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BOOK 2

GRANDVIEW HEIGHTS
NEIGHBOURHOOD CONCEPT PLAN
AREA 5A - ORCHARD GROVE
STAGE II SERVICING STRATEGY

FINAL

JANUARY 2012

CITY OF SURREY
ENGINEERING DEPARTMENT

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City of Surrey
Engineering Department

Neighbourhood Concept Plan
for
Grandview Heights Area 5A
Stage II Servicing Strategy

January 2012

Prepared by

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APPENDICES

1.0 GENERAL SERVICING

The objective of this document is to outline the engineering and servicing requirements (transportation, drainage, sanitary and water) for the area of Grandview Heights Neighbourhood Concept Plan Area 5A (NCP # 5A). This report outlines and identifies the requirements for servicing based on the Stage 1 Land Use Plan approved by Council in September 2010. This report also outlines a financial plan to ensure that the community can be built based on current City policy and procedures.

1.1 SERVICING PRINCIPLES & GUIDELINES

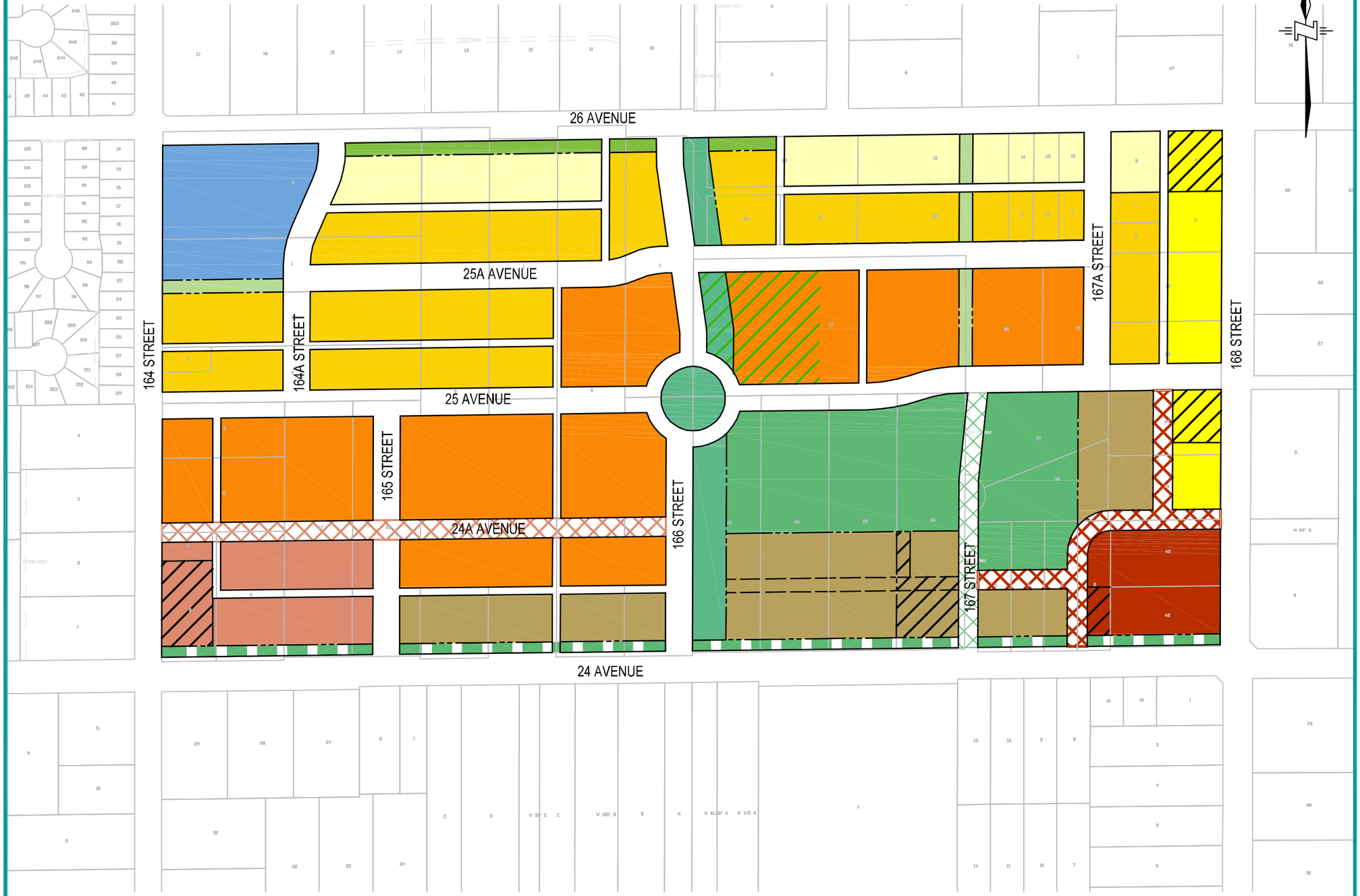
Planning for NCP # 5A (Orchard Grove) began, originally, as part of the larger Grandview Heights General Land Use Plan. The subject area was identified in May 2006 as a key area subject to future development and was identified by Surrey City Council as a separate Neighbourhood Concept Plan Area in July 2006.

Terms of Reference (ToR) were approved in July 2008 by Surrey City Council with the intent of identifying land uses and establishing locations for roads and lanes, proposed development densities and typologies and the locations and sizes of community amenities such as neighbourhood parks, walkways and open spaces.

The Plan area is bounded by 164 Street, 24 Avenue, 168 Street and 26 Avenue and consists of 53 individual properties. The total site area is approximately 30 hectares (76 acres) of land. The land is designated Suburban in the City of Surrey's Official Community Plan (OCP); however, as part of the long term development of the site, it is anticipated that the area will be designated Urban or Multi-Family in the OCP through ongoing development applications.

The Stage 1 Land Use Concept Plan (**Figure 1**) identifies a range of land uses for NCP # 5A, with the intent of creating a self-sustaining community with a range of housing typologies, amenities, parks, recreation spaces and unique infrastructure amenities including a comprehensive stormwater management plan.

The plan was developed through extensive consultation with a Citizen's Advisory Committee (CAC) and Public Open Houses were held to present the information to the public and feedback received was subsequently used to modify and adjust the plan.



LEGEND

- Large Lot Duplex or Large Lot Single Famiy (2-10 upa)
- Small Lot Single Family w/wo Coach House (10-15 upa)
- Single Family (10 upa) or Townhouse with Tree Preservation (15 upa)
- Townhouse (15-30 upa)
- Townhouse (15 upa) or Multi-Family with Tree Preservation (30 upa)
- Multi-Family (30-45 upa)
- Mixed-Use Commercial/Residential (30-45 upa)
- Stormwater Detention Pond
- Park
- Walkways
- Habitat Corridor
- Transition Landscape Buffer
- Special Commercial Street
- Green Street
- Residential Flex Street
- Multi-Use Pathway (8m SROW)
- Tree Preservation Area

0 50 100 150 200m

(ALL DIMENSIONS ARE IN METRES)

SCALE: 1:3000
NOVEMBER 2011

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ORCHARD GROVE
GRANDVIEW HEIGHTS AREA 5A

LAND USE CONCEPT PLAN

FIGURE 1

M:\Proj\121\1-027640 Surrey - Grandview Height 5A\10.0 DRAWINGS\10.3 Engineering\10.3.2 Drawings\dwg\027641 Land Use 11212 3.dwg, 12/13/2011 5:29:23 PM

2.0 TRANSPORTATION

2.1 INTRODUCTION

This section of the report provides an assessment of traffic impacts and recommended transportation improvements as part of the planned land use development for the Grandview Heights Area #5A located in South Surrey, shown in **Figure 2.1**. Updates to the bicycle and pedestrian networks, transit services and facilities, and roadway network will be required to accommodate increased travel activity to, from, and within this area based on anticipated growth and development. These improvements will provide travel choices for residents of Grandview Heights to walk, cycle or take transit which are not safe or convenient options today.

The recommendations made in this report are in line with Surrey's vision of developing Grandview Heights "as a complete community with a mix of residential densities, small commercial nodes, community facilities, schools, parks, pathways, trees and protected areas." The proposed network is to be a modified grid road system with greenways to encourage walking and cycling. Typical right-of-way widths will be 20m or 24m and road cross sections are to be based on City standards. A green road, with a 20m right-of-way is also included and is to be flexible in alignment to protect mature trees.

Figure 2.1: Study Area

2.2 STUDY AREA

The study area is located in South Surrey east of Highway 99 bounded by 26th Avenue, 164th Street, 168th Street, and 24th Avenue. Existing land use is rural with generally low density, single use residential properties throughout the study area.

The study area is surrounded by other neighbourhoods as part of the overall Grandview Heights area including Grandview Corners, Morgan Crossing, Morgan Heights, North Grandview., and Grandview Heights Area #2. Travel to and from Grandview Heights NCP Area #5A is expected to be influenced by development in these neighbouring communities. While NCP Area #5A is not expected to attract a significant number of trips (other than those generated by the small commercial node at 24th Avenue and 168th Street), residents of NCP Area #5A are expected to travel to and from local recreational and shopping destinations. Large scale retail in Grandview Corners and the commercial/residential development at Morgan Crossing, in particular, are likely to generate trips to and from NCP Area #5A. Morgan Heights (nearly built out), North Grandview Heights (not yet built out) and other areas of the Grandview Heights General Land Use Plan are highly connected to NCP Area #5A. As this broader area develops, travel to and from NCP Area #5A is expected to be affected.

2.2.1 Current Road Network

The current road network consists generally of a one mile grid of arterial roadways with collector roads providing access to neighbourhoods. A series of local roads provides access to individual properties but not a continuous grid network. Arterial and collector roads currently provide access to adjacent properties.

Figure 2.2 provides a summary of the existing road network for the study area followed by a brief discussion of roads and intersections.

Figure 2.2: Existing Road Network in Grandview Heights Area #5A

Roads

The City of Surrey defines roads based on a classification system as follows:

- **Provincial Highways –** are generally controlled access facilities that provide high speed connections to other parts of the region. The nearest facility to the study area is Highway 99 with on and off ramps located at 8th Ave and 32nd Ave.
- **Arterial Roads –** generally function to carry through traffic from one area to another with as little interference as possible from adjacent land uses. In some cases, arterial roads may provide direct access to adjacent properties as a secondary function, although this is generally not desirable.
- **Collector Roads –** primary function is to distribute traffic between arterial roads, other collector roads and local roads within an area. Collector roads may also provide access to adjacent properties as required.
- **Local Roads –** are generally low volume neighbourhood streets that provide access to individual properties.

Major roads in the Grandview Heights area include the following:

- **Highway 99 –** is a controlled access freeway with a posted speed of 100 km/h that connects the US Border at Peace Arch to Oak Street in the City of Vancouver. This largely four lane freeway provides the primary connection to Vancouver, Richmond (including the airport), South Delta (including the ferry terminals) and the United States.
- **24th Avenue –** is an arterial road that provides a significant east/west connection in South Surrey including a connection to Highway 15 and Campbell Heights – the largest employment area in South Surrey.
- **168th Street –** is an arterial road that runs north/south from 8th Ave to 96th Ave in North Surrey and also provides a connection between Highway 1 and Highway 10.
- **164th Street –** is a collector road that is runs north/south from 24th Ave to 32nd Ave, which provides a connection to Highway 99.

All collector and arterial roadways are currently two lane facilities within the study area. Posted speeds are 50 and 60 km/h for collector and arterial roadways respectively. Access to King George Highway with overpasses across Highway 99 includes 16th and 24th Avenue.

Intersections

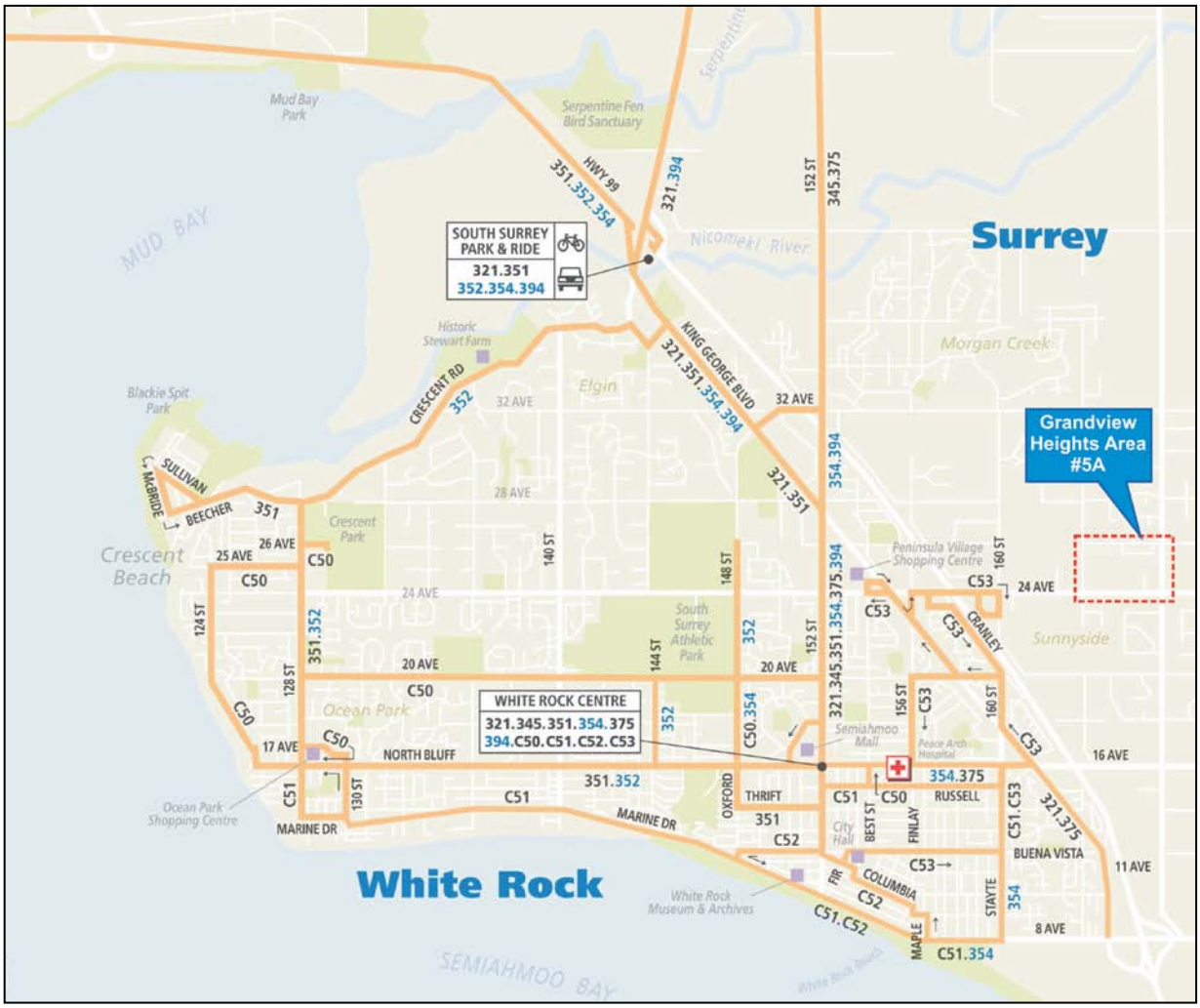
There is currently a signalized intersection at 24th Avenue at 168th Street. All approaches include an exclusive left turn bay and shared through and right turn lane. All left turns are permissive.

There is currently four two-way stop control at the remainder of the intersections. At 24th Avenue and 168th Street, priority is given to 24th Avenue. At 168th Street and 26th Avenue, priority is given to 168th Street. At 164th Street and 26th Avenue, priority is given to 26th Avenue. Access from local streets to arterial and collectors is usually with stop sign control.

2.2.2 Current Transit Services and Facilities

There are no transit services currently available for travel to and from Grandview Heights Area #5A. For regional transit services, the South Surrey Park and Ride facility located at King George Highway and Highway 99 provides connections to North Surrey, Richmond and Vancouver. The following map highlights the existing service coverage in South Surrey relative to the study area.

Figure 2.3: Current Transit Service Coverage in South Surrey



Source: South Surrey/White Rock Transit System Map on TransLink Website [http://www.translink.ca/en/Schedules-and-Maps/Transit-Maps/System-Maps.aspx]

TransLink's service design guidelines currently state that "At least 90% of all residents and employees in urbanized development areas should have less than 450 metres walking distance to a bus stop" with urbanized development areas being defined as areas having more than 15 residents or 20 jobs per hectare. With fewer than 15 residents per hectare currently in Grandview Heights Area #5A and limited employment, it does not meet the minimum guidelines for the provision of transit services. Furthermore, the service design guidelines tend to provide transit services directed towards town centres such as Semiahmoo. As such, there are no transit services within a convenient (or safe) walking distance from any of the properties within the study area.

Future growth in this area will push the population density above the minimum threshold for the provision of transit services as defined in TransLink's Service Design Guidelines. As these are just guidelines, there are a number of other factors that influence the transit planning process in Metro Vancouver. TransLink, through the development of the South of Fraser Area Transit Plan, has identified a number of service improvements in South Surrey including the study area that are discussed further in Section 2.4.3.

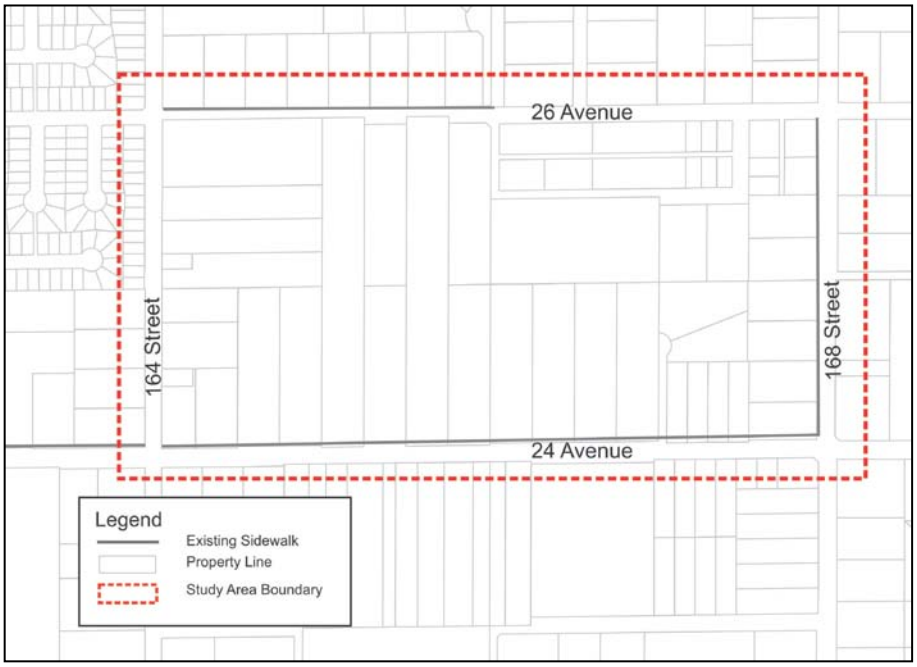
2.2.3 Current Walking and Cycling Facilities

Currently there are limited walking and cycling facilities in the study area. The following map shows the current sidewalk coverage in the Grandview Heights Area #5A.

A narrow sidewalk exists on 168 Street and 24th Avenue with a small boulevard between the road and the sidewalk. However, there is no pedestrian access along 164th Street, and it is discontinuous along 26th Avenue. Furthermore, there are no designated cycling routes or facilities within the study area. As such, walking and cycling are not safe or convenient modes of travel given the lack of sidewalk, pedestrian and cycling facilities.

There are plans to provide a complete network of sidewalks, multi-use corridors and cycling facilities as part of the planned improvements discussed further in Section 2.5.1. These improvements will allow residents and travelers to walk and cycle on safe and convenient facilities that are designated for these modes of travel.

Figure 2.4: Current Sidewalk Coverage in Grandview Heights Area #5A



2.3 CURRENT TRAFFIC CONDITIONS

The analysis of current traffic conditions was based on the Synchro traffic operations model using updated traffic count and signal timing information from the City of Surrey. This analysis was used to assess the level of service (LOS) at signalized and stop control intersections along arterial roads in the study area.

Levels of service range from A to F, where A represents uncongested conditions and F represents significant congestion. The following table provides a summary of the levels of service used to assess traffic conditions at both signalized and unsignalized intersections.

Table 2.1: Levels of Service at Signalized and Unsignalized Intersections

	Signalized Intersections		Unsignalized Intersections	
LOS	**Traffic Conditions**	**Avg Vehicle Delay**	**Traffic Conditions**	**Avg Vehicle Delay**
A	Very few vehicles stopping	<10 sec	Little or no delays	<10 sec
B	Some vehicles must stop	10-20 sec	Short traffic delays	10-20 sec
C	Significant proportion of vehicles must stop	20-35 sec	Average traffic delays	20-30 sec
D	Many vehicles stopped	35-55 sec	Long traffic delays	30-40 sec
E	Frequent individual cycle failures	55-80 sec	Very long traffic delays	40-60 sec
F	Oversaturation of intersection	>80 sec	Unacceptable delays	>60 sec

Traffic operations at signalized intersections are generally considered acceptable when automobile users would experience the following levels of service:

- Overall intersection LOS D or better;
- Through movement LOS D or better; and
- Left turn LOS E or better.

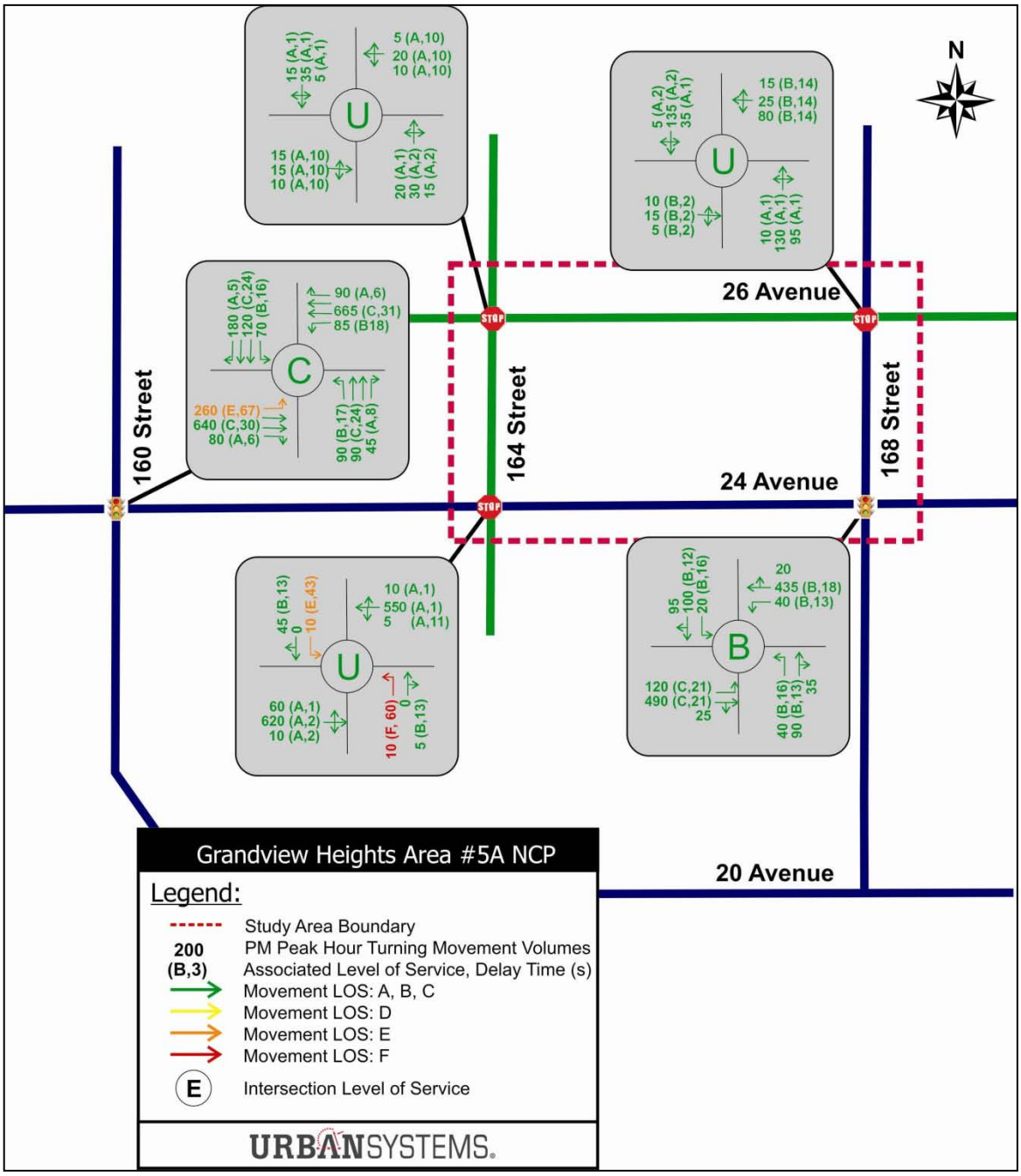
For unsignalized intersections, traffic operations are considered acceptable when motorists making left turns or through movements from the minor street would experience LOS E or better.

Most traffic on the arterial network consists of through travel with limited local trips given the nature and low density of the land uses in the study area. Recent traffic count information and traffic operations analysis show that the current road network and traffic signals are adequate for the level of demand. **Figure 2.5** provides a summary of the current traffic volumes and levels of service at key intersections in the study area during the afternoon peak hour which is the busiest time period of the day.

The signalized intersection at 168th Street and 24th Avenue operates at LOS B, with no approach that has a LOS less than C. The north and southbound left turns at 24th Ave and 164th St are currently operating at LOS F and E, respectively. With the exception of this northbound left turn lane, all traffic flow within the study area is currently operating at a satisfactory level of service.

As part of the Grandview Heights Neighbourhood Community Plan 2, there are already plans in place to improve 24th Ave and 164th St to be signalized intersections. This will alleviate the northbound left turn lane LOS of F, and will be discussed further in the network improvements within Section 2.6.

Figure 2.5: Current PM Peak Hour Vehicle Volumes and LOS in Study Area



2.3.1 Travel Patterns

Travel to and from Grandview Heights Area #5A consists largely of people using their private automobiles. Land use in the study area is generally single use, low density residential, which leaves the automobile as the only viable mode of transportation for most people to get to and from places of work, education, shopping and recreation. Furthermore, the lack of transit services and inadequate walking and cycling facilities do not provide convenient or safe choices for people to travel without using their automobiles. The future land use and transportation plan for this area, however, will provide more choices for people to use alternate modes of transport as described later in this report. Furthermore, with a more complete community with nearby shops and amenities, people will have more opportunities to access places of shopping, recreation and socializing using alternate modes of transport including walking, cycling and taking transit.

2.4 Proposed Development

The Grandview Heights Area #5A is planned to be developed from a primarily rural and low density residential area to a more densely populated urban/suburban neighbourhood. Population forecasts developed for the study area indicate that up to 2,450 people will make the Grandview Heights Area #5A their home. This represents the full build out scenario anticipated to occur over the next 20 years. The following table provides an inventory of the land use types used to assess the transportation impacts for this area.

Table 2.2: Inventory of Land Use Type for Development Scenario

Land Use Type	Acres	Low Units	Low Population	High Units	High Population
Large Lot Duplex or Large Lot Single Family 2-10 upa	4.0	8	24	40	120
Small Lot Single Family With/Without Coach House 10-15 upa	11.3	113	338	169	508
Single Family or Townhouse with Tree Preservation 10-15 upa	2.4	24	72	36	108
Townhouse 15-30 upa	14.7	225	562	450	1,124
Townhouse or Multi-Family with Tree Preservation 15-30 upa	2.9	43	108	86	215
Mixed-Use Commercial/Residential 30-45 upa	1.9	58	115	87	173
Multi-Family 30-45 upa	7.4	246	491	368	737
Total	44.5	716	1710	1236	2984

Source: City of Surrey Planning Department

Grandview Heights Area #5A is proposed to remain largely residential, with both suburban and urban-type densities planned. The corner of 24th Avenue and 168th Street will retain a small commercial node with no proposed industrial uses for the area.

Open space will remain a significant feature of the neighbourhood, with two parks, two connecting pathways, and a green street providing a variety of natural or nature-like areas.

2.4.1 Planned Improvements

As the Grandview Heights area develops and more people live, work, and play in this area, more travel activity will result. Added transportation infrastructure will be required to accommodate the increased demands for travelling to, from and within the study area. As such, transportation infrastructure (described in detail in Section 2.5) will be required to provide more capacity for the following modes of travel:

Walking – a more complete network of sidewalks, trails, and walkways for people to travel by foot around the Grandview Heights area. Better pedestrian facilities would also encourage transit use as riders would have better and safer access to bus stops and transit services.

Cycling – more on-road and off-road routes to promote cycling in and around the Grandview Heights area including connections to other parts of South Surrey. More facilities will help support the convenience, safety and reliability of cycling within Grandview Heights and the surrounding neighbourhoods.

Transit – more transit service as outlined in the South of Fraser Area Transit Plan to provide a competitive alternative to driving for longer trips. Improved transit facilities such as sheltered bus stops and safe walkways and waiting areas to enhance the customer experience while waiting for a bus or transferring between routes.

Auto – increased turning and through capacity along key corridors such that reasonable levels of service are maintained on the road network and at intersections. Improvements would include added turn lanes and through lanes as well as signal and signal timing upgrades to manage traffic flows efficiently.

2.4.2 South of Fraser Area Transit Plan

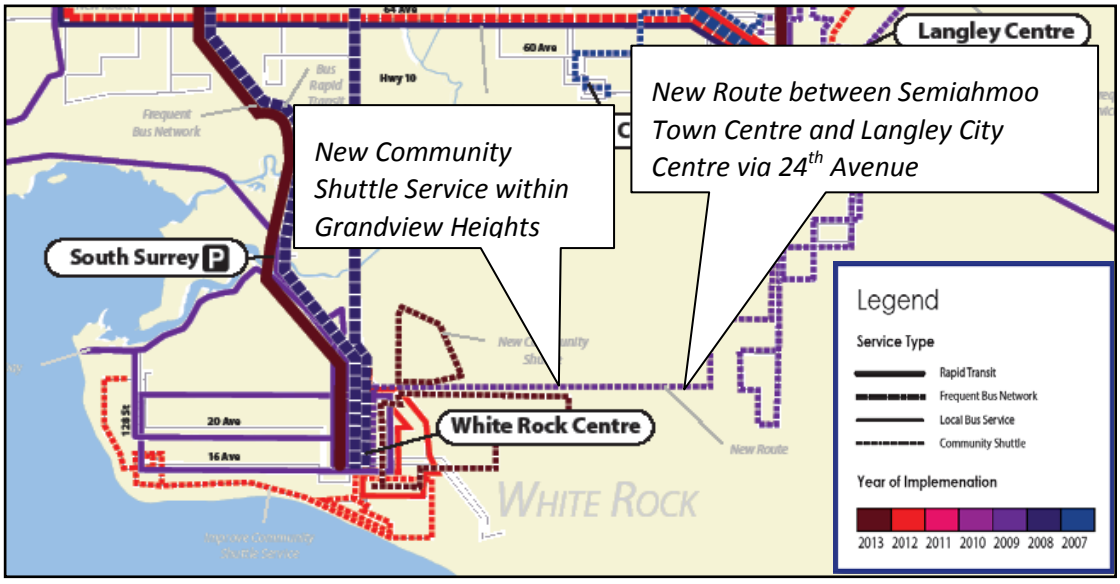
The South of Fraser Area (SoFA) Transit Plan sets out a long-range transit plan and vision for improved transit services in the South of Fraser Area including Grandview Heights. The SoFA plan sets out a short-term implementation plan as well as a longer term strategy. An extensive public and stakeholder consultation process was carried out over two years to build support for this plan, which was approved by the TransLink Board in the spring of 2008.

Several improvements will be implemented in the South Surrey area that will connect the Grandview Heights area to other parts of Surrey and beyond. Existing transit services are largely configured to move people from South of Fraser communities to Vancouver and the central core of Metro Vancouver. The changes in transit services as part of the SoFA plan provide more connections between South of Fraser communities to support local travel.

Relevant service improvements include a conventional transit route between White Rock Town Centre and Langley City Centre via 24th Ave. This new route will provide a connection through the Grandview Heights area that does not exist today and will provide access to the Campbell Heights industrial area. Other relevant service improvements include a new community shuttle service throughout the Grandview Heights area that will connect people to regional rapid bus services at a new exchange facility in the Semiahmoo Town Centre. The map below (**Figure 2.6**) highlights the relevant service improvements to the year 2013.

It is noted that the implementation timeline identified by Translink in Figure 5 may not be current. In particular, the new route between Semiahmoo Town Centre and Langely City Centre via 24th Avenue was scheduled for implementation in 2009, but has yet to be operational as of September 2011. Similar delays may be expected for the Grandview Heights Community Shuttle Service expected for implementation in 2013.

Figure 2.6: Proposed South of Fraser Transit Improvements to 2013



Source: South of Fraser Transit Plan, Phase 3 Report, 2013 Implementation Plan, Nov 2007.

2.4.3 South Surrey Long-Term Road Network Plan

The City of Surrey has, as part of their strategic planning process, identified road network improvements to accommodate growth in vehicle volumes. The 10 Year Servicing Plan (2010-2019) identifies transportation needs for arterials, major collectors and local roads. This plan also identifies projects that are cost shared with the Province as well as projects related to pedestrians, cyclists, and transit.

Of the projects listed in the 10 Year Servicing Plan, the New Arterial Construction (On-Ramps) at 24th Avenue and Highway 99. (Project ID 10056) will have the greatest influence on Grandview

Heights #5A. It is expected that this connection will improve the functionality of 24th Avenue as a arterial collection, and as a result, be an important factor in increasing the usage of this corridor.

Further to the 10 Year Servicing Plan, Surrey has identified road network improvements over a longer time horizon of thirty years.

Of importance to the Grandview Heights 5A Development is the widening of 24th Avenue to 4 Lanes between 176th Street and King George Highway. This coincides with longer term needs and a significant expansion of road network capacity as the South Surrey area continues to develop and become more congested. In this regard, the travel impact including the distribution of trips on the road network based on these improvements has been captured as part of this transportation modeling analysis.

2.4.4 Site-Generated Traffic

Congestion levels will increase as the study area becomes denser and the surrounding neighbourhoods in the South Surrey area continue to develop.

To evaluate the impact of traffic generated from the Grandview Heights 5A development, two future scenarios were developed for the year 2031; the Base Model and the Growth Model. Both rely on the recently updated South Surrey Sub-Area model, the Institute of Transportation Engineers Trip Generation Manuals (8th Edition), and the Grandview Heights 2 Neighbourhood Concept Plan Report (Urban Systems, 2007).

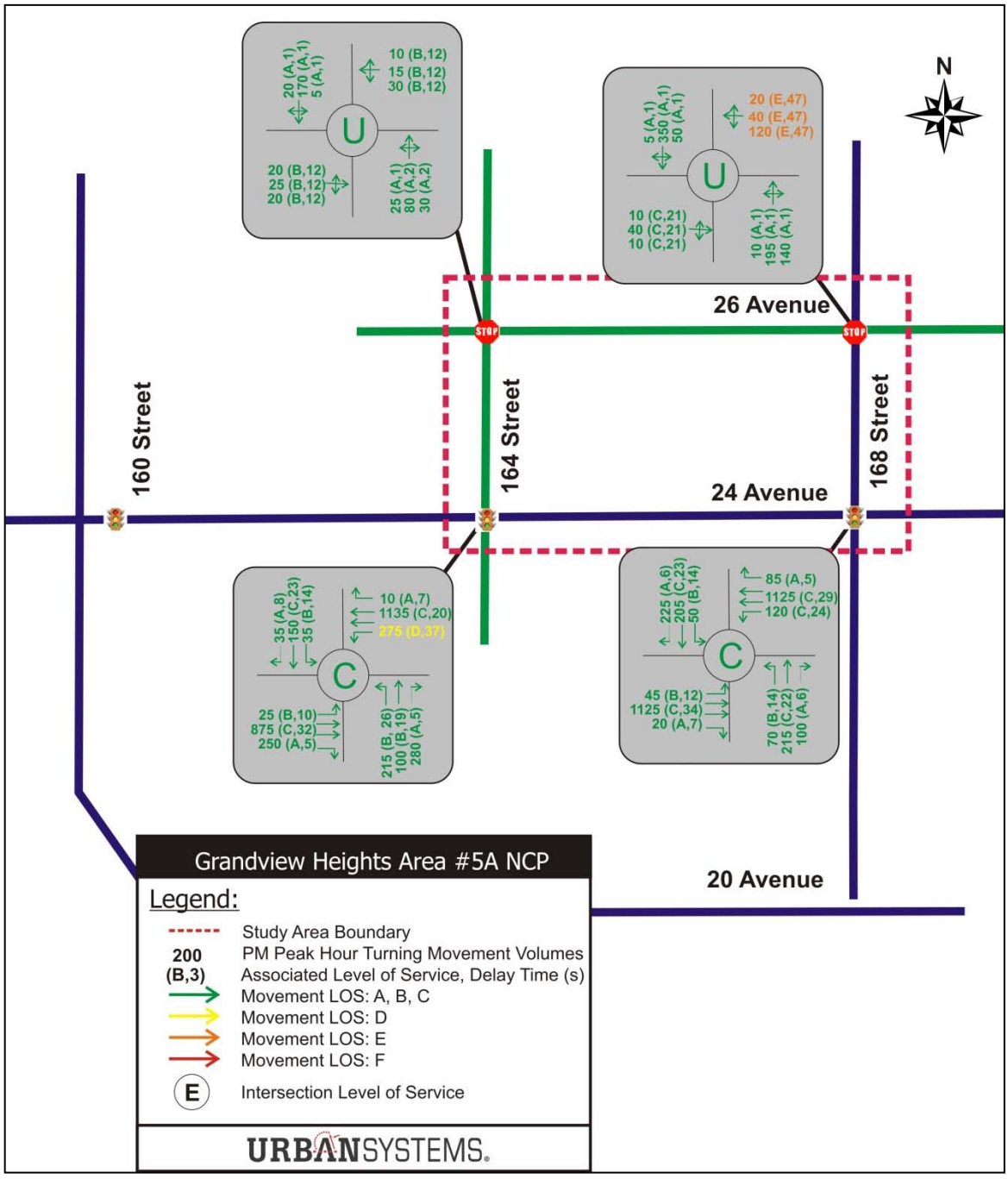
2031 Forecast Base

Traffic volume forecasts to the 2031 horizon, without the development of Grandview Heights 5A, were prepared using the following steps:

1. The volumes on 24th Avenue at 164th Street and 168th Street were taken from the Grandview Heights NCP 2 Report to ensure the base trips include the most recent plans of adjacent developments. The Grandview Heights NCP 2 was prepared using the South Surrey Sub Area model in Emme.
2. The northbound and southbound volumes on 26th Avenue at 164th Street and 168th Street were calculated from the northbound and southbound traffic volumes at 164th Street.
3. The eastbound and westbound volumes on 26th Avenue were calculated using existing 2011 volume distribution and with an assumed compound growth rate of 2%/year to base traffic volumes.
4. Automobile volumes were balanced to ensure network consistency and reasonableness.

Figure 2.7, below shows the results of the 2031 Forecast Base within the study area. It is observed that the intersections operate within acceptable levels of service. The intersection of 168th Street and 26th Avenue is experiencing notable delays as a result of the unsignalized condition within the base forecast. It is noted that the traffic signalization and intersection improvements along 24th Avenue at 164th Street and 168th Street that were included as a requirement within Grandview Heights NCP #2 were included in the forecast base for analysis.

Figure 2.7: 2031 Forecast Base PM Volumes and Levels of Service



Forecast Base plus Development

The following steps were used in developing a forecast base scenario with development. This model shows the traffic volumes expected with the development of Grandview Heights 5A, and was prepared using the following steps.

1. The trip generation volumes were calculated using the ITE Trip Generation Manual and the approved Stage 1 Land Use plan. Trip generation values were broken into four blocks within the development, as shown in Figure 7 below.
2. The trip distribution by direction was determined using the Emme sub-area model for Surrey.
3. The distribution of trips was applied to the trips generated, and then added to the 2031 base model to achieve the fully developed growth model for the study area.
4. Automobile volumes were balanced to ensure network consistency and reasonableness.

Table 2.3 below provides a summary of the ITE trip generation rates used to forecast the development related trips. **Table 2.4** summarizes the development trips calculated (high estimates) for the PM peak hour.

Table 2.3: ITE Trip Generation Rates

ITE Code	Description	Unit	AM Scenario			PM Scenario		
			Rate	% In	% Out	Rate	% In	% Out
210	Single Family Detached Housing	Dwelling Units	0.75	0.25	0.75	1.01	0.63	0.37
223	Mid-Rise Apartment	Dwelling Units	0.30	0.31	0.69	0.39	0.58	0.42
814	Specialty Retail Center	1000 Sq. Feet Leasable Area	6.84	0.48	0.52	2.71	0.44	0.56

Table 2.4: Forecast Development Trips (High Estimate) for the PM Peak Hour

Land Use Description	ITE Trip Generation Rates		Trip Generation Totals - PM														
			Block 1				Block 2			Block 3			Block 4			Total	
	ITE Code	Land Use Assumption	Total	Entering	Exiting	Total	Entering	Exiting	Total	Entering	Exiting	Total	Entering	Exiting	Total	Entering	Exiting
Large Lot Duplex or Large Lot Single Family 2-10 upa	210	Single Family Detached Housing	0	0	0	18	11	7	22	14	8	0	0	0	40	25	15
Small Lot Single Family w/wo Coach House 10-15 upa	210	Single Family Detached Housing	0	0	0	106	67	39	65	41	24	0	0	0	171	108	63
Single Family or Townhouse with Tree Preservation 15 upa	210	Single Family Detached Housing	0	0	0	0	0	0	25	15	9	12	7	4	36	23	13
Townhouse 15-30 upa	210	Single Family Detached Housing	252	159	93	55	35	20	147	92	54	0	0	0	455	286	168
Townhouse or Multi-Family with Tree Preservation 15-30 upa	210	Single Family Detached Housing	87	55	32	0	0	0	0	0	0	0	0	0	87	55	32
Multi-Family 30-45 upa	223	Mid-Rise Apartment	38	22	16	0	0	0	0	0	0	105	61	44	144	83	60
Mixed-Use Commercial/Residential 30-45 upa	223	Mid-Rise Apartment	0	0	0	0	0	0	0	0	0	25	14	10	25	14	10
Mixed-Use Commercial/Residential 30-45 upa	814	Specialty Retail Center	0	0	0	0	0	0	0	0	0	3	1	2	3	1	2
TOTALS			377	236	142	179	113	66	259	163	96	145	84	61	960	596	364

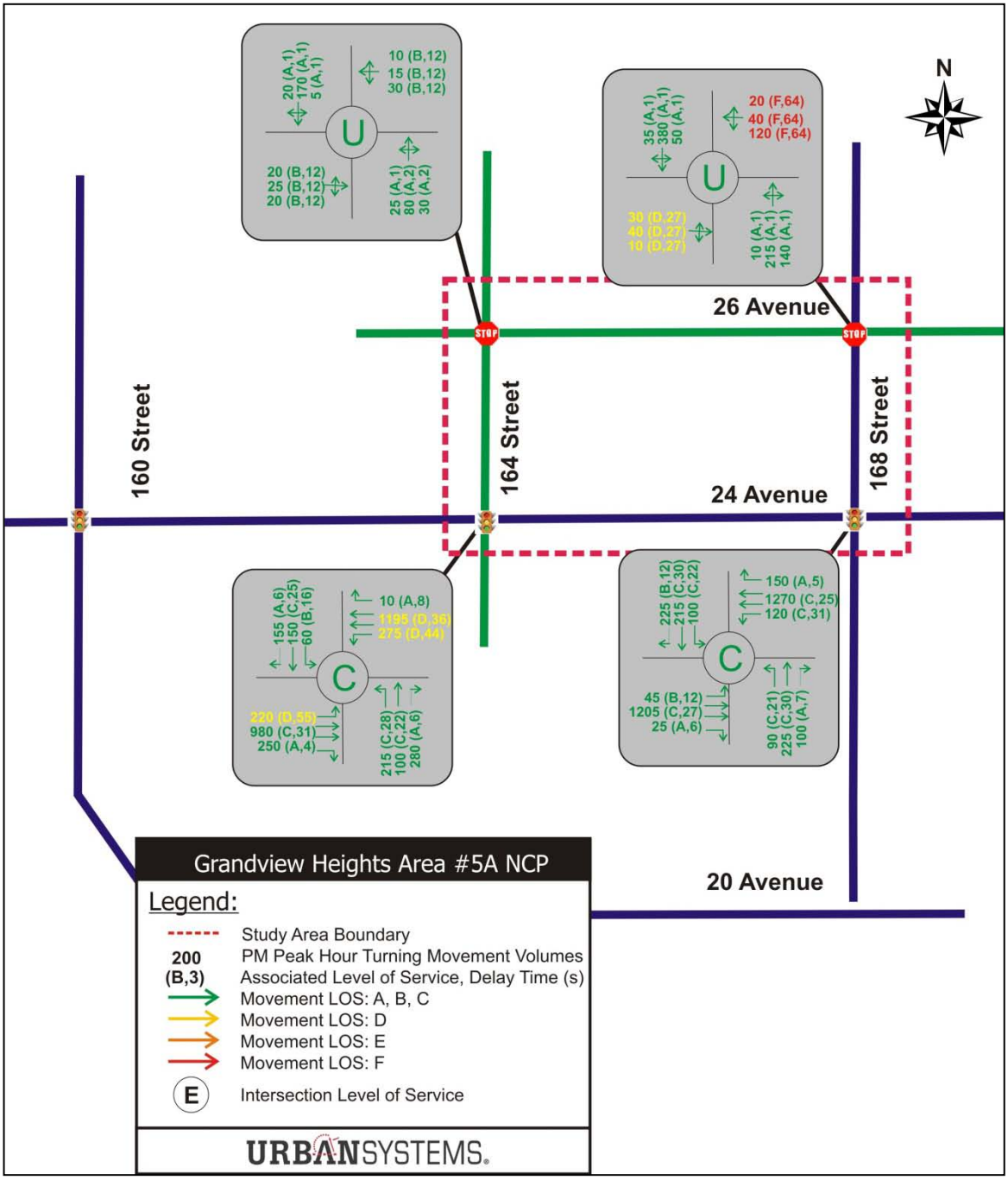
Note: For trip distribution purposes, the development area was evenly split into four 'blocks', divided by 25th Avenue and 166th Street

As identified in step two, the trips were then distributed into regional directions based on results from the Emme model and highlighted in Figure 2.7. Trips were manually assigned to the network based on these results.

Figure 2.8 - Network Distribution of Trips

Figure 2.9 shows the results of the 2031 Growth Model within the study area. All intersections perform with acceptable levels of service, with the exception of the intersection at 26th Avenue and 168th Street. External development pressure from the west side becomes significant enough to trigger failing levels of service when combined with the Grandview Heights traffic demands. Unsignalized intersections along 24th Avenue and 168th Street for the local roads of 166th Street and 25th Avenue are also expected to accommodate all vehicle turning movements to provide secondary access connections.

Figure 2.9: 2031 Forecast Base Plus Development PM Volumes and Levels of Service



Although not specifically taken into account for in the calculation of site development trips, it is expected that the change in travel mode during peak hour conditions for Grandview Heights #5A will be similar to that which was determined for Grandview Heights #2 as shown in the Table:

Table 2.5: Change in Travel Mode between 2006 and 2031

	2006		2031		Change	
Mode	**AM**	**PM**	**AM**	**PM**	**AM**	**PM**
Auto	86%	71%	75%	60%	-11%	-11%
Transit	2%	5%	9%	12%	+7%	+7%
Walk/Bike	13%	23%	16%	27%	+3%	+3%

There are a number of points to keep in mind with the development of the turning movement forecasts, network improvements and traffic operational analysis:

- The turning movement forecasts are a simplification of reality and therefore should be interpreted with caution. Traffic flows are very dynamic and can change significantly from day to day and season to season. What is being shown in this analysis is the most likely average weekday peak conditions for the future.
- As congestion levels increase slowly over time, people's tolerance of congestion will also increase as they become more accustomed to driving in a denser and more urbanized environment that is designed to give more priority for pedestrians, cyclists and transit users.

Without any improvements, future traffic conditions on the roadway network within the Grandview Heights area will deteriorate significantly. Roadway network improvements were then developed for critical turning movements that were unacceptable in terms of the level of service criteria. The following section describes the required transportation improvements in order to support the future needs of automobile users in the Grandview Heights area.

2.5 FUTURE TRANSPORTATION NETWORK

The following improvements for each mode of travel will be required in order to accommodate future travel demands anticipated as part of the development of the Grandview Heights Area #5A and surrounding South Surrey area. Furthermore, these enhancements will provide choices for people to travel using alternate mode of transport such as walking, cycling and transit.

2.5.1 Walking and Cycling Network Plan

The connectivity of the local road network within the study area has an impact on the amount of walking trips. As the street grid and land use are denser within the study area, pedestrians have more opportunities and quicker routes to get to their destination.

All local roads are to be built to Surrey's standard and will include sidewalks on both sides in order to provide an adequate walkway network within the study area. These will be especially important to provide safe access to schools and parks and commercial areas.

The following map highlights the network of sidewalks and walking trails that will be included as part of the transportation plan for Grandview Heights Area #5A. The following sub-section provides a description of some of the key facilities in the study area.

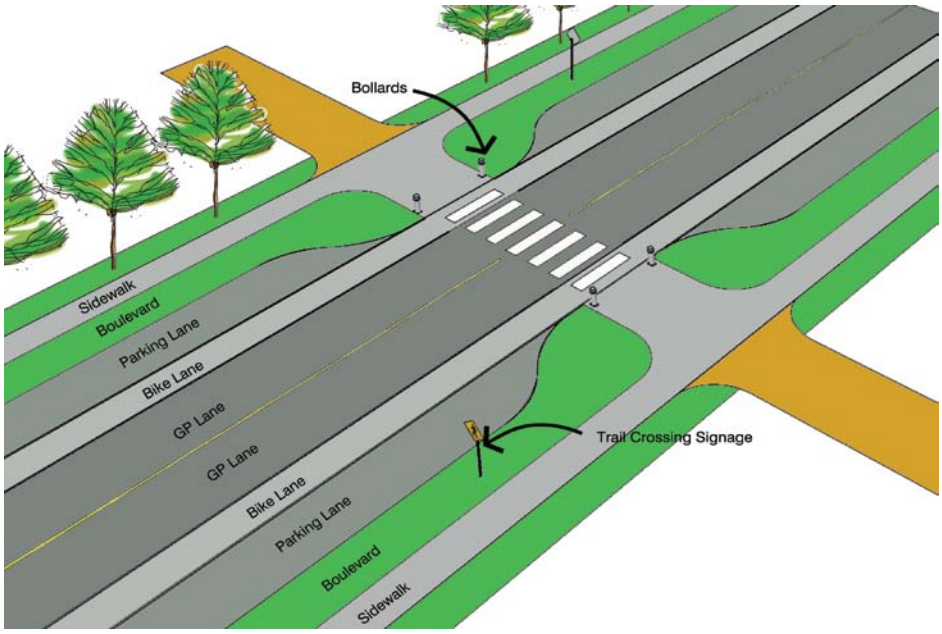
Figure 2.10: Proposed Pedestrian Network within Grandview Heights Area #5A

Multi-Use Corridors

Multi-use pathways have been identified along key corridors and other locations to provide a safe facility for pedestrians, cyclists, roller bladers and other vulnerable users that are physically separated from the roadway. Three corridors have been identified to include multi-use pathways including 24th Ave, an extension of 165th Street between 25 Ave and 25A Ave, and an extension of 167th Street between 25th Ave and 26th Ave. It is anticipated that all of these pathways will be a minimum of 4.0m in width.

Special treatments at the road crossings at 26th Avenue will be required since visibility will likely be obstructed by trees and shrubbery and a pathway/trail crossing might not be immediately obvious for auto drivers. The following figure highlights some of the recommended safety features that were proposed for the Grandview Ridge trail crossings at collector roads.

Figure 2.11: Trail Safety Features at Collector Roadway Crossing



Treatments at all roadway crossings including local streets should include similar features that generally enhance the safety and visibility of pedestrians. At local roadway crossings, features such as curb bulges, bollards and pedestrian crossing lane markings would enhance the comfort for trail users. Additional features could also include signage and possible pedestrian crossing signals to showcase walking as a more prominent mode of transport.

Cycling Lanes

As part of the 24th Avenue arterial widening projects, 1.8 m cycling lanes will be provided on both sides of the road. Dedicated bicycle lanes are also included on 164th Street, and 168th Street and 26th Avenue.

2.5.2 Transit Services and Facilities Plan

As mentioned earlier, TransLink has identified a number of transit improvements as part of the South of Fraser Area Transit Plan. In order to maximize the ridership on these new routes, there are enhancements that would be necessary to improve pedestrian access to these new services.

In addition to the above walking network improvements, we want to ensure that the future bus route along 24th Avenue connecting Semiahmoo Town Centre to Langley City Centre via Campbell Heights has adequate bus stop facilities. These should include two bus bays in both the east and westbound directions as per TransLink's standard bus stop spacing. The likely location of these would be the far side at the 164th and 168th Street intersections. Each bus bay should include sheltered and lit waiting areas, walkway or sidewalk connections to the pedestrian network.

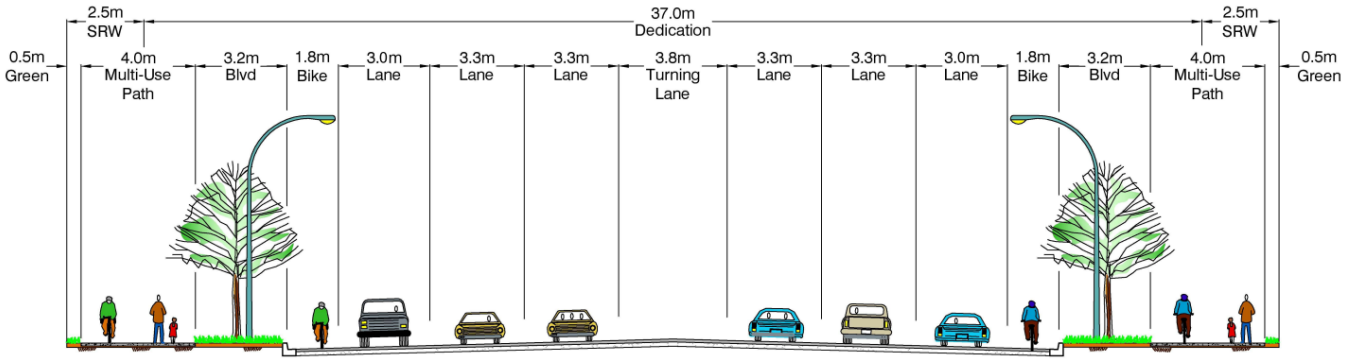
For the new Community Shuttle route, planned for 164th Street, adequate bus stop facilities should be provided along the proposed route. The 164th Street alignment meets TransLink's criteria for both the catchment area and pedestrian accessibility. These should include bus bulges or bus bays, shelters, benches, lighting and info tubes with schedule information to enhance the travel experience for transit users. Similar to the bus stops along 24th Avenue, adequate sidewalk and other pedestrian facilities should be provided to improve walk access to these bus stops.

2.5.3 Roadway Network and Intersection Plan

To accommodate walking, cycling, transit and parking needs, the City of Surrey has developed proposed pavement widths for the various functional road classifications. These widths are shown in **Figures 2.12 and 2.13** with allocation for the various road users including space for medians, boulevards and other features that would provide a network of complete streets.

Figure 2.12: Proposed Arterial Roads

24th Avenue



168th Street

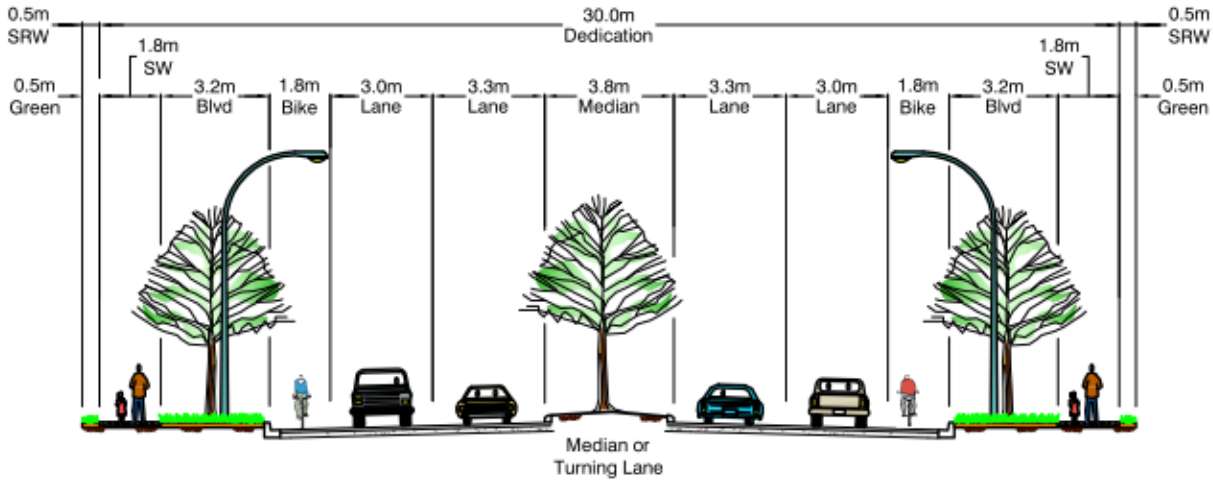
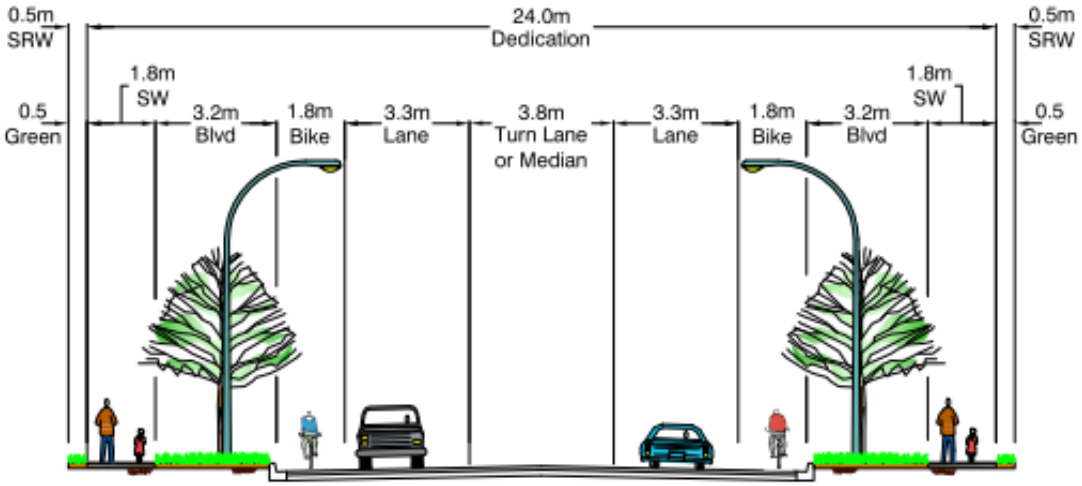
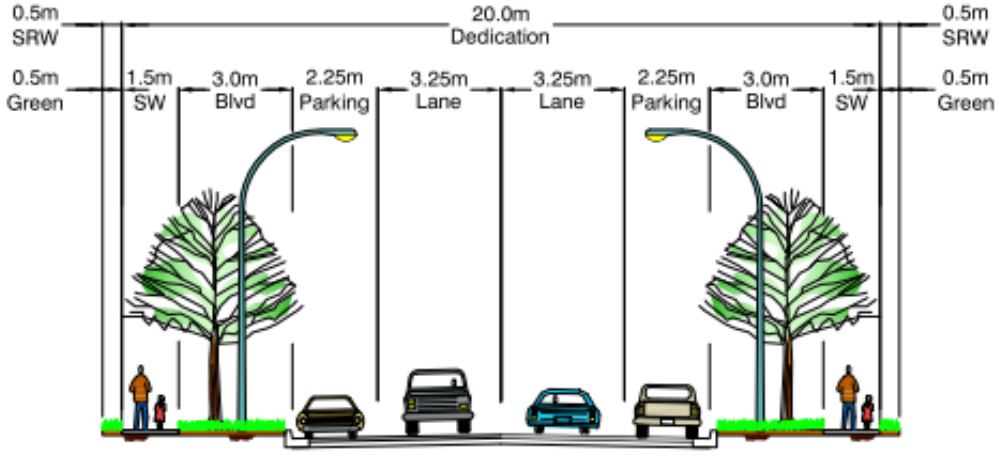


Figure 2.13: Proposed Collector and Local Roads

164th Street, 26th Avenue



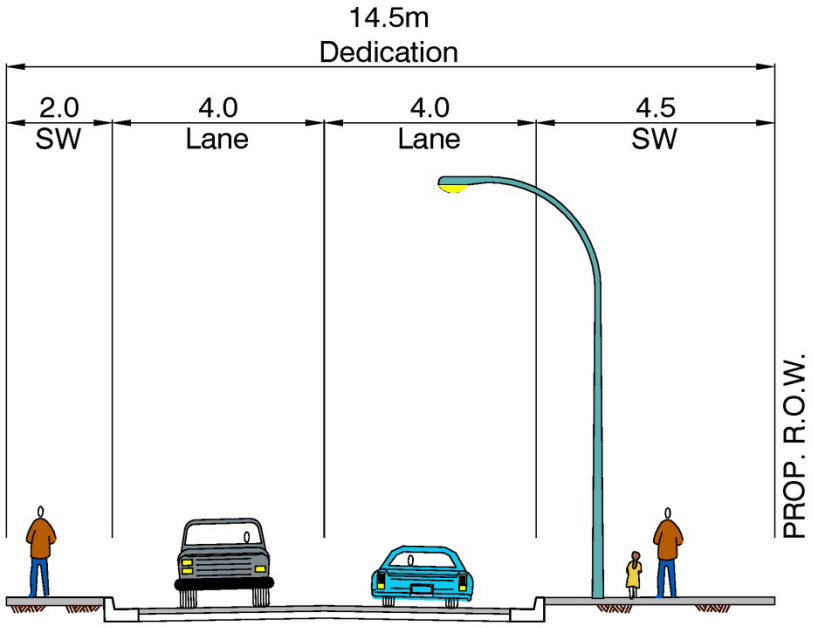
Local Roads



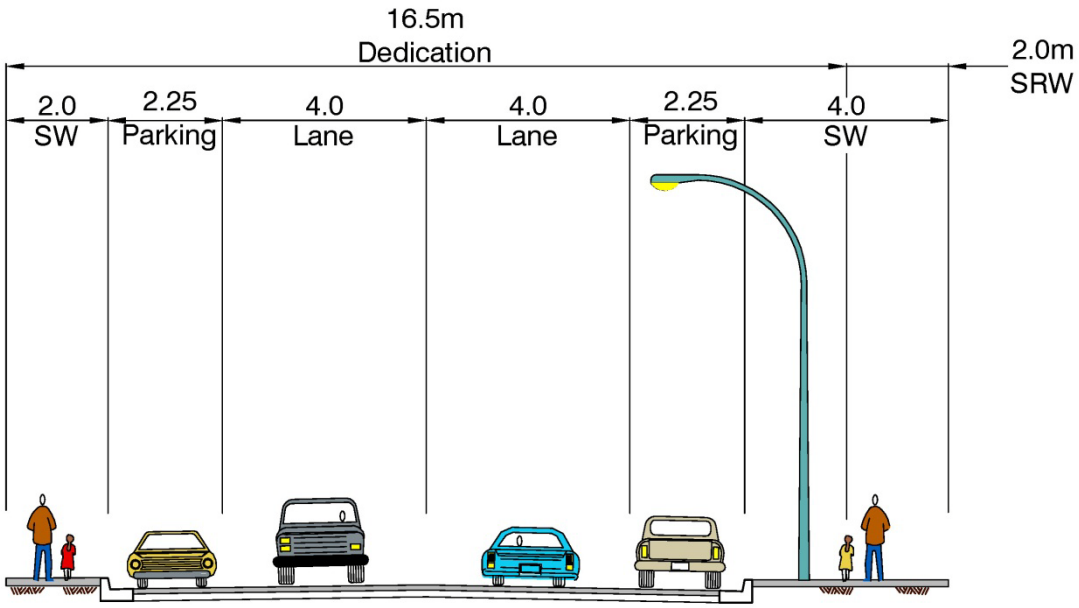
Note: 167th Street is noted as a Green Street. Sidewalk alignment within the corridor may vary to maintain existing trees.

Figure 2.14: Proposed Local Road in Commercial Area

Commercial Street (No Parking)



Commercial Street (With Parking)



2.6 REQUIRED ROADWAY NETWORK IMPROVEMENTS

Based on the traffic analysis outlined above, the improvements to the various components of the roadway network required to support increased traffic demands are as follows:

2.6.1 Intersections

24th Avenue/164th Street

- Upgrade to signalized intersection (all four approaches already contain left turn bays)
- Add channelized right turns at all four approaches
- *(Note: This improvement was identified as part of Grandview Heights NCP #2)*

24th Avenue/168th Street

- Upgrade signal to accommodate protected left turn phasing
- Add additional through lanes east and westbound
- Add channelized right turns for all four approaches
- *(Note: This improvement was identified as part of Grandview Heights NCP #2)*

26th Avenue/168th Street

- Recommend for future upgrade to signalized intersection if external development pressures identify further need. Other modes may also benefit from a signalized intersection for crossing purposes.
- *(Note: This improvement is not included within the finance/DCC calculations as it is driven by demands external to Grandview Heights Area #5A)*

2.6.2 Arterial and Collector Roads

The intersection upgrades mentioned above can accommodate the increased volumes due to the Grandview Heights Area #5A development, but the arterial roads will need to be widened to achieve reasonable levels of service in the future given the overall growth trends in the South Surrey area. Similar to what was noted within the Grandview Heights NCP #2, the additional traffic from the Grandview Heights Area #5A does not trigger the need to widen either 24th as most of the current and future traffic on these arterials is attributed to through traffic.

2.6.3 Internal Road Network

The approved land use plan identified corridors for the local road network as shown in Figure 13. This network is intended to provide a grid street system for better traffic circulation, access to neighbourhoods as well as a more complete pedestrian network with sidewalks. The principles used to develop the internal road network were to encourage internal connectivity with no cul-de-sacs, open and connected neighbourhoods and safer streets for walking and cycling. This finer grid also allows traffic to disperse throughout the network lowering the amount of vehicle volumes on any specific local street. Access to single family developments would be through laneways providing additional connectivity and dispersal of automobile traffic.

All local roads should be built to Surrey's standard two-way road with parking on both sides with 11 m of pavement. Consideration should also be given for possible traffic circles at local road intersections. A traffic circle is already identified in the Land Use Plan at the intersection of 25th Avenue and 166th Street. As a traffic calming element, this is also intended to potentially provide opportunity for storm water detention/treatment in the centre, as well as landscaping for neighbourhood beautification.

With the local road cross section providing wider lanes for cyclists and sidewalks on both sides with boulevards, there is little need for any additional traffic calming. Furthermore, having parking on both sides of the streets provides for additional traffic calming as motorists would be less likely to speed through areas with parked cars.

Access to and from collectors and arterials should be provided with stop control with allowance for left turns both inbound and outbound from the study area to maintain adequate traffic circulation between the local and collector/arterial networks.

It is noted that 26th Avenue shall be designated as a collector road. However, full build-out construction of this road is not expected to occur with Grandview #5A, but rather at a time when the north side redevelops.

Figure 2.15: Grandview Area #5A Future Roadway Network Plan

2.6.4 Parking Management Plan

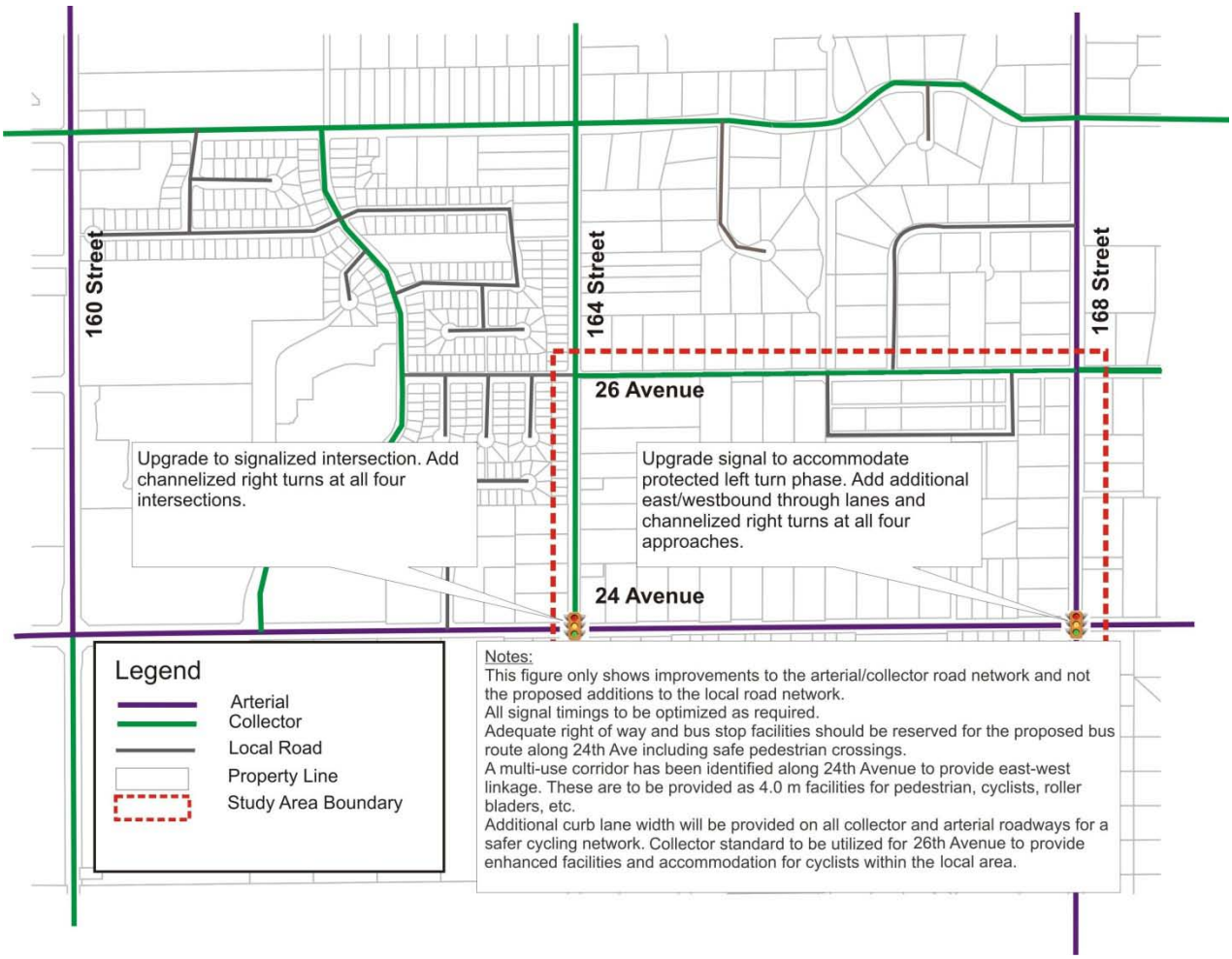
On-street parking will be provided along both sides of all local and collector roads within the study area. Parking on both sides of the street will also provide additional traffic calming as motorists will drive slower alongside parked vehicles. For the road abating the commercial node at 24th Avenue and 168th Street, no parking is provided at the two ends of this road, i.e., from 168th Street to the north south lane and from 24th Avenue to the east west lane. Parking for both sides is provided on the central section of this commercial street, see **Figure 2.13** for cross-section details.

2.6.5 Summary of Transportation Improvements

The above mentioned improvements will help facilitate the movement of people and traffic throughout the Grandview Heights Area #5A as it develops. **Figure 2.15** on provides an overall summary of the transportation network improvements.

Based on the future traffic volumes and level of service analysis with the recommended road improvements, all movements are at LOS D or better. These improvements satisfy the need for traffic mobility and provide enough roadway capacity for acceptable levels of service for future conditions.

Figure 2.16: Summary of Transportation Improvements



Notes: Future widening of 24th Avenues are needed based on overall growth in South Surrey traffic, not solely triggered by Area #5A traffic.

2.7 COST ESTIMATES

The cost estimates for the infrastructure needed for growth are based on the principle that development is responsible for funding the local and collector road infrastructure that fronts and/or is adjacent to the development lands. Because there is a higher standard for collector roads compared to local roads, an upsizing approach is utilized with the cost to upgrade from the local to the collector road standard being included as a DCC eligible item. For 26th Avenue we have assumed that an additional portion of the road widening will be funded from DCCs. ROW width is anticipated to be secured at the development stage and widening of the existing roadway will occur when traffic warrants it. We have not included any special road design features in our 26th Avenue cost estimate at this time. DCC eligible items include collector road works

and other items that serve the overall NCP. The cost estimates for Collector Roads at 164th Street and 26th Avenue are summarized in **Table 2.6.**

Table 2.6: Collector Road Cost Estimates

Capital Item	Total Cost
164 St Upgrade to Collector Standard	$309,000
26 Ave Upgrade to Collector Standard (1)	$1,133,500
Total	**$1,442,500**

Notes:

1. Will require additional 2m road dedication on each side (not included in costs).
2. Costs updated to January 2011 construction costs.

As mentioned above, Arterial Roads are treated on an overall city wide basis rather than an NCP by NCP basis. This is primarily due to the fact that the impact of arterial traffic is spread out over a wider area than the individual NCP. Also, as outlined previously the analysis does not indicate that traffic from the NCP triggers the need for any arterial widening other than the upgrading of 24th Avenue and 168th Street. Widening of the arterial roads through and adjacent to the NCP will be driven by overall growth in city wide traffic. We have assumed that one half of the 24th Avenue arterial costs will be attributed to Grandview Heights Area #2 NCP and 100% of the costs on 168th Street arterial improvements will be attributed to Grandview Heights Area 5A NCP. If we include the share of the cost of a new signal at 164th Street and 24th Avenue, the arterial road improvements will be $4.76 million.

2.7.1 10 Year Servicing Plan

It is recommended that the City review its 2010-2019 10 Year Servicing Plan to determine whether the works recommended in this report overlap with current projects included in the 10 Year Servicing Plan. **Table 2.7** lists projects currently identified in the 10 Year Servicing Plan that fall within the transportation study area. These projects should be reviewed.

Table 2.7: 10 Year Servicing Plan Projects to Review – Transportation

10 Year Servicing Plan Project ID		
7453	10619	10627
10628	10637	11754

3.0 DRAINAGE INFRASTRUCTURE

As part of the Stage 2 Engineering Services Plan, an overall drainage system was developed to service future development in the NCP # 5A area. The purpose of this study was to build upon previous assessments and recommendations as identified in previous studies completed in and around the area.

A site specific geotechnical investigation was commissioned to determine the potential for stormwater infiltration. Detailed modelling and analysis was undertaken to determine the magnitude of drainage infrastructure required to service the NCP # 5A area.

In general, the stormwater management works have been recommended with the aim of mitigating impacts to existing adjacent drainage conditions while conforming to surrounding area requirements identified by previous studies.

3.1 STORMWATER MANAGEMENT

The objectives of the drainage assessment for the Stage 2 NCP # 5A area report are:

1. Identify opportunities and constraints of the surrounding drainage system to determine essential requirements of a drainage system that will facilitate development of the neighbourhood;
2. Provide an adequate drainage system that will collect and safely convey stormwater from within the neighbourhood to the downstream receiving drainage system;
3. Assess and mitigate any downstream impacts to existing infrastructure and natural systems and to provide overall flood management to safely convey stormwater to the receiving drainage systems; and
4. Maintain and enhance the current watershed hydrology by use of source control strategies to improve stormwater retention and the quality of runoff.

The drainage system within the Grandview Heights Community and around NCP # 5A has been reviewed by several previous studies. The past studies that were extensively reviewed include:

- Stage 1 NCP # 5A Stormwater Servicing Study (KWL, 2010)
- Old Logging Ditch and Burrow's Ditch Draft ISMP (USL, 2010)
- Grandview Heights General Land Use Plan (COS, 2005)
- Grandview Heights Area NCP # 1 (Stantec, 2005)

The stormwater servicing plan prepared during the Stage 1 of NCP # 5A provided a general overview of the servicing strategy for the neighbourhood. System components reviewed and identified included storm sewer collection and conveyance systems, detention systems, infiltration systems and on-lot source controls. The Stage 1 report also identified the use of Stormwater Utility Corridors as potential locations for underground detention and infiltration as the primary means of release rate and volume control thereby essentially eliminating the need for an above ground detention facility. The Stage 1 report also identified a target capture volume of 25mm of rainfall for infiltration in the area.

The stormwater assessment conducted for the Grandview Area NCP # 1 assessed the overall drainage characteristics of the Old Logging Ditch system. The study identified key system components required to support future development which included the NCP # 5A area, and included many standard drainage Best Management Practices. The study determined detention volume targets for NCP # 5A as required to mitigate any potential effects downstream.

The Old Logging Ditch and Burrow's Ditch ISMP study further reviewed previous drainage studies and conducted a watershed level assessment. The study made recommendations for stormwater release rate and volume control via detention and retention requirements within the watershed.

3.1.1 Existing & Future Servicing Catchments

The purpose of this drainage assessment is to determine and understand characteristics of the existing drainage system as an aid in the evaluation and conceptual design of alternatives to extend the design of the existing drainage system.

Upon review of the previous drainage studies, it was concluded that further evaluation of the existing downstream receiving drainage system was not warranted at this time.

The existing system was evaluated at a macro level of detail by performing background investigation, site reconnaissance, and review of the drainage system record information and reports and ground topography.

3.1.1.1 Existing Drainage

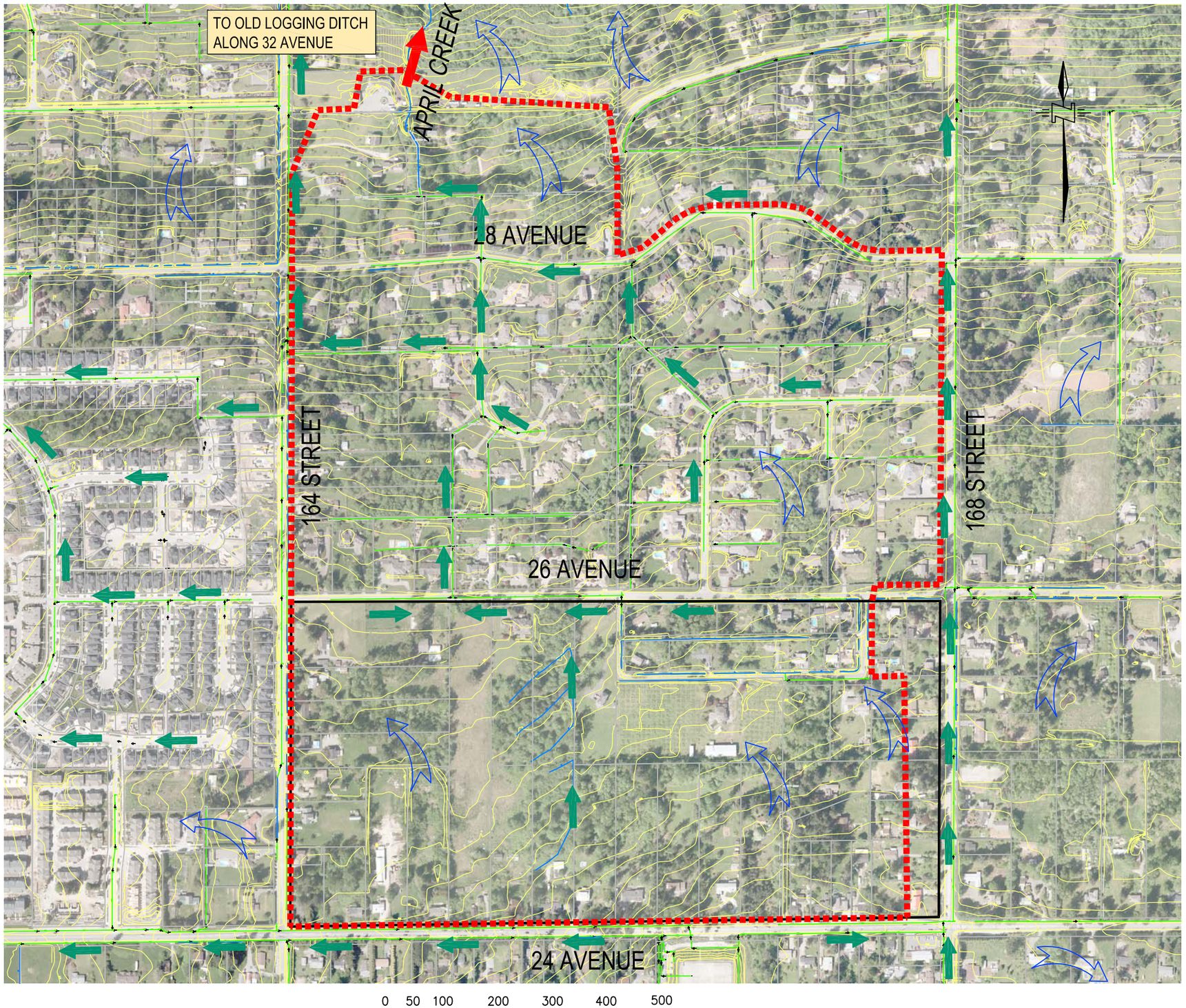
The overall catchment area is currently characterized as rural in nature having large acreage and half-acre parcels. Land cover generally consists of a mixture of a grassland, meadows and forested land. The land gently slopes from south-east to north-west with the low-point of the neighbourhood located immediately east of 164 Street and 26 Avenue. Residential houses are located throughout the study area. The majority of the watershed, north of 26 Avenue, is currently developed as half acre parcels and has an enclosed storm sewer system servicing the area. **Figure 2** outlines a general overview of the existing catchment area.

The current drainage system is rural in nature and primarily consists of open ditches collecting overland flows. Existing storm sewer mains are located along the perimeter of the neighbourhood area. The storm sewer mains along 164 and 168 Street generally service local roadways and proximal single family development; these storm sewers convey runoff north to the Old Logging Ditch along 32 Avenue. The storm sewer on 24 Avenue services the road ROW and fronting single family developments and conveys flow west to the Grandview Heights Area NCP #2 (Sunnyside Heights) drainage system.

All surrounding areas eventually drain to the agricultural lowlands that are subsequently drained by several open channel ditches. These lowlands are subject to periodic flooding and are sensitive to upland development that, if left unchecked, would produce increased peak flows and runoff volumes. Therefore, stormwater measures identified herein are recommended to mitigate impacts to the downstream lowland system that would result from future development within NCP # 5A.

Areas west of 164 Street are part of the Grandview Heights NCP #1 (Morgan Heights) area and stormwater flows from this area are conveyed west to Morgan Creek. Areas east of 168 Street drain north-east to the Old Logging Ditch and the Burrows Ditch at 32nd Avenue.

Currently, internal flows from the lands within NCP # 5A are conveyed overland to open ditches which direct flows to the existing storm sewer along 26 Avenue. This storm sewer system eventually drains to April Creek located north of the neighbourhood, east of 164 Street.



LEGEND

- Existing Storm Sewer
- Existing Watercourse
- Flow Route
- Overland Flow Direction
- Drainage Boundary
- NCP #5A Boundary

0 50 100 200 300 400 500

(ALL DIMENSIONS ARE IN METRES)

SCALE: 1:5000
NOVEMBER 2011

McElhanney

CITY OF SURREY
the future lives here.

ORCHARD GROVE
GRANDVIEW HEIGHTS AREA 5A

EXISTING DRAINAGE PLAN

FIGURE 2

The Grandview Heights NCP # 1 (Morgan Heights) drainage study assessed the performance of the current drainage systems and has put forward recommendations for detention requirements for the watershed in order to mitigate impacts due to future developments. The Old Logging and Burrow's Ditch ISMP re-iterated the requirements for detention and further recommended on-site retention requirements.

3.1.1.2 Soil Conditions

Review of published records indicates the NCP # 5A area is generally underlain by Capilano Sediments and Vashon Drift. The Capilano Sediments are comprised of marine and glaciomarine stony to stoneless slit to clay loam with minor sand and silt while the Vashon Drift soils are comprised of lodgement till and minor flow till containing interbeds of glaciolacustrine laminated stony stilt (Braun, 2011).

Braun Geotechnical Ltd. undertook a geotechnical exploration program that involved field investigation including the digging of test pits and undertaking percolation testing to characterize the soils of the area. The findings of the geotechnical exploration were generally consistent with the published regional information. The subsurface exploration generally encountered a shallow thickness of organics and loose sand or existing fills overlaying very stiff to hard silt and very dense silty fine sand (till-like soils). Depending on the season and/or weather conditions, near-surface groundwater seepage flows would be anticipated within the organic rich and upper loose to compact sand soil layers overlying the low permeable silt and till-like soils.

Infiltration testing was also undertaken to determine the potential to incorporate infiltration measures in the area. Test results revealed that non-measurable infiltration rates were present throughout the area. In some instances test holes actually filled with water, which revealed the presence of perched water table conditions. Tests readily concluded that sub-surface soils are not conducive to infiltration. Braun Geotechnical recommended that partial infiltration measures be provided due to the limited infiltration rates present in the area.

The findings of the geotechnical investigations were particularly important as the underground detention and infiltration systems proposed within the Stomwater Utility Corridors, as recommended in the Stage 1 Engineering Services Study, were no longer feasible and could no longer be successfully implemented.

This required a new approach to managing stormwater within the site.

3.1.1.3 Future Drainage & Constraints

The main constraints identified in the Stage 1 NCP # 5A report are related to increases in peak discharge rates and runoff volumes to downstream systems and lowland areas. As such, detention and retention requirements have already been identified for the area.

Flows from NCP # 5A area will be conveyed north along 164 Street via a trunk storm sewer to the Old Logging Ditch located along 32nd Avenue. The 5-year return period controlled discharge rate for the 164 Street trunk storm sewer was previously established at 15 l/s/ha under the Grandview Heights NCP #1 Drainage Study.

The lowland areas are subject to flooding and increased flooding magnitude and duration could result due to future development of the upland areas. Therefore, detention and retention measures would serve to mitigate the increase in peak flow and runoff volumes to the lowland areas.

The main objectives of the proposed storm water management works are:

1. Provide an adequate minor and major drainage system that would service proposed developments within the neighbourhood;
2. Provide a drainage system that allows for in-ground basements for single family residential developments;
3. Provide adequate community detention for the neighbourhood plan to mitigate any potential for downstream flooding resulting from increased discharge rates; and
4. Provide source control measures throughout the neighbourhood to mitigate increases in runoff volume introduced to the downstream system.

3.1.2 Design Criteria & Analysis

The City of Surrey's Design Criteria Manual (2004) forms the main source for drainage design criteria for this project. Additional sources were further used to establish the drainage design criteria for NCP # 5A. This includes the Grandview Heights NCP #1 Drainage Study which established the detention requirements of 15 l/s/ha for area and the Stage 1 NCP # 5A study which established the stormwater retention requirement of capturing the first 25mm of rainfall. These requirements were reviewed under this engineering services study.

Specific drainage design criteria for the neighbourhood are as follows:

- Provide a storm sewer system sized to accommodate the 100-year discharge and allow for in-ground basements of single family homes. These conditions impose that the major flow route be below ground and be conveyed via a storm sewer system;
- Provide stormwater detention for the neighbourhood based on the established release rate of 15 l/s/ha for the 5-year return period concluded from the Grandview Heights NCP #1 Drainage Study. Discharge beyond the 5-year return period should be safely conveyed to the downstream system; and
- Provide stormwater source controls throughout the neighbourhood to capture and retain onsite the first 25mm of rainfall as recommended under the Stage 1 NCP # 5A stormwater servicing study.

3.1.2.1 Analysis Methodology

The methodology chosen to assess the stormwater management systems is based on a single-event synthetic design storm approach. Computer modelling has been used to assess the proposed system by applying synthetic design storms of known return periods to evaluate the performance of the system.

The existing system has been assessed to determine the general drainage characteristics of the neighborhood and downstream areas. Detailed analysis using computer modelling was not applied to the existing system; that level of analysis was not considered necessary as a revised drainage plan and system would replace the existing system. However, existing drainage components were incorporated in to the proposed system where applicable. The stormwater strategies proposed follow characteristics similar to the existing drainage system.

Hydrologic modelling allows calculation of effective rainfall and obtaining an output runoff hydrograph by using a transfer function. The output runoff hydrograph can then be routed to the hydraulic components of the drainage system. The use of this hydrograph method of analysis allows for accurate simulations of the detention and retention areas since representative hydrographs take into account runoff volumes derived from tributary catchment areas. The US EPA SWMM-5 engine through the PCSWMM user interface has been utilized for the hydrologic and hydraulic analysis required during the study.

3.1.2.2 Model Input Parameters

Design storms derived from the Surrey Municipal Hall Rainfall recording station have been used in the analysis. Designs storms for the 5-year and 100-year return periods for 1, 2, 6, 12 and 24 hour duration were utilized to determine the governing peak runoff rates and volumes for sizing of storm sewers and the detention facility.

The hydrologic modelling of catchment areas requires several user inputs to characterize the rainfall-to-runoff process occurring during the simulation. Shown in **Table 1** are the global input parameters used for the hydrologic simulation of the catchment areas. Depression storages are based on typical values used for similar land uses and soil types. Infiltration losses are estimated using Horton's Equation and values are based on typical values for the underlying soil types encountered within the project area.

Table 1 Catchment Modelling Input Parameters

Impervious Mannings n	0.013
Pervious Manning n	0.035
Impervious Depression Storage (mm)	1.5
Pervious Depression Storage (mm)	6
% - Zero Impervious Depression Storage (%)	0
Horton's Maximum Infiltration Rate (mm/hr)	25
Horton's Minimum Infiltration Rate (mm/hr)	1.5
Horton's Infiltration Decay Constant (1/hr)	0.1

3.1.2.3 Modelling Results

Sub-catchment information and discharge rates of individual areas are summarized in **Table 2**. Model results represent peak discharges from the runoff hydrographs produced by the hydrologic simulation component of the model. All hydrographs were routed through the hydraulic model representing the physical hydraulic system comprised of the proposed storm sewers and storage facility. Outlined on **Figure 3** are the results of the hydraulic modelling that pertain to key drainage structures.

Table 2 Catchment Data and Model Results

Catchment No.	Area (ha)	Percent Imperv. (%)	5 Yr Flow (cms)	100 Yr Flow (cms)
A1	2.30	73	0.10	0.17
A2	3.83	25	0.06	0.10
A3	2.37	65	0.09	0.16
A4	2.00	65	0.08	0.13
A5	1.77	65	0.07	0.12
A6	2.58	65	0.10	0.16
A7	2.53	70	0.10	0.17
A8	2.83	76	0.12	0.21
A9	2.00	73	0.09	0.15
A10	1.32	65	0.05	0.09
A11	4.04	65	0.15	0.26

A12	1.35	80	0.06	0.11
A13	1.32	65	0.05	0.09
A14	1.64	73	0.06	0.11
A15	7.40	55	0.38	0.65
A16	4.50	55	0.14	0.24

3.1.3 Proposed Servicing Options

The main components that comprise the drainage system proposed under this neighbourhood plan include the following:

- Storm sewer system to collect and convey runoff from the various land uses proposed within the neighbourhood;
- Community detention facility to control post development flows to established rates for the 5-year return period;
- Off-site trunk sewer downstream of the neighbourhood to convey runoff from the NCP # 5A to the receiving downstream drainage system within the agricultural lowlands; and
- Source control measures located throughout the development to provide stormwater retention in order to meet volume reduction targets.

Figure 3 outlines the proposed drainage infrastructure system required for NCP # 5A.

3.1.3.1 Storm Sewers

A conventional storm sewer system is proposed for the neighbourhood plan which would collect and convey stormwater runoff from the development areas and road ROW. Traditional curb and gutter system will be used to collect runoff from the roadway areas. The system will also incorporate infiltration systems in conjunction with the traditional collection system. These infiltration systems are further discussed in Section 3.4 of this report.

As portrayed on **Figure 3**, a gravity storm sewer system will be located as shown and would convey runoff to the proposed detention facility located at 26 Avenue and 164 Street. Storm sewers fronting the single family residential properties will be deeper than in other development areas in order to allow for in-ground basement homes. The entire storm sewer system will be sized and constructed to safely convey the 100-year return period discharge below ground to the detention facility. The storm sewer system generally follows the same alignment as the gravity sanitary sewer system. This allows for installation of both systems in a common trench.

There is an existing storm sewer located on 26 Avenue that services portions of the existing neighbourhood and conveys flows north to April Creek. The proposed 26 Avenue sewer main will replace the existing main and will collect and divert all flows to the detention facility. The existing parcels along 26 Avenue are not serviced by the existing 26 Avenue storm sewer, and as such, this existing storm sewer will be abandoned without affecting service to existing homes.

In order to achieve desired in-ground basements, the hydraulic grade line (HGL) of the storm sewer system will need to be a minimum of 0.30m below the Minimum Building Elevation (MBE) of the proposed homes per the City's Design Criteria. A small portion of single family homes located adjacent to the detention pond

DRAINAGE SYSTEM DESIGN- CALCULATION SHEET

From MH	TO MH	Area No.	Tributary Area (ha) A	Tributary Area (ha) Sum A	FLOW (cms) Q5 (cms)	FLOW (cms) Q100 (tot)	SEWER DESIGN S %	SEWER DESIGN DIA mm	SEWER DESIGN L m	SEWER DESIGN V m/s	SEWER DESIGN Q cms	REMARKS Major Flow Route
D1	D2	A1	2.30	2.30	0.10	0.17	0.50	450	98.2	25.04	3.98	In Pipe
D2	D3	A2	3.83	6.13	0.15	0.26	2.10	450	88.2	2.60	0.41	In Pipe
D3	D4			6.13	0.15	0.26	2.10	450	53.8	2.60	0.41	In Pipe
D4	D5			6.13	0.15	0.26	1.40	450	144.9	2.12	0.34	In Pipe
D6	D7	A3	2.37	2.37	0.09	0.16	3.10	375	95.7	2.80	0.31	In Pipe
D7	D5			2.37	0.09	0.16	2.30	375	87.1	2.41	0.27	In Pipe
D5	D8	A6	2.58	11.08	0.24	0.41	1.80	600	220.6	2.91	0.82	In Pipe
D9	D10	A4	2.00	2.00	0.08	0.13	2.40	375	200.6	2.46	0.27	In Pipe
D11	D10	A5	1.77	1.77	0.07	0.11	5.20	450	154.4	4.09	0.65	In Pipe
D10	D8			3.77	0.14	0.24	0.70	525	94.1	1.66	0.36	In Pipe
D8	D12			14.85	0.47	0.81	1.10	750	65.8	2.64	1.17	In Pipe
D13	D12	A7	2.53	2.53	0.10	0.17	1.00	375	91.4	1.59	0.18	In Pipe
D12	D15			17.38	0.56	0.97	1.10	900	90.5	2.98	1.90	In Pipe
D14	D15	A8	2.83	2.83	0.12	0.21	1.10	525	245.6	2.08	0.45	In Pipe
D15	HW1			20.21	0.74	1.27	6.60	900	55.0	7.31	4.65	In Pipe
D16	D17	A9	2.00	2.00	0.09	0.15	2.10	375	168.6	2.30	0.25	In Pipe
D17	D21	A10	1.32	3.32	0.13	0.23	2.00	450	323.2	2.54	0.40	In Pipe
D18	D20	A11	4.04	4.04	0.15	0.25	1.60	450	285.7	2.27	0.36	In Pipe
D20	D21	A12	1.35	5.39	0.21	0.36	3.70	450	95.0	3.45	0.55	In Pipe
D21	D22	A13	1.32	10.03	0.38	0.66	1.00	750	250.2	2.52	1.11	In Pipe
D22	HW2			10.03	0.38	0.66	2.00	750	55.4	3.56	1.57	In Pipe
HW3	D23				0.48	1.35	1.50	750	54.6	3.09	1.36	In Pipe
D23	D24	A15	7.40	37.64	0.73	1.75	3.40	750	153.0	4.65	2.05	In Pipe
D24	D25			37.64	0.73	1.75	3.40	750	153.3	4.65	2.05	In Pipe
D25	D26	A16	4.50	42.14	0.83	1.95	3.40	750	153.3	4.65	2.05	In Pipe
D26	D27			42.14	0.83	1.95	3.40	750	153.3	4.65	2.05	In Pipe

PROPOSED 750mmØ TRUNK STORM SEWER

COMMUNITY DETENTION POND
5 Yr. Volume = 1,200 m³
Footprint Area = 8,500 m²
Active Depth = 1.5m

EXISTING STORM SEWER ON 26 AVENUE TO BE ABANDONED

EXISTING STORM SEWER ON 24 AVENUE TO BE MAINTAINED TO SERVICE EXISTING ROAD ROW

26 AVENUE
25A AVENUE
25 AVENUE
24A AVENUE
24 AVENUE
164 STREET
164A STREET
165 STREET
166 STREET
167 STREET
167A STREET
168 STREET

A1 2.30 ha.
A2 3.83 ha.
A3 2.37 ha.
A4 2 ha.
A5 1.77 ha.
A6 2.58 ha.
A7 2.53 ha.
A8 2.83 ha.
A9 2.00 ha.
A10 1.32 ha.
A11 4.04 ha.
A12 1.35 ha.
A13 1.32 ha.
A14 1.64 ha.
A15 7.40 ha.
A16 4.50 ha.

LEGEND

- Existing Storm Sewer
- Existing Watercourse
- Proposed Storm Sewer
- D11 Manhole Number
- Proposed Catchment Boundary
- A1 2.21 ha. Catchment Area
- Detention Pond
- Proposed Park
- Habitat Corridor

0 50 100 150 200m
(ALL DIMENSIONS ARE IN METRES)

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GRANDVIEW HEIGHTS AREA 5A

PROPOSED DRAINAGE PLAN

FIGURE 3

cannot be provided with in-ground basements. This is due to the hydraulic grade lines of the detention pond and storm sewer mains in close proximity to the detention pond.

3.1.3.2 Community Detention Facility

A community stormwater detention facility is required to control the increase in peak discharges resulting from development of the neighbourhood. Past studies have identified constraints in the receiving downstream lowland drainage system. The Grandview Heights NCP # 1 drainage study identified the required detention for NCP # 5A. Detention requirements for NCP # 5A have been established as limiting the 5-year peak post development discharge to 15 l/s/ha. This translates to a maximum 5-year release of 0.48 m^3/s for the NCP # 5A Area.

As shown on **Figure 3**, the pond would be located at the northwest corner of neighbourhood at 26 Avenue and 164 Street. This is an optimal location for the pond as this location is the low-point of the site and all stormwater from NCP # 5A can be treated by the detention facility. Developments adjacent to the detention pond cannot be provided with in-ground basements as explained previously. Pond relocation would impact its overall volume, size, and footprint, and could further impact the potential for in-ground basements in other areas and the sizing of the downstream trunk sewer along 164 Street.

The pond is sized to control discharges up to the 5-year return period with an overflow provided for up to the 100-year return period discharge. **Table 3** provides a summary of the characteristics of the detention pond facility.

Table 3 Detention Pond Operation

5-year Inflow	1.12 m3/s
100-year Inflow	1.94 m3/s
5-year Outflow	0.48 m3/s
100-Year Outflow	1.35 m3/s
Total 5-year Storage	1,200 m3

The proposed detention pond will be a designed with a permanent pool to enhance water quality of the released stormwater runoff. The pond inlets and outlets are to be submerged to allow any floatables such as debris and oils to be retained within the facility. General design characteristics of the pond follow the City of Surrey Design Criteria for wet ponds and are summarized as follows:

- 7:1 side slopes (from top of Pond to NWL)
- 4:1 side slopes (from NWL to Pond Bottom)
- 1.5m active storage depth (NWL to HWL)
- 1.5m dead storage depth (NWL to Pond Bottom)
- Min. 0.5m freeboard
- 3.0m perimeter access pathway

The outlet of the detention pond will be designed to convey flows up to the 100-year return period. The pond would discharge to the off-site trunk sewer located along 164 Street.

In order to maximize the overall benefit of this detention pond, it will be prudent to integrate the proposed detention pond as a public amenity for the neighbourhood. This can be achieved by means of incorporating creative landscaping and soft engineering features into the design of the detention pond.

Provided on **Figure 4** and **Figure 5**, respectively, are a conceptual pond layout and section that illustrate the potential to integrate the stormwater facility as a public amenity through the incorporation of park-like pathways, trails, look-out points and vegetation.

3.1.3.3 Off-Site Works

Discharge from NCP # 5A is eventually conveyed north to the Old Logging Ditch located on 32 Avenue. The route for this conveyance is along 164 Street. As such a trunk storm sewer will be required to convey runoff from the proposed community detention facility to 32 Avenue.

An existing storm sewer is located along 164 Street, however a section of this sewer does not have adequate capacity to convey the 100-year discharge released from the proposed detention pond. Therefore a storm sewer upgrade is required to safely convey the 100-year stormwater discharge along 164 Street. The existing 600mm diameter sewer on 164 Street would be replaced by the proposed 750mm diameter trunk main up to 29 Avenue. The existing ditch along 164 Street would remain to collect and convey runoff from 164 Street pavement area and fronting properties.

Figure 6 outlines the proposed off-site trunk sewer upgrade required along 164 Street.

3.1.4 10-Year Servicing Plan

To accommodate the future development of NCP # 5A, the proposed community detention facility and off-site trunk sewer will need to be constructed prior to any development in the neighbourhood.

The items listed in Table 4 below are DCC eligible infrastructure.

Table 4 Drainage DCC Eligible Items and Costs

DCC Item	Total Cost
Trunk Sewer	$ 933,000
Detention Pond[1]	$4,766,200
Total	**$5,699,200**

Note: 1. Includes land acquisition cost based on current (2011) assessed land value of $1.2M/ac

3.2 Flood Control & Erosion

The proposed storm sewers for the NCP # 5A area will be sized based on the 100-year return period discharges and will act as the major system for flow routing. The detention system will be sized to control discharges up to the 5-year return period and will convey discharges and maintain a below ground HGL for up to the 100-year return period. The pond outlet and storm trunk sewer along 164 Street will also convey runoff for up to the 100-year return period. Instead of discharging directly to April Creek, the trunk sewer will convey all runoff from NCP # 5A along 164 Street to the Old Logging Ditch along 32 Avenue. This will help alleviate and mitigate any current and future erosion within April Creek.

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DETENTION POND DETAILS - PLAN

FIGURE 4

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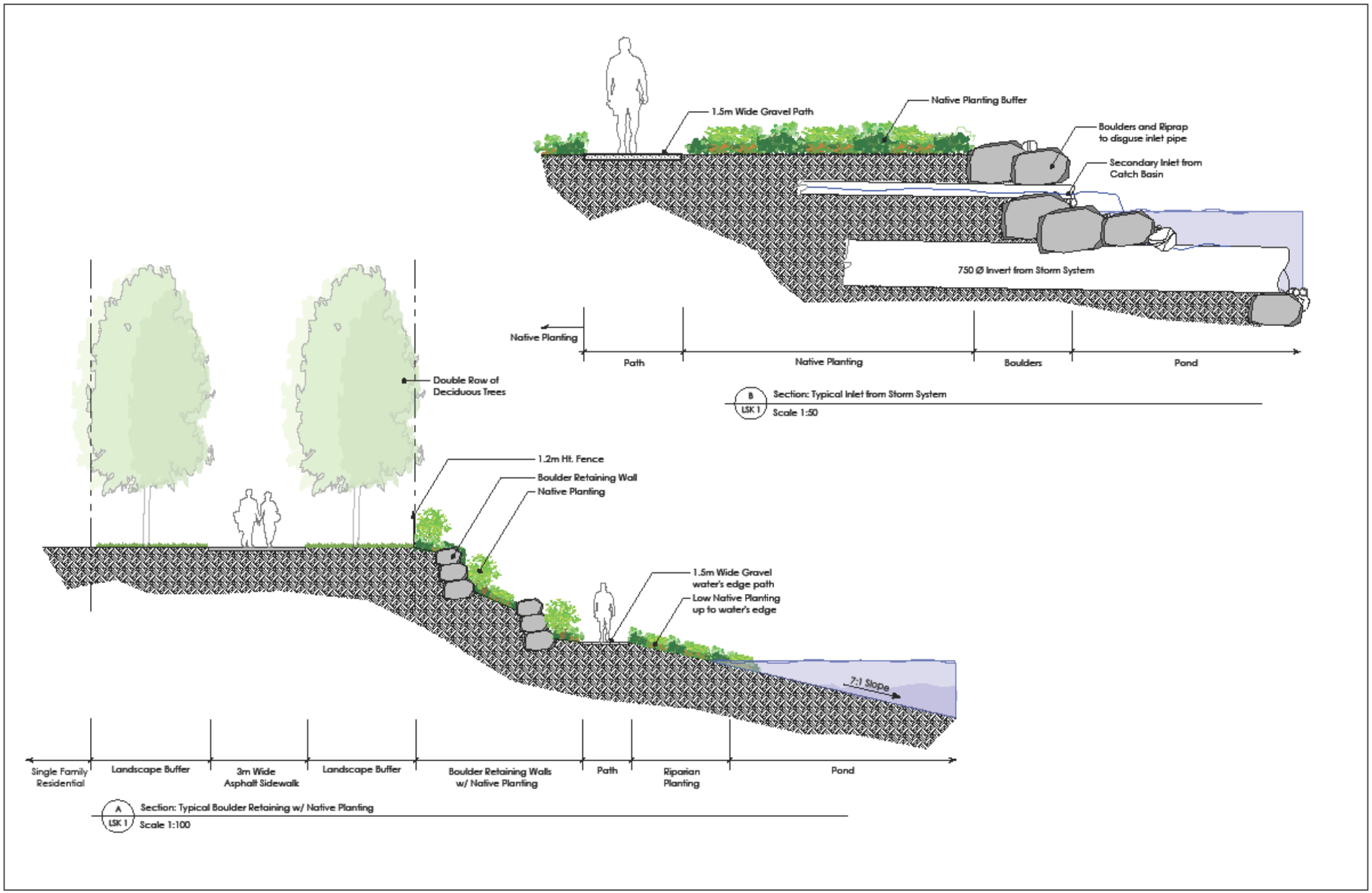

ORCHARD GROVE
GRANDVIEW HEIGHTS AREA 5A

DETENTION POND DETAILS - SECTION

FIGURE 5

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3.3 ENVIRONMENTAL CONSIDERATIONS

The current neighbourhood contains several open channel ditches, none of which are classified as sensitive fish habitat watercourses. Therefore, no environmental study was required for the Stage 2 Engineering Services phase of the NCP. The Old Logging Ditch and Burrow's Ditch ISMP conducted an environmental study for the areas surrounding NCP # 5A. Outcomes of the ISMP's environmental study have no bearing on, or relevance to, NCP # 5A.

Stormwater generated from the neighbourhood does contribute runoff to watercourses located further downstream that provide and support fish habitat. Source control measures proposed for this neighbourhood will help sustain minimum base flows and will provide water quality benefits to maintain and enhance downstream fish habitat watercourses.

3.4 STORMWATER SOURCE CONTROLS

In addition to peak flow conveyance and detention requirements, stormwater retention through implementation of source control measures is also recommended for the NCP # 5A. The City of Surrey's current design standards encourage more effective methods to manage post-development flows, runoff volumes, and maintaining base flows in efforts to protect properties and sensitive receiving water courses. This approach to stormwater management is being carried forward for NCP # 5A area through the use of stormwater source controls.

The downstream agricultural lowlands, through which NCP # 5A eventually drains, are subject to periodic flooding. The magnitude and duration of flooding of the agricultural lowland areas can be further exacerbated by development of the upland areas. Although peak flow reduction through detention provides mitigation against increases in peak flows, source control measures are also required to alleviate the increase in runoff volume that will be introduced to the lowlands area resulting from development.

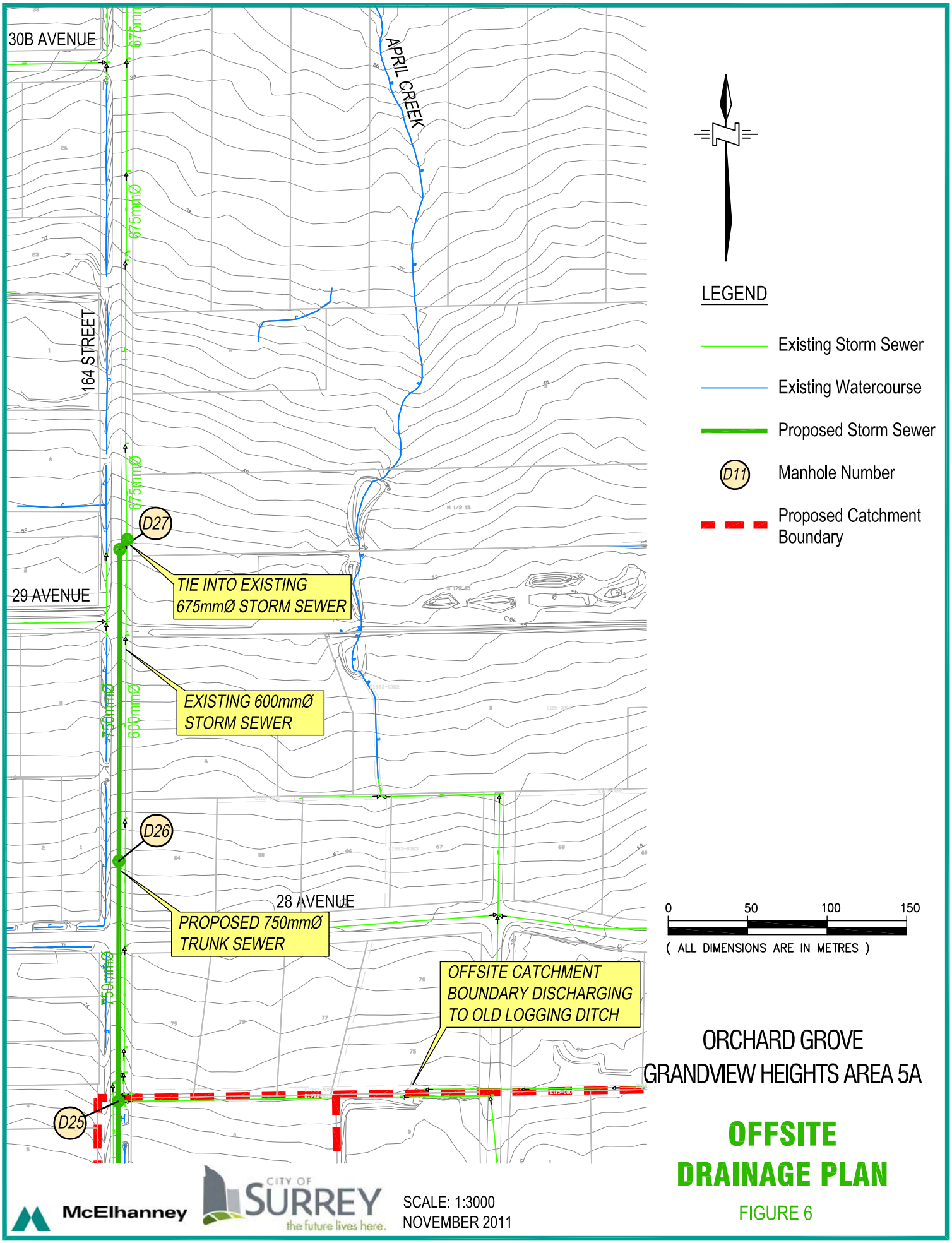
Table 5 compares the goals and objectives of both detention and infiltration mitigation measures. While detention provide peak flow and water quality controls (if a wet pond is used), source controls via infiltration provide the added benefit of reducing runoff volumes and augmenting base flows of valuable downstream watercourses.

Table 5 Detention and Source Control Goals and Objectives

Stormwater Management	Peak Flow Control	Runoff Volume Control	Water Quality Control	Base Flow	Design Target
Detention	Yes	No	Yes	No	Significant Storms
Infiltration/ Source Controls	Yes	Yes	Yes	Yes	Frequent Small Events

3.4.1 Source Control Considerations & Targets

Targets for source control measures were investigated in detail under the Stage 1 component of the stormwater servicing study. The study concluded that a capture target volume of 25mm of rainfall is required from all impervious surfaces within the neighbourhood. This translates into an impervious area



ORCHARD GROVE
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OFFSITE DRAINAGE PLAN

FIGURE 6

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retention of 250m^3/ha for the neighbourhood. This target achieves the stormwater retention objective to maintain base flows and mimic the local natural hydrology while not exacerbating downslope seepage. The concern of increased downslope seepage was identified by Piteau Associates Ltd. during a Hydrogeological investigation for the North Grandview Heights Area and NCP Servicing Plans.

The Old Logging Ditch and Burrow's Ditch ISMP also references the target retention volumes identified under the Stage 1 Stormwater Servicing Study. The ISMP recommends 300m^3 of retention volume per hectare of development. This value is in-line with the above specific target of 250m^3 per hectare of impervious area, however does not distinguish needs based on percent imperviousness. Therefore the target of 250m^3/ha of impervious area has been used for NCP # 5A.

The target retention volume of 250m^3/ha was also reviewed under the Stage 2 study by performing a water balance of the NCP # 5A area using a Water Balance Model. A source control infiltration system chosen for the neighbourhood incorporated equivalent surface area, depth and release rate parameters as a means to reduce the post development flow duration and runoff volumes to pre-development levels. The total retention volume determined from the water balance calculations were comparable to the target retention volume recommended under the Stage 1 report, concluding the target 250m^3/ha of impervious area is acceptable for NCP # 5A.

One of the biggest challenges in incorporating stormwater retention for this area is the limitation on the depth of below ground infiltration systems, due to the shallow/perched ground water conditions identified. This restricts the use of below ground infiltration systems to shallow depths, which therefore require systems that collect and infiltrate water at the source as opposed to systems that collect, convey and then infiltrate at centralized collection areas. Deeper infiltration systems may be installed at locations where further site specific geotechnical data indicate deeper ground water conditions. However, in the absence of further site specific geotechnical information at locations where below-ground infiltration systems are called for, it is recommended that they should not be installed deeper than approximately 1.2m below ground.

Due to challenging site conditions within NCP # 5A, an important consideration at the time of detailed design is the use of an underflow for all infiltration systems. The underflow can be simple as a small orifice placed at the bottom of the outlet of an infiltration system, which would connect to the outletting storm sewer system. Past studies including work in East Clayton (MCSL 2002) and Fergus Creek ISMP (MCSL 2010) have proved the need to have a very small underflow to allow the infiltration systems located in areas of very low infiltration capacity to drain between storm events. This is particularly important during the winter months where multiple back-to-back rainfall events occur over long durations. Low flow augmentation would occur following a rainfall event which would extend the duration of base flows within downstream watercourses. Furthermore, the systems would act as small detention systems to reduce peak flows at the source. The underflow should be sized to release runoff from the infiltration system at a rate of 1.0 l/s/ha as determined during the water balance analysis performed under this study.

3.4.2 Recommended Source Control Measures

Several source control measures for use and consideration within this neighbourhood have been investigated and reviewed. The following recommended source control measures represent the most feasible means for the locations and development types within the neighbourhood:

- Disconnected roof leader for various residential development units allowing direct runoff to pervious areas;

- Placement of 300mm layer of enhanced / amended topsoil on all pervious areas throughout the neighbourhood;
- Absorbent landscaping / planting incorporated into all landscaped areas to promote retention of stormwater ;
- Below ground infiltration trenches / galleries;
- Above ground rain gardens ; and
- Porous concrete/pavement for sidewalks and pathways.

The NCP # 5A area can be divided into three distinct areas requiring various levels and types of source controls to meet the retention volume targets. These three types of areas are described as:

- Single Family Residential Developments and Park Areas;
- Townhouse / Multi-Family / Commercial Developments; and
- Road Rights-of-Way Areas.

Figure 7 outlines these areas and the types of source controls required for each.

3.4.3 Single Family Residential & Park Areas

The simplest non-structural source control is the disconnection of roof leaders from the storm sewer service connections to allow roof runoff onto splash pads directing runoff to the surrounding yard area. The disconnection of roof leaders is an existing criterion for new developments in Surrey. The other primary source control measure to be implemented for the single family developments is the use of amended topsoil throughout all landscaped areas of the development. The required thickness of the top soil layer is 300mmn which is cited by both the Old Logging/Burrow's Ditch ISMP and the Stage 1 NCP # 5A Stormwater Servicing Study. Additionally, the enhanced topsoil would be applied to all pervious surfaces on the private property and fronting boulevard areas within the municipal Right-of-Ways.

In summary, the following source control measures are recommended for all single family residential developments with the NCP:

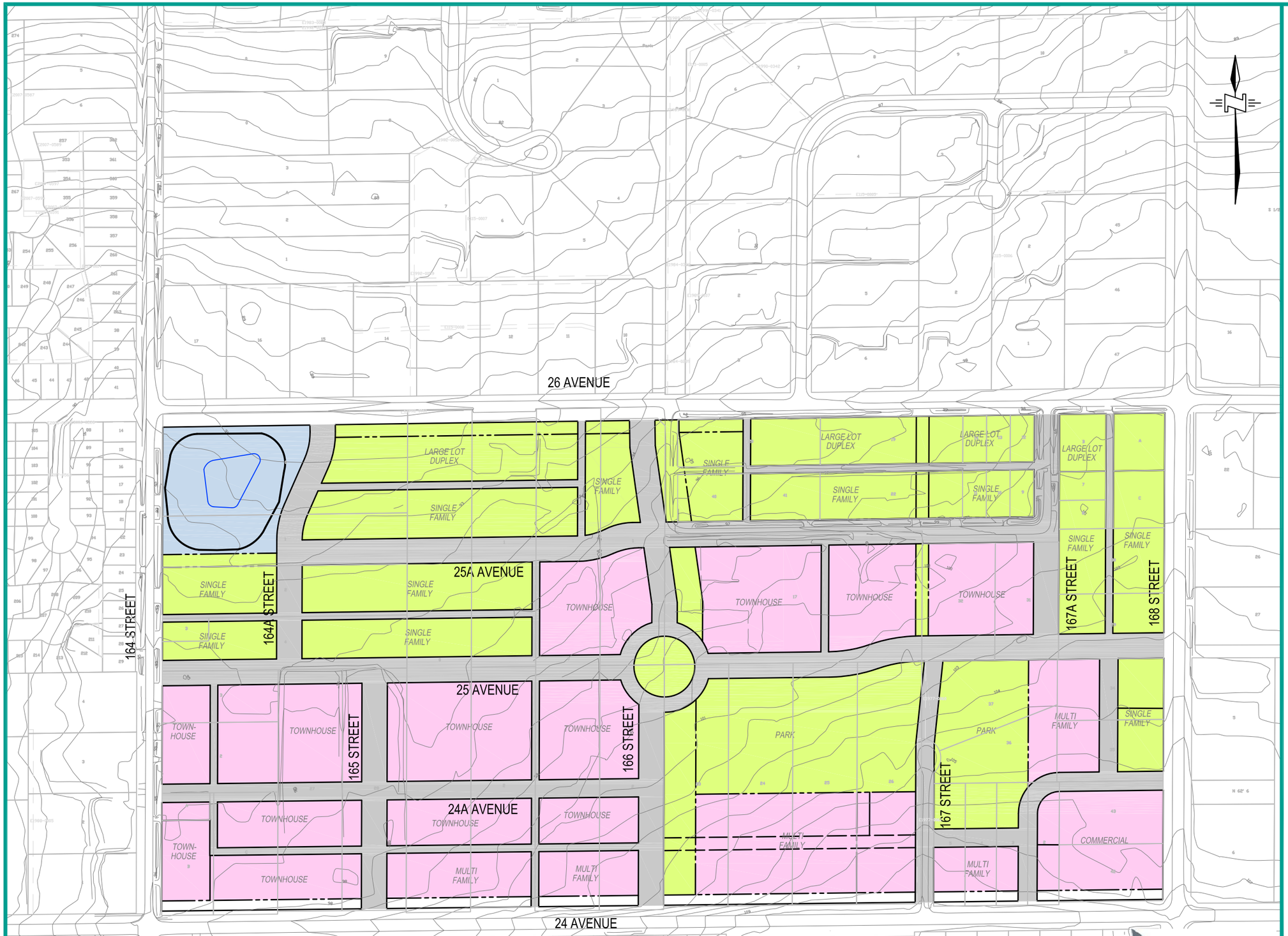
- Disconnected roof leaders that direct roof runoff to splash pads;
- 300mm layer of enhanced / amended topsoil placed on all pervious areas of the site; and
- Absorbent landscaping / plantings that promote the retention of stormwater runoff.

These measures can be implemented and enforced during the house construction phase of development. As part of the building permit and construction process, inspection of these measures can be completed in conjunction with other mandatory inspections.

3.4.4 Townhouse / Multi-Family / Commercial Developments

The multiple residential and commercial development sites offer more opportunity for incorporation of site specific infiltration measures as source controls. In particular, townhouse development sites can include several source control measures to be designed and implemented through the building permit process. This allows for design professionals to take responsibility for the design and implementation of site specific source control measures. Recently constructed townhouse sites in the South Newton area provide examples of how implementation of underground infiltration galleries can be successfully incorporated in to the overall stormwater management plan for such developments.

Recommended source control measures for townhouse, multi-family and commercial developments include:



LEGEND

Road ROW Infiltration
- Rain Gardens
- Infiltration Trenches
- Porous Concrete Sidewalks

Single Family/Park Areas
- Disconnected Roof Leaders
- 300mm Topsoil

Townhouse/Multi Family/Commercial
- 250m³/ha (Retention/ Impervious Area)
- 300mm Topsoil
- Porous Concrete Sidewalks/ Pathways

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PROPOSED INFILTRATION AREAS

FIGURE 7

- 300mm layer of enhanced or amended topsoil placed on all pervious areas of the site;
- Absorbent landscaping that promotes the capture and retention of stormwater; and
- Infiltration galleries installed to provide a retention volume of 250 m^3/ha of impervious area. An underflow designed to release at a rate of 1.0 l/s/ha shall be provided.

Figure 8 outlines how a typical townhouse development site can incorporate various forms of source control measures described above.

3.4.5 Road Right-of-Way Areas

The road rights-of-way (ROW) areas also require their own designated source control measures separate from measures located on private property. Retention of stormwater runoff from the ROW areas, particularly from impervious road surfaces, is important as significant runoff contribution and pollutant loadings originate from the pavement areas of local roads and rear access lanes in the neighbourhood.

Boulevards within the road ROW provide opportunities to apply the 300mm layer of enhanced/amended topsoil, consistent with the single and multi-family developments in the neighbourhood. This installation of topsoil within the ROW would coincide with topsoil placement during construction of the single family/multifamily developments. The topsoil will help to retain rainfall and promote rainwater absorption within the boulevard.

To help promote infiltration, thereby reducing runoff, porous concrete sidewalks are proposed for all sidewalks and pathways located throughout the neighbourhood.

Two options have been identified to apply source control measures for the road ROW areas.

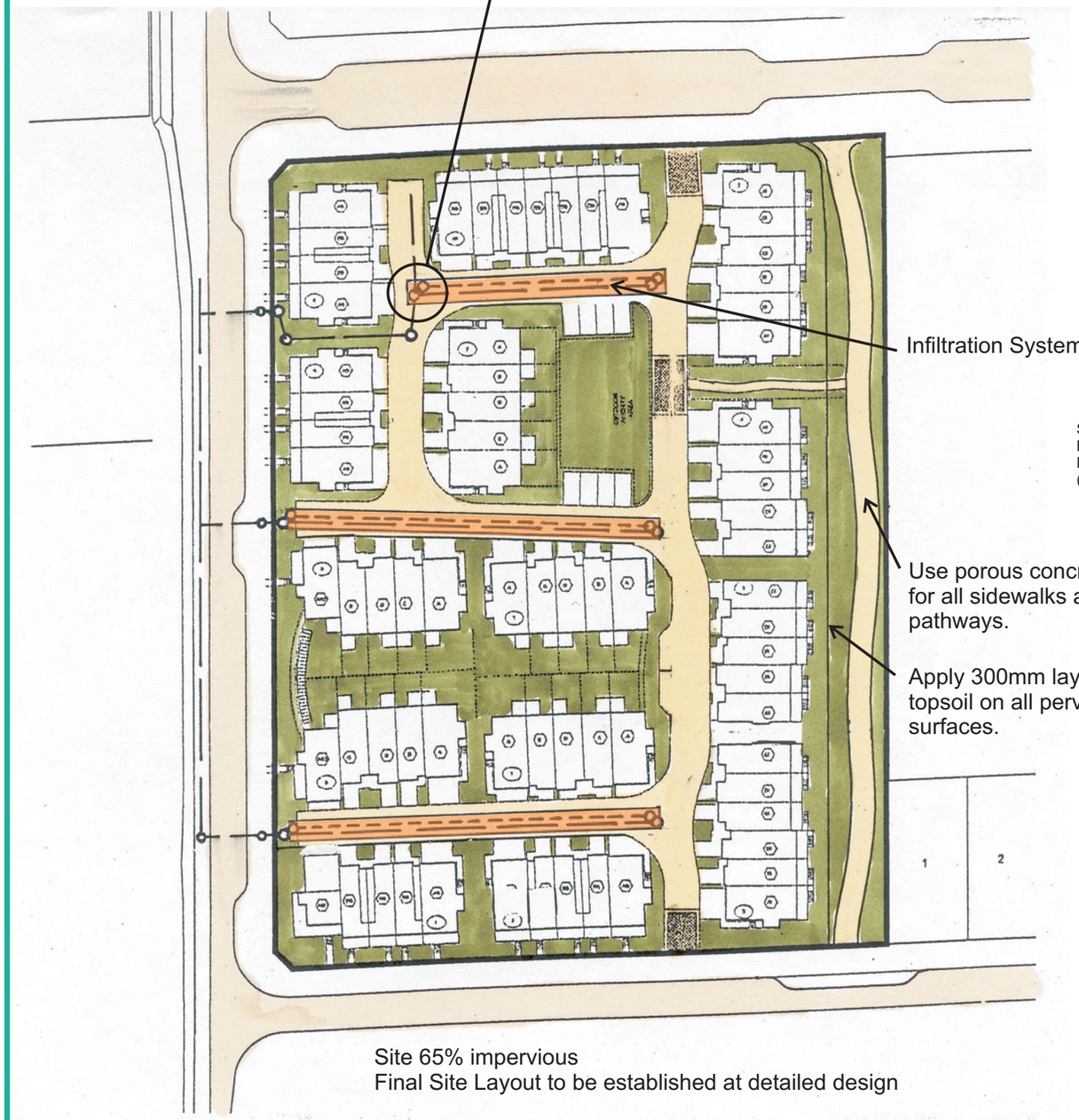
The first option utilizes a 1.5m wide by 0.45m deep infiltration trench located along both sides of the road ROW to provide retention volume to meet the stormwater retention targets for road ROW areas. Flow control catchbasins are provided to convey runoff that exceeds infiltration trench capacity to the storm sewer main. The infiltration trench and flow control catchbasins are shown in **Figure 9**.

The second option is to incorporate the use of an above ground rain garden within the boulevards of the road ROW. **Figure 10** provides detail of how rain gardens could be incorporated into the local road ROW cross-section to provide stormwater retention. Runoff from the roadway area is directed to the rain garden using a curb-cut inlet instead of a traditional catchbasin. An overflow grated drain is provided within the rain garden to discharge overflows to the storm sewer main. In addition, an underflow would be required as previously described.

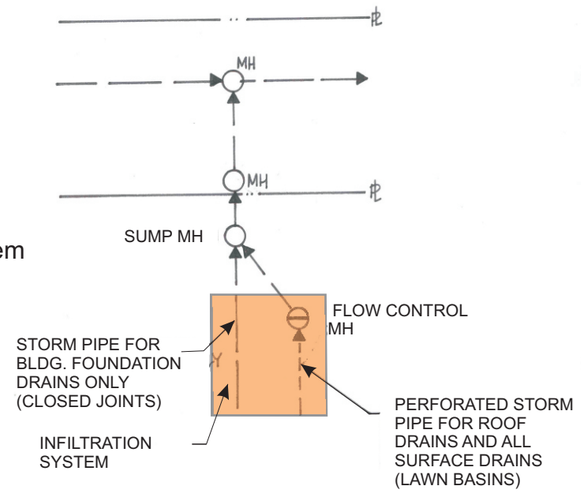
The rear access lanes located throughout the single family development areas also require an infiltration trench system similar to the local road section described above. The required infiltration trench width, however, is reduced. **Figure 9** also outlines a typical lane section with the infiltration trench in place.

In summary, recommended source control measures for road ROW areas include:

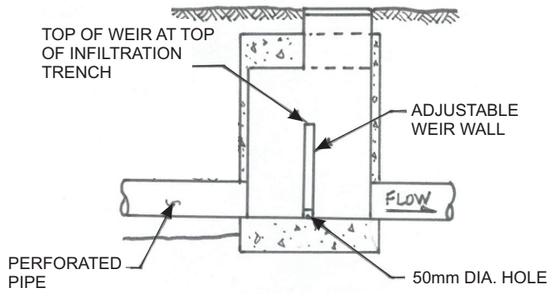
- 300mm layer of enhanced or amended topsoil placed on all pervious areas of the boulevard;
- Porous concrete for all sidewalks and pathways; and
- Infiltration galleries and/or rain gardens installed within the boulevard and rear lanes to provide a retention volume of 250 m^3/ha of impervious area. An underflow designed to release at a rate of 1.0 l/s/ha shall be provided.



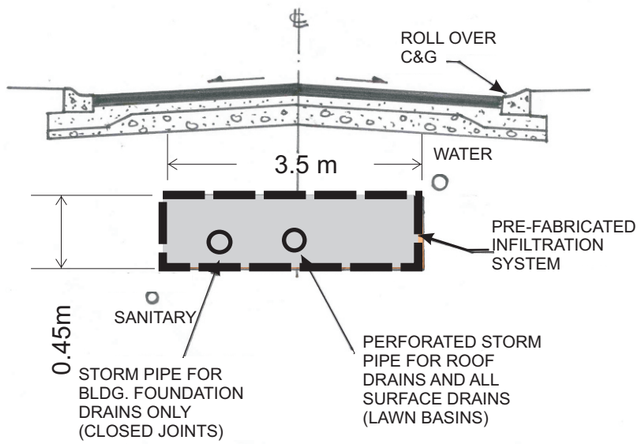
TYPICAL PLAN



PLAN DETAIL



FLOW CONTROL MANHOLE



TYPICAL SECTION

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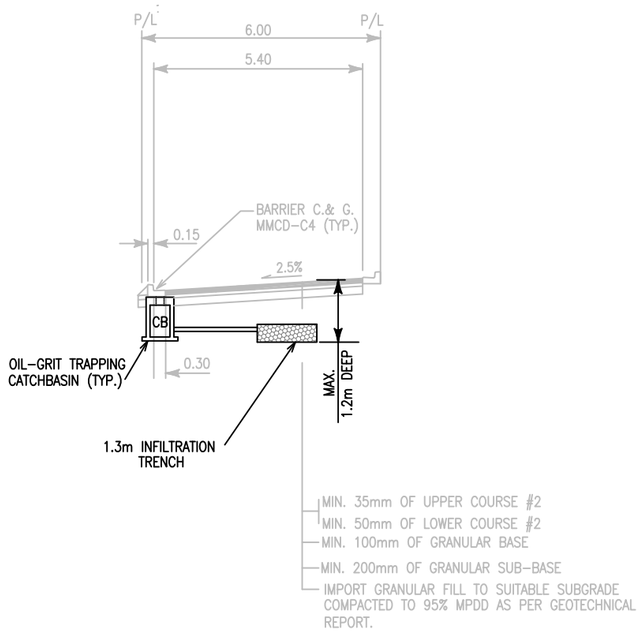
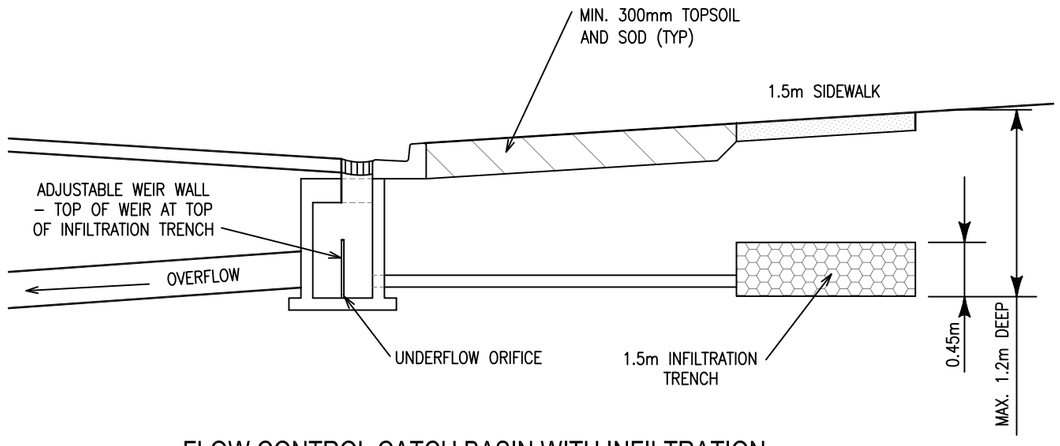
MULTI FAMILY INFILTRATION SYSTEM

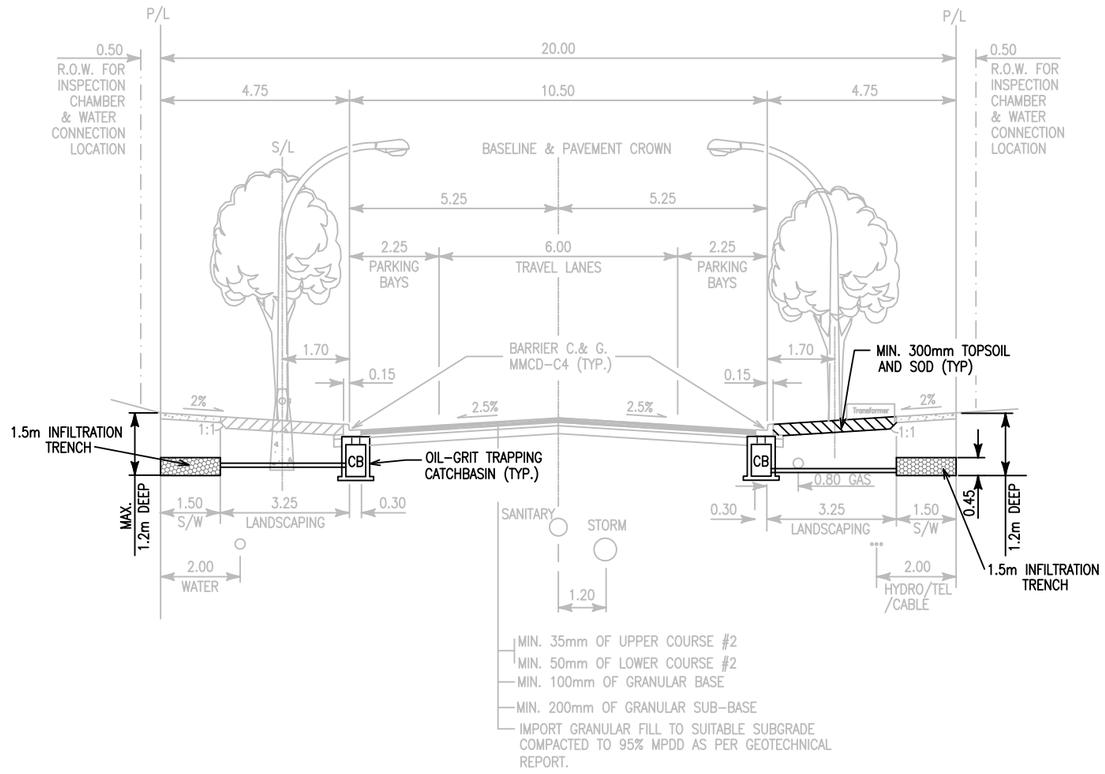
FIGURE 8



6.0m ROW: LANE CROSS SECTION
WITH INFILTRATION TRENCH



FLOW CONTROL CATCH BASIN WITH INFILTRATION
TRENCH AND OVERFLOW TO STORM PIPE



20.0m ROW: STREET CROSS SECTION
WITH INFILTRATION TRENCH

ORCHARD GROVE
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INFILTRATION TRENCH DETAILS

FIGURE 9

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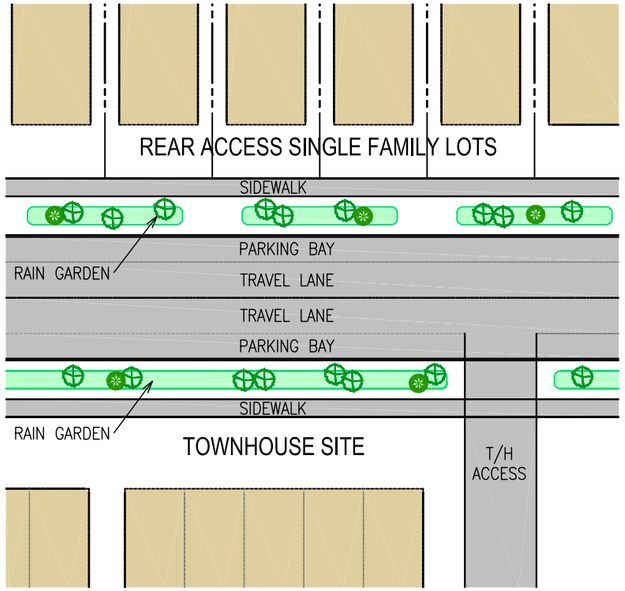
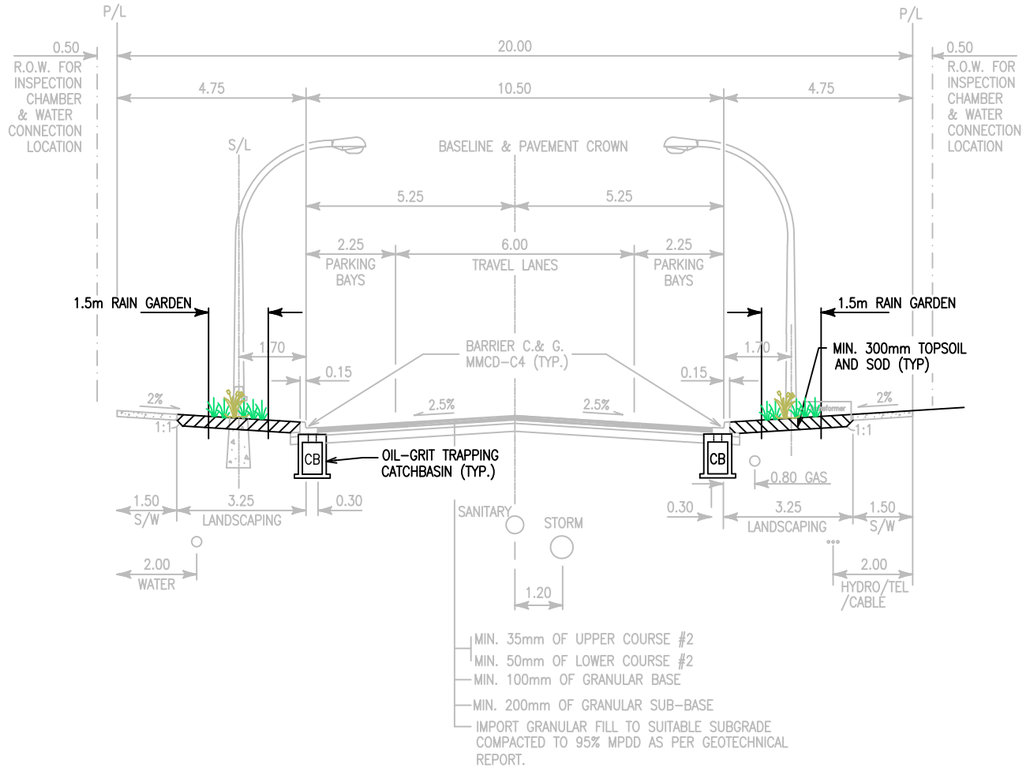


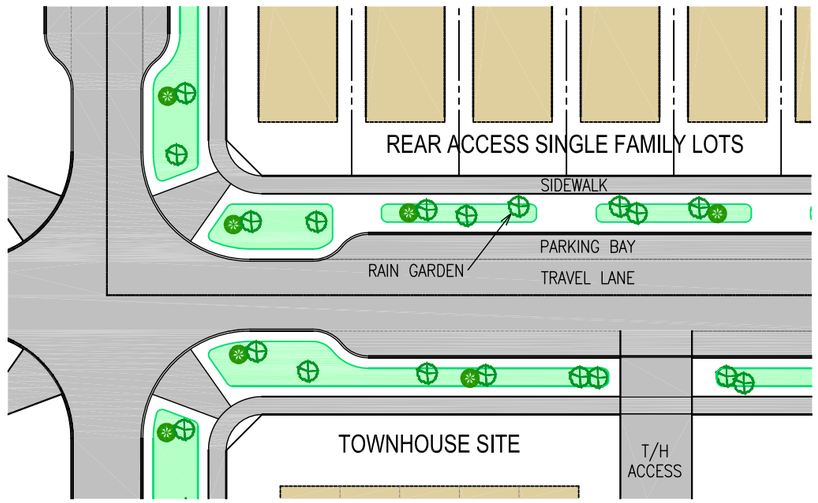
20.0m ROW: STREET PLAN VIEW
WITH RAIN GARDEN

TYPICAL CURB CUT

TYPICAL INTERSECTION

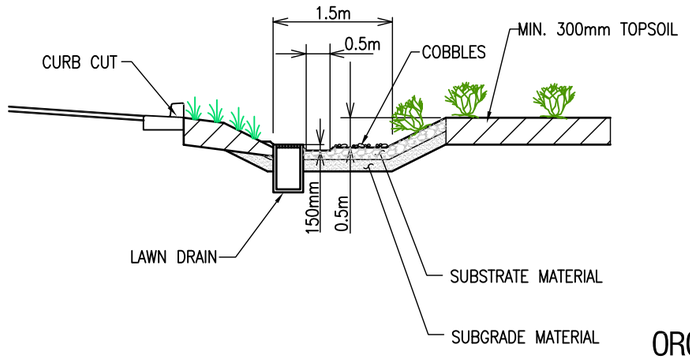


20.0m ROW: STREET CROSS SECTION
WITH RAIN GARDEN



INTERSECTION DETAIL PLAN VIEW
WITH RAIN GARDEN

TYPICAL LAWN DRAIN



RAIN GARDEN DETAIL

ORCHARD GROVE
GRANDVIEW HEIGHTS AREA 5A

RAIN GARDEN DETAILS

FIGURE 10

McElhanney

SCALE: NOT TO SCALE
NOVEMBER 2011

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3.5 WATER QUALITY

The source control measures listed above will provide the most significant water quality benefits for the neighbourhood. Past studies including the Fergus Creek ISMP shows significant reduction in TSS loadings in runoff with the implementation of the above mentioned volume reduction measures. Furthermore, the proposed detention pond will also provide water quality benefits as the pond is proposed to incorporate a permanent water level to allow both dynamic and quiescent settling of suspended solids. The detention pond should be optimized during detail design of the facility to provide water quality benefits. Examples include maximization of retention time of runoff, prescription plantings to promote water quality, and use of submerged outlets for trapping of floatable debris.

In addition to the recommended source control measures described previously, water quality BMPs that are recommended for use within this neighbourhood include:

- Use of oil / water separators and/or vortex separators for multi-family sites;
- Use of oil-grit traps on catchbasins located with roadways; and
- Regular street sweeping and maintenance to remove sediment at the roadway source.

4.0 SEWER INFRASTRUCTURE

4.1 EXISTING & FUTURE SERVICING CATCHMENTS

The existing half acre and acreage single family properties within the NCP # 5A area are currently serviced through a combination of septic tanks and septic fields. Currently, there is no existing sanitary infrastructure for the majority of the neighborhood area. The only existing sanitary infrastructure is located along 164 Street, north of 25 Avenue, which ultimately leads to the Grandview North Gravity Interceptor located at 160 Street, north of 28 Avenue.

The subject neighborhood area gently slopes from south-east to north-west with the low-point of the neighbourhood located immediately east of 164 Street and 26 Avenue. With the development of NCP # 5A, new sanitary sewer mains will be required throughout the neighborhood to service the residential and commercial land uses proposed.

As part of the Stage 2 Engineering Services Study, a sanitary sewer analysis was undertaken to determine peak sewage flows resulting from the build-out of the NCP # 5A area and to determine the sanitary sewer infrastructure requirements. The proposed sanitary sewer model developed under this study assessed anticipated sewage flows for the NCP # 5A study limit up to the corner of 26th avenue and 164th street. The sanitary servicing report under NCP #1 identified a sanitary trunk sewer proposed to travel north along 164 Street and west on 28 Avenue and tie-in to the North Grandview Gravity Interceptor.

4.2 DESIGN CRITERIA & ANALYSIS

The analysis completed for NCP # 5A considers the various land uses proposed for the neighborhood and the corresponding equivalent populations in accordance with the City of Surrey Design Criteria Manual. A future community center located outside NCP # 5A is included in the analysis. Sanitary flows generated from this community centre will be routed through NCP # 5A and therefore the demands of the facility have been incorporated into the analysis to determine the required sizes of sanitary sewer main within NCP # 5A.

In completing the flow and sizing calculations for the sanitary system the Surrey Design Criteria Manual was followed and included the following specific criteria:

- Average daily flows of 350L/cap/day
- Harman Peaking Factor applied
- Manning's 'n' of 0.013 used for all pipes
- Infiltration value of 11,200L/ha/day
- Flows within sanitary sewer local main shall not exceed 50% of internal diameter
- Flows within sanitary sewer trunk main shall not exceed 70% of internal diameter
- Maximum depth of sanitary sewers = 3.5m
- Minimum depth of sanitary sewers = 2.0m
- Minimum pipe slope of 0.5% on local sewers
- Minimum slope on terminal sections of local sewers to be 1.0%
- Future community center population density = 50 persons/hectare

4.3 PROPOSED SERVICING

Due to the gentle and consistent grade of the NCP # 5A area, the entire neighborhood can be serviced by a gravity sewer system with the outlet to the existing sanitary sewer system located at the intersection of 26 Avenue and 164 Street. Outlined on **Figure 11** is the proposed sanitary sewer system for NCP # 5A. The majority of NCP # 5A can be serviced by 200mm diameter local sewers. The exception is a portion of sewer along 26 Avenue between 164 Street and 168 Street, where approximately 185 meters of 250mm diameter sewer is required primarily due to shallow grades. This 250mm diameter sewer would still be classified as a local sewer as the sewage flow is under 40l/s within this section of sewer.

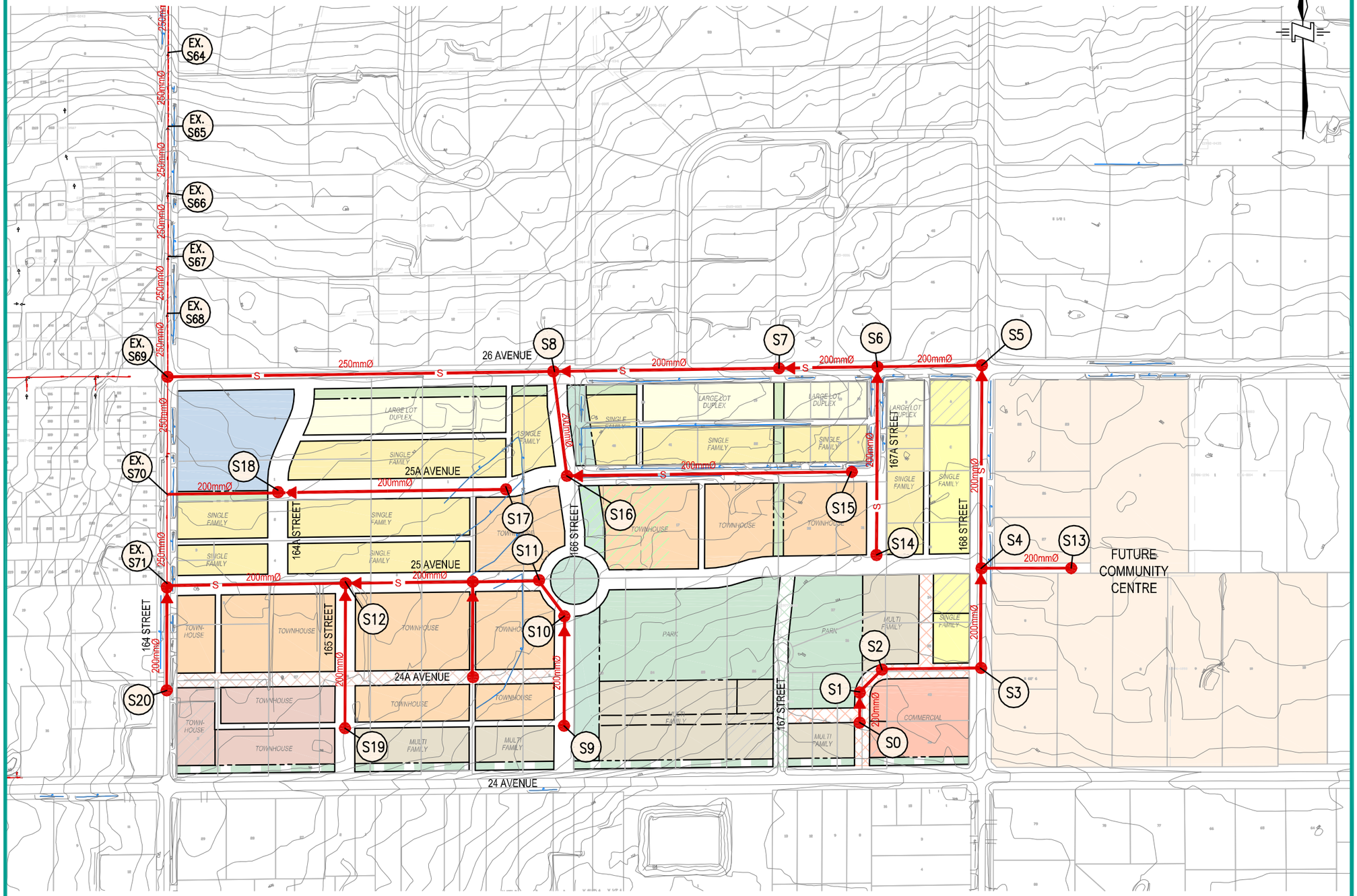
The alignment of all sewers is based on compatibility with the proposed road and land use plan, and grades of sewers are based on existing topography. The alignment also generally follows the alignment of the proposed storm sewer mains to allow for installation of both mains in a single trench. Generally, proposed sanitary sewer mains located north of 25 Avenue will be deeper to accommodate in-ground basements within the single family residential areas of NCP # 5A.

The proposed sanitary sewer mains within NCP # 5A tie-in to the existing mains located along 164 Street. The future trunk sewer along 164 Street north of 26 Avenue was designed under NCP #1 and has recently been constructed to replace the existing 200mm diameter main. Analysis of this sanitary trunk system downstream of NCP # 5A confirmed capacity is available for ultimate development of the catchment area. The catchment areas and calculated populations for areas downstream 26 Avenue and 164 Street were taken from NCP # 1 and used in the analysis of the sanitary system.

4.4 10-YEAR SERVICING PLAN

The sanitary sewer infrastructure required to service NCP # 5A consists only of sanitary sewer mains that are considered the base size for development. The base size for sanitary sewers is defined as mains that convey less than 40 l/s of sewage flows. However, 250mm diameter on 26 Avenue from 166 Street to 164 Street is considered oversized, as a 200mm diameter main is the minimum size required by fronting developments. This oversizing is a DCC eligible expenditure of $40,600.

The proposed sanitary sewers required for NCP # 5A do not duplicate any works within the City of Surrey 10-Year Servicing Plan. Therefore none of the projects identified in the 10-Year Servicing Plan fall within NCP # 5A. The 10-Year Servicing Plan needs to be updated to include the proposed sanitary sewer DCC works identified above.



LEGEND

- Existing Sanitary Sewer
- Existing Watercourse
- Proposed Sanitary Sewer

0 50 100 150 200m

(ALL DIMENSIONS ARE IN METRES)

SCALE: 1:4000
NOVEMBER 2011

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ORCHARD GROVE
GRANDVIEW HEIGHTS AREA 5A

CONCEPTUAL SANITARY PLAN

FIGURE 11

M:\Proj\2111-02764-0 Surrey - Grandview Height 5A\10.0 DRAWINGS\10.3 Engineering\10.3.2 Drawings\dwg\02764 Sanitary.dwg, 12/4/2011 4:02:10 PM

5.0 WATER INFRASTRUCTURE

5.1 EXISTING & FUTURE SERVICING CATCHMENTS

The NCP # 5A area is located entirely within the 142 m HGL Grandview pressure zone and existing ground elevations within the study area range between approximately 90 m to 110 m. The Grandview Reservoir has a top of water level of 114m and the Grandview Pump Station boosts pressures to the 142m pressure zone. Both the reservoir and pump station are located adjacent to the study area, on the south side of 24 Avenue, east of 166 Street. A GVRD transmission main is located on 24 Avenue which supplies the reservoir.

There are several existing 150mm diameter watermains located inside the NCP # 5A area. A 150mm main exists along 167 Street which is currently an existing half cul-de-sac, and a looped system of 26 Avenue -166 Street – 25A Avenue – 167A Street, which are currently quite narrow local roads. Apart from the section of 150mm watermain along 26 Avenue between 166 Street and 168 Street, the border of the study area is serviced with 250 diameter and 300 diameter watermains.

5.2 DESIGN CRITERIA & ANALYSIS

Design of the water distribution system generally follows the City's Design Criteria Manual for water distribution main sizing. Specific criteria for the water distribution system include the following:

- Average Day Demand of 500L/cap/day
- Maximum Day Demand of 1000L/cap/day
- Peak Hour Demand of 2000L/cap/day
- Minimum pressure of 28m during peak hour demands
- Minimum pressure of 14m at a fire hydrant during maximum daily demand plus fire flows
- Maximum Hydraulic Grade of 0.5% for mains 250mm or greater
- Maximum Velocity of 2m/s

Table 6 below lists the equivalent population along with interim and ultimate fire flows for various zonings within NCP # 5A area.

Table 6 Equivalent Population and Fire Flows

Zoning/Land Use	Equivalent Population (ppha)	Ultimate Fire Flow (l/s)	Interim Fire Flow (l/S
RF-9C	216	60	45
RM-D	114	90	70
RM-15	103	120	90
RM-30	206	120	90
RM-45	266	120	90

After studying the land use plan provided by the City of Surrey, a calculation of equivalent populations was undertaken and was based on the areas and proposed land use of the NCP. Using these equivalent

populations it was possible to calculate expected average, maximum and peak water demands for the various land uses. After completing calculation of demands, a conceptual layout for proposed watermains and services was developed.

This data and servicing concept was modeled using the City's overall WaterCAD model. The results of this water model was used to determine the proposed watermain pipe sizes that can achieve the adequate fire flow requirements for the proposed land use densities during the peak daily demands.

5.3 PROPOSED SERVICING OPTIONS

Analysis of the water system confirmed that the proposed water distribution system outlined on **Figure 12** is adequate to service NCP # 5A.

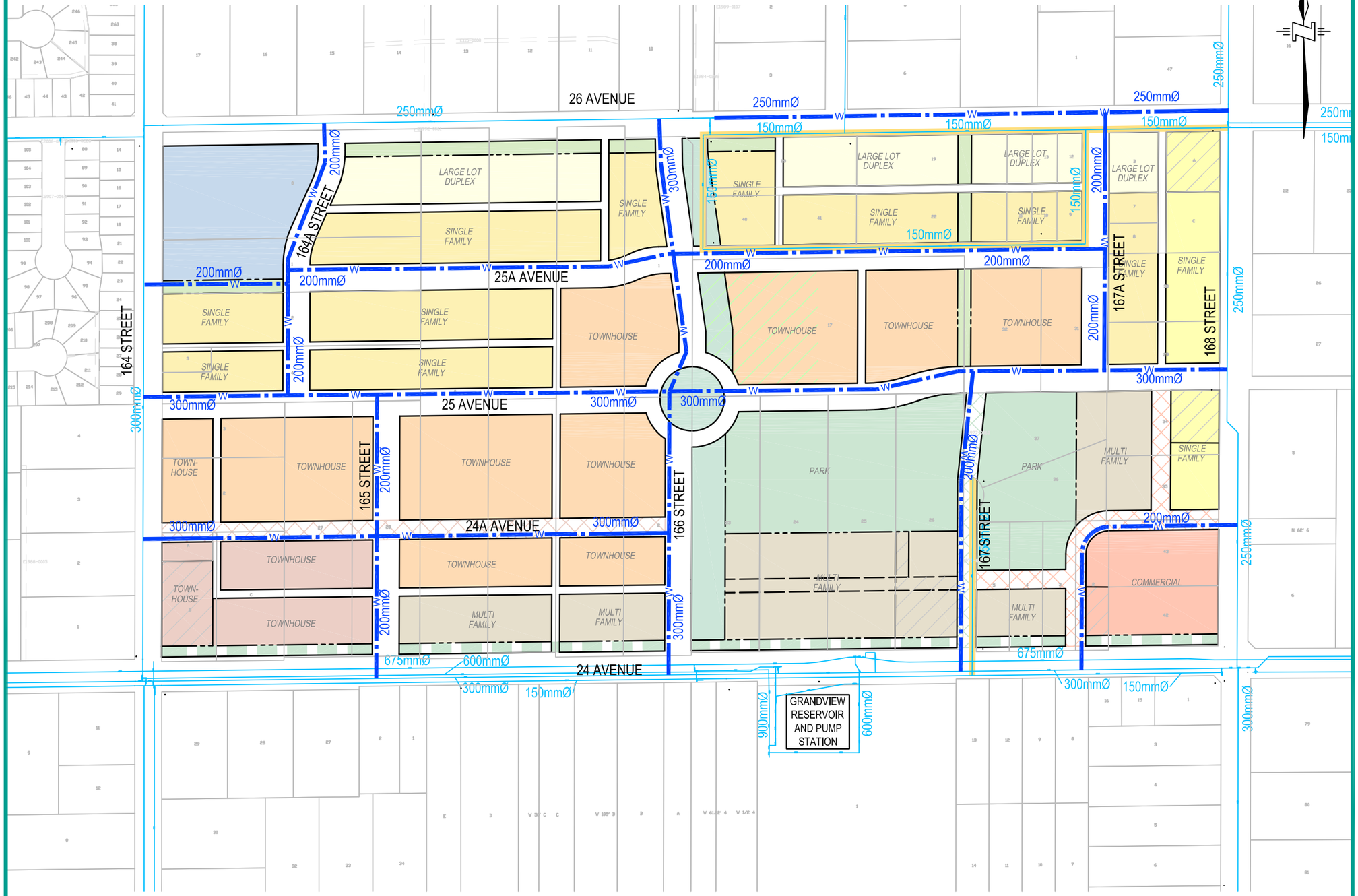
The majority of the proposed watermains for the NCP # 5A will be 200mm diameter mains with several locations requiring larger mains. The following sections of watermain will need to be 300mm diameter:

- 25A Avenue between 164 Street and 168 Street
- 24A Avenue between 164 Street and 166 Street
- 26 Avenue between 166 Street and 168 Street
- 166 Street between 24 Avenue and 26 Avenue

The 300mm diameter watermains along 26 Avenue and 166 Street listed are required to provide domestic demands and fire flows at adequate pressures for NCP # 5A and other areas. Particularly, the 300mm water along 166 Street is required for delivery of water to future developments north of NCP # 5A. Both 300mm water mains along 26 Avenue and 166 Street qualify as DCC for upsizing beyond the base size of 200mm.

The 300mm diameter watermains along 25A Avenue and 24A Avenue listed above are only required to deliver interim phasing of developments in NCP # 5A should the full looped system not be fully constructed. As a result, the watermain network shown will support the phasing of developments within NCP # 5A. Although these two locations have sizes greater than the base size of 200mm diameter, these watermains do not qualify as DCC upsizing items as a 200mm diameter main would be sufficient should the watermain be extended the entire length upfront.

The existing 150mm diameter watermains on 167 Street, 26 Avenue, 166 Street, 25A Avenue and 167 Street would be abandoned as they do not meet the City's minimum diameter requirements for water service. In addition to these proposed watermains, new service connections to existing watermains that border the NCP # 5A area will be required for the parcels on the perimeter of the study area.



LEGEND

- Existing Watermain
- Abandoned Watermain
- Proposed Watermain

0 50 100 150 200m

(ALL DIMENSIONS ARE IN METRES)

SCALE: 1:3000
NOVEMBER 2011

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ORCHARD GROVE
GRANDVIEW HEIGHTS AREA 5A

CONCEPTUAL WATER PLAN

FIGURE 12

5.4 10-YEAR SERVICING PLAN

Some of the works recommended in this report are also identified as projects to be completed as part of the City's 2010-2019 10 Year Servicing Plan. **Table 7** lists projects identified in the 10 Year Servicing Plan that fall within the limits of the NCP study area.

Table 7 Water Project Currently in 10-Year Servicing Plan

Project ID	Location	Description
9949	26 Ave: 166 St – 167A St	280m of 250mm W/M
	25A / 26 Ave: 166 St – 167 A St	460m of 200mm W/M

As all of the proposed watermains involved in NCP # 5A are directly fronting future developing properties there are no anticipated offsite works required to service future anticipated development.

The 250mm diameter watermain on 26 Avenue and the 300mm diameter watermain on 166 Street are both eligible as DCC upsizing items. This oversizing is a DCC eligible expenditure of $88,900. The 10-Year Servicing Plan needs to be updated to include the proposed water DCC works identified above.

6.0 EXTERNAL UTILITY AGENCIES

6.1 POWER (BC HYDRO):

NCP # 5A is primarily provided with electrical power by overhead power lines. All new hydro lines which would provide service to the Neighbourhood Area will be installed underground as per current City of Surrey policy. BC Hydro will expand its system as development proceeds.

6.2 TELECOMMUNICATIONS / CABLE:

The NCP area is serviced by typical overhead telephone lines. As development occurs and the NCP area is developed, new lines will be installed underground in compliance with the City's Subdivision and Development Bylaw. As development proceeds, new services will be extended as needed.

6.3 NATURAL GAS

The provision of natural gas is a responsibility of Fortis BC. The gas system that will service the NCP 5A community will be improved and expanded as required.

APPENDIX A

GEOTECHNICAL REPORT

Foundations, Excavation & Shoring Specialists

March 9, 2011

Reference: 11-5504

Via email: nsandhu@mcelhanney.com

McElhanney Consulting Services Ltd.
13160 88th Avenue
Surrey, BC
V3W 3K3

Attn: Nav Sandhu, P.Eng.

Re: Geotechnical Exploration Report
Grandview Heights Area 5A, Stage II Servicing Study
City of Surrey, BC

Braun Geotechnical
110 – 19188 94th Ave
Surrey, BC
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Fax: 604-513-4195
info@braungeo.com

www.braungeo.com

Foundations

Excavation & Shoring

Slope Stability

Natural Hazards

Pavement Design and Management

Reinforced Soil Walls and Slopes

1.0 INTRODUCTION

As requested, Braun Geotechnical Ltd. has carried out a geotechnical exploration for the above-referenced project. The geotechnical work has been performed in general accordance with the terms and conditions of the Braun Geotechnical proposal dated December 16, 2010 (our reference No. P10-3508).

The scope of services provided by Braun Geotechnical was limited to geotechnical aspects of the study and included a geotechnical exploration with field percolation testing.

No consideration has been given to any environmental issues.

2.0 SITE AND PROJECT DESCRIPTION

The subject site consists of the Grandview Heights Neighbourhood Area 5A, bounded by 164 Street to the west, 24 Avenue to the south, 168 Street to the east, and 26 Avenue to the north, in Surrey, BC.

Site grades generally slope downwards from southeast to northwest. City of Surrey topographic information shows existing grades vary from approximately El 109m to about El 91m. The area drains north and northwest following the natural ground contours and a series of existing drainage ditches. Substantial watercourses and existing storm sewer systems were not observed during the field work.

It is understood that geotechnical input is required for the Neighbourhood Concept Plan (NCP) for Grandview Heights Area #5A for the design of proposed drainage infiltration systems. It is understood the primary drainage management feature proposed for the Neighbourhood Concept Plan is the use of enhanced infiltration systems through a network of stormwater utility corridors.

It is understand that basement home construction is proposed for the development area and should be considered in the design of proposed infiltrating stormwater management systems.

3.0 SITE EXPLORATION

Four test pits (TPs 11-01 to 11-04) were advanced along existing roadway right of way areas within the study site on March 8, 2011, using a rubber tired backhoe under subcontract to Braun Geotechnical. The test pits were excavated to depths of up to 2.4m below existing grade. A single hand dug test pit (TP11-05) was also advanced to 1.2m depth on March 8, 2011. The purpose of the hand dug pit was to avoid damaging existing underground utilities at this location.

Percolation tests were completed at each of the test pit locations at depths ranging from 1.2 to 1.8m. BC Ministry of Environment guidelines for percolation testing were adopted for the project. The test pits and percolation test locations were backfilled on March 9, 2011.

The soil conditions and groundwater infiltration rates were logged in the field by an Engineer from Braun Geotechnical and representative soil samples were returned for routine moisture content testing and further classification. Test pit locations are shown on the attached plan (Dwg. 11-5504-01).

4.0 SOIL AND GROUNDWATER CONDITIONS

A review of available published and in-house geological information indicated that the study site area is underlain by Capilano Sediments, comprised of marine and glaciomarine stony to stoneless silt to clay loam with minor sand and silt, and Vashon Drift, comprised of lodgment till (with sandy loam matrix), and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt.

The findings of the geotechnical exploration were generally consistent with the regional geological information. Subsurface conditions at test pit locations are provided on the attached test pit logs. A subsoil profile based on the test pits is provided below:

FILL:

SAND and GRAVEL to SAND with some gravel, and trace silt, was encountered within TP's 11-02 and -05, to depths of 0.5 and 1.5m respectively.

ORGANICS:

Dark brown, sandy SILT to silty SAND with some organics encountered immediately below existing grades at TP 11-01, -03, -04 & TP 11-05.

Thickness encountered at test pits varied from 0.2 to 0.3m.

SAND:

Rusty-brown, damp to wet, loose to compact SAND with some gravel with trace to some silt, and occasional cobbles / boulders was encountered at each of the test pits except TP11-05. The SAND soils extended to depths varying from 0.9 to 1.5m below existing grades at test pit locations.

SILT / TILL:

Grey, damp to moist, very stiff to hard SILT with some fine sand and gravel, and very dense silty fine SAND (till-like), soils with trace to some gravel were encountered to the depth of test pit exploration at each of the test pits. Percolation testing was carried out within these natural soils at each pit location.

GROUNDWATER:

Groundwater sidewall seepage was encountered within each of the test pits except TP11-04. The depth to groundwater seepage ranged from 0.9 to 1.4m.

The seepage was generally interpreted to represent near-surface groundwater flows within the upper relatively free draining SAND soils overlying the low permeable SILT and till-like soils. This is also consistent with rust staining observed in the sand layer. At TP11-01 slight sidewall seepage was observed within the underlying silty fine sand (till-like) soils during exploration.

Information on semi-static water levels was obtained from the published groundwater well summary document titled, "Groundwater Supply – Fraser Lowland", Halstead, 1986. Well information in the vicinity of the site indicated semi-static water levels were variable and ranged from about 70 ft to 200 ft. No well records were indicated within the subject study site area. Artesian flows were reported from water wells located north of the study site along 32nd Avenue.

The subsurface conditions described were encountered at the test pit locations only. Subsurface conditions at other locations could vary.

5.0 PERCOLATION TESTING

Percolation testing was carried out at the base of the excavated test pits. At TP11-01, a second pit adjacent to the exploration test pit was excavated to attempt percolation testing within the upper zone of the dense silty sand above the observed groundwater seepage.

Detailed information on the percolation tests is provided on the attached Percolation Test Information Sheet. A summary of percolation testing is provided below.

Test Pit	Depth Infiltrating	Soil Type	Field Percolation Rate	Factored Infiltration Rate
TP11-01	1.4m	very dense silty fine SAND	Note 1	-
TP11-02	1.7 m	very stiff to hard sandy SILT	Note 2	-
TP11-03	1.8m	very dense silty fine SAND	Note 2	-
TP11-04	1.7m	very stiff to hard SILT	Note 1	-
TP11-05	1.2m	very stiff SILT	Note 1	-

Notes:

1.) Water levels within the percolation pit increased during the monitoring period
2.) Percolation pit was filled naturally by groundwater seepage prior to the test pre-soak

A percolation rate within the underlying natural silt / till like soils could not be determined in the field using conventional percolation testing procedures due to the near surface groundwater flows encountered, and the low permeability of the underlying natural soils.

Available published information (Freeze & Cherry) suggest the hydraulic conductivity of glacial till and hard silt type soils to be in the range of 10^{-6} to 10^{-10} m/s.

6.0 DISCUSSION AND RECOMMENDATIONS

The subsurface exploration generally encountered a shallow thickness of organics and loose sand or existing fills overlying very stiff to hard silt and very dense silty fine sand (till-like soil). Depending on the season and/or weather conditions, near-surface groundwater seepage flows would be anticipated within organic rich and upper loose to compact sand soil layers overlying the low permeable silt and till-like soils.

Near-surface run-off flows are expected to fluctuate seasonally, and with drainage conditions. In addition, further development in the area is expected to substantially impact near surface seepage.

BCMELP Land Development Guidelines for Protection of Aquatic Habitat, 1993 provide criteria for assessing suitability of sites for management of stormwater by infiltration methods. The guideline document provides specific site conditions where infiltration systems are not recommended:

- "Where the seasonal high groundwater table is within 0.6m of the proposed infiltrating surface."
- "Where the infiltrating surface is located on top of fill."
- "The adjacent or underlying soils have a fully saturated percolation rate of less than 0.5 inches per hour."

Local published Guidelines for the design of Infiltration systems are provided in the GVRD (Metro Vancouver) Stormwater Source Control Guidelines 2005. Concept designs for Infiltration Swale and Rain Garden systems are provided for site specific conditions based on permeability of the underlying subsurface conditions, including conditions for low permeability.

Recent stormwater management studies for the City of Surrey have also indicated that infiltration rates as low as 1.0 to 2.0 mm per hour may be possible to use in design (East Clayton Stormwater Management Study). It is considered that for very low infiltration rates, the design infiltration surface for full infiltration becomes impractical, and potential for overloading infiltration galleries by relatively minor, but sequential rainfall events is considered likely.

Based on the results of the field exploration, and in accordance with the referenced Metro document, it is recommended that infiltration systems be designed for "partial infiltration" with appropriate subdrainage piping systems provided to accommodate full design inflows.

Infiltration drainage systems should consider "do no harm" conditions for existing and proposed development elements, whereby the subdrainage piping system is established at appropriate grades to reduce saturation of roadway fills underground structures and building backfills.

Additionally waterproofing measures for underground electrical services should be evaluated with utility service providers.

7.0 CLOSURE

This report is prepared for the exclusive use of McElhanney Consulting Services Ltd. and their designated representatives and may not be used by other parties without the written permission of Braun Geotechnical Ltd. The City of Surrey may also rely on the findings of this report.

This report should not be included in the specifications without suitable qualifications approved by the geotechnical engineer.

The use of this assessment report is subject to the conditions on the attached Report Interpretation and Limitations sheet. The reader's attention is drawn specifically to those conditions, as it is considered essential that they be followed for proper use and interpretation of this report.

We hope the above meets with your requirements. Should any questions arise, please do not hesitate to contact the undersigned.

Yours truly,
Braun Geotechnical Ltd.

PROFESSIONAL ENGINEER
S.W. HRYSIO
30255
2011 Nov 28

Stuart Hrysio, P.Eng.
Geotechnical Engineer

Braun Geotechnical Ltd.

James Wetherill, P.Eng.
Geotechnical Engineer

Encl: Report Interpretation and Limitations
Test Pit Location Plan
Test Pit Logs (5)
Percolation Test Information Sheet

REPORT INTERPRETATION AND LIMITATIONS

1. STANDARD OF CARE

Braun Geotechnical Ltd. (Braun) has prepared this report in a manner consistent with generally accepted engineering consulting practices in this area, subject to the time and physical constraints applicable. No other warranty, expressed or implied, is made.

2. COMPLETENESS OF THIS REPORT

This Report represents a summary of paper, electronic and other documents, records, data and files and is not intended to stand alone without reference to the instructions given to Braun by the Client, communications between Braun and the Client, and/or to any other reports, writings, proposals or documents prepared by Braun for the Client relating to the specific site described herein.

This report is intended to be used and quoted in its entirety. Any references to this report must include the whole of the report and any appendices or supporting material. Braun cannot be responsible for use by any party of portions of this report without reference to the entire report.

3. BASIS OF THIS REPORT

This report has been prepared for the specific site, development, design objective, and purpose described to Braun by the Client or the Client's Representatives or Consultants. The applicability and reliability of any of the factual data, findings, recommendations or opinions expressed in this document pertain to a specific project at described in this report and are not applicable to any other project or site, and are valid only to the extent that there has been no material alteration to or variation from any of the descriptions provided to Braun. Braun cannot be responsible for use of this report, or portions thereof, unless we were specifically requested by the Client to review and revise the Report in light of any alterations or variations to the project description provided by the Client.

If the project does not commence within 18 months of the report date, the report may become invalid and further review may be required.

The recommendations of this report should only be used for design. The extent of exploration including number of test pits or test holes necessary to thoroughly investigate the site for conditions that may affect construction costs will generally be greater than that required for design purposes. Contractors should rely upon their own explorations and interpretation of the factual data provided for costing purposes, equipment requirements, construction techniques, or to establish project schedule.

The information provided in this report is based on limited exploration, for a specific project scope. Braun cannot accept responsibility for independent conclusions, interpretations, interpolations or decisions by the Client or others based on information contained in this Report. This restriction of liability includes decisions made to purchase or sell land.

4. USE OF THIS REPORT

The contents of this report, including plans, data, drawings and all other documents including electronic and hard copies remain the copyright property of Braun Geotechnical Ltd. However, we will consider any reasonable request by the Client to approve the use of this report by other parties as "Approved Users." With regard to the duplication and distribution of this Report or its contents, we authorize only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of this Report by those parties. The Client and "Approved Users" may not give, lend, sell or otherwise make this Report or any portion thereof available to any other party without express written permission from Braun. Any use which a third party makes of this Report – in its entirety or portions thereof – is the sole responsibility of such third parties. BRAUN GEOTECHNICAL LTD. ACCEPTS NO RESPONSIBILITY FOR DAMAGES SUFFERED BY ANY PARTY RESULTING FROM THE UNAUTHORIZED USE OF THIS REPORT.

Electronic media is susceptible to unauthorized modification or unintended alteration, and the Client should not rely on electronic versions of reports or other documents. All documents should be obtained directly from Braun.

5. INTERPRETATION OF THIS REPORT

Classification and identification of soils and rock and other geological units, including groundwater conditions have been based on exploration(s) performed in accordance with the standards set out in Paragraph 1. These tasks are judgemental in nature; despite comprehensive sampling and testing programs properly performed by experienced personnel with the appropriate equipment, some conditions may elude detection. As such, all explorations involve an inherent risk that some conditions will not be detected.

Further, all documents or records summarizing such exploration will be based on assumptions of what exists between the actual points sampled at the time of the site exploration. Actual conditions may vary

significantly between the points investigated and all persons making use of such documents or records should be aware of and accept this risk.
The Client and "Approved Users" accept that subsurface conditions may change with time and this report only represents the soil conditions encountered at the time of exploration and/or review. Soil and ground water conditions may change due to construction activity on the site or on adjacent sites, and also from other causes, including climactic conditions.
The exploration and review provided in this report were for geotechnical purposes only. Environmental aspects of soil and groundwater have not been included in the exploration or review, or addressed in any other way.
The exploration and Report is based on information provided by the Client or the Client's Consultants, and conditions observed at the time of our site reconnaissance or exploration. Braun has relied in good faith upon all information provided. Accordingly, Braun cannot accept responsibility for inaccuracies, misstatements, omissions, or deficiencies in this Report resulting from misstatements, omissions, misrepresentations or fraudulent acts of persons or sources providing this information.

6. DESIGN AND CONSTRUCTION REVIEW

This report assumes that Braun will be retained to work and coordinate design and construction with other Design Professionals and the Contractor. Further, it is assumed that Braun will be retained to provide field reviews during construction to confirm adherence to building code guidelines and generally accepted engineering practices, and the recommendations provided in this report. Field services recommended for the project represent the minimum necessary to confirm that the work is being carried out in general conformance with Braun's recommendations and generally accepted engineering standards. It is the Client's or the Client's Contractor's responsibility to provide timely notice to Braun to carry out site reviews. The Client acknowledges that unsatisfactory or unsafe conditions may be missed by intermittent site reviews by Braun. Accordingly, it is the Client's or Client's Contractor's responsibility to inform Braun of any such conditions.
Work that is covered prior to review by Braun may have to be re-exposed at considerable cost to the Client. Review of all Geotechnical aspects of the project are required for submittal of unconditional Letters of Assurance to regulatory authorities. The site reviews are not carried out for the benefit of the Contractor(s) and therefore do not in any way effect the Contractor(s) obligations to perform under the terms of his/her Contract.

7. SAMPLE DISPOSAL

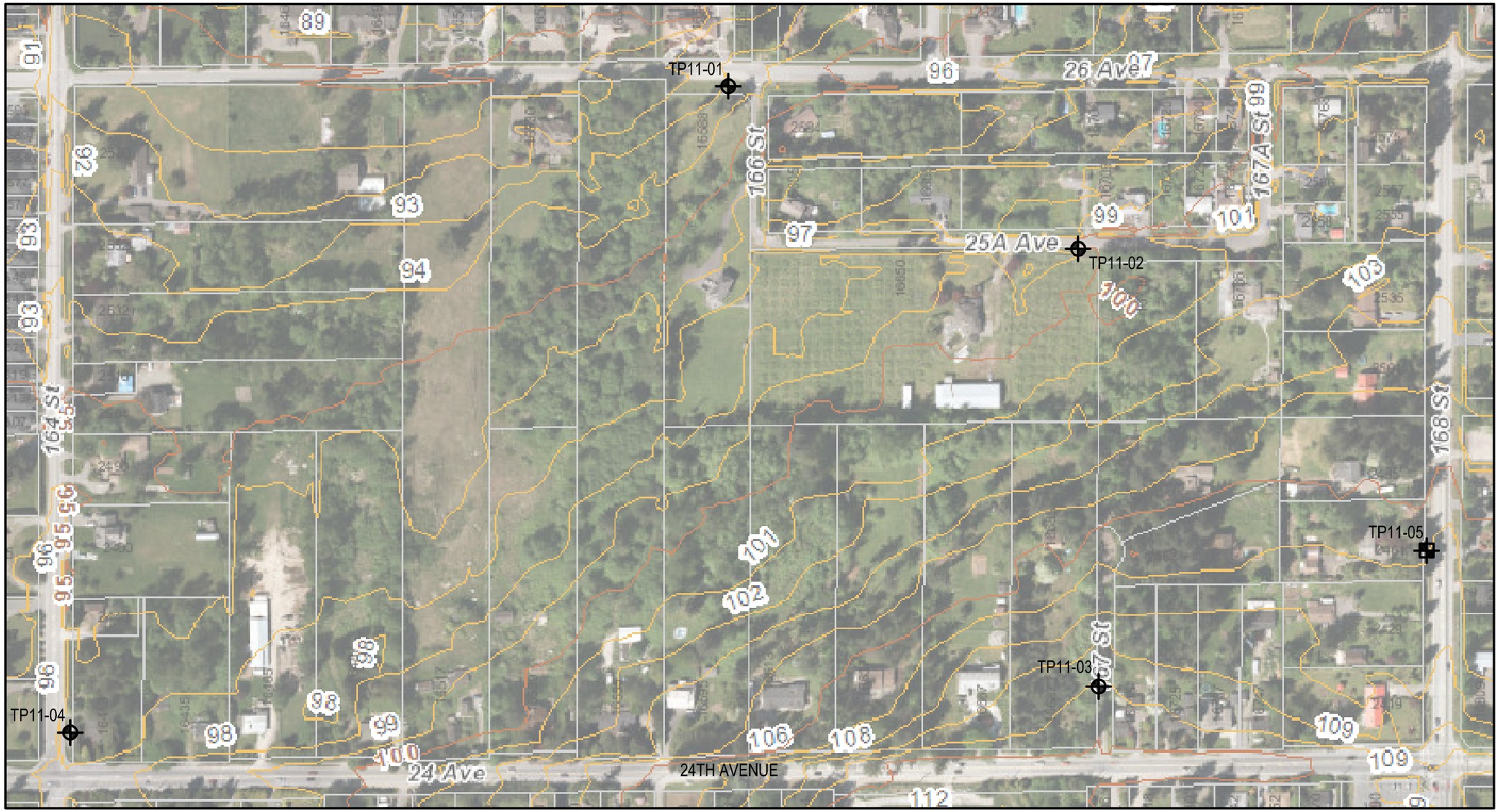
Braun will dispose of all samples 3 months after issuance of this report, or after a longer period of time at the Client's expense if requested by the Client. All contaminated samples remain the property of the Client and it will be the Client's responsibility to dispose of them properly.

8. SUBCONSULTANTS AND CONTRACTORS

Engineering studies frequently requires hiring the services of individuals and companies with special expertise and/or services which Braun Geotechnical Ltd. does not provide. These services are arranged as a convenience to our Clients, for the Client's benefit. Accordingly, the Client agrees to hold the Company harmless and to indemnify and defend Braun Geotechnical Ltd. from and against all claims arising through such Subconsultants or Contractors as though the Client had retained those services directly. This includes responsibility for payment of services rendered and the pursuit of damages for errors, omissions or negligence by those parties in carrying out their work. These conditions apply to specialized subconsultants and the use of drilling, excavation and laboratory testing services, and any other Subconsultant or Contractor.

9. SITE SAFETY

Braun Geotechnical Ltd. assumes responsibility for site safety solely for the activities of our employees on the jobsite. The Client or any Contractors on the site will be responsible for their own personnel. The Client or his representatives, Contractors or others retain control of the site. It is the Client's or the Client's Contractors responsibility to inform Braun of conditions pertaining to the safety and security of the site – hazardous or otherwise – of which the Client or Contractor is aware.
Exploration or construction activities could uncover previously unknown hazardous conditions, materials, or substances that may result in the necessity to undertake emergency procedures to protect workers, the public or the environment. Additional work may be required that is outside of any previously established budget(s). The Client agrees to reimburse Braun for fees and expenses resulting from such discoveries. The Client acknowledges that some discoveries require that certain regulatory bodies be informed. The Client agrees that notification to such bodies by Braun Geotechnical Ltd. will not be a cause for either action or dispute.



LEGEND:

TP11-05 — 2011 HAND EXCAVATED TEST PIT WITH PERCOLATION TEST

TP11-01 — 2011 MACHINE EXCAVATED TEST PIT WITH PERCOLATION TEST

REFERENCE AIR PHOTO FROM CITY OF SURREY COSMOS

BRAUN GEOTECHNICAL LTD.

Rev.	Description	Date

Client: McElhanney Consulting Services Ltd.

Project: Stage II Servicing Study
Grandview Heights Area 5A, City of Surrey, BC

Title: LOCATION PLAN

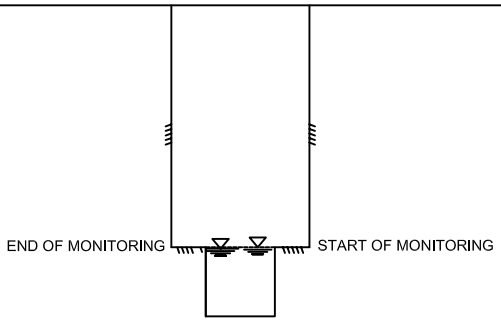
Project no.	Drawn	Design	Checked	Date	Scale	Drawing no.
11-5504	HD	HD	SH	March 10, 2011	~1:2500	11-5504-01

Test Pit Log: TP11-01

File: 11–5504
Project: Grandview Heights Area 5A, Stage II Servicing Study
Client: McElhanney Consulting Services Ltd.
Location: Grandview Heights Neighborhood Area 5A, Surrey, BC

BRAUN GEOTECHNICAL LTD.

Depth (ft)	Depth (m)	Sample	Soil Description	Sample #	Water Cont.	Percolation Pit Details
0	0		dark brown, moist, loose silty SAND with some organics			
		O	rust brown, damp, loose to compact SAND with some gravel, trace silt, and occasional cobbles and boulders	S1		
5	1		grey, slightly brown mottled, damp, very dense silty fine SAND with some gravel and occasional cobbles and boulders (TILL-LIKE)			
		O	-seepage at 1.4m	S2	13%	
10	2					
			End of Test Pit @ 2.4m			
15	3					
20	4					
	5					
	6					



Base of Percolation Test @ 1.4m

- Percolation Test Pit flooded by Braun Geotechnical
- Water level increase measured during monitoring
- See Percolation Test Information Sheet for measurements

Equipment: Rubber Tire Backhoe
Sampling Method: Lump Sample
Hammer Type: N/A

Datum: Ground Surface
Groundwater: Seepage at 1.4m
Elevation: 93.5m
(From City of Surrey Cosmos)

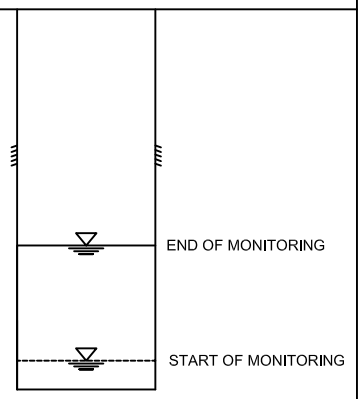
Logged By: HD
Exploration Date: March 8, 2011
Dwg No.: 11-5504-TP11-01
Page: 1 of 1

Test Pit Log: TP11-02

File: 11–5504
Project: Grandview Heights Area 5A, Stage II Servicing Study
Client: McElhanney Consulting Services Ltd.
Location: Grandview Heights Neighborhood Area 5A, Surrey, BC

BRAUN GEOTECHNICAL LTD.

Depth	Sample	Soil Description	Sample #	Water Cont.	Percolation Pit Details
0 ft / 0 m		dark brown, moist, loose silty SAND with some organics (ORGANIC FILL)			
		grey, damp, compact SAND and GRAVEL with trace silt (FILL)			
		rust brown, moist, loose to compact SAND with some gravel and silt			
1	○	-seepage at 1.2m	S1		
		grey, damp to moist, very stiff to hard SILT with some fine sand and gravel			
5 / 2	○		S2	25%	
		End of Test Pit @ 2.4m			
10 / 3					
15 / 4					
5					
20 / 6					



Base of Percolation Test @ 1.7m

- Percolation Test Pit flooded by groundwater seepage
- Water level increase measured during monitoring
- See Percolation Test Information Sheet for measurements

Equipment: Rubber Tire Backhoe
Sampling Method: Lump Sample
Hammer Type: N/A

Datum: Ground Surface
Groundwater: Seepage at 1.2m
Elevation: 100m
(From City of Surrey Cosmos)

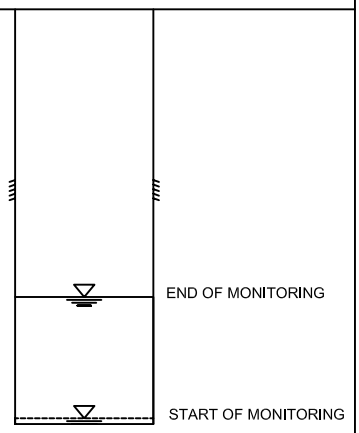
Logged By: HD
Exploration Date: March 8, 2011
Dwg No.: 11-5504-TP11-02
Page: 1 of 1

Test Pit Log: TP11-03

File: 11–5504
Project: Grandview Heights Area 5A, Stage II Servicing Study
Client: McElhanney Consulting Services Ltd.
Location: Grandview Heights Neighborhood Area 5A, Surrey, BC

BRAUN GEOTECHNICAL LTD.

Depth	Sample	Soil Description	Sample #	Water Cont.	Percolation Pit Details
0 ft / 0 m		dark brown, moist, soft sandy SILT with some organics			
		rust brown, moist, loose to compact SAND with some gravel, trace to some silt, trace roots, and occasional cobbles and boulders			
1	○	-seepage at 1.2m	S1		
	○	grey-brown, moist to wet, compact SAND with some gravel and trace silt	S2		
5 / 2	○	grey, moist, very dense silty fine SAND with some gravel (TILL-LIKE)	S2	11%	
		End of Test Pit @ 1.8m			
10 / 3					
4					
15 / 5					
6					
20					



Base of Percolation Test @ 1.8m

- Percolation Test Pit flooded by groundwater seepage
- Water level increase measured during monitoring
- See Percolation Test Information Sheet for measurements

Equipment: Rubber Tire Backhoe
Sampling Method: Lump Sample
Hammer Type: N/A

Datum: Ground Surface
Groundwater: Seepage at 1.2m
Elevation: 109m
(From City of Surrey Cosmos)

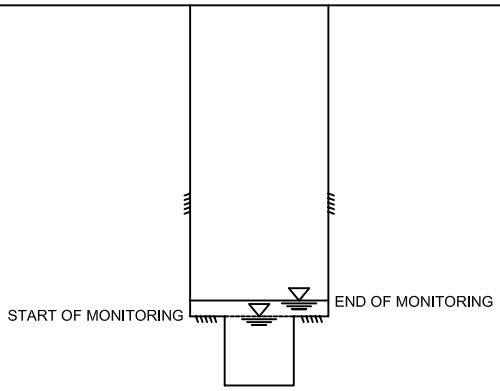
Logged By: HD
Exploration Date: March 8, 2011
Dwg No.: 11-5504-TP11-03
Page: 1 of 1

Test Pit Log: TP11-04

File: 11-5504
Project: Grandview Heights Area 5A, Stage II Servicing Study
Client: McElhanney Consulting Services Ltd.
Location: Grandview Heights Neighborhood Area 5A, Surrey, BC

BRAUN GEOTECHNICAL LTD.

Depth	Sample	Soil Description	Sample #	Water Cont.	Percolation Pit Details
0 ft / 0 m		dark brown, moist, loose silty SAND with some organics			
		rust brown, damp, loose to compact SAND with trace to some sand, and trace silt and rootlets			
1		grey-brown, damp to moist, loose to compact SAND and GRAVEL with trace silt			
		grey, brown mottled, damp to moist, very stiff SILT with some fine sand and gravel			
5	○		S1	31%	
		End of Test Pit @ 1.7m			
2					
10 / 3					
4					
15 / 5					
6					
20					



Base of Percolation Test @ 1.7m

- Percolation Test Pit flooded by Braun Geotechnical
- Water level increase measured during monitoring
- See Percolation Test Information Sheet for measurements

Equipment: Rubber Tire Backhoe
Sampling Method: Lump Sample
Hammer Type: N/A

Datum: Ground Surface
Groundwater: Not Encountered
Elevation: 97m (From City of Surrey Cosmos)

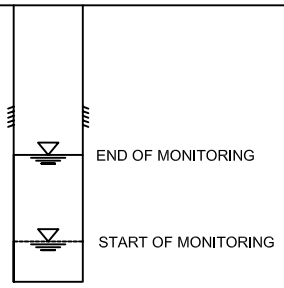
Logged By: HD
Exploration Date: March 8, 2011
Dwg No.: 11-5504-TP11-04
Page: 1 of 1

Test Pit Log: TP11-05

File: 11-5504
Project: Grandview Heights Area 5A, Stage II Servicing Study
Client: McElhanney Consulting Services Ltd.
Location: Grandview Heights Neighborhood Area 5A, Surrey, BC

BRAUN GEOTECHNICAL LTD.

Depth		Sample	Soil Description	Sample #	Water Cont.	Percolation Pit Details
0 ft / 0 m			grey, damp, compact SAND and GRAVEL with trace silt (FILL)			
			grey, damp, compact SAND with trace to some gravel and trace silt (FILL) -minor seepage at 0.9m			
1		O	grey, brown mottled, very stiff SILT with trace to some fine sand and gravel	S1	31%	
			End of Test Pit @ 2.4m			
5 / 2						
10 / 3						
4						
15 / 5						
6						
20						



Base of Percolation Test @ 1.2m

- Percolation Test Pit flooded by Braun Geotechnical
- Water level increase measured during monitoring
- See Percolation Test Information Sheet for measurements

Equipment: Rubber Tire Backhoe
Sampling Method: Lump Sample
Hammer Type: N/A

Datum: Ground Surface
Groundwater: Seepage at 0.9m
Elevation: 106m
(From City of Surrey Cosmos)

Logged By: HD
Exploration Date: March 8, 2011
Dwg No.: 11-5504-TP11-05
Page: 1 of 1

Percolation Test Information Sheet:

File: 11–5504
Project: Grandview Heights Area 5A, Stage II Servicing Study
Client: McElhanney Consulting Services Ltd.
Location: Grandview Heights Neighborhood Area 5A, Surrey, BC

BRAUN GEOTECHNICAL LTD.

TEST PIT	TIME & DATE	WATER LEVEL	TEST PIT	TIME & DATE	WATER LEVEL
TP11-01	March 8, 2011		TP11-04	March 8, 2011	
	10:30 AM	305mm		12:29 PM	305mm
DEPTH: 1.4m	12:59 PM	280mm	DEPTH: 1.7m	12:55 PM	305mm
	3:07 PM	280mm		3:03 PM	330mm
NOTE 1	4:39 PM	280mm	NOTE 1	4:36 PM	340mm
	March 9, 2011			March 9, 2011	
	8:53 AM	300mm		9:06 AM	375mm
	9:15 AM	300mm		10:29 AM	375mm
TP11-02	March 8, 2011		HP11-01	March 8, 2011	
	11:16 AM	125mm		2:54 PM	175mm
DEPTH: 1.7m	1:03 PM	405mm	DEPTH: 1.2m	3:13 PM	200mm
	3:10 PM	445mm		4:27 PM	215mm
NOTE 2	4:43 PM	570mm	NOTE 1	4:54 PM	215mm
	March 9, 2011			March 9, 2011	
	8:54 AM	635mm		8:57 AM	560mm
	9:35 AM	635mm		10:55 AM	560mm
TP11-03	March 8, 2011		NOTE 1: Percolation Pit flooded by Braun Geotechnical at start of test NOTE 2: Percolation Pit filled by natural groundwater seepage		
	11:40 AM	25mm			
DEPTH: 1.8m	11:48 AM	150mm			
	1:11 PM	305mm			
NOTE 2	2:57 PM	405mm			
	4:32 PM	455mm			
	March 9, 2011				
	8:54 AM	560mm			
	9:35 AM	560mm			

Exploration Date: March 8/9, 2011
Logged By: HD

Dwg No.: 11-5504-PTIS

APPENDIX B

DRAINAGE MODELLING INPUT / OUTPUT

Model Input

[GRANDVIEW HEIGHTS 5A INPUT]

[OPTIONS]

FLOW_UNITS	CMS
INFILTRATION	HORTON
FLOW_ROUTING	DYNWAVE
START_DATE	09/12/2011
START_TIME	00:00:00
REPORT_START_DATE	09/12/2011
REPORT_START_TIME	00:00:00
END_DATE	09/12/2011
END_TIME	12:00:00
SWEEP_START	01/01
SWEEP_END	12/31
DRY_DAYS	0
REPORT_STEP	0:01:00
WET_STEP	0:05:00
DRY_STEP	0:05:00
ROUTING_STEP	5
ALLOW_PONDING	NO
INERTIAL_DAMPING	PARTIAL
VARIABLE_STEP	0.75
LENGTHENING_STEP	0
MIN_SURFAREA	0
NORMAL_FLOW_LIMITED	BOTH
SKIP_STEADY_STATE	NO
FORCE_MAIN_EQUATION	H-W
LINK_OFFSETS	DEPTH
MIN_SLOPE	0

[EVAPORATION]

;;Type	Parameters
;;-------------	----------
CONSTANT	0.0
DRY_ONLY	NO

[RAINGAGES]

;;Name	Rain Type	Time Intrvl	Snow Catch	Data Source
MH5Y1	INTENSITY	0:05	1.0	TIMESERIES MH5Y1
MH5Y24	INTENSITY	0:20	1.0	TIMESERIES MH5Y24
MH100Y1	INTENSITY	0:05	1.0	TIMESERIES MH100Y1
MH100Y24	INTENSITY	0:20	1.0	TIMESERIES MH100Y24

[SUBCATCHMENTS]

;;Name	Raingage	Outlet	Total Area	Pcnt. Imperv	Width	Pcnt. Slope	Curb Length	Snow Pack
A13	MH5Y1	D21	1.32	65	150	1.3	0	
A8	MH5Y1	D14	2.83	76	200	2	0	
A10	MH5Y1	D17	1.32	65	220	2	0	
A9	MH5Y1	D16	2	73	240	2	0	
A1	MH5Y1	D1	2.3	73	240	2.5	0	
A11	MH5Y1	D18	4.04	65	250	2.2	0	
A2	MH5Y1	D2	3.83	25	360	0.5	0	
A3	MH5Y1	D6	2.37	65	360	3.5	0	
A12	MH5Y1	D20	1.35	80	120	5	0	
A6	MH5Y1	D8	2.58	65	240	2.5	0	
A4	MH5Y1	D9	2	65	240	3.8	0	
A14	MH5Y1	D15	1.64	73	128	0.5	0	
A7	MH5Y1	D13	2.53	70	180	1.25	0	
A5	MH5Y1	D11	1.77	65	216	1.5	0	
A15	MH5Y1	D23	7.4	55	300	6	0	
A16	MH5Y1	D23	4.5	55	200	4	0	

[SUBAREAS]

;;Subcatchment	N-Imperv	N-Perv	S-Imperv	S-Perv	PctZero	RouteTo	PctRouted
A13	0.013	0.035	1.5	6	0	OUTLET	
A8	0.013	0.035	1.5	6	0	OUTLET	
A10	0.013	0.035	1.5	6	0	OUTLET	
A9	0.013	0.035	1.5	6	0	OUTLET	
A1	0.013	0.035	1.5	6	0	OUTLET	
A11	0.013	0.035	1.5	6	0	OUTLET	
A2	0.013	0.035	3.5	6	0	OUTLET	
A3	0.013	0.035	1.5	6	0	OUTLET	
A12	0.013	0.035	1.5	6	0	OUTLET	

A6	0.013	0.035	1.5	6	0	OUTLET
A4	0.013	0.035	1.5	6	0	OUTLET
A14	0.013	0.035	1.5	6	0	OUTLET
A7	0.013	0.035	1.5	6	0	OUTLET
A5	0.013	0.035	1.5	6	0	OUTLET
A15	0.013	0.035	1.5	6	0	OUTLET
A16	0.013	0.035	1.5	6	0	OUTLET

[INFILTRATION]

;;Subcatchment	MaxRate	MinRate	Decay	DryTime	MaxInfil
A13	25	1.5	0.1	7	0
A8	25	1.5	0.1	7	0
A10	25	1.5	0.1	7	0
A9	25	1.5	0.1	7	0
A1	25	1.5	0.1	7	0
A11	25	1.5	0.1	7	0
A2	25	1.5	0.1	7	0
A3	25	1.5	0.1	7	0
A12	25	1.5	0.1	7	0
A6	25	1.5	0.1	7	0
A4	25	1.5	0.1	7	0
A14	25	1.5	0.1	7	0
A7	25	1.5	0.1	7	0
A5	25	1.5	0.1	7	0
A15	25	1.5	0.1	7	0
A16	25	1.5	0.1	7	0

[JUNCTIONS]

;;	Invert	Max.	Init.	Surcharge	Ponded
;;Name	Elev.	Depth	Depth	Depth	Area
D1	102	2.5	0	0	0
D2	101.5	2.5	0	0	0
D4	98.5	2.5	0	0	0
D5	96.5	2.5	0	0	0
D8	92.5	2.5	0	0	0
D12	91.5	3.5	0	0	0
D13	93	2.5	0	0	0
D15	90.5	2.5	0	0	0

D14	93.5	2.5	0	0	0
D9	98	2.5	0	0	0
D11	94	1.5	0	0	0
D10	93.2	4.8	0	0	0
D16	100.5	2.5	0	0	0
D6	101.5	2.5	0	0	0
D17	97	2.5	0	0	0
D21	90.5	2.5	0	0	0
D20	94	2.5	0	0	0
D18	98.5	2.5	0	0	0
D23	86	2.5	0	0	0

[OUTFALLS]

;;	Invert	Outfall	Stage/Table	Tide
;;Name	Elev.	Type	Time Series	Gate
;;--------------	----------	----------	----------	----
D25	75.5	FREE		NO

[STORAGE]

;;	Invert	Max.	Init.	Storage	Curv	Ponded	Evap			
;;Name	Elev.	Depth	Depth	Curve	Params	Area	Frac.	Infiltration	Parameters	
;;--------	--------	--------	----------	--------	--------	--------	--------	--------	------	
DETENTION	86.9	2	0	TABULAR	Pond	1200	0			

[CONDUITS]

;;	Inlet	Outlet		Manning	Inlet	Outlet	Init.	Max.
;;Name	Node	Node	Length	N	Offset	Offset	Flow	Flow
;;--------------	----------	----------	----------	----------	----------	----------	-------	
C1	D1	D2	98.9	0.013	0	0	0	0
C3	D14	D15	245.6	0.013	0	0.3	0	0
C2	D2	D4	142	0.013	0	0	0	0
C4	D4	D5	144.9	0.013	0	0	0	0
C5	D5	D8	220.6	0.013	-0.15	0	0	0
C6	D8	D12	65.8	0.013	-0.25	0	0	0
C7	D13	D12	91.4	0.013	0	0.5	0	0
C8	D9	D10	200.6	0.013	0	0	0	0
C9	D11	D10	154.4	0.013	0	0	0	0
C10	D10	D8	94.1	0.013	-0.075	0	0	0
C11	D12	D15	90.5	0.013	0	0	0	0

C13	D6	D5	180.8	0.013	0	0	0	0
C12	D16	D17	168.6	0.013	0	0	0	0
C14	D17	D21	323.2	0.013	-0.075	0	0	0
C15	D18	D20	285.7	0.013	0	0	0	0
C17	D20	D21	95	0.013	0	0	0	0
C18	D21	DETENTION	250	0.013	0	0	0	0
C16	D23	D25	306	0.013	0	0	0	0
C21	D15	DETENTION	55	0.013	0	0	0	0

[OUTLETS]

;;	Inlet	Outlet	Outflow	Outlet	Qcoeff/		Flap
;;Name	Node	Node	Height	Type	QTable	Qexpon	Gate
;;----------	----------	----------	----------	----------	----------	----------	----
OL1	DETENTION	D23	0	TABULAR/HEAD	Discharge		NO

[XSECTIONS]

;;Link	Shape	Geom1	Geom2	Geom3	Geom4	Barrels
;;----------	----------	----------	----------	----------	----------	--------
C1	CIRCULAR	0.45	0	0	0	1
C3	CIRCULAR	0.525	0	0	0	1
C2	CIRCULAR	0.45	0	0	0	1
C4	CIRCULAR	0.45	0	0	0	1
C5	CIRCULAR	0.6	0	0	0	1
C6	CIRCULAR	0.75	0	0	0	1
C7	CIRCULAR	0.375	0	0	0	1
C8	CIRCULAR	0.375	0	0	0	1
C9	CIRCULAR	0.45	0	0	0	1
C10	CIRCULAR	0.525	0	0	0	1
C11	CIRCULAR	0.9	0	0	0	1
C13	CIRCULAR	0.375	0	0	0	1
C12	CIRCULAR	0.375	0	0	0	1
C14	CIRCULAR	0.45	0	0	0	1
C15	CIRCULAR	0.45	0	0	0	1
C17	CIRCULAR	0.45	0	0	0	1
C18	CIRCULAR	0.75	0	0	0	1
C16	CIRCULAR	0.75	0	0	0	1
C21	CIRCULAR	0.9	0	0	0	1

[LOSSES]

;;Link	Inlet	Outlet	Average	Flap Gate
C1	0.5	1	0	NO
C3	0.5	1	0	NO
C2	0.5	1	0	NO
C4	0.5	1	0	NO
C5	0.5	1	0	NO
C6	0.5	1	0	NO
C7	0.5	1	0	NO
C8	0.5	1	0	NO
C9	0.5	1	0	NO
C10	0.5	1	0	NO
C11	0.5	1	0	NO
C13	0.5	1	0	NO
C12	0.5	1	0	NO
C14	0.5	1	0	NO
C15	0.5	1	0	NO
C17	0.5	1	0	NO
C18	0.5	1	0	NO
C21	0.5	1	0	NO

[CURVES]

;;Name	Type	X-Value	Y-Value
Discharge	Rating	0	0.000
Discharge		0.5	0.276
Discharge		1	0.391
Discharge		1.5	0.478
Discharge		2	3
Pond	Storage	0	340
Pond		0.5	607
Pond		1	951
Pond		1.5	1373
Pond		2	1871

[TIMESERIES]

```
;;Name           Date       Time       Value
;;-------------- ---------- ---------- ----------
MH5Y1                       0          8.06
MH5Y1                       00:05      9.68
MH5Y1                       00:10      14.51
MH5Y1                       00:15      14.51
MH5Y1                       00:20      16.13
MH5Y1                       00:25      17.74
MH5Y1                       00:30      22.58
MH5Y1                       00:35      17.74
MH5Y1                       00:40      12.9
MH5Y1                       00:45      11.29
MH5Y1                       00:50      9.68
MH5Y1                       00:55      6.45

MH5Y24                      0:00       1.3
MH5Y24                      0:20       1.3
MH5Y24                      0:40       1.3
MH5Y24                      1:00       1.62
MH5Y24                      1:20       1.62
MH5Y24                      1:40       1.62
MH5Y24                      2:00       1.95
MH5Y24                      2:20       1.95
MH5Y24                      2:40       1.95
MH5Y24                      3:00       2.27
MH5Y24                      3:20       2.27
MH5Y24                      3:40       2.27
MH5Y24                      4:00       2.91
MH5Y24                      4:20       2.91
MH5Y24                      4:40       2.91
MH5Y24                      5:00       3.88
MH5Y24                      5:20       3.88
MH5Y24                      5:40       3.88
MH5Y24                      6:00       5.51
MH5Y24                      6:20       5.51
MH5Y24                      6:40       5.51
MH5Y24                      7:00       6.8
MH5Y24                      7:20       6.8
MH5Y24                      7:40       6.8
MH5Y24                      8:00       5.18
MH5Y24                      8:20       5.18
```

MH5Y24	8:40	5.18
MH5Y24	9:00	4.21
MH5Y24	9:20	4.21
MH5Y24	9:40	4.21
MH5Y24	10:00	3.88
MH5Y24	10:20	3.88
MH5Y24	10:40	3.88
MH5Y24	11:00	3.24
MH5Y24	11:20	3.24
MH5Y24	11:40	3.24
MH5Y24	12:00	2.59
MH5Y24	12:20	2.59
MH5Y24	12:40	2.59
MH5Y24	13:00	2.91
MH5Y24	13:20	2.91
MH5Y24	13:40	2.91
MH5Y24	14:00	1.95
MH5Y24	14:20	1.95
MH5Y24	14:40	1.95
MH5Y24	15:00	2.59
MH5Y24	15:20	2.59
MH5Y24	15:40	2.59
MH5Y24	16:00	1.95
MH5Y24	16:20	1.95
MH5Y24	16:40	1.95
MH5Y24	17:00	1.62
MH5Y24	17:20	1.62
MH5Y24	17:40	1.62
MH5Y24	18:00	1.3
MH5Y24	18:20	1.3
MH5Y24	18:40	1.3
MH5Y24	19:00	1.62
MH5Y24	19:20	1.62
MH5Y24	19:40	1.62
MH5Y24	20:00	1.3
MH5Y24	20:20	1.3
MH5Y24	20:40	1.3
MH5Y24	21:00	1.3
MH5Y24	21:20	1.3
MH5Y24	21:40	1.3
MH5Y24	22:00	1.62
MH5Y24	22:20	1.62

MH5Y24	22:40	1.62
MH5Y24	23:00	1.3
MH5Y24	23:20	1.3
MH5Y24	23:40	1.3
MH100Y1	0	13.53
MH100Y1	00:05	16.32
MH100Y1	00:10	24.36
MH100Y1	00:15	24.36
MH100Y1	00:20	27.08
MH100Y1	00:25	29.78
MH100Y1	00:30	37.91
MH100Y1	00:35	29.78
MH100Y1	00:40	23.30
MH100Y1	00:45	18.95
MH100Y1	00:50	16.32
MH100Y1	00:55	10.83
MH100Y24	0:00	1.92
MH100Y24	0:20	1.92
MH100Y24	0:40	1.92
MH100Y24	1:00	2.4
MH100Y24	1:20	2.4
MH100Y24	1:40	2.4
MH100Y24	2:00	2.88
MH100Y24	2:20	2.88
MH100Y24	2:40	2.88
MH100Y24	3:00	3.36
MH100Y24	3:20	3.36
MH100Y24	3:40	3.36
MH100Y24	4:00	4.32
MH100Y24	4:20	4.32
MH100Y24	4:40	4.32
MH100Y24	5:00	5.75
MH100Y24	5:20	5.75
MH100Y24	5:40	5.75
MH100Y24	6:00	8.15
MH100Y24	6:20	8.15
MH100Y24	6:40	8.15
MH100Y24	7:00	10.06
MH100Y24	7:20	10.06
MH100Y24	7:40	10.06

MH100Y24	8:00	7.67
MH100Y24	8:20	7.67
MH100Y24	8:40	7.67
MH100Y24	9:00	6.24
MH100Y24	9:20	6.24
MH100Y24	9:40	6.24
MH100Y24	10:00	5.75
MH100Y24	10:20	5.75
MH100Y24	10:40	5.75
MH100Y24	11:00	4.79
MH100Y24	11:20	4.79
MH100Y24	11:40	4.79
MH100Y24	12:00	3.84
MH100Y24	12:20	3.84
MH100Y24	12:40	3.84
MH100Y24	13:00	4.32
MH100Y24	13:20	4.32
MH100Y24	13:40	4.32
MH100Y24	14:00	2.88
MH100Y24	14:20	2.88
MH100Y24	14:40	2.88
MH100Y24	15:00	3.84
MH100Y24	15:20	3.84
MH100Y24	15:40	3.84
MH100Y24	16:00	2.88
MH100Y24	16:20	2.88
MH100Y24	16:40	2.88
MH100Y24	17:00	2.4
MH100Y24	17:20	2.4
MH100Y24	17:40	2.4
MH100Y24	18:00	1.92
MH100Y24	18:20	1.92
MH100Y24	18:40	1.92
MH100Y24	19:00	2.4
MH100Y24	19:20	2.4
MH100Y24	19:40	2.4
MH100Y24	20:00	1.92
MH100Y24	20:20	1.92
MH100Y24	20:40	1.92
MH100Y24	21:00	1.92
MH100Y24	21:20	1.92
MH100Y24	21:40	1.92

```
MH100Y24                   22:00      2.4
MH100Y24                   22:20      2.4
MH100Y24                   22:40      2.4
MH100Y24                   23:00      1.92
MH100Y24                   23:20      1.92
MH100Y24                   23:40      1.92


[REPORT]
INPUT      YES
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL


[TAGS]


[MAP]
DIMENSIONS       0               0               10000           10000
UNITS            Meters


[COORDINATES]
;;Node           X-Coord         Y-Coord
;;-------------- ---------------- ----------------
D1               517725.127       5432773.588
D2               517627.505       5432773.096
D4               517478.69        5432756.233
D5               517336.862       5432757.776
D8               517118.228       5432756.627
D12              517053.836       5432757.424
D13              516959.306       5432757.403
D15              517053.805       5432849.563
D14              517299.839       5432851.876
D9               517316.344       5432659.288
D11              516963.44        5432655.161
D10              517118.222       5432659.276
D16              517650.674       5432802.72
D6               517339.171       5432582.176
D17              517650.598       5432965.452
```

D21	517327.695	5432961.63
D20	517340.077	5432861.538
D18	517625.909	5432863.601
D23	516940.738	5433000.842
D25	516940.738	5433256.749
DETENTION	517007.128	5432915.464

[VERTICES]

;;Link	X-Coord	Y-Coord
C2	517487.161	5432758.769
C17	517326.663	5432953.375
C18	517078.688	5432961.51

[Polygons]

;;Subcatchment	X-Coord	Y-Coord
A13	517090.823	5432971.892
A13	517281.79	5432973.967
A13	517282.05	5432906.27
A13	517080.147	5432903.393
A13	517089.805	5432929.235
A13	517090.823	5432971.892
A8	517080.147	5432903.393
A8	517282.05	5432906.27
A8	517281.913	5432861.867
A8	517287.914	5432862.315
A8	517314.194	5432871.062
A8	517325.355	5432872.487
A8	517331.459	5432872.574
A8	517340.509	5432807.958
A8	517340.464	5432793.571
A8	517324.741	5432784.253
A8	517315.62	5432768.414
A8	517245.986	5432767.518
A8	517246.096	5432803.965
A8	517064.91	5432801.453
A8	517065.234	5432859.66
A8	517066.133	5432869.056
A8	517080.147	5432903.393

A10	517412.63	5432975.522
A10	517640.642	5432977.267
A10	517641.078	5432920.234
A10	517412.278	5432916.972
A10	517412.63	5432975.522
A9	517743.879	5432785.663
A9	517640.997	5432784.292
A9	517641.078	5432920.234
A9	517640.64	5432977.555
A9	517744.756	5432980.202
A9	517743.694	5432785.661
A9	517743.879	5432785.663
A1	517743.694	5432785.661
A1	517640.997	5432784.292
A1	517636.708	5432764.233
A1	517636.865	5432663.896
A1	517629.53	5432652.26
A1	517628.149	5432631.747
A1	517629.012	5432574.184
A1	517742.944	5432575.527
A1	517742.944	5432575.527
A1	517743.879	5432785.663
A1	517743.694	5432785.661
A11	517641.48	5432920.239
A11	517640.997	5432784.292
A11	517640.997	5432784.292
A11	517553.271	5432783.123
A11	517539.819	5432782.483
A11	517524.636	5432779.953
A11	517512.129	5432776.308
A11	517496.439	5432772.189
A11	517473.701	5432770.575
A11	517384.805	5432769.409
A11	517315.62	5432768.414
A11	517315.62	5432768.414
A11	517315.62	5432768.414
A11	517315.62	5432768.414
A11	517324.741	5432784.253
A11	517340.464	5432793.571
A11	517340.509	5432807.958
A11	517331.459	5432872.574
A11	517411.31	5432873.7

A11	517411.31	5432873.7
A11	517412.278	5432916.972
A11	517641.48	5432920.239
A2	517321.435	5432737.518
A2	517315.933	5432748.417
A2	517315.62	5432768.414
A2	517315.62	5432768.414
A2	517473.701	5432770.575
A2	517496.439	5432772.189
A2	517524.636	5432779.953
A2	517539.819	5432782.483
A2	517553.271	5432783.123
A2	517640.997	5432784.292
A2	517636.708	5432764.233
A2	517636.865	5432663.896
A2	517629.53	5432652.26
A2	517629.239	5432631.76
A2	517562.717	5432630.976
A2	517548.217	5432631.193
A2	517548.336	5432660.387
A2	517330.043	5432658.329
A2	517330.263	5432729.085
A2	517321.435	5432737.518
A2	517321.435	5432737.518
A2	517321.435	5432737.518
A3	517330.043	5432658.329
A3	517548.336	5432660.387
A3	517547.899	5432631.197
A3	517629.214	5432630.041
A3	517629.012	5432574.184
A3	517451.104	5432572.087
A3	517329.77	5432570.657
A3	517329.905	5432614.057
A3	517330.043	5432658.329
A12	517412.63	5432975.522
A12	517281.79	5432973.967
A12	517281.913	5432861.867
A12	517287.914	5432862.315
A12	517303.634	5432867.177
A12	517314.194	5432871.062
A12	517325.355	5432872.487
A12	517331.459	5432872.574

A12	517411.31	5432873.7
A12	517412.278	5432916.972
A12	517412.63	5432975.522
A6	517064.91	5432801.453
A6	517246.096	5432803.965
A6	517245.986	5432767.518
A6	517315.62	5432768.414
A6	517315.933	5432748.417
A6	517321.435	5432737.518
A6	517330.263	5432729.085
A6	517330.081	5432670.708
A6	517130.282	5432668.018
A6	517128.963	5432766.012
A6	517064.826	5432765.187
A6	517064.91	5432801.453
A4	517329.77	5432570.657
A4	517131.624	5432568.322
A4	517130.278	5432668.355
A4	517330.081	5432670.708
A4	517331.26	5432570.675
A4	517329.77	5432570.657
A14	516953.77	5432837.123
A14	516955.492	5432968.778
A14	517090.823	5432971.892
A14	517090.823	5432971.892
A14	517090.823	5432971.892
A14	517089.805	5432929.235
A14	517089.805	5432929.235
A14	517080.147	5432903.393
A14	517069.312	5432878.885
A14	517066.133	5432869.056
A14	517065.234	5432859.66
A14	517064.996	5432838.773
A14	516953.805	5432837.124
A14	516953.77	5432837.123
A7	516954.13	5432666.261
A7	516953.805	5432837.124
A7	517064.996	5432838.773
A7	517064.826	5432765.204
A7	517128.963	5432766.012
A7	517130.113	5432668.353
A7	516954.13	5432666.261

```
A5              516954.596      5432666.285
A5              517130.278      5432668.355
A5              517131.624      5432568.322
A5              516954.32       5432566.232
A5              516954.13       5432666.261
A5              516954.596      5432666.285
A15             517084.58       5433263.4
A15             517086.24       5433162.31
A15             517149.47       5433161.856
A15             517150.903      5433062.028
A15             517341.125      5433061.711
A15             517340.98       5432974.65
A15             516955.492      5432968.778
A15             516955.23       5432942.523
A15             516934.127      5432942.571
A15             516934.795      5433261.334
A15             517084.58       5433263.4
A16             517085.339      5433264.396
A16             517335.571      5433262.036
A16             517340.62       5433061.771
A16             517150.194      5433062.295
A16             517149.669      5433162.492
A16             517086.194      5433163.016
A16             517085.339      5433264.396
```

[SYMBOLS]

```
;;Gage           X-Coord         Y-Coord
;;-------------- ---------------- ----------------
```

Model Output

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.022)

****
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
****

****
Analysis Options
****
Flow Units ..... CMS
Process Models:
  Rainfall/Runoff ..... YES
  Snowmelt ..... NO
  Groundwater ..... NO
  Flow Routing ..... YES
  Ponding Allowed ..... NO
  Water Quality ..... NO
Infiltration Method ..... HORTON
Flow Routing Method ..... DYNWAVE
Starting Date SEP-12-2011 00:00:00
Ending Date SEP-12-2011 12:00:00
Antecedent Dry Days 0.0
Report Time Step 00:01:00
Wet Time Step 00:05:00
Dry Time Step 00:05:00
Routing Time Step ..... 5.00 sec

WARNING 03: negative offset ignored for Link C5

WARNING 03: negative offset ignored for Link C6

WARNING 03: negative offset ignored for Link C10

WARNING 03: negative offset ignored for Link C14

****

Element Count

****

Number of rain gages 4

Number of subcatchments ... 16

Number of nodes 21

Number of links 20

Number of pollutants 0

Number of land uses 0

****

Raingage Summary

****

Name	Data Source	Data Type	Recording Interval
MH5Y1	MH5Y1	INTENSITY	5 min.
MH5Y24	MH5Y24	INTENSITY	20 min.
MH100Y1	MH100Y1	INTENSITY	5 min.
MH100Y24	MH100Y24	INTENSITY	20 min.

****

Subcatchment Summary

****

Name	Area	Width	%Imperv	%Slope	Rain Gage	Outlet
A13	1.32	150.00	65.00	1.3000	MH5Y1	D21
A8	2.83	200.00	76.00	2.0000	MH5Y1	D14
A10	1.32	220.00	65.00	2.0000	MH5Y1	D17
A9	2.00	240.00	73.00	2.0000	MH5Y1	D16
A1	2.30	240.00	73.00	2.5000	MH5Y1	D1
A11	4.04	250.00	65.00	2.2000	MH5Y1	D18
A2	3.83	360.00	25.00	0.5000	MH5Y1	D2
A3	2.37	360.00	65.00	3.5000	MH5Y1	D6
A12	1.35	120.00	80.00	5.0000	MH5Y1	D20
A6	2.58	240.00	65.00	2.5000	MH5Y1	D8
A4	2.00	240.00	65.00	3.8000	MH5Y1	D9
A14	1.64	128.00	73.00	0.5000	MH5Y1	D15
A7	2.53	180.00	70.00	1.2500	MH5Y1	D13
A5	1.77	216.00	65.00	1.5000	MH5Y1	D11
A15	7.40	300.00	55.00	6.0000	MH5Y1	D23

A16 4.50 200.00 55.00 4.0000 MH5Y1 D23

****

Node Summary

****

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
D1	JUNCTION	102.00	2.50	0.0	
D2	JUNCTION	101.50	2.50	0.0	
D4	JUNCTION	98.50	2.50	0.0	
D5	JUNCTION	96.50	2.50	0.0	
D8	JUNCTION	92.50	2.50	0.0	
D12	JUNCTION	91.50	3.50	0.0	
D13	JUNCTION	93.00	2.50	0.0	
D15	JUNCTION	90.50	2.50	0.0	
D14	JUNCTION	93.50	2.50	0.0	
D9	JUNCTION	98.00	2.50	0.0	
D11	JUNCTION	94.00	1.50	0.0	
D10	JUNCTION	93.20	4.80	0.0	
D16	JUNCTION	100.50	2.50	0.0	
D6	JUNCTION	101.50	2.50	0.0	
D17	JUNCTION	97.00	2.50	0.0	
D21	JUNCTION	90.50	2.50	0.0	
D20	JUNCTION	94.00	2.50	0.0	
D18	JUNCTION	98.50	2.50	0.0	
D23	JUNCTION	86.00	2.50	0.0	
D25	OUTFALL	75.50	0.75	0.0	
DETENTION	STORAGE	86.90	2.00	1200.0	

****

Link Summary

****

Name	From Node	To Node	Type	Length	%Slope	Roughness
C1	D1	D2	CONDUIT	98.9	0.5056	0.0130
C3	D14	D15	CONDUIT	245.6	1.0994	0.0130
C2	D2	D4	CONDUIT	142.0	2.1131	0.0130
C4	D4	D5	CONDUIT	144.9	1.3804	0.0130
C5	D5	D8	CONDUIT	220.6	1.8135	0.0130

C6	D8	D12	CONDUIT	65.8	1.5199	0.0130
C7	D13	D12	CONDUIT	91.4	1.0942	0.0130
C8	D9	D10	CONDUIT	200.6	2.3935	0.0130
C9	D11	D10	CONDUIT	154.4	0.5181	0.0130
C10	D10	D8	CONDUIT	94.1	0.7439	0.0130
C11	D12	D15	CONDUIT	90.5	1.1050	0.0130
C13	D6	D5	CONDUIT	180.8	2.7665	0.0130
C12	D16	D17	CONDUIT	168.6	2.0764	0.0130
C14	D17	D21	CONDUIT	323.2	2.0115	0.0130
C15	D18	D20	CONDUIT	285.7	1.5753	0.0130
C17	D20	D21	CONDUIT	95.0	3.6867	0.0130
C18	D21	DETENTION	CONDUIT	250.0	1.4401	0.0130
C16	D23	D25	CONDUIT	306.0	3.4334	0.0130
C21	D15	DETENTION	CONDUIT	55.0	6.5595	0.0130
OL1	DETENTION	D23	OUTLET			

****

Cross Section Summary

****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
C1	CIRCULAR	0.45	0.16	0.11	0.45	1	0.20
C3	CIRCULAR	0.53	0.22	0.13	0.53	1	0.45
C2	CIRCULAR	0.45	0.16	0.11	0.45	1	0.41
C4	CIRCULAR	0.45	0.16	0.11	0.45	1	0.34
C5	CIRCULAR	0.60	0.28	0.15	0.60	1	0.83
C6	CIRCULAR	0.75	0.44	0.19	0.75	1	1.37
C7	CIRCULAR	0.38	0.11	0.09	0.38	1	0.18
C8	CIRCULAR	0.38	0.11	0.09	0.38	1	0.27
C9	CIRCULAR	0.45	0.16	0.11	0.45	1	0.21
C10	CIRCULAR	0.53	0.22	0.13	0.53	1	0.37
C11	CIRCULAR	0.90	0.64	0.23	0.90	1	1.90
C13	CIRCULAR	0.38	0.11	0.09	0.38	1	0.29
C12	CIRCULAR	0.38	0.11	0.09	0.38	1	0.25
C14	CIRCULAR	0.45	0.16	0.11	0.45	1	0.40
C15	CIRCULAR	0.45	0.16	0.11	0.45	1	0.36
C17	CIRCULAR	0.45	0.16	0.11	0.45	1	0.55
C18	CIRCULAR	0.75	0.44	0.19	0.75	1	1.34
C16	CIRCULAR	0.75	0.44	0.19	0.75	1	2.06
C21	CIRCULAR	0.90	0.64	0.23	0.90	1	4.64

*************************	Volume	Depth
Runoff Quantity Continuity	hectare-m	mm
*************************	---------	-------
Total Precipitation	0.588	13.439
Evaporation Loss	0.000	0.000
Infiltration Loss	0.228	5.197
Surface Runoff	0.321	7.334
Final Surface Storage	0.042	0.967
Continuity Error (%)	-0.436	

*************************	Volume	Volume
Flow Routing Continuity	hectare-m	10^6 ltr
*************************	---------	---------
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.321	3.211
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.321	3.213
Internal Outflow	0.000	0.000
Storage Losses	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.000	0.000
Continuity Error (%)	-0.053	

****
Time-Step Critical Elements
****
None

****
Highest Flow Instability Indexes
****
All links are stable.

****
Routing Time Step Summary
****

Minimum Time Step	:	5.00 sec
Average Time Step	:	5.00 sec
Maximum Time Step	:	5.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.00

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff CMS	Runoff Coeff
A13	13.44	0.00	0.00	4.70	7.82	0.10	0.05	0.582
A8	13.44	0.00	0.00	3.23	9.13	0.26	0.12	0.679
A10	13.44	0.00	0.00	4.70	7.84	0.10	0.05	0.583
A9	13.44	0.00	0.00	3.63	8.79	0.18	0.09	0.654
A1	13.44	0.00	0.00	3.63	8.79	0.20	0.10	0.654
A11	13.44	0.00	0.00	4.70	7.81	0.32	0.15	0.581
A2	13.44	0.00	0.00	10.08	2.51	0.10	0.06	0.187
A3	13.44	0.00	0.00	4.70	7.84	0.19	0.09	0.584
A12	13.44	0.00	0.00	2.69	9.63	0.13	0.06	0.717
A6	13.44	0.00	0.00	4.70	7.82	0.20	0.10	0.582
A4	13.44	0.00	0.00	4.70	7.84	0.16	0.08	0.583
A14	13.44	0.00	0.00	3.63	8.75	0.14	0.06	0.651
A7	13.44	0.00	0.00	4.03	8.40	0.21	0.10	0.625
A5	13.44	0.00	0.00	4.70	7.82	0.14	0.07	0.582
A15	13.44	0.00	0.00	6.05	6.61	0.49	0.23	0.492
A16	13.44	0.00	0.00	6.05	6.61	0.30	0.14	0.492

****
Node Depth Summary
****

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days	hr:min
D1	JUNCTION	0.02	0.24	102.24	0	00:35
D2	JUNCTION	0.01	0.19	101.69	0	00:35
D4	JUNCTION	0.02	0.22	98.72	0	00:37
D5	JUNCTION	0.02	0.22	96.72	0	00:37
D8	JUNCTION	0.03	0.34	92.84	0	00:38
D12	JUNCTION	0.03	0.41	91.91	0	00:38
D13	JUNCTION	0.02	0.21	93.21	0	00:36
D15	JUNCTION	0.02	0.24	90.74	0	00:38
D14	JUNCTION	0.02	0.19	93.69	0	00:37
D9	JUNCTION	0.01	0.14	98.14	0	00:35
D11	JUNCTION	0.01	0.18	94.18	0	00:35
D10	JUNCTION	0.02	0.22	93.42	0	00:37
D16	JUNCTION	0.01	0.15	100.65	0	00:35
D6	JUNCTION	0.01	0.15	101.65	0	00:35
D17	JUNCTION	0.01	0.18	97.18	0	00:36
D21	JUNCTION	0.03	0.27	90.77	0	00:37
D20	JUNCTION	0.02	0.19	94.19	0	00:36
D18	JUNCTION	0.02	0.21	98.71	0	00:35
D23	JUNCTION	0.05	0.31	86.31	0	00:40
D25	OUTFALL	0.05	0.31	75.81	0	00:40
DETENTION	STORAGE	0.14	1.38	88.28	0	01:02

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr
D1	JUNCTION	0.099	0.099	0	00:35	0.202	0.202
D2	JUNCTION	0.056	0.153	0	00:35	0.096	0.299

D4	JUNCTION	0.000	0.152	0	00:36	0.000	0.299
D5	JUNCTION	0.000	0.240	0	00:36	0.000	0.485
D8	JUNCTION	0.098	0.470	0	00:37	0.202	0.981
D12	JUNCTION	0.000	0.562	0	00:38	0.000	1.194
D13	JUNCTION	0.096	0.096	0	00:35	0.213	0.213
D15	JUNCTION	0.060	0.736	0	00:38	0.143	1.596
D14	JUNCTION	0.119	0.119	0	00:35	0.258	0.258
D9	JUNCTION	0.079	0.079	0	00:35	0.157	0.157
D11	JUNCTION	0.068	0.068	0	00:35	0.138	0.138
D10	JUNCTION	0.000	0.144	0	00:35	0.000	0.296
D16	JUNCTION	0.086	0.086	0	00:35	0.176	0.176
D6	JUNCTION	0.094	0.094	0	00:35	0.186	0.186
D17	JUNCTION	0.052	0.136	0	00:35	0.103	0.279
D21	JUNCTION	0.050	0.387	0	00:36	0.103	0.829
D20	JUNCTION	0.064	0.207	0	00:35	0.130	0.446
D18	JUNCTION	0.147	0.147	0	00:35	0.316	0.316
D23	JUNCTION	0.375	0.730	0	00:39	0.787	3.213
D25	OUTFALL	0.000	0.730	0	00:40	0.000	3.212
DETENTION	STORAGE	0.000	1.118	0	00:38	0.000	2.428

****

Node Surcharge Summary

****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Meters	Min. Depth Below Rim Meters
DETENTION	STORAGE	0.96	0.483	0.617

****

Node Flooding Summary

****

No nodes were flooded.

****

Storage Volume Summary

****

Storage Unit	Average Volume 1000 m3	Avg Pcnt Full	E&I Pcnt Loss	Maximum Volume 1000 m3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CMS
DETENTION	0.090	4	0	1.053	52	0 01:02	0.458

****

Outfall Loading Summary

****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CMS	Max. Flow CMS	Total Volume 10^6 ltr
D25	98.60	0.075	0.730	3.212
System	98.60	0.075	0.730	3.212

****

Link Flow Summary

****

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
C1	CONDUIT	0.098	0 00:35	1.30	0.48	0.48
C3	CONDUIT	0.115	0 00:37	1.71	0.26	0.35
C2	CONDUIT	0.152	0 00:36	2.15	0.37	0.46
C4	CONDUIT	0.151	0 00:37	1.94	0.45	0.49
C5	CONDUIT	0.238	0 00:37	1.82	0.29	0.47
C6	CONDUIT	0.469	0 00:38	2.11	0.34	0.50
C7	CONDUIT	0.095	0 00:36	1.60	0.52	0.53
C8	CONDUIT	0.077	0 00:35	1.70	0.29	0.48
C9	CONDUIT	0.066	0 00:35	0.98	0.32	0.44
C10	CONDUIT	0.140	0 00:37	1.18	0.38	0.54

C11	CONDUIT	0.562	0	00:38	2.70	0.30	0.36
C13	CONDUIT	0.093	0	00:35	2.18	0.32	0.48
C12	CONDUIT	0.085	0	00:35	1.84	0.34	0.44
C14	CONDUIT	0.133	0	00:36	1.68	0.33	0.50
C15	CONDUIT	0.145	0	00:36	2.14	0.41	0.44
C17	CONDUIT	0.206	0	00:36	2.49	0.38	0.52
C18	CONDUIT	0.383	0	00:37	2.26	0.29	0.68
C16	CONDUIT	0.730	0	00:40	4.27	0.35	0.41
C21	CONDUIT	0.736	0	00:38	3.96	0.16	0.63
OL1	DUMMY	0.458	0	01:02			

****
Flow Classification Summary
****

	Adjusted	--- Fraction of Time in Flow Class ----						Avg.	Avg.
	/Actual		Up	Down	Sub	Sup	Up	Down	Froude	Flow
Conduit	Length	Dry	Dry	Dry	Crit	Crit	Crit	Crit	Number	Change
C1	1.00	0.01	0.00	0.00	0.89	0.10	0.00	0.00	0.61	0.0001
C3	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	1.22	0.0001
C2	1.00	0.01	0.00	0.00	0.61	0.38	0.00	0.00	1.00	0.0001
C4	1.00	0.01	0.00	0.00	0.59	0.39	0.00	0.00	0.97	0.0001
C5	1.00	0.01	0.00	0.00	0.76	0.23	0.00	0.00	0.81	0.0001
C6	1.00	0.01	0.00	0.00	0.70	0.29	0.00	0.00	0.85	0.0001
C7	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	1.25	0.0001
C8	1.00	0.01	0.00	0.00	0.91	0.07	0.00	0.00	0.57	0.0001
C9	1.00	0.01	0.00	0.00	0.98	0.01	0.00	0.00	0.50	0.0001
C10	1.00	0.01	0.00	0.00	0.98	0.00	0.00	0.00	0.52	0.0001
C11	1.00	0.01	0.00	0.00	0.64	0.35	0.00	0.00	0.98	0.0001
C13	1.00	0.01	0.00	0.00	0.91	0.08	0.00	0.00	0.57	0.0001
C12	1.00	0.01	0.00	0.00	0.63	0.36	0.00	0.00	1.00	0.0001
C14	1.00	0.01	0.00	0.00	0.91	0.08	0.00	0.00	0.52	0.0001
C15	1.00	0.01	0.00	0.00	0.39	0.60	0.00	0.00	1.16	0.0001
C17	1.00	0.01	0.00	0.00	0.40	0.59	0.00	0.00	1.14	0.0001
C18	1.00	0.01	0.00	0.00	0.20	0.79	0.00	0.00	1.19	0.0001
C16	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	2.22	0.0001
C21	1.00	0.01	0.00	0.00	0.17	0.81	0.00	0.00	2.35	0.0000

****
Conduit Surcharge Summary
****

No conduits were surcharged.

Analysis begun on: Fri Nov 25 16:34:06 2011
Analysis ended on: Fri Nov 25 16:34:06 2011

APPENDIX C

SANITARY SEWER CALCULATION SHEET

Project No.: 2111-02764-0 | Per Capita Flow: 350 l/d/per | Date: September 2011

Project Description: Grandview Heights 5A | By: MD

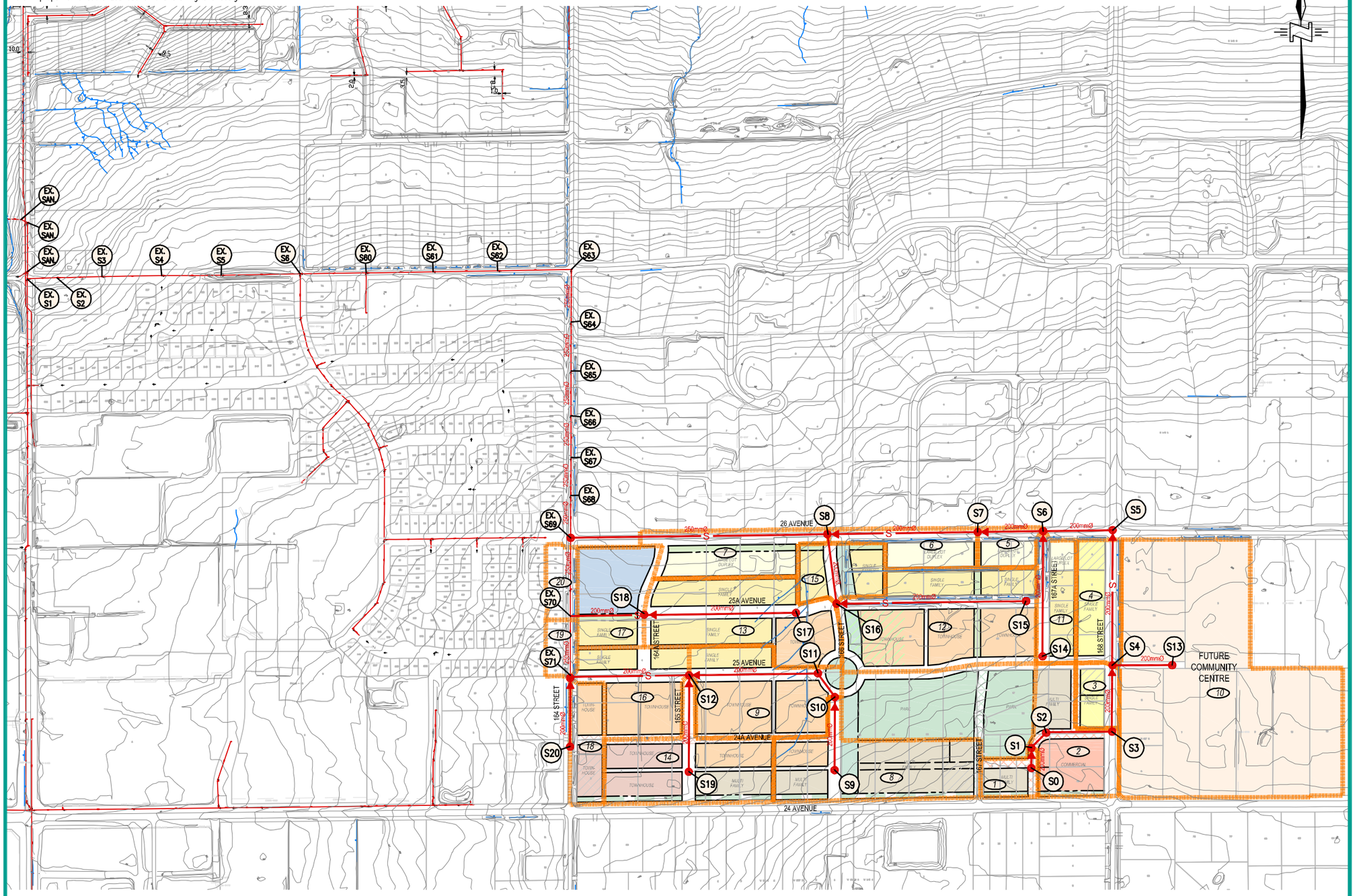
Location: 24 Ave to 26 Ave - 164 St to 168 St | Checked By: NS

Infiltration: 11200 l/d/ha

Mannings Coeff. (n): 0.013

NODE LOCATION			ZONING										PROPOSED SANITARY SEWER DESIGN							
Catchment ID	NODE From	NODE To	ZONE	AREA (ha)	POP./ha	POPULATION	ACCUM. POPULATION	ADWF (L/s)	PEAKING FACTOR	INFILTRATION AREA (ha)	INFILTRATION (L/s)	PWWF (L/s)	Pipe Cap. full (l/s)	Pipe Size (mm)	Length (m)	Slope (%)	Pipe Vel. full (m/s)	Design Vel. (m/s)	CLASS	Comments
1	S0	S1	RM-45	0.2333	107	25	25	0.10	4.37	0.06	0.01	0.45	32.80	200	31	1.00	1.04	0.36	LOCAL	MEETS CAP
	S1	S2		0	0	0	25	0.10	4.37	0.06	0.01	0.45	32.80	200	32	1.00	1.04	0.36	LOCAL	MEETS CAP
2	S2	S3	C-5	0.7652	60	46	125	0.51	4.22	0.20	0.03	2.17	32.80	200	98	1.00	1.04	0.58	LOCAL	MEETS CAP
			RM-45	0.5089	107	54		0.00	4.50											
3	S3	S4	RM-15	0.3208	103	33	158	0.64	4.18	0.20	0.03	2.71	32.80	200	99	1.00	1.04	0.62	LOCAL	MEETS CAP
4	S4	S5	RM-15	0.6967	103	72	734	2.97	3.88	0.40	0.05	11.59	46.38	200	202	2.00	1.48	1.23	LOCAL	MEETS CAP
	S5	S6		0	0	0	734	2.97	3.88	0.21	0.03	11.57	46.38	200	104	2.00	1.48	1.23	LOCAL	MEETS CAP
5	S6	S7	RF	0.3079	66	20	825	3.34	3.85	0.20	0.03	12.90	46.38	200	98	2.00	1.48	1.26	LOCAL	MEETS CAP
6	S7	S8	RF	0.4848	66	32	857	3.47	3.84	0.45	0.06	13.40	36.67	200	226	1.25	1.17	1.07	LOCAL	MEETS CAP
7	S8	EX S69	RF	0.7025	66	46	1480	6.00	3.68	0.76	0.10	22.18	66.49	**250**	382	1.25	1.35	1.21	LOCAL	MEETS CAP
12	S15	S16	RM-30	0.6008	206	124	499	2.02	3.97	0.57	0.07	8.11	36.67	200	283	1.25	1.17	0.92	LOCAL	MEETS CAP
			RM-30	0.5365	206	111														
			RM-30	0.7927	206	163														
			RF-9	0.3076	128	39														
			RF-9	0.4847	128	62														
15	S16	S8	RF-9	0.2875	128	37	577	2.34	3.94	0.21	0.03	9.24	56.81	200	105	3.00	1.81	1.32	LOCAL	MEETS CAP
			RF-9	0.3196	128	41														
8	S9	S10	RM-45	1.3714	107	147	235	0.95	4.12	0.22	0.03	3.95	56.81	200	110	3.00	1.81	1.01	LOCAL	MEETS CAP
			RM-45	0.2775	107	30														
			RM-30	0.2832	206	58														
	S10	S11		0	0	0	235	0.95	4.12	0.09	0.01	3.93	46.38	200	43	2.00	1.48	0.88	LOCAL	MEETS CAP
9	S11	S12	RM-30	0.5935	206	122	610	2.47	3.93	0.39	0.05	9.75	40.17	200	193	1.50	1.28	1.04	LOCAL	MEETS CAP
			RM-30	0.8846	206	182														
			RF-9	0.5499	128	70														
18	S12	EX S71	RM-30	0.8839	206	182	1126	4.56	3.77	0.35	0.05	17.22	40.17	200	177	1.50	1.28	1.22	LOCAL	MEETS CAP
			RF-9	0.2718	128	35														
18	S20	EX S71	RM-30	0.293	206	60	121	0.49	4.22	0.21	0.03	2.09	46.38	200	103	2.00	1.48	0.73	LOCAL	MEETS CAP
			RM-30	0.2929	206	60														
13	S17	S18	RM-30	0.6302	206	130	321	1.30	4.07	0.46	0.06	5.34	36.67	200	228	1.25	1.17	0.82	LOCAL	MEETS CAP
			RF-9	0.8141	128	104														
			RF-9	0.6759	128	87														
17	S18	EX S70	RF-9	0.3349	128	43	363	1.47	4.04	0.22	0.03	5.98	32.80	200	110	1.00	1.04	0.78	LOCAL	MEETS CAP
14	S19	S12	RM-45	0.4025	107	43	299	1.21	4.08	0.29	0.04	4.98	36.67	200	144	1.25	1.17	0.80	LOCAL	MEETS CAP
			RM-30	0.4224	206	87														
			RM-30	0.41	206	84														
			RM-30	0.4111	206	85														
19	EX S71	EX S70	RF-9	1.6237	128	208	1454	5.89	3.69	0.26	0.03	21.77	77.76	250	129	1.71	1.58	1.36	TRUNK	MEETS CAP
20	EX S70	EX S69	RF-9	0.5064	128	65	1883	7.63	3.61	0.15	0.02	27.52	83.47	250	77	1.97	1.70	1.51	TRUNK	MEETS CAP
10	S13	S4	COMMUNITY	10.07	50	504	504	2.04	3.97	0.18	0.02	8.13	32.80	200	90	1.00	1.04	0.85	LOCAL	MEETS CAP
11	S14	S6	RF-9	0.4688	128	60	71	0.29	4.28	0.37	0.05	1.28	40.17	200	187	1.50	1.28	0.58	LOCAL	MEETS CAP
			RF	0.1658	66	11														
	EX S69	EX S68					3362	13.62	3.40	0.13	0.02	46.33	82.61	250	63	1.93	1.68	1.72	TRUNK	MEETS CAP
	EX S68	EX S67				42	3405	13.79	3.40	0.12	0.02	46.84	121.87	250	60	4.20	2.48	2.32	TRUNK	MEETS CAP
	EX S67	EX S66				30	3435	13.91	3.39	0.13	0.02	47.21	146.75	250	63	6.09	2.99	2.63	TRUNK	MEETS CAP

Project No.: 2111-02764-0													Per Capita Flow:	350 l/d/per					Date: September 2011	
Project Description: Grandview Heights 5A																			By: MD	
Location: 24 Ave to 26 Ave - 164 St to 168 St																			Checked By: NS	
													Infiltration:	11200 l/d/ha						
													Mannings Coeff. (n):	0.013						
NODE LOCATION			ZONING										PROPOSED SANITARY SEWER DESIGN							
Catchment ID	NODE		ZONE	AREA	POP./ha	POPULATION	ACCUM.	ADWF	PEAKING	INFILTRATION	INFILTRATION	PWWF	Pipe Cap.	Pipe	Length	Slope	Pipe Vel.	Design Vel.	CLASS	Comments
	From	To		(ha)			POPULATION	(L/s)	FACTOR	AREA (ha)	(L/s)	(L/s)	full (l/s)	Size (mm)	(m)	(%)	full (m/s)	(m/s)		
	EX S66	EX S65				25	3460	14.01	3.39	0.13	0.02	47.51	109.33	250	67	3.38	2.23	2.15	TRUNK	MEETS CAP
	EX S65	EX S64				20	3480	14.10	3.39	0.15	0.02	47.76	165.23	250	73	7.72	3.37	2.88	TRUNK	MEETS CAP
	EX S64	EX S63				20	3500	14.18	3.38	0.16	0.02	48.00	146.51	250	78	6.07	2.98	2.66	TRUNK	MEETS CAP
	EX S63	EX S62				30	3530	14.30	3.38	0.22	0.03	48.38	110.89	375	109	0.40	1.00	0.97	TRUNK	MEETS CAP
	EX S62	EX S61				40	3570	14.46	3.38	0.19	0.03	48.86	116.30	375	97	0.44	1.05	1.00	TRUNK	MEETS CAP
	EX S61	EX S60				32	3602	14.59	3.37	0.20	0.03	49.25	116.30	375	101	0.44	1.05	1.00	TRUNK	MEETS CAP
	EX S60	EX S6				67	3669	14.86	3.37	0.20	0.03	50.06	172.68	375	98	0.97	1.56	1.34	TRUNK	MEETS CAP
	EX S6	EX S5				1,841	5510	22.32	3.21	0.23	0.03	71.58	208.19	375	117	1.41	1.89	1.70	TRUNK	MEETS CAP
	EX S5	EX S4				50	5560	22.52	3.20	0.18	0.02	72.14	300.12	375	90	2.93	2.72	2.22	TRUNK	MEETS CAP
	EX S4	EX S3				50	5610	22.72	3.20	0.18	0.02	72.70	446.66	375	91	6.49	4.04	2.96	TRUNK	MEETS CAP
	EX S3	EX S2				60	5670	22.97	3.19	0.13	0.02	73.37	392.05	375	65	5.00	3.55	2.70	TRUNK	MEETS CAP
	EX S2	EX S1				83	5753	23.30	3.19	0.09	0.01	74.30	105.20	375	44	0.36	0.95	1.03	TRUNK	MEETS CAP
	EX S1	INTERCEPT				6,300	12053	48.82	2.87	0.19	0.02	140.33	760.76	450	93	7.12	4.78	3.64	TRUNK	MEETS CAP



LEGEND

- Existing Sanitary Sewer
- Existing Watercourse
- Proposed Sanitary Sewer
- Sanitary Catchment Boundary
- (16) Sanitary Catchment ID No.

0 50 100 150 200m
(ALL DIMENSIONS ARE IN METRES)

SCALE: 1:6000
NOVEMBER 2011

McElhanney

CITY OF SURREY
the future lives here.

ORCHARD GROVE
GRANDVIEW HEIGHTS AREA 5A

SANITARY CATCHMENT PLAN

APPENDIX D

WATER MODELLING ANALYSIS

Water Analysis Results
Project : NCP #5A Grandview Heights
Date : 24-Mar-11
Designer : MEC

TABLE B1 - Peak Hour Demand Node Summary

Node	Elevation (m)	Demand (l/s)	HGL (m)	Pressure (psi)
N1	90	2.4	146.15	80
N2	92.3	0.8	146.25	77
N3	93.5	0.7	146.37	75
N4	94.5	1.3	146.58	74
N5	94.9	0	146.89	74
N6	88.7	1	146.14	82
N7	91.2	2.9	146.18	78
N8	93.5	3	146.21	75
N9	91.6	1.4	146.02	77
N10	94.4	2.7	146.06	73
N11	97	7.9	146.15	70
N12	99.4	3.2	146.51	67
N13	104.4	5.6	146.9	60
N14	94.8	3.4	146.88	74
N15	99.4	0.9	145.8	66
N16	97.5	0.6	145.85	69
N17	99.8	0.8	145.85	65
N18	102.3	4.5	145.83	62
N19	93.8	0	145.92	74
N20	102.6	0.8	145.7	61

Water Analysis Results
Project : NCP #5A Grandview Heights
Date : 24-Mar-11
Designer : MEC

TABLE B2 - Peak Hour Demand Pipe Summary

Pipe	Start Node	End Node	Diameter (mm)	Flow (l/s)	Velocity (m/s)
P1	N2	N7	200	10.5	0.32
P2	N3	N8	200	16.1	0.5
P3	N4	N12	200	5.1	0.16
P4	N8	N7	200	7.4	0.23
P5	N7	N6	200	7.2	0.22
P6	N7	N10	200	7.8	0.24
P7	N8	N11	200	5.7	0.17
P8	N13	N12	200	24.7	0.76
P9	N12	N11	200	26.6	0.82
P10	N11	N10	200	11.8	0.36
P11	N10	N9	200	7	0.22
P12	N12	N15	250	21	0.43
P13	N15	N16	250	15.1	0.3
P14	N10	N17	200	9.8	0.3
P15	N11	N18	200	12.5	0.39
P16	N18	N17	200	6.4	0.2
P17	N17	N16	200	2.6	0.08
P18	N16	N19	250	13.1	0.26
P19	N18	N20	200	14.8	0.46
E1	N5	N4	321.1	72.4	0.89
E2	N4	N3	321.1	66	0.82
E3	N3	N20	321.1	49.3	0.61
E4	N2	N1	321.1	38	0.47
E5	N1	N6	250	8.3	0.17
E6	N5	N13	321.1	90.8	1.12
E7	N6	N9	250	14.5	0.3
E8	N9	N14	250	21	0.43
E9	N20	N19	268.7	17.9	0.32

Water Analysis Results
Project : NCP #5A Grandview Heights
Date : 24-Mar-11
Designer : MEC

TABLE B2 - Fire Flow Study Node Summary

Node	Fire Flow Satisfied (True / False)	Fire Flow Needed (l/s)	Fire Flow Available (l/s)	Flow Total Needed (l/s)	Flow Total Available (l/s)
N1	TRUE	60	300	62.4	302.4
N2	TRUE	60	300	60.8	300.8
N3	TRUE	120	300	120.7	300.7
N4	TRUE	120	300	121.3	301.3
N5	TRUE	60	300	60	300
N6	TRUE	90	300	91	301
N7	TRUE	60	300	62.9	302.9
N8	TRUE	120	300	123	303
N9	TRUE	90	300	91.4	301.4
N10	TRUE	120	300	122.7	302.7
N11	TRUE	120	300	127.9	307.9
N12	TRUE	120	300	123.2	303.2
N13	TRUE	120	300	125.6	305.6
N14	TRUE	60	300	60.3	300.3
N15	TRUE	90	300	90.9	300.9
N16	TRUE	90	300	90.6	300.6
N17	TRUE	120	300	120.8	300.8
N18	TRUE	120	300	124.2	3004.2
N19	TRUE	60	300	60	300
N20	TRUE	120	300	120.8	300.8

APPENDIX E

10-YEAR SERVICING PLAN ELIGIBLE PROJECTS

Appendix E

10-Year Servicing Plan Projects

Project	Project Cost	Growth Cost Component (10 Year Plan Cost)	Funding Outside the 10 Year Plan
Water Works			
400m of 250mm dia watermain upsize 26 Ave: 166 St to 168 St	$31,000	$31,000	
400m of 300mm watermain upsize 166 St: 24 Ave to 26 Ave	$58,000	$58,000	
Sanitary Sewer			
250m of 250mm dia sanitary sewer upsize 26 Ave: 165 St to 168 St	$41,000	$41,000	
Storm Sewer			
300m of 750mm trunk sewer (off-site works) 164 St: 26 Ave to 2700 Block	$933,000	$395,000	$538,000
Storm Sewer Detention Pond 26 Ave at 164 St	$4,766,000	$2,018,000	$2,748,000
Non-Arterial Streets			
164 St: 24 Ave to 26 Ave Upgrade to collector standard	$309,000	$309,000	
26 Ave: 164 St to 168 St Upgrade to collector standard	$1,134,000	$1,134,000	
Arterial Roads			
168 St: 24 Ave to 26 Ave Upgrade to arterial standard	$2,308,000	$2,308,000	
24 Ave: 164 St to 168 St Upgrade to arterial standard	$2,308,000	$2,308,000	
Traffic Signal 24 Ave / 165 St	$140,000	$140,000	

Appendix E

10-Year Servicing Plan Eligible Projects

Project	Project Cost	Growth Cost Component (DCC)	Balance (DWA Value)
Water Works			
400m of 250mm dia watermain upsize 26 Ave: 166 St to 168 St	$31,000	$31,000	
400m of 300mm watermain upsize 166 St: 24 Ave to 26 Ave	$58,000	$58,000	
Sanitary Sewer			
250m of 250mm dia sanitary sewer upsize 26 Ave: 165 St to 168 St	$41,000	$41,000	
Storm Sewer			
300m of 750mm trunk sewer (off-site works) 164 St: 26 Ave to 2700 Block	$933,000	$395,000	$538,000
Storm Sewer Detention Pond 26 Ave at 164 St	$4,766,000	$2,018,000	$2,748,000
Non-Arterial Streets			
164 St: 24 Ave to 26 Ave Upgrade to collector standard	$309,000	$309,000	
26 Ave: 164 St to 168 St Upgrade to collector standard	$1,134,000	$1,134,000	
Arterial Roads			
168 St: 24 Ave to 26 Ave Upgrade to arterial standard	$2,308,000	$2,308,000	
24 Ave: 164 St to 168 St Upgrade to arterial standard	$2,308,000	$2,308,000	
Traffic Signal 24 Ave / 165 St	$140,000	$140,000	