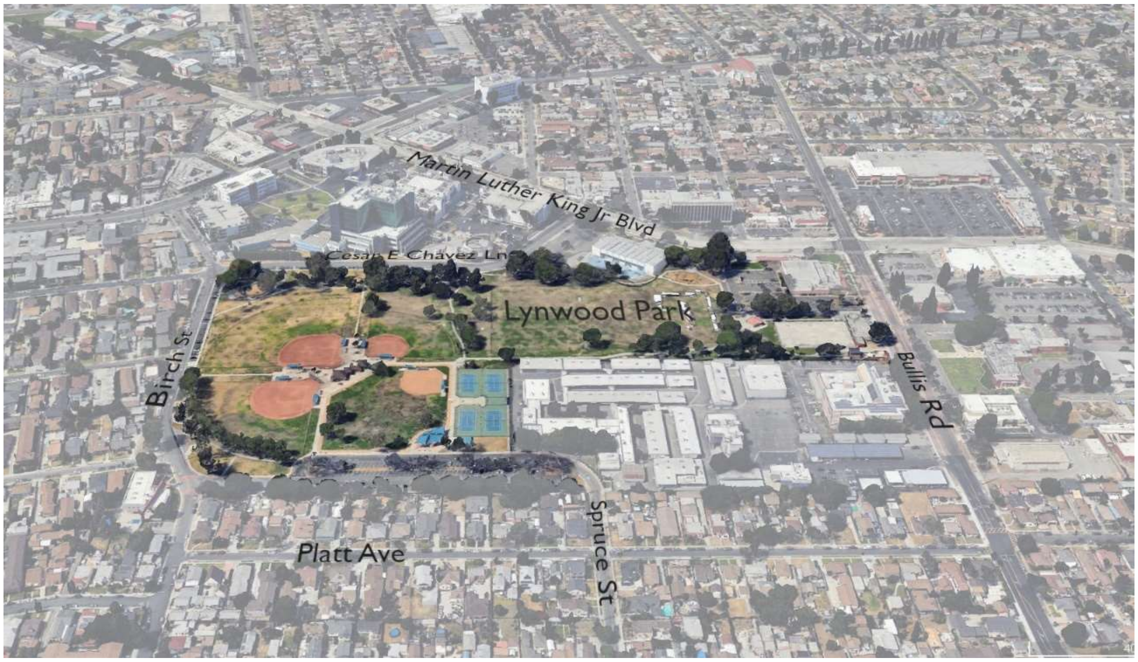
MEMO

TO:	Mir T. Fattahi, Acting City Engineer – City of Lynwood
FROM:	Courtney Semlow & Yulun Wu – Craftwater Engineering, Inc.
SUBJECT:	Lynwood Park Stormwater Capture Project Stormwater Capture Study Technical Memorandum
DATE:	June 9, 2023

The Lower Los Angeles River Watershed Management Program (LLAR WMP) Group has been charged with achieving reductions of pollutants in the subwatersheds of Reach 1 and Reach 2 of the Lower Los Angeles River, Compton Creek, and Rio Hondo. In accordance with the plans outlined in the LLAR WMP, a regional project has been identified at Lynwood Park in the City of Lynwood. The project is intended to intercept the dry-weather flow and a sizeable portion of the wet-weather flows from an adjacent storm drain. Stormwater will be diverted from a 72" reinforced concrete pipe (RCP; BI 0006 Unit 3 Line D) along Birch Street and an 81" reinforced concrete pipe (RCP; BI 0006 Unit 3 Line A) along Bullis Road, both managed by the Los Angeles County Flood Control District (LACFCD). Subsurface and surface best management practices (BMP) are proposed at the Lynwood Park site to capture stormwater from the diverted storm drain. Project constraints and potential options will be detailed in this memo to present an array of options that will contribute to both water quality goals and other important project considerations and desired outcomes.

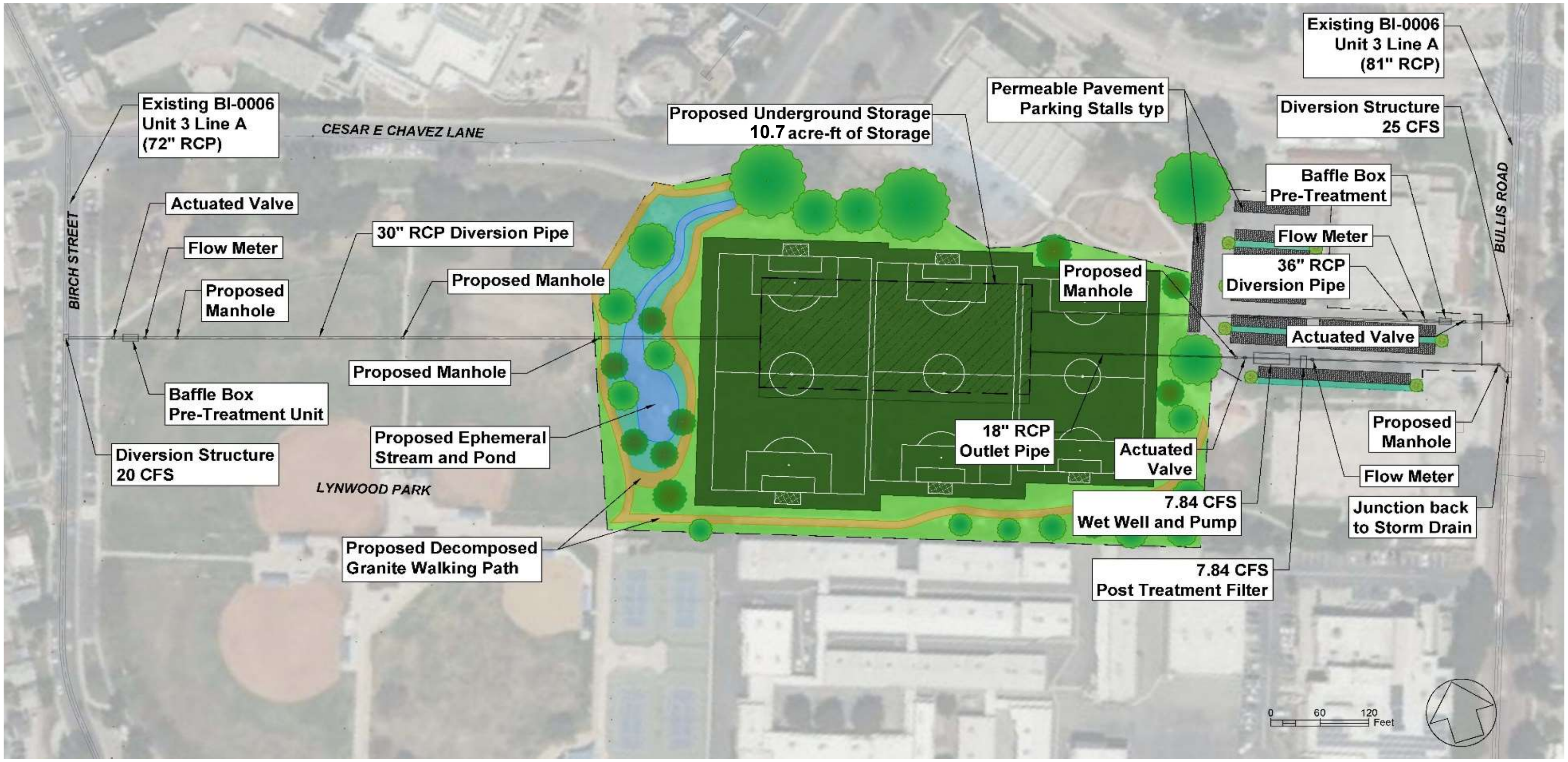


1.0 OBJECTIVES

To identify the most effective stormwater capture configuration at the project site, decision support modeling has been conducted to identify the optimal BMP configuration using a balanced approach that incorporates design storm hydrologic targets as well as long-term water quality considerations. This optimal configuration addresses stormwater runoff that will be diverted to the project site from the storm drain pipes along Birch St and Bullis Rd.

BMP configuration recommendations will be made for Lynwood Park for three key design parameters: 1) diversion rates, 2) discharge rates, and 3) BMP storage size. Each parameter can take a range of feasible values based on baseline hydrology and site assessment. The long-term performance of all the feasible BMP configurations was simulated by a custom BMP model that allows robust assessment of a range of treatment options using hourly Loading Simulation Program C++ (LSPC) data in Water Years 2009-2018. The updated Watershed Management Modeling System (WMMS 2.0) developed by LACFCD and LACDPW was used to generate the LSPC data. The resulting performance statistics of these alternative configurations were then evaluated against water quality objectives and construction and O&M considerations. The optimal BMP configurations that fulfill all the requirements are recommended. ***Figure 1-1*** is the preliminary concept schematics of the proposed BMP.

This memo explains how the recommended BMP configurations at Lynwood Park were developed. Section 2.0 introduces the existing condition of the watersheds draining to Lynwood Park. Section 3.0 explains how the BMP optimization model was set up and how BMP performance should be evaluated and compared. Section 4.0 presents the modeling results showing the water quality benefits different BMP alternatives could attain. Section 5.0 analyzes the results from Section 4.0 using the methods in Section 3.0, and recommends the BMP configurations that fulfill all the project requirements while maintaining cost-effectiveness.


Existing BI-0006 Unit 3 Line A (72" RCP)
CESAR E CHAVEZ LANE
Proposed Underground Storage 10.7 acre-ft of Storage
Permeable Pavement Parking Stalls typ
Existing BI-0006 Unit 3 Line A (81" RCP)
Diversion Structure 25 CFS
Baffle Box Pre-Treatment
BULLIS ROAD
Actuated Valve
30" RCP Diversion Pipe
Flow Meter
BIRCH STREET
Proposed Manhole
Proposed Manhole
Proposed Manhole
Flow Meter
36" RCP Diversion Pipe
Actuated Valve
Proposed Manhole
Baffle Box Pre-Treatment Unit
Proposed Ephemeral Stream and Pond
18" RCP Outlet Pipe
Actuated Valve
Proposed Manhole
Flow Meter
Diversion Structure 20 CFS
LYNWOOD PARK
7.84 CFS Wet Well and Pump
Junction back to Storm Drain
Proposed Decomposed Granite Walking Path
7.84 CFS Post Treatment Filter
0 60 120 Feet

2.0 BASELINE SITE CONDITIONS

The following subsections summarize the baseline watershed, hydrologic, and on-site conditions and constraints that will be accounted for in BMP configuration and optimization analysis for the Lynwood Park site.

2.1 Watershed Characterization

For this study, the Loading Simulation Program C++ (LSPC) software was used to simulate the contaminant loading, runoff volume, and flow rate associated with a long-term, 10-year continuous time series (Water Year 2009 to Water Year 2018). LSPC was also used for 85th percentile design storm calculations. A regionally calibrated LSPC model was used as this model was used in EWMP/WMP development and is accepted by the Los Angeles Water Quality Control Board for compliance analyses. This LSPC model is a component of the updated Watershed Management Modeling System (WMMS 2.0).

The drainage area delineations for the project site (***Figure 2-1***) were developed using geospatial data associated with the LSPC modeling subwatersheds and verified/corrected slightly using further GIS analysis where full subwatersheds did not coincide with project locations and where subsurface storm drains overlapped. Digital stormwater pipe inventories and high-resolution Light Detection and Ranging (LiDAR) elevation data were used to accomplish subwatershed splitting. Developed drainage areas were used to model runoff and water quality baseline time series. These were then incorporated into BMP models to optimize the BMP decision variables. The overall area and impervious fraction are summarized in ***Table 2-1***. ***Figure 2-2*** depicts the land uses within the drainage area. The watershed's impervious area is predominantly composed of residential areas.

Table 2-1. Summary of Watershed and Hydrologic Conditions for the Lynwood Park BMP Drainage Areas

Location	Drainage Area (acres)	Impervious Area (acres, %)	85th Percentile Design Storm (inches)	Avg. Annual Runoff (ac-ft)	Avg. Annual Zinc Load (lbs)	85th Percentile Storm Runoff (ac-ft)	85th Percentile Storm Peak Flow (cfs)
Birch St.	399	221 (55.42%)	0.92	165	86.7	9.2	16.6
Bullis Rd.	556	299 (53.69%)		226	107.3	12.6	24.2
Total	955	520 (54.4%)		391	194	21.8	40.8

2.2 Hydrologic Considerations

Long-term baseline flows and pollutant loads to the site are also summarized in ***Table 2-1***. The total loadings presented in this table represent the maximum possible reductions that could be achieved by control measures at the project site. However, pragmatic diversion limitations, space constraints, and subsequent treatment mechanisms will ultimately limit how much runoff and pollutant mass can potentially be diverted into the BMP. Peak flow rate and total runoff for the 85th percentile design storm (0.92 in., taken from isohyetal data for the centroid of the drainage areas) are found in ***Table 2-1***. The precipitation and baseline storm drain runoff time series are plotted in ***Figure 2-3***.

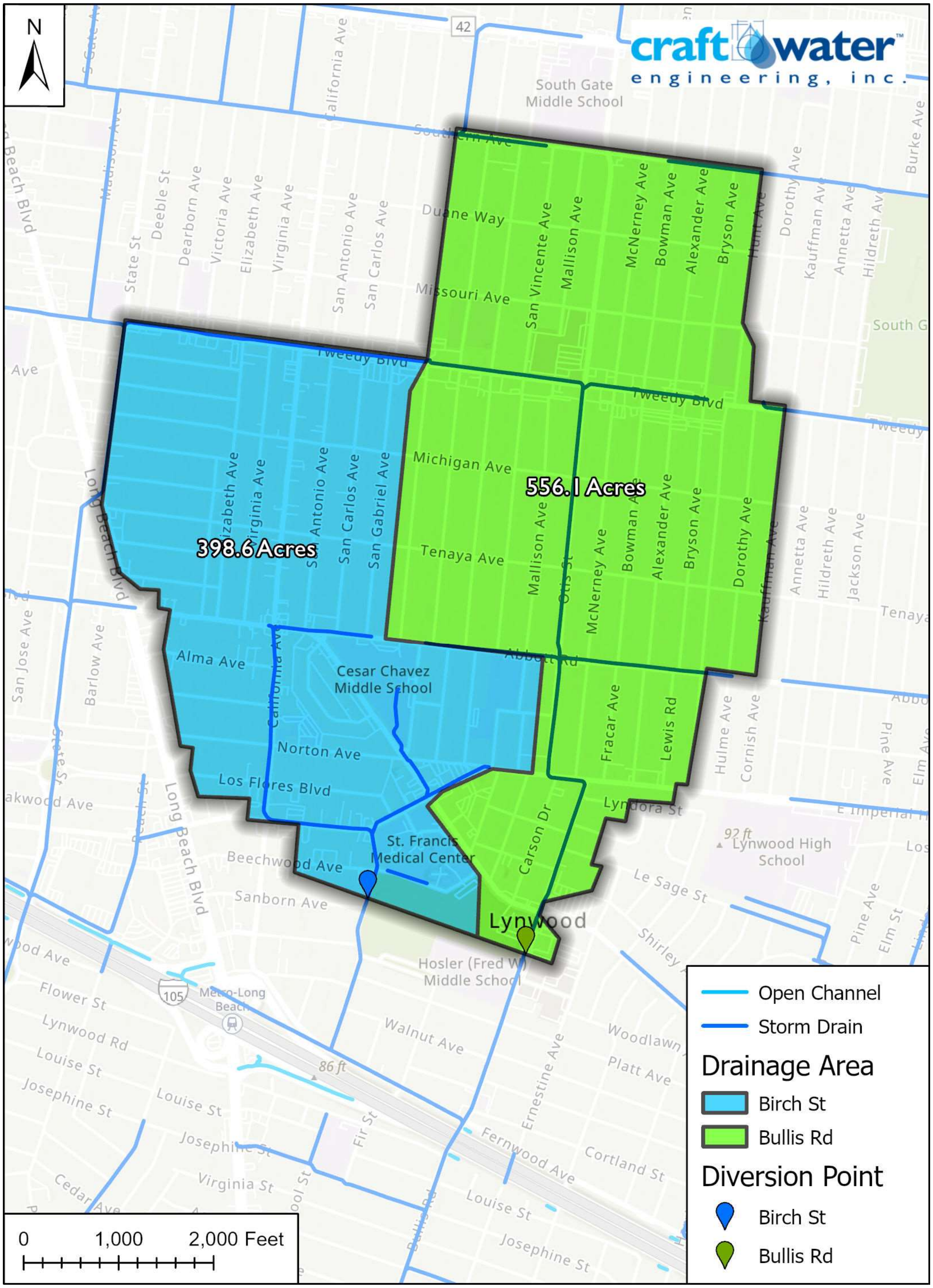


Figure 2-1. Lynwood Park Project Drainage Area

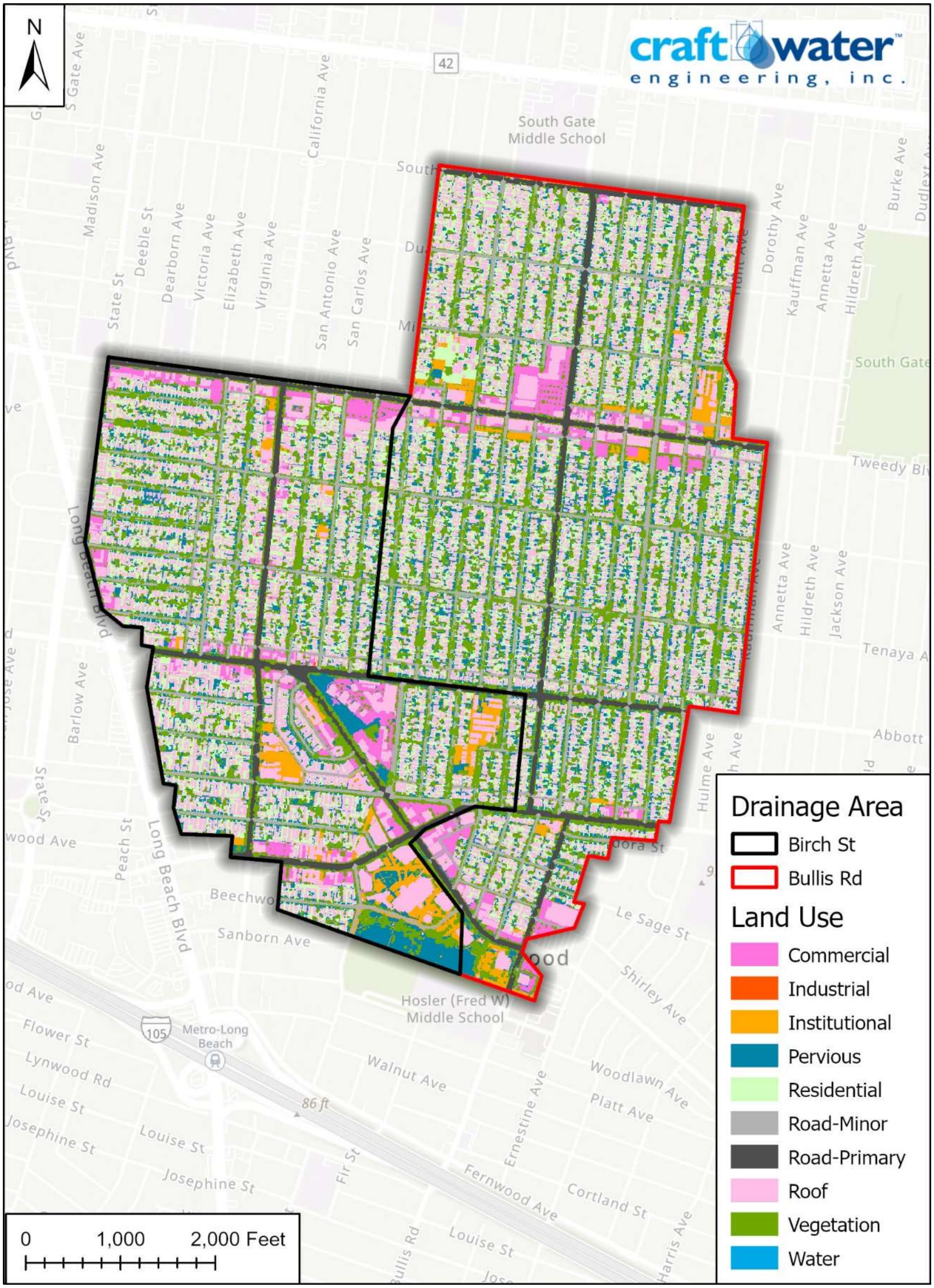


Figure 2-2. Lynwood Park Project Drainage Area Land Use

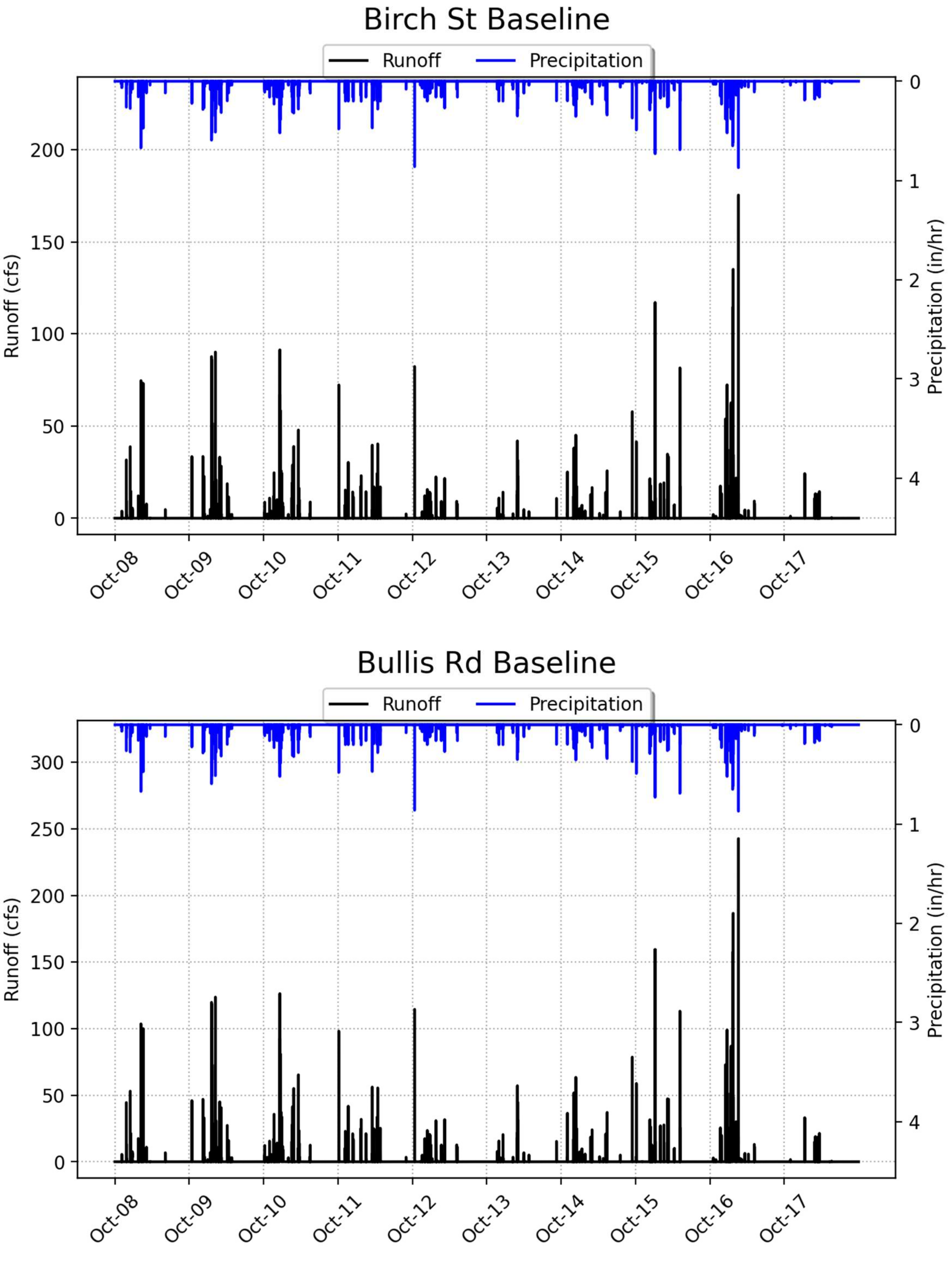


Figure 2-3. Precipitation and Baseline Storm Drain Runoff (top: Birch St drain, bottom: Bullis Rd drain)

3.0 STORMWATER CAPTURE OPTIMIZATION METHODS

3.1 Water Quality Optimization Strategy

The primary design goal of the Lynwood Park Project is to reduce long-term annual loading of pollutants in the LLAR Watershed using zinc as the limiting pollutant of interest in the analysis as established by the LLAR WMP. According to the latest WMP Reasonable Assurance Analysis, the City needs to install a total BMP volume of 95.4 acre-ft by 2028 to meet the final compliance milestone. To ensure that the system will be sized to maximize load reductions in a cost-effective manner, optimization modeling was performed.

The purpose of optimization modeling is to balance design components (including BMP volume, inflow diversion rates, and outflow treatment rates) such that no one component limits the performance of the system subject to potential discharge options (see ***Figure 3-1*** at right). Optimization supports decision making throughout the design process by guiding selection of the most cost-effective system design.

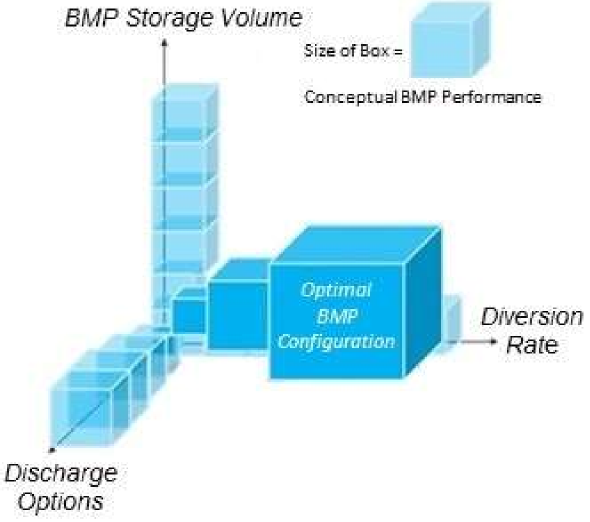


Figure 3-1. Conceptual illustration of optimization modeling balancing various design components to maximize performance.

The model setup for water quality simulation and optimization is complex, involving several modeling systems and iterative feedback from design engineers. The general methodology is discussed below, and the results are presented thereafter.

3.2 BMP Performance Modeling and Optimization

The first step of the modeling was to predict BMP performance for a range of 1) potential diversion rates, 2) discharge alternatives, and 3) BMP sizes. Different combinations of these parameters will lead to different BMP performance statistics, including runoff capture and pollutant capture. These BMP model inputs and outputs are discussed in this section.

A custom BMP model was used to improve upon certain modeling limitations in EPA's System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN). This custom model is grounded in the physical BMP representations used in SUSTAIN, and it provides built-in optimization algorithms to more systematically automate the process of evaluating many different BMP configurations to select an effective solution related to project goals. The model was run using 10 years of runoff and pollutant loading time-series data generated by LSPC at an hourly time step for water years 2009-2018. For each potential BMP configuration, the hourly inflow, storage, and outflow of stormwater and pollutants were simulated. The simulated performance statistics of all the BMP configurations are then evaluated against the objectives and considerations in Section 3.3 to develop the optimal project configuration alternatives.

3.2.1 Model Input - Diversion Rates

Model runs were limited to feasible diversion ranges for the proposed diversion point based on prior project knowledge related to the drainage area and potential project storage size. Diversion rates from the Birch St diversion point and the Bullis Rd diversion point were both modeled over the range of 15 to 35 cfs, varying in 5 cfs increments. Gravity diversion is feasible at the site and is generally more cost effective than pump diversion especially at higher diversion rates.

3.2.2 Model Input - Discharge Alternatives

Infiltration

Falling head percolation tests performed by Ninyo & Moore in March 2023 produced adjusted percolations rates of 0.61, 0.01, 0.32, and 0.34 inches/hour using a safety factor of 4 (boring P-1, P-2, P-3 and P-4, respectively). The 0.61 in/hr test was performed at a 3-5' depth while the other three tests were performed at a 15-20' depth. Because the proposed subsurface BMP footprint only covers P-3 and P-4, 0.32 inches/hour was selected as the design infiltration rate that is used in modeling.

Filtration

Several commonly available stormwater filtration devices (at 2.88 cfs, 5.76 cfs, and 7.84 cfs discharge rates) were modeled. These values were chosen to cover a range of potential outflows common to off-the-shelf proprietary filter products. If the desired outflow rate changes, rates can be revaluated in later stages of design. Water treated through filtration would be returned downstream of the diversion point through gravity flow.

Filtration and Infiltration

A combination of filtered outlet and infiltration outlet provides both water quality and water supply benefits. To allow for gravity flow, the filter outlet needs to be set at a level below the maximum water level within the BMP storage. Water will only flow through the filter when the water level is above the filter outlet. Filter outlet heights of 0.1, 0.5, 1, 3, 6, and 9 ft are modeled to explore its effect on BMP performance. The vertical configuration of the BMP is illustrated in ***Figure 3-2***.

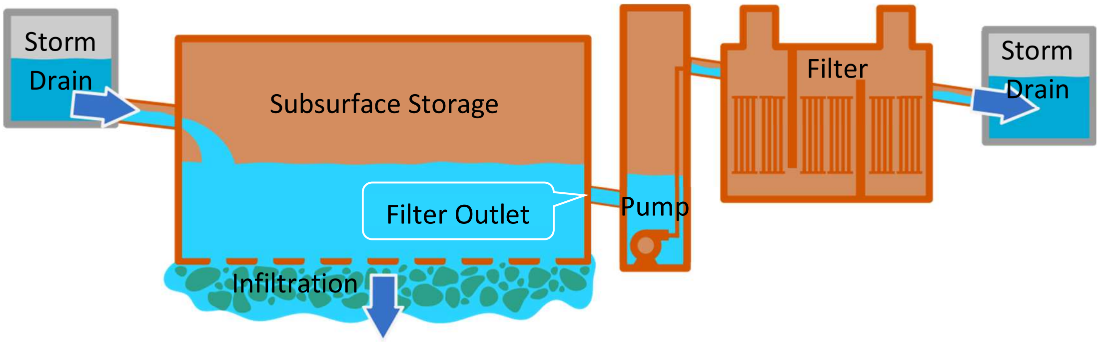


Figure 3-2. Filtration and Infiltration BMP Profile Illustration

The ephemeral stream and pond shown in ***Figure 1-1*** are landscape features that are not modeled as surface BMPs because of their much smaller scales compared to the subsurface BMP. They are also designed to not interfere with the performance of the subsurface BMP. This memo only models the filtration and infiltration processes within the subsurface BMP.

3.2.3 Model Input - Storage Volume

Commonly available storage depths of 5' and 10' are modeled. Other storage depths may be used during later stages of design. Modeling was carried out for a BMP footprint ranging from 0.1 to 2.0 acres (maximum feasible footprint due to site constraints) at 0.01-acre increments.

3.2.4 Model Output – 85th Percentile 24-hour Design Storm Performance Statistics

A separate spreadsheet model was developed to verify whether a combination of diversion rate, treatment rate and storage volume can fully capture the peak flow and total runoff volume resulted from an 85th percentile 24-hour design storm.

3.2.5 Model Output – Long-term BMP performance statistics

Hourly inflow and outflow of runoff and pollutant loads can be generated by the custom model for each BMP configuration. This output time series data can be summarized into the following performance statistics that are relevant to the project objectives for BMP optimization:

- **Average Annual Runoff Reduction**: The average amount of stormwater removed from the storm drain system due to infiltration per year.
- **Average Annual Divertible Pollutant (Zinc) Load:** The average mass of pollutants (Total Zinc) the diversion structure can theoretically divert to the BMP per year if the BMP has infinite storage volume.
- **Average Annual Pollutant (Zinc) Load Reduction:** The average mass of pollutants (Total Zinc) the BMP can remove through treatment per year.
- **Cost-effectiveness**: Measured by the planning-level construction cost to capture one pound of Zinc per year, namely the marginal cost of Zinc reduction. This value is only used to compare the cost-effectiveness of alternatives in terms of water quality benefits.

3.3 BMP Optimization Objectives and Considerations

This section discusses how the BMP performance statistics described in Section 3.2.5 are used for BMP optimization. Multiple aspects and stages of the project are considered when optimizing the BMP, including 1) how the BMP contributes to water supply, water quality and flood control, 2) how this project integrates with the Safe Clean Water Program, and 3) whether the BMP is optimized for construction and O&M.

3.3.1 General Project Objectives

From a watershed management perspective, BMP projects should be evaluated against these objectives:

- **Water Quality**: The amount of stormwater pollutants the BMP can remove, and the volume of stormwater the BMP can treat. This will be the primary objective of the Lynwood Park project.
- **Water Supply**: The volume of stormwater that can be used for water supply. As discussed in Section 3.2.2, water supply is not used as a BMP optimization objective.
- **Flood Control**: The peak flow rate the BMP can capture and the runoff volume the BMP can store during a storm event to reduce flooding. The BMPs should be sized to capture the peak flow rate and runoff volume of at least the 85th percentile 24-hour design storm if feasible.

3.3.2 Safe Clean Water Program (SCWP) Metrics

Benefits predicted for different BMP configuration options must also be weighed against Safe Clean Water Program (SCWP) scoring criteria to determine the optimal choice for a given site to ensure a Project meets the needs of this important regional program. The following SCWP scoring categories are primarily dependent on the proposed treatment type:

- **Wet Weather vs. Dry Weather BMP:** Does the proposed BMP capture the 85th percentile storm of the targeted drainage area? If so, it is historically defined as a wet weather project per the SCWP Scoring Committee. Otherwise, it is a dry weather BMP. Wet Weather and Dry Weather BMPs have different water quality scoring criteria, as detailed below. Both BMP types can still fulfill all other project related SCW scoring criteria (Water Supply, Community Investment, etc.)
- **Water Quality:**
    - Wet Weather BMP: Removal of 50%/80% of divertible pollutants.
    - Dry Weather BMP: Removal of 100% of all tributary dry weather flows
- **Water Supply**: Utilizing captured stormwater to replenish local water supply (water reclamation and groundwater recharge).
    - Scoring thresholds for SCW occur at 25, 100, 200, and 300 ac-ft of water supply benefit.
- **Nature Based Solutions**: Implement or mimic natural processes to treat stormwater (infiltration).

3.3.3 Construction and O&M Considerations

Making the BMP size larger increases water quality benefits but also increases construction cost and maintenance efforts. A larger diversion rate requires a pre-treatment unit with a larger capacity which also increases construction and maintenance costs. **Therefore, when the key objectives described in Section 3.3.1 and 3.3.2 can be fulfilled, the lowest diversion rate, the smallest BMP storage size and the smallest filtration rate are recommended to ensure the project is cost-effective.** The cost-effectiveness of all BMP alternatives is reviewed in the next section.

4.0 OPTIMIZATION MODELING RESULTS

The performance statistics of different BMP configurations are presented. The results in this section are then evaluated against the BMP optimization objectives and considerations in the next section to develop the optimal BMP configuration.

4.1 85th Percentile Design Storm Capture

The minimum diversion rate and the minimum storage volumes required to fully capture the 85th percentile storm is summarized in ***Table 4-1***. The filter outlet is set at the bottom of the storage structure.

Table 4-1. BMP Diversion Rate and Volume Required to Capture the 85th Percentile Storm

85th Percentile 24-hr Storm	BMP Design Alternative	Birch St Diversion	Bullis Rd Diversion	Combined
Minimum Diversion Rate (cfs)	All alternatives	16.6	24.2	40.8
Minimum Storage Volume (ac-ft)	0.32 in/hr infil., 5’ storage depth	8.3	11.3	19.6
	2.88 cfs filter & infil., 10’ depth	4.2	7.2	15.8
	5.76 cfs filter & infil., 10’ depth	1.9	3.7	11.3
	7.84 cfs filter & infil., 10’ depth	1.2	2.6	8.5

4.2 Storm Drain Diversion BMP Optimization

4.2.1 Water Quality Performance Comparison

Figure 4-1 compares the water quality performance of the BMPs with or without a filter, and the performance of different filter sizes and storage depths. The filter options in the figure have the filter outlet set at the bottom of the storage as explained in Section 3.2.2.

For smaller BMP sizes, adding a filter greatly improves the zinc reduction performance because the filter treats stormwater at a faster rate than infiltration. As BMP size becomes larger, there is a diminishing return in Zinc reduction because 1) the BMP is larger enough to treat most of the pollutants, so the additional volume brings little benefits, and 2) storage volume is no longer the design component that is limiting zinc load reduction.

A 5 ft deep BMP has twice the footprint of a 10 ft deep BMP with the same volume, and therefore has twice the infiltration flow rates (infiltration flow rate = infiltration rate (inches/hour) × footprint (ft^2)). When infiltration is the only treatment mechanism, a 5 ft deep BMP removes more zinc load than 10 ft deep BMP with the same volume. However, for BMPs with both filtration and infiltration treatment, the increase in infiltrate flow rate due to a larger footprint does not have a significant impact on zinc load reduction because filtration rather than infiltration captures most of the zinc load.

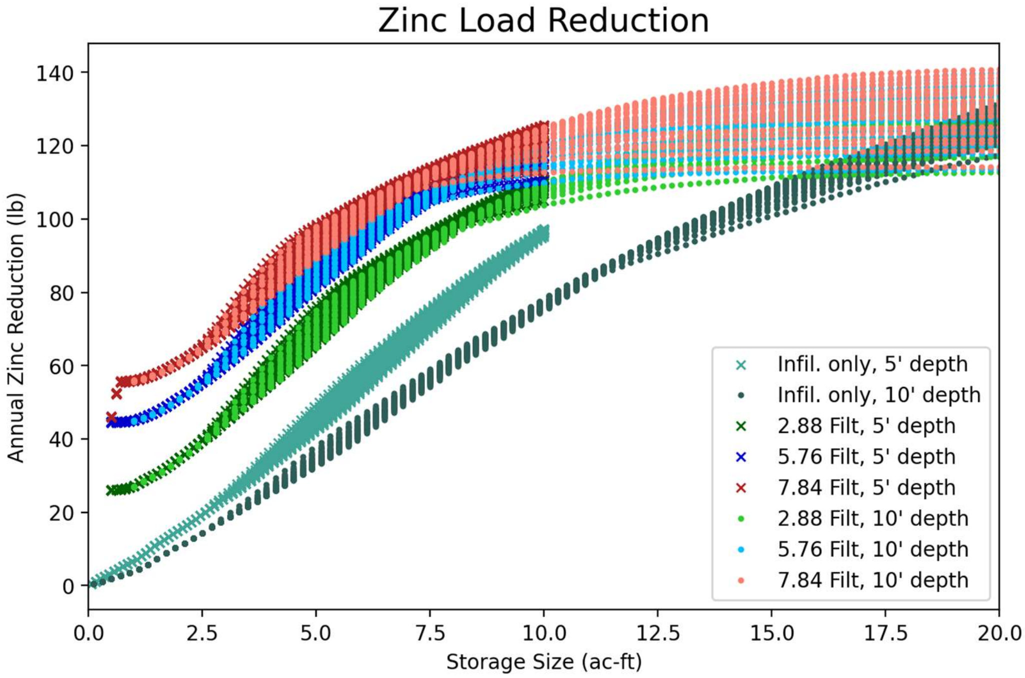


Figure 4-1. Lynwood Park Both Diversion - Zinc Reduction of All Alternatives

Figure 4-2 compares the water quality performance of different filter sizes and diversion rates. These diversion rates are the total diversion capacity at the Birch St and Bullis Rd diversion points.

When other conditions are the same, a larger filter significantly improves the zinc reduction of smaller BMPs. The smaller BMPs treat stormwater primarily through filtration because they have smaller footprints and therefore lower infiltration flow rates. Larger BMPs can treat more water through infiltration but can still benefit from larger filters.

No diversion rate performs the best in all cases. When storage size is close to zero, zinc reduction is hardly affected by diversion rate because storage size is the limiting design factor. As storage size increases, lower diversion rates become more favorable because they can better utilize the storage. Higher diversion rates would fill the storage too early during a storm and bypass most of the flow that could have been partially treated if there is still space in the storage. When storage size further increases, higher diversion rates become more favorable because diversion rate is now the limiting factor. A higher diversion rate simply allows more pollutant into the storage which is big enough to treat the additional runoff being diverted.

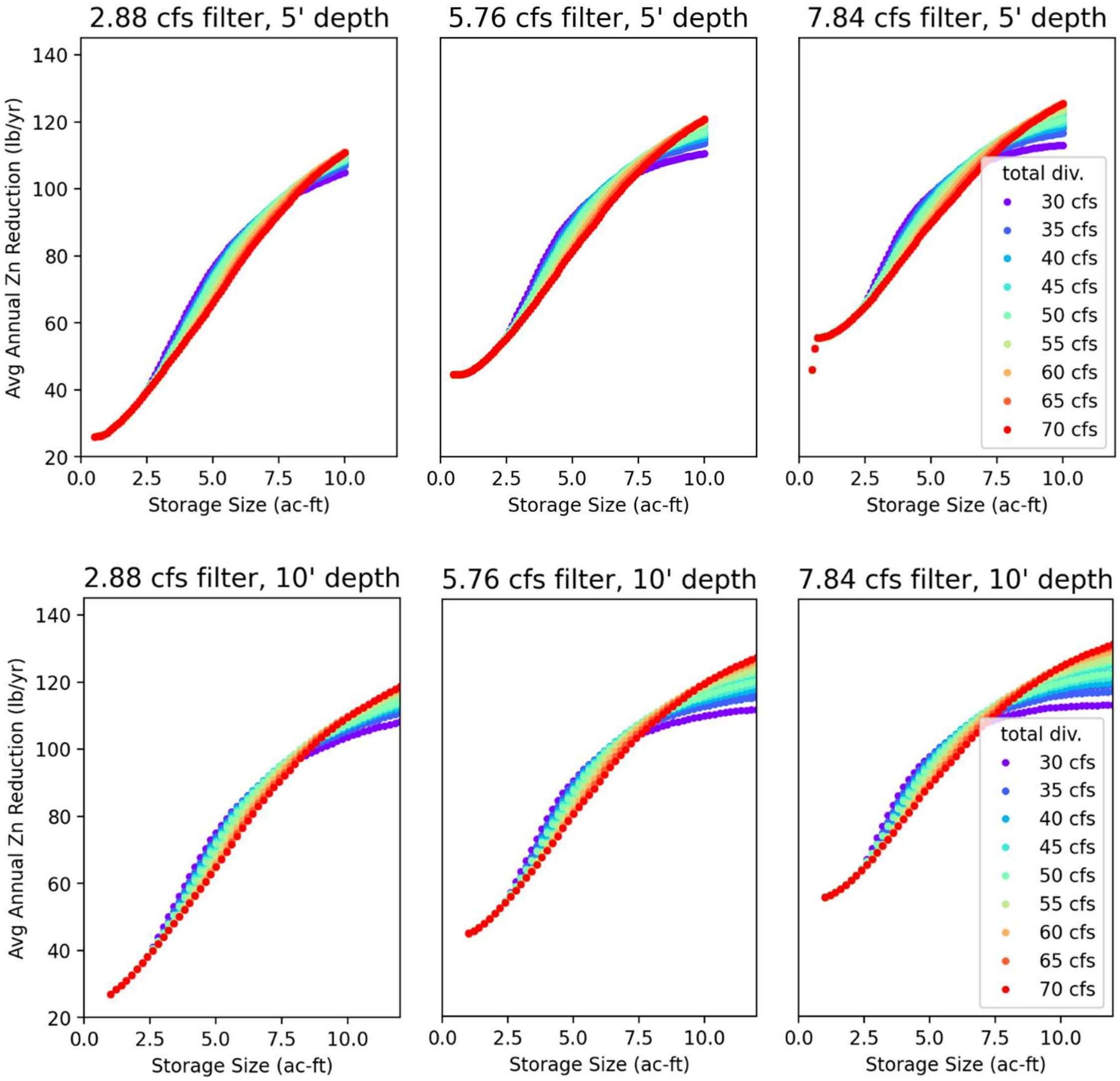


Figure 4-2. Lynwood Park Both Diversion - Zinc Reduction of Filtration & Infiltration Options

4.2.2 Cost Effectiveness Comparison

The planning-level marginal cost of Zinc load reduction is compared in ***Figure 4-3***. The 5'-deep storage options are generally less cost effective because they occupy a larger footprint to achieve the same storage volume, which increases the cost of excavation and backfill.

Alternatives with bigger filters are generally more cost effective because the increase in Zinc reduction outweighs the increase in cost (lower marginal cost = cost, slight increase / zinc reduction, bigger increase). For the same reason, higher diversion rates are more cost effective for large storage sizes. However, high diversion rates are not cost effective in 5'-deep BMPs and the smaller 10'-deep BMPs.

It should be noted that, although *marginal cost (in $/(lb Zn/yr))* does not increase monotonically with storage size, diversion rate and filter size, a BMP with a larger storage size, higher diversion rate and higher filtration rate always has a higher *construction cost (in $)*.

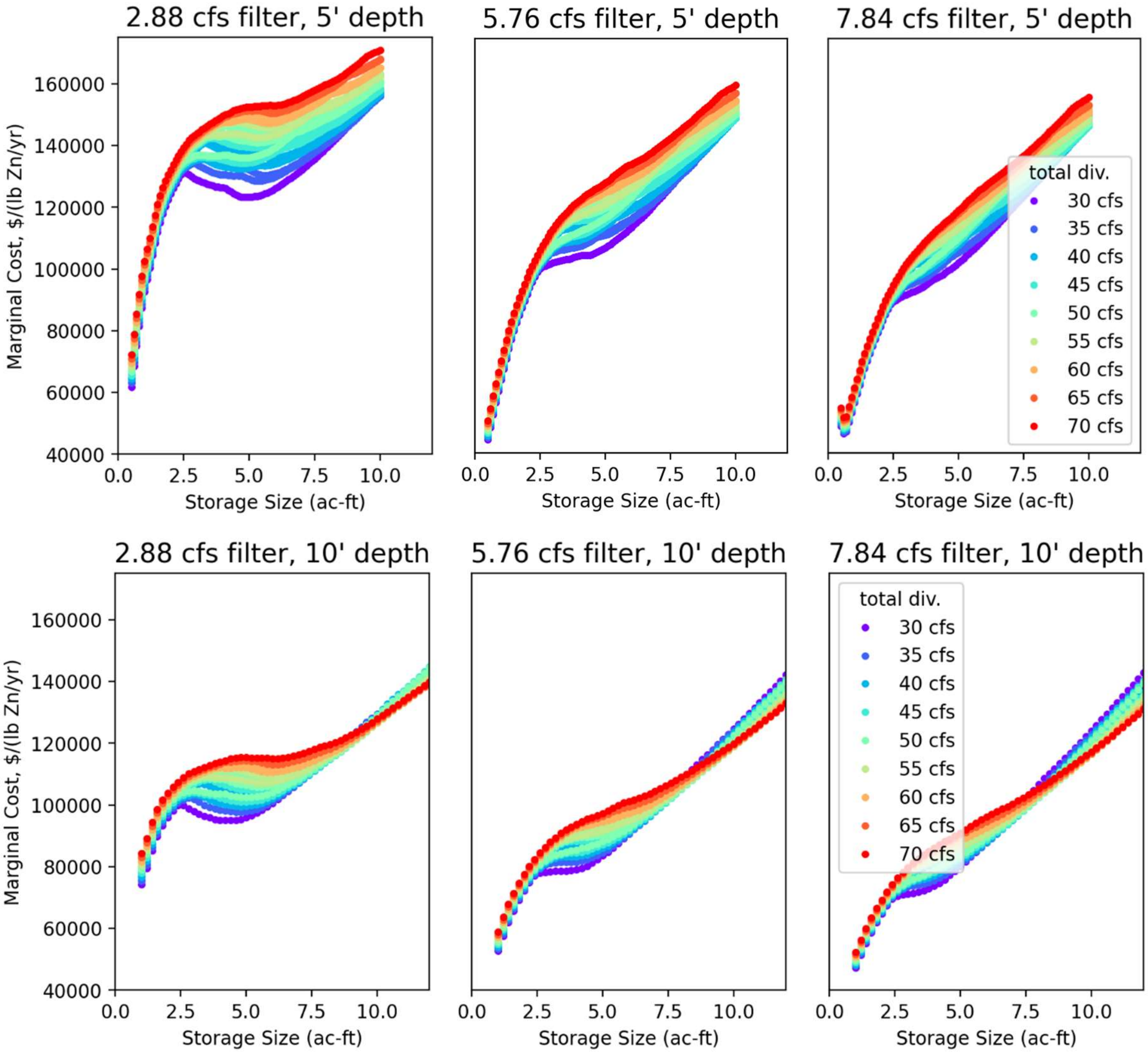


Figure 4-3. Lynwood Park Both Diversion – Marginal Cost of Filtration & Infiltration Options

4.2.3 Water Quality and Water Supply Performance Comparison

Infiltration treatment can potentially recharge groundwater and provide water supply benefits, whereas filtration treatment returns the treated water to the storm drain. The proportion of infiltrated and filtered stormwater can be adjusted by setting the filter outlet within the subsurface storage, as explained in Section 3.2.2. Stored water under the filter outlet level is only available for infiltration, while the water above the outlet can be both infiltrated and filtered.

Figure 4-4 illustrates the trade-off between 1) the water quality benefits measured by average annual zinc load reduction and 2) the water supply benefits measured by average annual groundwater recharge volume. All plotted alternatives have a 7.84 cfs filter, a 10'-deep storage, and a total diversion rate of 45 cfs. Each rainbow-colored line represents the BMP alternatives with the same filter height (0.1 ft, 0.5 ft, …, 9 ft). The grey dotted lines are contours of BMPs with the same storage volume. The blue, red, and green lines are SCW program benchmarks.

There is a trade-off between water quality and water supply benefits. Other configurations unchanged, a higher filter outlet generally leads to more water supply benefit and less water quality benefits, because it reserves more water for infiltration (except for some of the largest BMPs in the plot). More infiltration means more water supply since filtration does not provide water supply, and less pollutant removal because infiltration is slower at removing pollutants. No optimal filter height can maximize both objectives. Therefore, a point has to be picked to balance the water quality and water supply benefits of the BMP. The next section will recommend a BMP configuration using the modeling results presented in Section 4.

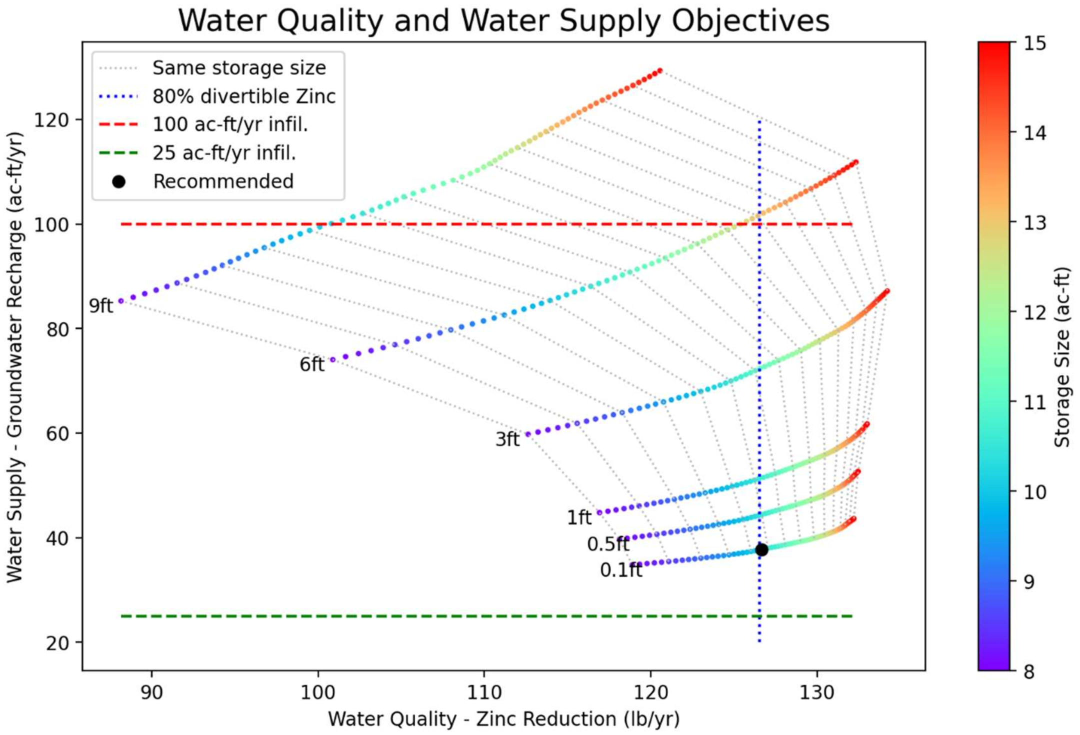


Figure 4-4. Compare Water Quality and Water Supply Objectives using Various Filter Heights

5.0 PROJECT ALTERNATIVES AND RECOMMENDATIONS

5.1 Lynwood Park BMP Recommendation

The recommended BMP for Lynwood Park has the following design parameters:

- **Filter height**: the filter outlet should be set at the bottom of the subsurface storage to prioritize water quality benefits (modeled as 0.1 ft above the bottom). This design maximizes pollutant reduction while also providing more than 25 ac-ft/yr of water supply.
- **Storage depth**: 10 ft storage depth is recommended because it is more cost effective than 5 ft storage depth, as explained in Section 4.2.2.
- **Filter size**: a 7.84 cfs filter is recommended. The large filter treats more pollutant and is more cost-effective, and it greatly reduces the storage volume required to fully capture the 85th percentile storm (***Table 4-1***). Water is pumped from the bottom of the subsurface storage to the filter and then discharged into the Bullis Rd storm drain.
- **Diversion rate**: divert 20 cfs from the Birch St storm drain and 25 cfs from the Bullis Rd storm drain. These two values are larger than the 85th percentile peak flows (***Table 4-1***). Knowing the BMP will have a 7.84 cfs filter and a 10’ storage depth, the storage size must be above 8.5 ac-ft to capture the 85th percentile storm (***Table 4-1***). At this size, although larger diversion rates are more cost-effective in terms of zinc reduction (***Figure 4-3***), those BMPs also cost more to build. The recommended diversion rates can fulfill all the project requirements with the lowest construction cost.
- **Storage volume**: a 10.7 acre-ft storage volume with a footprint of 1.07 acres is recommended. This size is selected to treat 80% of the removable zinc load while capturing the 85th percentile storm.

In conclusion, the recommended BMP has **a 20 cfs gravity diversion from the Birch St storm drain, a 25 cfs gravity diversion from the Bullis Rd storm drain, a 10.7 acre-feet 10’-deep subsurface storage volume that allows infiltration at the bottom, and a 7.84 cfs filter that takes water from the bottom of the subsurface storage**.

5.2 Summary of Expected Performance Statistics

The recommended BMP configurations and their expected long-term performance statistics are summarized in ***Table 5-1***.

Table 5-1. Summary of Recommended Configurations and Performance Statistics

Configuration	Diversion Rate	20 cfs gravity diversion from the Birch St storm drain 25 cfs gravity diversion from the Bullis Rd storm drain
	BMP Type	Subsurface Storage with Infiltration
	Depth	10 ft
	Volume	10.7 ac-ft
	Discharge	0.32 in/hr infiltration + 7.84 cfs pumped filtration
Performance	Zinc Load Reduction (lb/yr)	127
	% Divertible Zinc Load Reduction	80.6%
	Water Supply (ac-ft/yr)	38
	Capture 85th Percentile Storm	Yes

6.0 CONCLUSIONS

This Stormwater Capture Memo was prepared for the Lynwood Park Stormwater Capture Project to demonstrate progress towards compliance for City of Lynwood. The existing hydrology and water quality conditions were first characterized, then an optimization analysis informed data-driven selection of effective solutions. The optimization analysis aimed to identify the BMP which provides cost-effective protection to the watershed while contributing to regional goals. ***This analysis determined that a subsurface infiltration BMP that diverts*** **20 cfs from the Birch St storm drain and 25 cfs gravity diversion from the Bullis Rd storm drain through gravity*****, has 10.0 ft of storage depth, 10.7 ac-ft storage volume and 7.84 cfs pumped filtration discharge is the optimum BMP configuration.*** The proposed BMP can fully capture the 85th percentile 24-hour storm, remove at least 80% of the divertible Zinc load, and provide more than 25 ac-ft/year of groundwater recharge.