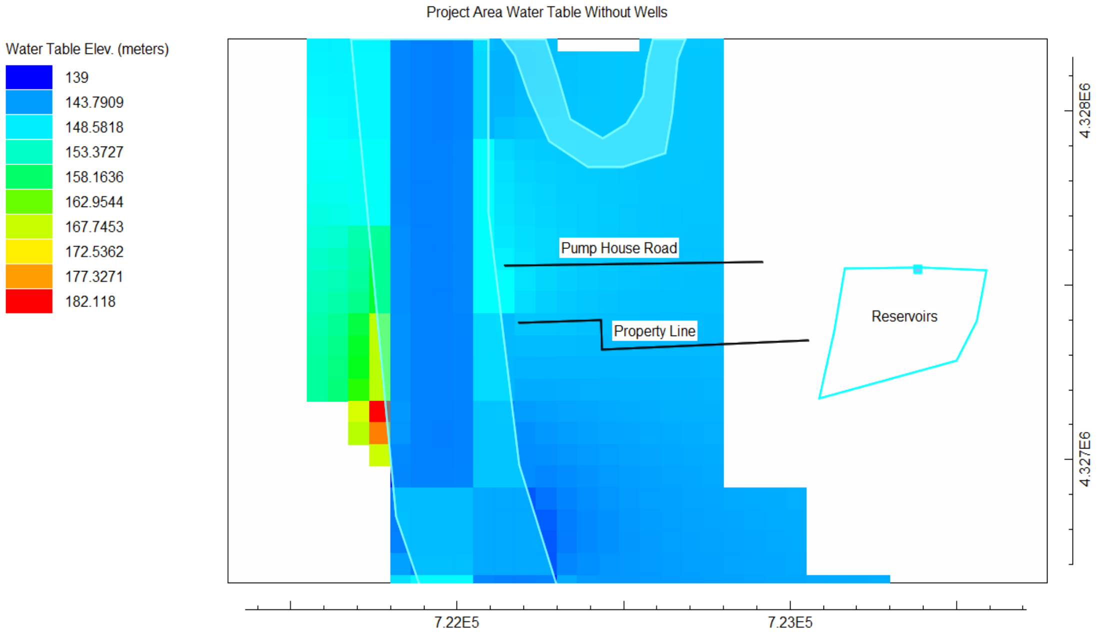


Figure 3: Hydraulic Head of the project area without any wells installed

2.6. Running the Model and Well Placement

Following running the model without extraction points, wells were added to evaluate feasible pumping rates. Per the project RFP, we wanted to evaluate how feasible 200 MGD would be from wells on the project site, and if we could not obtain that amount, how it would be possible with additional wells at Coney Island/Riverbend Park/Belterra Park. Our threshold for determining if a well was infeasible was if the water table was drawn below 127 meters in elevation (2 meters above the well bottom). Our group made that determination to be conservative in our evaluation. We learned in the previous semester from discussion with Louisville and the design of the B.E Payne treatment facility that they space their wells by over 1000 meters. The project site has only 1000 meters to collect twice the amount as B.E. Payne, so we were initially skeptical of the feasibility of 200 MGD from riverside land owned by GCWW. Wells were given a depth of 125 meters, 4 meters above the bedrock.

The model was unable to run with four 50 MGD wells on the property, spaced equidistant from each other. (Figure 4). This is most likely due to there being too large of head flux at the project site, draining the aquifer before the river can recharge it. MODFLOW will run with large percent discrepancies in the water and head balance, but if the values are too extreme, it will not produce results which happened in this case.

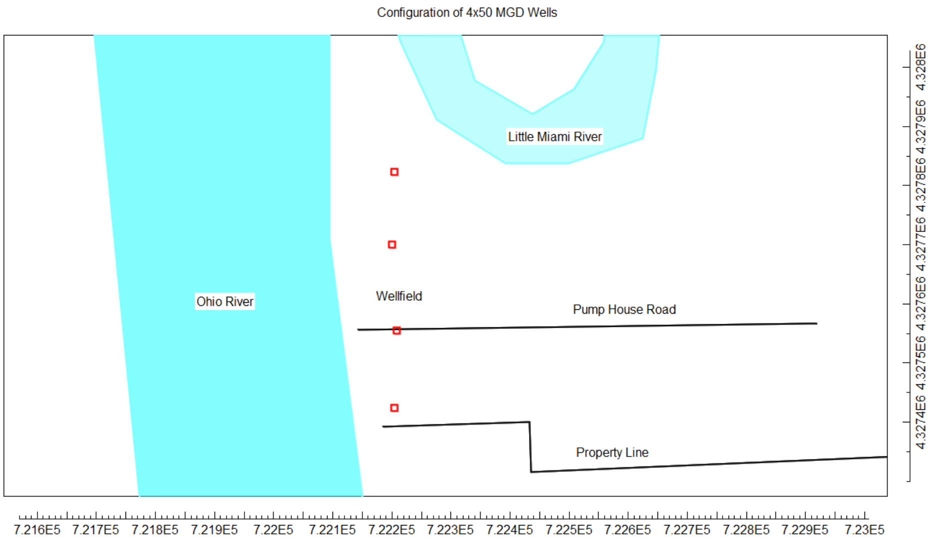


Figure 4: Project area with four wells

The next step was to evaluate the feasibility of three 50 MGD pumps. The wells were placed at 125 meters, pumping 50 MGD each, in a row along the banks of the Ohio river, spaced equidistant apart (Figure 5). The simulation was able to terminate with 0% discrepancy.

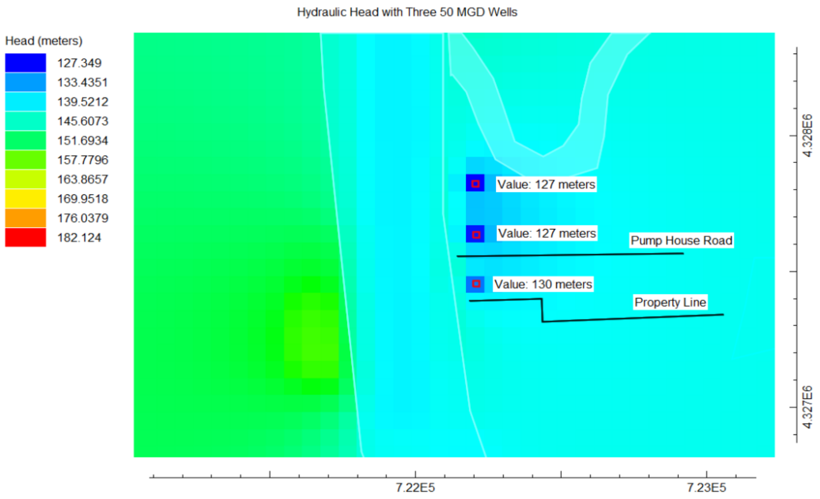


Figure 5: Three wells in a line parallel to the Ohio River. The value of head is close to the threshold of infeasibility set by the group.

Our group created another arrangement of wells to see if the effect would be any different, in a triangular formation. The effects show that proximity to the Ohio River is an important consideration, as the third well pumped the water table to below the well (Figure 6). The triangular arrangement was thus considered infeasible.

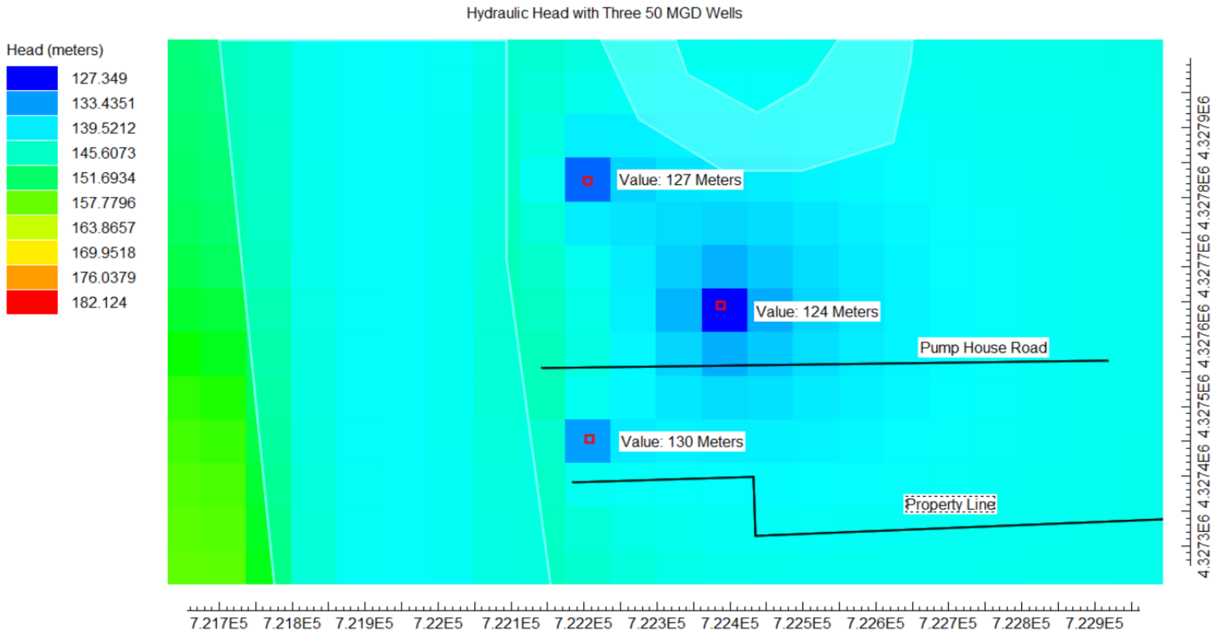


Figure 6: Three 50 MGD Wells in a triangular arrangement. Note that the center well has pumped the water table below the well.

Three wells in parallel produced values of head that are just above our criterion for determination of infeasibility. Though it technically does not cross that threshold, we were cautious to recommend placing three wells on the property owned by GCWW, as there are assumptions made by the group, especially hydraulic conductivity, that could bring a three well scenario out of feasibility. Our next task was to see if two wells would produce results that we were more comfortable recommending. The results of 2 wells spaced as far apart as the property allows is displayed in Figure 7. We are much more comfortable recommending a design with 2 wells on GCWW's property, with values of head at 131 meters, giving 7 m (23 ft) of water table above the bottom of the wells. The results from Figure 7 were used for the design in Section 5.1 Well Design and Section 5.2 Pipe Routing

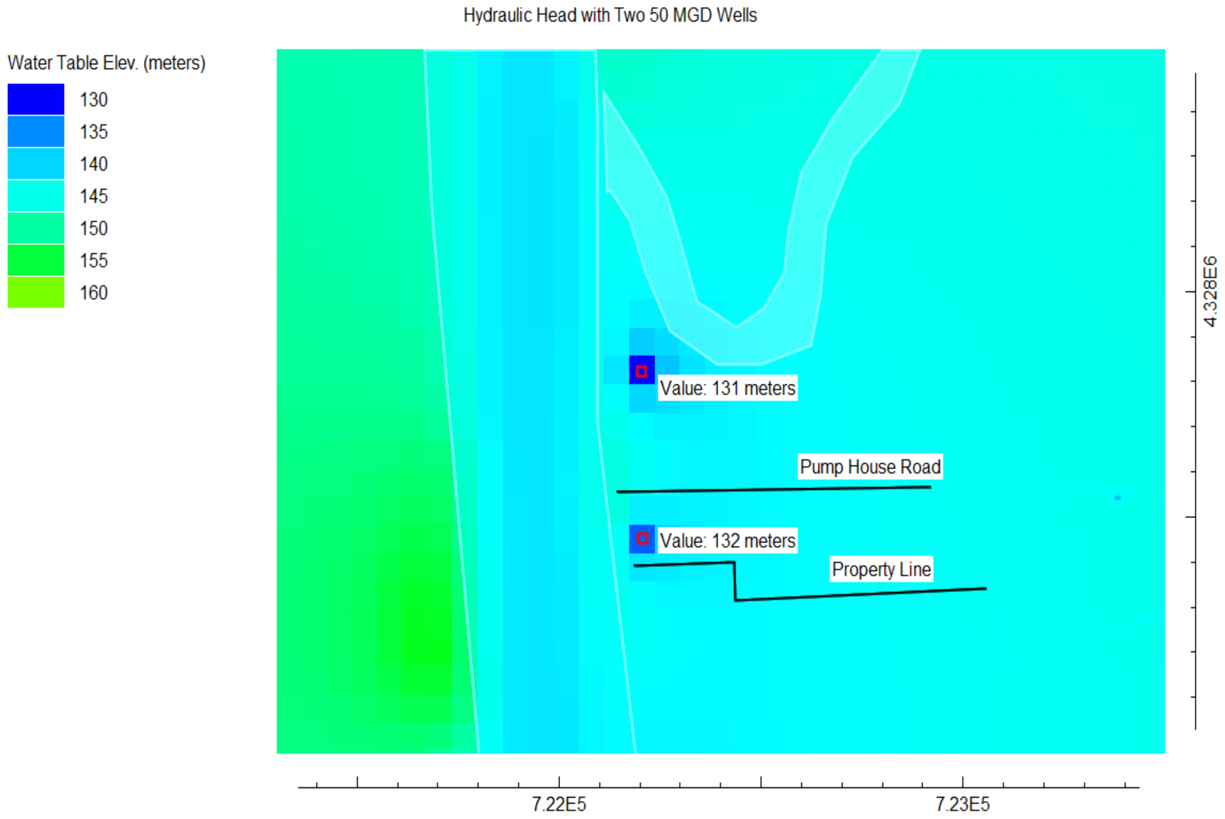


Figure 7: Project Area with two 50 MGD Wells

Our group wanted to analyze the drop of the on site water table with a range of extraction amounts. Ranging from 5 to 50 MGD, the results of the hydraulic head are located in Figure 8. Despite being more proximate to the Little Miami River, the north well lowers the water table more than the southern well in our model. The slope of the line is linear until 45 MGD, then decreases after 45 MGD, before it levels off. Our group discussed this trend and would not consider the values after 50 MGD to be accurate of an actual system, and a value of 65 MGD has the north well extraction water below its depth in the aquifer, which is infeasible and impossible.

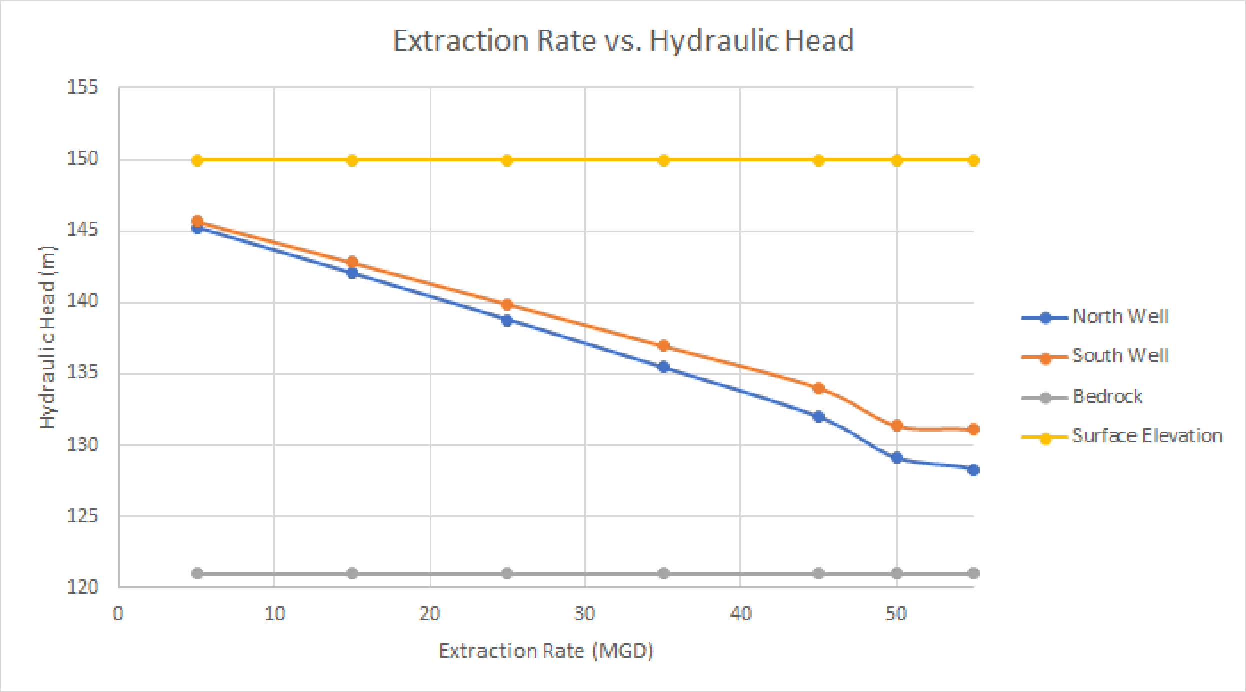


Figure 8: Extraction Rate vs Hydraulic Head for two wells, from 5 MGD to 65 MGD

2.7. Coney Island

The scope of this project was to determine the feasibility of 200 MGD, and with additional riverside land we expect 200 MGD to be feasible. Our group identified suitable land on Coney Island located near the riverside, and without any apparent land use (Figure 9). An important consideration would be obtaining permission from the current land owners, and due to the close proximity of the Ohio River, the pumphouses would need to be elevated to prevent flooding, or with a constructed wall that would prevent public access as well as protect against flooding.

Figure 9: A 300 meter stretch of riverside land close to the Ohio River. Source: Google Earth

After increasing the active zone of the model to include the land on Coney Island, the model was run with the same parameters as previously stated. The difference between the north and south well at GCWW's property is likely due to increasing the range that the model is calculating values, and less likely to be the cause of upstream Coney Island withdrawals affecting the stage of the river (Figure 10). From the simulation results, the wells at Coney Island produce a greater aquifer response than the wells at GCWW. The northern well at Coney Island, surprisingly, crosses our threshold for infeasibility. The northern well at Coney Island would need to be placed deeper in the aquifer, or extract less water. Our group is unsure of the reason for less water to be extracted from the Coney Island location.

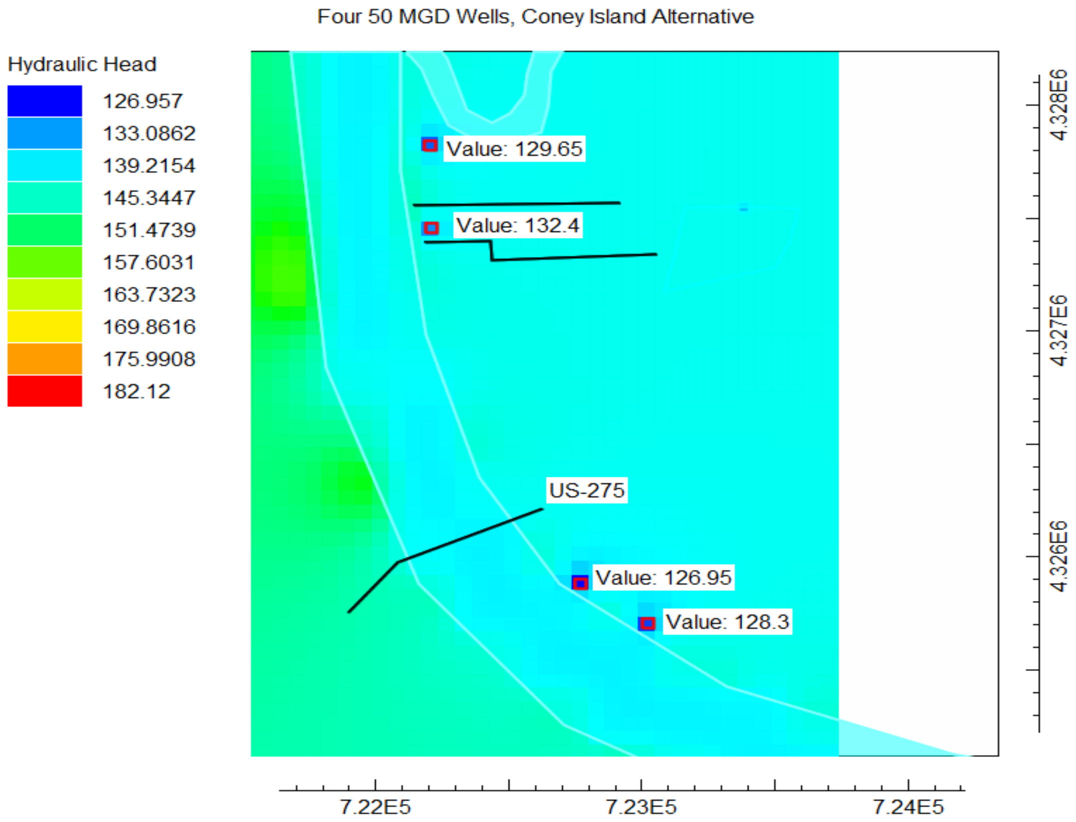


Figure 10: Results with four 50 MGD wells. Note that the water table has been drawn down to 2 meters above the bottom of the northern well at Coney Island.

3. Sensitivity Analysis

Important parameters to the feasibility of this project, that were estimated by the project group, were global Hydraulic Conductivity, Riverbed Conductance, and Ohio River Stage. Hydraulic Conductivity was based on a reasonable distribution of sand, silt, clay, rock, and gravel profile, detailed in Table 5 in the appendix and in Section 11. To determine how these values could change the effectiveness of the aquifer's ability to yield water, the team conducted sensitivity analyses on these three parameters.

3.1. Hydraulic Conductivity

Hydraulic Conductivity varied from 100 m/day to 500 m/day, and the model was run with 2 wells in the configuration shown in Figure 11. It can be seen from

Figure 11 that a value less than 250 m/day will cause the water table to fall below the elevation of the wells (125 meters).

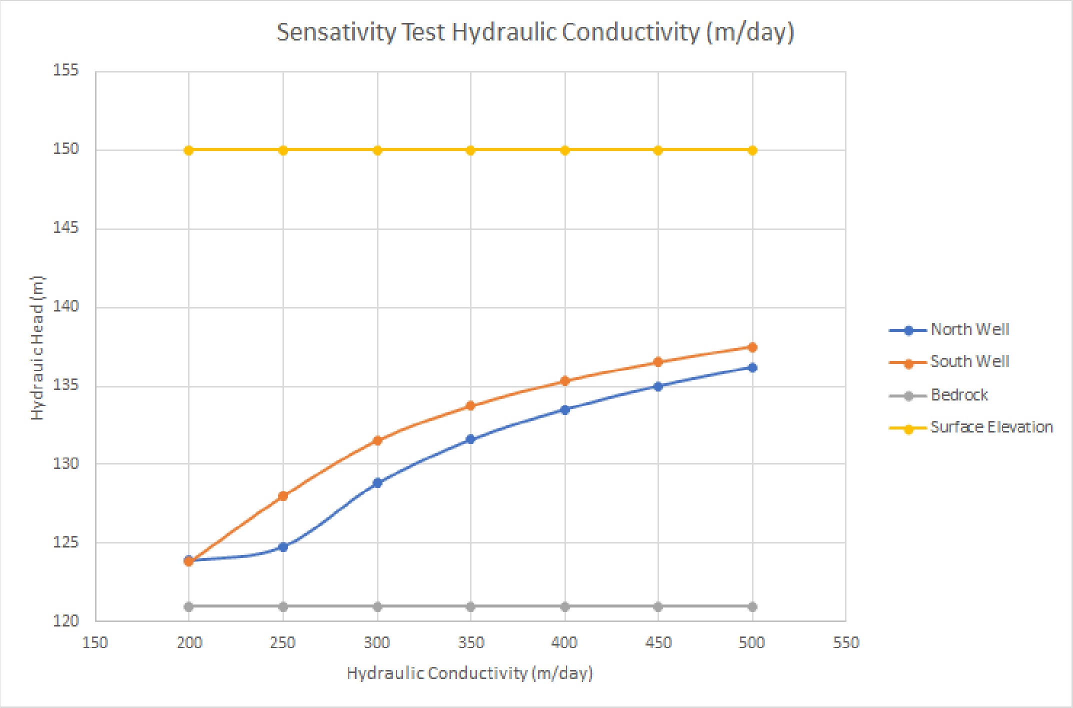


Figure 11: Sensitivity of the Hydraulic Head to Hydraulic Conductivity

3.2. Riverbed Conductance

Riverbed conductance is the ability of the surface water to percolate through the riverbed. The default value used for testing was 100 m/day. Values from 0.1 to 100 m/day were tested. From Figure 12, an interesting result is that a value above 15 m/day did not significantly impact the hydraulic head, but below 10, the head rapidly decreases to the point that the water table is brought below the depth of the wells.

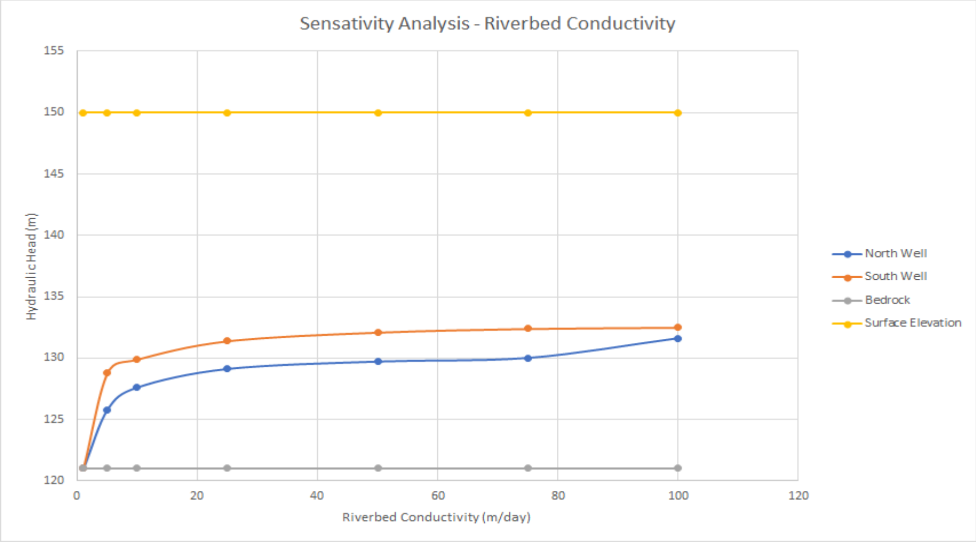


Figure 12: Sensitivity of Hydraulic Head to Riverbed Conductance

3.3. River Stage

Since the 1960's with the completion of the locks and dams on the Ohio River, the stage of the Ohio River at Cincinnati has not fallen below 25 ft (7.62 meters). The default value for river stage in this model was 8 meters. Testing a range from slightly below model default (7.62 meters, 25ft), up to severe flood stage of 21.36 meters (70 ft), the relationship between river stage and hydraulic head was quite linear (Figure 13).

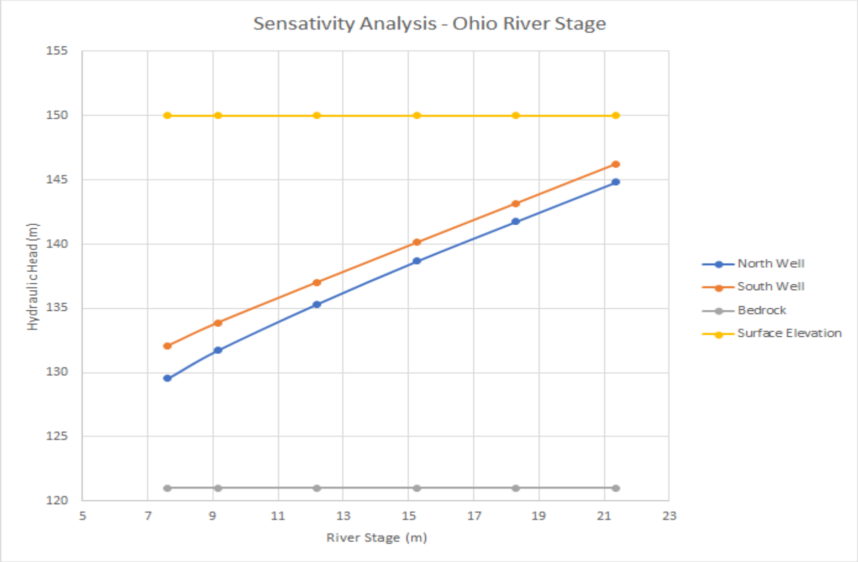


Figure 13: Sensitivity of Hydraulic Head to Ohio River Stage

4. Model Calibration

One of the most important steps in creating a groundwater model of a real world example is model calibration. Calibration is the process of changing parameter values based on known head values, such as water table elevation from piezometric, production, or other monitoring well. Calibration will help to account for real world discrepancies, such as heterogeneities in the composition of the aquifer materials. There are several parameters that HydroSynergistic Solutions recommends GCWW investigate further, to increase modeling accuracy.

Characterization of hydraulic conductivity will be one of the most important parameters. From the sensitivity analysis that was conducted, if values of hydraulic conductivity are lower than 250 m/day, then 100 MGD from on site wells would be infeasible according to the model. An additional refinement that could be made is to include a topographic map of the bedrock elevation, similar to what was created for surface elevation. Our project team was unable to find a bedrock map of the Kentucky side of the river. The bedrock elevation will be more accurate for showing how groundwater flows towards the Ohio River for the majority of the year, with the direction reversing only in time of heavy flood.

Our recommendation to Greater Cincinnati Water Works is to install a series of monitoring wells at the project site. From our discussion with Louisville Water Company, to measure the aquifer response before they installed additional production wells, they installed a pilot well after having a monitoring well in place for over 10 years, which was used to estimate hydraulic conductivity and drawdown.

5. Preliminary Engineering Design

5.1. Well Design

Both vertical wells and horizontal collector wells are commonly used in riverbank filtration applications, though horizontal collector wells were more recently developed and offer unique advantages. Because well screens cover the well’s laterals, they are distributed over a larger area than on a vertical well. This reduces the velocity of water passing through the screen, resulting in less clogging and lower head loss at the entrance (Ray *et al.*, 2002). Also, because the well screens can be located lower in the aquifer than on a vertical well, drawdown is not so limited (Ray *et al.*, 2002). Due to these advantages, horizontal collector wells have been selected for the proposed riverbank filtration system at the Richard Miller Treatment Plant.

Kansas City's Nearman Water Treatment Plant features one of the horizontal collector wells with the greatest capacity used for riverbank filtration in the US. The plant features one well with a 54 MGD capacity located along the Missouri River (Kansas City BPU, 2016). Because of the similar capacity and application, the Kansas City well serves as a basis for the design at RMTP, with alterations for geology and client needs.

Two horizontal collector wells are proposed along the Ohio River, each producing 50 MGD as identified from modeling. Each well caisson is constructed of reinforced concrete with a 6-meter internal diameter, based on the RBF collector well in Kansas City (USBR, 2006). The wells extend 26 meters in depth to an elevation of 124 meters, leaving 3 meters between the bottom of the caisson and the bedrock layer at 121 meters. From modeling, the water table is expected at an elevation of 131 meters within the well compared to 142 meters outside the range of drawdown. The general well design is shown in Figure 14.

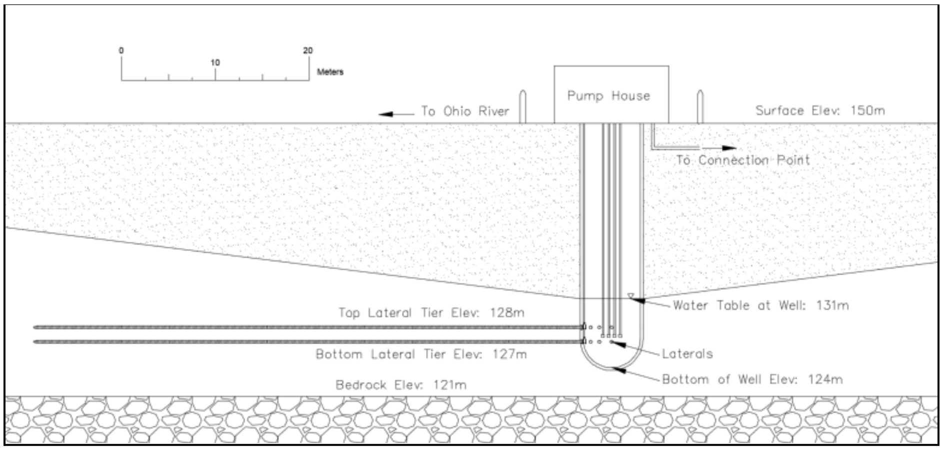


Figure 14: Preliminary Well Design

Figure 15 shows a cross-sectional view of a lateral tier. Each collector well features two tiers of laterals five feet apart in elevation with seven laterals on each, based on the Kansas City well design (Anonymous, 2000). The tiers are located at a moderate distance between the top of bedrock and the water table when accounting for drawdown, at an average elevation of 127.5 meters. The laterals are distributed horizontally 30° from the next lateral over a total range of 180°, and they range between 47 and 58 meters in length similar to the well in Kansas City (Anonymous, 2000). The sole 58-meter lateral points towards the Ohio River, and the others decrease in length gradually so that the two positioned perpendicular to the river are the shortest, with a length of 47 meters. By positioning the laterals over 180° facing towards the river, a pressure gradient is created to direct river water towards the well. Each lateral has a diameter of 12 inches and features a stainless steel, wire-wound screen along the entire length, as used in Louisville Water Company's RBF wells (USBR, 2006). This type of screen can be installed by the projection pipe method, offering stronger construction than the traditional installation using perforated pipe sections (Ray *et al.*, 2002). Additionally, each lateral will feature a control valve at the connection point to the caisson.

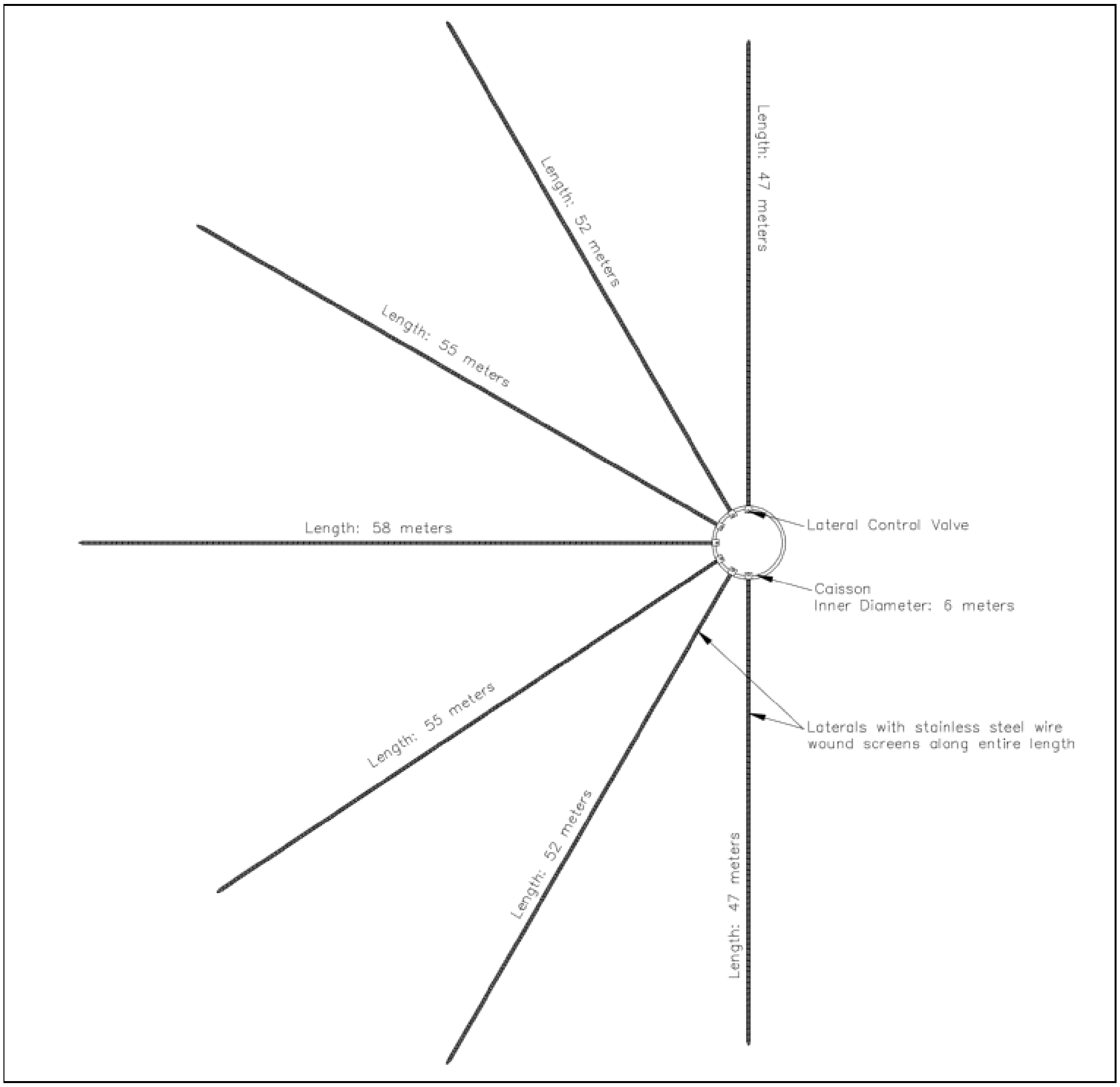


Figure 15: Cross Section of a Tier of Laterals

The proposed pump house is located at surface level, with a 3-meter tall wall surrounding to protect from flooding in a similar design to the current pump house along the river at RMTP.

5.2. Pipe Routing and Pump Design

Four vertical turbine diffusion vane pumps draw water from each well. Within the pump house, the flow from each pump is combined to a 36-inch cast iron pipe, which transports water to a manifold combining the flow from the two wells. A booster pump located just after the manifold provides head to convey flow through a 60-inch cast iron pipe to the connection point at the existing 60-inch cast iron pipe discussed with GCWW. The second existing 60-inch pipe is undisturbed by this project so it can continue to provide surface water when necessary. An aerial view of this flow process has been developed in AutoCAD Civil 3D and is shown in Figure 16.

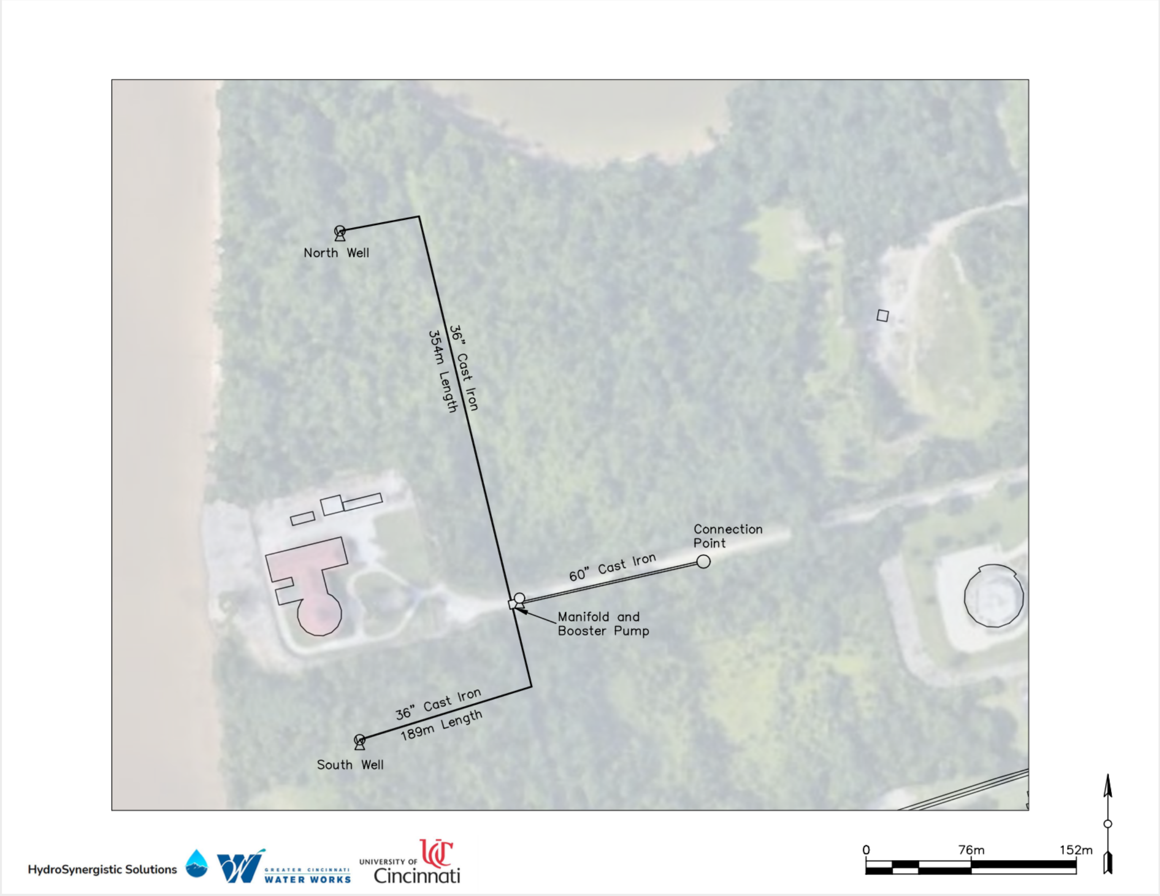


Figure 16: Overview of pipe routing design

The feasibility of this pipe routing design was verified in EPANET using the schematic shown in Figure 17. Junctions J_NW and J_SW represent the two wells, each shown with four pumps. J_MAN1 and J_MAN2 represent the manifold, and J_RES represents the existing pond reservoirs at RMTP. This model produced the nodal and link results shown in Tables 2 and 3, respectively. Because all flow and pressure values were positive throughout the system, the routing design is shown to be feasible and the pumps selected should provide enough head to transport the water from the proposed RBF wells to the existing reservoirs.

Based on the current head value calculated and the pump curve provided by SimFlo, the calculated horsepower based on the curve was 645. The pump curves are listed in the Appendix, Section 11.1.4. The headloss was estimated based on the elevation difference between water surface elevation, and headloss due to pipe friction.

An alternative design without a booster pump was also evaluated using EPANET, but the model recorded a negative pressure value between junctions J_MAN and J_RES. This indicates that the booster is necessary to successfully convey water to the reservoir.

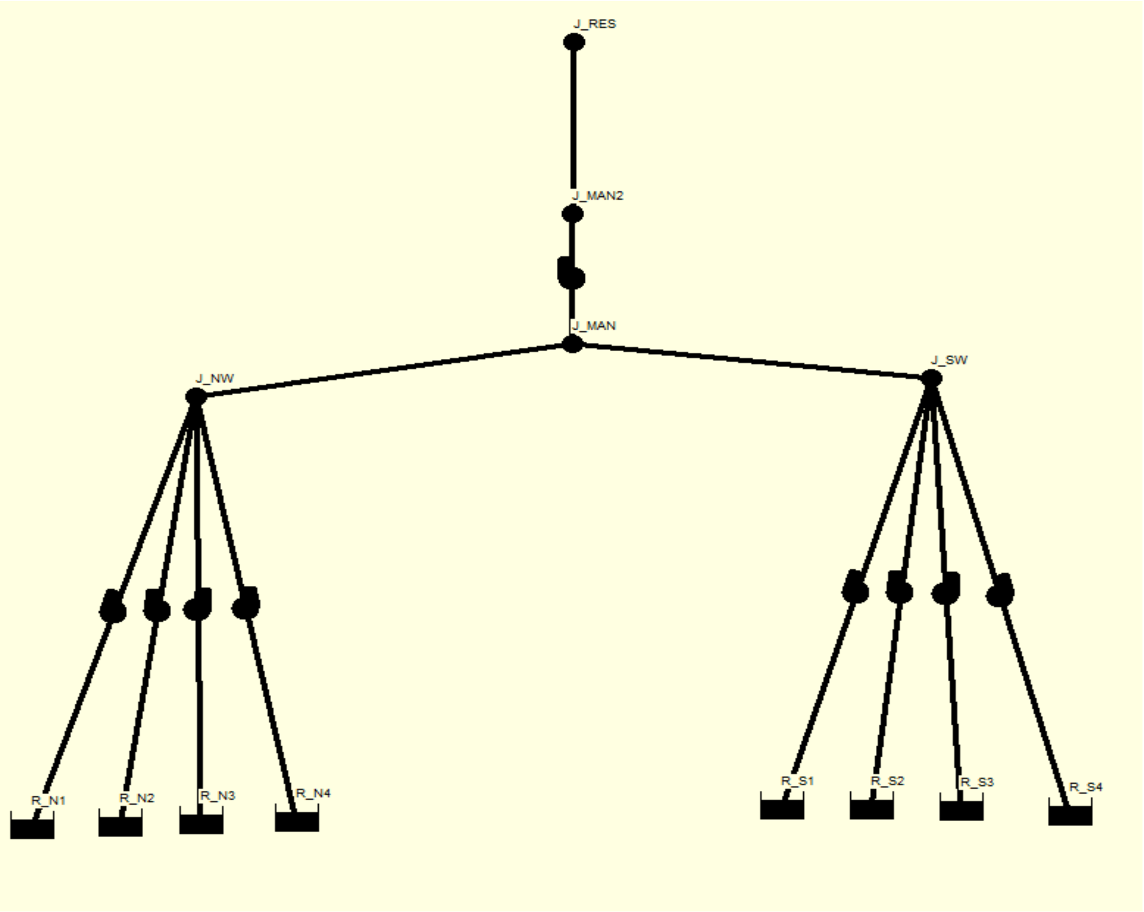
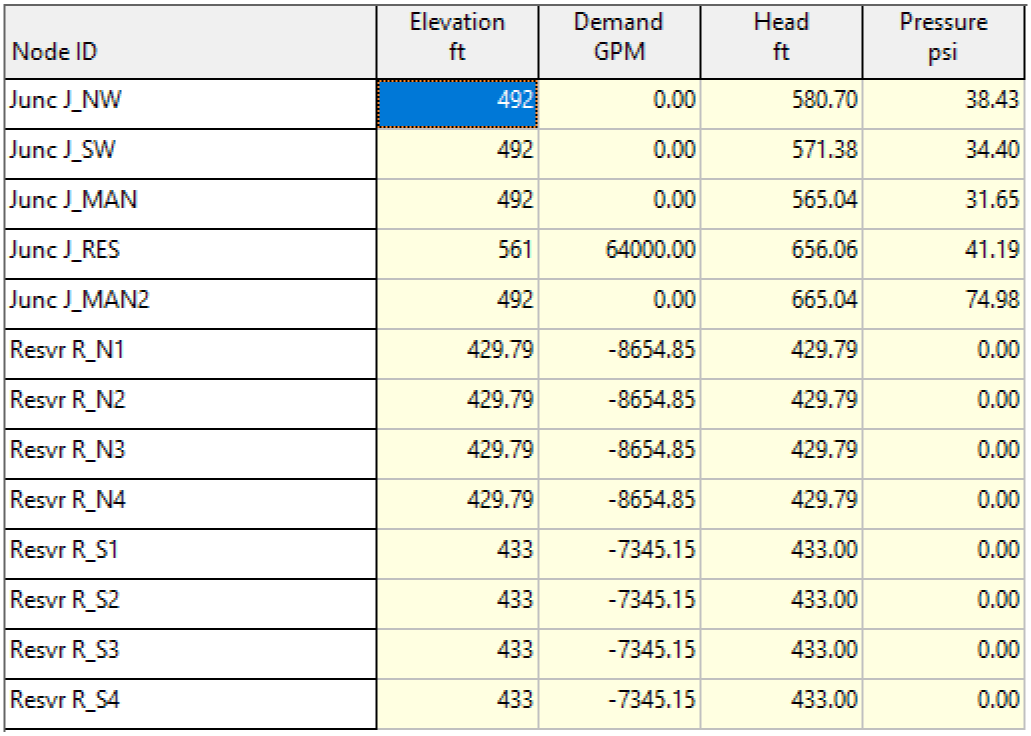


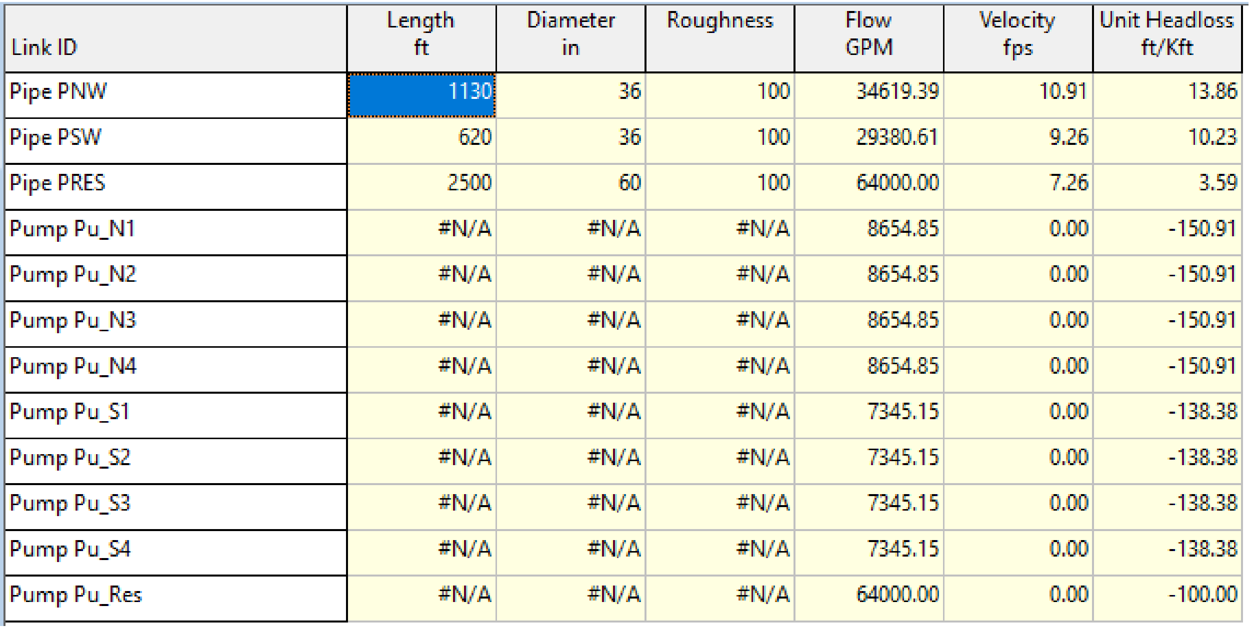
Figure 17: Schematic of Flow Routing created in EPANET

Table 2: Nodal results from running the model



Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc J_NW	492	0.00	580.70	38.43
Junc J_SW	492	0.00	571.38	34.40
Junc J_MAN	492	0.00	565.04	31.65
Junc J_RES	561	64000.00	656.06	41.19
Junc J_MAN2	492	0.00	665.04	74.98
Resvr R_N1	429.79	-8654.85	429.79	0.00
Resvr R_N2	429.79	-8654.85	429.79	0.00
Resvr R_N3	429.79	-8654.85	429.79	0.00
Resvr R_N4	429.79	-8654.85	429.79	0.00
Resvr R_S1	433	-7345.15	433.00	0.00
Resvr R_S2	433	-7345.15	433.00	0.00
Resvr R_S3	433	-7345.15	433.00	0.00
Resvr R_S4	433	-7345.15	433.00	0.00

Table 3: Link results from running the model



Link ID	Length ft	Diameter in	Roughness	Flow GPM	Velocity fps	Unit Headloss ft/Kft
Pipe PNW	1130	36	100	34619.39	10.91	13.86
Pipe PSW	620	36	100	29380.61	9.26	10.23
Pipe PRES	2500	60	100	64000.00	7.26	3.59
Pump Pu_N1	#N/A	#N/A	#N/A	8654.85	0.00	-150.91
Pump Pu_N2	#N/A	#N/A	#N/A	8654.85	0.00	-150.91
Pump Pu_N3	#N/A	#N/A	#N/A	8654.85	0.00	-150.91
Pump Pu_N4	#N/A	#N/A	#N/A	8654.85	0.00	-150.91
Pump Pu_S1	#N/A	#N/A	#N/A	7345.15	0.00	-138.38
Pump Pu_S2	#N/A	#N/A	#N/A	7345.15	0.00	-138.38
Pump Pu_S3	#N/A	#N/A	#N/A	7345.15	0.00	-138.38
Pump Pu_S4	#N/A	#N/A	#N/A	7345.15	0.00	-138.38
Pump Pu_Res	#N/A	#N/A	#N/A	64000.00	0.00	-100.00

6. Economic Analysis

6.1. Overview

The economic analysis for this project was conducted using data provided by GCWW. Data provided by GCWW consisted of: Alum and Polymer usage and cost, Total Raw Water Pumping, Recycled Backwash, Lamella Sludge Flow, Sludge Concentration, Lamella Sludge cost, and Reservoir cleaning cost. A construction cost estimation was provided by Michael Spicer from Moody’s of Dayton, a groundwater well contractor. The deep well turbine jet pump curve was also provided by Moody’s from SimFlo.

This analysis was primarily conducted to model the cost differences between their current system and the River Bank filtration system provided by HydroSynergistic Solutions. It incorporates the two 50 MGD wells located on the GCWW property. If the system does not turn a yearly profit, the main benefit would be the health and safety that the RBF system would provide to the citizens of Cincinnati.

6.2. Assumptions

The costs provided in this report are present costs, where the realistic timeline of this project is based on Louisville's B.E. Payne RBF Facility, would consist of at least 10 years of groundwater observation data to confirm feasibility. The cost of the observation well was out of the scope of HydroSynergistic Solutions, so the cost was not calculated. The cost of infrastructure related to the design of this project was not included in the final cost of the project. Such infrastructure would be the construction of the pump houses and the cost of labor for installation of new pipes, for example.

This analysis is based on the assumption that the TSS in the infiltrated water is essentially zero. This is based on the study conducted by Gutierrez, van Halem, and Rietveld, where the TSS in RBF water was removed at a 4 log magnitude.

The main components analyzed in this report are focused on the sedimentation process, where operation would change; we assume that the other processes of water treatment at GCWW such as the Granular Activated Carbon, the UV disinfection, and chlorination would remain unchanged.

The data supplied was based on the past three years. Since the average for each year in almost every metric is fairly constant, a hypothetical scenario was created using the 3 year data as a reference compared to RBF use and the costs associated. This assumption can be accurate in a short time frame, but not in long term applications. All missing values were filtered out of the data. GCWW has their own rate of electricity per KWH, which is not known. An electrical cost of 8 cents per Kilowatt hour was used by GCWW in supplied data, and was used in the calculations of this report.

6.3. Economic Analysis - Chemical Usage Savings

The main chemicals used by GCWW in flocculation and sedimentation are Alum and Polymer. The current average use of Alum and Polymer at GCWW is 13,207 lbs and 614 lbs, respectively. The average cost for both chemicals based on the data provided is $2,600/day. If GCWW uses their max 200 MGD treatment rate, their chemical costs will be reduced by 50%, as the TSS of induced infiltration water is close to 0. Because the average flow for GCWW is approximately 109 MGD, the chemical cost can be considered negligible if little surface water is used. If no surface water is used, then there should be no chemical cost. This is based on the assumption that no chemicals would need to be added to the system if 100% RBF water was used, though a small amount may be needed for compliance, and TSS could enter the system through the uncovered storage reservoirs.

Because groundwater consistently contains high amounts of positive ions in the water, Lime would be added to the process to soften the water. Without an observation well, the makeup of the groundwater is unknown, so predicting the Lime usage would be non-practical. This will be an additional cost to GCWW, but as the cost of Lime is $176/ ton, it can be predicted to be lower than the average chemical cost before RBF implementation. This can't be proven without a chemical makeup of the groundwater.

6.4. Economic Analysis - Potential Sludge Return Savings

Sludge is currently being returned to the Ohio River once it is removed from the system in the sedimentation process. It is possible that future regulation will reduce or prohibit sludge from being returned to the Ohio River, so induced infiltration with its low TSS concentration will greatly reduce sludge production, eliminating the need for sludge disposal alternatives.

By using the daily 3 year flow data provided by GCWW, a predicted sludge removal estimation and cost was created using the given lamella sludge flow and concentration data per day. Average sludge flow is 4.53 MGD. With the conservative assumption that 95% of sludge weight is water, the mean dry weight per day is 1369 lbs. The volume of the sludge is then calculated using a density of 84 lb/ft^3 to be approximately 40 cubic feet per day, or ⅛ of the typical volume of a dump truck.

If GCWW was to dry then remove their sludge, the cost of installing a waste dewatering unit, transportation, and storage will cost a significant sum of money. By using RBF water, only 0.02 MGD of sludge on average would be dried, instead of 4.53 MGD, where the average volume needed to be dried is 4.18 cubic feet per day, which comes out to be 0.21 cubic feet/day of dried sludge that would need to be disposed.

6.5. Economic Analysis - Electrical Usage

Based on the current head value calculated and the pump curve provided by SimFlo, the calculated horsepower based on the curve was 645. By converting that value to KiloWatt Hours, the calculated value becomes 483.75 KWH. Using a KWH rate used by GCWW in their data of 8 cents, the cost per day of one pump was determined to be $928.80. The total electrical use per day of all 8 pumps is

$7,430.40. We believe that our system will use more electricity than GCWW's current system due to the increased number of pumps and the greater head, as well as additional friction due to the nature of induced infiltration, but for the purposes of this report, we will assume that RBF water and current surface water use the same amount of electricity to be pumped to the storage reservoir.

6.6. Economic Analysis - Backwashing

Based on data provided by GCWW, the backwash of the filter beds are broken into two components based on need for backwash, turbidity and head loss. Head loss is the primary cause of backwashes being run by GCWW. Head loss of the pumps is caused by the filter bed becoming condensed due to the pressure differential. Turbidity refers to turbidity breakthrough, when the filter bed breaks through and deposits sediment into the waterline. Backwash also occurs due to mechanical reasons. Because mechanical backwashing would occur at a similar rate with or without RBF water, the savings in cost is low. The savings cost was calculated by calculating the mechanical head loss then adding a ratio amount of 9 MGD/ 109 MGD multiplies to head loss and turbidity cost to account that this would still occur, though the specific amount of turbidity breakthrough and head loss can only be accurate if experiments are run at GCWW.

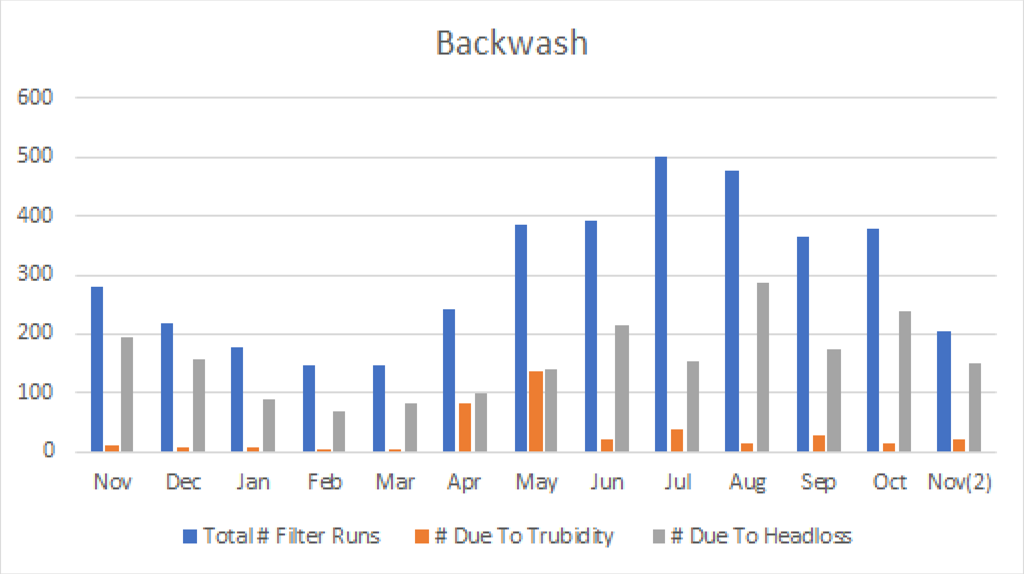


Figure 18: Backwashings per month

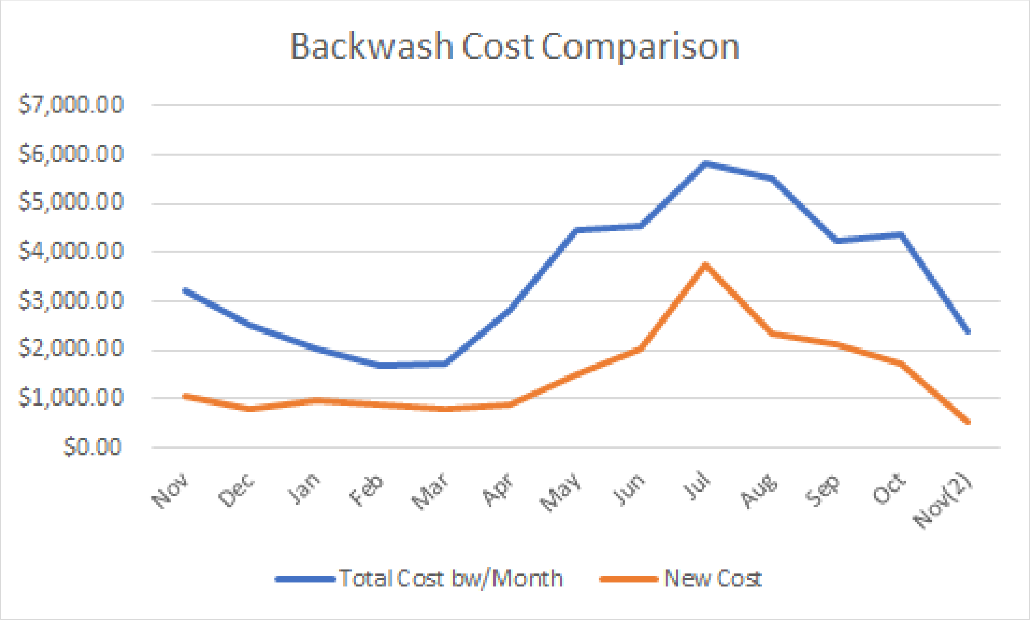
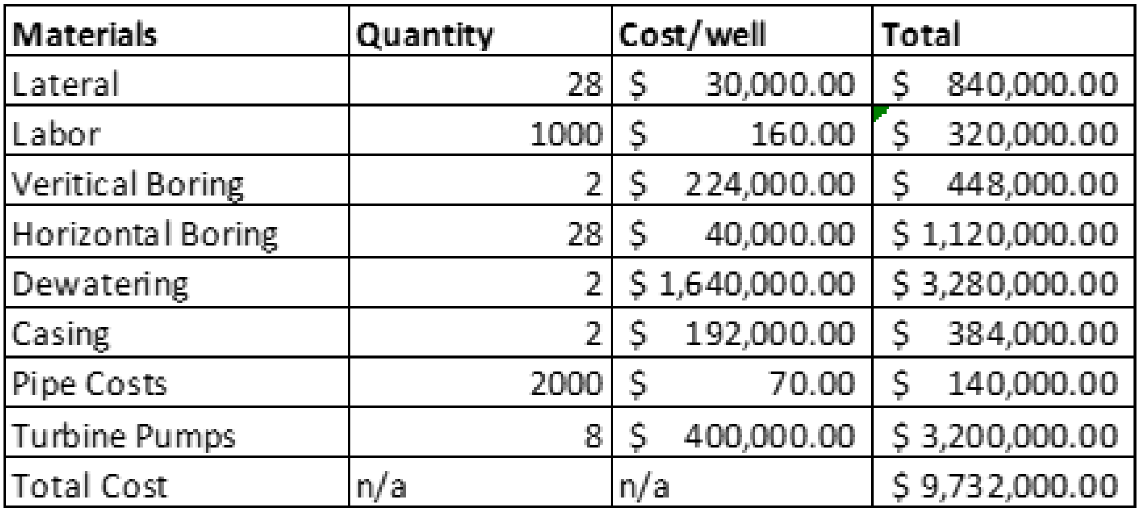


Figure 19: Cost Comparison of Backwash Per Month

6.7. Economic Analysis - Construction Costs

The cost estimation for the installation of the well and the pump were provided by Moody's of Dayton. The cost matrix is provided in Table 4.

Table 4: Cost Matrix



Materials	Quantity	Cost/well	Total
Lateral	28	$ 30,000.00	$ 840,000.00
Labor	1000	$ 160.00	$ 320,000.00
Veritical Boring	2	$ 224,000.00	$ 448,000.00
Horizontal Boring	28	$ 40,000.00	$ 1,120,000.00
Dewatering	2	$ 1,640,000.00	$ 3,280,000.00
Casing	2	$ 192,000.00	$ 384,000.00
Pipe Costs	2000	$ 70.00	$ 140,000.00
Turbine Pumps	8	$ 400,000.00	$ 3,200,000.00
Total Cost	n/a	n/a	$ 9,732,000.00

As seen, the main cost from the installation is from the dewatering process for both the vertical and horizontal bores. The labor cost uses the Davis Bacon

Wage rates to estimate the cost per labor hour. Pipe costs are the price per foot of 2000 ft of piping that will be required to convey water from the wells to the connection line in Figure 16. The total capital cost is estimated to be a little under $10 Million.

6.8. Economic Analysis - Payback Period

The total calculated expenses are shown in Table 5. This payback period does not incorporate GCWW's current electrical usage on the surface water pumps since the data is unknown. Their current electrical usage would be subtracted from the RBF electrical usage to get a price difference from the two systems. If their current electrical usage is equal to $1,800,831.99 or higher, then GCWW would have a positive payback period. For this report, it was assumed that the current electrical use by GCWW is equal to the new electrical output from the RBF system.

Backwashing was calculated with only the mechanical backwashing based on an assumption from the Clermont groundwater treatment facility where backwashing rarely occurs from turbidity breakthrough or head loss. A ratio of average new surface water usage to old daily surface water usage was multiplied to the head loss and turbidity to take these factors into account. This model uses the average MGD as 109, using 100 MGD as RBF water and 9 MGD as surface water. The ratio used would then be 9 MGD/ 109 MGD. GCWW provided a labor cost of $22,100 per year to clean the lamella sludge tanks. Because it is impossible to predict the change in sludge without experimentation, GCWW could have additional cost savings up to the specified amount if the RBF system has no sludge production.

Overall, this new system will save GCWW approximately $911,264.01 per year in operational costs. This number is approximated using the data given to us by GCWW. In table 5, the costs are labeled as positive and the savings are labeled in parenthesis. The payback period for GCWW to make money from this system is approximately 13 years, assuming an inflation of 3%.

Table 5: Payback Period Cost Estimation

Construction	$ 9,732,000.00
Electrical	$ -
Backwash	$ (19,359.53)
Chemical	$ (891,904.48)
Operational Costs Per Year	$ (911,264.01)
Payback period	13 years

7. Permitting and Compliance

Investigation into the governing regulations revealed the several documents and permits that will be necessary and some that may be required depending upon the results of pre-construction investigations. There is considerable confidence that the following permits will be required due to the site being in the wetland of the Ohio River and over 1 acre in size, a Section 10 Rivers and Harbors Act Permit from Army Corps of Engineers and a Construction General Permit from the EPA. The Construction General Permit will require a developed and approved Storm Water Pollution Prevention Plan (SWPPP) and a Spill Prevention, Control, and Countermeasure plan (SPCC). Both of these plans will need to be created based on the specific plans of construction and onsite equipment, so further recommendations on their contents cannot be made. A Section 401 Clean Water Certification will also be required and if dredging material is to be dumped into the waterway a CWA Section 404 Permit will also be necessary. This project will need approval from the director of the Ohio EPA and the application for this approval will need to include a Notice of Intent to change operations of a public water system, the new water source, and the siting of the wells within the floodplain.

An Environmental Assessment will also be necessary to determine the effects of the construction on the surrounding environment, depending on the impact findings an incidental take permit may be necessary instead of a Construction General Permit with an impact statement submitted to the EPA. As for changes in filtration operations, due to the groundwater being under the direct influence of surface water, sandbed filtration will still be required even if 100% of the plant's intake is from the RBF wells, this is based on the Ohio Administrative Code rule 3745-81-73.

8. Final Discussion

After modeling the project area with ModelMuse and determining that two 50 MGD wells would be feasible, our group created a flow diagram and model using EPANET that would connect to GCWW's existing system and convey the water from induced infiltration to the storage reservoirs. An alternative groundwater model was created in ModelMuse for two more wells located on available land at Coney Island. A sensitivity analysis showed that the parameter that influenced the response of the water table the most was hydraulic conductivity, and recommendations were made to GCWW on specific site parameters and testing that should be done in the future.

A preliminary design was created for two 26-meter deep horizontal collector wells. Each collector well features laterals consisting of wire-wrapped continuous slot screens. The laterals are directed towards the Ohio River to draw induced river water. A pipe routing system featuring a booster has also been developed and verified in EPANET. It was found that the head at junction points were between 593 and 604 feet, while the head at the aquifer was found to be 429 to 433 feet. The flow and pressure values were found to be feasible once a booster pump was added after the manifold.

Construction costs were estimated from input by Moody Inc. out of Dayton and Louisville Water Company's B.E. Payne Treatment facility.

A discussion of permitting requirements for the installation of wells, land clearing, and proximity to the Ohio River were discussed and should be considered before any construction begins.

Induced Infiltration is a feasible and robust water collection system that our group believes will create a more robust source of drinking water for the City of Cincinnati. This investigation and preliminary design uses groundwater modeling, flow routing, economic analysis, and permitting considerations to show how induced infiltration could be implemented at the Richard Miller Treatment Plant.

9. Acknowledgements

HydroSynergistic Solutions would like to thank the following individuals for their guidance and involvement with this project:

- Dr. Drew McAvoy at the University of Cincinnati for providing guidance during the semester
- Mr. Bruce Witteberry at Greater Cincinnati Water Works for organizing the group and providing feedback
- Prof. Reza Soltanian at the University of Cincinnati for giving critical insight on modeling groundwater
- Haishan Piao, Richard Stuck, and Jim Springer for their data collection
- Louisville Water Company, Chris Bobay, Eric Zhu, and Larry Bryant
- Michael Spicer, Moody Inc., Dayton, Ohio

10. References

10.1. Academic References

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10.2. Software References

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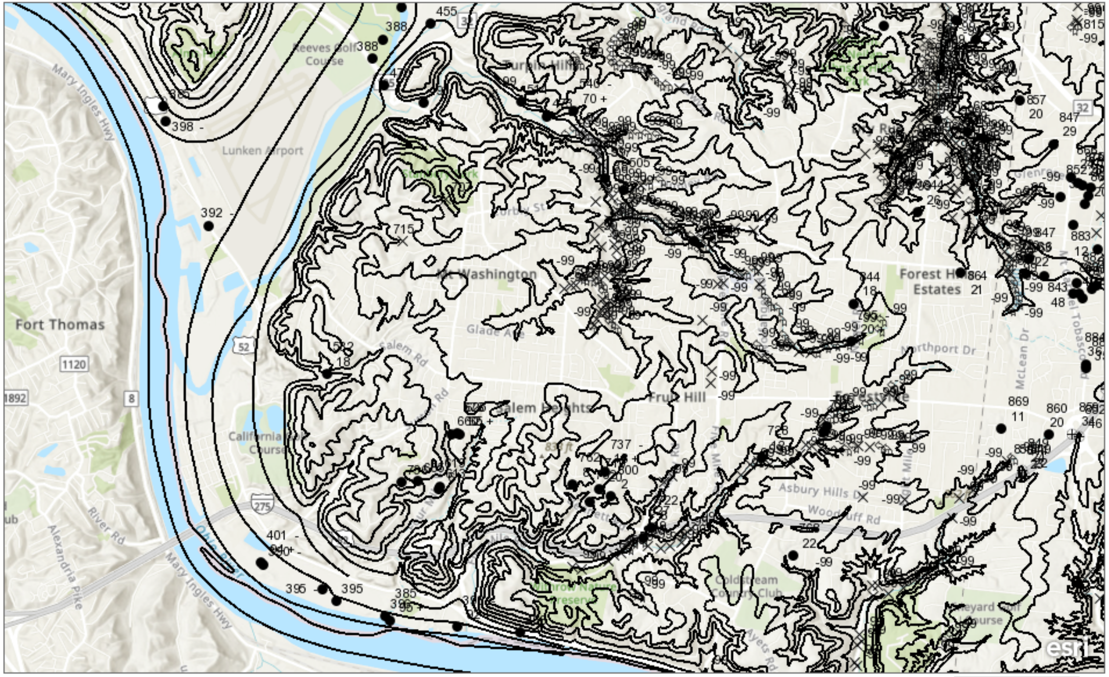
11. Appendices

11.1. Appendix A: Data Collected

11.1.1. Topographical Data

Bedrock Topography of Ohio 24K (ODNR-DGS)



This dataset is used to depict the buried bedrock topography of Ohio. The dataset is an essential component in mapping the bedrock geology of Ohio.

Esri, NASA, NGA, USGS, FEMA | LINK-GIS/PDS, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA | Ohio Department of Natural Resources-Division of Geological Survey

Figure 20: Bedrock Elevation Map of Project area

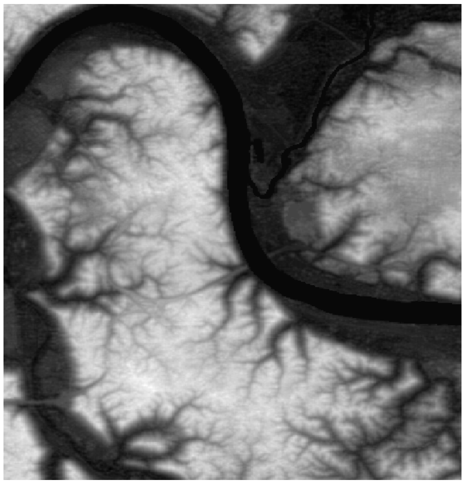


Figure 21: Topographical Map used in creation of the model (Source: ODNR)

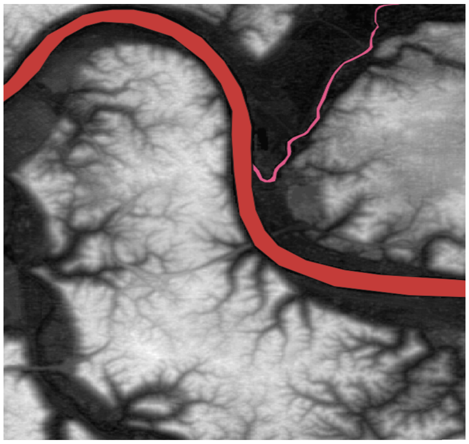


Figure 22: Topographic Map used in creation of the model with Ohio River and Little Miami Rivers traced as Shapefiles. The shapefiles were imported into model muse as objects.

11.1.2. Hydrogeologic Data

Table 6: Estimation of Hydraulic Conductivity

Component	K low (m/sec)	K high (m/sec)	% Composition
Gravel	0.0003	0.03	0.15
Coarse Sand	0.0000009	0.006	0.3
Medium Sand	0.0000009	0.0005	0.2
Fine Sand	0.0000002	0.0002	0.1
Silt	0.000000001	0.00002	0.05
Till	0	0.000002	0.05
Clay	0	0.0000000047	0.05
(rocks)			
Karst	0.000001	0.02	0.05
Limestone	0.000000001	0.000006	0.05

The values of K was calculated by averaging the high and low K values of each component, and multiplying the number by % composition, then adding all parts together to obtain:

K (m/s) = .0037

K (m/day) = 322

11.1.3. Sensitivity Data

Table 7: Sensitivity Analysis Data on Extraction Amount

Extraction Amount (MGD)	North Well (m)	South Well (m)
5	145.25	145.67
15	142.05	142.8
25	138.79	139.9
35	135.44	136.99
45	131.97	134.05
50	129.1	131.4
55	128.29	131.08
60	126.38	129.58
65	124.42	128

Table 8: Sensitivity Analysis on Hydraulic Conductivity

Hydraulic Conductivity (m/day)	North Well (m)	South Well (m)
50	-	-
100	121	-2
150	121	121
200	123.9	123.8
250	124.8	128
300	128.8	131.52
350	131.58	133.71
400	133.5	135.3
450	135	136.5
500	136.2	137.5

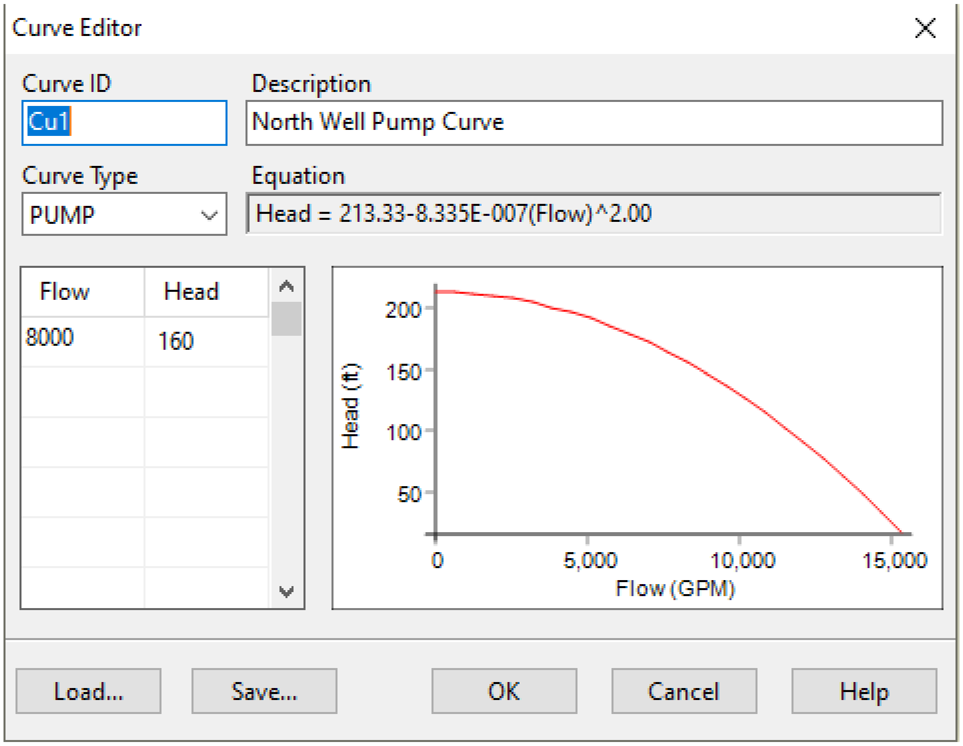
Table 9: Sensitivity Analysis Data on Riverbed Conductance

Conductance (m/day)	North Well (m)	South Well (m)
1	121	121
5	125.8	128.8
10	127.6	129.9
25	129.1	131.4
50	129.7	132.1
75	130	132.4
100	131.6	132.5

Table 10: Sensitivity Analysis Data on River Stage

Stage (m)	North Well (m)	South Well (m)
7.62	129.55	132.1
9.14	131.73	133.88
12.19	135.34	137.04
15.24	138.67	140.13
18.28	141.75	143.18
21.36	144.83	146.26

11.1.4. Pump Curves for Flow Routing


Curve Editor

Curve ID: Cu1

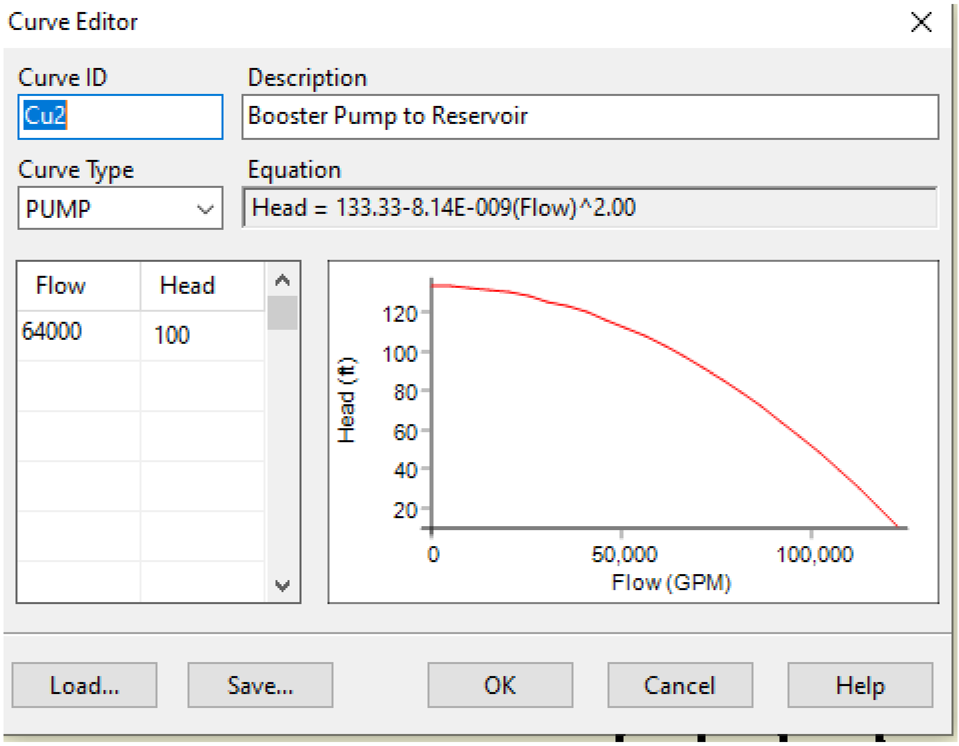
Description: North Well Pump Curve

Curve Type: PUMP

Equation: Head = 213.33-8.335E-007(Flow)^2.00

Flow	Head
8000	160

Figure 23: North Well Pump curve generated in EPANet


Curve Editor

Curve ID: Cu2

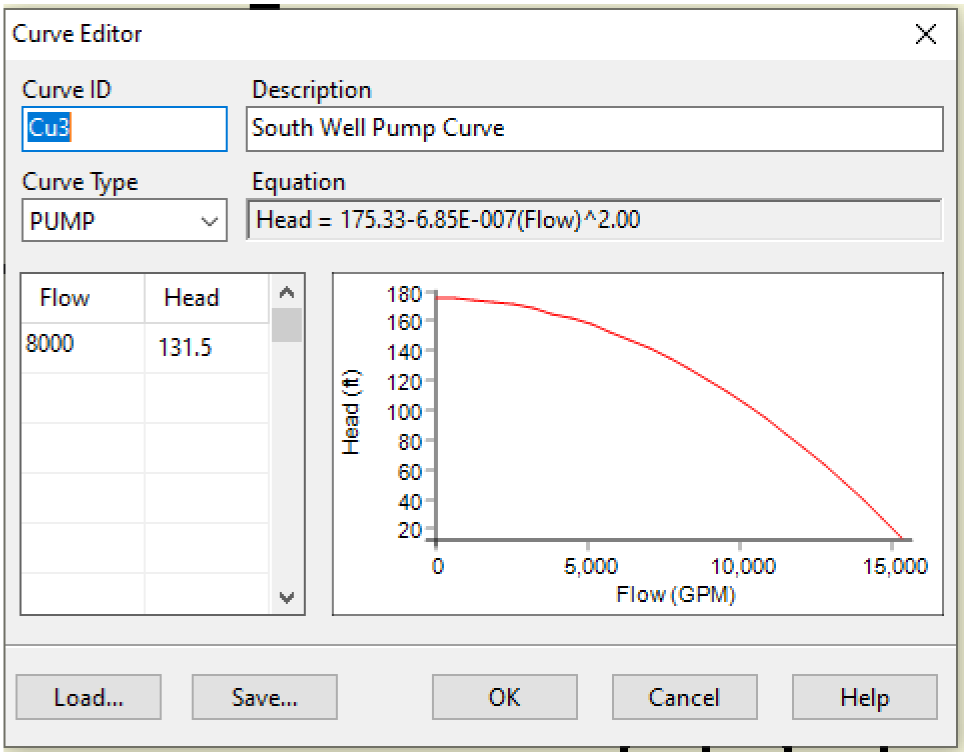
Description: Booster Pump to Reservoir

Curve Type: PUMP

Equation: Head = 133.33-8.14E-009(Flow)^2.00

Flow	Head
64000	100

Figure 24: Booster Pump curve generated in EPANeT



Curve ID: Cu3

Description: South Well Pump Curve

Curve Type: PUMP

Equation: Head = 175.33-6.85E-007(Flow)^2.00

Flow	Head
8000	131.5

Figure 25: South Well pump curve generated in EPANet

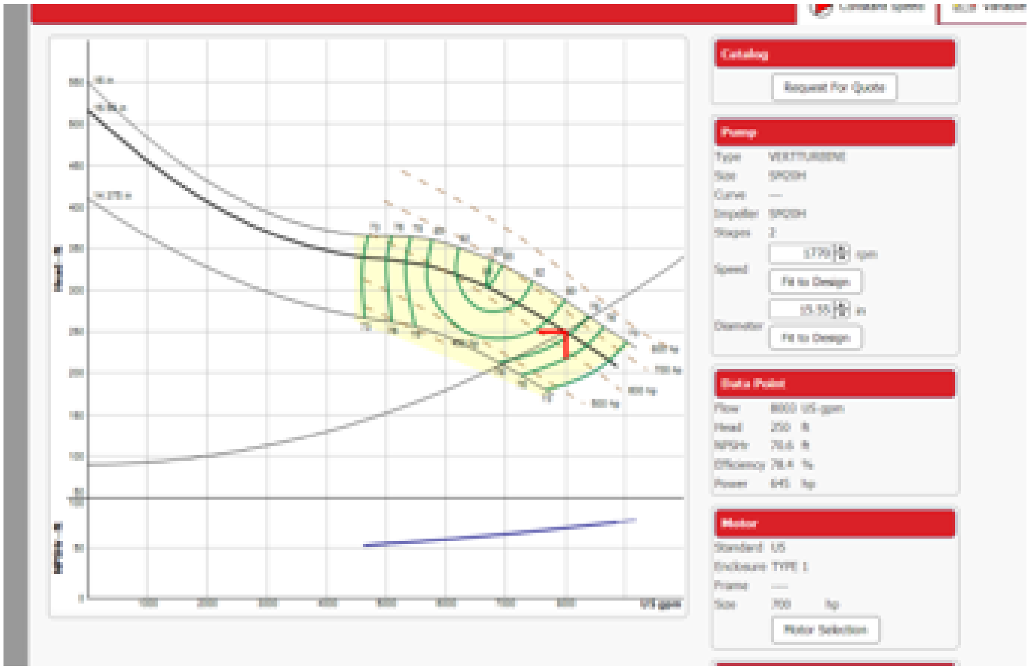
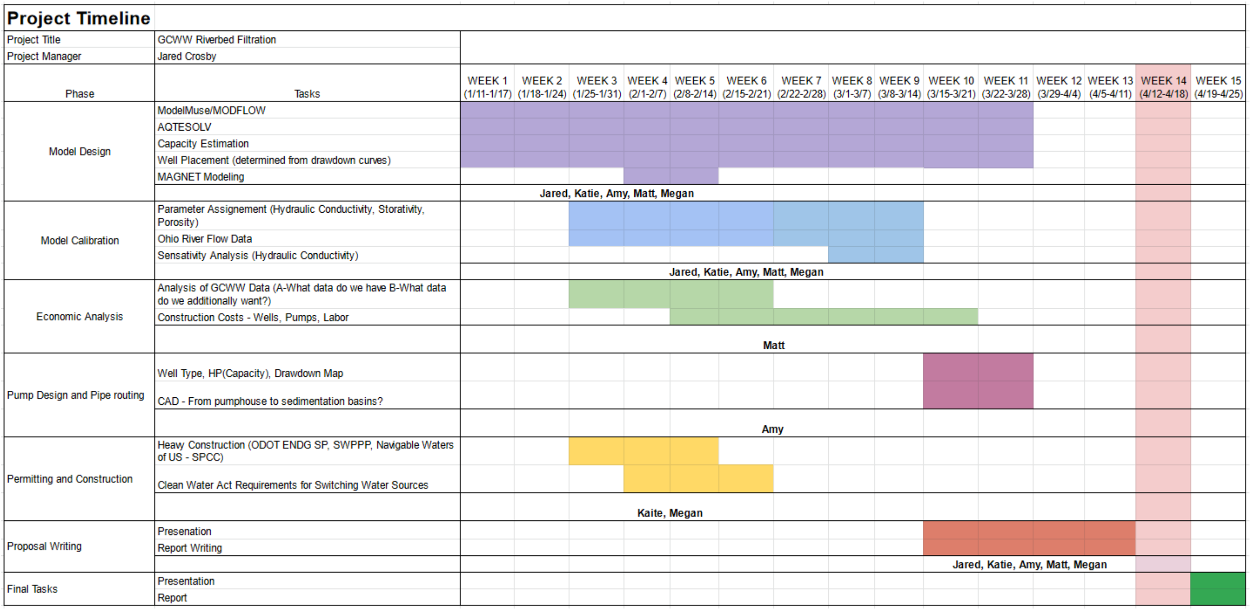


Figure 26: Pump Curve developed in SimFlo. The resolution is small, but can be accessed at:

https://simflo.pump-flo.com/app/pump.aspx?sid=simflo&CATID=741&SELID=11206210&PSID=125997451

12. Appendix B: Gantt Chart for Spring Semester

12.1.1. Appendix B: Gantt Schedule for Design Phase



Project Timeline																
Project Title	GCWW Riverbed Filtration															
Project Manager	Jared Crosby															
Phase	Tasks	WEEK 1 (1/11-1/17)	WEEK 2 (1/18-1/24)	WEEK 3 (1/25-1/31)	WEEK 4 (2/1-2/7)	WEEK 5 (2/8-2/14)	WEEK 6 (2/15-2/21)	WEEK 7 (2/22-2/28)	WEEK 8 (3/1-3/7)	WEEK 9 (3/8-3/14)	WEEK 10 (3/15-3/21)	WEEK 11 (3/22-3/28)	WEEK 12 (3/29-4/4)	WEEK 13 (4/5-4/11)	WEEK 14 (4/12-4/18)	WEEK 15 (4/19-4/25)
Model Design	ModelMuse/MODFLOW	■	■	■	■	■	■	■	■	■	■	■				
	AQTESOLV	■	■	■	■	■	■	■	■	■	■	■				
	Capacity Estimation	■	■	■	■	■	■	■	■	■	■	■				
	Well Placement (determined from drawdown curves)	■	■	■	■	■	■	■	■	■	■	■				
	MAGNET Modeling				■	■										
				Jared, Katie, Amy, Matt, Megan												
Model Calibration	Parameter Assignement (Hydraulic Conductivity, Storativity, Porosity)			■	■	■	■	■	■	■						
	Ohio River Flow Data			■	■	■	■	■	■	■						
	Sensativity Analysis (Hydraulic Conductivity)								■	■						
							Jared, Katie, Amy, Matt, Megan									
Economic Analysis	Analysis of GCWW Data (A-What data do we have B-What data do we additionally want?)			■	■	■	■									
	Construction Costs - Wells, Pumps, Labor					■	■	■	■	■	■					
							Matt									
Pump Design and Pipe routing	Well Type, HP(Capacity), Drawdown Map										■	■				
	CAD - From pumphouse to sedimentation basins?										■	■				
							Amy									
Permitting and Construction	Heavy Construction (ODOT ENDG SP, SWPPP, Navigable Waters of US - SPCC)			■	■	■										
	Clean Water Act Requirements for Switching Water Sources				■	■	■									
					Kaite, Megan											
Proposal Writing	Presenation										■	■	■	■		
	Report Writing										■	■	■	■		
												Jared, Katie, Amy, Matt, Megan				
Final Tasks	Presentation															■
	Report															■

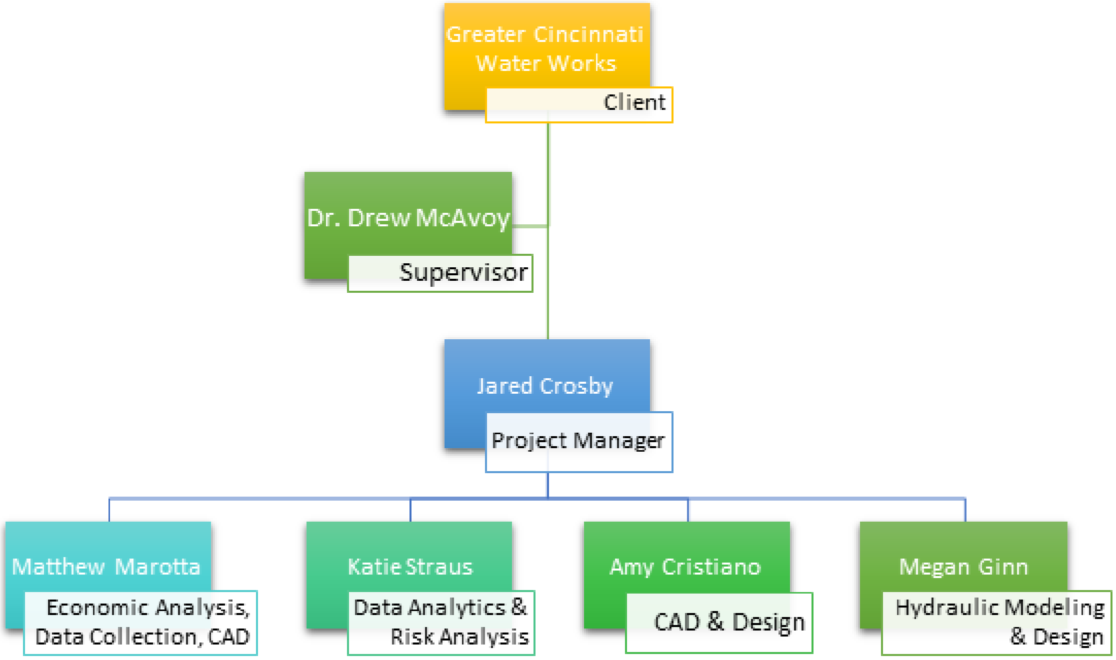
13. Appendix C Vision Statement and Team Organization

13.1. Vision Statement

HydroSynergistic Solutions

HydroSynergistic Solutions provides quality drinking water through the disciplined use of hydraulic engineering concepts. We prioritize community safety while delivering economic solutions to our clients.

Organizational Chart



Engineer Biographies

Amy Cristiano, CAD and Design Specialist

Amy Cristiano is a fifth year Environmental Engineering student at the University of Cincinnati. She has worked at Prime AE in Akron, working on bridge and roadway design. She then worked at Greater Cincinnati Water Works as a Survey Intern and assisted with field related surveying tasks. Her final Co-op was at AECOM, where she worked on environmental remediation projects.

Jared Crosby, Project Manager and Groundwater Modeling

Jared Crosby is a 5th year Environmental Engineering student at the University of Cincinnati. He has worked at Marathon Petroleum Corp. in Findlay, Ohio and at Duke Energy Corp. in Cincinnati, Ohio where he worked in permitting and compliance. He currently works in the lab of Dr. David Wendell at the University of Cincinnati where his projects include designing environmental sensors for endangered species and COVID-19 detection at the University. After graduation he will be working for the Utah Department of Environmental Quality as an Air Permitting Engineer.

Megan Ginn, Hydraulic Modeling, GIS Modeling, and Design Specialist

Megan Ginn is a fifth year Environmental Engineering student at the University of Cincinnati. She is also pursuing a minor in biological sciences and participating in the Accelerated Engineering Degree Program to complete a Master of Science degree while finishing undergraduate work. She has completed co-ops with the Hamilton County Soil and Water Conservation District, Groundwater Consortium, and Fishbeck. Most recently, she worked as a contractor to the USEPA, where she co-authored two journal articles and contributed to research in nutrient recovery.

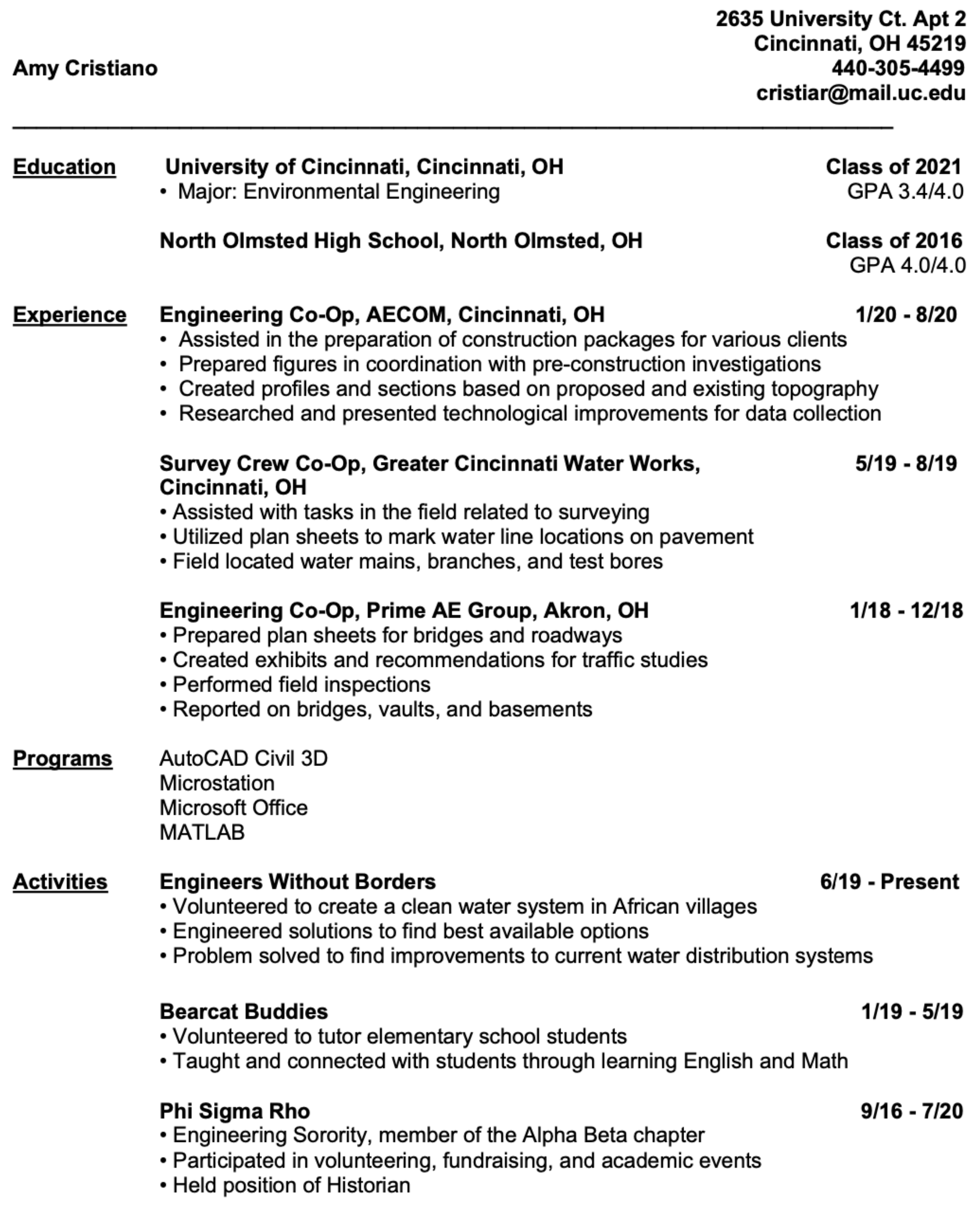
Catherine Straus, Data Analytics and Risk Analysis Specialist

Catherine (Katie) Straus is a fifth year Environmental Engineering student and Track and Field Athlete at the University of Cincinnati. She is adding a minor in computational sciences and applying for graduate degrees in Oceanic and Atmospheric Sciences. She has completed five co-ops, two with Kroger's Environmental Compliance team, two as a researcher, and another partial term with the consulting firm PSARA. She is in an ongoing time-series data analytics research project through the University for Cincinnati's Metropolitan Sewer District.

Matthew Marotta, Economic Analysis, Data Collection, GIS Modeling, and CAD Specialist

Matthew Marotta is a 5th year Environmental Engineering student at the University of Cincinnati pursuing a dual degree in a Masters of Business Administration by participating in the ACCEnD program. He has completed co-op rotations with Rough Brothers, Inc., where he worked as a systems engineer, technical salesman, project manager, and HVAC/CAD Designer. He has currently accepted a full time offer with Kimley-Horn and is relocating to Orlando post graduation to work as a water resources and wastewater engineer.

Engineer Resumes



2635 University Ct. Apt 2
Cincinnati, OH 45219
440-305-4499
cristiar@mail.uc.edu

Amy Cristiano

Education

University of Cincinnati, Cincinnati, OH **Class of 2021**
- Major: Environmental Engineering GPA 3.4/4.0

North Olmsted High School, North Olmsted, OH **Class of 2016**
GPA 4.0/4.0

Experience

Engineering Co-Op, AECOM, Cincinnati, OH **1/20 - 8/20**
- Assisted in the preparation of construction packages for various clients
- Prepared figures in coordination with pre-construction investigations
- Created profiles and sections based on proposed and existing topography
- Researched and presented technological improvements for data collection

Survey Crew Co-Op, Greater Cincinnati Water Works, Cincinnati, OH **5/19 - 8/19**
- Assisted with tasks in the field related to surveying
- Utilized plan sheets to mark water line locations on pavement
- Field located water mains, branches, and test bores

Engineering Co-Op, Prime AE Group, Akron, OH **1/18 - 12/18**
- Prepared plan sheets for bridges and roadways
- Created exhibits and recommendations for traffic studies
- Performed field inspections
- Reported on bridges, vaults, and basements

Programs

AutoCAD Civil 3D
Microstation
Microsoft Office
MATLAB

Activities

Engineers Without Borders **6/19 - Present**
- Volunteered to create a clean water system in African villages
- Engineered solutions to find best available options
- Problem solved to find improvements to current water distribution systems

Bearcat Buddies **1/19 - 5/19**
- Volunteered to tutor elementary school students
- Taught and connected with students through learning English and Math

Phi Sigma Rho **9/16 - 7/20**
- Engineering Sorority, member of the Alpha Beta chapter
- Participated in volunteering, fundraising, and academic events
- Held position of Historian

Jared Crosby

479-899-1089 | crosbyje@mail.uc.edu

Education **Class of 2021**

B.S. ENVIRONMENTAL ENGINEERING, UNIVERSITY OF CINCINNATI

Professional Experience

STUDENT RESEARCHER – UNIVERSITY OF CINCINNATI, CINCINNATI, OH **MAR 2020 – APRIL 2021**

· Assisted in development of transgenic zebrafish for biological development/environmental indicator
· Sampled and ran PCR analysis on freshwater rivers for eDNA detection of endangered species
· Assembled New Brunswick Bioflow Bioreactor for yeast cultivation

ENVIRONMENTAL PROGRAMS CO-OP – DUKE ENERGY CORP. CINCINNATI, OH **MAY 2019 – AUG 2019 & AUG 2018 – DEC 2018**

· Recommended compliance reclassification from heavy metals analysis at gas turbine generation sites
· Projected regulatory classification for co-firing natural gas at coal plants under CO2 regulations
· Managed groundwater data entry for dozens of duke energy monitoring wellfields
· Audited SPCC plans at multiple Duke Energy sites

TERMINAL, TRANSPORT, & RAIL CO-OP – MARATHON PETROLEUM CORP. FINDLAY, OH **JAN 2018 – MAY 2018**

· Conduced economic and environmental emissions analysis on tank seal upgrades using TANKS 4.09D
· Detected VOC emissions from leaking tank seals with FTIR camera as preparation for future compliance
· Created training and reference documents on common haz-waste streams for terminal operators
· Presented to terminal & refinery teams on new EPA hazardous waste manifest tracking website

Projects/Skills

· Team lead on Capstone Project "Evaluating Feasibility of Induced Infiltration at Greater Cincinnati Water Works"
· ArcGIS, MODFLOW, Microsoft Office (Excel, PowerPoint, etc.), HEC-RAS, EPA PMF, EPA SWMM, Matlab, R, Python

Awards and Activities

S-STEM SCHOLAR **JAN 2019 – APRIL 2021**
· ACCEND program, concurrent Master and Bachelor of Science Degrees
· Maintain 3.2 GPA and 15 hours of STEM based tutoring each semester

CINCINNATUS SCHOLAR **AUG 2016 – APRIL 2021**
· Maintained 3.2 GPA and 30 hours of annual community service

THE UNIVERSITY OF CINCINNATI | DIVISION 1 NCAA SWIM & DIVE **AUG 2016 – SEPT 2017**
· Devoted 30+ hours a week to practice, strength and conditioning, meetings, travel, competition, and academics
· Men's Freshman team captain, providing communication with coaching staff, organizing team community service events, and maintaining team relationships

BEARCAT BUDDIES **JAN 2019 – DEC 2019**
· Tutored local Cincinnati elementary students in math, reading, and science

RAC AQUAHAWGS CLUB SWIM TEAM **AUG 2005 – AUG 2016**

Future Availability: Summer 2021 (Full Time)

Megan Ginn

513.638.4524 | ginnme109@gmail.com | linkedin.com/in/megan-ginn

Education

University of Cincinnati **Class of 2021**

Bachelor of Science, Environmental Engineering

- Minor: Biological Sciences
- Honors: Dean's List (7/7 Semesters), Cincinnatus Scholar (August 2016 – Present)

University of Cincinnati **Class of 2021**

Master of Science, Environmental Engineering

- Accelerated Engineering Degree Program: Completed graduate and undergraduate courses simultaneously

Experience

Pegasus Technical Services (Contractor to USEPA), Research Assistant November 2019 – Present

- Co-authored article, *A review on 3D printing techniques for environmental applications*
    - Accepted to *Current Opinion in Chemical Engineering*
- Performed literature review on nutrient recovery technologies to identify areas for research
- Reviewed technical articles and made revisions for content and clarity

Fishbeck, Thompson, Carr & Huber, Seasonal Technician August 2018 – August 2019

- Created base maps from survey data using AutoCAD Civil 3D to show all utilities in project areas
- Determined repairs to be made to sewers and manholes using CCTV and manhole inspection data
- Modeled sanitary and storm sewer flow from remote monitoring data using Microsoft Excel

Hamilton to New Baltimore Groundwater Consortium, Intern March 2018 – August 2018

- Chaired Race For Global Water 5K committee to raise $11,000 for Water For People
- Coordinated public education events including school visits, field trips, and festivals
- Managed public outreach and image through the Consortium website and social media

Hamilton County Soil and Water Conservation District, Intern January 2018 – May 2018

- Managed records of student contest proposals, scores, budgets, and contacts
- Mentored high school students in proposal writing for an environmental contest
- Planned finalist presentation, reception, and recognition ceremony for over 100 attendees

Cincinnati Nature Center, Camp Counselor June 2017 – August 2017

- Guided children through outdoor programs while encouraging passion and stewardship
- Developed engaging and safe camp activities with a team of eight co-counselors
- Coached high school aged volunteers by providing feedback in leadership development

Skills

AutoCAD Civil 3D, ArcGIS, MATLAB, Microsoft Office Suite, Asset Management, Environmental Education

Involvement

University of Cincinnati Bearcat Bands August 2016 – Present

- Section Leader (2019 – Present)

Tau Beta Sigma, National Honorary Band Sorority January 2017 – Present

- Secretary (2020 – Present); Historian (2018 – 2020)

Tau Beta Pi, Engineering Honorary March 2019 – Present

- Secretary (2020 – Present)

Mortar Board, National Honorary for College Seniors March 2020 – Present

MATTHEW L. MAROTTA

Mobile: 513-429-9666 • Email: marottml@mail.uc.edu • www.linkedin.com/in/matthew-marotta

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Education

University of Cincinnati • Cincinnati, OH **Expected Graduation May 2021**

Bachelor of Science, Environmental Engineering GPA: 3.48/4.00

Master of Business Administration, ACCEND Scholar GPA: 3.90/4.00

- Pursuing Carl H. Lindner MBA degree alongside undergraduate degree

Work Experience

HSE Engineer CO-OP• Cummins Corporation • Mineral Point, WI **May 2020 – August 2020**

- Offer rescinded due to COVID-19

Systems Engineer • Rough Brothers, Inc. • Cincinnati, OH **May 2019 – August 2019**

- Devised a new product that was manually built over a 12-week span, worth $100,000
- Traveled with salesmen across the United States providing technical assistance for potential customers and engineered solutions to various problems that arose
- Engineered an irrigation system for a project in Illinois that entailed product selection, fluid engineering calculations, and a completed professional drawing set sent to customers
- Implemented a new standard of irrigation and systems design drawings for Rough Brothers, Inc. that has increased efficiency of system drawing set completion

Systems Engineer • Rough Brothers, Inc. • Cincinnati, OH **August 2018 – December 2018**

- Designed various systems in AutoCAD to incorporate with many different greenhouse structures, working directly with customers and vendors for irrigation, lighting plans, bench layouts, odor control, heating and cooling, environmental controls, etc.
- Collaborated in a team to provide and integrate various multimillion-dollar systems to customers, while providing technical support and working directly with the installers and MEP's on site
- Traveled to Salt Lake City, UT, and provided an on-site installation of a new crop support system to a pre-existing structure

Systems Engineer • Rough Brothers, Inc. • Cincinnati, OH **January 2018 – May 2018**

- Selected to travel to California for two weeks to be trained on HVAC CAD design and pipe engineering to provide expertise to the company and educate co-workers
- Supplied multiple design contracts and drawing sets for irrigation, bench layout, lighting layout, and environmental controls to salesman that used them as tools to increase sales
- Aided in the founding and technical marketing of a new sub-company, called Tetra Indoor Grow

Leadership & Involvement

Undergraduate Research Assistant • University of Cincinnati • Cincinnati, OH **January 2020 – May 2020**

- Performed spatial data analysis query on Ohio River watershed using ArcGIS
- Compiled data from USGS and NOAA servers and converted data into usable CSV files using R
- Conducted 30 literature reviews and summarized information into a document

Vice President • Founder • Society of Environmental Engineers • Cincinnati, OH **January 2017 – Present**

- Organized a group of students and secured faculty support to reinstate the Society of Environmental Engineers as a club on campus
- Worked directly with the President to oversee and support the other executive members
- Facilitated meetings between the club members and the supporting faculty including a bi-weekly club status meeting with the environmental engineering department head

Standards Chair • Theta Chi Fraternity • Cincinnati, OH **January 2017 – December 2019**

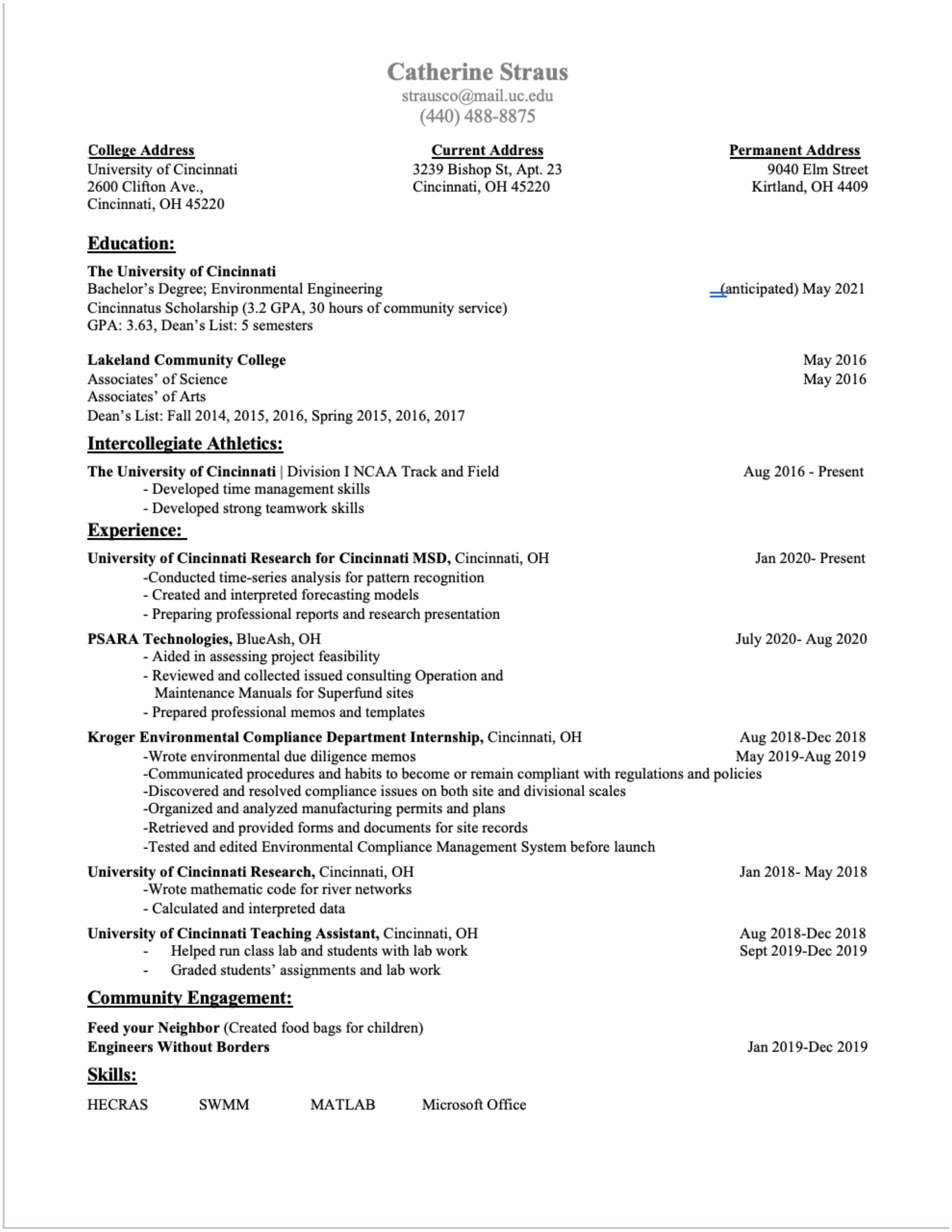
- Created and oversees a small committee to hold hearings of members who infringe on the organization's and the university's policies
- Worked with members who are placed on probationary status to improve grades

Skills

- Matlab, MS Office, AutoCAD, Adobe Acrobat, ArcGIS, Rstudio

Availability

June 2021 as a full time employee or co-op



Catherine Straus

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(440) 488-8875

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University of Cincinnati
2600 Clifton Ave.,
Cincinnati, OH 45220

Current Address
3239 Bishop St, Apt. 23
Cincinnati, OH 45220

Permanent Address
9040 Elm Street
Kirtland, OH 4409

Education:

The University of Cincinnati
Bachelor's Degree; Environmental Engineering (anticipated) May 2021
Cincinnatus Scholarship (3.2 GPA, 30 hours of community service)
GPA: 3.63, Dean's List: 5 semesters

Lakeland Community College May 2016
Associates' of Science May 2016
Associates' of Arts
Dean's List: Fall 2014, 2015, 2016, Spring 2015, 2016, 2017

Intercollegiate Athletics:

The University of Cincinnati | Division I NCAA Track and Field Aug 2016 - Present
- Developed time management skills
- Developed strong teamwork skills

Experience:

University of Cincinnati Research for Cincinnati MSD, Cincinnati, OH Jan 2020- Present
- Conducted time-series analysis for pattern recognition
- Created and interpreted forecasting models
- Preparing professional reports and research presentation

PSARA Technologies, BlueAsh, OH July 2020- Aug 2020
- Aided in assessing project feasibility
- Reviewed and collected issued consulting Operation and Maintenance Manuals for Superfund sites
- Prepared professional memos and templates

Kroger Environmental Compliance Department Internship, Cincinnati, OH Aug 2018-Dec 2018
May 2019-Aug 2019
- Wrote environmental due diligence memos
- Communicated procedures and habits to become or remain compliant with regulations and policies
- Discovered and resolved compliance issues on both site and divisional scales
- Organized and analyzed manufacturing permits and plans
- Retrieved and provided forms and documents for site records
- Tested and edited Environmental Compliance Management System before launch

University of Cincinnati Research, Cincinnati, OH Jan 2018- May 2018
- Wrote mathematic code for river networks
- Calculated and interpreted data

University of Cincinnati Teaching Assistant, Cincinnati, OH Aug 2018-Dec 2018
Sept 2019-Dec 2019
- Helped run class lab and students with lab work
- Graded students' assignments and lab work

Community Engagement:

Feed your Neighbor (Created food bags for children)
Engineers Without Borders Jan 2019-Dec 2019

Skills:

HECRAS SWMM MATLAB Microsoft Office

Appendix D: Request for Proposal

University of Cincinnati Capstone Program
Request for Proposal
August 24, 2020

Requested By:	Greater Cincinnati Water Works
Project Title:	Investigation and Preliminary Design of an Induced Infiltration System to Supplement or Replace GCWW's Surface Water Intakes

Introduction

For over 100 years, Greater Cincinnati Water Works (GCWW) has directly utilized the Ohio River as the water source for the Richard Miller Treatment Plant (RMTP). This plant accounts for approximately 85% of the water supply for GCWW. The RMTP is located in California, Ohio and is rated to produce 240 million gallon per day (MGD). On average, the plant treats an average of 110 MGD, but depending on need, will regularly treat at higher rates.

The Ohio River is an abundant source of water, but with additional upstream industrialization, increasing harmful algal blooms, and more challenging issues managing solids from the drinking water treatment process, the possibility of converting part or all of the water supply for the RMTP from surface water to ground water with induced infiltration has become increasingly attractive. An induced infiltration system could help alleviate some of these water quality concerns at the RMTP.

Project Description

The purpose of this project is to provide a preliminary investigation and design for an induced infiltration system to supplement or replace the source supply for the RMTP. The goals of this change would be to improve water quality, minimize risk of contamination from spills in the river, and reduce the amount of treatment residuals requiring management or disposal.

With this system, a series of water wells would be installed, and the water conveyed to the current treatment plant. The river would act as a recharge source for the wells, and the sand and gravel would filter the water, thereby providing a higher and more consistent water quality prior to treatment. This study will consist of the following components:

1. Gather existing geologic, hydrogeologic and land use information for the unconsolidated (sand &gravel) aquifer in the vicinity of the RMTP.
2. Use the information to estimate the maximum sustained yield which could be developed in the aquifer within the study area shown in Figure 1.
3. Develop a conceptual design for the wells and a collection system to convey the water to the treatment plant.

4. Estimate a high-level construction cost for the recommended conceptual design.
5. Provide a cost/benefit analysis based on the results of the preliminary investigation and estimates.
6. Provide recommendations for actions beyond this study.

Services Required

Desktop Study

Conduct a review of existing hydrogeologic, land use, and engineering information for locating riverbank filtration sites near the RMTP. This may include hydrogeologic studies, existing water well data, review of data from aerial photos, local planning agencies, visits to other induced infiltration sites (e.g., Louisville Water), and any other necessary information that could help in the designing the induced infiltration system.

Modeling

Conduct a review of hydrogeological models for simulating induce riverbank filtration and determine the best approach via an alternative analysis. Utilizing data collected in the desktop review and the most appropriate ground water flow model to estimate safe yield. This may involve running different simulations based on different engineering designs (well type, well layout, etc.).

Preliminary Engineering Design

Based on information from the desktop review and modeling evaluation, provide a preliminary engineering design for an induced infiltration and conveyance system to the RMTP.

Cost Benefit Analysis

Develop a cost benefit analysis to aid in decision making. This should include a preliminary construction cost estimate for the design, as well as operation and maintenance costs over the expected lifespan of the system. In addition, a summary of assumptions used in the cost estimate and items not estimated should be provided. The project should also identify costs and benefits associated with environmental impacts, risk, risk reduction, or other impacts not easily quantified in a financial manner.

Deliverables

Fall Semester

The consultant team should complete the following tasks by the end of the Fall Semester.

- Provide a summary of the desktop review, including data reviewed and information obtained.
- Conduct an evaluation of potential sites for the water abstraction wells.
- Conduct an alternative analysis of exiting model formulations to determine the best approach for simulating the abstraction of water from the Ohio River.
- Prepare a proposal report on the key findings and recommended options.
- Provide a presentation to the Sponsor on the key findings and recommended options.

Spring Semester

The consultant team should complete the following tasks by the end of the Spring Semester.

- Provide a description of the modeling effort including model used, hydrogeologic assumptions, scenarios evaluated, and results of the modeling that can be used for decision making purposes.
- Provide preliminary engineering design drawings showing proposed well locations, well design; and design and location of the conveyance system to RMTP.
- Prepare an itemized Construction Cost Estimate along with operation and maintenance costs.
- Conduct a Cost Benefit Analysis that includes the benefits of reduced treatment costs and improvements in water quality.
- Provide recommendations for further work.
- Prepare a final report that includes all tasks from the Fall Semester and Spring Semester.
- Provide an oral presentation of key findings at the end of the semester.

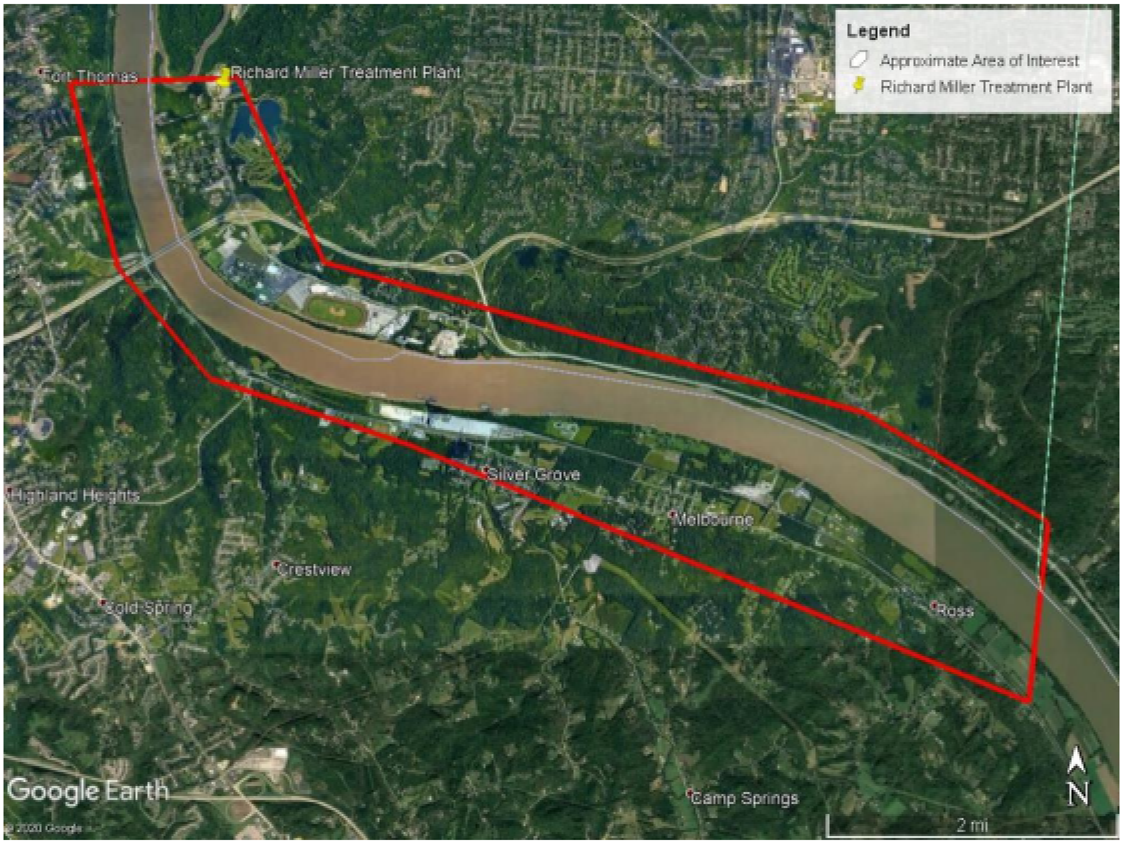

Figure 1. Project Study Area