Appendix 3.5-1

Hydrology and Water Quality Evaluation

MEMORANDUM

To:	City of San Bruno Public Works Department
From:	Felicia Dean, PE, LEED AP
Prepared By:	Felicia Dean, PE.
Copy:	Heidi Mekkelson, ICF and Rajeev Bhatia, Dyett & Bhatia
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Subject:	Hydrology and Water Quality Evaluation for the Bayhill Specific Plan and the YouTube Phase 1 Office Development

1.0 INTRODUCTION

This Technical Memorandum was prepared to evaluate the potential impacts of the proposed Bayhill Specific Plan and the Phase 1 Development of the YouTube Expansion Plan related to hydrology, stormwater infrastructure and water quality. This study presents the analysis of the pre- and post-development runoff to evaluate stormwater discharge flows from the Specific Plan and the Phase 1 areas.

2.0 PROJECT DESCRIPTION

The Bayhill Specific Plan Area (Planning Area) is located in the City of San Bruno with an area of approximately 92.2 acres and is generally bounded by Interstate 380 to the north, Interstate 280 to the west, San Bruno Avenue West to the south from Interstate 280 to Elm Avenue and El Camino Real to the east, excluding those properties fronting on El Camino Real. See Figure 1 for extents of the Planning Area. Existing development on the Planning Area includes the Bayhill Office Park, the Bayhill Shopping Center and a hotel. The Planning Area is largely made up of buildings and extensive surface parking lots with limited landscaped areas around the buildings and trees planted throughout the parking lots. The area adjacent to Interstate 280 is undeveloped.

The Planning Area is made up of 17 large parcels of which 8 are owned by YouTube and are part of a 20-year campus expansion plan to be developed in five phases. See Figure 2 for the YouTube Expansion Plan Phasing Map. In total, the Bayhill Specific Plan development will transform the area to add up to approximately 2.46 million square feet of net new development, replacing the surface parking lots with new buildings and with parking provided in subterranean structures. See Figure 3 for potential extents of subterranean parking structures.

2.1 PHASE 1 DEVELOPMENT

The proposed Phase 1 Development includes two parcels totaling approximately 8.4 acres. The Phase 1 site is bisected by Grundy Lane and is bordered by Cherry Avenue to the West, Interstate 380 to the North, Bayhill Drive to the south, and an adjacent property to the East. "Phase 1" includes the development of two three-story buildings (each on its own parcel) that are located to the north and south of Grundy Lane. The Phase I Buildings will be constructed on the existing surface parking lots adjacent to the existing 900 and 1000 Cherry Avenue buildings, which are to remain.

The two proposed buildings are referred to as the “North Building” and the “South Building” and collectively as the “Phase 1 Buildings”. Phase 1 contains a total of approximately 440,000 square feet of office space and three levels of subterranean parking.

The Phase 1 Development project also includes the following: construction of a new private multi-modal center at the 950 Elm Avenue parcel; the realignment of Grundy Lane and the vacation of the north end of Elm Avenue; infrastructure improvements throughout Grundy Lane and Bayhill Drive (between Cherry Avenue and Traeger Avenue); parking improvements at 1100 Grundy Lane and 950 Elm Avenue; and the demolition of the existing buildings located at 1150-1250 Bayhill Drive for temporary parking during Phase 1 construction (and future development of the Phase 2 buildings).

3.0 EXISTING AND PROPOSED DRAINAGE SYSTEM

3.1 EXISTING CONDITIONS

The Planning Area represents approximately 6.5% of the land area in “Watershed A”, which is largely made up of fully developed land, and contributes less than 7% of the overall runoff within the Watershed A storm drain trunk system. Stormwater from the Planning Area and vicinity is collected through existing City storm drain networks that connect to a 72-inch main trunk line located on the eastern portion of the Planning Area as shown in Figure 4. This 72-inch main serves as the backbone to the City’s 1,415-acre Watershed A pipe network as identified in the City of San Bruno Storm Drain Master Plan, discussed below in Section 3.2. Refer to Figure 5 for a map of the watershed areas studied in the Master Plan. The area west of Cherry Avenue drains to a pipeline in Cherry Avenue which flows to the north and connects to the 72-inch main trunk line. The area between Cherry Avenue and Elm Avenue drains into pipelines in Grundy Lane and Bayhill Drive which flow to the east and connects to the 72-inch main at Elm Avenue. The 72-inch main also collects flows from several pipes east of Elm Avenue and continues easterly and southerly until it exits the Planning Area near El Camino Real. The Phase 1 Development area is currently served by existing pipes ranging from 12-inch to 48-inch located in parking lots and along Grundy Lane and Bayhill Drive between Cherry Avenue and Elm Avenue. Topographic survey[1] prepared by BKF Engineers shows pipe collection systems that increase to 24 inches and 48 inches in Grundy Lane and Bayhill Drive, respectively, at their connections to the 72-inch main, however detailed pipe information (e.g. pipe size, slope, capacity, condition, etc.) are not available for all storm drain pipes within the Planning Area.

Pipeline capacity deficiencies in the 72-inch diameter trunk line that runs through the Planning Area were noted in the Master Plan. Additional downstream deficiencies, easterly of the Planning Area were also noted as part of this pipeline network for Watershed A. To date, no improvements have been constructed to address these deficiencies and funding has not been identified.

3.2 CITY OF SAN BRUNO STORM DRAIN MASTER PLAN

The City of San Bruno Storm Drain Master Plan, dated June 2014, was prepared specifically to address localized flooding throughout the City and to determine proposed improvements and construction costs for inclusion in a Stormwater Capital Improvement Plan (CIP). Figure 6 shows the proposed improvement projects from the Storm Drain Master Plan. Multiple options were identified in the Master Plan to address the capacity deficiencies in Watershed A described above. One proposed option identified in the Master Plan is to construct an enlarged detention basin (62.5 acre- feet of storage) located within the Crestmoor Canyon, located northwest and upstream

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[1] YouTube Vesting Tentative Map and Phase 1 Entitlement Plans, dated October 2019

of the Planning Area, to limit the amount of flow to existing pipes. This option has since been determined to be infeasible by the City. The second option is the installation of a second, parallel, 72-inch pipeline north of and within the Planning Area along pipeline sections A-2, A-4, and A-5, as shown in Figure 6. Based upon the hydraulic modeling completed as part of the Master Plan, the additional 72-inch diameter pipeline is needed to carry the peak flows from a 25-year storm event. Pipeline sections A-2 and part of A-4 are located within Phase IV (1100 Grundy Lane) and Phase V (950 Elm Avenue and 999/1001 Bayhill Drive) of the YouTube development parcels.

Adding a second 72-inch pipeline or upsizing the existing 72-inch pipeline within the Planning Area will not completely address the storm drain capacity deficiencies that are outside the Planning Area. The Storm Drain Master Plan stated that substantial backwater occurs in the lower reaches of Watershed A, east of El Camino Real, near Highway 101, in part due to backwater in the San Bruno Channel which is tidally influenced. This backwater, when combined with peak storm discharge, causes localized flooding at Angus and 7th Avenue during the 25-year storm event that can only be partially addressed by upsizing of the storm drain pipe network. As shown in Figure 6, five pipe upgrades projects (named as A-projects) were identified in Watershed A to reduce flooding, two of which are in the Planning Area (Pipe ID #s 363, 365, 367, in the Master Plan), one of which is upstream, and two of which are downstream. The most substantial downstream project needed to mitigate flooding is Project A-1, which requires upsizing of the Belle Air storm drain by adding a third 9' x 5' Reinforced Concrete Box (RCB). The remaining four projects, inclusive of the 72-inch parallel pipe segments in Phase IV and V, are required due to localized sections of pipe being undersized for the 25-year design flow.

3.3 PHASE 1 DEVELOPMENT PROPOSED IMPROVEMENTS

Stormwater from Phase I Development[1] will be directed to on-site stormwater treatment facilities which are collected by piped private storm drain systems prior to discharging into the public storm drain system. Proposed treatment improvements include bioretention areas, flow-through planters, green-roofs, and pervious pavements that drain to native soil. The two building sites include bioretention planters adjacent to the buildings to collect roof runoff and landscape areas that direct infiltration to the underlying soil. Building 1 North also has a partially vegetated roof (green roof) and pervious pavement. Phase 1 Development flows will be directed to the proposed 24-inch public storm drain pipeline in Grundy Lane and existing stormwater collection system in Bayhill Drive between Cherry Avenue and Elm Avenue. Bioretention planters are planned for the treatment of street improvements in the realigned portions of Grundy Lane and the modified surface parking areas located on the 950 Elm Avenue parcel and 1100 Grundy Lane parcel. Refer to Figure 7A for the existing and proposed storm drain infrastructure in the public right-of-way, and Figure 7B for the anticipated tributary drainage areas.

Based on hydraulic capacity calculations and an allowance for potential additional flows from future phases of development, it is recommended that the storm drain pipe at Grundy Lane be upsized to a 30-inch diameter pipe. Pipe sizes, slopes, and capacity for the existing stormwater collection system in Bayhill Drive will need to be field verified and evaluated, but stormwater flows to these pipes are expected to be reduced from the pre-development condition as there is less contributing drainage area with the realignment of Grundy Lane. See Section 5.4 Hydraulic Analysis for further discussion on pipe sizing, pipeline capacity analysis and recommendations. Figure 7B provides a summary of the results.

3.4 PLANNING AREA PROPOSED IMPROVEMENTS

Future improvements within the Planning Area include the relocation of the existing 72-inch trunk line with the Phase IV and Phase V Developments in order to maximize the developable area on the parcels. See Figure 7A. The proposed pipeline relocation to the parcel boundaries will require large junction structures at the angle points of the pipe alignment as it generally follows the property line. In addition, the Master Plan recommends installing a parallel 72" diameter pipeline as part of the CIP improvements identified in the 2014 SDMP. Constructing a larger, single conveyance structure to carry the 25-year storm peak flows as an alternative to the two parallel 72-inch pipelines could be an option if timing, funding and agreements between the developer and the City are in place. An updated hydraulic study and design evaluation shall be conducted to analyze the performance and confirm the feasibility of the proposed storm drain improvements to address existing capacity deficiencies.

Other improvements will include stormwater management facilities for each development to meet local, state and federal requirements for water quality treatment as well as flood control. While the specific improvements for future development are not known at this time, they are anticipated to be similar to the "C.3" post-construction water quality treatment measures that are planned for the Phase 1 Development, such as bioretention areas, flow-through planters, green-roofs and pervious pavements that drain to native soil. Stormwater runoff would be captured in drainage facilities or infiltrated into native soil to recharge groundwater. All drainage facilities would be designed to meet City of San Bruno Standards and drain to the existing public storm drain system.

4.0 HYDROLOGY AND LAND USE

4.1 IMPERVIOUS AND PERVIOUS SURFACES

The permeability of the ground surface is a key factor in quantifying the amount of stormwater runoff that can be expected from a contributing area. The change in the permeability of the ground surface in land development has a direct impact to the quantity of runoff. An increase in impervious surfaces can increase runoff resulting in increased peak flows to the storm drain system. A reduction in impervious surfaces can decrease the peak flows generated by surface water as more water drains into the soil or landscaping. Therefore, a comparison of pre-development impervious areas and post-development impervious areas is used to determine the project's impact on the storm drainage system.

Impervious (impermeable) surfaces are mainly artificial structures—such as buildings and pavements (roads, sidewalks, driveways and parking lots), that are covered by impenetrable materials such as asphalt and concrete.

Pervious (permeable) surfaces are mainly grass or soil surfaces that allow runoff to percolate into the ground relatively easily. This includes permeable paving which is a type of paving for vehicle and pedestrian pathways that allows for infiltration into infinite soil below.

Pre-project land use currently consists of a mix of buildings and surface parking lots (impervious surfaces) and areas of landscaping (pervious surface). It is estimated that the landscape areas are approximately 20% of the Planning Area and approximately 24% of the Phase I Development.

The proposed YouTube expansion project within the Bayhill Specific Plan Area development proposes larger buildings with extensive subsurface parking structures which limits opportunities for stormwater reduction from infiltration through pervious surfaces. For the purposes of addressing site hydrology and the comparison of pre-and post-project drainage evaluation, all surfaces above the parking substructure are considered impervious. State Water Board has provided feedback to the City staff that pervious pavement over any underground structure (impervious facility) is considered impervious; however, the gravel layer, depending on the depth, can be considered storage.

4.1.1 Specific Plan Area Development

The percent impermeability comparison presented in this report is based on ground level surfaces only and provides a means to estimate the likely change in stormwater quantity without introducing other measures to limit runoff. The existing conditions were based on an aerial image.

Figure 8 shows the general outline of existing and proposed development landscape areas (e.g. planting, green roof, pervious pavement that drain to native soil, etc.) which were used to quantify and compare pervious and impervious areas and relative impact to stormwater runoff. The existing percent impermeability of the Planning Area was estimated at approximately 80%. Based on a review of the planned open space, and greenway landscaped areas it is estimated that the percent impermeability of the Planning Area after Specific Plan buildout would be approximately 85%. This increase in impervious area is primarily due to the potential development of the currently undeveloped parcel adjacent to Highway 280 at the western end of the Planning Area.

4.1.2 Phase 1 Development

The Phase 1 development proposes the construction of two new buildings in the location of existing surface parking lots. Subterranean parking structures will be constructed to replace the surface lots. The new parking structures are more expansive than the building footprint and restrict areas for stormwater infiltration. The information provided for evaluating the Phase 1 Development pre- and post-development impervious areas consisted of a Vesting Tentative Map dated October 4, 2019, Preliminary Design Drawings dated October 4, 2019, 2019 and a memorandum dated August 29, 2019 from BKF titled “YouTube Phase 1 C.3 Narrative” along with the submitted “C.3 and C.6 Development Review Checklist” forms. A C.3 Checklist enumerating the pre-and post-construction impervious and pervious areas was submitted for each parcel affected by the Phase 1 Development. The C.3 Narrative and Checklists were provided to the City as part of the YouTube Vesting Tentative Map and Phase 1 plan submittal. The information provided on the Checklists was reviewed for consistency with the pervious and impervious areas identified on the design drawings. The Narrative and compiled data from the C.3 Checklists which describe the change in impervious areas, show that there is no increase. However, the preliminary design plans show that a portion of the proposed pervious pavement area is above the parking structure and therefore this area cannot be considered pervious as infiltration to native soils is limited. The estimated percent impermeability is 76% pre-project based on a review of aerial maps of the areas of parking lots, roadways and rooftops compared to the total Phase 1 development. This compares to 77% post-project impervious surfaces as detailed on the Phase 1 documents, therefore the initial review shows a potential increase in surface runoff.

5.0 STORMWATER RUNOFF CALCULATIONS

The evaluation of stormwater impacts is based on the change in impervious and pervious surfaces of the development. Calculations provided are for comparison of pre-development and post-development flows. The rational method was used to calculate the flow, Q, from Q=CiA. Where C is the drainage runoff coefficient, “i” is the intensity for the given design storm frequency and storm duration, and “A” is the drainage area.

5.1 PARAMETERS AND ASSUMPTIONS

The parameters used in the stormwater runoff calculations are summarized in the following tables and based on the assumptions as follows:

- Land Use and Impervious Areas: Based on the information available for the entire Specific Plan Area, primarily the allowable footprint of the subterranean parking structures, (Figure 3), which limits infiltration, and open space greenway plans (Figure 9), the impervious area increases from approximately 80% to 85%

percent of the total area. The project site percent imperviousness is closely related to the runoff coefficient "C" factor in the rational method calculation. The lower the "C" coefficient, the greater the site's infiltration capability. The high "C" factor areas such as rooftops and pavements have low infiltration and more surface runoff is generated. The runoff coefficients used in the calculations are in accordance with the City of San Bruno's Municipal Code for hydrology calculations and are based on the type of development. Parks and Open Areas have a "C" coefficient of 0.35 and Commercial and Paved Areas have a "C" of 0.95.

For the Phase 1 Development, land use areas were taken from preliminary design information provided by the City including the C.3 Narrative and Checklist forms dated October 4, 2019 prepared by YouTube for the Phase 1 Development. Based on the compiled Checklist information, the pre-development condition consists of approximately 688,083 square feet of impervious area. Post-development condition (Phase 1 Development) shows an increase in impervious area with approximately 9,000 square feet of pervious paving above the parking structure, which is considered impervious, in addition to the 688,083 square feet of proposed impervious area indicated on the Checklist forms. As a result, additional pervious area shall be allocated into the project to maintain the pre-project impervious surfaces. The calculations presented below reflect the increase of impervious areas based on the review of the preliminary design information.

- Design Storm: The 25-year and 100-year storm events were selected for consistency with the City's municipal code requirements for hydrology evaluation. (Per municipal code section 12.44.090, the 25-year storm is used for pipe sizing for the street storm drain system. Pipes shall be designed with the hydraulic grade line six inches below the flow line of the curb to avoid damage from a 50-year storm and the 100-year design storm shall be contained in the street right of way.)
- Rainfall Intensity: The rainfall intensity was obtained from the NOAA Atlas 14 precipitation frequency estimates. See attached Figure 10. A "Duration" of 10 minutes is used to be consistent with the City of San Bruno's municipal code for storm drainage calculations.
- Drainage Patterns: The drainage patterns are generally maintained from the pre-development condition. The Planning Area slopes from west to east, toward the San Francisco Bay. Runoff is collected in a conventional storm drain system that conveys storm water to a 72" diameter trunk line on the eastern portion of the site near Elm Avenue.

5.2 CALCULATIONS – SPECIFIC PLAN AREA

Hydrologic calculations to compare flow rates in the pre-project and post-project Planning Area conditions were prepared based on the standard Rational Method which utilizes several variables to estimate peak runoff flow rates for various storm events:

$Q = C_w iA$
Q = Flow rate [cfs]
C_w = Weighted Rational Runoff Coefficient
i = Rainfall Intensity [in/hr]
A = Area [acres]

A weighted C was calculated for both pre and post conditions. The National Oceanic and Atmospheric Administration's (NOAA) Precipitation Frequency Data Server was used to determine rainfall intensity for both the 25 and 100-year storm events. Based on a time of concentration of 10 minutes, rainfall intensity values for the 25 and 100-year storm event were 2.43 inches/hour and 3.08 inches/hour respectively per Figure 10.

5.2.1 Calculation of Weighted "C", Cw:

$$C_w = \frac{C_i A_i + C_p A_p}{A_T}$$

C_w =	Weighted runoff coefficient for drainage area	A_i =	Impervious Drainage Area (acres)
C_i =	Impervious Area Runoff Coefficient	A_p =	Pervious Drainage Area (acres)
C_p =	Pervious Area Runoff Coefficient	A_T =	Total Drainage Area (acres)

SPECIFIC PLAN AREA: PRE-DEVELOPMENT WEIGHTED "C":

Pervious Area, A_p =	18.44 ac	C_p=0.35
Impervious Area, A_i =	73.76 ac	C_i=0.95
Total Area, A_T =	92.2 ac	
$C_{W(pre)}$ = 0.83		

SPECIFIC PLAN AREA: POST DEVELOPMENT WEIGHTED "C"

Pervious Area, A_p =	14.0 ac	C_p=0.35
Impervious Area, A_i =	78.2 ac	C_i=0.95
Total Area, A_T =	92.2 ac	
$C_{W(post)}$ = 0.86		

5.2.2 CALCULATION OF 25-YEAR PEAK FLOW AND 100-YEAR PEAK FLOW, Q

Q = Peak Flow (cfs) for drainage area
i = Intensity (in/hr) for the given design frequency
C_W = Weighted runoff coefficient
A_T = Total Drainage Area (acre)

25 YEAR PRE-DEVELOPMENT RAINFALL PEAK FLOW

C_W =	0.83
i =	2.43 in/hr
A_T =	92.2 acres
$Q_{25\ year\ (pre)}$ =	**186.0 cfs**

25 YEAR POST-DEVELOPMENT RAINFALL PEAK FLOW

C_W =	0.86
i =	2.43 in/hr
A_T =	92.2 acres
$Q_{25\ year\ (post)}$ =	**192.7 cfs**

100 YEAR PRE-DEVELOPMENT RAINFALL PEAK FLOW

C_W =	0.83
i =	3.08 in/hr
A_T =	92.2 acres
$Q_{100\ year\ (pre)}$ =	**235.7 cfs**

100 YEAR POST-DEVELOPMENT RAINFALL PEAK FLOW

C_W =	0.86
i =	3.08 in/hr
A_T =	92.2 acres
$Q_{100\ year\ (post)}$ =	**244.2 cfs**

Based on this preliminary analysis, it is estimated that the peak flow runoff from the Bayhill Specific Plan area during full development is approximately 192.7 cubic feet per second (cfs). The estimated peak flow runoff from the existing site is approximately 186.0 cfs. Thus, the quantity increases from the existing condition by approximately 6.7 cfs under the assumptions presented for the 25-year storm event. This amount results in a 3.6% increase in peak flow runoff and contributes to an existing drainage system that is over capacity.

5.3 CALCULATIONS – PHASE 1 DEVELOPMENT

A weighted C was calculated for both pre and post Phase 1 Development conditions. The National Oceanic and Atmospheric Administration's (NOAA) Precipitation Frequency Data Server was used to determine rainfall intensity for both the 25 and 100-year storm events. Based on a time of concentration of 10 minutes, rainfall intensity values for the 25 and 100-year were 2.43 inches/hour and 3.08 inches/hour respectively per Figure 10.

5.3.1 Calculation of Weighted "C", C_W, $C_w = \frac{C_i A_i + C_p A_p}{A_T}$

C_w =	Weighted runoff coefficient for drainage area	A_i =	Impervious Drainage Area (acres)
C_i =	Impervious Area Runoff Coefficient	A_p =	Pervious Drainage Area (acres)
C_p =	Pervious Area Runoff Coefficient	A_T =	Total Drainage Area (acres)

Phase 1 - Pre-Development Weighted "C"

Pervious Area, A_p =	4.96 ac	C_p=0.35
Impervious Area, A_i =	15.80 ac	C_i=0.95
Total Area, A_T =	20.76 ac	
$C_{W(pre)}$ = 0.81		

PHASE 1 - POST DEVELOPMENT WEIGHTED "C"

Pervious Area, A_p =	4.76 ac	C_p=0.35
Impervious Area, A_i =	16.0 ac	C_i=0.95
Total Area, A_T =	20.76 ac	
$C_{W(post)}$ = 0.82		

5.3.2 CALCULATION OF 25-YEAR PEAK FLOW AND 100-YEAR PEAK FLOW, Q

Q = Peak Flow (cfs) for drainage area; i = Intensity (in/hr) for the given design frequency

C_W = Weighted runoff coefficient; A_T = Total Drainage Area (acres)

25 YEAR PRE-DEVELOPMENT RAINFALL PEAK FLOW

C_W =	0.81
i =	2.43 in/hr
A_T =	20.76 acres
$Q_{25\ year\ (pre)}$ =	**40.9 cfs**

25 YEAR POST-DEVELOPMENT RAINFALL PEAK FLOW

C_W =	0.82
i =	2.43 in/hr
A_T =	20.76 acres
$Q_{25\ year\ (post)}$ =	**41.4 cfs**

100 YEAR PRE-DEVELOPMENT RAINFALL PEAK FLOW

C_W =	0.81
i =	3.08 in/hr
A_T =	20.76 acres
$Q_{100\ year\ (pre)}$ =	**51.8 cfs**

100 YEAR POST-DEVELOPMENT RAINFALL PEAK FLOW

C_W =	0.82
i =	3.08 in/hr
A_T =	20.76 acres
$Q_{100\ year\ (post)}$ =	**52.4 cfs**

The calculations reflect an increase in runoff of approximately 0.5 cfs, or approximately 1%, with the increase in impervious area.

5.4 HYDRAULIC ANALYSIS

Hydraulic analysis is needed to evaluate the capacity of existing and proposed stormwater systems and their ability to collect and convey stormwater flows from Phase 1 Development and the Planning Area, however, due to limited information, only the proposed pipes in Grundy Lane were fully studied. Autodesk Hydraflow[2] was used to model the proposed pipes within Grundy Lane along with their respective tributary drainage areas to identify improvements to be constructed during Phase I to serve Phase I and future development. The hydraulic capacity analysis was based on the variables that were inputted into the Hydraflow model, which include but are not limited to the following: design flow quantity, pipe size, pipe slope, roughness coefficient based on pipe material, etc. The design flow quantity, Q, was determined using the Rational Method, consistent with the storm runoff calculation parameters noted in Section 5.3. The drainage areas, A, used to calculate the design flows were based on the proposed Phase I grading, utility and stormwater plans[1], hydrology and land use evaluation as described in Section 4.0, and estimate of future contributing drainage areas. It is assumed that future development of Phase II and IV will have drainage contribution to the Grundy Lane pipe network to account for drainage from the building setback areas and portions of the building roofs. Pipe size and slope were also based on the proposed utility plan

[2] Autodesk Hydraflow Extensions ® within Autodesk Civil 3D® is a hydrology and hydraulics modeling tool. Hydraflow utilizes the Manning Formula for sizing of circular pipes which is consistent with the City of San Bruno Municipal Code.

and the roughness coefficient was based on the use of reinforced concrete pipe, as required by the Municipal Code.

The hydraulic analysis results of the Phase 1 Development pipe system are shown in the “Proposed Pipe Flow & Capacity” table on Figure 7B. The design pipe fullness (depth/Diameter) criteria used for evaluating pipe capacity were set at ¾ to completely full for existing pipes and ½ full for new pipes during the peak flow of the design storm. As a result, 30-inch storm drain pipes are recommended for the realigned Grundy Lane, pipe segments G-L2, G-L3, and G-L4 as shown on Figure 7B. Capacity of existing pipes in Bayhill Drive, which carries a portion of the flows from the Phase 1 Development, could not be analyzed due to unknown pipe sizes and slopes. However, future flow quantity to the Bayhill Drive pipes is anticipated to be less than the pre-development condition as the tributary area has been reduced due to the realignment of Grundy Lane. Existing conditions of the remainder of the pipe networks within the Planning Area are also unknown and could not be analyzed; therefore, recommendations are not currently available. See Section 3.4 for proposed improvements to address existing capacity deficiency of the 72-inch main trunk line.

6.0 STORMWATER QUALITY

The City of San Bruno administers stormwater quality protection through the Municipal Regional Stormwater Permit (MRP) which is issued by the Regional Water Quality Control Board (San Francisco Bay Region) under the National Pollution Discharge Elimination System (generally referred to as the NPDES permit). The City is also a member of the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), which is a program created to coordinate pollution prevention programs and works with the City to continue their compliance and continued issuance of the stormwater discharge permits by the Regional Water Quality Control Board.

6.1 WATER QUALITY DURING CONSTRUCTION

Construction activities could generate dust, sediment, litter, oil and other pollutants that could temporarily contaminate water runoff from the site. Implementation of the developments, Phase 1 and the full Planning Area, are subject to the City’s Municipal Code and Construction Site Control Program requirements. A Storm Water Pollution Prevention Plan (SWPPP) is required for all construction projects. Projects that have a land area disturbance of greater than 1 acre in size are also required to submit the SWPPP to the State Water Board, as well as a Notice of Intent for coverage under the statewide Construction General Permit (CGP). The SWPPP is required to be submitted prior to issuance of construction permits, including but not limited to demolition and grading permits, by the City of San Bruno. Compliance with the City’s grading permit and the CGP will require use of temporary Best Management Practices (BMPs) to control soil erosion and sediment and restrict non-stormwater discharges from the construction site, as well as release of hazardous materials. The SWPPP is prepared by a Qualified SWPPP Developer (QSD) and implemented by a Qualified SWPPP Practitioner during construction and is required to be updated as needed based on project progression and changed conditions. The State Water Board requires an annual report and the annual report shall be provided to the City for reference as well. Compliance with the City and State regulatory requirements are to ensure that construction activities do not result in a violation of water quality standards or waste discharges requirements, or otherwise result in water quality degradation.

Interim or temporary site improvements, such as the proposed parking lots to be used during Phase 1 construction, shall also comply with water quality standards that provide pollutant control and reduce or limit surface runoff to pre-project conditions.

An assessment of groundwater impacts is covered in a separate technical memorandum.

6.2 POST CONSTRUCTION WATER QUALITY IMPACTS

The development of the Bayhill Specific Plan area, including the Phase I Development, is subject to the stormwater treatment requirements in Provision C.3 of the MRP. Per the MRP, the City of San Bruno is tasked with enforcement of the requirements for stormwater controls for development projects. Provision C.3 of the MRP requires that development projects mitigate impacts on water quality by incorporating “Low Impact Development” (LID) measures including site design, pollutant source control, stormwater treatment and flow control measures. LID treatment measures have been required on regulated projects since 2011. These treatment measures include “capture and re-use” or rainwater harvesting, infiltration and bioretention basins or flow-through planters and green roofs. The City of San Bruno is a member of the San Mateo County Water Pollution Prevention Program (SMCWPPP) and requires developers to use SMCWPPP guidance material for implementing LID and green infrastructure.

The MRP also requires permittees to comply with Provision C.10, Trash Load Reduction, to limit trash-related pollutants from entering receiving waters. Implementation of trash control measures and other actions to reduce trash loads from entering municipal storm drain systems is required to demonstrate compliance to meet the goal of 100 percent trash load reduection or no adverse impact to receiving waters from trash by July 2022. The City of San Bruno requires that all new development shall provide trash capture devices on all drain inlets that connect to the municipal storm drain system.

In addition, the City has recently adopted a Green Infrastructure Plan (GI Plan) for compliance with the MRP, Provision C.3.j.The GI Plan addresses long-term measures for the inclusion of vegetated or green landscape into public rights-of-way and public properties in additon to private developments. Green landscape in public and private properties is required by the MRP to address the stormwater quality impacts from paved roadways, sidewalks, parking lots and other areas where stormwater collects pollutants which would otherwise flow to the San Francisco Bay. In addition to capturing pollutants, green infrastructure slows and reduces runoff, and allows infiltration of stormwater for recharging of groundwater. The Bayhill Specific Plan is noted in the GI Plan as an opportunity for implementation of green infrastructure to further the long term goals of the GI Plan to reduce pollutants in the discharge of stormwater.

6.2.1 Phase 1 Development

The Phase 1 preliminary design documents including the “C.3 and C.6 Development Review Checklist” and Stormwater Control Plan drawings identify LID areas and methods for treatment of stormwater runoff. The Stormwater Control Plan also provides a LID treatment sizing summary table based on the combination flow and volume sizing method and an assumed ponding depth of 12 inches. The Phase 1 project proposes to utilize the bioretention method in “flow through planters” to treat both the roof runoff and on-site surface flows. The proposed vegetated “green” roof areas and pervious pavements that drain directly to native soil around the new building sites reduce the amount of impervious areas requiring treatment. The locations and sizes of the LID features are noted on the Stormwater Control Plan for the building sites, Phase 1 North and Phase 1 South as well as for Grundy Lane. Stormwater treatment facilities that provide infiltration into the underlying soils are limited due to the size (footprint) of the subterranean parking garages, which encompass a substantial portion of the developable property. This is a preliminary plan and will be updated with the final design plans to be submitted for construction permits. To determine compliance with C.3 regulations, the City will review the final design plans including grading plans and direction of stormwater flow, storm drain system utility plans, and stormwater treatment measure standard details. A Stormwater Control Plan Report, including updated C.3 and C.6 Development Review Checklist, a description of site design and source control measures, drainage management areas, stormwater treatment measure sizing calcuations, and a maintenance plan, shall be submitted with the final design plans.

Roadway runoff from the realignment of Grundy Lane (Part 1 and 3) would be directed to bioretention areas located in the street planter strip for compliance with C.3 regulations. The reduced pavement area within the right of way in Grundy Lane (Part 2) replaces impervious pavement areas with a linear landscape strip with new trees located between the street curb and sidewalk. This new streetscape would reduce surface water flows and promote infiltration through the landscaping into the underlying soil.

6.2.2 Specific Plan Area

Subsequent phases of development will likely utilize similar LID treatment methods as used in Phase 1 and will be required to follow the guidelines of the GI Plan for public area improvements as well as meet current regulatory requirements, at the time of each development, for stormwater managment. In addition to the bioretention planters, green roofs and permeable pavement used in Phase 1, other potential LID measures for future phases of the development may include rainwater harvesting and re-use for non-potable water uses, including irrigation. Given the site constraints of the subterreanan parking structures, it is expected that an increased use of green roofs or detention facilities will be necessary. These treatment measures are required to be included in the preliminary design phases of specific development proposals as part of the site design approval.

6.3 HYDROMODIFICATION

The Bayhill Specific Plan area adds or replaces more than 1 acre of impervious area but is in an Exempt Area per the Hydromodification Control Areas Map from Appendix H of the SMCWPPP C.3 Stormwater Technical Guidance. See Figure 11. Because the Planning Area is not located within a Hydromodification applicability area, it is not subject to Hydromodification requirements, which are intended to minimize downstream erosion in receiving waters.

7.0 CONCLUSIONS AND RECOMMENDATIONS

As discussed above, existing capacity deficiencies have been identified in the 72-inch diameter trunk line that runs through the Planning Area as well as storm drain infrastructure further downstream. The City's Storm Drain Master Plan concludes that upsizing the existing 72-inch pipeline within the Planning Area will not completely address the storm drain capacity deficiencies that are outside the Planning Area. Therefore, any increase in discharge flows from the Planning Area, including the Phase I Site, would exceed the downstream system capacity. Furthermore, the sizes and capacities of the existing stormwater collection system in Bayhill Drive and Cherry Avenue are unknown and require further study as part of future development.

7.1 IMPACTS

7.1.1 Hydrology and Storm Drain Impacts – Phase 1

The stormwater runoff calculations for pre-development peak flow and post-development peak flow show an increase in post-development peak flows. The recommended mitigations will require that the Phase 1 Development be designed to maintain or reduce stormwater discharge into the existing storm drain infrastructure. The increase in peak flow is a consequence of an increase in impervious surface areas. If maintaining or decreasing the amount of impervious area is not possible, then any increase in ground level impervious areas, can be offset by further increasing the amount of vegetated green roof areas (as shown on Phase 1 buildings) or by implementing on-site detention to maintain or decrease peak flows from pre-development conditions. There can be no net increase to peak flows given the current capacity constraint of the existing storm system. The project applicant, YouTube, has stated that they plan to provide additional pervious areas in the final design documents or otherwise demonstrate in a drainage analysis study that the final design will not increase flows from pre-project levels.

A Final Drainage Design Report is required as mitigation for the Phase 1 development ensuring that no increase in discharge flow is allowed and storm drain infrastructure is adequately sized, including detention facilities if required. Phase I documentation must include all project areas including the new surface parking areas located in Phase II and IV and the private multimodal center. The Drainage Report shall contain a hydrologic and hydraulic analysis to demonstrate that there will be no net increase in stormwater flows directed to the existing drainage infrastructure that is noted to have an existing capacity deficiency.

Construction phase impacts, including temporary surface parking, also require stormwater flows to be maintained at or below pre-construction levels. Construction staging areas and temporary parking areas will need to maintain pervious areas to maintain pre-development runoff conditions. Detention facilities can also be implemented to maintain pre-development runoff conditions. No groundwater pumping or dewatering for construction of subterranean parking is anticipated in Phase 1.

7.1.2 Water Quality Impacts for Phase 1 Development

The use of bio-retention planters, green roof areas and permeable pavements are noted in the Phase 1 preliminary design documents. A preliminary Stormwater Control Plan has been provided which documents the location and size of the treatment facilities. A final Stormwater Control Plan is required as part of the construction documents and will be reviewed by City staff for compliance with MRP requirements and for consistency with SMCWPPP's C.3 Stormwater Technical Guidance[3].

The Phase 1 Development preliminary design and project documents dated October 4, 2019, indicate that several stormwater treatment measures will be incorporated into the design for Phase 1 building sites, including pervious pavements, green roof areas, bio-retention planters and extensive landscaping at the public plaza areas and roadways. The plan for the realignment of Grundy Lane, associated reconfigured parking areas, and the multimodal transit hub have also been designed to incorporate bioretention treatment areas. Updated plans and calculations demonstrating compliance with regulatory requirements will be required with the final design subject to review for construction permits.

Construction phase impacts are addressed by implementing the guidelines and requirements of the Stormwater Pollution Prevention Plan (SWPPP). The SWPPP will be prepared by the applicant and submitted to the City for review and to the State Water Board for compliance with the statewide NPDES Construction General Stormwater permit. The SWPPP details best management practices for reducing erosion and preventing sediments and other pollutants from entering the storm drain system.

Groundwater impacts are addressed in a separate memorandum.

7.1.3 Hydrology and Storm Drain Impacts – Specific Plan

Based on the review of the maximum allowable development within the Bayhill Specific Plan Area, the lot coverage, subterranean parking layouts and proposed greenways, Kimley-Horn estimated that the percent impermeability could increase from approximately 80% to approximately 85%. Without mitigation, this could result in an increase in surface water runoff and stormwater discharge to the public storm drain system. While the potential increase in peak flows is less than 4%, these flows would exceed the capacity of the existing storm drain system. The existing 72-inch pipe near the eastern Planning Area boundary near Elm Avenue (Phases IV and V) and downstream

[3] The SMCWPPP C.3 Stormwater Technical Guidance is being updated and will be renamed the "C.3 Regulated Projects Guide". The new Guide will be available on the SMCWPPP website by March 2020.

conveyance facilities were reported to have existing capacity deficiencies in the City's 2014 Storm Drain Master Plan, such that development within the Planning Area must be designed for no increase in stormwater discharge. The Bayhill Specific Plan will need to include stormwater control measures in the project to limit the post-development runoff to the pre-development conditions as required to avoid impact to the existing storm drain system. Each development project will need to maintain or reduce stormwater discharge to the public storm drain system by limiting post-project impervious areas to be less than or equal to pre-development conditions, or mitigate for increased surface runoff by adding on-site detention facilities, capture and re-use programs, green roofs and/or other methods approved by the City. These measures are consistent with requirements for Low Impact Development and Green Infrastructure in the MRP.

A Final Drainage Design Report for each future proposed development should be required as mitigation ensuring that adequately sized storm drain infrastructure, including detention facilities, if required, are designed into each project and no increase in stormwater discharge to the public storm drain system is allowed.

Groundwater pumping and discharge associated with dewatering for the construction of the below grade parking structures is not anticipated to increase the peak flows into the storm drain system. The total maximum rate is 257 gallons per minute (gpm) which equates to less than one half of 1% of the total flows for the 25-year storm event. The groundwater discharge will be managed to avoid a major storm event as part of the SWPPP permit and standard construction practices. The estimated rates and volumes of construction dewatering and analysis of impacts is provided in the technical memorandum prepared by EKI.[4]

7.1.4 Water Quality Impacts - Specific Plan

Implementation of the Specific Plan would not violate any water quality standards or otherwise result in water quality degradation during operation because stormwater runoff from the Planning Area will be managed consistently with the provisions of the MRP. Construction phase impacts are addressed by implementing the guidelines and requirements of the Stormwater Pollution Prevention Plan (SWPPP).

Stormwater requirements mandate treating 100% of the water quality design flow and volume of runoff with low impact development (LID) measures. These measures typically include bioretention treatment in planters, rainwater harvesting and re-use, infiltration systems, green roofs and permeable pavements. A stormwater control plan is required for each development. Post-construction measures must meet the requirements of the MRP and the San Mateo County Water Pollution Prevention Program.

Incorporation of recommendations from the City's recently adopted Green Infrastructure Plan into the Specific Plan policies will align proposed developments with the City's long-term goals for pollutant reduction and reduced runoff and stormwater discharge from impervious areas associated with development. Types of treatment facilities that can be constructed in public spaces include bioretention planters in the roadway landscaping. Stormwater tree filters and pervious pavements are not encouraged in the public right-of-way due to the increased maintenance cost of these types of treatment facilities.

Groundwater impacts associated with dewatering for the construction of the below grade parking structures are addressed in a separate memorandum.

[4] Groundwater Assessment in Support of Bayhill Specific Plan Environmental Impact Report, dated 8/15/2019.

7.1.5 Cumulative Impact

The geographic area studied for cumulative hydrology and water quality impact analysis includes the Planning Area and its surrounding area within Watershed A. The geographic area is fully developed; therefore, buildout of cumulative projects would involve redevelopment of existing developed sites that contain substantial impervious surfaces, and these projects would be required to comply with the applicable city policies for stormwater discharge. Cumulative projects would be required to comply with applicable requirements in the statewide Construction General Stormwater Permit, City of San Bruno Municipal Code, and MRP standards to reduce hydrology and water quality impacts.

7.2 GENERAL RECOMMENDATIONS

Applicants for the Phase 1 Development and future projects under the Specific Plan, shall provide a Drainage Design Report for City approval before construction permits are issued containing a hydrologic analysis of existing and proposed peak flows which demonstrates that the project as designed will reduce or not increase stormwater peak flow volumes from the existing condition. Pipe sizing and hydraulic analysis consistent with the City of San Bruno's municipal code shall be included. A final stormwater quality analysis shall also be prepared based on the proposed development final design, identifying LID site design, source control, and treatment measures and sizing calculations in compliance with MRP requirements and consistent with SMCWPPP C.3 Stormwater Technical Guidance.

Site design, source control, and treatment measures for stormwater quality shall be subject to the review of the City. Design may include LID practices and the treatment measure options included in the City's Green Infrastructure Plan, SMCWPPP's Green Infrastructure Design Guide, and SMCWPPP's C.3 Stormwater Technical Guidance. These include green roofs, bio-retention areas and planters, tree well filters, rainwater harvesting for capture and re-use and permeable pavements that drain directly to underlying soil and recharge groundwater.

The Specific Plan polices should incorporate the guidelines of the Green Infrastructure Plan for public spaces including street rights of way. Biotreatment planter areas should be incorporated into the retrofitted streetscape within the Planning Area, including Grundy Lane (Part 2) and Bayhill Drive, to be consistent with the requirements of the MRP Provision C.3.j and the Green Infrastruction Plan.

7.2.1 Proposed Mitigation Measures

Mitigation Measure Hydro 1A: Prepare Drainage Report and Implement Stormwater Control Measures to Avoid Increase in Peak Flows

Applicants proposing development shall prepare Drainage Report(s) for City review and approval prior to issuance of a Grading, Building, Site Development or any construction permits. All development, including interim conditions during construction and interim conditions with temporary improvements, within the Planning Area is required to address stormwater management and implement stormwater control measures, including but not limited to on-site detention facilities, capture and re-use measures, green roofs and/or other measures approved by the City, designed to maintain or reduce current, pre-development, surface runoff and stormwater discharge to the public storm drain system.

These Drainage Report(s) shall contain the following:

- Verification of existing pipe network including pipe size, elevation, material and condition including determination of the size and capacity of all elements of the existing stormwater collection system in Bayhill Drive and Cherry Avenue.
- Hydrologic analysis of construction period conditions and implementation of all temporary facilities necessary during construction to avoid increases in peak flows.
- Hydrologic analysis of existing and proposed peak flows that accounts for all areas that will be disturbed by the new development.
- Hydraulic analysis for evaluating pipe capacity and sizing of new pipes. The capacity of existing pipes that are proposed for re-use and new pipes shall be sized in accordance with the City's methodology, as noted in the municipal code or otherwise approved by the City Engineer. New pipes in the public right of way, if required, shall be RCP and have a minimum size of 15 inches. Applicants shall implement all permanent facilities necessary to avoid increases in operational peak flows.

Mitigation Measure Hydro 1B – Dedicate Storm Drain easements for Public Infrastructure

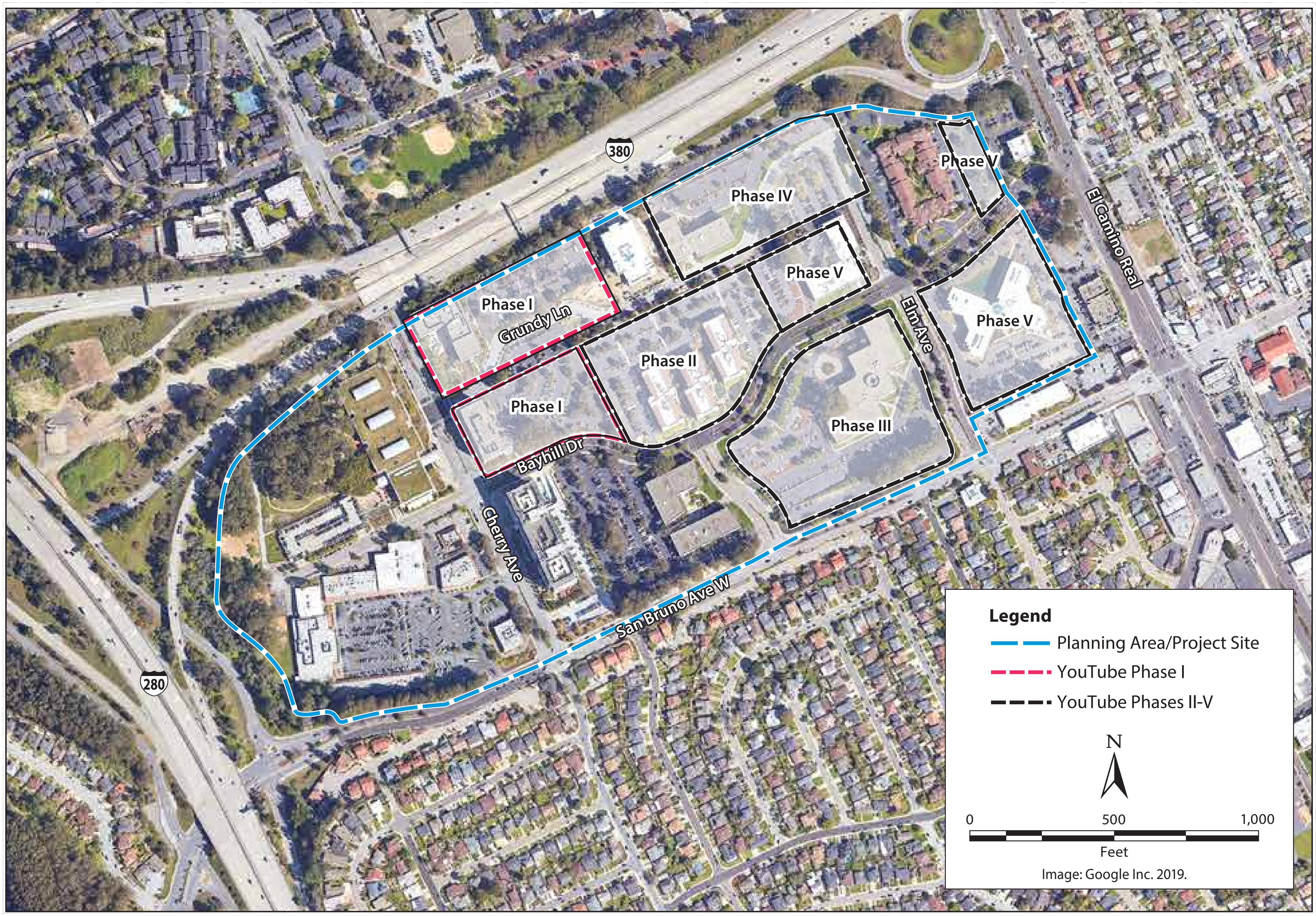
All storm drain pipes and related structures constructed as part of the City of San Bruno's stormwater conveyance system shall be contained within an easement dedicated to the City of San Bruno if the storm drain improvements are located outside of the public right of way. Storm Drain easements shall have a minimum width in accordance with the following:

- Minimum clearance between Outside Diameter (O.D.) of pipe to easement line shall be five (5) feet.
- Minimum clearance between pipes (O.D. to O.D) shall be five (5) feet.
- Minimum clearance between outside of structure to easement line shall be four (4) feet.
- Easement width must meet above requirements but shall not be narrower than fifteen (15) feet.

Figure 1 Vicinity Map

City of San Bruno Bayhill Specific Plan

Kimley»Horn



Source: ICF 2019

Figure 2 Phasing Map

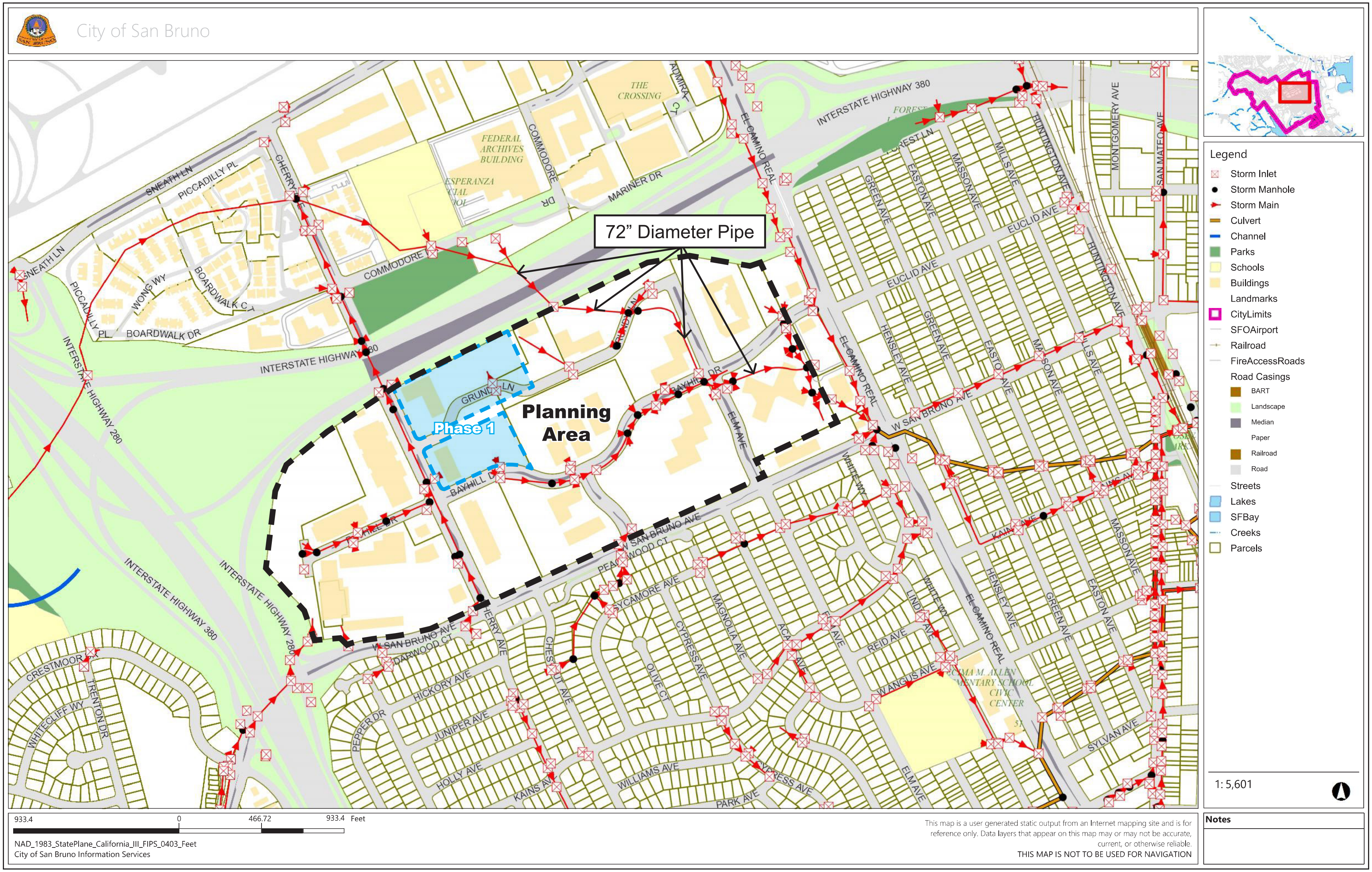
City of San Bruno Bayhill Specific Plan

Kimley»Horn

Figure 3 Potential Subterranean Parking Areas

City of San Bruno Bayhill Specific Plan

Kimley»Horn

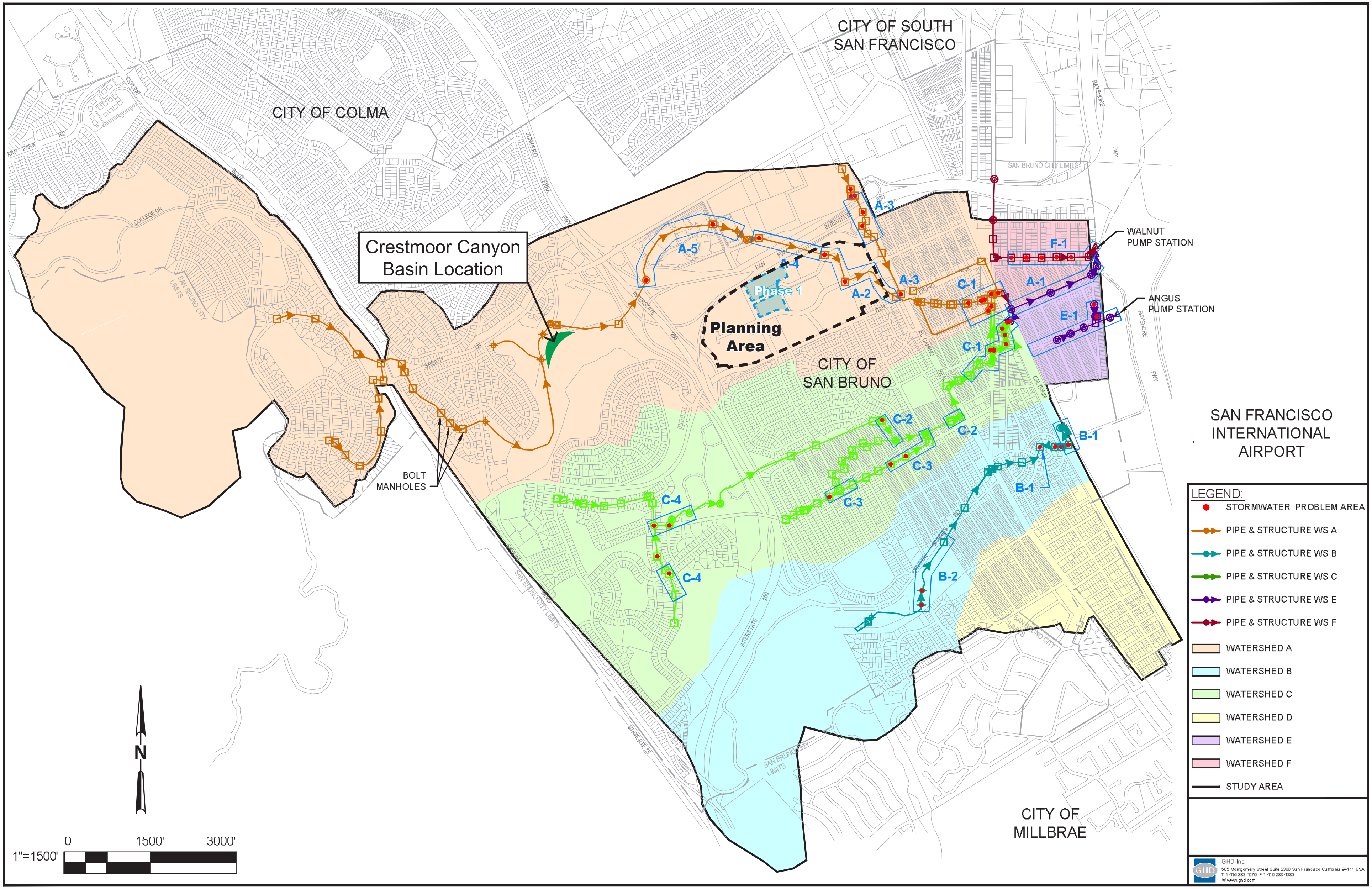


Source: City of San Bruno, Storm Drain Master Plan, 2014

Figure 4 Existing Storm Drain Network

City of San Bruno Bayhill Specific Plan

Kimley»Horn

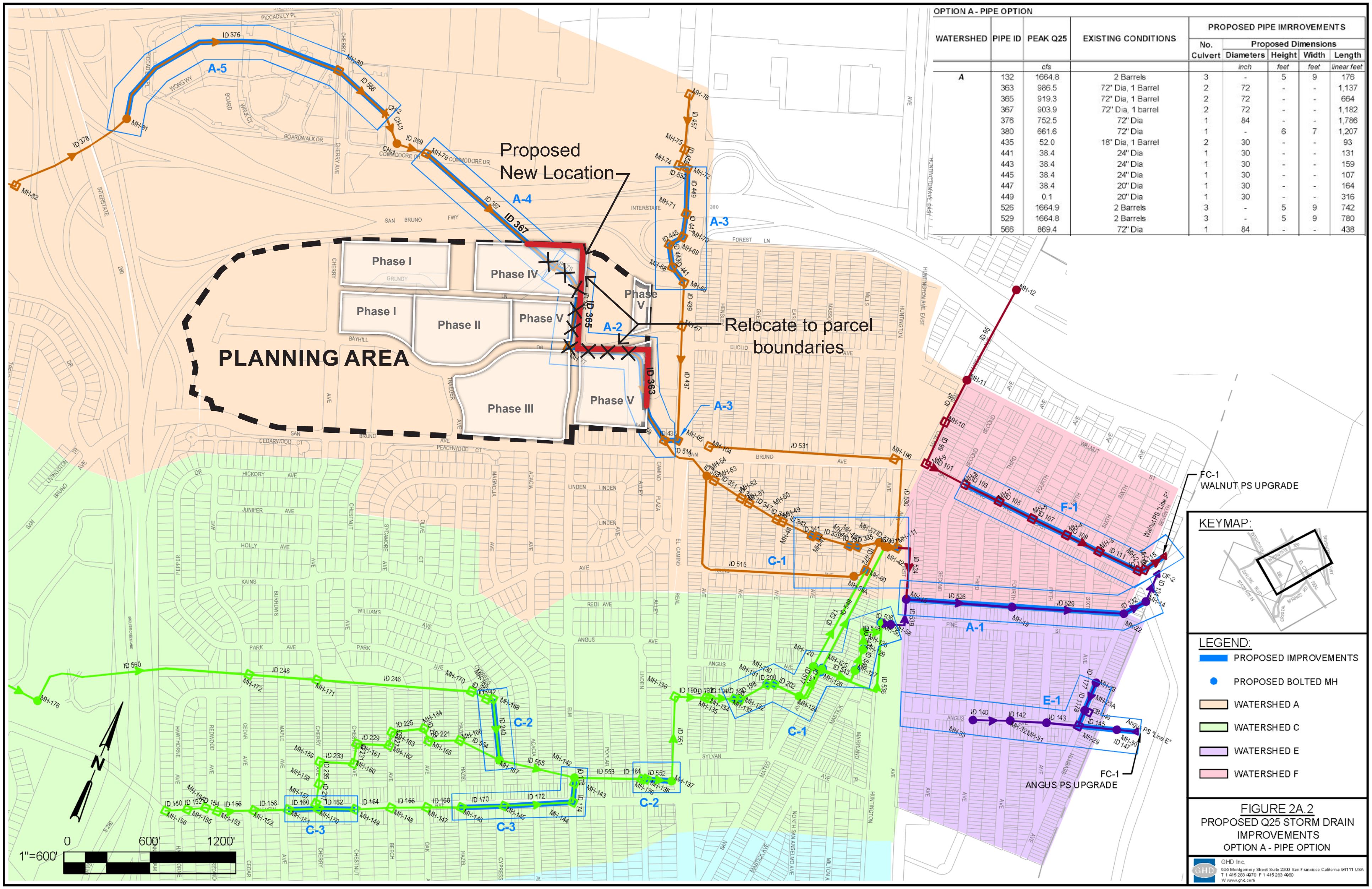


Source: City of San Bruno, Storm Drain Master Plan, 2014

Figure 5 Storm Drain Master Plan Program Areas

City of San Bruno Bayhill Specific Plan

Kimley»Horn



OPTION A - PIPE OPTION

WATERSHED	PIPE ID	PEAK Q25	EXISTING CONDITIONS	PROPOSED PIPE IMRROVEMENTS				
				No. Culvert	Proposed Dimensions			
					Diameters	Height	Width	Length
		cfs			inch	feet	feet	linear feet
A	132	1664.8	2 Barrels	3	-	5	9	176
	363	986.5	72" Dia, 1 Barrel	2	72	-	-	1,137
	365	919.3	72" Dia, 1 Barrel	2	72	-	-	664
	367	903.9	72" Dia, 1 barrel	2	72	-	-	1,182
	376	752.5	72" Dia	1	84	-	-	1,786
	380	661.6	72" Dia	1	-	6	7	1,207
	435	52.0	18" Dia, 1 Barrel	2	30	-	-	93
	441	38.4	24" Dia	1	30	-	-	131
	443	38.4	24" Dia	1	30	-	-	159
	445	38.4	24" Dia	1	30	-	-	107
	447	38.4	20" Dia	1	30	-	-	164
	449	0.1	20" Dia	1	30	-	-	316
	526	1664.9	2 Barrels	3	-	5	9	742
	529	1664.8	2 Barrels	3	-	5	9	780
	566	869.4	72" Dia	1	84	-	-	438

Source: City of San Bruno, Storm Drain Master Plan, 2014

Figure 6 Storm Drain Master Plan Proposed Improvements (Pipe Option)

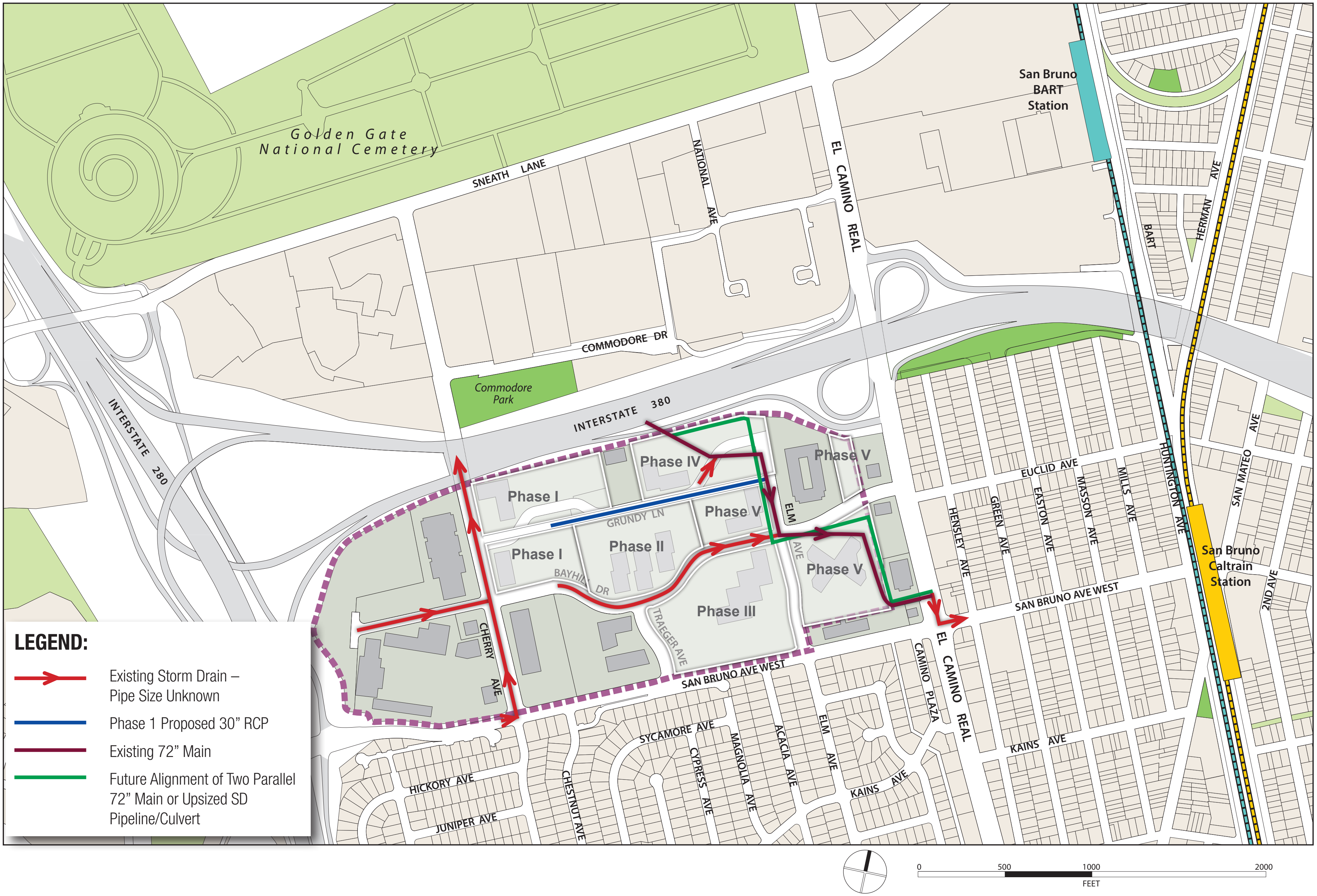


Figure 7A Storm Drain System

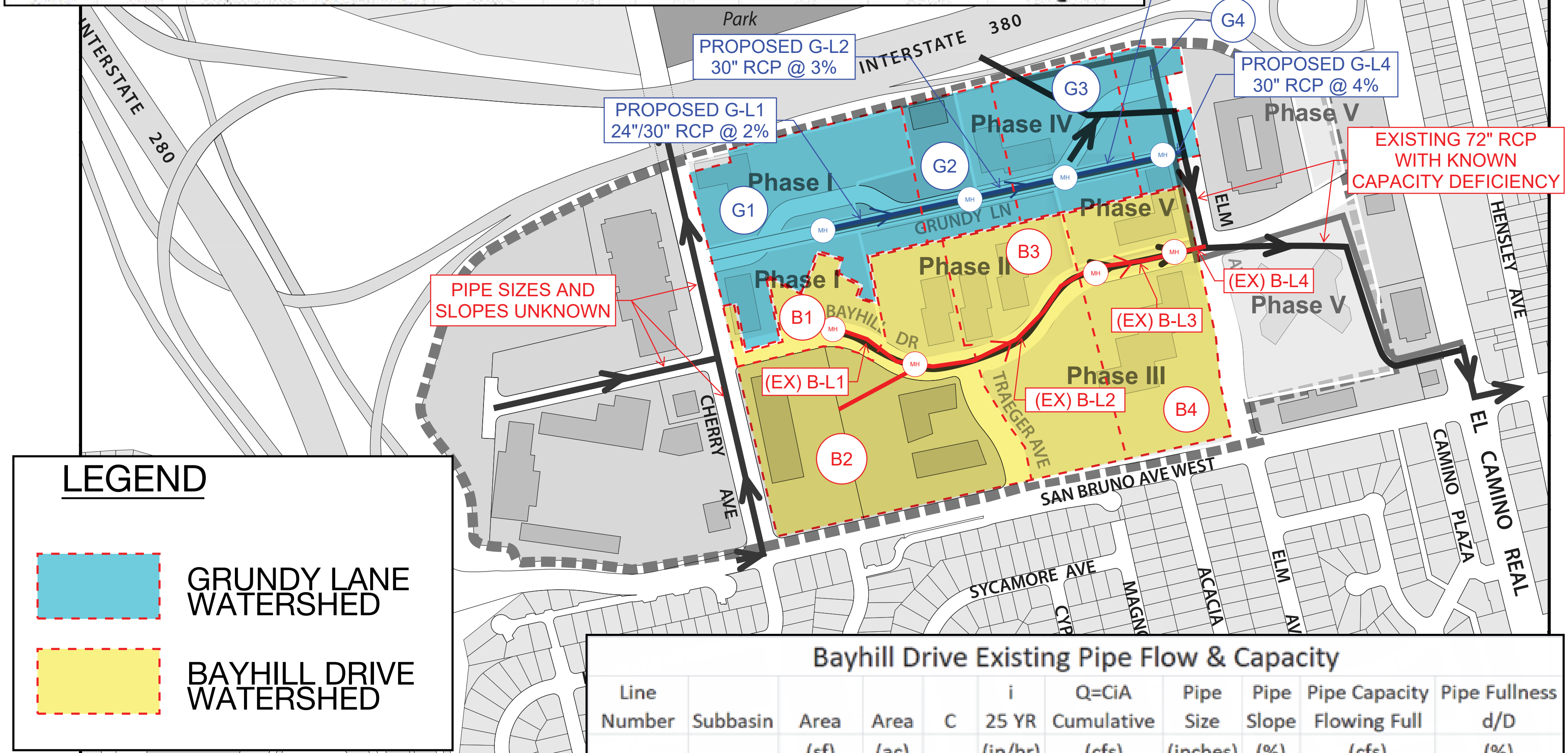
City of San Bruno Bayhill Specific Plan

Kimley»Horn

*BASED ON DRAWINGS PROVIDED BY BKF ENGINEERING CALLED YOUTUBE PHASE 1 REVISION 4 DATED 10/04/2019.

Grundy Lane Proposed Pipe Flow & Capacity

Line Number	Subbasin	Area (sf)	Area (ac)	C	i 25 YR (in/hr)	Q=CiA Cumulative (cfs)	Pipe Size (as designed*) (inches)	Pipe Slope (as designed*) (%)	Pipe Capacity Flowing Full (cfs)	Pipe Fullness d/D (%)	Recommended Pipe Size (inches)
G-L1	G1	336,500	7.72	0.82	2.43	15.4	24	2	32	50%	**24/30**
G-L2	G2	186,200	4.27	0.86	2.43	24.3	24	3	39	57%	**30**
G-L3	G3	216,100	4.96	0.86	2.43	34.7	24	3	39	73%	**30**
G-L4	G4	113,800	2.61	0.86	2.43	40.2	24	3	39	85%	**30 @ 4%**

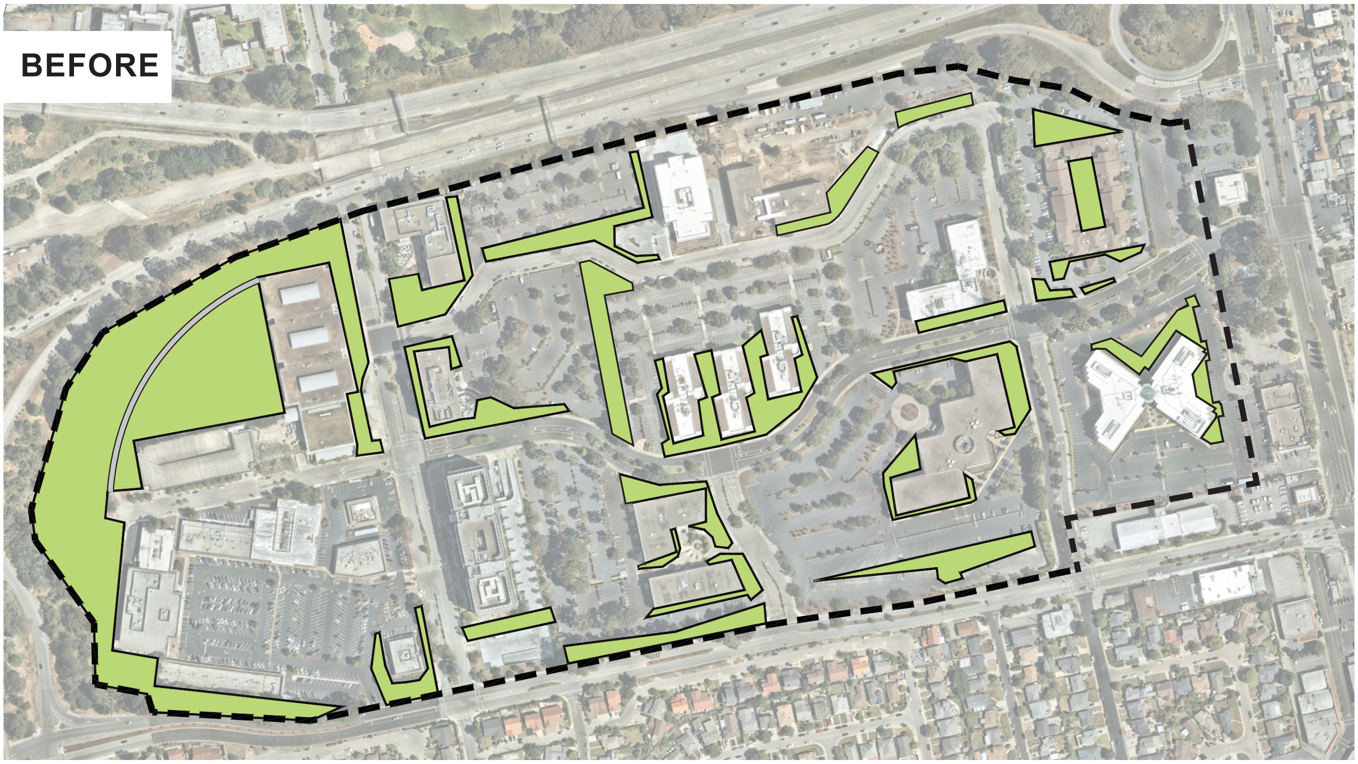


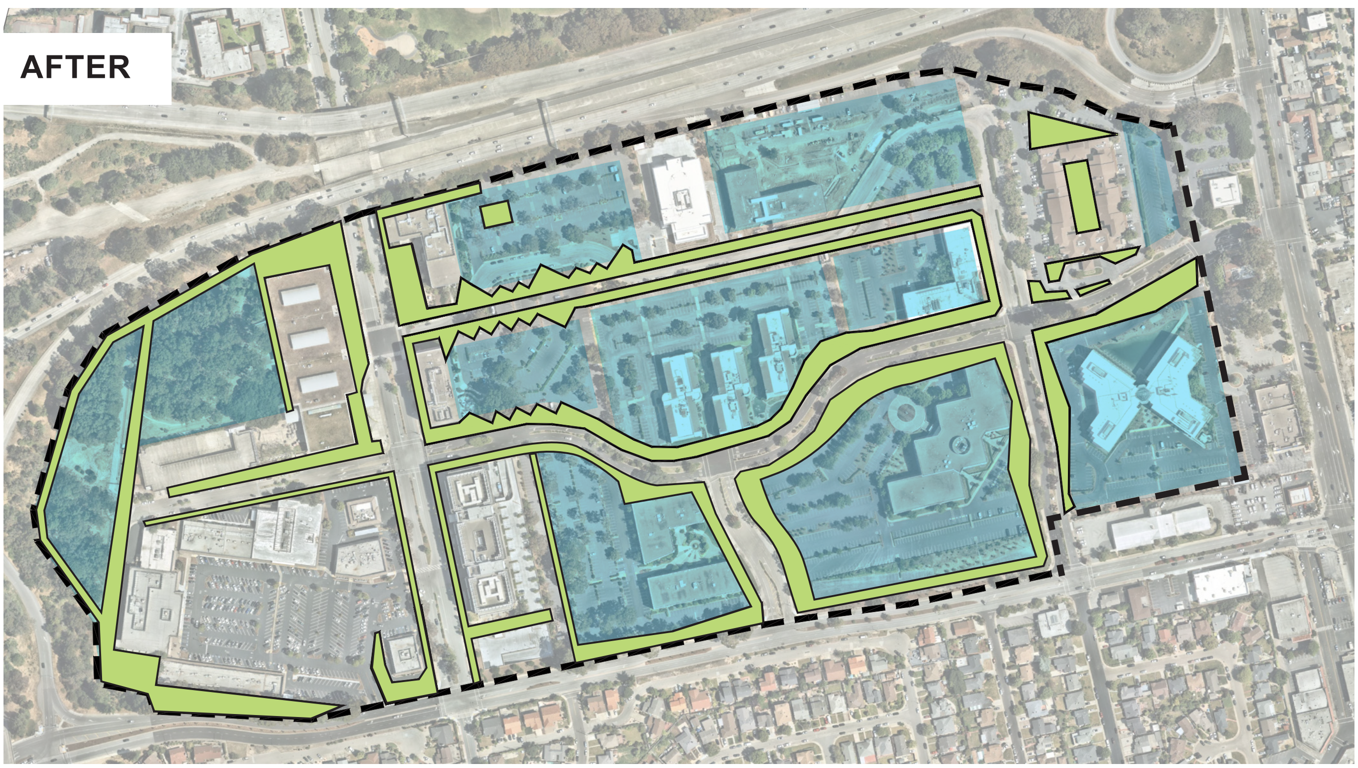
Bayhill Drive Existing Pipe Flow & Capacity

Line Number	Subbasin	Area (sf)	Area (ac)	C	i 25 YR (in/hr)	Q=CiA Cumulative (cfs)	Pipe Size (inches)	Pipe Slope (%)	Pipe Capacity Flowing Full (cfs)	Pipe Fullness d/D (%)
B-L1	B1	99,000	2.27	0.86	2.43	4.7	unknown, field verification needed			
B-L2	B2	526,500	12.09	0.86	2.43	30.0	unknown, field verification needed			
B-L3	B5	306,500	7.04	0.86	2.43	44.7	unknown, field verification needed			
B-L4	B6	363,500	8.34	0.86	2.43	62.2	unknown, field verification needed			

Figure 7B Storm Drain System Analysis
City of San Bruno Bayhill Specific Plan

Kimley»Horn

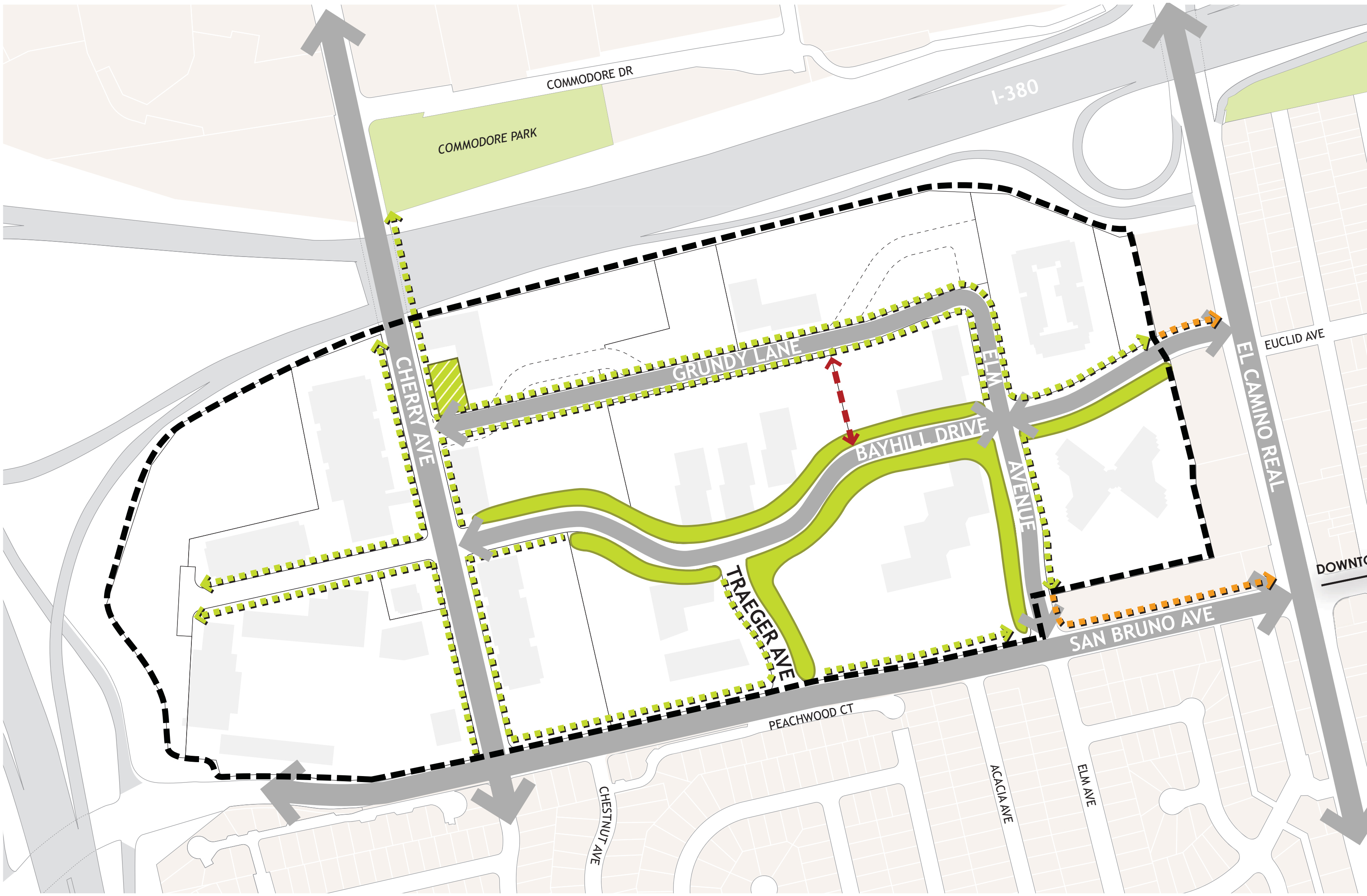




Project Boundary
Landscape/Pervious Surfaces
New Building Surfaces

Figure 8 Before and After Connected Landscape Areas

City of San Bruno Bayhill Specific Plan



Publicly Accessible Greenway
Publicly Accessible Open Space
Multi-Modal Transit Center
Enhanced Pedestrian Ways
Enhanced Pedestrian Ways (per TCP)
Specific Plan Area Boundary

Source: Bottomley and Associates

Figure 9 Public Realm Concept
City of San Bruno Bayhill Specific Plan

Kimley»Horn

NOAA Atlas 14, Volume 6, Version 2
Location name: San Bruno, California, USA*
Latitude: 37.6297°, Longitude: -122.422°
Elevation: 75.35 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**1.64** (1.45-1.87)	**1.98** (1.75-2.27)	**2.45** (2.16-2.81)	**2.83** (2.47-3.29)	**3.38** (2.83-4.09)	**3.83** (3.12-4.75)	**4.30** (3.38-5.50)	**4.79** (3.64-6.35)	**5.47** (3.96-7.64)	**6.04** (4.18-8.80)
10-min	**1.18** (1.04-1.34)	**1.42** (1.25-1.62)	**1.75** (1.54-2.01)	**2.03** (1.77-2.35)	**2.43** (2.03-2.93)	**2.74** (2.23-3.41)	**3.08** (2.42-3.94)	**3.43** (2.61-4.55)	**3.92** (2.84-5.48)	**4.33** (2.99-6.31)
15-min	**0.948** (0.840-1.08)	**1.14** (1.01-1.31)	**1.41** (1.24-1.62)	**1.64** (1.43-1.90)	**1.96** (1.64-2.37)	**2.21** (1.80-2.75)	**2.48** (1.96-3.18)	**2.76** (2.10-3.66)	**3.16** (2.29-4.42)	**3.49** (2.42-5.08)
30-min	**0.650** (0.576-0.740)	**0.784** (0.694-0.896)	**0.968** (0.854-1.11)	**1.12** (0.980-1.30)	**1.34** (1.12-1.62)	**1.52** (1.23-1.88)	**1.70** (1.34-2.18)	**1.89** (1.44-2.51)	**2.17** (1.57-3.03)	**2.39** (1.66-3.48)
60-min	**0.459** (0.407-0.524)	**0.555** (0.491-0.634)	**0.685** (0.603-0.785)	**0.794** (0.693-0.920)	**0.949** (0.793-1.15)	**1.07** (0.872-1.33)	**1.20** (0.948-1.54)	**1.34** (1.02-1.78)	**1.53** (1.11-2.14)	**1.69** (1.17-2.46)
2-hr	**0.336** (0.298-0.383)	**0.404** (0.357-0.460)	**0.494** (0.436-0.567)	**0.572** (0.498-0.662)	**0.680** (0.568-0.822)	**0.766** (0.623-0.950)	**0.856** (0.675-1.10)	**0.951** (0.724-1.26)	**1.09** (0.784-1.52)	**1.19** (0.826-1.74)
3-hr	**0.278** (0.246-0.316)	**0.333** (0.295-0.381)	**0.409** (0.361-0.469)	**0.473** (0.412-0.547)	**0.562** (0.469-0.679)	**0.633** (0.514-0.786)	**0.707** (0.557-0.905)	**0.785** (0.598-1.04)	**0.895** (0.647-1.25)	**0.984** (0.682-1.44)
6-hr	**0.195** (0.172-0.222)	**0.235** (0.208-0.269)	**0.290** (0.256-0.333)	**0.337** (0.293-0.390)	**0.401** (0.335-0.485)	**0.452** (0.368-0.562)	**0.506** (0.399-0.648)	**0.563** (0.428-0.746)	**0.642** (0.464-0.897)	**0.705** (0.489-1.03)
12-hr	**0.124** (0.110-0.141)	**0.153** (0.136-0.175)	**0.193** (0.170-0.221)	**0.226** (0.197-0.262)	**0.272** (0.228-0.329)	**0.309** (0.251-0.384)	**0.347** (0.274-0.445)	**0.387** (0.295-0.514)	**0.444** (0.321-0.620)	**0.488** (0.338-0.712)
24-hr	**0.080** (0.073-0.091)	**0.102** (0.092-0.115)	**0.130** (0.117-0.147)	**0.154** (0.138-0.176)	**0.187** (0.162-0.220)	**0.213** (0.180-0.256)	**0.240** (0.198-0.296)	**0.268** (0.215-0.340)	**0.307** (0.237-0.406)	**0.338** (0.252-0.463)
2-day	**0.051** (0.046-0.058)	**0.064** (0.058-0.073)	**0.082** (0.074-0.093)	**0.096** (0.086-0.110)	**0.116** (0.101-0.137)	**0.132** (0.112-0.159)	**0.148** (0.122-0.183)	**0.165** (0.132-0.209)	**0.188** (0.145-0.249)	**0.207** (0.154-0.283)
3-day	**0.039** (0.035-0.044)	**0.049** (0.044-0.055)	**0.061** (0.055-0.070)	**0.072** (0.065-0.082)	**0.087** (0.075-0.102)	**0.098** (0.083-0.118)	**0.110** (0.091-0.136)	**0.122** (0.098-0.155)	**0.139** (0.107-0.184)	**0.152** (0.113-0.208)
4-day	**0.032** (0.029-0.036)	**0.040** (0.036-0.045)	**0.051** (0.046-0.057)	**0.059** (0.053-0.068)	**0.071** (0.062-0.084)	**0.080** (0.068-0.097)	**0.090** (0.074-0.111)	**0.100** (0.080-0.126)	**0.113** (0.087-0.149)	**0.123** (0.092-0.169)
7-day	**0.023** (0.021-0.026)	**0.029** (0.026-0.033)	**0.037** (0.033-0.041)	**0.043** (0.038-0.049)	**0.051** (0.044-0.060)	**0.058** (0.049-0.069)	**0.064** (0.053-0.079)	**0.071** (0.057-0.090)	**0.080** (0.062-0.106)	**0.087** (0.065-0.119)
10-day	**0.018** (0.016-0.020)	**0.023** (0.021-0.026)	**0.029** (0.026-0.033)	**0.034** (0.030-0.038)	**0.040** (0.035-0.047)	**0.045** (0.038-0.054)	**0.050** (0.041-0.062)	**0.055** (0.044-0.070)	**0.062** (0.048-0.082)	**0.067** (0.050-0.092)
20-day	**0.012** (0.011-0.013)	**0.015** (0.014-0.017)	**0.019** (0.017-0.021)	**0.022** (0.020-0.025)	**0.026** (0.022-0.031)	**0.029** (0.025-0.035)	**0.032** (0.026-0.039)	**0.035** (0.028-0.044)	**0.039** (0.030-0.051)	**0.042** (0.031-0.057)
30-day	**0.010** (0.009-0.011)	**0.012** (0.011-0.014)	**0.015** (0.014-0.017)	**0.018** (0.016-0.020)	**0.021** (0.018-0.025)	**0.023** (0.020-0.028)	**0.025** (0.021-0.031)	**0.028** (0.022-0.035)	**0.030** (0.023-0.040)	**0.032** (0.024-0.044)
45-day	**0.008** (0.007-0.009)	**0.010** (0.009-0.011)	**0.012** (0.011-0.014)	**0.014** (0.013-0.016)	**0.017** (0.015-0.020)	**0.019** (0.016-0.022)	**0.020** (0.017-0.025)	**0.022** (0.018-0.028)	**0.024** (0.018-0.032)	**0.025** (0.019-0.035)
60-day	**0.007** (0.006-0.008)	**0.009** (0.008-0.010)	**0.011** (0.010-0.013)	**0.013** (0.012-0.015)	**0.015** (0.013-0.018)	**0.017** (0.014-0.020)	**0.018** (0.015-0.022)	**0.019** (0.015-0.024)	**0.021** (0.016-0.028)	**0.022** (0.016-0.030)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Figure 10 NOAA Rainfall Intensity

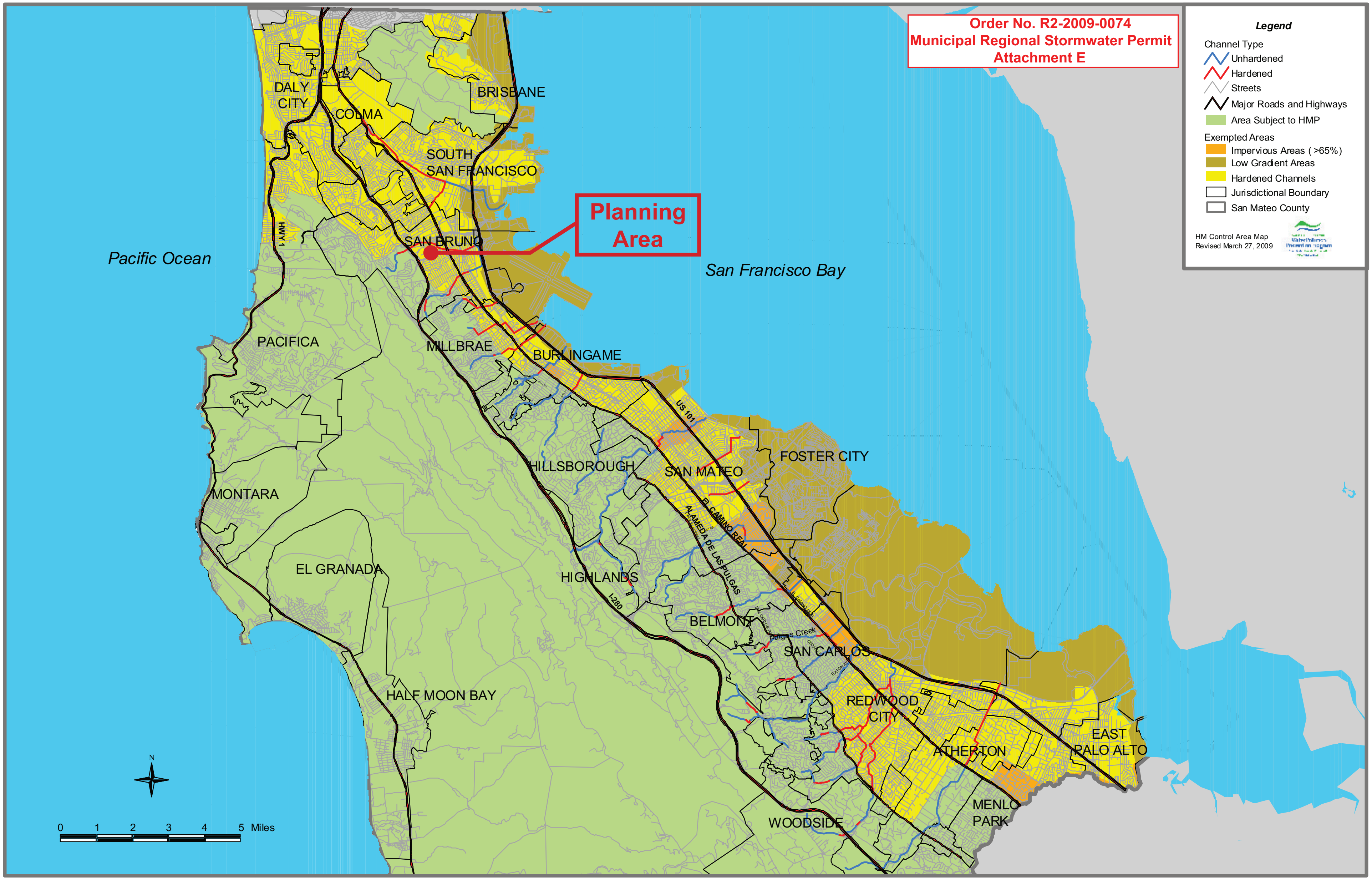


Figure 11 Municipal Regional Stormwater Permit

City of San Bruno Bayhill Specific Plan

Kimley»Horn