Whistle Bend Master Concept Plan

VOLUME 2: Servicing



AECOM

City of Whitehorse

Yukon

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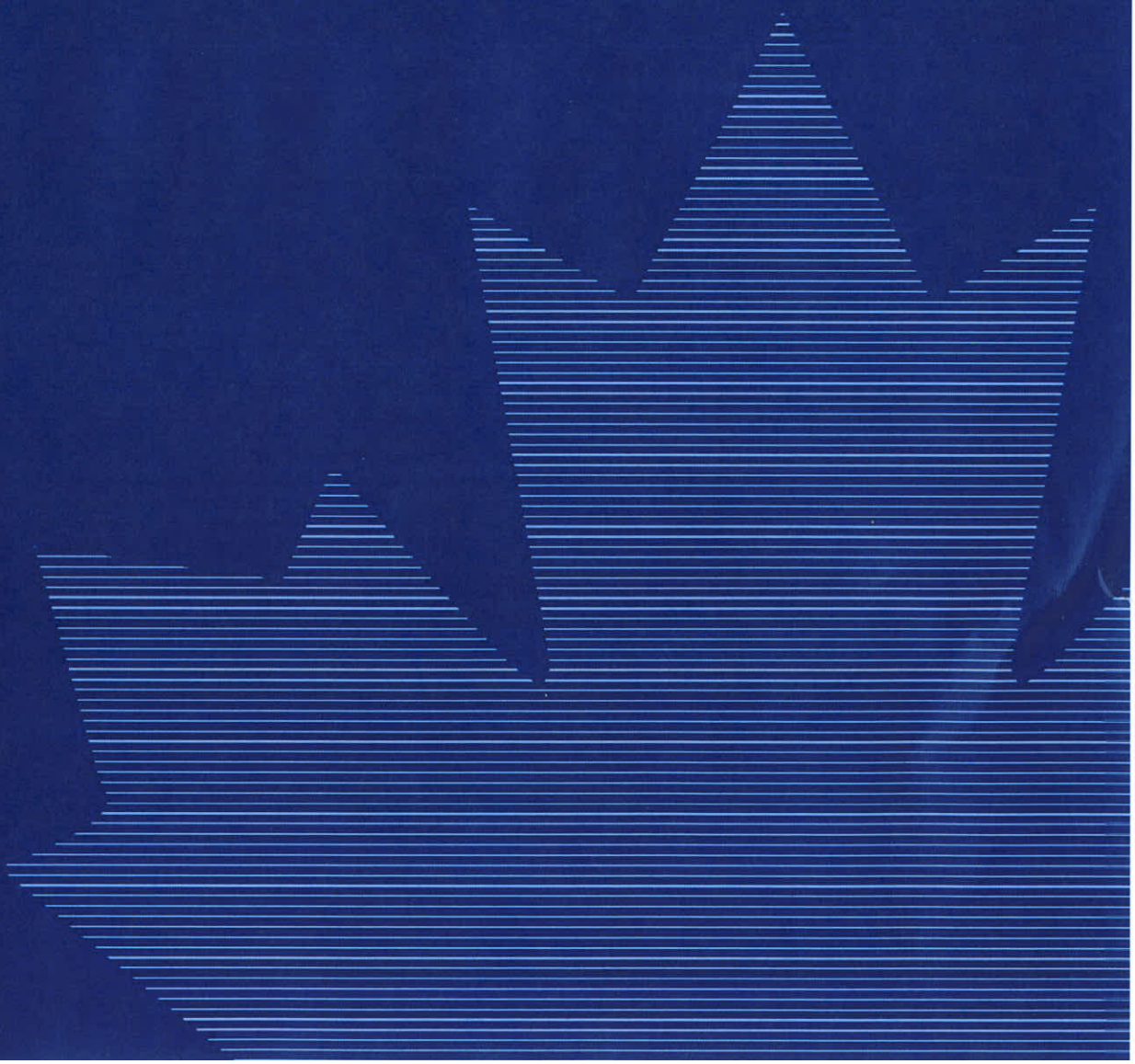
1.0 WHISTLE BEND OFF-SITE SERVICING REPORT

AECOM

Report

City of Whitehorse

Whistle Bend
Off-Site Servicing Report



City of Whitehorse

Whistle Bend
Off-Site Servicing Report

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Date: March 23, 2009

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March 23, 2009 Project Number: 2501-040-00

Mr. Wayne Tuck, P.Eng.
City Engineer
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4210 4th Avenue
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Dear Wayne:

RE: Whistle Bend Off-Site Servicing Report

Attached is the final revision of the Off-Site Servicing Report addressing water, wastewater, drainage and transportation servicing for the proposed Whistle Bend development. We have incorporated all comments and feedback received from the City and the Yukon Government. Our analysis and recommendations incorporate sustainability principles throughout. The basis for the development is the charrette concept from 2006 with an ultimate build-out population of 10,000. A 20 year build-out schedule was assumed to develop net present value costing and for evaluating impacts from growth elsewhere in the City. However, phasing is indicated based on percentage build-out and not in years. Work was completed in collaboration with Quest Engineering Group.

We recognize that things may change when the development concept plan is finalized at the end of Phase 1 of this project. These changes may be a result of alterations in density and housing types based on what is marketable in Whitehorse. Any such changes would directly impact the off-site servicing requirements. For this reason, we recommend that the off-site services preliminary engineering design originally scheduled to be part of Phase 1 be deferred until Phase 2, when there will be greater clarity as to land use allocations and densities.

The analysis for the water and wastewater off-site servicing is at a feasibility level and includes the evaluation of options and recommendations complete with Class D cost estimates. Drainage and transportation is covered on a conceptual level and will require further investigation once the development concept is firmed up for Phase 2.

Sincerely,

AECOM Canada Ltd.



Peter Takacs, P.Eng.
Senior Engineer
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PT:cla

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
0		August 22, 2008	DRAFT for client review
1		December 9, 2008	Final Report
2		March 23, 2009	Revised Final Report

Signature Page

Report Prepared By:	Report Reviewed By:
	
Peter Takacs, P.Eng. Senior Engineer	Bill Jenkins, P.Eng. Senior Engineer

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1. Executive Summary

This report serves as an initial background analysis for off-site servicing and its impact on a proposed new development known as Whistle Bend situated on the lower Porter Creek Bench in Whitehorse. It forms part of a larger planning and engineering study to generate an overall land use and subdivision plan to guide future development of this approximately 730 hectare area in the City. In designing for the future, a focus on sustainability forms an integral component of the work.

The off-site servicing assessment has adopted a target average water consumption rate of 375 litres per capita per day (lpcd), which is less than the current City target of 500 lpcd and significantly lower than the current actual consumption of 690 lpcd in Porter Creek. While this may 'push the envelope' somewhat, this target should be achievable with the use of low flow fixtures and appliances, metering and other water use reduction strategies. The target is also in line with the current national average rate. Flow analysis for both water and wastewater was based on phasing in the reduced rate over the initial 50% build-out of the development starting with the current City target of 500 lpcd.

Various scenarios were modeled and analyzed to determine the optimal option for providing water to the proposed development. The option of a separate and dedicated water supply system for Whistle Bend was eliminated due to cost. A further option of providing a separate fire supply system utilizing a river intake or a well was also assessed, but found to not be feasible from a cost perspective.

The off-site water system infrastructure upgrades recommendations, phased over the build-out of the development are as follows:

0% Build-Out (Front End):

- Extend the existing 350 mm trunk main on Range Road with a 450 mm main to Whistle Bend (supply from Service Area 2). This provides the peak domestic flows for the ultimate build-out but fire flow of only up to 150 l/s for the first 5 years. The adequacy of this fire flow will depend on the nature of the development. 150 l/s is adequate for the assumed residential development in the first phases of development, but additional fire flow capacity will be required once commercial / institutional development begins. Ultimate fire flow requirements up to 300 l/s are assumed for the built-out development.
- Add one pump to the Two Mile Hill Booster pumphouse.
- Add 2 new 5,000 m^3 cells to the Valleyview Reservoir. The ultimate increase in storage is estimated to be 15,000 m^3. Adding the additional storage in phases is recommended due to uncertainties with the rate of development in other parts of the Valleyview Service Area.

25% to 50% Build-Out:

- Add a 350 mm trunk main from McIntyre Creek (Service Area 3) to provide adequate fire flow. This will also provide domestic service to the proposed Porter Creek "D" development. If this other development does not move forward, this item may be eliminated.
- If Porter Creek D is not developed, add a 300 mm connection from Wann Road to Whistle Bend to provide additional fire flow.
- Add a new 6,000 m^3 cell to the Porter Creek Reservoir. (Note: the timing of this upgrade is impacted by the demand for additional development in the existing Porter Creek and Alaska Highway commercial areas, and therefore the City may wish to accelerate this upgrade if capital funding is available.)

50% to 75% Build-Out:

- Add another pump to the Two Mile Hill Booster pumphouse
- Add one more 5,000 m^3 cell to the Valleyview Reservoir

The sanitary flows from Whistle Bend are to be transported to the City lagoons on the north side of the Yukon River. The City lagoons and headworks have adequate capacity to handle the additional flows from Whistle Bend. The Porter Creek flush tank (PCFT) and gravity force main have adequate excess capacity to handle the additional flows up to the 75% development horizon. Various options were analyzed, and it is recommended to construct a major pump station in the development area that pumps directly to the flush tank at Porter Creek. Flows from the development will be collected within the various phases to minor pump stations that will pump over to this major pump station. After the 75% horizon, or when the gravity main is near capacity, some twinning of the gravity force main will be required to increase hydraulic capacity. Delaying this work until the twinning is actually required will be optimal from a present value perspective. The twinning requirement may be delayed further or even eliminated if the ultimate build-out of the existing Porter Creek catchment area is not achieved or if the per capita flows are reduced even further than targeted.

The off-site wastewater system infrastructure upgrades recommendations are as follows:

0% Build-Out (Front End):

- Construct the major Whistle Bend sanitary pump station (125 l/s at 45 m TDH; 90 hp) and a 370 m long 450 mm forcemain to the PCFT

75% Build-Out: PCFT gravity main at capacity for peak wet weather flows

- Twin approximately 500 m of the 450 mm gravity force main by constructing 200 m of new main and connecting the spare river crossing (300 m)
- Option to abandon the flush tank control valve by leaving it open.

Recommended drainage strategies are based on Alberta standards and are practical for the unique conditions of the North. The intent is to achieve a post development zero net increase in run-off from the site and is supportive of sustainability principles. Generally, the Whistle Bend site has favourable drainage characteristics and strategies incorporating infiltration can be utilized to reduce the run-off from the development and roadways by about 50% and 30% respectively. Minor and major system will still be required to handle the additional run-off which will be directed via piped systems and swales to detention facilities. These systems would also serve as a back-up to the infiltration systems that would be affected when the ground is frozen and snow melt has to be conveyed away from the site. Options for detention include the pot holes at the north end of the site and the golf course to the east. Smaller detention ponds that are designed to infiltrate can also be built in each development phase. Water quality enhancement will also be provided with these systems.

Off-site transportation impacts have also been investigated. Primarily access into the neighbourhood will be from a new major entrance at the intersection of Whistle Bend Connector and Mountainview Drive, at a location that ties into the future extension road proposed to service the Porter Creek "D" development and Pine Street Extension to Alaska Highway. With the ultimate build-out of Whistle Bend, the adjacent street network will require upgrading and improvements. Mountainview Drive, which links the new community with Downtown Whitehorse, will need to be widened to a four lane cross section between 2nd Avenue and the proposed Whistle Bend Connector. Initial review of the roadway width requirements (based on a TAC classification of UCU-70 and City Standards for a major collector street) is approximately 17 m width based on maintaining two travel lanes of 3.5 m plus on-road bicycle lanes of 1.5 m and no on-street parking per direction. The existing right-of-way (ROW) of Mountainview between Tliingit Road and 12th Avenue (based on cadastral information) is in the order of 60 m plus, and is likely sufficient to accommodate the proposed widening of the Mountainview corridor. Intersection improvements including geometric upgrades, signalization and signal optimization, will be required at Mountainview Drive and Range Road, at Quartz Road and Industrial Road, Two Mile Hill and Industrial Road, and at Quartz Road and Chilkoot Way. Transit improvements will also be required to service the additional demand. These improvements may include the extension of existing transit lines (i.e. Transit Line 5: Takhini – College - CGC), increases in frequency to 10- and 20-minutes headways, and new transit service (Transit Line 7: Downtown – Whistle Bend - Porter Creek). Transit services will be explored further in the design concepts as a way of embracing sustainable transportation alternatives.

Cycling to and from Whistle Bend can be explored via Range Road, assuming a downgrading of this road to serve transit and cyclists between Mountainview Drive and Whistle Bend. Additionally, a bike trail is proposed which connects the new neighbourhood with Downtown via a facility which combines an on-road should bike lane with an off-road trail. The trail is proposed as a 2m wide compacted gravel path connecting between Range Road and Mountainview Drive, running parallel to Mountainview Drive to its southerly intersection with Range Road.

Order of magnitude costs for the proposed off-site servicing requirements are summarized in Table 1.1.

Table 1-1 - Summary of Order of Magnitude Costs

% Build-Out	Service	Item	Cost
Front End (0%)	Water	Range Road Trunk Main	$3,500,000
		Valleyview Reservoir (2 cells)	$5,600,000
		Two Mile Booster	$300,000
	Sanitary	Lift Station & force main	$1,800,000
	Roads*	Industrial Road / Two Mile Hill Signalization	$250,000
		Range Road / Two Mile Hill Geometric Improvements	$50,000
		Whistle Bend Connector	$1,770,000
	Bike Trail	Bike Trail (Whistle Bend - Mountainview Dr)	$500,000
	Power		not available
	Telecom		not available
		Subtotal Front End (0% Build-out)	**$13,770,000**
25%	Water	None	$0
	Sanitary	None	$0
	Roads	Pine Street Extension	$6,910,000
	Power		not available
	Telecom		not available
		Subtotal 25% Build-out	**$6,910,000**
50%	Water	Porter Creek D extension	$2,900,000
		Porter Creek Reservoir (1 cell)	$3,400,000
	Sanitary	None	$0
	Roads	Alaska Highway Connector	$5,660,000
		College Access Road	$2,400,000
		Whistle Bend Connector – 4-lane widening	$2,010,000
		Mountainview Drive / Whistle Bend Connector Intersection geometrics and signalization	$1,970,000
		Mountainview Drive Corridor Intersection improvements	$200,000
		Downtown Intersections improvements	$280,000
	Power		not available
	Telecom		not available
		Subtotal 50% Build-out	**$18,820,000**
75%	Water	Valleyview Reservoir (1 cell)	$2,800,000
		Two Mile Booster	$500,000
	Sanitary	Twin section of PCFT main	$170,000
	Roads	Mountainview Drive 4-lane (Range Rd - Whistle Bend Connector)	$3,330,000
		Mountainview Drive Intersection Improvements	$200,000
	Power		not available
	Telecom		not available
		Subtotal 75% Build-out	**$7,000,000**
100%	Water	None	$0
	Sanitary	None	$0
	Roads	Mountainview Drive 4-lane	$5,140,000
		Alaska Highway / Prospector Road	$1,010,000
		Hamilton Boulevard / Arkell Access Road	$310,000
	Power		not available
	Telecom		not available
		Subtotal 100% Build-out	**$6,460,000**

*Note: Roadway requirements for Front end are based on what is required to service the development at inception, and up to 10% build-out. The Pine Street Extension is required at the 10% build out and has been included in the 25% requirements as it is not an upfront cost.

2. Sustainable Design Criteria for Water/Wastewater

The Whistle Bend development is to adopt sustainable water usage and resultant wastewater discharge principles with the goal of significantly reducing water consumption from current City levels. The intention is also to have the development become a model of sustainable design for the North.

The current City design criteria for water consumption for new development is 500 lpcd. Current, actual residential based on 2007 flow data of 2006 Census consumption in the Porter Creek Service Area, is in the range of 690 lpcd (see Section 3.1) based on 2007 flow data for the McIntyre Creek pumphouse and the 2006 Census Data.

Typical single family water usage can be reduced a number of ways. The most effective strategy would be a combination of metering and the use of water conservation devices for toilets, clothes washers, showers, and faucets. There are a number of Canadian studies on the effect of metering/volume based pricing on domestic water consumption, and reductions vary from about 15% to 30%. These studies do not specifically mention any effect from low flow fixtures; however, part of the likely outcome of implementing volume based pricing is some customers changing their fixtures to reduce water use. When municipalities implement a metering program, raising awareness and subsidizing of low flow fixtures is frequently part of the package. We feel that requiring all new Whistle Bend dwellings to be metered and the requirement to install water efficient devices will reduce domestic water usage from current target levels by up to 30%.

An analysis of City-wide daily water usage from 2006 indicates a peak in June and July which is likely attributable to a combination of irrigation, increased tourism, washing cars, etc. On a per capita basis, the summer increase is in the order of 15% over the annual average consumption. While the irrigation component is unknown, it is likely a large component of the 15% increase and implementing sustainable best practices to reduce the usage of potable water for irrigation should be encouraged for Whistle Bend. The most effective strategy to achieve this is xeriscaping which is defined as creative landscaping including the smart usage of plants (either native species or drought resistant), reduction in turf, soil improvements, design, etc. It has been shown that xeriscaping can reduce irrigation water use by 50% to 75%, and should therefore be implemented in some form for Whistle Bend. The use of rain-barrels is another good option. Many municipalities have rain-barrel programs in place that encourage residents to install them and reduce the dependence on potable water for irrigation of vegetable and flower gardens. Gray water re-use gets a lot of mention in literature, but its implementation is not common and if it is used, it is typically in commercial/institutional buildings. From the single family home owner's perspective, it is an expensive, added complication to their building system. For Whistle Bend, gray water re-use should be investigated further for the commercial and multi-family developments.

While the intent is to utilize all practical best practices to reduce water consumption as much as possible from current levels, we have to recommend a realistic achievable design criteria for system sizing. With the phased approach of the upgrades and ongoing monitoring, there will be an opportunity to revisit the design criteria and adjust the flows if warranted. If actual consumption is less than the design criteria, some of the phased upgrades could be rescheduled or even eliminated.

We recommend that an achievable domestic consumption rate is 30% from the current City target, or a reduction from 500 to 350 lpcd. Allowing for 15% net leakage for the Whistle Bend development and a 10% non-residential demand component, the overall reduction in water consumption usage is 26% from the current City target. Note that this percentage may be increased if non-residential buildings are also required to install water efficient devices; however the impact of this initiative is not expected to be great.

Therefore, for Whistle Bend, we recommend a design consumption of 375 lpcd average residential demand. This represents a reduction in average water consumption of approximately 45% over the current 690 lpcd consumption in Porter Creek, and 25% from the current City design target of 500 lpcd. With metering, low usage fixtures and irrigation water use reduction strategies, this target should be achievable.

The water and wastewater servicing analysis in this report has assumed a phased reduction in per capita flows will occur over the initial development period while users become accustomed to metered use. Initial consumption will assume the current design target rate of 500 lpcd, with a stepped reduction over 50% build-out, assumed to occur over 10 years.

While the 375 lpcd target may appear ambitious based on current demands, it is in line with current average residential usage in Canada. Earth Tech's 2007 benchmarking study identified an average municipal water usage rate of 313 lpcd based on 2005 data from 34 water utilities (Source: National Water and Wastewater Benchmarking Initiative, Earth Tech, 2007). A bar chart from that report including data for 2003 through 2005 is attached in Appendix A.

Furthermore, flow data for the Copper Ridge development suggests that, currently, consumption may be in the order of 375 lpcd. While the data is somewhat suspect and has not been completely verified, it suggests that the newer development, complete with heat traced service connections, minimal leakage, and homes with presumably more efficient fixtures and appliances, has significantly lower consumption than the older City neighbourhoods.

3. Water Servicing

3.1 Background Information

The most recent overall water study completed for the City of Whitehorse was the 2004 Water and Sewer Study completed by Stantec.

In the January 2004 Final Report, Stantec identified that the 2001 average water consumption for the City was 691 lpcd. Stantec reported the following statistics for the Porter Creek Service Area 3.

Table 3.1 - Statistics for the Porter Creek Service Area

Sub Area Demand	Population	Composite Residential Demand (l/s)	Non-residential Demand (l/s)	Total
Porter Creek	4139	21 l/s	1.5 l/s	25.4 l/s
Crestview	799	3.7 l/s	0	3.7 l/s
Kopper King	316	1.8 l/s	0.3 l/s	2.1 l/s
Totals	5254	29.5 l/s	1.8 l/s	31.2 l/s

Based on the above statistics the calculated average day demand (ADD) would be 2,700 m^3/day.

The ratio of non-residential demand to total demand is approximately 6%.

Stantec reported an approximate average annual growth rate for the City at 2.0% for the short term.

The 2006 Census Canada Data identifies a total population for the Porter Creek Service Area as 4,280, including Porter Creek, Crestview and Kopper King. Assuming a 2% growth rate, the 2007 population could be calculated to be 4,366.

The average daily water consumption for this Service Area is metered at the existing McIntyre Creek Booster pumphouse. Data provided by the City for 2007 suggests an average daily consumption of approximately 3,200 m^3/day.

Assuming the ratio of non-residential demand has not significantly changed, the composite residential consumption would be 94% of 3,200 m^3/day, or approximately 688 lpcd.

It appears average daily residential consumption has remained relatively constant for the Service Area.

3.2 Proposed Whistle Bend Development Water Demand

The proposed Whistle Bend development is to provide mixed residential, commercial and institutional development for a population of up to 10,000. For this report, we have assumed a 20 year development horizon, however, phasing will be determined by % build-out.

As outlined in Section 2.0, we have assumed that a phased reduction in water usage from 500 to 375 lpcd will occur over the initial 50% build-out of the development. Based on this, the water consumption rates are as follows:

Table 3.2 – Water Consumption Rates over 20 years

% Build-Out	0	25	50	75	100
lpcd @ 2% annual reduction until 50% development	500	437.5	375	375	375
Population	0	2500	5000	7500	10,000
ADD m^3/day	0	1094	1875	2812.5	3750
ADD l/s	0	12.7	21.7	32.6	43.4
MDD l/s (ADD x 2)	0	25.4	43.4	65.2	86.8
PHD l/s (ADD x 4)	0	50.8	86.8	130.4	173.6

Note: MDD is maximum day demand and PHD is peak hour demand

Suggested consumption ratios for MDD are as recommended in the 2004 Stantec report. Suggested consumption ratio for PHD has been increased to 4 to represent the lower base demand rate, and the expected higher PHD ratio for this development. This is more in line with an expected peak hour demand rate based on other similar developments.

3.3 Water Supply Options

The following water supply options were identified during the 2006 Design Charrette discussions:

- Extension of existing piped water network
- Ground water wells – likely at one of the pot holes at north end of site which may be hydraulically connected to the river
- Surface water supply from Yukon River or McIntyre Creek

A surface water supply would likely require both filtration and disinfection. A reservoir of sufficient size to provide contact time for disinfection, and emergency and balancing storage would likely be required. Unless an elevated reservoir could be constructed to provide gravity head, the water system would require constant pressurization by pumping. Capital and operating costs would be significant.

A well supply would not likely require filtration, but would require disinfection. The same reservoir requirements would be needed as for the surface water source. Based on the known information about an existing well at the Hyland Farm on the lower bench, it is considered unlikely that a suitable well water source could be developed at the site.

The City's current piped water system consists of a series of pressure zones incorporating booster pump stations and reservoirs to supply the various service areas in the City. Service area extents are determined primarily by development elevation and location. Previous studies have suggested extending the existing piped water system as a suitable water supply option for Whistle Bend.

The current City water supply is provided by a combination of surface water from Schwatka Lake and ground water wells from the Selkirk aquifer. The existing water quality is good, and is expected to meet the anticipated long term needs of the City.

Extension of the existing piped water system appears to be the most economical and sustainable option of those identified.

3.4 Service Area Options

Previous reports have suggested that Whistle Bend could be serviced from either the Porter Creek Service Area 3, or the Valleyview Service Area 2.

Both reservoir service areas will provide higher than desired operating pressures, therefore pressure reduction valves will be required on the supply line to the development. Desirable operating pressures are between 280 and 550 kPa, as per the City Servicing Standards.

Operating Pressures (Whistle Bend average Elev. 675 m).

Area 2 Servicing

Valleyview Reservoir	HGL 754-759 m
Low Pressures	754 – 675 = 79 m (775 kPa)
High Pressures	759 – 675 = 84 m (824 kPa)

Area 3 Servicing

Porter Creek Reservoir	HGL 769-774 m
Low Pressures	769 – 675 = 94 m (922 kPa)
High Pressures	774 – 675 = 99 m (971 kPa)

Servicing from the Porter Creek Service Area 3 would require the additional pumping of all water from Area 2 to Area 3 through the McIntyre Creek Booster pumphouse. The pumphouse would require upgrading to meet the expected ultimate development demands.

Service Area 2 supply results in reduced pumping requirements; therefore it will be investigated for supply potential.

3.5 Piped System Extension Options

Previous reports suggested extension of the existing 350 mm trunk main along Range Road as the most favourable service option. The extension requires crossing of the existing McIntyre Creek in the vicinity of Range Road.

Modeling of the existing and proposed water system improvements was carried out using the City of Whitehorse existing 2003 water model, which has been updated to include recent development conditions.

The following water demand data was incorporated in the model review:

- ADD demands, phased as suggested in 2.0
- MDD demands with a demand ratio of ADD x 2
- PHD demands with a demand ratio of ADD x 4 (due to lower base demands)

  The current City design recommendation of 3 x ADD for PHD is based on the current base demand which is close to 700 l/s on average. 4 x ADD is more often used for PHD demand design in other areas, and with the reduced base demand is considered more appropriate. It likely will not affect system sizing, as MDD plus fire flow will govern in most cases.

- Fire flow requirements of 250 l/s minimum, and 300 l/s desirable at MDD flows.

  Fire flow requirements are determined by development density and exposures, construction type, floor area, number of floors, sprinklers, etc.

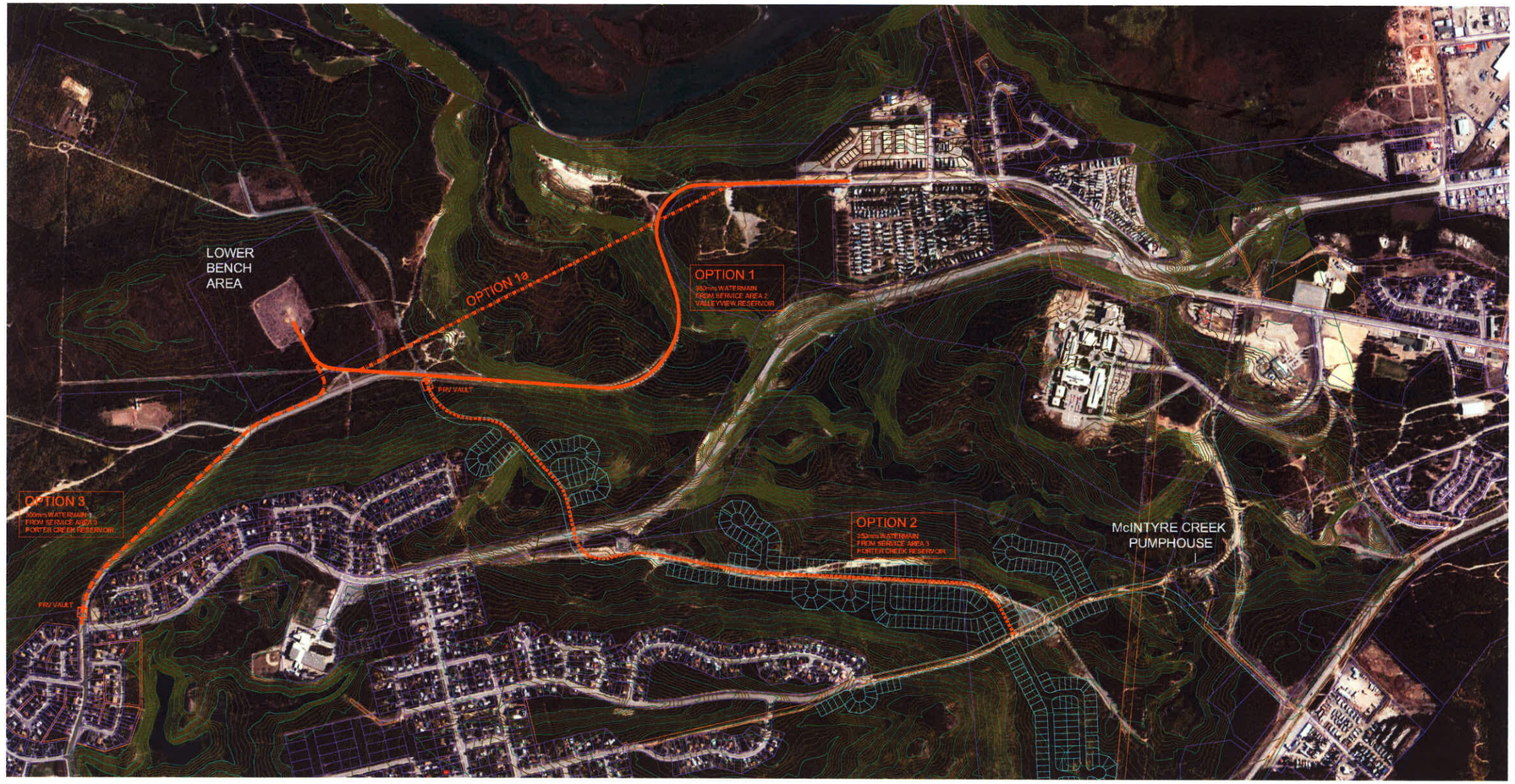
  Typical residential fire flow requirements range from 75 to 125 l/s depending on above criteria.

  Commercial and institutional development requires higher fire flows. Typical commercial fire flows for neighbourhood commercial or strip mall development is 200 to 250 l/s.

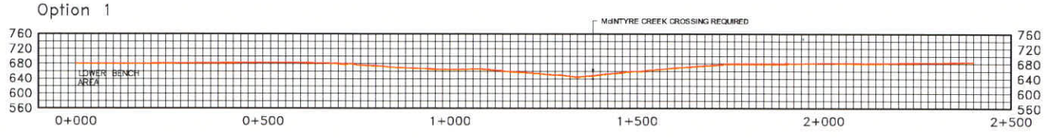
  Institutional fire flows for schools or community buildings can range from 250 l/s to 500 l/s.

  The maximum suggested fire flow for Whitehorse is 300 l/s based on the assumption that the maximum capacity of 3 pumper units is approximately 300 l/s, and most development will be below this fire flow requirement. The current City pumper capacity is up to 100 l/s per pumper. Assuming 3 pumpers could respond to any given fire, the required capacity could be 250 to 300 l/s. In previous design discussions, the maximum required capacity was suggested as 300 l/s for anticipated Whitehorse developments and pumper capacity. This design guideline was developed during the Copper Ridge development years, and we have carried it forward.

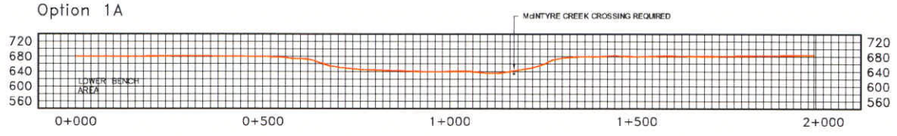
These demands were applied to a single model node representing the approximate centroid of the proposed development to establish assumed trunk main lengths. Refer to the water servicing options plan included in Figure 1 for the various scenarios and options that were modeled and are detailed below.



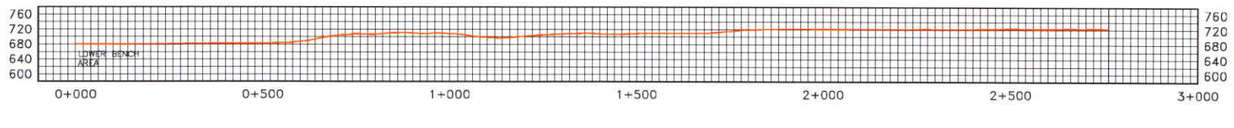
Option 1



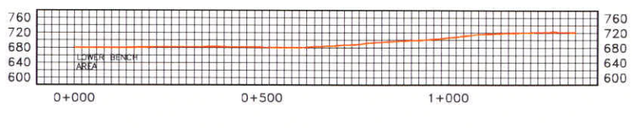
Option 1A



Option 2



Option 3



NOTES:

Yukon Government
Community Development Branch

City of Whitehorse
ENGINEERING DEPARTMENT

Quest Engineering Group Inc.
P.O. Box 31454, Whitehorse, Yukon Y1A 6K8
Tel: (867) 633-8930 Fax: (867) 633-8933 E-mail: contact@questengineering.ca

REVISIONS :

NO.	DATE	ENG.	SUBJECT
01	JULY 28 2008	R.S.	ISSUED FOR REVIEW

PROJECT :
PORTER CREEK BENCH
PLANNING
AND PREDESIGN

DRAWING TITLE :
PORTER CREEK BENCH
WATER SERVICING
OPTIONS

SCALE :	H 1:7,500, V 1:7,500
DATE :	2008/07/28
DESIGN :	R.S.
DRAWN :	F.V.D.
CHECKED :	R.S.
APPROVED :	R.S.

DRAWING NUMBER :	SHEET :
101	01 of 01

Figure 1

Scenario 1: Extend the existing 350 mm trunk main along Range Road from Northlands Park, to Whistle Bend. This is shown as Option 1.

Assessment: Meets 25% ADD, MDD, PHD and provides up to 152 l/s fire flow @ MDD
Meets 50% ADD, MDD, PHD and provides up to 135 l/s fire flow @ MDD
Meets 75% ADD, MDD, PHD and provides up to 113 l/s fire flow @ MDD
Meets 100% ADD, MDD, cannot meet PHD and provides up to 91 l/s fire flow @ MDD

Conclusion: Scenario 1 meets domestic demand requirements up to the 75% build-out horizon but cannot meet the anticipated long term PHD or fire flow requirements as a single source supply. Provides adequate fire flow for typical residential development, which is assumed for the early stages of development.

Scenario 2: try various size upgrades for Scenario 1 to test for increased PHD and fire flow.

Assessment: 400 mm upgrade cannot meet PHD and provides up to 129 l/s fire flow @ MDD
450 mm upgrade meets PHD and provides up to 148 l/s fire flow @ MDD
500 mm upgrade meets PHD and provides up to 160 l/s fire flow @ MDD
600 mm upgrade meets PHD and provides up to 172 l/s fire flow @ MDD

Conclusion: Size upgrading to 450 mm can meet PHD but does not provide sufficient fire flow improvements. Additional upgrading beyond 450 mm does not provide sufficient fire flows due to the restrictions in the existing 350 mm trunk main, Pressure Reducing Valve (PRV) and metering station upstream of the existing development on Range Road.

The existing metering station near the Range Road recirculation station near Crow Street creates some restriction in the 350 supply main. Bypassing the metering station with a PRV to allow increase fire flows to bypass the meter, results in improved fire flows up to 163 l/s from 148 l/s. If the PRV is set at 30 m, all flows up to PHD are fully metered, and the PRV opens only during fire flows.

Upgrading of additional existing 350 mm along Range Road to 450 mm all the way to the Range Road PRV station, approximately 1450 m, can provide increased fire flows up to 228 l/s, but is not considered economical compared to other options, due to the high cost of replacement along the existing developed right of way, and crossing of Mountainview Drive. Other options should be considered which provide greater benefit for the costs.

Extension of a single supply source can provide the required long term PHD but cannot provide the fire protection requirements. An additional supply source is required to provide additional fire flow.

Scenario 3: Provide a 350 mm supply line from the McIntyre Creek area to service the proposed Porter Creek "D" development, and extend the service to Whistle Bend to provide domestic and fire flow. Supply is from the high pressure, Service Area 3, tied into the existing Porter Creek trunk main in the vicinity of Porter Creek "D" development. This is shown as Option 2.

Assessment: Meets 25% ADD, MDD, PHD and provides up to 154 l/s fire flow @ MDD.

Meets 50% ADD, MDD, PHD and provides up to 133 l/s fire flow @ MDD.
Meets 75% ADD, MDD, cannot meet PHD and provides up to 111 l/s fire flow @ MDD.
Meets 100% ADD, MDD, cannot meet PHD and provides up to 90 l/s fire flow @ MDD.

A test run was made with this trunk main tied to the low pressure side of McIntyre Creek pumphouse. At all develop horizons, the trunk main experiences negative pressures during fire flow conditions, therefore it is not recommended to tie this line to the low pressure, Service Area 2 supply, and this trunk main should not be considered as the primary supply source for Whistle Bend due to increased pumping requirements when connected to the high pressure Service Area 3.

This scenario provides similar results to Scenario 1, Option 1, but is not preferred because all consumption is from Service Area 3 requiring additional pumping at McIntyre Creek pumphouse.

Scenario 4: Supplement fire flow only, for Option 1, with a 350 mm supply line from the McIntyre Creek area to service the proposed Porter Creek "D" development, and extend the service to the Whistle Bend to provide additional fire flow. Supply is from the high pressure, Service Area 3, tied into the existing Porter Creek trunk main in the vicinity of Porter Creek "D" development. This combines Options 1 and 2.

Assessment: Meets 25% ADD, MDD, PHD and provides up to 350 l/s fire flow @ MDD.
Meets 50% ADD, MDD, PHD and provides up to 332 l/s fire flow @ MDD.
Meets 75% ADD, MDD, PHD and provides up to 302 l/s fire flow @ MDD.
Meets 100% ADD, MDD, PHD and provides up to 291 l/s fire flow @ MDD.

A test run was made with this trunk main tied to the low pressure side of McIntyre Creek pumphouse. At all develop horizons, the trunk main experiences negative pressures during fire flow conditions, therefore it is not recommended to tie this line to the low pressure, Service Area 2 supply.

Note that the high pressure supply provides only the additional fire flow requirements; therefore normal consumption is from Service Area 2 resulting in reduced pumping requirements at McIntyre Creek pumphouse.

Scenario 5: Provide a 300 mm fire/emergency supply connection to Wann Road. This option was previously recommended as a possible alternate/backup supply for Whistle Bend. This is shown as Option 3.

This option was modeled with and without the Scenario 4 connection.

Assessment: without Scenario 4 connection:
Meets 25% ADD, MDD, PHD and provides greater than 315 l/s fire flow @ MDD
Meets 50% ADD, MDD, PHD and provides 307 l/s fire flow @ MDD.
Meets 75% ADD, MDD, PHD and provides 298 l/s fire flow @ MDD.
Meets 100% ADD, MDD, PHD and provides 288 l/s fire flow @ MDD.

In combination with Scenario 4 connection:

Meets 25% ADD, MDD, PHD and provides 387 l/s fire flow @ MDD.

Meets 50% ADD, MDD, PHD and provides 371 l/s fire flow @ MDD.
Meets 75% ADD, MDD, PHD and provides 349 l/s fire flow @ MDD.
Meets 100% ADD, MDD, PHD and provides 328 l/s fire flow @ MDD.

Note: without an upgrade of a short section of 200 mm on Wann Road, this scenario produces low pressures in the area of Hickory, Green and Tamarack. Upgrading the short section of 200 mm to 300 mm results in acceptable residual pressures in the upper Porter Creek Service Area and an increase in fire flows to 288 or 328 l/s @ the 100% build-out horizon.

Assessment Summary

- A single 350 mm supply source from Range Road to Whistle Bend can meet the ultimate ADD and MDD but cannot meet the 100% build-out PHD, and can only provide 91 l/s fire flow at the ultimate MDD demand. This scenario is shown as Option 1.
- A single 350 mm supply source from McIntyre Creek (Porter Creek "D" area) can meet ADD and MDD but cannot meet the 75% and 100% build-out PHD, and can only provide 90 l/s fire flow at the ultimate MDD. This scenario is shown as Option 2.
- Both Options provide similar level of service, however the Range Road option is preferred as the primary supply source, as all domestic consumption is from Service Area 2 resulting in reduced pumping requirements. Pumphouse upgrades at McIntyre Creek pumphouse are therefore not required. Option 1 is also shorter, but requires a creek crossing, so installation costs are similar. Option 2 has the advantage of providing service for both Porter Creek "D" and Whistle Bend.
- Connecting Option 2 to the low pressure service area does not provide adequate service pressures in the proposed Porter Creek "D" area during fire flow conditions; therefore, this scenario is not suitable. Negative pressures are developed in Option 2 due to the increased length of main (almost twice as long, and reduced pipe size) resulting in higher friction losses. Ground elevations are also higher in the future Porter Creek "D" area, than along Range Road. Negative pressures would occur at high points in Porter Creek "D" area as a result. Negative pressures do not occur along Range Road because of the reduced pipe length, with limited flows and velocities.

  Ground elevations in Porter Creek "D" vary from approximately 700 m to 725 m. If serviced from Valleyview reservoir pressures would range from 285 kPa to 580 kPa. Many services would require booster pumps. This could be considered as an option; however, there are other issues such as low and negative pressures during fire conditions, which make this option undesirable.
- Option 1 is the preferred supply source and can provide 152 l/s fire flow at the 25% build-out development horizon, and 135 l/s at the 50% build-out horizon. These fire flows are likely sufficient to service the development up to this development horizon when fire flow demands will be primarily for residential development. Beyond the 50% build-out horizon, fire flow demands will likely increase as commercial and institutional development occurs.
- If the Porter Creek "D" development begins within the 50% build-out development horizon, Option 2 should be constructed to service Porter Creek "D", and be extended to the Lower Bench to meet the additional fire flow requirements providing up to 332 l/s at the 50% build-out horizon, 302 l/s at the 75% build-out horizon and 291 l/s at the ultimate 100% build-out horizon. This also provides a second supply source for security of domestic supply.

- If the Porter Creek "D" development does not take place, and alternate 300 mm fire flow connection can be made to Wann Road to provide 307 l/s fire flow at the 50% build-out horizon, 298 l/s at the 75% build-out horizon, and 288 l/s at the ultimate 100% build-out horizon. See Option 3. A short section of existing 200 mm main on Wann Road should be upgraded to 300 mm with this scenario. This results in acceptable residual pressures in upper Porter Creek, and increased fire flows in Whistle Bend. This option also can provide a second supply source for security of domestic supply.
- Option 2 is twice the length of Option 3 but has the added benefit of servicing up to 400 proposed lots in the Porter Creek "D" area, therefore Option 2 is preferred over Option 3 to provide the additional fire flow requirements in Whistle Bend, but only if the Porter Creek "D" development is going ahead as proposed.
- If, after both Option 1 and 2 have been constructed, there is a need for additional fire flow requirements in Whistle Bend above the available 291 l/s, then Option 3 could also be constructed to provide additional fire flows up to 328 l/s. Further increases in fire flow are possible with additional upgrading of existing 250 mm and 300 mm watermains along Wann Road, to 400 mm. However, the incremental gains in fire flow may not justify the costs for these additional improvements.
- A review of the actual fire flow requirements at the various development horizons will help determine the most appropriate secondary supply option.

Piped System Extension Recommendations

- Construct an extension of the existing 350 mm trunk main along Range Road to service Whistle Bend. Upgrading to 450 mm for this new section can meet the ultimate PHD for Whistle Bend. This option should provide adequate domestic demand and fire flow demand up to approximately the 50% development horizon, depending on the ultimate development density and fire flow requirements. *Fire flow requirements will have to be monitored to determine when additional fire flow supply is required.* This option results in lower pumping costs as all consumption is from Service Area 2. See Option 1.

  Two options for extending the waterman were considered and shown. Both options require crossing of McIntyre Creek.

  An alignment along the road is longer, and still requires a creek crossing. The crossing could however be installed in the crossing backfill, above the existing culvert, or suspended from a bridge crossing.

  The shorter crossing through the existing valley also requires a creek crossing. The suggested drilled or jacked crossing could be desirable under a YESAA review, as it results in minimal impact on the existing creek. A further geotechnical investigation of this option found the in-situ conditions not favourable for a drilled crossing of the valley. In addition, the crossing right of way would require maintenance access. Therefore, Option 1A is rejected and not considered further.

- If Porter Creek "D" is constructed within the 50% build-out development horizon, construct a new 350 mm trunk main from the high pressure side of McIntyre Creek to service the Area D development. Extend this trunk main to Whistle Bend to provide the additional fire flow requirements for development beyond the 50% build-out horizon. See Option 2. A pressure reducing valve will be required on this supply. The downstream pressure setting will ensure that only fire flows are drawn from this supply. All domestic consumption will be from Area 2 along Range Road. A small residual flow will be required to prevent freezing and stagnation in this main during non-fire conditions. A

controlled bypass could be provided in the PRV vault. The required bypass flow is a detailed design issue which cannot be identified at this time and requires more information such as pipe depth, ground conditions, etc. Freeze protection requirements will be dealt with at the detailed design stage, to maintain a suggested minimum velocity of 0.15 m/s which is the suggested minimum in the Cold Climate Utilities Manual.

The routing for this connection would be along the proposed Mountainview Drive to Range Road Connector. The road will be staged, with two (2) lanes constructed initially, and the ultimate four-lane configuration being added later. The future trunk watermain would therefore be installed under the future lanes or future shoulder.

- If Porter Creek "D" is not going to be developed with the 50% build-out horizon, then construct an alternate 300 mm fire supply from Whistle Bend to Wann Road to provide the additional fire flow requirements for the lower bench. Upgrade a short section of 200 mm on Wann Road to 300 mm to provide better residual pressures in upper Porter Creek and increased fire flow to the lower bench. See Option 3. A pressure reducing valve will be required on this service. The downstream pressure will be set to ensure that only fire flows are drawn from this supply. All domestic flow will be from Area 2 along Range Road. A small residual flow will be required to prevent freezing and stagnation in this main. A controlled bypass can be provided in the PRV vault. (See note above with respect to bypass flow requirements.)

3.6 Other Off-Site Water System Impacts

Additional off-site water system infrastructure affected by the Whistle Bend development includes:

- Selkirk intake supply and well supply
- Selkirk Pumphouse
- Two Mile Hill Booster Pumphouse
- McIntyre Creek Pumphouse
- Valleyview Reservoir
- Porter Creek Reservoir

Selkirk Intake Supply and Well Supply

In 2007, Gartner Lee completed a groundwater assessment and test drilling program. They identified the best potential for additional ground water was in the Riverdale area. A test drilling program identified an additional sub-aquifer below the existing Selkirk aquifer. The new sub-aquifer is capable of producing significant additional groundwater at temperatures between 5 and 7 degrees Celsius.

In 2007, a new warm water well (No. 5 N) was developed and tied into the City water supply system. The new well is capable of producing a long term yield of 168 l/s. Four existing wells in the existing Selkirk aquifer can produce up to 190 l/s. Two additional production wells were drilled in 2008 in the lower aquifer, and produce an additional 70 l/s and 90 l/s each. This brings the total groundwater production to approximately 500 l/s. Production meets the current and proposed ultimate MDD depending on development in other areas of the City.

Upgrading requirements for the Selkirk Pumphouse and the siphon intake will be impacted by the extent and capacity of additional ground water well development. The City would prefer to use ground water to avoid the need to construct a new water filtering station. During periods of high turbidity, the surface water use must be restricted and supplemented with ground water. Warm ground water is also used to temper the surface water during the cold months of the year. If ground water production is available, the siphon intake and Selkirk Pumphouse upgrading can be delayed or possibly avoided. If ground water wells are developed with high head pumps, the existing Selkirk booster pumps could be by-passed completely avoiding the need for upgrading. A detailed assessment of the existing and proposed well production and Selkirk Pumphouse capacity is being done in conjunction with a new well pump study being done by others.

The current intake is a twin siphon from Schwatka Lake with a single supply line from the siphon to the Selkirk Pumphouse. The current intake capacity is approximately 440 l/s. The current City-wide MDD is approximately 300 l/s. With the addition of the Whistle Bend, the MDD would increase to 387 l/s at ultimate build-out of Whistle Bend only. The expected ultimate MDD for the overall serviced area, plus the addition of Whistle Bend is 677 l/s, based on an assumed overall population of approximately 45,000, 10,000 of which will reside in Whistle Bend. This assumes Whistle Bend consumption rates at 375 lpcd and other area consumption rates at 500 – 600 lpcd, as per the Stantec report.

Since the City is planning to use a total ground water supply, the existing intake will not require upgrading. The intent is to keep the existing intake in place as an emergency supply. The capacity of the intake, together with the current well capacity is sufficient to meet the anticipated ultimate MDD requirements for the City.

Selkirk Pumphouse

The current capacity of the Selkirk Pumphouse is 341 l/s. This capacity is sufficient for the current MDD, but will not meet the ultimate MDD with addition of Whistle Bend, beyond the 25% development horizon. Due to on-going development in other areas of the City, Stantec recommended upgrading of the Selkirk Pumphouse within 5 years. The current pumphouse cannot be economically upgraded as there is insufficient room for expansion, and the piping is considered to be beyond its service life.

The capacity of the existing Selkirk Pumphouse can be improved slightly by pumping production wells on the suction side of the booster pumps. However, the increased capacity is only sufficient to MDD demands with the addition of Whistle Bend to the 25% development horizon.

Two Mile Hill Booster Station

The current capacity of the Two Mile Hill Booster Station is 345 l/s. This is sufficient to meet current MDD and the addition of Whistle Bend up to the 25% development horizon. The Two Mile Hill Booster was designed to accommodate two additional pump units to provide up to 500 l/s MDD. At least one additional pump unit will be required within the initial development phases, and the second additional pump required prior to the ultimate development.

McIntyre Creek Pumphouse

The current capacity of the McIntyre Creek Pumphouse is 90 l/s. The current MDD for the Service Area 3 is 74 l/s. If Whistle Bend is serviced from Service Area 2, no upgrading is required at the McIntyre Creek

pumphouse. If Area D is developed, the McIntyre Creek pumphouse will have to be upgraded to accommodate that separate development.

The additional MDD suggested for the proposed Porter Creek "D" area was identified by Stantec as 16.4 l/s. The current MDD is 74 l/s and the estimated capacity of the pumphouse is 90 l/s. If only Area D was developed, the pumphouse would have just enough capacity; however, any additional development in upper Porter Creek, Crestview or Kopper King also impacts the demands on the pumphouse. Upgrading of the pumphouse will depend on rate of development in all these areas, as well as the proposed Porter Creek "D" development.

Valleyview Reservoir

The Valleyview reservoir is a buried concrete structure consisting of two rectangular cells with a current effective storage capacity of 5,030 m^3. The following table outlines the recommended storage capacity from the current case through to the ultimate build-out of Whistle Bend.

Valleyview reservoir can supply fire storage for the anticipated 50% development horizon which assumes fire flow requirements would not exceed 150 l/s based on mainly residential development. The current fire storage for Valleyview is based on 250 l/s for 3.5 hours (Stantec). Fire storage is available, but the proposed distribution system can only provide up to 150 l/s.

Table 3.3 - Valleyview Reservoir Storage Requirements

	Current case		25%		50%		100%	
	Requirement	Capacity	Requirement	Capacity	Requirement	Capacity	Requirement	Capacity
Fire Storage	250 lps for 3.5 hr	3,150	250 lps for 3.5 hr	3,150	300 lps for 4 hr	4,300	300 lps for 4 hr	4,300
Emergency Storage (100% ADD)	100% x 26.3 lps	2,300	100% x 74.3 lps	6,420	100% x 83.3 lps	7,200	100% x 117 lps	10,110
Balancing Storage (25% MDD)	25% x 52.7 lps	1,150	25% x 148.6 lps	3,210	25% x 166.6 lps	3,600	25% x 234 lps	5,055
Total req		**6,600**		**12,780**		**15,100**		**19,465**
Deficiency from current		**1,570**		**7,750**		**10,070**		**14,435**

The additional reservoir capacity can be phased as follows:

- add 2 additional 5,000 m^3 cells immediately to meet the current storage shortfall for Area 2 and the additional Whistle Bend storage requirements up to the 50% development horizon.
- at 50% build-out, construct an additional 5,000 m^3 cell to meet the ultimate development requirements.

The recommended sizing of the Valleyview reservoir is slightly higher than Stantec's suggested size because the design population for Whistle Bend has been increased by 30%. Also the recommended fire storage is increased slightly. The proposed sizing includes an allowance for future developments in Zone 2, but is based on Stantec's assumptions for development densities in these areas. This may have to be reviewed if higher density developments are planned for the future.

Upgrade staging is dependent on the rate of anticipated development, and the areas affected. We have assumed a 20 year development horizon for Whistle Bend. Pre-building required future storage 10-15 years in advance may not be cost effective, especially if development trends change in other areas during that time. As long as adding cells is a feasible alternative, it is preferable from a net present value (NPV) perspective. Available land at the existing reservoir site should be confirmed.

Porter Creek Reservoir

The Porter Creek reservoir is a single cell buried circular concrete structure with a current effective storage capacity of 5,190 m^3. The recommended storage capacities are indicated in Table 3.4.

Table 3.4 - Porter Creek Reservoir Storage Requirements

	Current Case		Ultimate	
	Requirement	Capacity	Requirement	Capacity
Fire Storage	250 lps for 3.5 hr	3,150	300 lps for 4 hr	4,300
Emergency Storage (100% ADD)	100% x 37 lps	2,700	100% x 51.1 lps	4,415
Balancing Storage (25% MDD)	25% x 74 lps	1,350	25% x 102.2 lps	2,210
Total required		7,950		10,925
Deficiency from current		2,760		5,735

Note that the ultimate capacity is based on additional demands for the Porter Creek "D" development and fire flow only for Whistle Bend. The current storage deficiency is offset by the fact that the McIntyre Creek pumphouse can provide more than the current MDD; therefore, domestic storage can be maintained.

The current storage deficiency does not impact the Whistle Bend development as all supply and fire flow can be provided from the Valleyview reservoir up to the 10 year development horizon.

If the proposed Area D development proceeds within the 10 year development horizon both the McIntyre Creek pumphouse and the Porter Creek reservoir should be upgraded to meet the increased supply and storage demands for that development. If Porter Creek "D" does not proceed before the 50% development horizon, Porter Creek reservoir (Service Area 2) should be upgraded to meet the additional fire flow requirements for Whistle Bend.

The Porter Creek reservoir will have to provide up to 150 l/s of additional fire flow to supplement available fire flow from Valleyview. Since a supply disruption from Valleyview could occur with only a single supply line, it may be essential to provide all fire flow from Porter Creek under this scenario. Therefore, Porter Creek should be sized to provide the ultimate fire storage to Whistle Bend, which is assumed to be 300 l/s beyond the 50% development horizon.

Therefore, construct 1 additional 6,000 m^3 cell, within either the 50% development horizon, or when the Area D development proceeds.

The Stantec report recommended the upgrading of Porter Creek reservoir immediately as it is a single cell reservoir, with minimal opportunity for maintenance, situated in a remote area at the end of a long single supply line. There is no potential for cascading of water from other higher head reservoirs.

However, Stantec also noted that the McIntyre Creek booster pumphouse can provide more than the MDD flow, therefore storage can be maintained.

Since the current storage deficiency at Porter Creek is minimal, and storage flows can be maintained, it is considered more important to upgrade the Valleyview reservoir first, as all domestic supply and storage for Whistle Bend will be from this reservoir.

With respect to the Porter Creek reservoir, we do not disagree that the Porter Creek reservoir requires upgrading, only that the priority of this upgrade has changed, with respect to the proposed Whistle Bend development. Stantec's recommendation was based on the assumption that Porter Creek "D" and infill, and also Kopper King development would likely precede the lower bench development.

Porter Creek reservoir is only marginally deficient, and has been so for many years. It could remain only marginally deficient for many more years, depending on the rate and timing of further Porter Creek development.

Our assessment and recommendations are based solely on our assumptions with respect to timing and rate of development for Whistle Bend and Porter Creek "D", and the required storage to service these new developments. However, other factors such as possible infill in Porter Creek, and highway commercial development at Kopper King could also impact the timing and priority of upgrading, but these factors are outside the scope of our assessment.

Other factors beyond the scope of our assessment, such as the current availability of funding, may supersede our recommendations, and the City should take all factors into consideration and plan the required upgrading based on all these additional factors.

Other System Infrastructure Impacts or Requirements

Other system infrastructure affected by the proposed Whistle Bend development includes the Range Road Pressure Control Vault, and the existing supply trunk mains between Selkirk, Two Mile Hill, McIntyre Creek and Range Road.

The Range Road PRV is set to control downstream pressure at 55 m (540 kPa). Tweaking of the Range Road PRV to allow slightly higher pressures in the Range Road trunk main can provide slightly improved fire flows to Whistle Bend in the short term.

Increasing the downstream pressure to 60 m (590 kPa) results in increased fire flows without negatively affecting static pressures in other lower elevation areas. The suggested increase of 5 m head (approximately 50 kPa) should not negatively impact the existing infrastructure. Takhini Trailer Park recently upgraded all their existing water system to new HDPE piping.

All existing trunk mains within the current distribution network have adequate capacity to meet the current and ultimate development demands for Whistle Bend. Only the suggested upgrade on Wann Road would be required to meet ultimate fire flow requirements.

3.7 Cost Estimates

Class D cost estimates for the various piped system extension options and recommended off-site infrastructure upgrades are included in Appendix B.

3.8 Proposed Implementation Schedule

The following implementation schedule is based on the assumed phased development of Whistle Bend. It also incorporates existing system deficiencies and impacts from the potential parallel development at Porter Creek Area D.

0% Build-Out

1. Construct a new 450 mm trunk main extension on Range Road to provide primary supply to Whistle Bend development (Option 1). Monitor fire flow requirements in Whistle Bend to determine when additional fire supply is required.

2. Add one booster pump to the Two Mile Hill Booster pumphouse.

3. Construct 10,000 m^3 of additional storage at the Valleyview Reservoir.

25% – 50% Build-Out

5. Construct 350 mm trunk main from McIntyre Creek area to service Porter Creek Area D development and provide additional fire flow for Whistle Bend area (Option 2).
   The timing will depend on actual fire flow demand in Whistle Bend.

6. Construct 6,000 m^3 additional storage at the Porter Creek reservoir.

7. If Porter Creek Area D is being constructed, upgrade the McIntyre Creek Pumphouse to provide additional MDD capacity.

50% to 100% Build-Out

8. Add additional booster pump at Two Mile Hill Booster Pumphouse.

9. Add a minimum additional 5,000 m^3 storage at the Valleyview Reservoir. Depending on development in other areas of the City, this minimum amount may have to be increased.

4. Separate Fire Supply Assessment

The 2006 Design Charrette identified a separate fire and non-potable water supply system as an initiative worth exploring further. The general idea was that a separate system utilizing a direct supply from either the Yukon River or groundwater would result in savings to the domestic supply system. As part of the off-site servicing investigation, we have carried out a conceptual assessment on the feasibility of a separate system.

Maximum fire flow demand is dictated by the maximum City pumper truck capacity of 300 l/s, based on a maximum of 3 pumpers at 100 l/s each responding to a fire. This demand would be reasonable for commercial, institutional and multi-family residential areas in Whistle Bend. For single family residential the criteria would be a required fire flow of 150 l/s. As the development concept is still to be resolved, we used the charrette concept and an ultimate population of 10,000 for this assessment.

4.1 Alternative Fire Flow Source

An intake on the Yukon River would be feasible in the vicinity of the existing sanitary force main crossing. Issues such as silt in the water and winter freezing would have to be considered in the intake and pump station design.

Potential groundwater sources are the pothole depressions at the north end of the site. There are two of these features with the western one about 9.5 m deep and the eastern one about 16 m deep. Our geotechnical consultant speculates that the potholes are hydraulically connected to the river but this has not been confirmed via test wells. Our analysis assumes that the desired flow is achievable.

These alternative sources for fire flow would require water board and YESAA approvals.

Preliminary pump sizing for both scenarios and for 300 l/s and assuming 75% efficiency, indicates 650 HP (485 kW). See Appendix C for the assumptions and calculations.

Another option would be to utilize storm water retention ponds for the supply and have the pumper units pump directly from the ponds. We do not consider this a reliable option as freezing during the winter and dry up during the summer would be a problem. Additionally, fire crews would have to rely on tankers to transport water to sites that are some distance from the ponds. While this is acceptable practice in low density rural areas, it would not be acceptable in a high density development such as Whistle Bend.

4.2 Fire Flow Distribution System

To provide adequate flows and a residual pressure of 140 kPa, a system consisting of a 350 mm trunk from the supply source and along the principal roads and 250 mm looped system within the various neighbourhoods has been assumed. Based on the charrette plan and a rule of thumb of 40 m of road per acre of developable land, a total main length of 21,000 m with 235 hydrants and 300 valves has been calculated.

The primary challenge to overcome in such a system that is essentially a stand-by emergency system would be freeze protection. Therefore, a recirculation and heating system would be required.

4.3 Construction Cost Comparison

The feasibility level cost estimates in 2008 dollars are included in Appendix C. The base case is a conventional combined domestic and fire flow system. This base case is compared to separated systems. For this high level assessment, we have used the same cost for the river intake option and the well option for the separate fire supply system. The summary of this comparison is indicated in the following table:

Table 4.1 – Construction Costs

System	Construction cost including contingency
Combined domestic and fire flow system	**$17.4 million**
Separate fire flow system	$17.5 million
Separate domestic system	$9.8 million
Total for separate systems	**$27.3 million**

In summary, separate fire supply and domestic supply systems for Whistle Bend would cost approximately $10 million, or 55%, more than the cost of a conventional combined system. While separate systems require duplication of systems, modeling determined that the only real saving realized by a separate domestic system was a pipe size reduction from 300 mm to 200 mm. Note that this high level analysis does not take into account some reduction in the required increased reservoir capacity that would be realized with separate systems. It also does not take into account additional operation and maintenance costs that would be required for the ongoing operation of separate systems. And any savings in disinfection costs for the City system are minor at best, as fire flows are required only intermittently during emergency events and system flushing.

In conclusion, our finding is that a separate fire supply system is not cost effective and would place an unreasonable burden on the City's operational budget and provide minimal benefit. We recommend that Whistle Bend incorporate a conventional domestic and fire supply system connected to the existing City system as detailed in Section 3.

5. Wastewater Servicing

5.1 Background Information

Using sewage flow data for 2006, 2007 and 2008 year to date provided by the City and the 2006 Census Data, we have calculated the Porter Creek Flush Tank (PCFT) average daily flows equal 547 lpcd. This flow was based on a serviced population of 3,353, which was calculated by comparing the census dissemination areas against the PCFT sewer catchment area. It should be noted that the 2004 Stantec report listed a population of 4,139 for the PCFT catchment (498 lpcd flow). This information is summarized in the following table.

Table 5.1 - Summary of Existing Wastewater Flows for the Porter Creek Flush Tank

Year	Assumed Serviced Population	PCFT Sewage Flows (lpcd)	Source
2001	4139	498	Jan 2004 Stantec Report
2006	3353	547	2006 Census and City Data

The existing PCFT sewer catchment area is located on the Upper Porter Creek (UPC) bench and includes three minor pumping stations that discharge wastewater via gravity sewers to the PCFT, which is located at the intersection of Larch and Oak Streets. When full, the flush tank drives wastewater through a 4 km, 450 mm nominal diameter force main by gravity to the Livingston Trail Environmental Control Facility (LTECF) for treatment.

According to the May 1996 David Nairne & Associates' Porter Creek Effluent Transfer Design Brief, the system was sized to service an ultimate upper and lower Porter Creek population of 14,412 with a peak flow of 209 l/s. The hydraulic capacity of the system is 221 l/s.

From data provided by the City for the PCFT (see Appendix D), the following flows were calculated:

- 2006 average daily flow = 21.2 l/s
- 2006 maximum daily flow = 33.5 l/s
- 2007 average daily flow = 20.2 l/s
- 2007 maximum daily flow = 31.4 l/s
- 2008 YTD (to July 17) average daily flow = 23.3 l/s
- 2008 YTD (to July 17) maximum daily flow = 31.4 l/s

Stantec's January 2004 water and sewer study estimated the ultimate UPC area to be approximately 437 ha with a population of 6,065. Using these figures, a City water usage target of 500 lpcd and a 90% recovery rate, the ultimate Peak Wet Weather Flow (PWWF) for the UPC area can be calculated as 130 l/s. For system modeling purposes, we have assumed the following UPC wastewater flow characteristics:

Table 5.2 – Assumed UPC Wastewater Flow Characteristics

% Build-0ut	0	25	50	75	100
UPC Population (assumed Population Growth Rate = 2.5%)	3,701	4,187	4,738	5,360	6,065
UPC wastewater generation lpcd	547	525	500	475	450
UPC Average Dry Weather Flows (ADWF) l/s	23.4	25.4	27.4	29.5	31.6
UPC Peaking Factor (from Harman Equation)	3.36	3.32	3.27	3.22	3.17
UPC Peak Dry Weather Flow (PDWF) l/s	78.8	84.4	89.6	94.8	100.0
UPC Peak Wet Weather Flow (PWWF) l/s	109.1	114.7	119.9	125.1	130.3

For this study, we have applied the Harman Equation to determine the peaking factor. For small developments, this equation results in a peaking factor of approximately 4, which is the same as the peaking factor outlined in the City of Whitehorse Servicing Standard Manual (January 2007). However, the Harman Equation will reduce the peaking factor as the population increases, accounting for the attenuation of peak flows associated with larger development areas such as the UPC area and the proposed Whistle Bend development. An inflow and infiltration rate of 6000 l/ha/day was used as per the City of Whitehorse Servicing Standard Manual (January 2007).

5.2 Proposed Whistle Bend Development Wastewater Flows

As outlined in Section 2, we have assumed that a phased reduction in water usage from 500 lpcd to 375 lpcd will occur over the first 10 years of the development. Assuming a 90% recovery of water usage for wastewater flows, we have calculated the following wastewater discharge rates for Whistle Bend:

Table 5.3 – Wastewater Discharge Rates from Whistle Bend

Development %	0	25	50	75	100
lpcd	450	393.8	337.5	337.5	337.5
Population	0	2,500	5,000	7,500	10,000
ADWF m^3/day	0	985	1688	2531	3375
ADWF l/s	0.0	11.4	19.5	29.3	39.1
Peaking Factor (from Harman Eqn.)	NA	3.51	3.25	3.08	2.95
PDWF l/s (ADWF x Peaking Factor)	0.0	40.0	63.4	90.2	115.4
Contributing area (ha)	0.0	31.0	62.0	93.0	124.0
Inflow and Infiltration (I&I) l/s (Contributing area x 0.0694 l/s)	0.0	2.2	4.3	6.6	8.6
PWWF l/s (PDWF + I&I)	0.0	42.1	67.7	96.6	124.0

Note that the analysis is based on % build-out of Whistle Bend. However, a 20 year timeframe was assumed to investigate impacts from growth in Upper Porter Creek and for net present value costing.

To transport the above flows, it is assumed that the development will be serviced by a network of gravity sewers, minor pump stations and force mains, which will discharge to a major pump station. The final location of this major pump station is still to be determined but for this exercise we have located it northwest of the proposed Whistle Bend development area.

As the topography is flat, we expect that a collection system incorporating minor lift stations will be more cost effective than a gravity only system. The development area is large and sewer grades at the City's minimum slope criteria would lead to very deep sewers. This item will be addressed in more detail once the development concept is finalized and we proceed to preliminary design for the on-site servicing.

To facilitate phasing of the Whistle Bend development area, the onsite pump stations and force mains should be carefully designed to accommodate increasing flows over time.

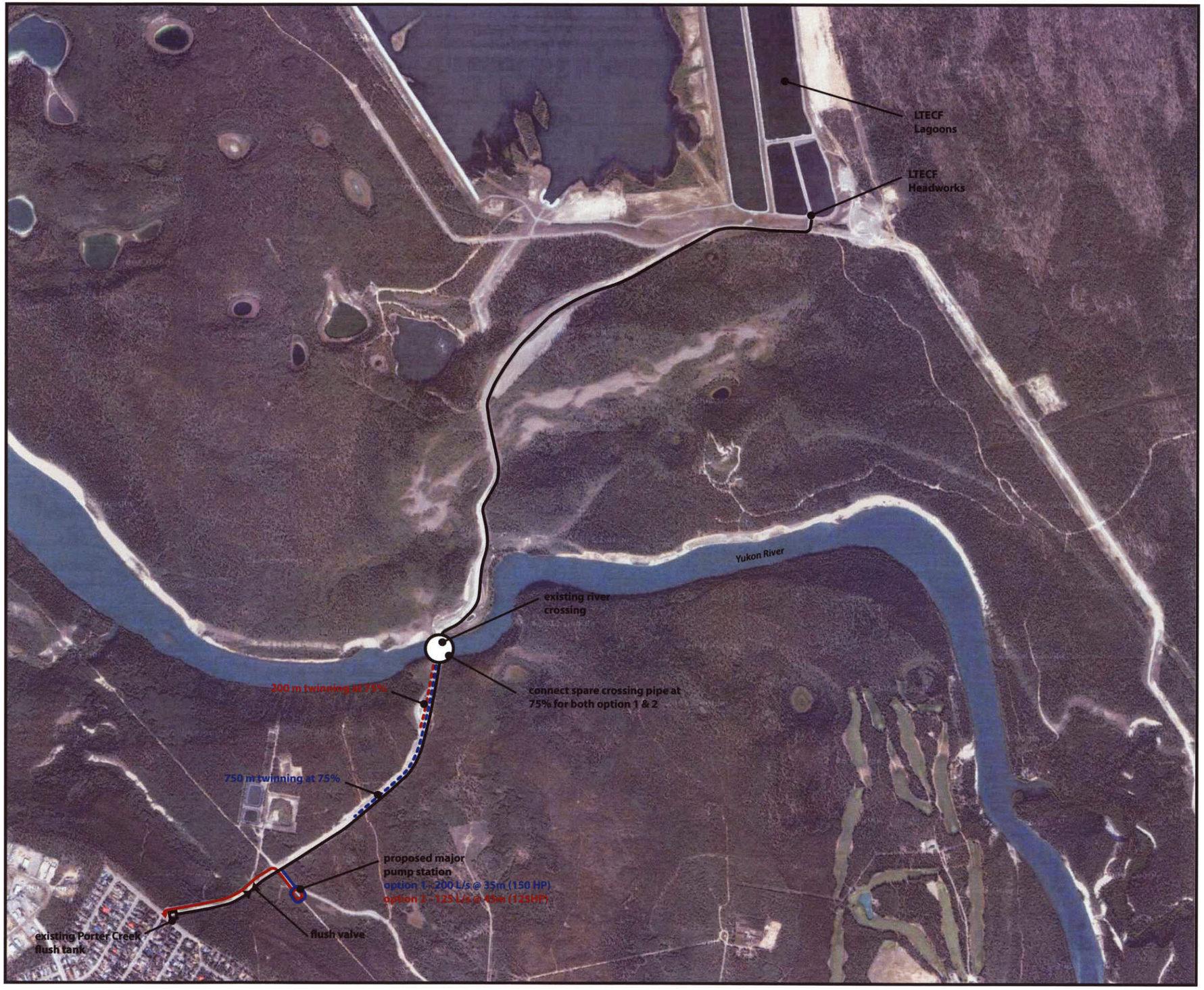
If possible, the preliminary development stages should be located in such a way that wastewater transportation distances are minimized. This will reduce the wastewater infrastructure required to service early land releases.

As discussed further below, the LTECF has sufficient capacity to accommodate both the proposed Whistle Bend development and future UPC growth.

5.3 Off-Site Wastewater Options and Implementation Schedule

Based on ultimate build-out for upper Porter Creek, the existing PCFT system currently has excess capacity to accommodate approximately 90 l/s of additional PWWF from Whistle Bend without any system augmentations. This is dependant on the actual growth and whether water usage is reduced to the City target of 500 lpcd.

Four options are identified for the off-site wastewater servicing of Whistle Bend. Each of these options were modeled in EPANET 2.0 and our findings are discussed in more detail below. Refer to Figure 2 for the options and the modeling results.



existing porter creek flush tank system

option 1 0%

option 1 75%

option 2 0%

option 2 75%

NOTE: 1. options 3 & 4 not shown
2. all proposed forcemains are 450mm nominal outside diameter (400mm inside diameter)

Scale 1:5000
1 Centimeter = 50 Meters
-200 0 200 400 600 800 Meters

Figure 2
City of Whitehorse
Whistle Bend
OFF-SITE WASTEWATER OPTIONS

AECOM

Revised March 16, 2008

Option 1 – Pump wastewater directly into the existing PCFT force main

This option would require a major pump station (200 l/s @ 35 m TDH; 150 HP based on 60% efficiency) with a rising main connecting directly into the existing PCFT force main as shown on the diagram in Appendix E. The duty flow rate of this pump station needs to be higher than the maximum anticipated Whistle Bend PWWF as it can only pump when the PCFT is not discharging. The Whistle Bend pump station will have to be interlocked with the PCFT control valve such that only one system operates at a time. The new pump station should not pump when the PCFT is discharging as:

- Pumping against the increased head resulting from the PCFT discharge would require additional energy; and
- Self-cleansing flow for the rising main between the PCFT and new rising main connection could not be guaranteed.

As flows from the proposed development increase, the existing PCFT force main restricts flows hydraulically. To provide the additional capacity required, twinning of the existing PCFT force main would be the best means of providing the additional capacity required. As there is still significant spare capacity in the main, twinning is not required until after 75% build-out. For this option, we have determined the following upgrade implementation timeline:

0% Build-Out

1. Construct new pump station (200 l/s @ 35 m) and 50 m long 450 mm diameter force main complete with tie-in to PCFT force main

25% Build-Out

2. Do Nothing.

50% Build-Out

3. Do Nothing.

75% Build-Out

4. Construct new 750 m long 450 mm diameter force main parallel to existing PCFT force main and connect existing second 450 mm river crossing (300 m), effectively twinning 1,050 m.

Option 2 – Pump wastewater up to the PCFT

This option would involve pumping wastewater from the proposed development via a force main directly to the PCFT on the upper bench as shown in Appendix E. The pump station flow requirement would be reduced from what is required for Option 1 as the flows from Whistle Bend would be accommodated along with flows from Porter Creek in each flush. To accommodate the additional development flows, the PCFT force main would eventually require an increase in capacity. As flows increase, the PCFT control

valve can eventually be left open as cleansing velocities will be more than adequate. Similar to Option 1, we have determined the following upgrading implementation timeline:

0% Build-Out

1. Construct new pump station (125 l/s @ 45 m; 125 HP based on 60% efficiency) and 370 m long 450 mm diameter force main up to the PCFT complete with tie-in

25% Build-Out

2. Do nothing.

50% Build-Out

3. Do nothing.

75% Build-Out

4 Construct new 200 m long 450 mm diameter force main parallel to existing PCFT force main and connect existing second 450 mm river crossing (300 m), effectively twinning 500 m.

Option 3 – New Pump Station to Pump both Whistle Bend and UPC flows to LTECF

This option involves abandoning the flush tank concept and collecting all flows from both Porter Creek and Whistle Bend at a new larger pump station and then utilizing the existing 450 mm system as the force main to the LTECF. This station would have to be sized to accommodate the ultimate peak flows for both areas, a total flow of 255 l/s. At a total dynamic head of 50 m, the pumps would be 300 HP. While feasible, this option would not benefit from the spare capacity in the PCFT system and would require significantly more installed horsepower. As this would have to be installed during the first phase of development, it would not be attractive from a net present value and operating cost perspective. This option is not considered further in this report.

Option 4 – Pump flows via a new rising main to the LTECF

This option involves the construction of a new pump station and separate force main between the development and the LTECF. While this option is plausible, it would not benefit from the efficiencies and economies resulting from connection to the PCFT system and its spare capacity. Furthermore, the system would have to be constructed in its entirety during the first phase of development. For this reason, this option is not considered further in this report.

Table 5.4 - Off Site Wastewater Options and Implementation

Description / % Build-Out	Option 1 **Pump WB flows directly into PCFT force main (200 l/s / 150 hp)**	Option 2 **Pump WB flows to PCFT (125 l/s / 125 hp)**	Option 3 **Pump both UPC and WB flows to LTECF (255 ls / 300 hp)**	Option 4 **Pump WB flows to LTECF via separate force main (125 l/s / 100 hp)**
0%	Install new 200 l/s pump station and 50 m force main	Install new 125 l/s pump station and 370 m of 450 mm force main to PCFT	Install new 255 l/s pump station and 50 m 450 mm gravity main and 50 m 450 mm force main	Install new 125 l/s pump station and 3,750 m long 450 mm force main to CTECF
25%	Do nothing	Do nothing	Do nothing	Do nothing
50%	Do nothing	Do nothing	Do nothing	Do nothing
75%	Existing PCFT force main at capacity: 221 l/s			
75%	Twin 750 m of 450 mm force main and connect 2nd river crossing pipe	Twin 200 m of 450 mm force main and connect 2nd river crossing pipe	Do nothing	Do nothing
NPV	$2.7 million	$2.3 million	Not calculated	Not calculated

Option 1 and Option 2 both require a major pump station. The lift station will have an emergency back-up generator. The station, as with any minor station, will be landscaped and finished to suitably blend into the development. The pump station for Option 2 has smaller capacity and will be less expensive to construct. Option 2 has a shorter twinned force main length requirement than Option 1. Option 2 also has a reduced present value economic advantage over Option 1. Also, as the installed pump horsepower is less, operating costs would be lower. We consider that Option 2 is the most cost effective means of transporting the proposed development wastewater flows.

5.4 Cost Estimates

Class D cost estimates in 2008 dollars and the calculated net present value for Options 1 and 2 can be found in Appendix E.

5.5 Other Off-Site Wastewater Infrastructure Impacts

From the David, Nairne & Associates design brief (June 7, 1996), the Livingston Trail Environmental Control Facility (LTECF) headworks capacity is a PWWF of 820 l/s and the lagoon capacity is an ADWF of 391 l/s.

The two areas discharging to the LTECF are the Marwell Lift Station catchment and Porter Creek area (including the proposed Whistle Bend development). PWWF flows from both these areas are discussed in more detail below.

LTECF Headworks Capacity

The Stantec report states that the Marwell Lift Station has a capacity of 502 l/s with two pumps running (there are 2 electric pumps with 2 diesel pumps providing 100% back-up capacity). The Stantec report also states that the upgrade of the Marwell Lift Station "can be avoided if composite sewage generation is reduced to 570 lpcd from 685 lpcd and beyond Copper Ridge and Riverdale Expansion are not serviced through Marwell Lift Station." However, the report also suggests that Lift Station #1 could be upgraded to handle beyond Copper Ridge flows and discharge directly to LTECF.

The calculated ultimate PWWF for the UPC area is 130 l/s and the ultimate PWWF for the proposed Whistle Bend development is 124 l/s.

The ultimate PWWF discharged to the LTECF headworks from the Marwell Lift Station and the Porter Creek area (including Whistle Bend) combined is approximately 756 l/s, which is less than the 820 l/s LTECF headworks capacity.

Flows discharged to the LTECF should be monitored and the LTECF headworks may need to be upgraded if:

- The Marwell Lift Station starts using more than two pumps to transport peak flows
- The Marwell Lift Station is upgraded beyond the 502 l/s capacity
- New flows are pumped to the LTECF

LTECF Lagoon Capacity

The LTECF lagoons have been sized based on an average dry weather flow of 391 l/s. The Stantec Ultimate ADWF for Marwell Lift Station was 218 l/s. The ultimate ADWF for the UPC area is approximately 32 l/s and the ultimate ADWF for the Whistle Bend development is approximately 39 l/s.

The ultimate ADWF arriving at the LTECF headworks from the Marwell Lift Station and the Porter Creek area (including Whistle Bend) is approximately 289 l/s, which is less than the LTECF lagoon capacity.

We note that the City already has a design in place for an additional secondary cell for the LTECF for when the City population exceeds 35,000. However, the proposed Whistle Bend development is not expected to take the City population to this level.

Therefore, the LTECF headworks and lagoons have adequate capacity to accommodate the additional flows from Whistle Bend and we do not anticipate any upgrade requirements.

LTECF Odor Control

Odors from the LTECF lagoons have been reported as a nuisance issue in the City, and the proximity of Whistle Bend to the LTECF may exacerbate the issue. The sulphide levels may be considered a health issue and there is also the possibility that mitigation measures will need to be addressed as part of a YESAA submission. Furthermore, the perceived odor problem may impact the saleability of new lots in Whistle Bend. G.J. Bull & Associates Air Quality Assessment for the Lower Bench from July 2005, took a

high level look at the issue and did suggest some mitigation measures. Other than being identified as a potential issue, the odor problem and possible control measures are beyond the scope of this report and are being investigated further with the Yukon Government and the City of Whitehorse.

6. Porter Creek Lagoon's Remediation

The lagoon system consists of two approximately 5.5 m deep lined treatment lagoons in series connected to the Yukon River via a 300 mm outfall. The system was disconnected in 1996 when the Livingston Trail Environmental Control Facility (LTECF) was built and Porter Creek was connected via the flush tank and gravity force main. The lagoons were not drained or pumped out at that time.

In addition, a sludge drying pit was used by induction trucks to dump sanitary waste up to 3 to 4 years ago.

As the first step in developing a scope of work to decommission the lagoons and drying pit, the quantity and quality of the supernatant and sludge in the lagoons and dried out sludge in the pit has to be determined. Based on assumed depths, these volumes have been estimated. The letter report is attached in Appendix F. In summary the two lagoons and the drying pit are estimated to contain between 8,500 to 10,000 m^3 of supernatant and 1,900 to 3,300 m^3 of sludge. These volumes will have to eventually be confirmed via sampling and analytical testing will be required to determine if there are contaminants that will impact the transportation and disposal of the material.

7. Drainage

7.1 Proposed Development

The proposed Whistle Bend development is to adopt sustainable drainage principles in order to achieve the stated goal of no net increase of water run-off from the development. In order to achieve this goal, the reduction of run-off will need to become a major component of the site development and the municipal infrastructure. Furthermore, the recommended drainage strategies have to be practical for the North. With this in mind, our recommendations are based on systems outlined in the Alberta Environment Servicing Standards and implemented in Edmonton and northern Alberta.

Mixed residential, commercial and institutional development would normally result in approximately five to seven hundred percent increase in run-off created when compared to undeveloped lands depending on the current drainage characteristics of the undeveloped land. In order to achieve the no net increase goal, the development will need to reduce the effective drainage coefficient from approximately 0.7 to 0.35. This 50% reduction in run-off and delay can be achieved through various strategies including (see Appendix G for details):

- Reduce the foot print of the buildings and parking areas and increase the percentage of green space within the development:
    - Use of water gardens (flat areas of planting with 600 mm to 1,000 mm depth of topsoil) and depressed ponding areas
    - Infiltration systems connected to roof leaders and sumps where soil conditions are favourable
    - Use of pervious pipe systems and pervious catch basins where soil conditions are favourable
    - Use of permeable pavement for parking surfaces
    - Use of storage and reuse ponds

The municipal infrastructure, specifically roadways, would normally result in a five hundred percent increase in run-off created when compared to undeveloped lands. In order to reduce this run-off, we recommend that the hard surfaced areas be reduced by decreasing the paved surface widths and increasing green space. The reduction of road width from 11.5 metre on a 24.5 metre right-of-way to 9.0 metres of a 25 metre right-of-way reduces the drainage coefficient from approximately 0.5 to 0.35. The inclusion of an infiltration trench and connection to the infiltration trench at each catch basin could also be incorporated to help reduce water run-off further (see marked up City of Whitehorse typical street section in Appendix G). This possible reduced road width will have to be coordinated with transportation planning as it would impact available parking. Another strategy that reduces the impermeable road surface and encourages infiltration is the use of permeable pavers in the parking lanes.

7.2 Minor / Major Drainage Design Criteria

The minor storm collection system will still need to be designed to convey a 1 in 5 year storm, but due to the reduction of run-off coefficients and the delay that will take place as the run-off travels through the various systems, the storm sewers can be smaller diameter. The time of concentration can be reduced from a normal time of approximately 10 minutes to up to 30 minutes depending on the size of the lots and systems implemented.

The piped system will then discharge into grass swales that will meander their way to stormwater detention facilities. We envision a single detention facility per phase of development.

The swales and detention facilities will be designed for a 1 in 100 year storm event with the discharge restricted to the pre-development flow rates. The stormwater management facilities and swales could also be incorporated into the existing golf course as water hazard features and used for irrigation of the golf course and parks areas. Locations of these facilities would need to be selected. The existing pothole depressions at the north end of the site and identified on Figure 3 below should definitely be incorporated into the system. The detention facilities could be excavated to connect to the existing gravel seams and incorporate infiltration into their designs. These facilities should be set back away from any steep slopes to the river and outfalls will need to be carefully designed and preferably use existing drainage features in the area (i.e. the potholes).

By locating the detention facilities such that infiltration occurs, we do not expect that stagnant water will be an issue. If there is any stagnant water, a mosquito abatement program will be required.

Addressing snow melt and winter maintenance of both the minor and major systems will have to be incorporated into the design.

7.3 Storm-Water Quality

The various systems mentioned above and included in Appendix G will also provide enhanced water quality for the run-off from the development. If desired by the City, the addition of oil/grit separators at the outlet locations may further enhance the run-off water quality. We however do not see them being required as the recommended systems should achieve the same results. Additionally, the separators would then become an additional City maintenance item.

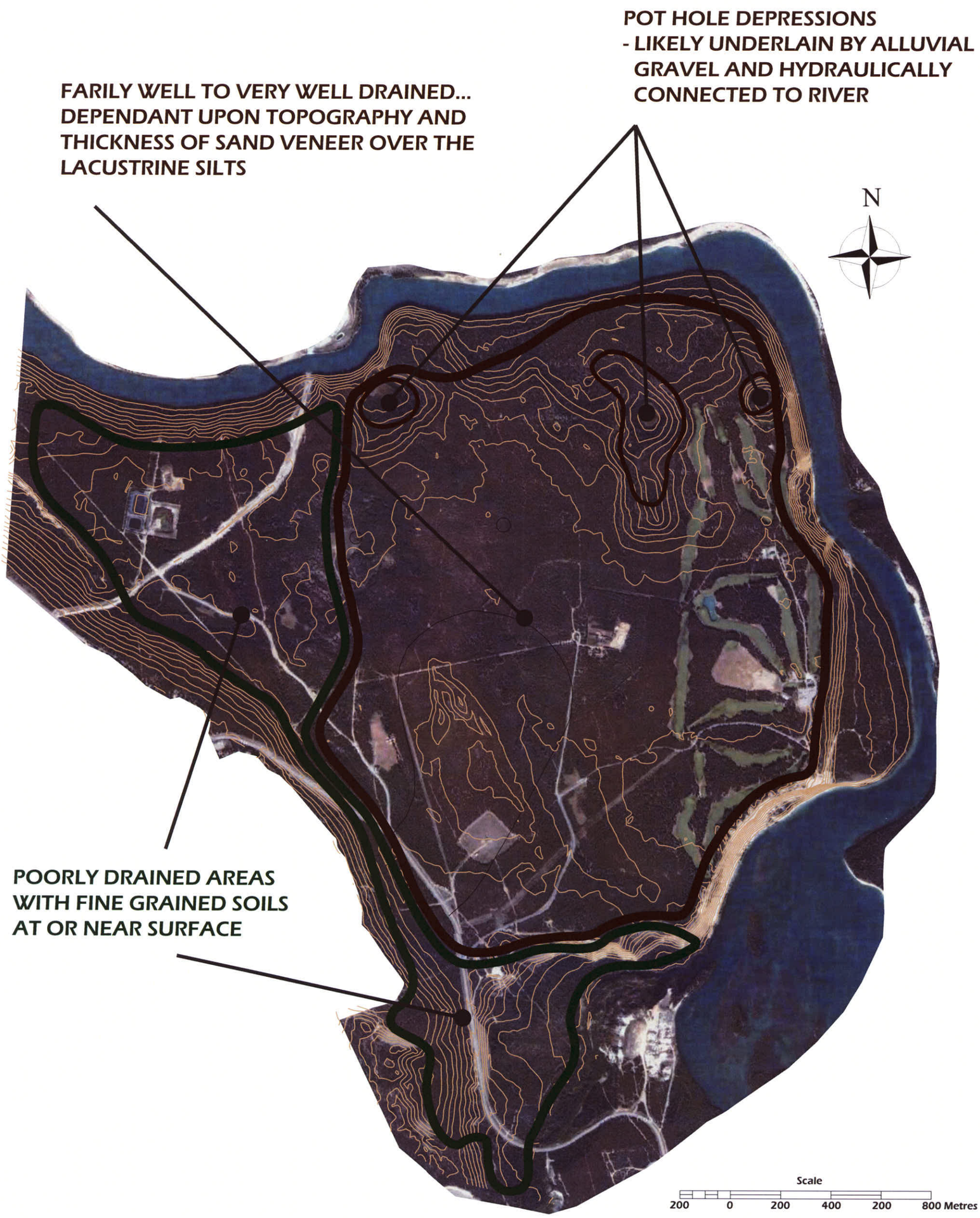


Figure 3

AECOM

Revised August 20, 2008

City of Whitehorse
Whistle Bend
GENERAL SITE DRAINAGE

8. Transportation

The proposed Whistle Bend development is expected to accommodate up to 10,000 residents in the area adjacent to the existing Porter Creek neighbourhood. Following the 2006 Design Charrette, the City of Whitehorse commissioned the Whistle Bend Transportation Network Impact Study. The Study is a result of the City's interest in wanting to develop the area formerly known as the Porter Creek lower bench area in a sustainable manner with an eye to understanding the impacts on the municipal transportation network. With up to 10,000 residents in this new community area, the effects of their living and working in Whitehorse will be felt throughout the City. This section thus summaries the findings of that report with a focus on the off-site transportation network requirements resulting from the proposed development build-out.

8.1 Existing Transportation Network

Access to the development area is provided for various modes of transportation via the City's road and trail network. Vehicular traffic is accommodated through a hierarchy of road infrastructure on the adjacent network including:

- Highways: Alaska Highway
- Arterial/Major Collector Roads: Mountainview Drive (south of 12th Avenue)
- Minor Collector Roads: Hickory Street, 12th Avenue, Clyde Wann Road, Range Road
- Local Roads

Cycling to the site is primarily accommodated via the on-road (shoulder/bike lane) facilities on Mountainview Drive and Copper Road between Tlingit Street and 12th Avenue, and along the Alaska Highway. There is a general lack of on-road pedestrian facilities such as sidewalks, given the natural/rural state of the area. However, an extensive system of trails connecting the Porter Creek neighbourhood with Whistle Bend, as documented by Gartner Lee (2006) exists. These trails are used year-round by a diverse mix of people, for motorized and non-motorized recreational activities including for walking, cycling, horseback riding and exploring on ATV's.

Transit service to the area adjacent is provided by City of Whitehorse Transit Route Lines 3 (Porter Creek-Crestview), 5 (Takhini-College-CGC) and 6 (Porter Creek-Ponderosa). Route 3 provides northbound service on Mountainview Drive via Hickory Street and Clyde Wann Road en-route to areas west of Alaska Highway. Route 5 provides connecting service to the Takhini neighbourhoods, Takhini Arena, Yukon College and the Canada Games Centre. The routing provides a loop service via Quartz and Copper Roads, Mountainview Drive, Range Road and Two Mile Hill. Route 6 services the existing Porter Creek neighbourhood via a continuous loop from Mountainview Drive, via 12th Avenue to local streets connecting to Centennial Street, Clyde Wann Road, and Hickory Street to Mountainview Drive.

8.2 Off-Site Road Network Improvements

To gain a better understanding of the impact of the new Whistle Bend community on the City's transportation network, the City's newly developed EMME model was utilized. Modeling of existing and proposed transportation system improvements was carried out for various stages of development including 10%, 50% and 100% build-out, focusing on capacity requirements for the immediately adjacent local street network as well as downstream infrastructure. A subsequent sensitivity scenario based on

75% build out was undertaken to support the development requirements of the 50% and 100% build-outs, and as a sensitivity test of the development requirements should Whistle Bed not reach the anticipated development threshold of 10,000 people at full capacity. The scenario also provides an indication of what element from the 100% threshold will be required sooner.

The following sections discuss the roadway and transit infrastructure improvements required to service the various stages of development.

8.3 Infrastructure Improvements to 10% Build-out

This build-out threshold represents the initial development requirements to support the new community of Whistle Bend. It identifies the front end and parallel/concurrent infrastructure and service improvements required to enable development up to 10% build-out. Infrastructure and network improvements required at this stage include:

- New access and connector into the Whistle Bend community (Whistle Bend Connector)
- New Pine Street Extension road link to Alaska Highway
- Geometric and signalization improvements at existing downstream intersections
- Transit Line 5 improvements.

Roadway

Access to the new community is anticipated via a link (Whistle Bend Connector) with a connection to Mountainview Drive. A preliminary alignment for a new two-lane collector connecting existing Range Road to Mountainview Drive, at a location where the Pine Street Extension/Alaska Highway connector would terminate on Mountainview Drive, was examined (based on rough alignments as illustrated in the Whistle Bend and Porter Creek "D" neighbourhood plans), and found to provide service to the developing Whistle Bend community. Initially this junction is expected to operate as a stop controlled intersection, and is required in parallel to service lots coming online.

With other areas of the planned development in the City at build-out at this stage, most of the new population forecast for the City at this future stage is expected to be located in and around Whistle Bend. This begins to stress the transportation network between the City's Downtown area and the Porter Creek region. Existing development in Porter Creek as well as new development in Whistle Bend will benefit from the extension of Pine Street to Alaska Highway, as it creates network capacity for population traveling to and from the north part of the City. This element, required at 10%, may be staged to connect with the construction of the Alaska Highway Connector. It is assumed that this extension can be provided between 10% – 25% build-out. With additional traffic generated by growth with origins and destinations in this part of the City, transportation routes from Downtown experience increased travel delays at major intersections.

Further downstream, the intersections of Range Road and Industrial Road at Two Mile Hill were identified as requiring improvements. At Range Road and Two Mile Hill geometric improvements (dedicated northbound right lane) were identified to accommodate increasing northbound traffic volumes and delays. To accommodate increasing traffic volumes and delays at the currently stop-controlled intersection of Industrial Road and Two Mile Hill, especially for the southbound left turn movement, signalization of this location was recommended and assumed to be in place for future development.

Transit

Several alternatives were considered to provide transit service to the new development at this stage of build-out. These included diverting or extending additional service or providing a separate service explicitly for the proposed development. It is important to provide transit service in advance of substantial completion of major new developments in order to build and retain market share. However, at this stage of development, transit passenger volumes generated by the development would likely be modest and insufficient to support a new transit route. Extending the existing Transit Line 5 (Takhini–College-CGC) was considered as the most effective and affordable means of serving the proposed development at this build-out.

8.4 Infrastructure Improvements to 50% Build-out

This build-out threshold represents the 50% development with a new community of approximately 5,500 people in Whistle Bend. Infrastructure and network improvements required at this stage include:

- new Alaska Highway Connector (from Mountainview Drive to Pine Street Extension)
- new College access road extension
- 4 laning of Whistle Bend Connector
- new traffic signals at Mountainview Drive and Whistle Bend Connector (Mountainview Drive to Casca Boulevard) intersection
- internal Whistle Bend intersection improvements at connection with old Range Road
- Mountainview corridor intersection auxiliary laning improvements: the Whistle Bend Connector; Range Road; Quartz Road / Industrial Road
- Downtown intersection improvements.
- New Transit Line 7 and Transit Line 5 improvements

Roadway

At 50% build-out, the portion of the two lane collector connecting the Pine Street Extension with Mountainview Drive (known herein as the Alaska Highway Connector), at the Whistle Bend Connector intersection, was examined. Modelling results indicate that the facility will be well used, with traffic shifting from Mountainview Drive to Alaska Highway, providing service for the developing neighbourhood with direct access to the highway.

In addition, an extension of the College Access Road to the Pine Street Extension is anticipated to be required (based on a rough alignment developed and illustrated in the Porter Creek "D" neighbourhood plan). This extension will serve several functions including secondary access for the future Porter Creek "D" development, providing alternative access to the Yukon College than via College Access and Range Road, and providing opportunity for transit servicing (i.e. looping.) This element thus improves and completes the transportation network in the area, by providing redundancy and alternative access.

At this stage, the Whistle Bend Connector of development, 4 laning of the link is required to accommodate increasing traffic usage. Traffic volumes and requirements for geometric improvements at the intersection with Mountainview Drive indicate the need for these improvements to support the development.

Intersection Improvements

With the increased volumes generated by the Whistle Bend development, several intersection improvements including signalization and geometric upgrades are identified to support the development, as follows:

- *Mountainview Drive and Whistle Bend Connector:* To accommodate increasing northbound and westbound traffic volumes and delays at the stop controlled intersection, especially for the northbound right turn and westbound left turn movements, it is recommended that this intersection be signalized by 50% build-out. A preliminary assessment of the volumes at the intersection suggests a dedicated free-flow northbound right turn lane with sufficient storage, two westbound left turn lanes in split phase, and associated widening of the Whistle Bend Connector between Mountainview Drive and Range Road.
- *Range* Road and *Whistle Bend Connector*: To accommodate increasing northbound and westbound traffic volumes and delays at the stopped controlled intersection, especially for the northbound right turn and westbound left turn movements, it is recommended that this intersection be stopped controlled southbound on Range instead of westbound on *Whistle Bend Connector* by this stage of build-out. Concepts for this intersection include the potential installation of roundabouts. Final intersection control philosophy should await detailed design.
- *Mountainview Drive Corridor Signalized Intersections Geometric Improvement*: To accommodate increasing traffic usage on Mountainview Drive, the number of lanes in the north-south directions should be increased at signalized intersections on the corridor, namely at Mountainview Drive and Range Road and Quartz Road at Industrial Road. The dedicated northbound right turn lane at Mountainview / Range is recommended for conversion to a shared through and right turn lane. Quartz Road at Industrial Road is recommended for widening allowing two shared through lanes in both directions.
- *Downtown Intersections Geometric Improvements*: To accommodate increasing northbound and southbound traffic volumes and delays at signalized intersections on 4th Avenue, it is recommended that current road dieting on 4th Avenue at Black Street and Main Street be relaxed to provide dedicated northbound and southbound right turn lanes with sufficient storage

Transit

The general increase in population and employment in Whistle Bend leads to an increase in transit demand throughout the city. The resulting transit demand renders the City's current transit strategy of 35-minutes headways on all routes and a common timed-transfer point unworkable. Our analysis suggests that a comprehensive review of transit operations will be appropriate as the City continues to grow. For this current work, we have identified desirable transit improvements to support the assumed population and employment distribution consistent with the current transit strategy with a base headway of 35 minutes. However, increased demand on some services requires additional bus service at 17.5-minutes headway and some routes have running times close to or exceeding the required 35 minute turn-round time. Consequently, the transit improvements identified herein should be regarded as provisional pending a comprehensive review of long term transit needs in the City.

To accommodate increasing passenger load of the Transit Line 5 Extension identified for the 10% build-out, servicing the developing neighbourhood of Whistle Bend, a preliminary concept of a new Transit Line 7 (Downtown–Whistle Bend-Porter Creek) with 17.5-minutes headway is proposed. The preliminary concept of the new transit line will provide service to Porter Creek Bench, Porter Creek, Porter Creek "D"

and Downtown. The line will be well used during the peak hour, with modelling results indicating a ridership of 365 passengers.

Additional, to accommodate increasing passenger load of the Transit Line 5 Extension, the transit line requires frequency improvement to 17.5-minutes headway, with modelling results indicating an increase in ridership of 294 passengers in the peak hour.

8.5 Infrastructure Improvements to 100% Build-out

This build-out threshold represents the full development of the Whistle Bend community, representing 10,000 population. It identifies the infrastructure and service improvements required to support full build-out of the area. Infrastructure and network improvements required to service the increase in populace and traffic at this stage include:

- full widening of Mountainview Drive to four lanes between the Whistle Bend Connector and 2nd Avenue, with associated intersection improvements
- new traffic signals and geometric laning improvements for the Alaska Highway intersection at Prospector Road
- new traffic signals and geometric laning improvements at Hamilton Boulevard and Arkell Access Road
- Transit Service Improvements

Roadway

With the ultimate build-out of Whistle Bend, the Mountainvew Corridor will be near/at capacity suggesting the need for widening the corridor to a four lane cross section. Initial modelling results indicate that the entire Mountainview Drive Corridor in the north-south directions should be widened to 4 lanes between the Whistle Bend Connector and 2nd Avenue. The model illustrates that some traffic will shift from westbound Two Mile Hill and northbound Alaska Highway, to westbound 2nd Avenue and northbound Quartz Road, Copper Road, and Mountainview Drive, with the increased capacity on Mountainview Drive.

Initial review of the roadway width requirements (based on a TAC classification of UCU-70 and City Standards for a Major Collector street) is approximately 17 m based on maintaining two travel lanes of 3.5 m plus on-road bicycle lanes of 1.5 m and no on-street parking per direction. The existing right-of-way (ROW) of Mountainview Drive between Tliingit Road and 12th Avenue (based on cadastral information) is in the order of 60 m plus, and is likely sufficient to accommodate the proposed widening of the Mountainview corridor. It should be noted, that during the original construction of Mountainview Drive, the west side of the corridor between Tlingit and Range Roads was filled with unsuitable material, which will have to be addressed and mitigated through the design process.

Intersection Improvements

To accommodate increasing traffic usage and 4-lane widening of the Mountainview Drive Corridor, it is recommended that the number of through lanes in the north-south directions be increased at signalized intersections on the Mountainview Drive Corridor, namely:

- Mountainview Drive at Whistle Bend Connector: A preliminary assessment of the volumes at this intersection suggests two dedicated free-flow northbound right turn lanes, two westbound left turn lanes, and two southbound shared through lanes
- Mountainview Drive at Range Road: The dedicated southbound right turn lane at this intersection is recommended for conversion to a shared through and right turn lane. To accommodate increasing northbound and eastbound traffic volumes and delays at the currently signalized intersection, eastbound and westbound shared through and left turn lanes should be converted to dedicated left turn lanes while dedicated right turn lanes in the same approaches should be converted to shared through and right turn lanes.
- Quartz Road at Chilkoot Way: The preliminary assessment indicates that this intersection will require an additional through lane in the north-south directions.

To accommodate increasing northbound and westbound traffic volumes and delays at the currently stop-controlled intersection, especially for the northbound right turn and westbound left turn movements, signalization of the Alaska Highway / Prospector Road intersection is warranted from a traffic volume perspective. A preliminary assessment of the volumes at the intersection suggests a dedicated northbound right turn lane with sufficient storage, a westbound left turn lane in split phase, and two southbound through lanes merging back to a single lane after the intersection. Signals will be required by the anticipated westbound left turn traffic volumes in the morning peak hour.

With the overall increase in travel demand on the City's transportation network, the intersection of Hamilton Boulevard and Arkell Access Road warrants signalization to accommodate increasing northbound and southbound traffic volumes and eastbound stop-controlled delays.

Transit

To accommodate the general forecast increase in transit ridership at 100% build-out of Whistle Bend, the following transit frequency improvements are recommended:

- Transit Line 4 (McIntyre-Logan-Granger) Increase Frequency to a 20-minutes headway
- Transit Line 5 (Takhini–College-CGC) Increase Frequency to a 10-minutes headway
- Transit Line 7 (Downtown–Whistle Bend-Porter Creek) Increase Frequency to a 10-minutes headway
- Transit Lines 1-3 and 6 Reduce Frequency to a 40-minutes headway

To accommodate the increasing passenger load of Transit Line 4, the transit line requires frequency improvement to a 20-minutes headway after a review of the passenger volumes and layover time. Results indicate that an increase in ridership of 156 passengers in the peak hour. To accommodate the increasing passenger load of the Transit Line 5 Extension and New Line 7, which services the developing neighbourhood of Whistle Bend, the transit lines require frequency improvement to a 10-minutes headway after a review of the passenger volumes and layover time. Results indicate that an increase in ridership of 511 and 184 passengers in the peak hour respectively. The remaining transit lines can reduce frequency to a 40-minutes headway to maintain consistency at the common timed-transfer point on Ogilvie Road.

8.6 Infrastructure Improvements to 75% Build-out - Sensitivity

This build-out threshold represents the 75% build-out of the Whistle Bend community, and is provided as an indication of what elements from the 100% threshold will be required sooner. *Infrastructure and network improvements required at this stage include:*

- 4 – laning of Mountainview Drive (Range Road and Whistle Bend Connector)
- Alaska Highway / Prospector Road Signalization
- Transit Service Improvements

Roadway

At the 75% build-out, widening of the Mountainview Drive corridor will be required to accommodate increasing traffic usage in the north-south directions. Modelling results indicate the corridor should be widened to 4 lanes between Whistle Bend Connector and Range Road, resulting in an improvement in travel time between Downtown and Whistle Bend.

Intersection Improvements

At this stage, increasing northbound and westbound traffic volumes and delays at the currently stop-controlled intersection of Alaska Highway / Prospector Road indicate the need for signalization. A preliminary assessment of the volumes at the intersection suggests a dedicated northbound right turn lane with sufficient storage, and a westbound left turn lane. Signals will be required by the anticipated westbound left turn traffic volumes in the morning peak hour.

Transit

To accommodate the increasing passenger load of Transit Line 4, the transit line requires frequency improvement to a 20-minute headway after a review of the passenger volumes and layover time. Results indicate that an increase in ridership of 152 passengers in the peak hour. To accommodate the increasing passenger load of the Transit Line 5 Extension and New Line 7, which services the developing neighbourhood of Whistle Bend, the transit lines require frequency improvement to a 10-minute headway after a review of the passenger volumes and layover time. Results indicate that an increase in ridership of 456 and 160 passengers in the peak hour for the two lines respectively. The remaining transit lines can reduce frequency to a 40-minute headway to maintain consistency at the common timed-transfer point on Ogilvie.

8.7 Access to Whistle Bend

Whistle Bend Connector

A preliminary engineering exercise was undertaken to examine the length of the Whistle Bend Connector and Connector from the proposed entrance to the community to the ultimate connection to Alaska Highway, via the Pine Street Extension.

Design criteria, based on TAC Geometric Design Guidelines and City of Whitehorse Standards (2005), were prepared to inform the development of the conceptual alignment (documented in Appendix H), and includes the following elements:

- 60 km/h design speed for the 2 lane section between Alaska Highway and Mountainview Drive, and 70 km/h design speed for the 4 lane section between Mountainview and Range Road respectively
- 2 and 4 lane cross sections, with minimum lane travel widths of 3.75m, plus 2.5 m shoulder which will accommodate cycling per direction. The road is designed as a rural collector.
- Vertical curves designed to meet or exceed minimum criteria for curves per TAC for 60 kmh and 70 kmh design speed
- Horizontal curves designed to meet or exceed minimum criteria per TAC for 60 kmh and 70 kmh design speed
- Design Vehicle - WB-19

Major constraints considered during the development of the alignment included:

- An environmentally sensitive zone (a major beaver habitat), east of Range Road
- Existing substation west of Mountainview Drive
- Two peaks west of Mountainview Drive, and east of Ponderosa Drive
- Minimizing impacts on the existing escapement, resulting in a road designed to a lower speed through the proposed Porter Creek "D" development area.

From its start at the planned Whistle Bend community entrance, the proposed 4 lane road rises at a approximately 4% grade as it climbs west to intersect with Mountainview Drive. With this alignment, the current connection to Range Road is re-configured as a minor connection at a T-intersection. The four lane cross section extends beyond the Mountainview intersection, reducing to a two-lane cross section towards the Alaska Highway. The alignment avoids the substation to its east, and maintains vertical curves that exceed the minimum design criteria per the design document.

From Mountainview Drive, the road climbs at approximately 4% towards the future Porter Creek "D" neighbourhood. The alignment was shifted to the eastern edge of the bluff, overlooking the lower bench such that all developable lands for the future neighbourhood are to the west of the Connector. As the road approaches the crest of the Porter Creek neighbourhood escarpment, and continues towards the future connection to the Pine Street Extension alignment, the grade flattens, not exceeding 1%.

The Pine Street Extension is realigned so as to provide a T-intersection with the Alaska Connector which maximizes the availability of developable lands, and minimizes the grades at the approach to the intersection. As the existing grade on Pine Street are close to 10% with a drop in elevation of approximately 40m, the Pine Street extension was lengthened to provide relatively flatter grades at the intersection.

The proposed roadway drops to approx. 4.5% to the proposed McIntyre Creek crossing, as it descends towards the planned connection to the College Road Extension. To minimize structural requirements and costs at the crossing, grades of the approach to Alaska Highway were steepened; opportunity may exist to refine the grades based on the structural design of the crossing.. Depending on the availability of fill, opportunity may exist to reduce these grades by modifying the road profile or adjust the connection to include directional ramps.

The proposed McIntyre Creek Crossing proposed replacing the existing foot bridge with a multi-use, open bottomed arched culvert, with multi-use paths on either side of the creek. The road crossing would be constructed above this proposed foot bridge.

It should be noted that for the most part, this alignment is designed with vertical curves that exceed the minimum design criteria for curves per TAC for 60 kmh and 70 kmh facilities.

Figure 4 shows the proposed road plan and profile, and typical sections.

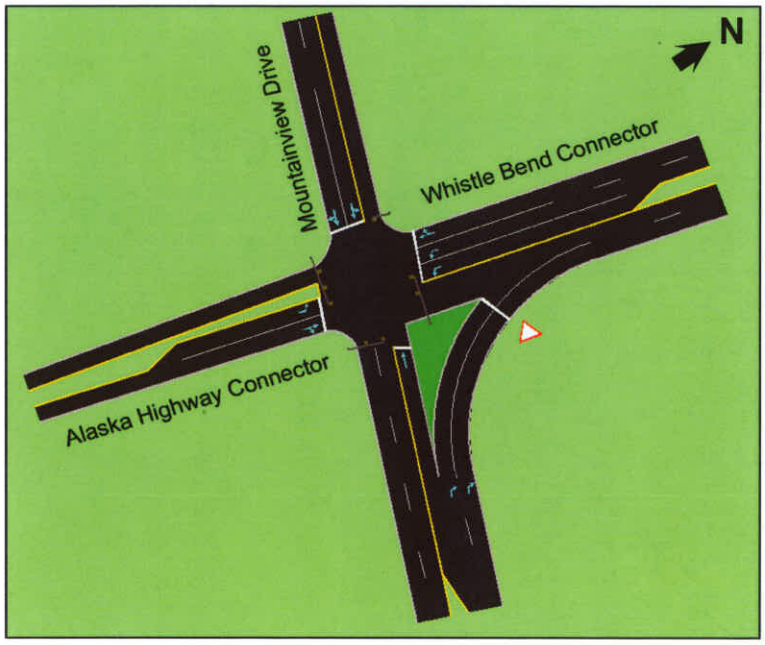
The order of magnitude cost of construction for the preliminary alignment is approximately $18 Million, including engineering and contingency. The costs do not include any property costs or environmental mitigation costs. The order of magnitude costs are attached in Appendix H.

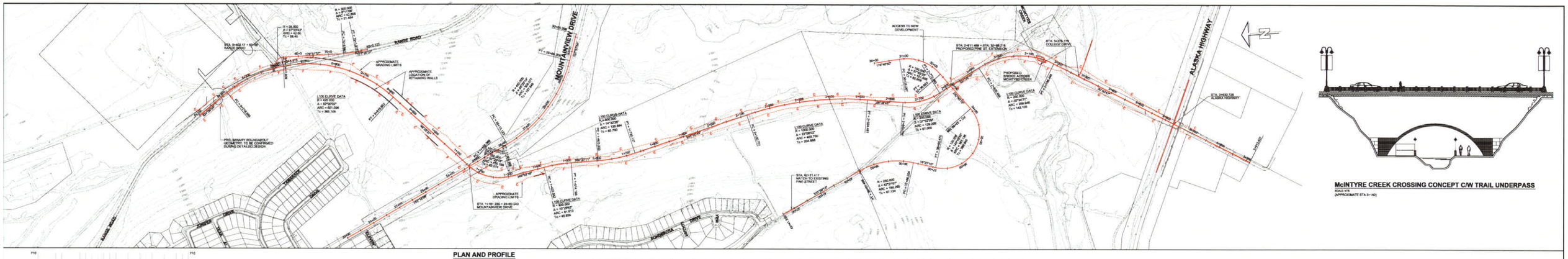
Main Access to Whistle Bend

With the development to the Whistle Bend community, the primary access into the area will be via a signalized intersection at Mountainvew Drive. The 2008 Whistle Bend Transportation Network Impact Study identified the need for a single access into the community, illustrated in Figure 5. This configuration provides the same service as the right turn merge lane from Mountainview Drive to Range Road identified during the Design Charrette. However, it alleviates the need to upgrade Range Road to accommodate traffic, other than potentially alternative modes as identified in this work.

This access can initially be provided as a stop controlled intersection, but would required signalization by 50% build out.

Figure 5 - Mountainview Drive & Whistle Bend Connection

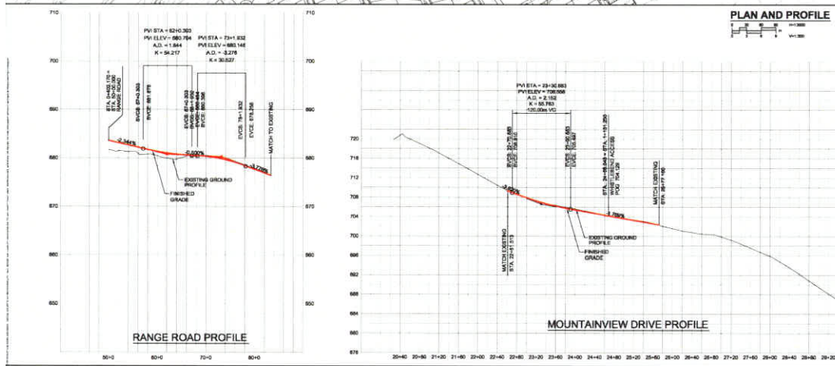


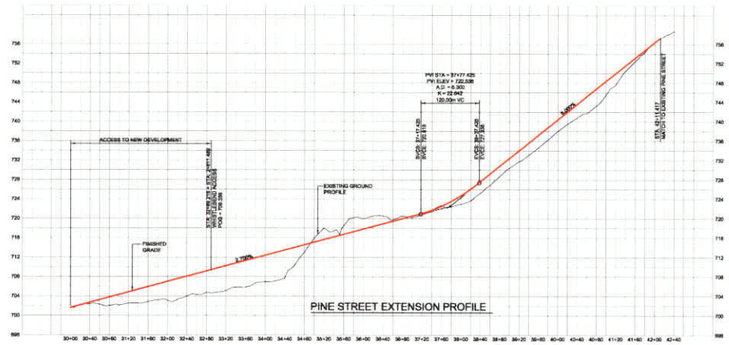


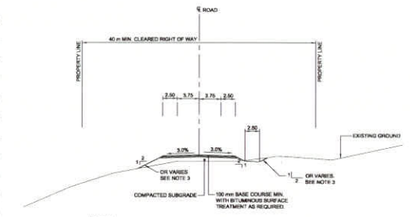
McINTYRE CREEK CROSSING CONCEPT C/W TRAIL UNDERPASS

SCALE: N.T.S.
(APPROXIMATE STA 0+150)

PLAN AND PLOT



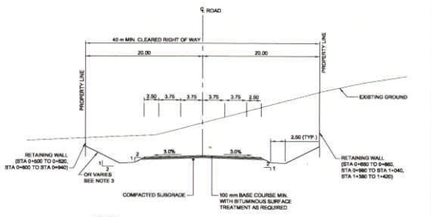




NOTES
1. MINIMUM ROAD STRUCTURE ROADWAY TO BE DESIGNED BASED ON SITE SPECIFIC SOIL CONDITIONS AND TRAFFIC LOADING. GRAVEL TO BE COMPACTED TO 98% STANDARD PROCTOR DENSITY.
2. SUBGRADE COMPACTED TO 98% STANDARD PROCTOR.
3. BACK SLOPES TO BE DESIGNED BY A GEOTECHNICAL ENGINEER BASED ON SITE SPECIFIC CONDITIONS.

TYPICAL SECTION

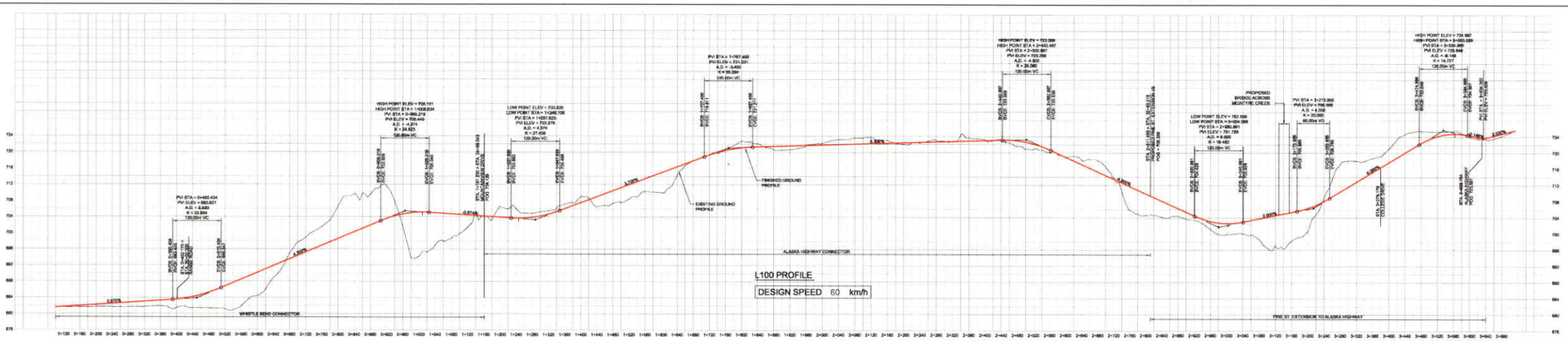
SCALE: N.T.S.
TWO LANE SECTION
STA 1+430 TO STA 3+630



NOTES
1. MINIMUM ROAD STRUCTURE ROADWAY TO BE DESIGNED BASED ON SITE SPECIFIC SOIL CONDITIONS AND TRAFFIC LOADING. GRAVEL TO BE COMPACTED TO 98% STANDARD PROCTOR DENSITY.
2. SUBGRADE COMPACTED TO 98% STANDARD PROCTOR.
3. BACK SLOPES TO BE DESIGNED BY A GEOTECHNICAL ENGINEER BASED ON SITE SPECIFIC CONDITIONS.

TYPICAL SECTION

SCALE: N.T.S.
FOUR LANE SECTION
STA 0+100 TO 1+400



L100 PROFILE

DESIGN SPEED 60 km/h

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 2009/03/23

City of Whitehorse

Pre-Design for Porter Creek Bench
Roadworks Plan and Profile
2501-040-00_00-CTP001

Figure 4

Date: 2009/03/23

Rev. C

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Range Road

The existing access to the area from Range Road has been identified as a potential transit and alternative modes facility. As the current minor collector is in poor condition, with narrow travel lanes, steep grades and curves, upgrading the facility for traffic use would encounter significant challenges, particularly at the McIntyre Creek area. Indeed road widening of this facility would likely require upgrades of the existing culverts, through an environmentally sensitive area. However, the potential for devolving this facility to provide service for transit and cycling only may partially mitigate the need to upgrade the facility.

8.8 Connectivity to Bicycle and Trail Network

The City of Whitehorse actively promotes alternative and greener methods of transportation for commuters and recreational travel. In the past five years, the City has promoted and developed a variety of programs to shift travelers out of their cars (as single drivers), to various alternative modes. This has included car pooling and active community programs (e.g., Commuter Challenge, Wheel to Work), development of dedicated bike lanes, information dissemination about routing (2005 bicycle commuter map), as well as improved walking trails from some neighbourhoods to the Downtown.

In support of the City's Integrated Community Sustainability Plan and policies, as well as the understanding and desire to develop the Whistle Bend (Porter Creek lower bench) area in a sustainable manner, consideration should be afforded to developing cycling and trail network connections that enable and encourage alternate modes of travel within the community, to adjacent neighbourhoods, and to the Downtown core.

Bicycle Network

The natural setting of Whistle Bend, while providing important and unique geo-physical character to the new neighbourhood, also provides challenges for the provision of active transportation modes such as walking and cycling. Cycling to and from the Whistle Bend community will be constrained by topographic challenges, with steep grades particularly for travel to and from the Downtown core. The Bike Network Plan within the 2004 City-wide Transportation Plan identified on-road and off-road facilities primarily for utilitarian cycle travel (to and from work, school, shopping). It included connections to the network via Mountainview Drive as well as along major trail corridors to provide connection between neighbourhoods and to offer an alternative to the road system. The plan proposed cycling on major collectors to be generally provided via on-road (shoulder/bike lane) facilities.

The Plan identified an off-road route connection between existing neighbourhoods' of Porter Creek and Takini with points south. With the development of Porter Creek "D" and the Pine Street Extension and concomitant roadworks, opportunity may exist to develop this bicycle connection as a bike lane; however, steep grades may render the facility a difficult one for the average cyclist.

Connections for utilitarian cycling to Whistle Bend may potentially be feasibility via Range Road if the road is downgraded to provide service for alternative modes only (i.e. transit and cyclists) between Mountainview Drive and Whistle Bend. Indeed, the 2005 Commuter Cycling Map identifies the road as one suitable for road bicycles, with the indication of a steep grade in both directions at McIntyre Creek.

A preliminary engineering exercise was undertaken to examine the potential for a more direct bike trail facility between Whistle Bend and Mountainview Drive via Range Road. This facility combines an on-road shoulder bike lane with an off-road trail. The bike trail is proposed to be a 2 m wide compacted gravel path. The off-road trail will be constructed on fill slope and will run parallel to Mountainview Drive n the east side. Where the trail climbs up to join Mountainview drive, the maximum grade is less than 4%. The proposed alignment, profile and typical section at the fill slope is shown in Figure 6.

The order of magnitude cost of construction for the preliminary alignment is approximately $0.5 Million, including engineering and contingency. The costs do not include any property costs or environmental mitigation costs. The order of magnitude costs are attached in Appendix H.

As the detail design process proceeds, opportunities should be explored that provide a variety of cycling facility types that provide more choice to cyclists of all levels.

Trail Network

The City's Integrated Community Sustainability Plan also identified the development of a multi use trail network that connects the various subdivisions to each other and the downtown core, as a means of meeting the City's goal of promoting alternate transportation.

The 2007 City of Whitehorse Trail Plan provided two broad classifications of trails. City trails are those facilities of interest in the City-wide context, and include major multi-use trails and bicycle paths. Neighbourhood trails are ones that are of primary interest to residents of adjacent neighbourhoods. The majority of these facilities have evolved over time through individual and group use.

The Trans Canada Trail (TCT), which runs through the Porter Creek neighbourhood, is a designated motorized multiuse trail. With the development of Whistle Bend, opportunity may exist to provide connection to the TCT at approximately Clyde Wann Road to the north, and adjacent to Whistle Bend Connector to the Pine Street Extension via the Mountainview Drive intersection.

Given the plethora of neighbourhood trails and networks, care should be afforded in the development of the onsite trail network to maximize connectivity to a hierarchy of trails, with the most well used trails forming the core system. This should be developed in consultation with Parks and Recreation.

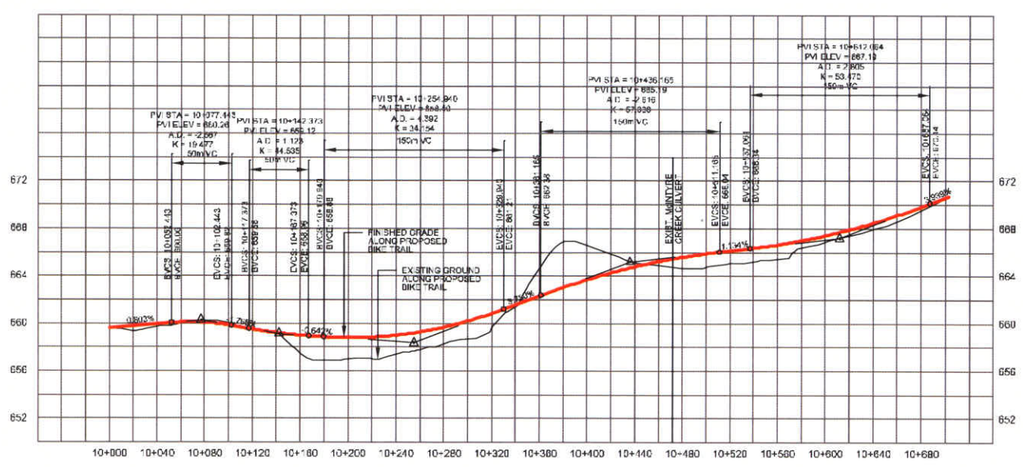
8.9 Summary of Off-Site Improvements

The off-site transportation improvements required to service various stages of the Whistle Bend are summarized in Table 8.1, with highlights illustrated in Figure 7. This table summarizes the various types and timing of the recommended, major road and intersection improvements, as well as options to be investigated for improving the transit network. These recommendations are based on good transit practices of providing regular service, expanding into unserviced and developing areas, and taking advantage of new road construction.

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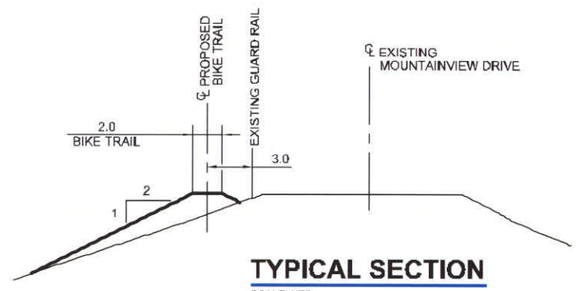




PROPOSED BIKE TRAIL

0 50 100 150 m H=1:5000

0 5 10 15 V=1:500



TYPICAL SECTION

SCALE: NTS

NOTES:

1. BIKE TRAIL PAVEMENT STRUCTURE TO BE CONFIRMED.
2. DRAINAGE DETAILS FOR THE FILL SECTION (e.g. PERMEABLE LAYERS) ALONG MOUNTAINVIEW DRIVE TO BE CONFIRMED.

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PRELIMINARY
NOT FOR CONSTRUCTION
Date: 2009/03/23

City Of Whitehorse
Pre-design for Porter Creek Bench
2501-040-00_00-CTF001

Proposed Bike Trail

Rev. B
2009/03/23

Figure - 6

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UMA FILE NAME: 2501-038-00_01-CTF811_RX.dwg Saved By: aguilae PLOT: 08/12/08 4:06:28 PM B SIZE 11" x 17" (279.4mm x 431.8mm)
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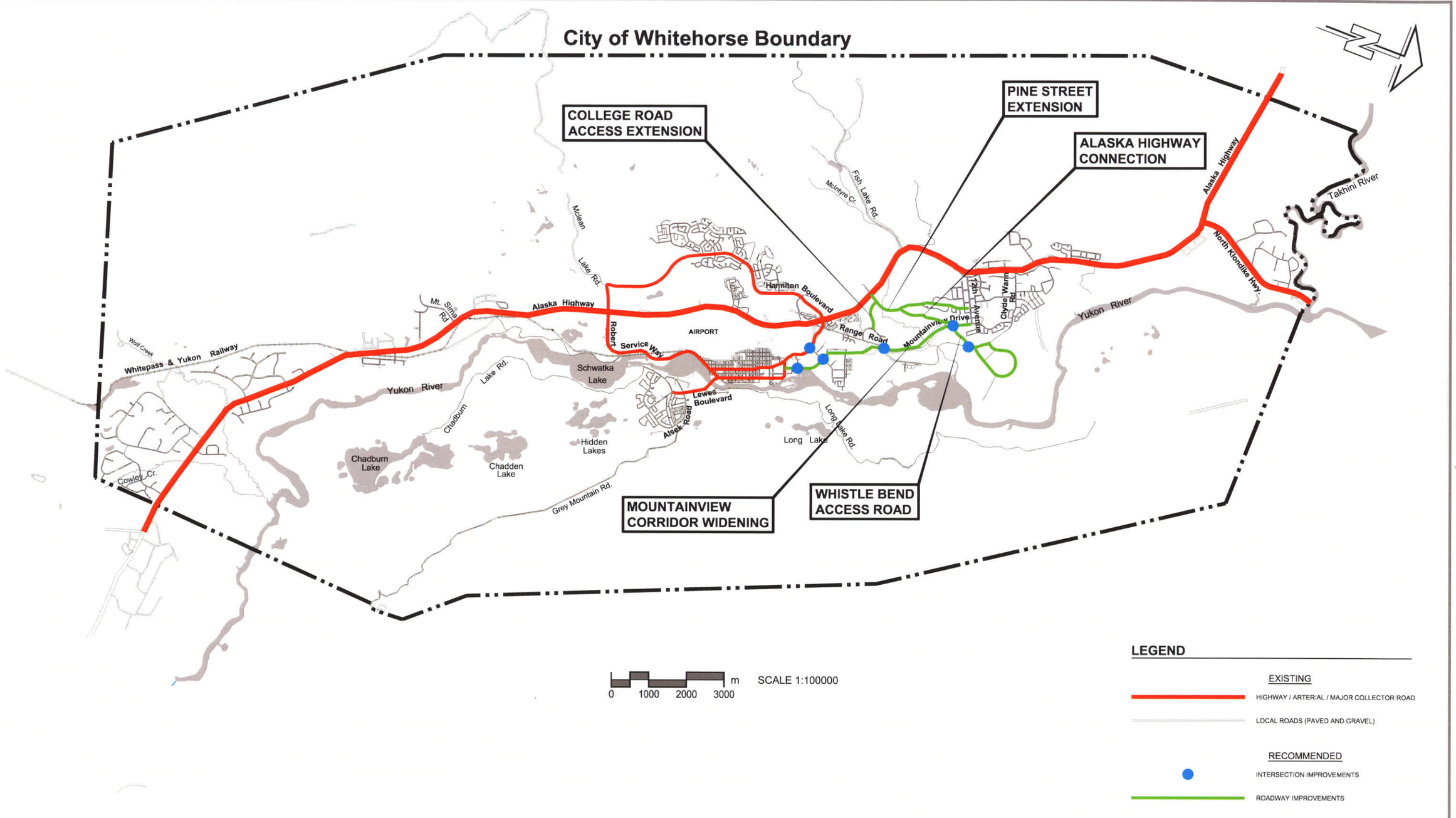


Figure 7

City of Whitehorse
Whistle Bend

Summary of Off-Site Transportation Improvements

December 2008

AECOM

Table 8.1 - Summary of Off-Site Improvements

Type of Off-Site Improvement	Whistle Bend Development % Build-Out		
	10% Build-Out	50% Build-Out	100% Build-Out
Roadway	• 2 lane Whistle Bend Connector connecting Mountainview Drive to Range Road • Pine Street Extension road link to Alaska Highway	• 2 lane connection from Whistle Bend Connector and Mountainview Drive to Pine Street Extension (Alaska Connector) • College Road Access Extension to Pine Street Extension • 4-laning of Whistle Bend Connector	• Mountainview Drive Corridor 4-lane Widening between 2nd Avenue and Whistle Bend Connector
Intersection	• Unsignalized intersection at Whistle Bend Connector and Mountainview Drive • Signalization of Industrial Road and Two Mile Hill intersection • Range Road and Two Mile Hill geometric improvements (dedicated NBR lane)	• Signalization and geometric improvements at intersection at Whistle Bend Connector and Mountainview Drive • Two-way stop control for Southbound Range at Whistle Bend Connector • Mountainview Drive and Range Road – geometric improvements (NBR to NBTR) • Quartz Road and Industrial Road geometric improvements with two shared through lanes in both directions • 4th Avenue at Main Street and Black Street: intersections: geometric improvements with dedicated northbound and southbound right turn lanes with sufficient storage	• Signal Optimization and geometric improvements at Mountainview Drive and Whistle Bend Connector: two dedicated free-flow NBR lanes, two WBL lanes, and two shared SBT lanes • Signalization and geometric improvements of Alaska Highway and Prospector Road intersection • Signal Optimization and geometric improvements at Mountainview Drive and Range Road: (SBR to SBTR lane), (EBLT to EBL and EBT lanes, and EBR to EBTR lanes) (WBLT to WBL and WBT lanes and WBR to WBTR) • Quartz Road at Chilkoot Way Geometric improvements: additional through lane in the north-south directions. • Hamilton Boulevard and Arkell Access Road signalization and EBR lane.
Transit	• Transit Line 5 (Takhini–College-CGC) Extension	• New Transit Line 7 (Downtown–Whistle Bend-Porter Creek) at a 17.5-minutes headway • Transit Line 5 (Takhini–College-CGC) Increase Frequency to a 17.5-minutes headway	• Transit Line 4 (McIntyre-Logan-Granger) Increase Frequency to a 20-minutes headway • Transit Line 5 (Takhini–College-CGC) Increase Frequency to a 10-minutes headway • Transit Line 7 (Downtown–Whistle Bend-Porter Creek) Increase Frequency to a 10-minutes headway • Reduction of Frequency to a 40-minutes headway for all other Transit Lines (1-3 and 6)

8.9.1 Order of Magnitude Costing of Improvements

To assist the City in planning for the various recommended road and intersection improvements, preliminary cost estimates were prepared for each element based on local construction unit rates. These order of magnitude costs based on City-wide development information (surface costs only), account for capital costs (clearing, grubbing, grading, and paving), but not property. A summary of the costs by element and horizon are illustrated in Table 8.2.

Table 8.2 – Cost Estimate of Recommended Road and Intersection Improvements

Horizon	Network Element Breakdown		Item	Cost
Whistle Bend 0 - 10% Build-out				
	Industrial Road / Two Mile Hill			
		Signalize Intersection	Signalize Intersection	$250,000
	Range Road / Two Mile Hill			
		NBR Lane	Auxiliary Lane (Urban)	$50,000
	Whistle Bend Connector			
		New Roadway	New Roadway (Rural)	$1,770,000
			Sub-Total	$2,070,000
Whistle Bend 10 - 25% Build-out				
	Pine Street Extension			
		New Roadway	New Roadway (Rural)	$6,910,000
			Sub-Total	$6,910,000
Whistle Bend 50% Build-out (30,000 pop)				
	Alaska Highway Connector			
		New Roadway	New Roadway (Rural)	$5,390,000
		New Roundabout	New Roundabout	$270,000
	College Access Road			
		New Roadway	New Roadway (Rural)	$2,400,000
	Whistle Bend Connector			
		Road Widen	Auxiliary Lane (Rural)	$2,010,000
	Mountainview Drive / Whistle Bend Connector			
		Road Widen	Auxiliary Lane (Rural)	$1,360,000
		Signalize Intersection	Signalize Intersection	$350,000
		EBL Lane	Auxiliary Lane (Rural)	$100,000
		WBL Lane	Auxiliary Lane (Rural)	$100,000
		SBR Lane	Auxiliary Lane (Rural)	$60,000
	Mountainview Drive Corridor Intersections			
		Mountainview/Range NB Acceleration Lane	Auxiliary Lane (Rural)	$100,000
		Quartz/Industrial NB Acceleration Lane	Auxiliary Lane (Urban)	$50,000
		Quartz/Industrial SB Acceleration Lane	Auxiliary Lane (Urban)	$50,000
	Downtown Intersections	4th/Black NBR Lane	Auxiliary Lane (Urban)	$70,000
		4th/Black SBR Lane	Auxiliary Lane (Urban)	$70,000
		4th/Main NBR Lane	Auxiliary Lane (Urban)	$70,000
		4th/Main SBR Lane	Auxiliary Lane (Urban)	$70,000
			Sub-Total	$12,520,000
Whistle Bend 75% Build-out				
	Mountainview Drive 4-lane			
		Road Widen	Auxiliary Lane (Rural)	$3,330,000
	Mountainview Drive Intersections			
		Mountainview / Range SB Acceleration Lane	Auxiliary Lane (Rural)	$200,000
			Sub-Total	$3,530,000

Horizon	Network Element Breakdown	Item	Cost
Whistle Bend 100% Build-out (35,000 pop) REVISED			
	Mountainview Drive 4-lane		
	Road Widen	Auxiliary Lane (Urban)	$1,890,000
	Road Widen	Auxiliary Lane (Rural)	$3,250,000
	Alaska Highway / Prospector Road		
	Signalize Intersection	Signalize Intersection	$350,000
	EBL Lane	Auxiliary Lane (Rural)	$60,000
	WBL Lane	Auxiliary Lane (Rural)	$60,000
	SBT Lane	Auxiliary Lane (Rural)	$200,000
	SBT Lane	Auxiliary Lane (Rural)	$160,000
	NBR Lane	Auxiliary Lane (Rural)	$180,000
	Hamilton Boulevard / Arkell Access Road		
	Signalize Intersection	Signalize Intersection	$250,000
	EBR Lane	Auxiliary Lane (Rural)	$60,000
		Sub-Total	$6,460,000

9. Power and Communications

The local providers, Yukon Electric and NorthwesTel, have been involved in the Whistle Bend master planning exercise for some time as part of the Technical Working Group. The off site servicing requirements and associated costs are still under development. While the general concepts are outlined below, the actual off site servicing costs to be borne by the developer are still to be determined. This is especially challenging as the development will be phased and the actual timing is very dependent on market demand.

9.1 Power

Yukon Electric intends to add Whistle Bend to their grid at two separate points. The first is at the existing overhead power-line corridor between Tamarack Drive in Porter Creek and Range Road and the other has tentatively been identified as the existing corridor along the PCFT right of way extending east from the end of Oak Street. The two points will be connected via a power line installed along the west boundary of Whistle Bend in the greenbelt along the base of the escarpment. Whether this power line is overhead or buried has not yet been determined. A new substation is required and a good location has been identified between the bottom of the upper bench escarpment and Range Road immediately east of the intersection of Tamarack Drive and Jupiter Drive As the development builds out a second substation may be required based on load. The location for this second substation has tentatively been identified as just north of the PCFT right of way.

Yukon Electric is undertaking the YESAA process for the proposed off site works.

9.2 Telecommunications

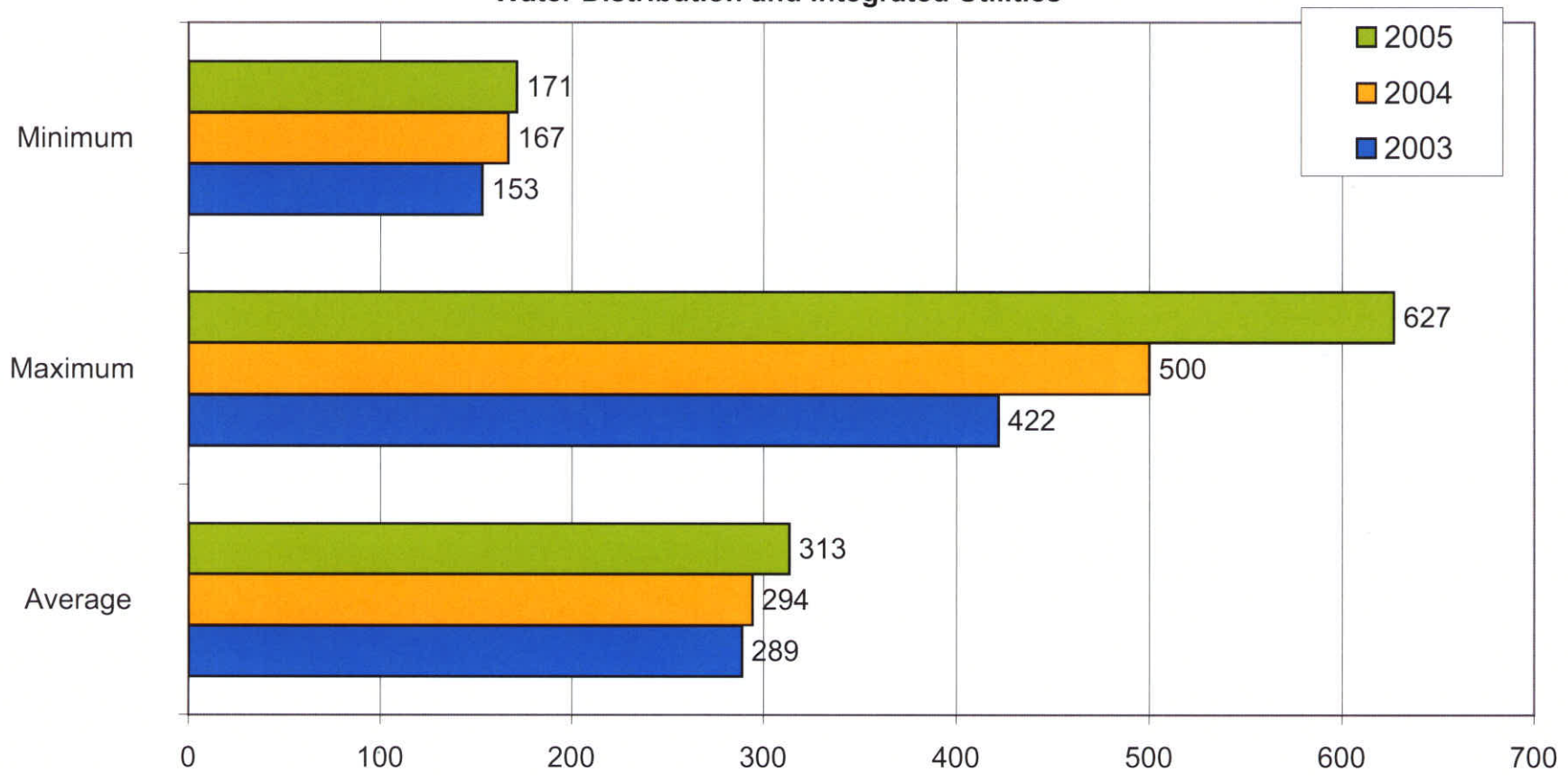
NorthwesTel's intentions are to serve the development with HFC (hybrid fiber coax) with additional fiber capacity available for commercial requirements. The tie-in points to the existing system are still to be determined.

Appendix A

Average Canadian Water Consumption Data

Per Capita Average Day Consumption for Residential Customers (in liters/capita/day)

Water Distribution and Integrated Utilities



Appendix B

Water Servicing Cost Estimates

City of Whitehorse | **Whistle Bend Off-Site Water Servicing** | **Cost Estimate Summary**

Options Summary

Option 1 - Range Road Ext.	**$3,534,375**
Option 2 - Porter Creek D Ext	**$2,885,625**
Option 3 - Wann Road Ext	**$1,511,875**

Estimates include 25% for Engineering and Contingencies

City of Whitehorse | ***Whistle Bend Off-Site Water Servicing*** | ***Cost Estimates***

Option 1- Open Cut Installation, with 450 DI pipe, Extension from Northlands along Range Roac

Range Road Extension - 2400 lineal meters, restrained joints for 800 lineal meters

Item	Description	Unit	Unit Rate	Quantity	Total
1	pipe, 450 mm DI, bare, un-restrained	l.m.	$225.00	1600	$360,000.00
	pipe, 450 mm DI, restrained joints	l.m.	$275.00	800	$220,000.00
2	Trench and Backfill, 3 - 4 m depth	l.m.	$250.00	2400	$600,000.00
3	pipe installation, unrestrained	l.m.	$125.00	1600	$200,000.00
	pipe installation, restrained	l.m.	$175.00	800	$140,000.00
4	drain rock or pea gravel pipe bedding	l.m.	$25.00	2400	$60,000.00
5	common excavation and pregrading allowance	cu.m.	$10.00	1000	$10,000.00
6	Hydrants and Hydrant tee assembly	each	$7,500.00	2	$15,000.00
7	Watermain fittings, 450 mm	each	$3,500.00	10	$35,000.00
8	Butterfly valves and valve boxes, 450 mm	each	$4,000.00	4	$16,000.00
9	Concrete Filled Bollards	each	$500.00	8	$4,000.00
10	Surface restoration, subgrade prep	sq.m.	$4.00	5000	$20,000.00
11	Surface restoration, surface course	sq.m.	$10.00	5000	$50,000.00
12	Clearing, grubbing and disposal allowance	sq.m.	$5.00	24000	$120,000.00
13	Tie to Existing Watermains	each	$5,000.00	1	$5,000.00
14	450 Saddles and Mainstops	each	$500.00	2	$1,000.00
15	Flushing and Chlorinating	lump sum	$25,000.00	1	$25,000.00
16	Pressure Testing	lump sum	$12,500.00	1	$12,500.00
17	Rock Excavation and waste (provisional)	cu.m.	$100.00	50	$5,000.00
18	Install trench plugs	each	$500.00	8	$4,000.00
19	PRV bypass vault allowance	lump sum	$150,000.00	1	$150,000.00
20	Creek crossing allowance - insulation, etc	lump sum	$250,000.00	1	$250,000.00
21	McIntyre Cr culvert & road widening allowance	lump sum	$500,000.00	1	$500,000.00
22	Mobilization / Demobilization	lump sum	$25,000.00	1	$25,000.00
	Subtotal				**$2,827,500.00**
	Eng. & Contingencies @ 25%				$706,875.00
	Total				**$3,534,375.00**

City of Whitehorse | ***Whistle Bend Off-Site Water Servicing*** | ***Cost Estimates***

Option 2- Open Cut Installation, with 350 DI pipe, Mountainview Drive Crossing

Porter Creek D Extension - 2800 lineal meters, restrained joints for 400 lineal meters

Item	Description	Unit	Unit Rate	Quantity	Total
1	pipe, 350 mm DI, bare, un-restrained	l.m.	$200.00	2400	$480,000.00
	pipe, 350 mm DI, restrained joints	l.m.	$225.00	400	$90,000.00
2	Trench and Backfill, 3 - 4 m depth	l.m.	$250.00	2800	$700,000.00
3	pipe installation, unrestrained	l.m.	$100.00	2400	$240,000.00
	pipe installation, restrained	l.m.	$150.00	400	$60,000.00
4	drain rock or pea gravel pipe bedding	l.m.	$25.00	2800	$70,000.00
5	common excavation and pregrading allowance	cu.m.	$10.00	5000	$50,000.00
6	Hydrants and Hydrant tee assembly	each	$7,500.00	2	$15,000.00
7	Watermain fittings, 350 mm	each	$3,000.00	10	$30,000.00
8	Butterfly valves and valve boxes, 350 mm	each	$3,500.00	4	$14,000.00
9	Concrete Filled Bollards	each	$500.00	8	$4,000.00
10	Surface restoration, subgrade prep	sq.m.	$4.00	0	$0.00
11	Surface restoration, surface course	sq.m.	$10.00	0	$0.00
12	Clearing, grubbing and disposal allowance	sq.m.	$5.00	45000	$225,000.00
13	Tie to Existing Watermains	each	$5,000.00	2	$10,000.00
14	350 Saddles and Mainstops	each	$500.00	2	$1,000.00
15	Flushing and Chlorinating	lump sum	$25,000.00	1	$25,000.00
16	Pressure Testing	lump sum	$12,500.00	1	$12,500.00
17	Rock Excavation and waste (provisional)	cu.m.	$100.00	50	$5,000.00
18	Install trench plugs	each	$500.00	4	$2,000.00
19	PRV bypass vault allowance	lump sum	$150,000.00	1	$150,000.00
20	Road crossing allowance, Mountainview Drive	lump sum	$100,000.00	1	$100,000.00
21	Mobilization / Demobilization	lump sum	$25,000.00	1	$25,000.00
	Subtotal				**$2,308,500.00**
	Eng. & Contingencies @ 25%				$577,125.00
	Total				**$2,885,625.00**

Note: Approximately 80% recoverable with Porter Creek D Development

Option 3- Open Cut Installation, with 300 DI pipe, Wann Road Extension

Wann Road Fire Supply Extension - 1350 lineal meters, restrained joints for 250 lineal meters

Item	Description	Unit	Unit Rate	Quantity	Total
1	pipe, 300 mm DI, bare, un-restrained	l.m.	$175.00	1100	$192,500.00
	pipe, 300 mm DI, restrained joints	l.m.	$200.00	250	$50,000.00
2	Trench and Backfill, 3 - 4 m depth	l.m.	$250.00	1350	$337,500.00
3	pipe installation, unrestrained	l.m.	$75.00	1100	$82,500.00
	pipe installation, restrained	l.m.	$125.00	250	$31,250.00
4	drain rock or pea gravel pipe bedding	l.m.	$25.00	1350	$33,750.00
5	common excavation and pregrading allowance	cu.m.	$10.00	1000	$10,000.00
6	Hydrants and Hydrant tee assembly	each	$7,500.00	2	$15,000.00
7	Watermain fittings, 300 mm	each	$2,500.00	10	$25,000.00
8	Butterfly valves and valve boxes, 30 mm	each	$3,500.00	4	$14,000.00
9	Concrete Filled Bollards	each	$500.00	8	$4,000.00
10	Surface restoration, subgrade prep	sq.m.	$4.00	0	$0.00
11	Surface restoration, surface course	sq.m.	$10.00	0	$0.00
12	Clearing, grubbing and disposal allowance	sq.m.	$5.00	20000	$100,000.00
13	Tie to Existing Watermains	each	$5,000.00	2	$10,000.00
14	300 Saddles and Mainstops	each	$500.00	2	$1,000.00
15	Flushing and Chlorinating	lump sum	$13,500.00	1	$13,500.00
16	Pressure Testing	lump sum	$7,500.00	1	$7,500.00
17	Rock Excavation and waste (provisional)	cu.m.	$100.00	50	$5,000.00
18	Install trench plugs	each	$500.00	4	$2,000.00
19	PRV bypass vault allowance	lump sum	$150,000.00	1	$150,000.00
20	Wann Road Watermain Upgrade Allowance, 100 m	lump sum	$100,000.00	1	$100,000.00
21	Mobilization / Demobilization	lump sum	$25,000.00	1	$25,000.00
	Subtotal				**$1,209,500.00**
	Eng. & Contingencies @ 25%				$302,375.00
	Total				**$1,511,875.00**

Two Mile Hill Booster Upgrade

Upgrade to provide 1 additional booster pump for 0% horizon and 50% year horizon

Estimated cost, 0%	$300,000
Estimated cost, 50%	$500,000

Valleyview Reservoir Upgrade

Upgrade to provide additional 10,000 cu.m. storage for 0% horizon

Estimated Cost $5,600,000

Upgrade to provide additional 5,000 cu.m. storage for 50% year horizon

Estimated Cost $2,800,000

Porter Creek Reservior Upgrade

Upgrade to provide additional 6,000 cu.m. storage for 50% horizon

Estimated Cost $3,400,000

Note: all costs are in 2008 dollars and include a 25% allowance for indirect costs and contingency

Appendix C

Separate Fire Supply Assessment

City of Whitehorse

Whistle Bend
Separate Fire Supply Analysis

Max fire pumper truck

Fire Flow required =	300	L/s
	18,000	L/min
Duration required based on FUS =	4	hour
Fire Flow required based on the required duraton =	4,320,000	L

Residential Areas

Fire Flow required =	150	L/s
	9,000	L/min
Duration required based on FUS =	2	hour
Fire Flow required based on the required duraton =	1,080,000	L

Fire Fighting Demands

Fire Flow = 300 L/s

Hazen Williams

Head loss under Fire Flow

L =	2200	m	
Q =	0.3000	m3/s	FF
C =	120		
D =	0.35	m	
V =	3.12	m/s	

Head Loss = HL

$$HL = \frac{10.7\ L\ Q^{1.852}}{C^{1.852}\ D^{4.87}}$$

= 59 m of head

= 84 psi

Fire Fighting Demands

Fire Flow = 150 L/s

Hazen Williams

Head loss under Fire Flow

L =	2200	m	
Q =	0.1500	m3/s	FF
C =	120		
D =	0.25	m	
V =	3.06	m/s	

Head Loss = HL

$$HL = \frac{10.7\ L\ Q^{1.852}}{C^{1.852}\ D^{4.87}}$$

= 85 m of head

= 120 psi

Pump Requirements

specific weight of water, γ =	9810	N/m3	
Rate of Flow, Q =	0.3000	m3/s	
Velocity =	3.12	m/s	
pressure head =	14	m	20 psi
elevation head =	49	m	
pipe friction head loss =	59	m	
Total Head, H =	122	m	

Power (kilowatts)= $\frac{\gamma\ Q\ H}{1000}$

	360	kW
	483	hp
Efficiency =	75%	
Required power =	480	kW
	644	hp

1hp = 0.746 kW

Pump Requirements

specific weight of water, γ =	9810	N/m3	
Rate of Flow, Q =	0.1500	m3/s	
Velocity =	3.06	m/s	
residual head =	14	m	20 psi
elevation head =	49	m	
pipe friction head loss =	85	m	
Energy Head, H =	148	m	

Power (kilowatts)= $\frac{\gamma\ Q\ H}{1000}$

	217	kW
	291	hp
Efficiency =	75%	
Required power =	290	kW
	388	hp

1hp = 0.746 kW

Fire Supply Options - Separate Fire and Domestic Systems, or Combined Fire/Domestic System

Assumptions: Separate Fire Supply System
300 l/s maximum required fire flow
3 m/s maximum velocity
fire flow in 2 directions
min. pipe area required is 0.05 sq.m.
min. pipe diameter required is 250 mm
trunk on main roads is 350 mm

Assumptions: Domestic Water Supply System
175 l/s ultimate PHD
3 m/s maximum velocity
flow in 2 directions
min. pipe area required is 0.029 sq.m.
min. pipe diameter required is 200 mm

Assumptions: Combined Domestic/Fire Water Supply System
87 l/s ultimate MDD
300 l/s maximum required fire flow
387 l/s maximum combined flow required
3 m/s maximum velocity
flow in 2 directions
min. pipe area required is 0.065 sq.m.
min. pipe diameter required is 300 mm

Assumptions: Required Length of Systems
length of mains required:
along main roads = 8,800 m
looped system in mixed res areas = 12,200 m
hydrants spaced @ 90 m average = 235
valves = 300

Separate Fire Supply System Costs (Common Trench with Domestic)

Item	Description	Unit	Unit Rate	Quantity	Total
1	pipe, 350 mm DI, bare, un-restrained	l.m.	$200.00	8800	$1,760,000.00
2	pipe, 250 mm DI, bare, un-restrained	l.m.	$125.00	12200	$1,525,000.00
3	Trench and Backfill, 3 - 4 m depth (common)	l.m.	$150.00	21000	$3,150,000.00
4	pipe installation, unrestrained	l.m.	$50.00	21000	$1,050,000.00
5	drain rock or pea gravel pipe bedding	l.m.	$15.00	21000	$315,000.00
6	Hydrants and Hydrant tee assembly	each	$7,500.00	235	$1,762,500.00
7	Watermain fittings, 250 and 350 mm	each	$2,500.00	275	$687,500.00
8	Valves and valve boxes, 250 and 350 mm	each	$3,000.00	300	$900,000.00
9	Flushing and Chlorinating	lump sum	$10.00	21000	$210,000.00
10	Pressure Testing	lump sum	$5.00	21000	$105,000.00
11	River Intake or Well Supply Option Allowance	lump sum	$250,000.00	1	$250,000.00
12	Fire Supply pumphouse, recirculation and heating	lump sum	$2,300,000.00	1	$2,300,000.00
	Subtotal				**$14,015,000.00**
	Eng. & Contingencies @ 25%				$3,503,750.00
	Total				**$17,518,750.00**

Note:
Additional operational costs include heating, circulation costs for freeze protection of system.
Some cost reduction for reduced treatment of fire water required under combined system.
Some cost reduction for capital cost of 2nd Fire Flow supply from Option 2 or 3.
Some cost reduction for capital cost of increased reservoir capacity for combined system.

Separate Domestic Supply System Costs (Common Trench with Fire Supply)

Item	Description	Unit	Unit Rate	Quantity	Total
1	pipe, 200 mm DI, bare, un-restrained	l.m.	$100.00	21000	$2,100,000.00
2	Trench and Backfill, 3 - 4 m depth (common)	l.m.	$150.00	21000	$3,150,000.00
3	pipe installation, unrestrained	l.m.	$50.00	21000	$1,050,000.00
4	drain rock or pea gravel pipe bedding	l.m.	$15.00	21000	$315,000.00
5	Hydrants and Hydrant tee assembly	each	$7,500.00	0	$0.00
6	Watermain fittings, 200 mm	each	$2,000.00	275	$550,000.00
7	Valves and valve boxes, 200 mm	each	$2,500.00	140	$350,000.00
8	Flushing and Chlorinating	lump sum	$10.00	21000	$210,000.00
9	Pressure Testing	lump sum	$5.00	21000	$105,000.00
	Subtotal				**$7,830,000.00**
	Eng. & Contingencies @ 25%				$1,957,500.00
	Total				**$9,787,500.00**

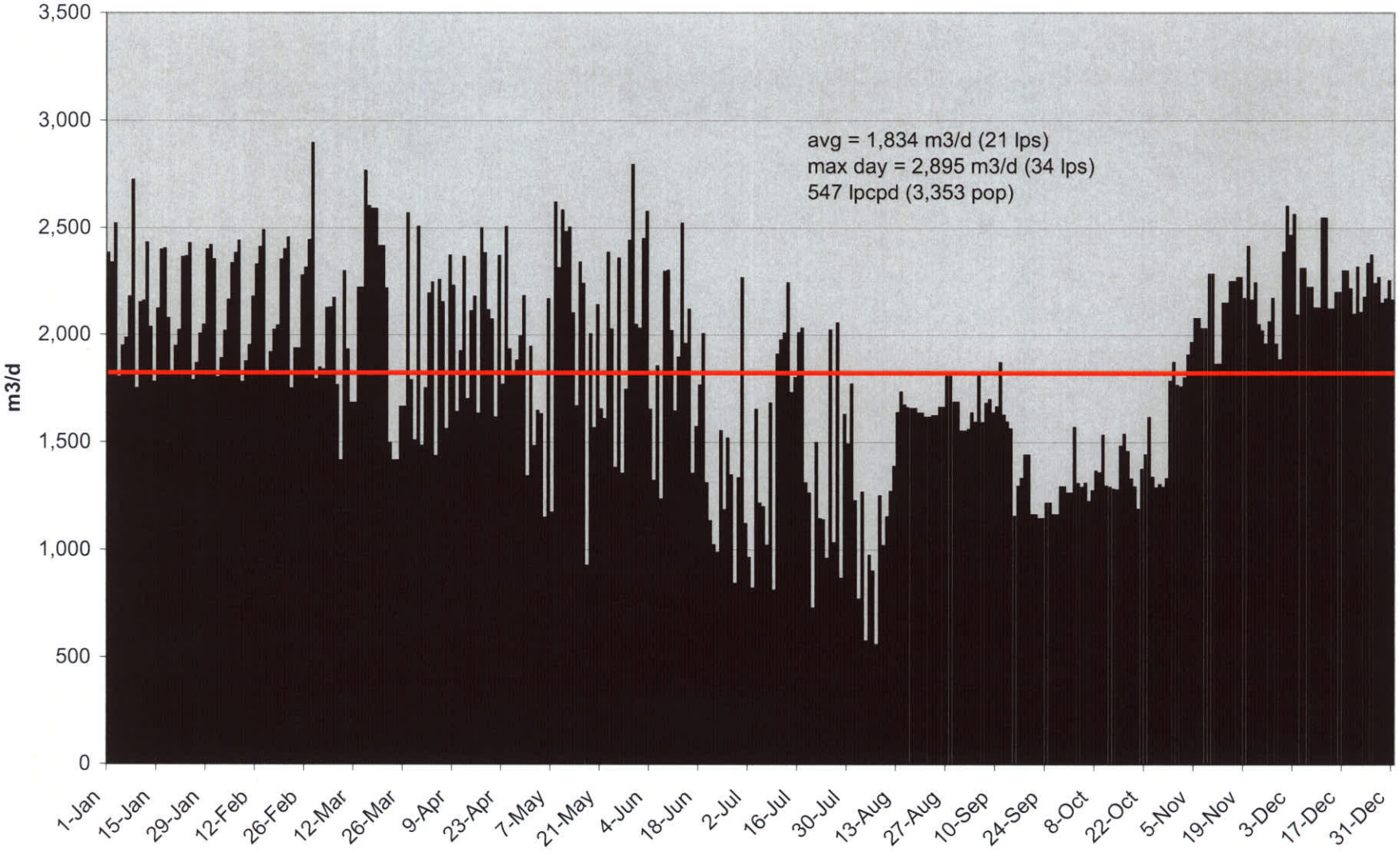
Combined Domestic / Fire Supply System Costs

Item	Description	Unit	Unit Rate	Quantity	Total
1	pipe, 300 mm DI, bare, un-restrained	l.m.	$150.00	21000	$3,150,000.00
2	Trench and Backfill, 3 - 4 m depth	l.m.	$250.00	21000	$5,250,000.00
3	pipe installation, unrestrained	l.m.	$50.00	21000	$1,050,000.00
4	drain rock or pea gravel pipe bedding	l.m.	$25.00	21000	$525,000.00
5	Hydrants and Hydrant tee assembly	each	$7,500.00	235	$1,762,500.00
6	Watermain fittings, 300 mm	each	$3,000.00	275	$825,000.00
7	Valves and valve boxes, 300 mm	each	$3,500.00	300	$1,050,000.00
8	Flushing and Chlorinating	lump sum	$10.00	21000	$210,000.00
9	Pressure Testing	lump sum	$5.00	21000	$105,000.00
	Subtotal				**$13,927,500.00**
	Eng. & Contingencies @ 25%				$3,481,875.00
	Total				**$17,409,375.00**

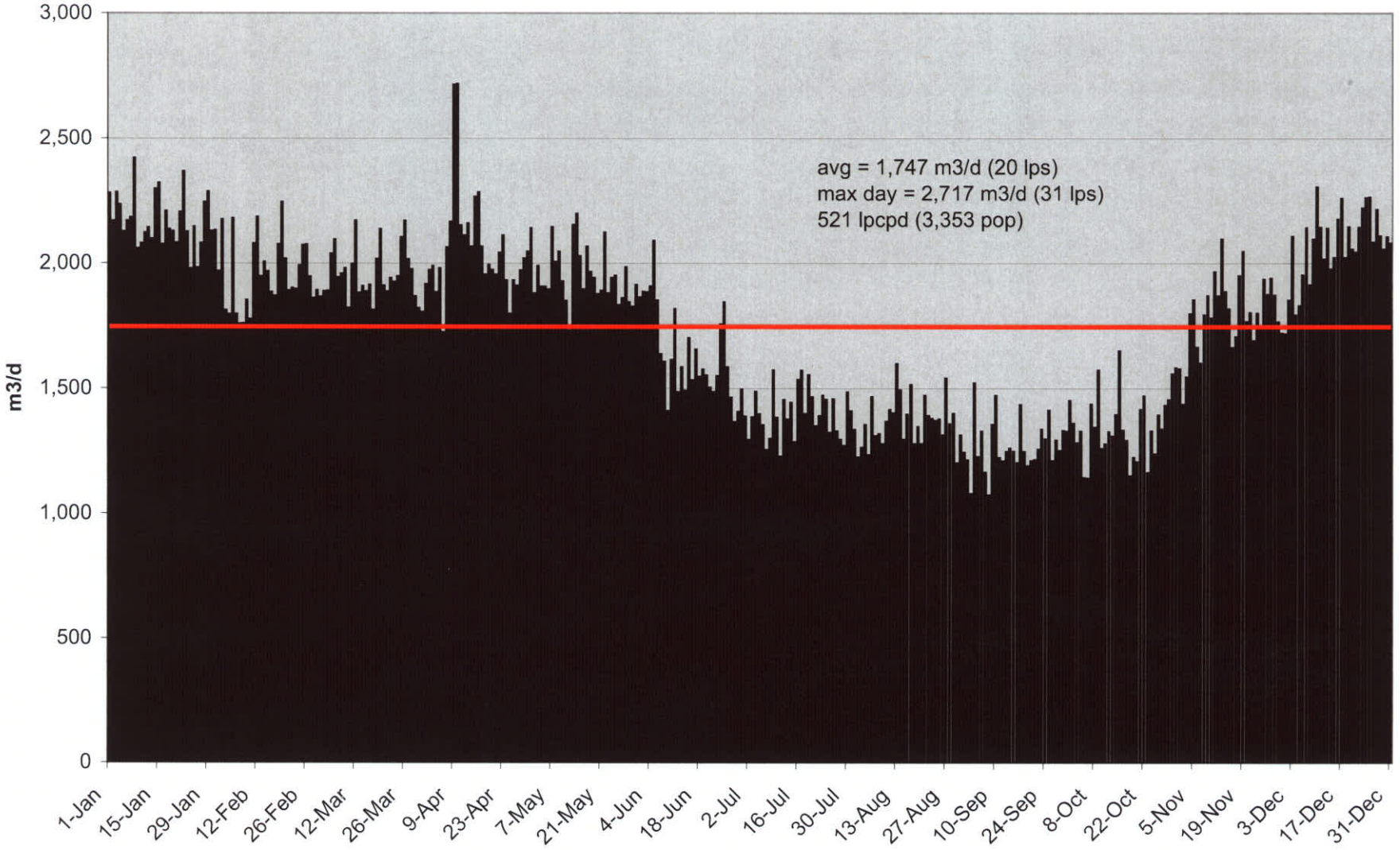
Appendix D

Porter Creek Wastewater Flow Data

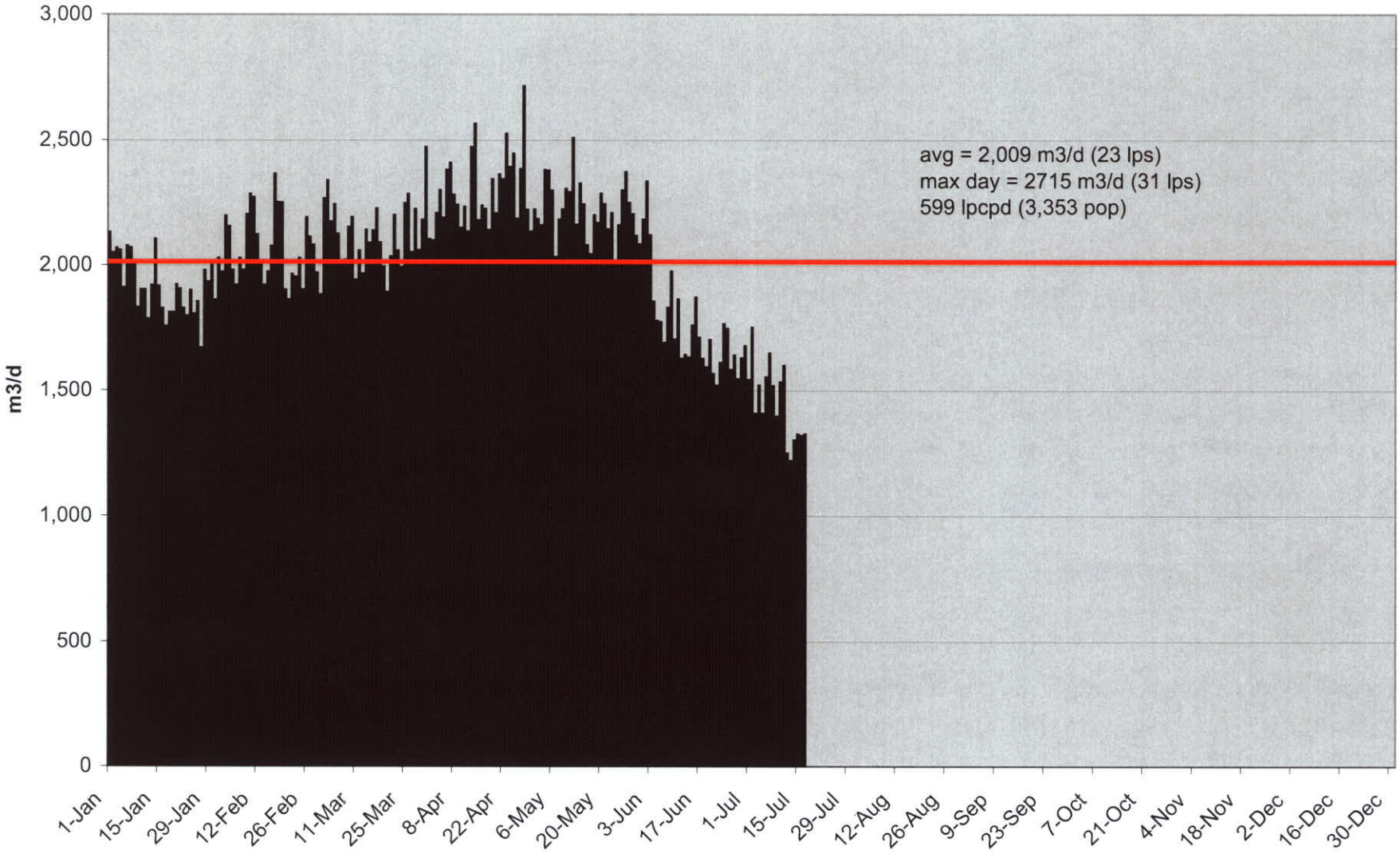
2006 PC Flush Tank Flows



2007 PC Flush Tank Flows



2008 PC Flush Tank Flows



Appendix E

Wastewater Servicing Cost Estimates

City of Whitehorse | ***Whistle Bend Off-Site Wastewater Servicing*** | ***Cost Estimates***

Option 1- connect Whistle Bend sanitary flows directly into PCFT force main

Horizon	Item	Description	Unit	Unit Rate	Quantity	Total
0%	1	Mobilization / Demobilization	lump sum	$25,000	1	$25,000
	2	Clearing, grubbing and disposal allowance	sq.m.	$5	1000	$5,000
	3	Pump station (200 lps at 35m TDH; 150 HP) - wet well / dry well c/w stand by power	lump sum	$2,000,000	1	$2,000,000
	4	450mm DR 17 HDPE pipe	l.m.	$225	50	$11,250
	5	Trench and Backfill, 3 - 4 m depth	l.m.	$250	50	$12,500
	6	pipe installation	l.m.	$125	50	$6,250
	7	drain rock or pea gravel pipe bedding	l.m.	$25	50	$1,250
	8	Tie-in to PCFT FM c/w chamber and valving	lump sum	$10,000	1	$10,000
	9	Flushing and testing	lump sum	$5,000	1	$5,000
		0% Subtotal				**$2,076,250**
25% (5 years)	1	Do nothing			1	$0
		25% Subtotal				**$0**
50% (10 years)	1	Do nothing			1	$0
		50% Subtotal				**$0**
75% (15 years)	1	Mobilization / Demobilization	lump sum	$10,000	1	$10,000
	2	Clearing, grubbing and disposal allowance	sq.m.	$5	3250	$16,250
	3	450mm DR 17 HDPE pipe	l.m.	$225	750	$168,750
	4	Trench and Backfill, 3 - 4 m depth	l.m.	$250	750	$187,500
	5	pipe installation	l.m.	$125	750	$93,750
	6	drain rock or pea gravel pipe bedding	l.m.	$25	750	$18,750
	7	Tie ins	lump sum	$30,000	1	$30,000
	8	Flushing and testing	lump sum	$1,500	1	$1,500
		75% Subtotal				**$526,500**
		Subtotal				**$2,602,750**
		Eng. & Contingencies @ 25%				$650,688
		Total				**$3,253,438**
		NPV (based on net 4% annual interest)				**$2,700,000**

Option 2- connect Whistle Bend sanitary flows directly into PCFT

Horizon	Item	Description	Unit	Unit Rate	Quantity	Total
0%	1	Mobilization / Demobilization	lump sum	$25,000	1	$25,000
	2	Clearing, grubbing and disposal allowance	sq.m.	$5	2000	$10,000
	3	Pump station (200 lps at 35m TDH; 125 HP) - wet well / dry well c/w stand by power	lump sum	$1,500,000	1	$1,500,000
	4	450mm DR 17 HDPE pipe	l.m.	$225	370	$83,250
	5	Trench and Backfill, 3 - 4 m depth	l.m.	$250	370	$92,500
	6	pipe installation	l.m.	$125	370	$46,250
	7	drain rock or pea gravel pipe bedding	l.m.	$25	370	$9,250
	8	Tie-in to PCFT c/w chamber and valving	lump sum	$15,000	1	$15,000
	9	Flushing and testing	lump sum	$5,000	1	$5,000
		0% Subtotal				**$1,786,250**
25% (5 years)	1	Do nothing			1	$0
		25% Subtotal				**$0**
50% (10 years)	1	Do nothing			1	$0
		50% Subtotal				**$0**
75% (15 years)	1	Mobilization / Demobilization	lump sum	$10,000	1	$10,000
	2	Clearing, grubbing and disposal allowance	sq.m.	$5	1000	$5,000
	3	450mm DR 17 HDPE pipe	l.m.	$225	200	$45,000
	4	Trench and Backfill, 3 - 4 m depth	l.m.	$250	200	$50,000
	5	pipe installation	l.m.	$125	200	$25,000
	6	drain rock or pea gravel pipe bedding	l.m.	$25	200	$5,000
	7	Tie ins	lump sum	$30,000	1	$30,000
	8	Flushing and testing	lump sum	$1,500	1	$1,500
		75% Subtotal				**$171,500**
		Subtotal				**$1,957,750**
		Eng. & Contingencies @ 25%				$489,438
		Total				**$2,447,188**
		NPV (based on net 4% annual interest)				**$2,300,000**

Appendix F

Porter Creek Lagoons Sludge and Supernatant Volumes

Gartner Lee Limited

September 8, 2008

Mr. Peter Takacs – Project Manager, Community Infrastructure
UMA Engineering Ltd.
275-3001 Wayburne Drive
Burnaby, BC V5G 4W3

Dear Peter:

Re: GLL 80424 – Sewage/Sludge Characterization of Porter Creek Lagoons and Infiltration Basin

The Porter Creek Lagoon system is made up of two sewage treatment cells, which we understand have remained inactive for a number of years, and an additional infiltration basin, which has been used for disposing of wastewater collected by eduction trucks from storm catch basins and sewer manholes.

It is our understanding that the Porter Creek Lagoons are to be decommissioned as part of the Whistle Bend (Lower Porter Creek Bench) Development. To help in developing decommissioning strategies, the sewage supernatant and sludge volumes for the Porter Creek lagoons and infiltration basin need to be estimated.

Based on the design drawings and assumed depths for the lagoons, Table 1 presents the order-of-magnitude estimates of lagoon supernatant and sludge volumes.

While drawings were available for the two treatment cells, they were not available for the infiltration basin. Dimensions for the infiltration basin were determined from a 2004 aerial photo of the lagoon site. The volumes based on these measurements and an assumed slope of 4:1 are also presented in Table 1. The volume calculations spreadsheet for the lagoons and infiltration basin are presented in the attached Table 2 for reference.

2251 2nd Avenue, Whitehorse, Yukon, Y1A 5W1 tel 867.633.6474 fax 867.633.6321
www.gartnerlee.com

Table 1: Estimated Supernatant and Sludge Volumes for the Porter Creek Lagoons and Infiltration Basin

	Assumed Depth		Order-of-magnitude Volumes	
	Total Sewage[1]	Sludge	Supernatant	Sludge
Lagoon Cell #1	3.2 m	0.5 to 1.0 m	2,233 to 2,713 m^3	469 to 948 m^3
Lagoon Cell #2	4 m	0.5 to 1.0 m	5,823 to 6,741 m^3	903 to 1,821 m^3
Infiltration Basin	1 m	0.5 m	512 m^3	504 m^3

1: Total Sewage Depth is assumed to be 2.0 m below the top of the berm for the lagoon cells, and level with the top of the berm for the basin.

The values presented in Table 1 reflect order-of-magnitude volumes of sewage/sludge contents in the two lagoons and the infiltration basin, and they can be used to determine decommissioning strategies. Depending on the strategies considered and option(s) selected, analytical sampling of the Porter Creek Lagoons may be needed for defining transporting and disposing sewage/sludge strategies/requirements.

Please contact us should you have any questions or wish to discuss this further.

Yours truly,
GARTNER LEE LIMITED

Greg Bull, M. Eng., P. Eng.
Sr. Environmental Engineer

Attachments: Table 2: Supernatant and Sludge Volume Calculations for the Porter Creek Lagoons and Infiltration Basin

Table 2: Supernatant and Sludge Volume Calculations for the Porter Creek Lagoons and Infiltration Basin

	[5]b: Width (m)	[5]a: Length (m)	Sd (m)	[6]d: Depth (m)	[4]S	[1]V: Volume (m)
Lagoon Cell # 1	32	29	1.7333	5.2	0.3333	5392
[2]total sewage	32	29	1.0667	3.2	0.3333	3182
supernatant (max)	32	29	0.9000	2.7	0.3333	2713
supernatant (min)	32	29	0.7333	2.2	0.3333	2233
sludge (max)	32	29	0.3333	1	0.3333	948
sludge (min)	32	29	0.1667	0.5	0.3333	469
Lagoon Cell # 2	32	56	2.0000	6	0.3333	11833
[2]total sewage	32	56	1.3333	4	0.3333	7645
supernatant (max)	32	56	1.1667	3.5	0.3333	6741
supernatant (min)	32	56	1.0000	3	0.3333	5823
sludge (max)	32	56	0.3333	1	0.3333	1821
sludge (min)	32	56	0.1667	0.5	0.3333	903
[3]**Infiltration Basin**	25	40	0.25	1	0.25	1016
supernatant	25	40	0.125	0.5	0.25	512
sludge	25	40	0.125	0.5	0.25	504

[1]Volume Calculation for rectangular basin with sloped sides and round corners:

$$V = d[(a + Sd)(b + Sd) + 0.0472\, S^2 d^2]$$

[2] It is assumed that the depth of the total sewage in both lagoons is 2m below the berm.

[3] It is assumed that depth of the total sewage in the infiltration basin is level with the top of the basin.

[4] The Slope for both lagoon cells was taken from the lagoon design drawings; the slope of the infiltration basin is assumed to be 4:1. (Slope =1/S)

[5] Dimensions for the Lagoons were determined from design drawings; Dimensions for the infiltration basin are determined from an aerial photo.

[6] d is based on assumed depths.

Appendix G

Drainage Strategies

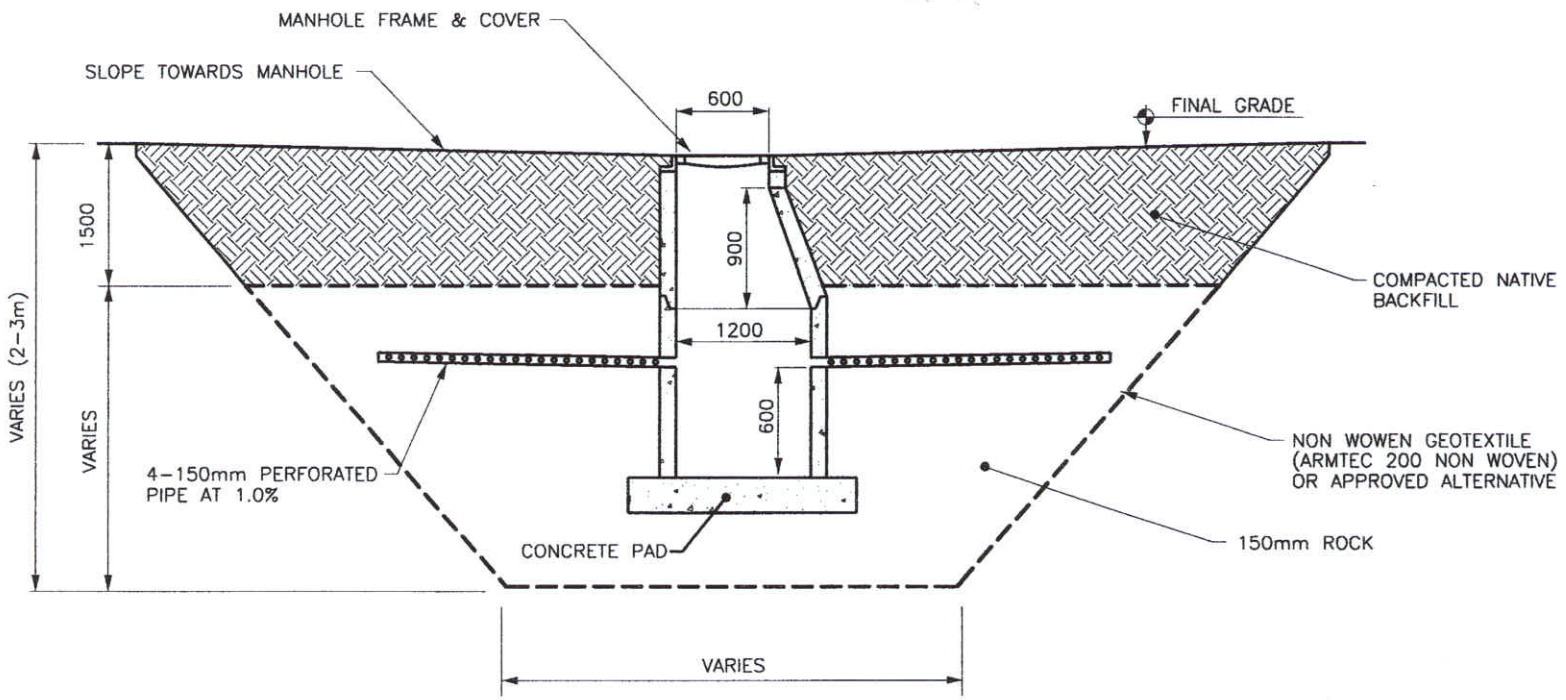
Engineering Department

City of Whitehorse

EXFILTRATION PIT

DATE: DECEMBER 2008

STD DWG



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED.
2. SIZE OF EXFILTRATION PIT TO BE DETERMINED BY ENGINEER.
3. EXFILTRATION PIT TO BE LOCATED IN LANDSCAPED AREAS WHERE POSSIBLE.

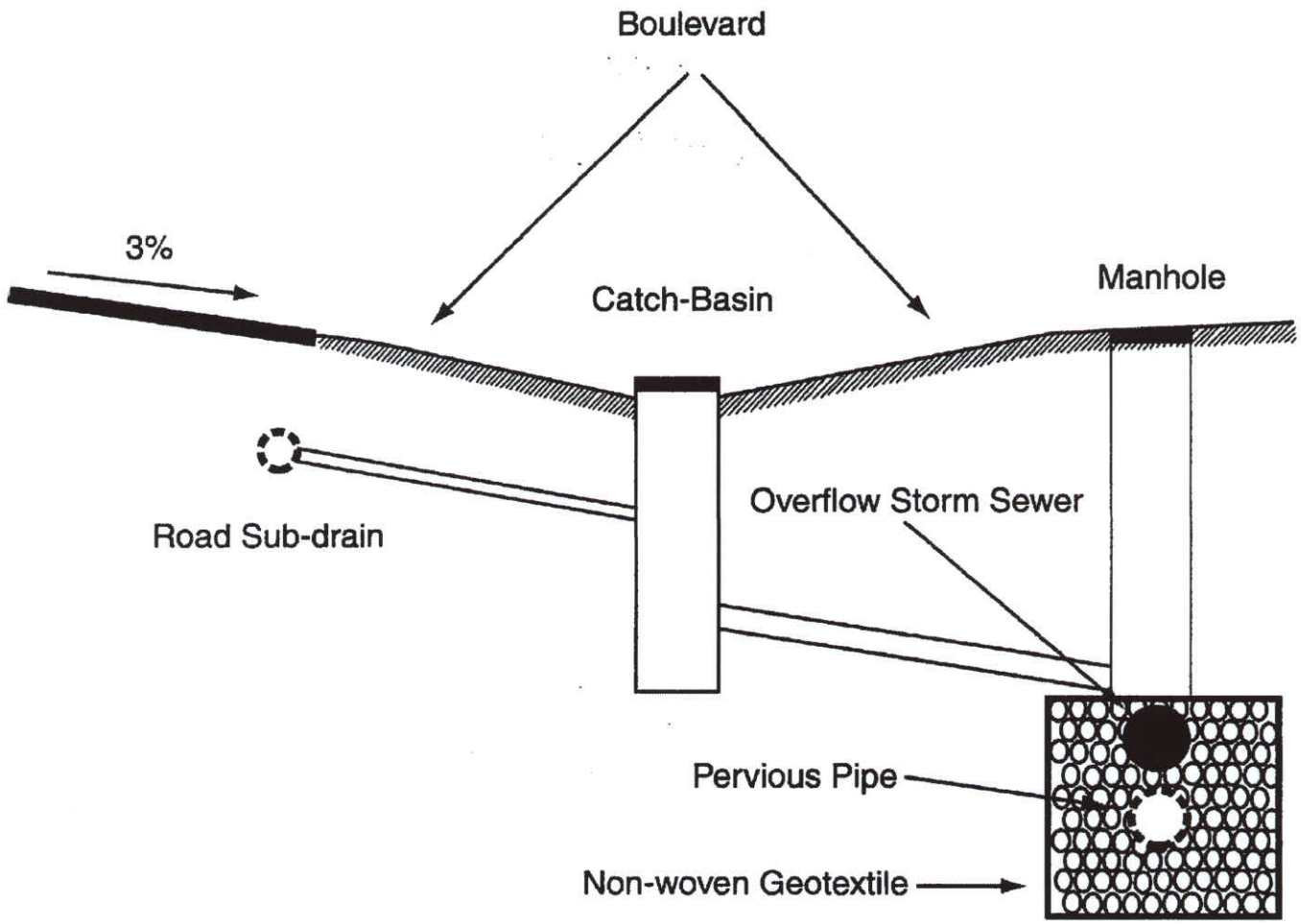


Figure 6.6

Pervious Pipe System

Rear Yard Ponding

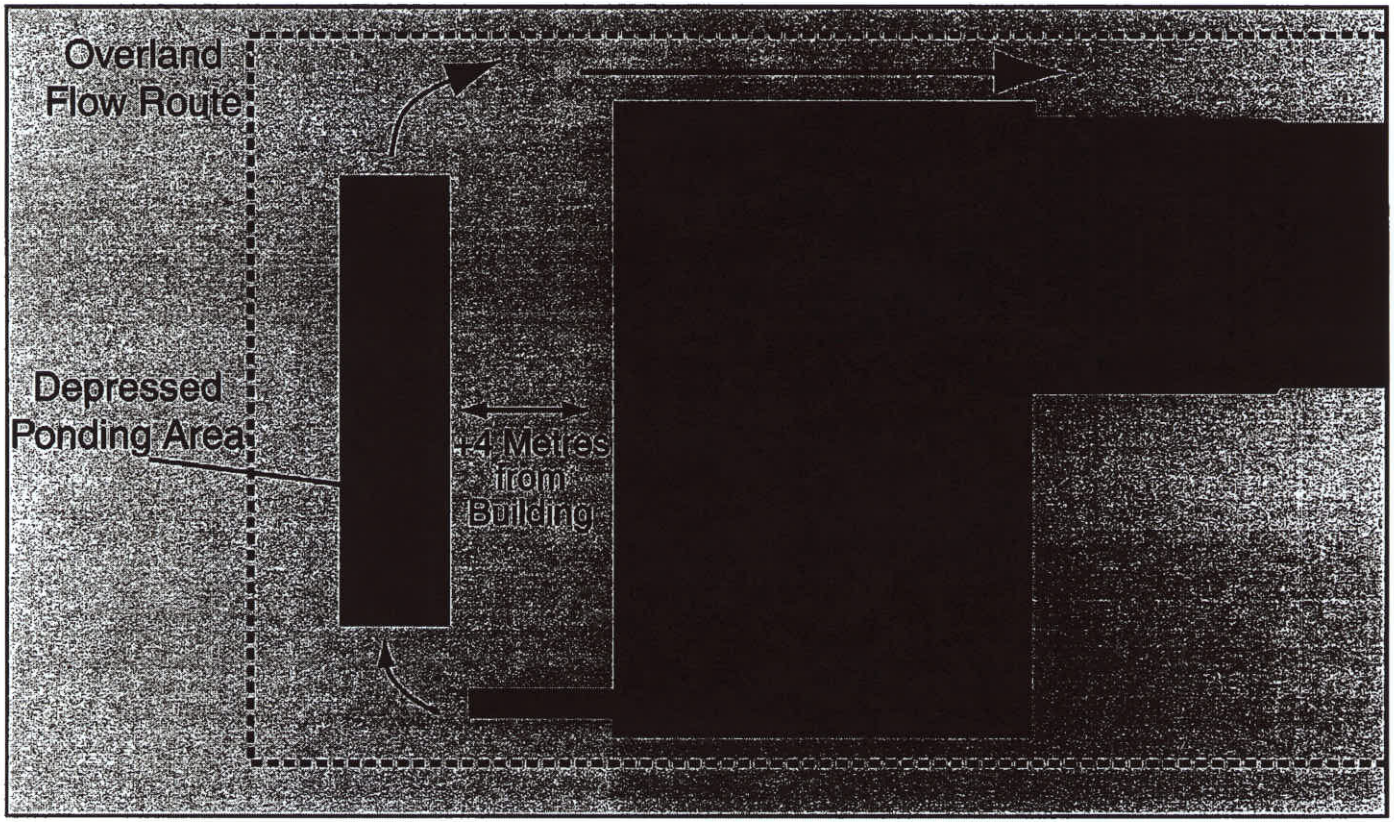


Figure 6.2

Rear Lot Ponding Guidelines

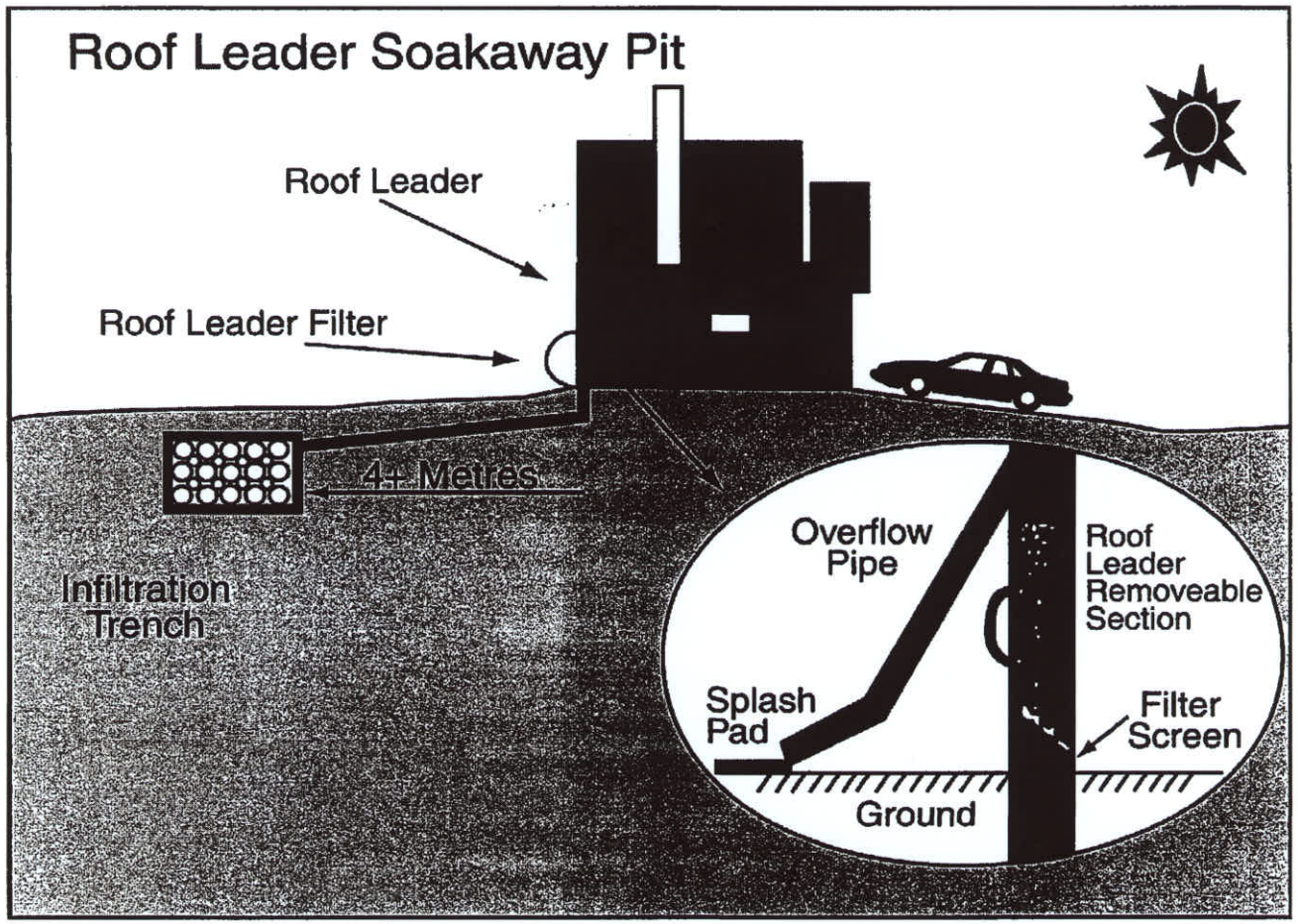


Figure 6.3

Infiltration System with Roof Leader Filter

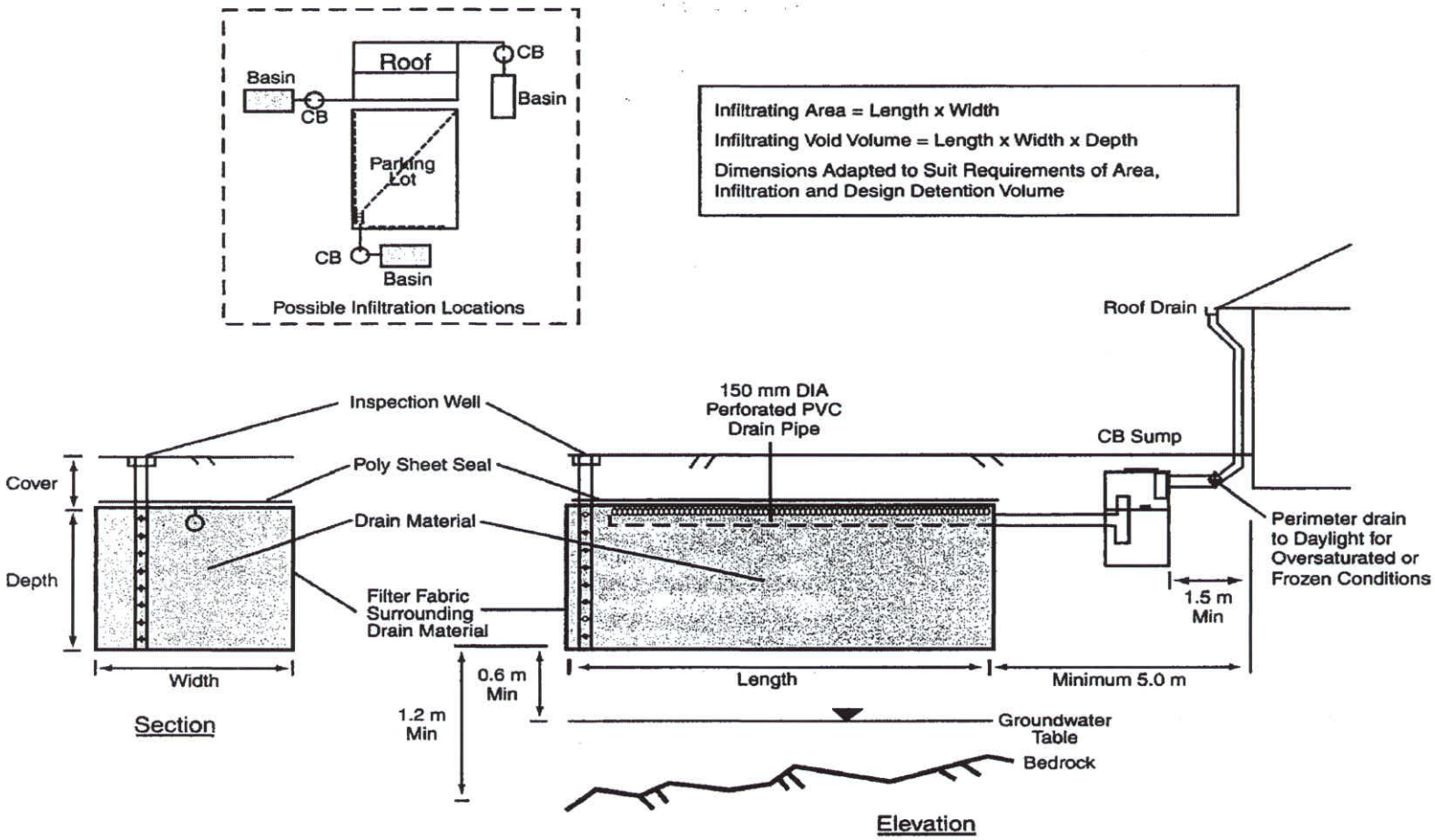


Figure 6.4
Infiltration System with Pretreatment Sump

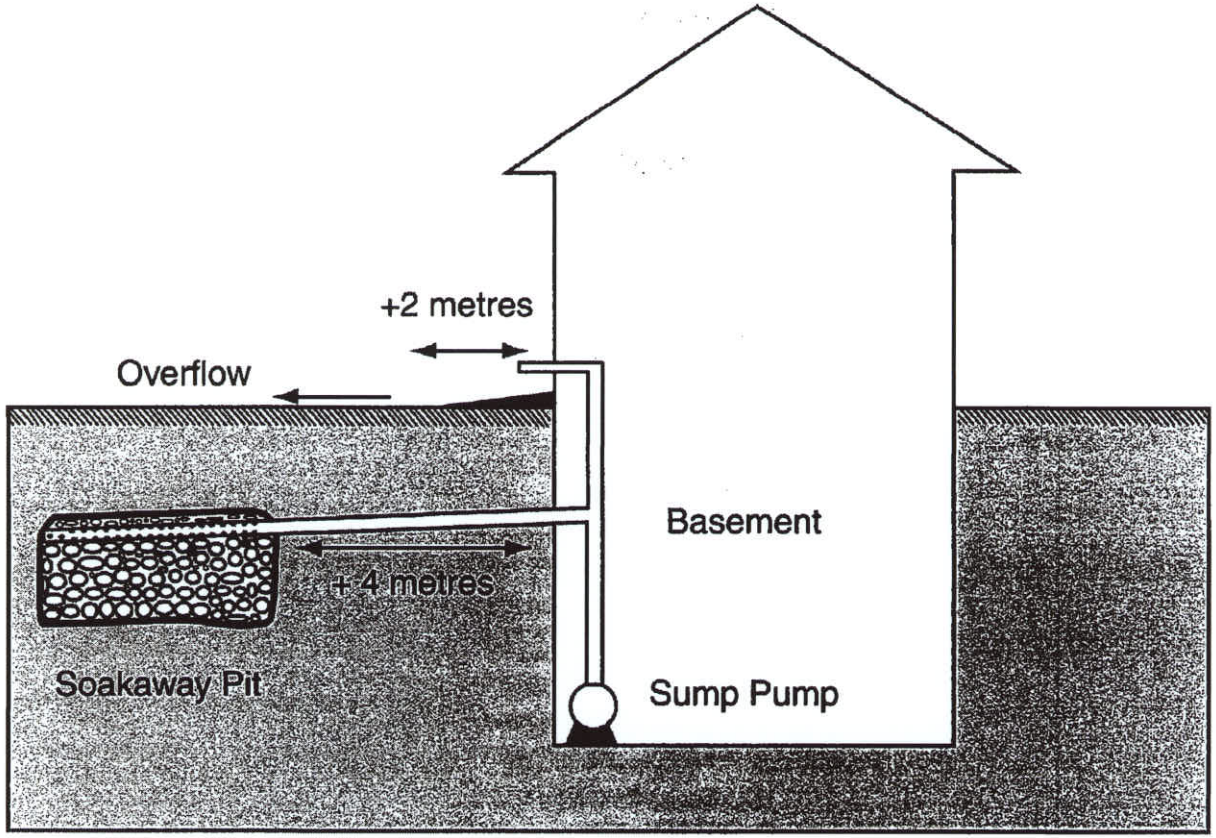


Figure 6.5

Sump Pump Foundation Drainage

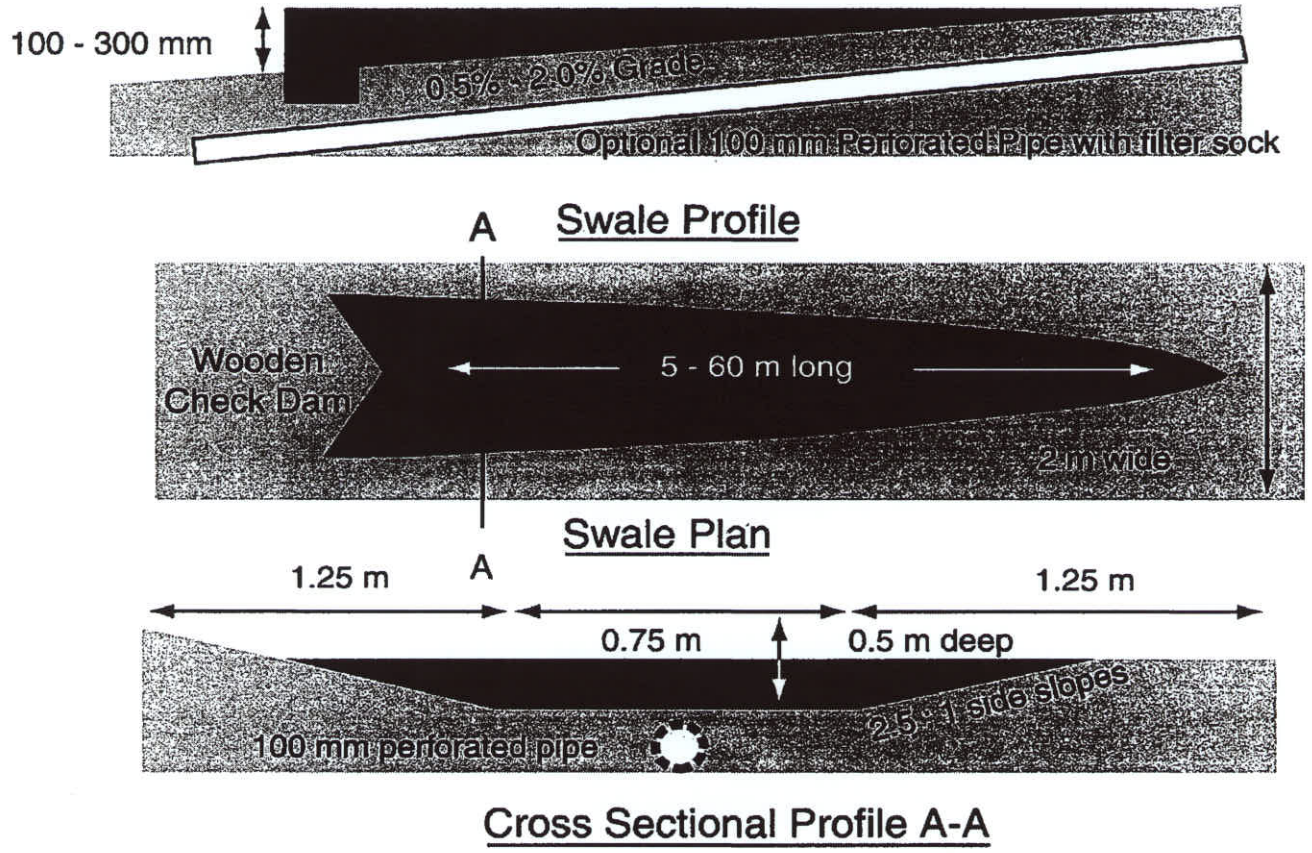


Figure 6.8

Grass Swale Design

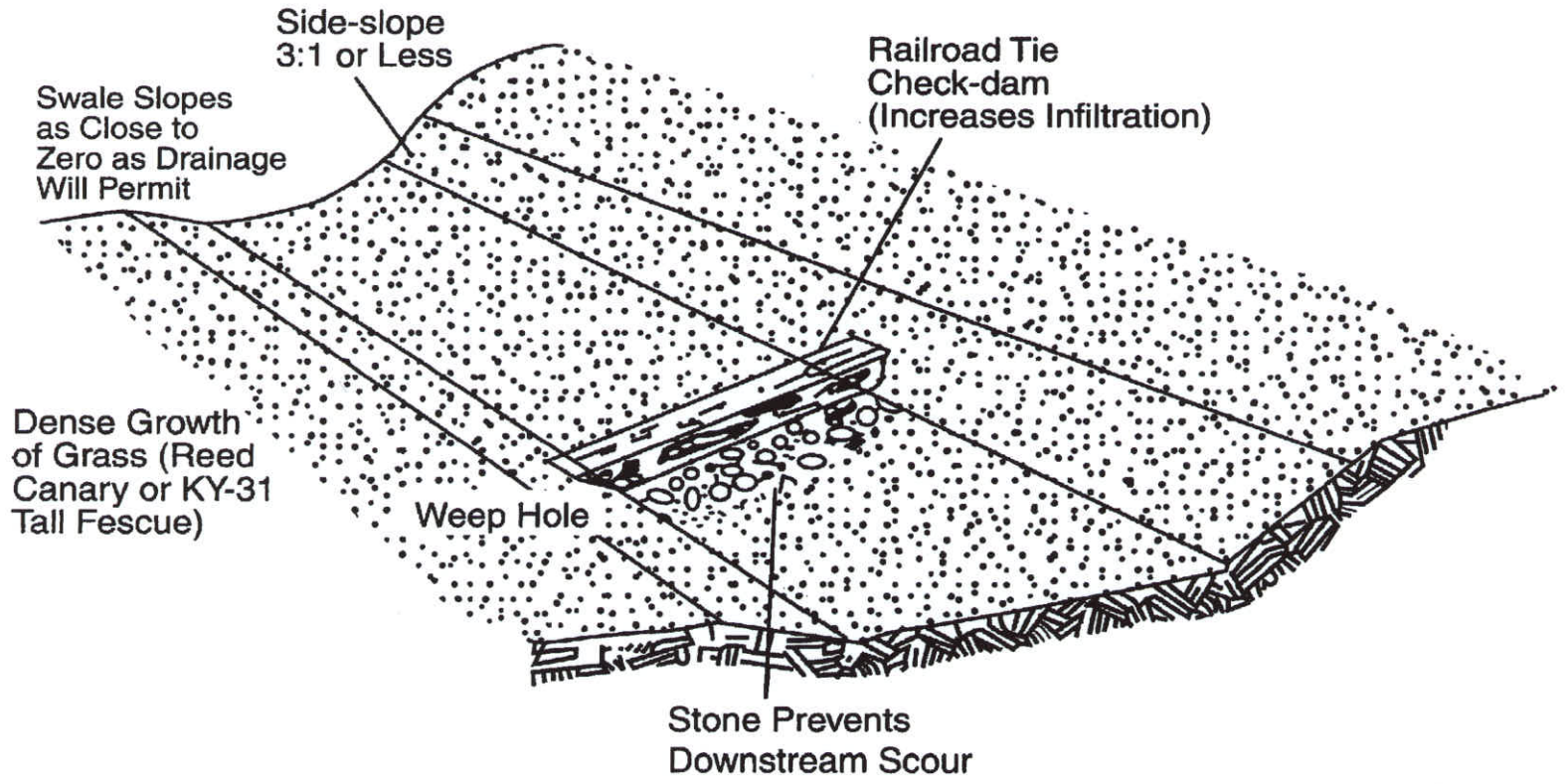


Figure 6.9

Grass Swale with Check Dam

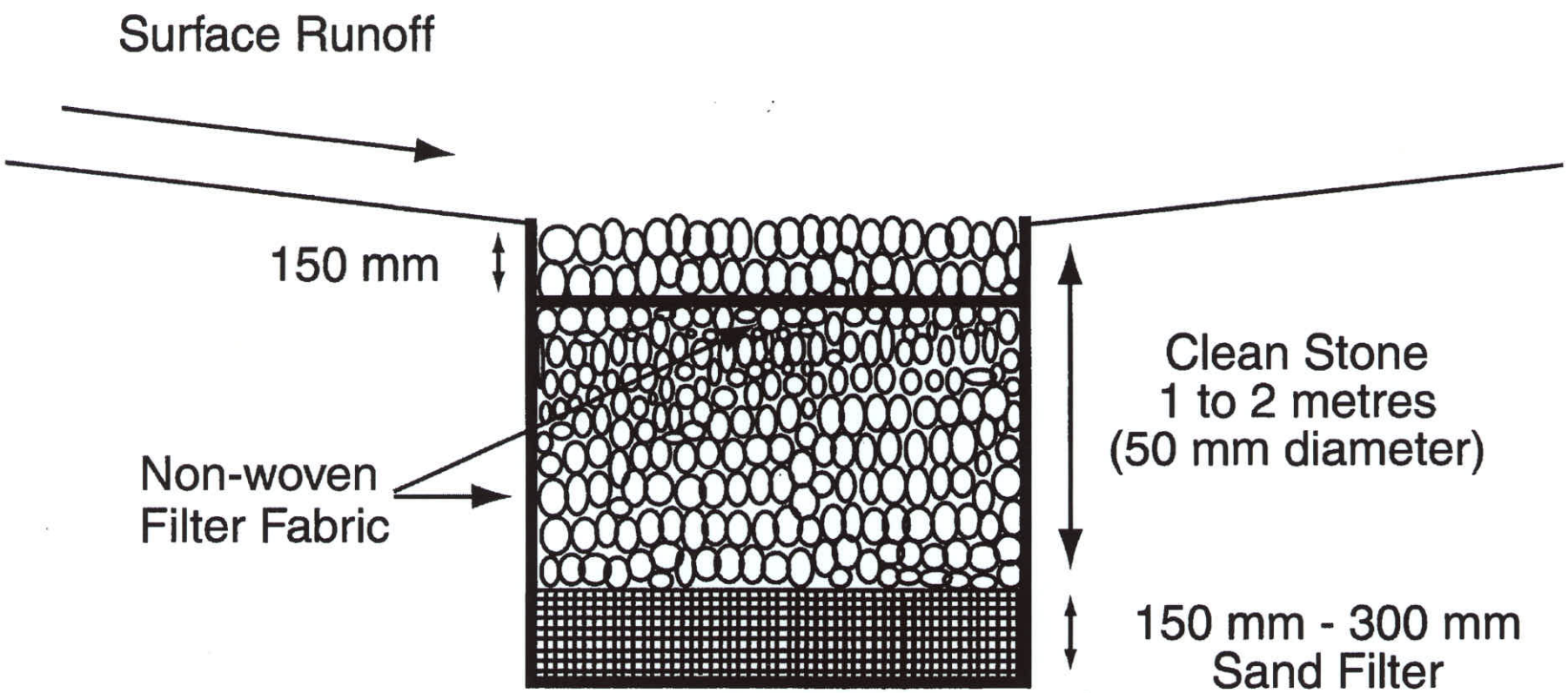


Figure 6.13

Surface Infiltration Trench

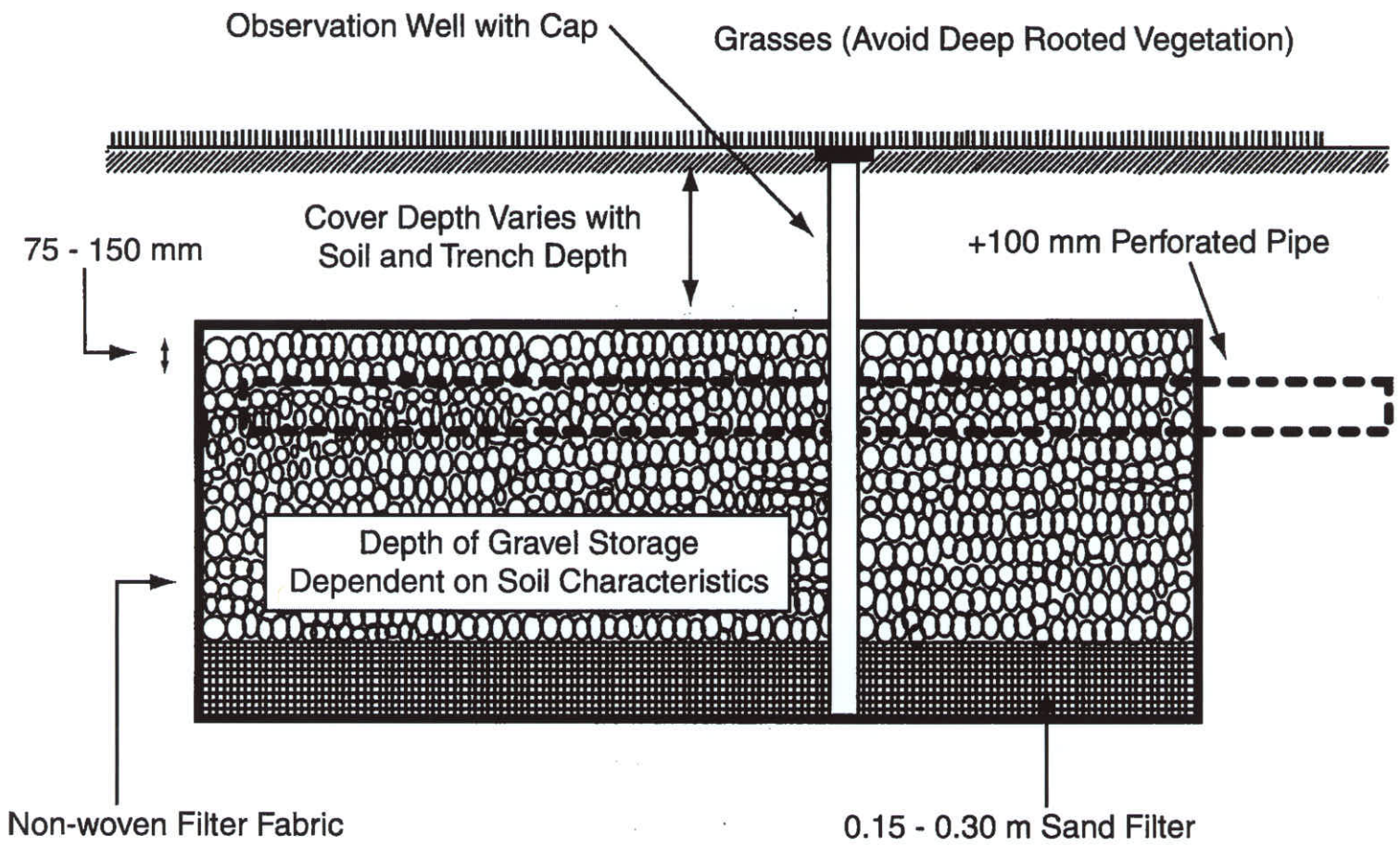


Figure 6.14

Subsurface Infiltration Trench

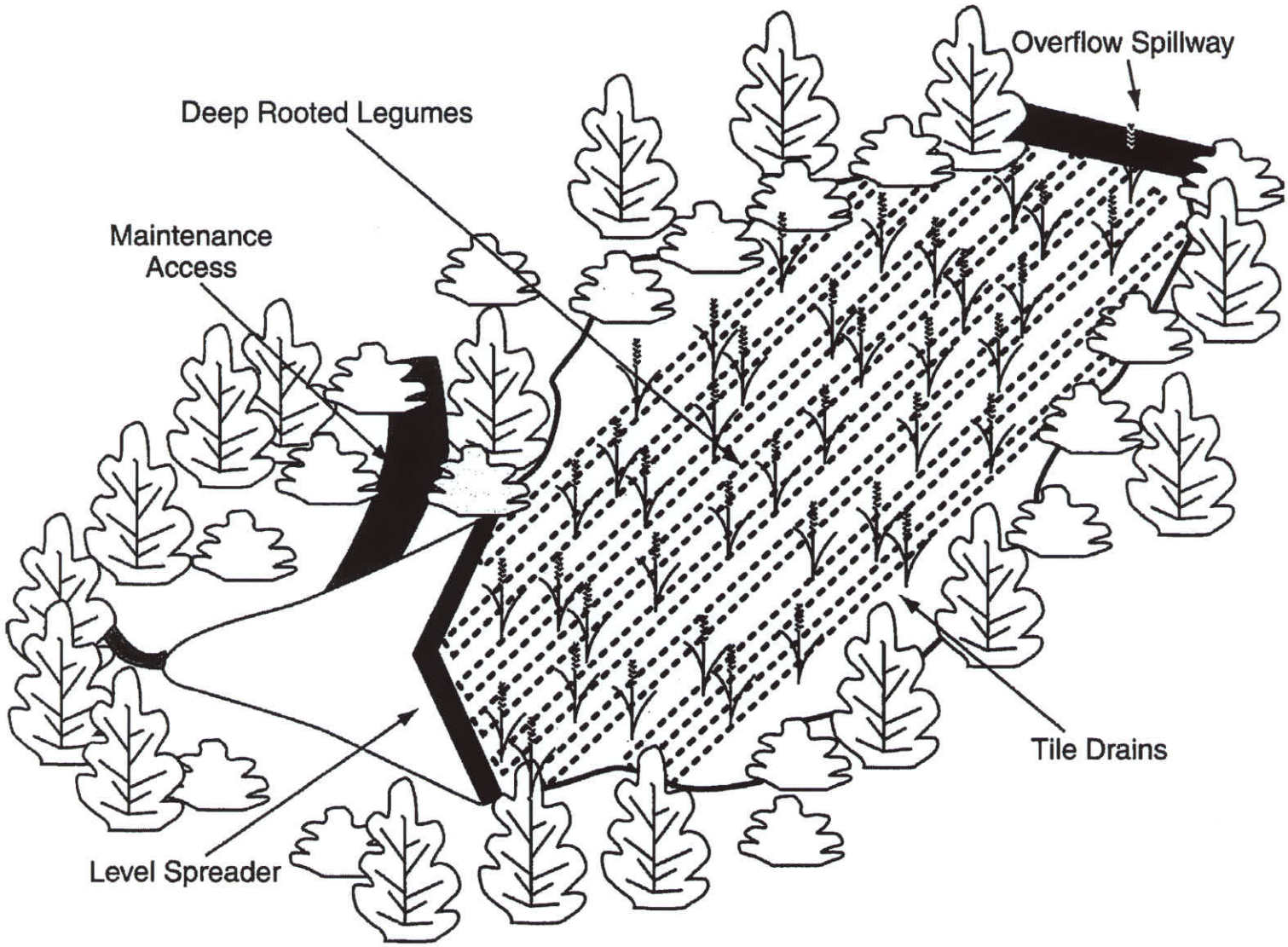


Figure 6.15

Infiltration Basin

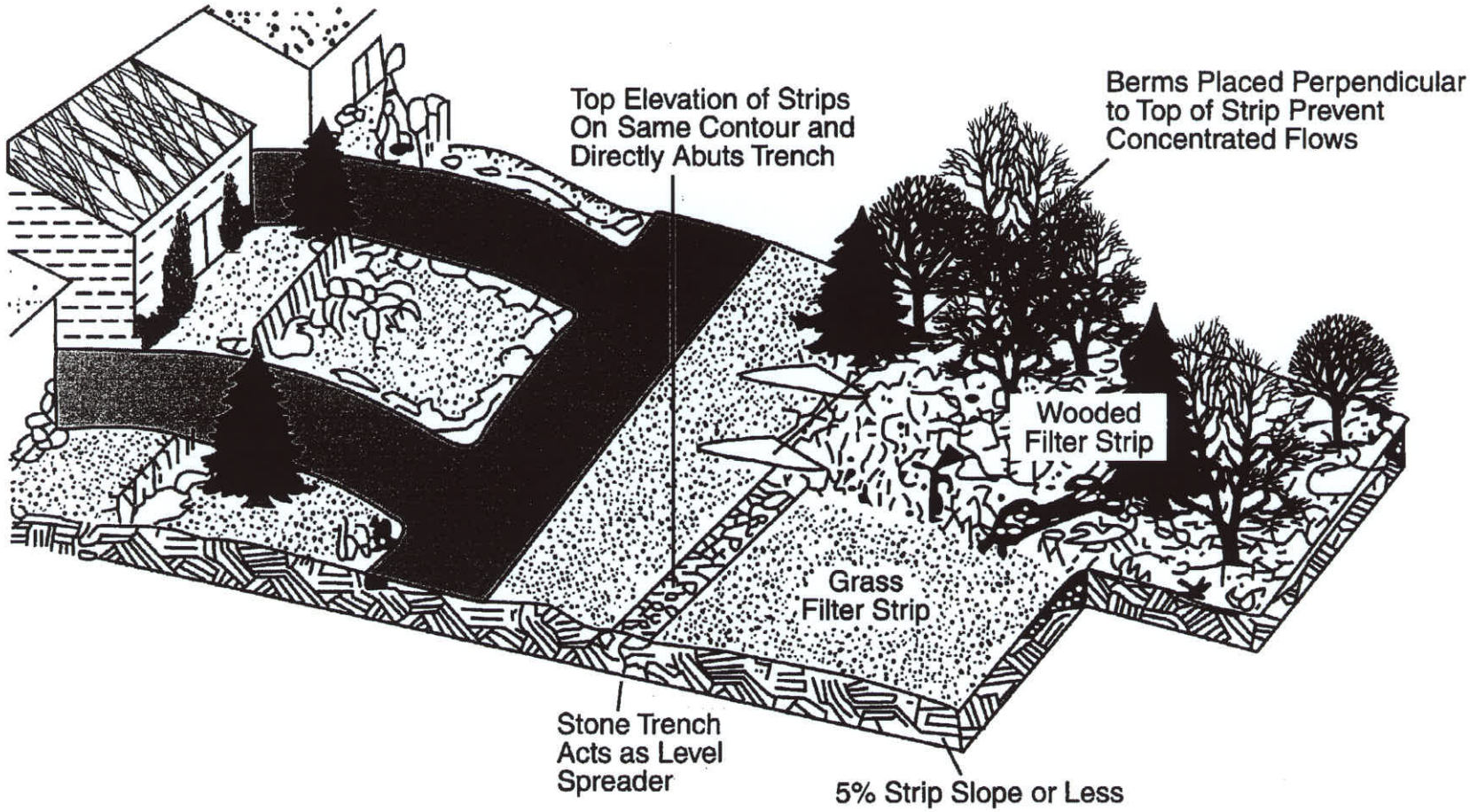


Figure 6.16
Schematic of Grassed and Wooded Filter Strip

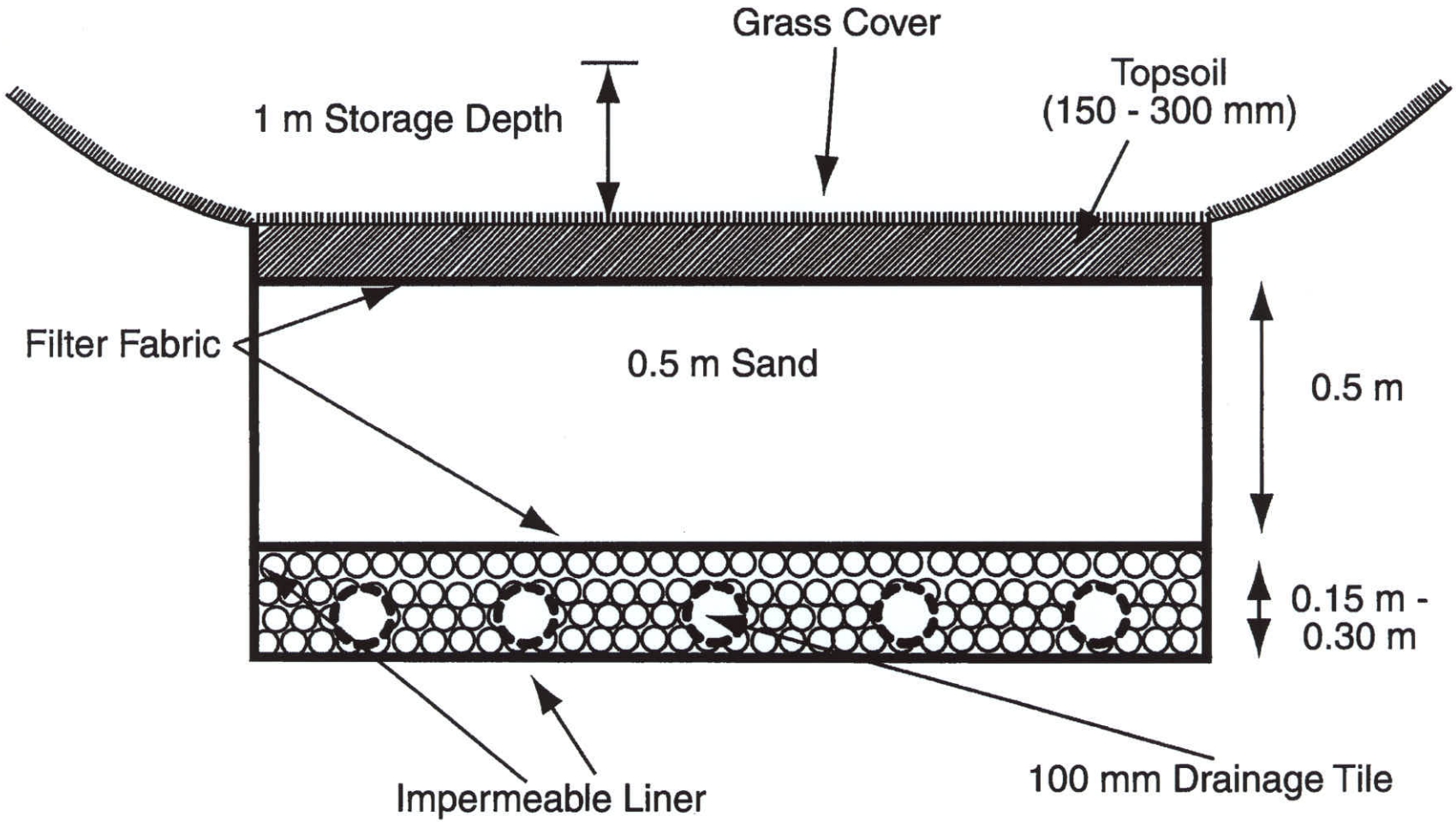


Figure 6.17

Sand Filter Cross Section Profile

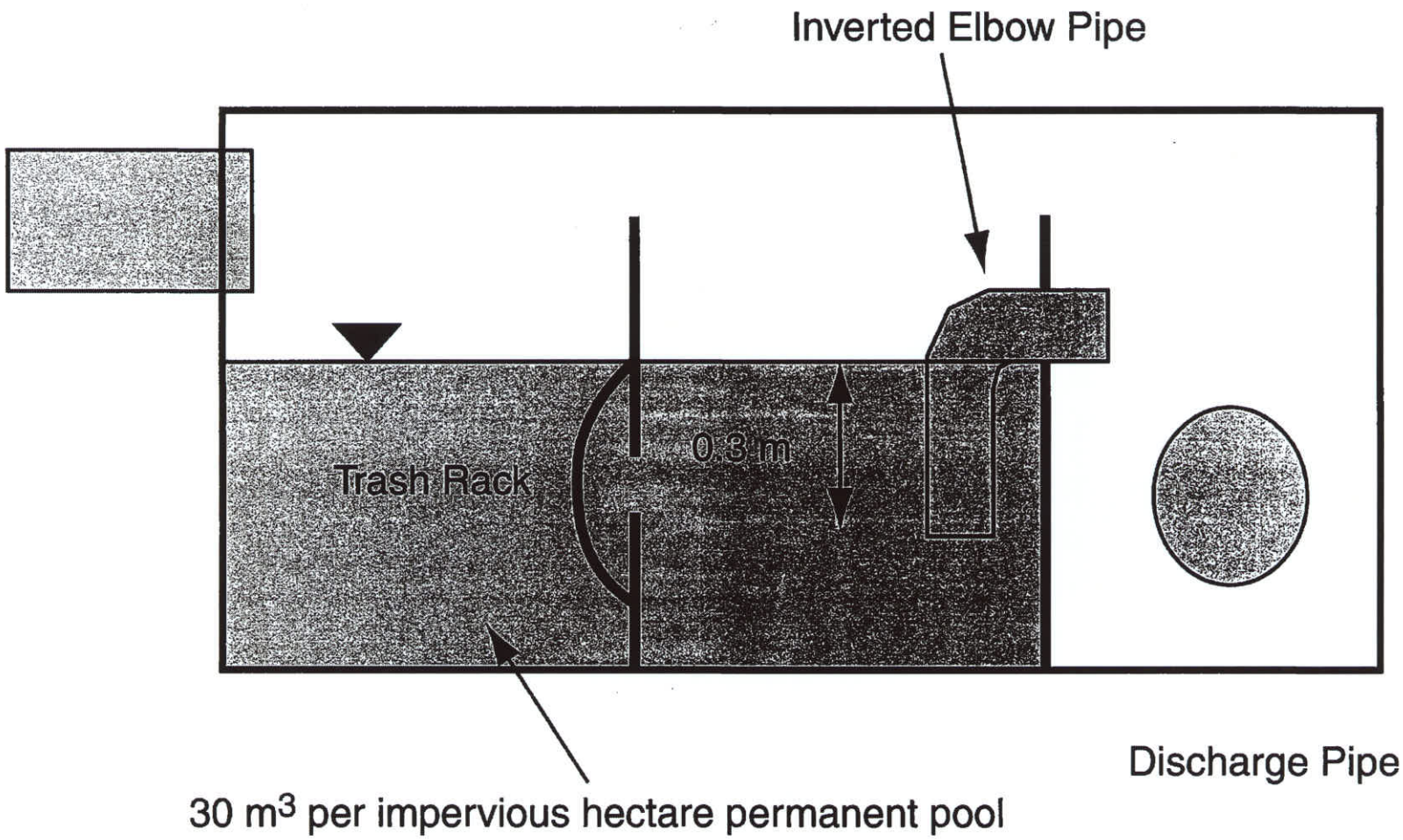


Figure 6.18

Standard 3 Chamber Oil/Grit Separator

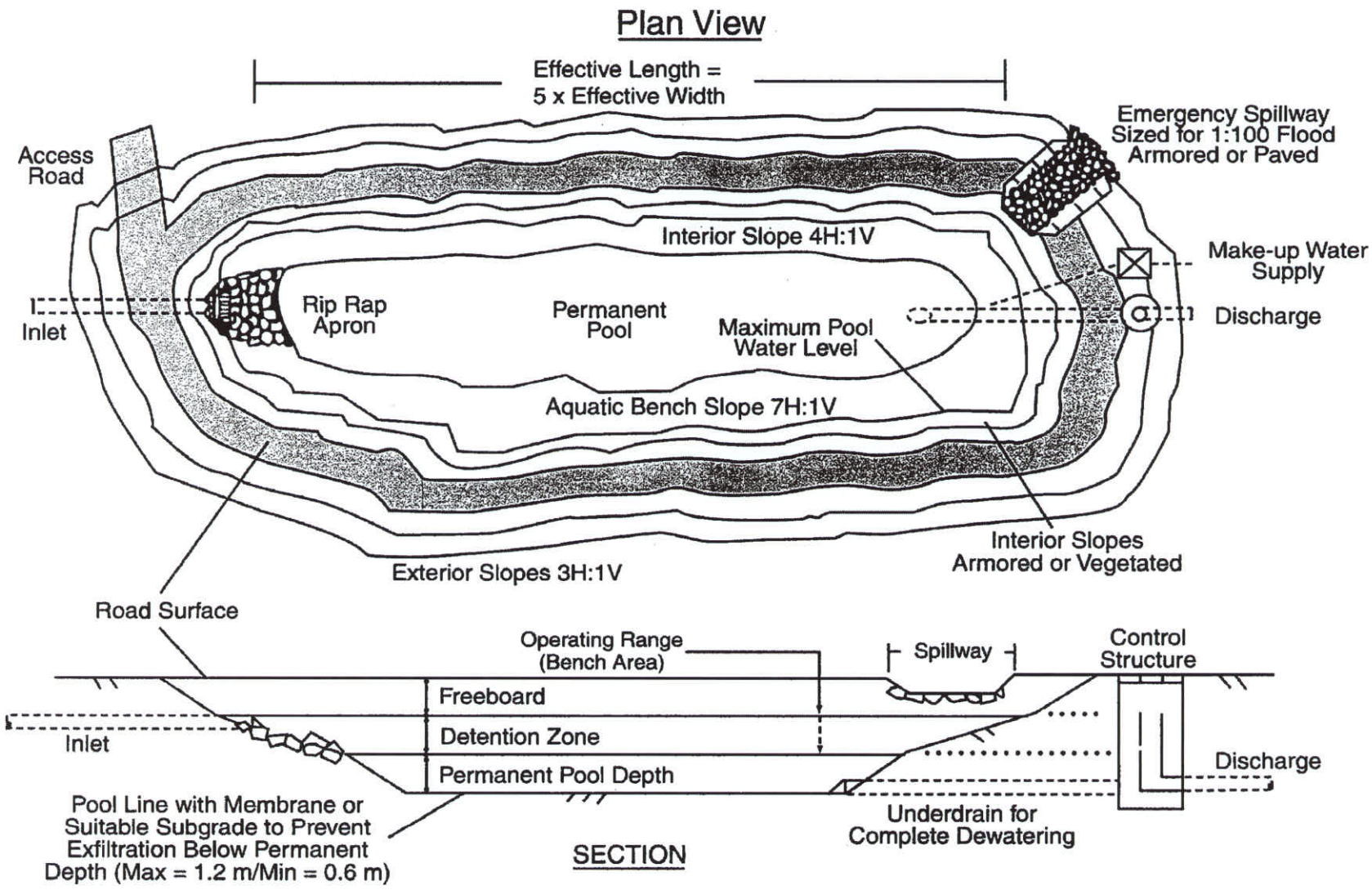


Figure 6.10
Wet Detention Pond Plan and Sections

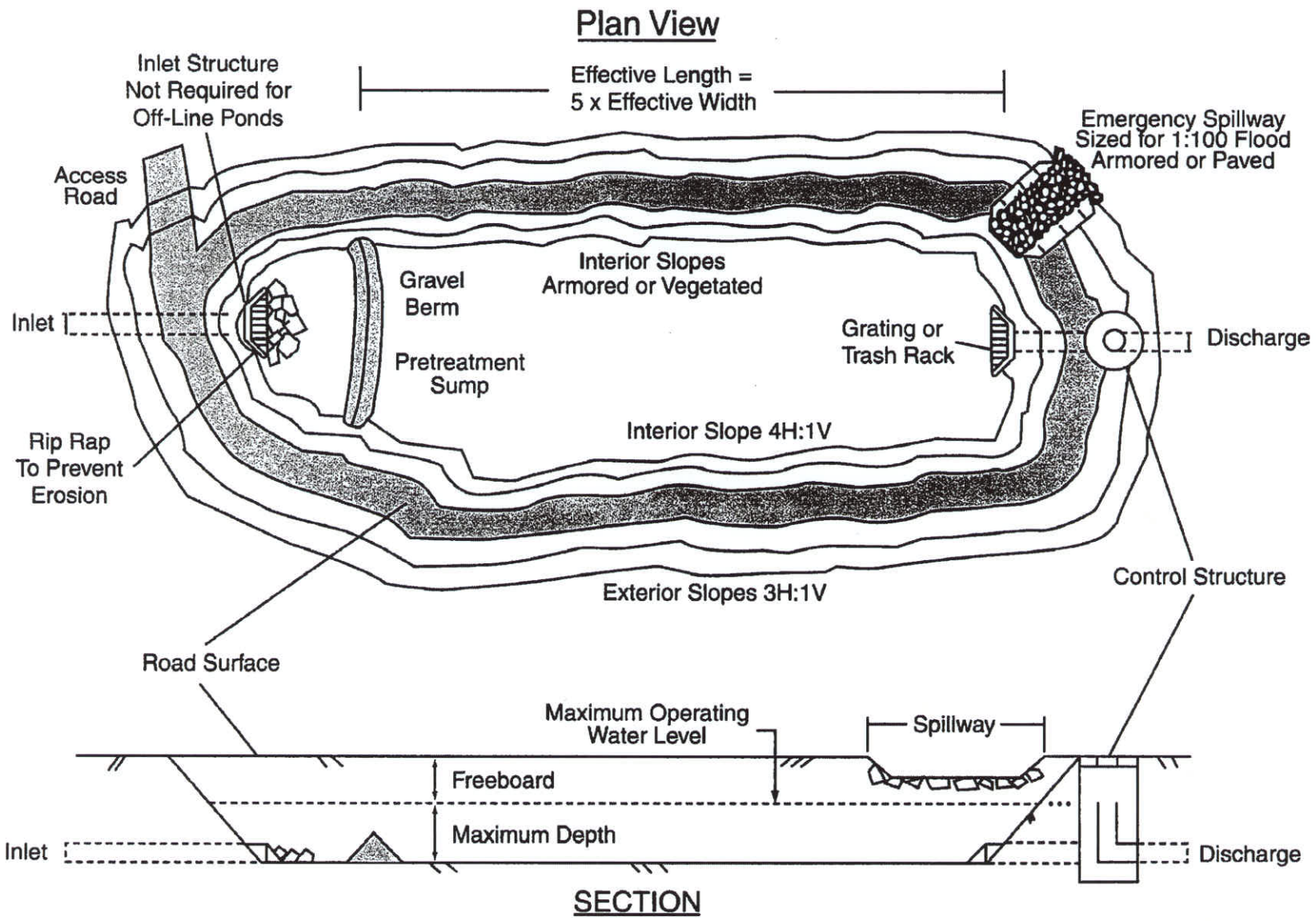
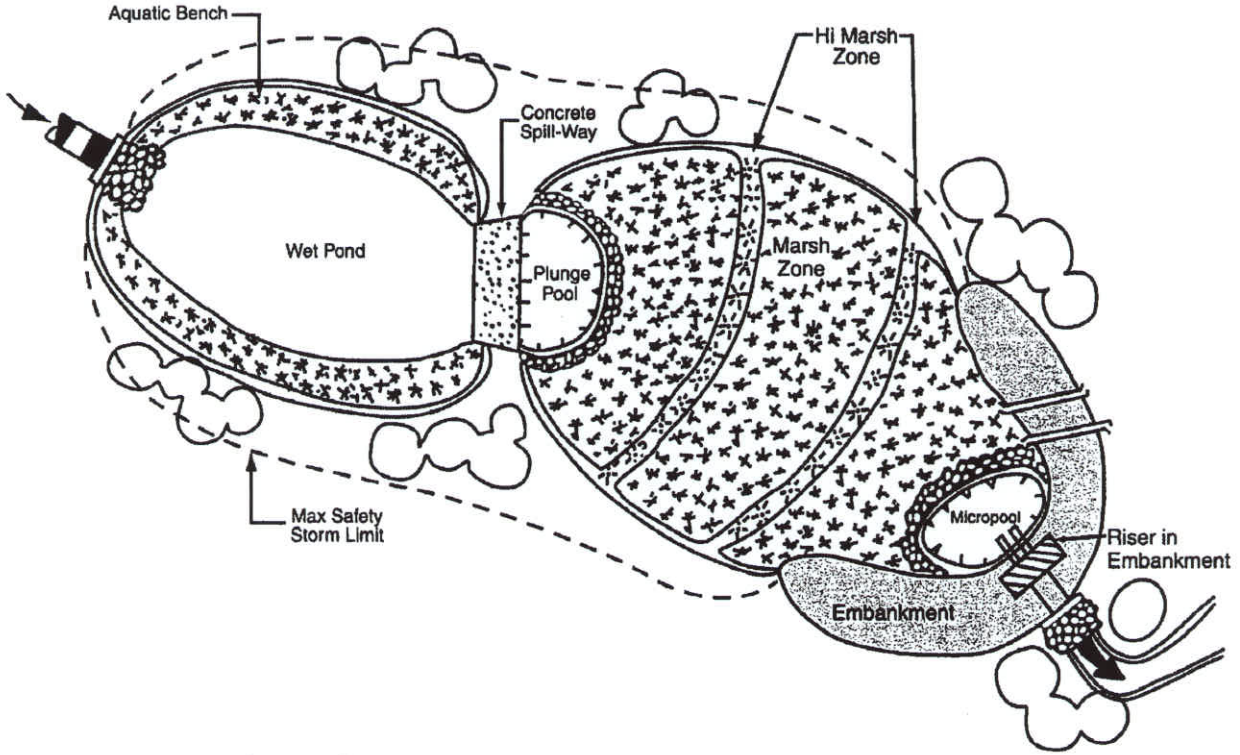
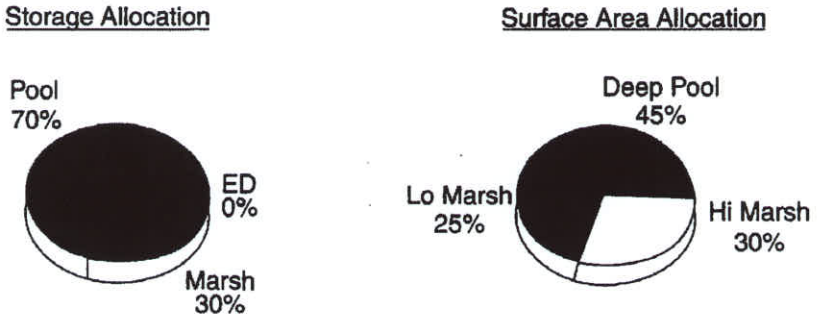


Figure 6.11

Dry Detention Pond Plan and Sections





The pond/wetland system consists of two separate cells - a deep pond leading to a shallow wetland. The pond removes pollutants, and reduces the space required for the system.

Figure 6.12

Stormwater Wetland

Appendix H

Transportation Design Criteria and Order of Magnitude Costs

CITY OF WHITEHORSE
WHISTLE BEND ACCESS & CONNECTOR
(LOWER BENCH CONNECTOR)

Rev.No. 0 Date November 4, 2008

DESIGN CRITERIA

Contract No. :

Project No. : 2501-040-00

Type of Work : Lower Bench Connector Conceptual Design

Location : Alaska Highway to Range Road

Length : n/a **Municipality:** City of Whitehorse

	Alaska – Mountainview	Mountainview – Range	
	Design Standards	**Design Standards**	**City of Whitehorse Service Standard**
Classification	UCU 70	UAU	Section 2.7.1
Design Speed	70 km/h	80 km/h	Section 2.7.3
Number of Basic Lanes	2	4	
Minimum Radius	200 m	280 m	Section 2.7.3
Equiv. Min. K. Factor	Crest 22 Sag 15	Crest 35 Sag 20	Section 2.7.2
Maximum Grade	Rolling - 7 % Mountainous - 10 %	Rolling - 5 % Mountainous - 7 %	TAC Table 2.1.3.1
Minimum S.S.D.	95-110 m	115-140 m	TAC Table 1.2.5.3
Lane Width	3.5-3.7 m	3.7 m	TAC Table 2.2.2.3
Road Width	14 m	n/a	Section 2.7.1
R.O.W. Width	Monolithic Sidewalk - 25.0 m Separate Sidewalk - 27.0 m	n/a	Section 2.7.1
Design Vehicle	WB-19	WB-19	n/a

Design Year	**Location**	**PM Peak Hour Traffic**	
		SB	**NB**
100% Whistlebend	Mountainview – Range	680	2480
	Alaska – Mountainview	110	640

Project No: 2501-040-00
Project Name: Pre-Design Porter Creek Bench

WHISTLEBEND CONNECTOR - ORDER OF MAGNITUDE COST OF CONSTRUCTION

Date: March 10, 2009

Item	Description	Quantity	Unit	Unit Price	Total Cost	Notes
1	Clearing and grubbing	120000	Sq.m.	$2.00	$240,000	
2	Stripping, 250 mm depth		Sq.m.	$2.00	$0	Stripping Qty included in earthworks
3	Common Excavation	0	cu.m.	$20.00	$0	
4	Off-site disposal (Type D)	50500	cu.m.	$30.00	$1,515,000	
5	Retaining Walls	3920	Sq.m.	$1,000.00	$3,920,000	Average height of wall = 7m
6	Subgrade Preparation (200 mm Depth)	67420	Sq.m.	$2.50	$168,550	
7	Sub-Base (80 mm, 150 Depth)	64370	Sq.m.	$8.00	$514,960	
8	Base (20 mm, 150 Depth)	62070	Sq.m.	$10.00	$620,700	
9	100 mm AC Surface	30440	Sq.m.	$45.00	$1,369,800	
10	Boulevard	0	Sq.m.	$15.00	$0	
11	Sidewalk	0	l.m.	$225.00	$0	
12	Curb/gutter	0	l.m.	$100.00	$0	
13	Street Lights	40.00	each	$5,000.00	$200,000	Considered streetlights only at I/S
14	Signalization	3.00	each	$250,000.00	$750,000	See notes below
15	Signs and Posts	100.00	each	$500.00	$50,000	
16	Roundabout (1 lane at Lower Bench Access)	1.00	each	$250,000.00	$250,000	
17	Bridge across McIntyre Creek (2 lane)	400.00	Sq.m.	$5,000.00	$2,000,000	
18	Footbridge under road bridge	1.00	each	$250,000.00	$250,000	
19	Guard Rails/barriers	3000.00	m	$100.00	$300,000	
20	Miscellaneous Drainage (inlets/outlets etc.)	1.00	LS	$100,000.00	$100,000	
	Subtotal				**$12,249,010**	
	Contingency @ 25%				**$3,062,253**	
	Engineering @ 15%				**$1,837,352**	
	GRAND TOTAL >>>				**$17,148,614**	

Assumptions and Notes:

1. Please refer to Drawing: CTP001-Rev C.dwg for conceptual alignment and grades and typical sections.
2. Whistlebend access road has been considered as a rural collector with design speed of 60km/hr
3. The cross-section north of Mountainview Drive is a 4 lane section with 4 x 3.75m lanes and 2 x 2.5m shoulders
4. The cross-section south of Mountainview Drive is a 2 lane section with 2 x 3.75m lanes and 2 x 2.5m shoulders
5. The proposed right of way width is 40m (20m on either side of centerline)
6. The following have been costed as signalized intersections, with detector loops or ped. cycle activation:
   - Mountainview Drive & Whistlebend Access
   - Pine Street Extension & Whistlebend Access
   - Alaska Highway & Whistlebend Access
7. The unit rates are based on unit costs by Quest Engineering for the City of Whitehorse. The shaded unit costs are derived from the B.C. MoT Construction and Rehabilitation Cost Guide
8. The order of magnitude cost of construction does not include any property acquisition costs, environmental mitigation costs and construction supervision costs
9. The above costs do not include any costs related to the Pine Street Extension or the accesses to the development

Project No: 2501-040-00
Project Name: Pre-Design Porter Creek Bench

PROPOSED BIKE TRAIL - ORDER OF MAGNITUDE COST OF CONSTRUCTION

Date: March 10, 2009

Item	Description	Quantity	Unit	Unit Price	Total Cost	Notes
1	Clearing and grubbing	10000	Sq.m.	$2.00	$20,000	
2	Stripping, 250 mm depth		Sq.m.	$2.00	$0	Stripping Qty included in earthworks
3	Borrow (Type D Fill)	8000	cu.m.	$20.00	$160,000	
6	Subgrade Preparation (200 mm Depth)	5030	Sq.m.	$2.50	$12,575	
7	Compacted Gravel (80 mm, 200 Depth)	4190	Sq.m.	$10.00	$41,900	
15	Signs and Posts	5.00	each	$500.00	$2,500	
19	Guard Rails/barriers	500.00	m	$100.00	$50,000	
20	Miscellaneous Drainage (inlets/outlets etc.)	1.00	LS	$10,000.00	$10,000	
	Subtotal				**$296,975**	
	Contingency @ 25%				**$74,244**	
	Engineering @ 15%				**$44,546**	
	GRAND TOTAL >>>				**$415,765**	

Assumptions and Notes:

1. Please refer to Drawing: CTF001RB.dwg for conceptual alignment and grades and typical sections
2. The unit rates are based on unit costs by Quest Engineering for the City of Whitehorse. The shaded unit costs are derived from the B.C. MoT Construction and Rehabilitation Cost Guide.
3. The order of magnitude cost of construction does not include any property acquisition costs, environmental mitigation costs and construction supervision costs

2.0 WHISTLE BEND ON-SITE SERVICING REPORT

AECOM

City of Whitehorse

Whistle Bend Onsite Servicing Report

Prepared by:

AECOM Canada Ltd.
200 – 415 Gorge Road East, Victoria, BC Canada V8T 2W1
T 250.475.6355 F 250.475.6388 www.aecom.com

Project Number:

2501-040-00-01

6 November, 2009

Statement of Qualifications and Limitations

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- represent Consultant's professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to Consultant which has not been independently verified;
- have not been updated since the date of issuance of the Report and their accuracy is limited to the time period and circumstances in which they were collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
- were prepared for the specific purposes described in the Report and the Agreement;
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time.

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6 November, 2009 Project Number: 2501-040-00-01

Wayne Tuck, P.Eng.
City Engineer
City of Whitehorse
Municipal Services Building
4210 – 4th Avenue
Whitehorse, YT Y1A 1C2

Dear Wayne:

Re: Whistle Bend Onsite Servicing Report

We are pleased to submit this final Onsite Servicing Report for the Whistle Bend Subdivision. The report covers all aspects of onsite servicing of the site including water distribution, sewage collection, stormwater management, and transportation. Class C cost estimates are provided for the first two phases of development and Class D estimates are provided for Phases 3 through 6. Hydro and Telecom costs are included in the cost estimates.

Offsite servicing was covered separately in the report submitted on March 23rd, 2009.

Both the offsite and onsite servicing costs were covered in the Cost Summary Report dated 4 November, 2009.

Preliminary design drawings will be submitted separately, shortly after submission of this report.

Please advise as to the number of bound copies of this document you would like to receive.

Sincerely,
AECOM Canada Ltd.



Ron Akehurst, P.Eng.
Manager, Municipal Infrastructure
Community Infrastructure
Ron.Akehurst@aecom.com

RA/bl
Attch.

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1. Executive Summary – Onsite Servicing

1.1 Water Supply and Distribution

The onsite water system has been designed by Quest Engineering Group of Whitehorse, based on criteria consistent with other large development areas in the city, and consists of a series of parallel looped watermains of various sizes to balance the flow through the parallel loops.

A detailed water system analysis has been completed by Quest using the City of Whitehorse EPA Net water model. The model was reviewed and updated to include the proposed new water system infrastructure and recirculation pumphouse requirements for the Whistle Bend development.

The following water demand design criteria are used in the water model:

-	Total serviced population	10,000 persons*
-	Residential demand	375 L/capita/day
-	Total average daily demand	3,750,000 L/day
-	Average demand rate	43.4 L/s
-	Maximum day demand rate	2 x ADD
-	Peak hour demand rate	4 x ADD
-	Night fill demand rate	0.1 x ADD (no flow through)
-	Node demand for model	0.35 L/s (ADD)

* Note that the design population of 10,000 for this development has been superseded as a result of the planning process, and reduced to 7,800. This reduction does not affect the sizing of proposed water distribution plant, since the determining factor is fire flow, which is not affected by the reduced population.

Recommended onsite water system improvements include:

- Installation of a new 350, 300, 250, 200 and 150 mm looped watermain system in the proposed expansion area, with forced circulation provided from a new circulation pumpstation. Watermain construction will be completed as staged development.
- A supply trunkmain will be constructed following the proposed main collector roadway. From this primary trunkmain, parallel loops can be constructed for phased development as required.
- A single recirculation and heating pumphouse can be located on the main trunkmain loop, such that a single pumphouse can provide recirculation and heating for the entire development.
- Three return loops will tie back to the recirculation pumphouse. Each loop will have a flow control valve to balance return flows at the pumphouse as required for the phased development.
- The pumphouse will have a common return suction header, and a common discharge header.

- A one-way bypass and fire flow bypass valve will connect the suction and discharge headers to allow bi-directional flow through the pumphouse for fire conditions, to increase available fire flows while minimizing distribution pipe sizes.
- Fire hydrants will be installed at regularly spaced intervals to provide 75 m radius coverage for all residential lots and 45 m radius coverage for all commercial lots.
- Insulated service stubs will be provided to each lot:
  - Minimum residential service to be 20 mm, insulated and impedance heat traced, or insulated recirculating services with 25 supply/20 return.
  - Minimum commercial services to be 50 mm supply with 20 mm recirculation line.
- Water model results indicate that the proposed watermain system can provide the required fire flows with acceptable maximum and minimum velocities:
  - Available fire flows: 105 to 300 L/s
  - Required fire flows: 75 L/s minimum, 300 L/s maximum
  - Minimum residual pressure: 140 kPa at ground elevation (nominal mode elevation) at MDD plus fire
  - Maximum velocity: 2.8 m/s at MDD plus fire
  - Minimum velocity: 0.03 m/s at NFD

All watermain construction will be as per the City of Whitehorse Servicing Standards manual, latest edition. Watermains will be installed at a minimum 3.0 m bury to obvert, to provide adequate cover for thermal protection. Isolation valves and on-line hydrants will be installed.

1.2 Wastewater Collection and Disposal

Several scenarios for wastewater collection and pumping were examined in this study. The chosen option involves construction of a gravity sanitary sewer system and a pumpstation sized for a peak flow of approximately 85 L/s, which will provide service for approximately 5,900 people and a catchment area of 189 ha (Phase 1 to Phase 5). The construction of this pumpstation and forcemain will occur during Phase 1 of development. A second pumpstation sized for a peak flow of approximately 35 L/s will be installed during Phase 3 of the development, and will provide service for approximately 1,900 people and a catchment area of 65 ha, consisting of a portion of Phase 3 and all of Phase 6. Gravity sanitary lines will be extended from the pumpstations to the phase boundaries as they progress.

The main pumpstation wet well will be built during Phase 1, however, the pumps and controls will be upsized as required as the flows increase. The pumpstation will be operated in a duplex configuration initially, but pre-piped for future triplex. The main pumpstation will include a building, a wet well, duplex submersible pumps, variable frequency drives, electrical/PLC/SCADA panels, ventilation and back-up power. The forcemain will be 300 mm diameter.

The smaller pumpstation will be a small package type unit (Flygt or similar) with a smaller diameter forcemain discharge. This forcemain will connect to the forcemain from the larger pumpstation.

Both pumpstations will pump sewage via a common forcemain to the Porter Creek Flush Tank. In conjunction with the single forcemain, it is recommended that the pumps in both stations be equipped with variable frequency drives.

The northeast and northwest corners of Phase 5 are lower in elevation to the point where gravity flow to the boundary of the phase is not feasible due to excessive depth. The use of pressure sewers and individual grinder pumps for this area was compared to gravity sewers and a small liftstation in the northeast corner. The liftstation option was found to be considerably less expensive, so this option has been chosen.

Design criteria will be in accordance with the City of Whitehorse Servicing Standards Manual, as follows:

- **Manholes** – maximum spacing 110 m.
- **Sewer Main Sizing** – 200 mm (minimum) to 400 mm, according to design flows.
- **Sewer Main Velocity** – minimum velocity to be 0.7 m/s with a Manning's pipe roughness coefficient n of 0.013. Minimum pipe slopes for 200 mm piping to be 0.4% and for 300mm piping to be 0.3% to achieve self-cleansing. The pipe grade on the first upstream length of each pipe is to be 0.6% minimum.
- **Depth of Bury** – the minimum cover will be 2.8 m. The sanitary sewer mains are to be designed such that gravity drainage is possible from the finished basement level of all residential building lots. The maximum depth of bury will be 6 m. To facilitate future maintenance of service connections where the sewer main is deeper than 5 m, a parallel local collection sewer will be installed at an approximate depth of 3 m.

1.3 Stormwater Management

The proposed development will adopt sustainable stormwater management principles in achieving the goal of no net increase in post-development water runoff.

The overall drainage concept proposes to retain existing drainage basins after development, to eliminate or minimize earthwork and re-grading of the land. The existing low points will be designated and developed as the ultimate receiving points for the runoff. There will be no runoff from this development to the river. Where these receiving points occur within the urban landscape, rain garden landscaping will be designed. Bio-swales will convey runoff to the receiving ponds and rain gardens, where appropriate.

The stormwater management system will consist of a major system and a minor system. The major system will be capable of handling a 100-year storm event, and will consist of surface routing the runoff through roads, rights-of-way, public utility lots, easements, reserves, and other public lands. The minor system will be capable of handling a 5-year storm event, and will consist of catchbasins, storm sewers, exfiltration pits, and bio-swales. Overflows from the minor system will be diverted to the major system.

Storm flows were analyzed by the Rational Method. Pipe sizing, determined by Manning's formula, indicates the minimum pipe size of 450 mm CSP pipe is suitable for all installations in Phases 1 and 2 of this development. Figure 1 of Appendix 5 of the onsite servicing report identifies seven subcatchments for this development and associated ponding areas and exfiltration pits that will serve as the disposal areas for runoff from the subcatchments.

In addition to the ponding areas, the system will include bio-swales and rain gardens to enhance water quality. Roof drainage will generally be allowed to infiltrate on the individual lots to reduce runoff quantities.

1.4 Transportation

Roads in the Whistle Bend subdivision will be designed in accordance with City of Whitehorse standards. Right-of-way concepts include:

- 18 m right-of-way for 8 m wide local road
- 22 m right-of-way for 11.5 m collector road
- 30 m right-of-way and two 10 m green corridors for arterial roads.

The Onsite Servicing report contains a detailed report on the onsite traffic model results. This model is based on an approximate population of 8,000 for the development at build-out. A brief description of the principal road and traffic elements resulting from the model analysis is presented herein.

Casca Boulevard will be the main arterial road within a 30-m wide right-of-way. Casca Boulevard will be built initially as a two-lane road with bike lanes and centre median. This ROW width will allow for future expansion to four lanes as traffic volumes warrant. This ROW will also be flanked by 10-m wide green space corridors on each side. Casca Boulevard will loop through the site and connect to Range Road in two locations. These intersections will be single-lane roundabouts initially. At build-out, the southerly Casca/ Range intersection will require signalization, or possibly a double roundabout..

Signalized intersections are required at Casca/Chakawana by the end of Phase 2, and at four other locations on Casca Boulevard at build-out of the subdivision.

The road design cross sections will be in accordance with recommendations presented in EBA Engineering Consultants Ltd. report of August 2009. Consistent with the City's Servicing Standards Manual, the EBA report recommends that no frost-susceptible (silt) material should be permitted within 1.7 m of the road surface. Figure 2 of the geotechnical report shows the extent of areas expected to have less than 1.5 m of sand over the frost-susceptible silt. This figure indicates a large portion of the site will require a deep granular subbase layer to prevent frost damage to the roads.

The site plan also indicates an extensive trail network within green space corridors. Trails will typically be 3 m wide with gravel surfacing on the internal trails and asphalt surfacing on the external (City) trail.

1.5 Cost Estimate Summary – Onsite Servicing

The total cost of development of all phases of the onsite work, including contingencies and engineering, but excluding Heiland and Ta'an sections, is $117,330,000. Class C Cost Estimates have been prepared for Phases 1 and 2 of the proposed development. The estimates are summarized as follows:

Phase 1

1.	Water Distribution System	$4,753,000
2.	Wastewater Collection and Disposal	4,613,900
3.	Stormwater Management	600,500
4	Landscaping	
5.	Transportation	4,856,600
6.	Hydro/Cable/Tel	2,247,000
	Subtotal	**$17,071,000**
	Mobilization	150,000
	Contingency and Estimating Allowance (+15%)	2,583,200
	Subtotal	**$19,804,200**
	Engineering (+15%)	2,970,600
	Total	**$22,774,800**
	Rounded Total	**$22,770,000**

Phase 2

1.	Water Distribution System	$2,298,000
2.	Wastewater Collection and Disposal	2,076,500
3.	Stormwater Management	986,900
4.	Transportation	7,402,900
5.	Hydro/Cable/Tel	2,061,000
	Subtotal	**$14,825,300**
	Mobilization	130,000
	Contingency and Estimating Allowance (+15%)	2,243,300
	Subtotal	**$17,198,600**
	Engineering (+15%)	2,579,800
	Total	**$19,778,400**
	Rounded Total	**$19,780,000**

Class D cost estimates have been prepared for Phases 3 through 6 of the proposed development. The estimate is summarized as follows:

Phase 3

1.	Water Distribution System	$2,031,700
2.	Wastewater Collection and Disposal	2,763,800
3.	Stormwater Management	611,500
4.	Transportation	7,003,400
5.	Hydro/Cable/Tel	2,523,000
	Subtotal	**$14,933,400**
	Mobilization	140,000
	Contingency and Estimating Allowance (+25%)	3,768,400
	Subtotal	**$18,841,800**
	Engineering (+15%)	2,826,200
	Total	**$21,670,000**
	Rounded Total	**$21,670,000**

Phase 4

1.	Water Distribution System	$1,128,300
2.	Wastewater Collection and Disposal	933,200
3.	Stormwater Management	689,000
4.	Transportation	6,708,400
5.	Hydro/Cable/Tel	1,002,000
	Subtotal	**$10,460,900**
	Mobilization	100,000
	Contingency and Estimating Allowance (+25%)	2,640,200
	Subtotal	**$13,201,100**
	Engineering (+15%)	1,980,200
	Total	**$15,181,300**
	Rounded Total	**$15,180,000**

Phase 5

1.	Water Distribution System	$1,114,100
2.	Wastewater Collection and Disposal	1,006,800
3.	Stormwater Management	537,400
4.	Transportation	2,931,400
5.	Hydro/Cable/Tel	930,000
	Subtotal	**$6,519,700**
	Mobilization	65,000
	Contingency and Estimating Allowance (+25%)	1,646,200
	Subtotal	**$8,230,900**
	Engineering (+15%)	1,234,600
	Total	**$9,465,500**
	Rounded total	**$9,470,000**

Phase 6

1.	Water Distribution System	$3,530,000
2.	Wastewater Collection and Disposal	3,167,000
3.	Stormwater Management	967,500
4.	Landscaping	
5	Transportation	9,361,900
6.	Hydro/Cable/Tel	2,604,000
	Subtotal	**$19,630,400**
	Mobilization	165,000
	Contingency and Estimating Allowance (+25%)	4,948,900
	Subtotal	**$24,744,300**
	Engineering (+15%)	3,711,600
	Total	**$28,455,900**
	Rounded Total	**$28,460,000**

Detailed breakdowns of the above costs are provided in the previously submitted Cost Summary Report.

Note that the above costs do not include the cost of servicing the Heiland or Ta'an lands in Phase 2 and Phase 5. These costs are summarized below as Class D estimates. Detailed breakdowns are also included in the Cost Summary Report.

Heiland

1.	Water Distribution System	$ 945,300
2.	Wastewater Collection and Disposal	603,900
3.	Stormwater Management	512,100
4.	Transportation	1,951,200
5.	Hydro/Cable/Tel	624,000
	Subtotal	**$4,636,500**
	Mobilization	50,000
	Contingency and Estimating Allowance (+25%)	1,171,600
	Subtotal	**$5,858,100**
	Engineering (+15%)	878,700
	Total	**$6,736,800**
	Rounded Total	**$6,740,000**

Ta'an

1.	Water Distribution System	$1,720,900
2.	Wastewater Collection and Disposal	1,530,400
3.	Stormwater Management	476,700
4.	Transportation	4,481,400
5.	Hydro/Cable/Tel	1,671,000
	Subtotal	**$9,880,400**
	Mobilization	100,000
	Contingency and Estimating Allowance (+25%)	2,495,100
	Subtotal	**$12,475,500**
	Engineering (+15%)	1,871,300
	Total	**$14,346,800**
	Rounded Total	**$14,350,000**

The cost estimates include a 15% contingency and estimating allowance for Class C design. The basic unit prices are, for the most part, derived from 2008 budget prices provided by Quest Engineering Ltd. Recent land development projects in Whitehorse have been awarded to out-of-town contractors at substantially lower prices. We have continued to use the Quest 2008 budget prices for these estimates, assuming that prices will return to near Whitehorse normal costs in the near future. The basic unit prices in the estimate are thus considered to be conservative on the high side. In conjunction with good quantity take-offs from the preliminary design drawings, a 15% contingency and estimating allowance is considered appropriate for all Class C estimates.

We have not attempted to estimate an escalation factor for future years, since we have no expertise in economic forecasting. We have reviewed the historical increases in Consumer Price Index for Whitehorse. (We were unable to find any records relating to construction cost index.) The Consumer Price Index indicates average inflation of less than 2% per year from 1998 to 2008. In 2007 and 2008, inflation was somewhat higher than average, at 2.5% and 3.6%, respectively.

Exclusions from the above estimates are as follows:

1. GST
2. Escalation after 2009
3. Land and legal costs, legal survey
4. Environmental site clean-up costs, if any.
5. Costs due to detailed design changes
6. Winter work.

2. Water Servicing

2.1 Acknowledgement

This section of the report is taken from a Technical Brief prepared by Quest Engineering Group, which includes a hydraulic network analysis of the onsite water system and a thermal analysis of the water system, with associated recommendations.

2.2 Design Criteria

The following design criteria have been recommended and used in the analysis of servicing requirements in accordance with City of Whitehorse servicing standards and the Whistle Bend Conceptual Design Report:

• Average Daily Demand (ADD)	375 L/c/day (residential)(ultimate demand)
• Maximum Day Demand (MDD)	2 x ADD
• Peak Hour Demand (PHD)	4 x ADD
• Night Fill Demand (NFD)	0.1 x ADD (no flow-through NFD in this area)
• Minimum Velocity	0.15 m/s @ ADD (or as identified by Thermal Analysis)
• Maximum Velocity	3.0 m/s @ PHD
•	5.0 m/s @ MDD plus Fire
• Minimum Pressures	280 kPa @ MDD (ground level)
•	140 kPa @ MDD plus Fire (ground level)
• Maximum Pressures	550 kPa (80 psi) (desirable)
•	700 kPa (100 psi) (maximum)
• Minimum Fire Flow	75 L/s (Residential) [1]
•	125 L/s (Multi-family row housing) [1]
• Maximum Fire Flow	300 L/s (based on Fire Fighting Capacities)

1. Based on recommendations from IAO (Insurers Advisory Organization)
   Fire flow requirements are higher due to increased development density and reduced exposure distances between dwellings units.

Minimum Depth of Bury

• (un-insulated mains)	3.0 m, obvert to gutter line
• Services	2.4 m, obvert to gutter line, or property line
• Ground Heat Transfer	3.1 W/m C (dry sand)
• Pipe Heat Transfer	50 W/m C (ductile iron)

2.3 Proposed Water System Infrastructure

The proposed on site water system is consistent with other large development areas in the City, and consists of a series of parallel looped watermains of various sizes to balance the flow through the parallel loops.

The primary water supply is provided by an extension of the Range Road water trunkmain, using a 450 mm supply main. This primary supply provides all domestic flow, with the capability of providing up to 150 L/s fire flow. The primary supply main feeds the new development distribution trunkmain from the south roundabout location.

A secondary supply and additional fire flow supply is provided by an extension of the Porter Creek supply main, from the high pressure side of McIntyre Creek pumphouse. This alternative supply is a 350 mm trunkmain which can provide alternative domestic flow, and additional fire flow up to 280 L/s. The alternate supply main feeds the new development distribution system from the north roundabout location, providing two independent water supplies for security of supply. A pressure reducing vault is required on this alternate supply to reduce the pressure for the development.

An alternative secondary and fire flow supply can be provided from an extension of the Wann Road supply main, if the McIntyre Creek supply main is not constructed.

A detailed water system analysis has been completed by Quest using the City of Whitehorse EPA Net water model. The model was reviewed and updated to include the proposed new water system infrastructure and recirculation pumphouse requirements for the Whistle Bend development.

The following water demand design criteria are used in the water model:

- Total Serviced population 10000 persons *
- Residential Demand 375 L/capita/day
- Total average daily demand 3,750,000 L/capita/day
- Average demand rate 43.4 L/s
- Max Day demand rate 2 x ADD
- Peak hour demand rate 4 x ADD
- Night fill demand rate 0.1 x ADD (no flow through)
- Node demand for model 0.35 L/s (ADD)

* Note that the design population of 10,000 for this development has been superseded as a result of the planning process, and reduced to 7,800. This reduction does not affect the sizing of proposed water distribution mains, since the determining factor is fire flow, which is not affected by the reduced population.

2.4 Recommended Onsite Water System Improvements Include:

- Installation of a new 350, 300, 250, 200 and 150 mm looped watermain system in the proposed expansion area, with forced circulation provided from a new circulation pumpstation. Watermain construction will be completed as phased development.

- A supply trunkmain will be constructed following the proposed main collector roadway. From this primary trunkmain, parallel loops can be constructed for phased development as required.

- A single recirculation and heating pumphouse can be located on the main trunkmain loop, such that a single pumphouse can provide recirculation and heating for the entire development.

- Three return loops will tie back to the recirculation pumphouse. Each loop will have a flow control valve to balance return flows at the pumphouse as required for the phased development.

- The pumphouse will have a common return suction header, and a common discharge header.

- A one-way bypass and fire flow bypass valve will connect the suction and discharge headers to allow bi-directional flow through the pumphouse for fire conditions, to increase available fire flows while minimizing distribution pipe sizes.

- fire hydrants will be installed at regular spaced intervals to provide 75 m radius coverage for all residential lots and 45 m radius coverage or all commercial lots.

- insulated service stubs will be provided to each lot.

    - Minimum residential service to be 20 mm, insulated and impedance heat traced, or insulated recirculating services with 25 mm supply/20 mm return.
    - Minimum commercial services to be 50 mm supply with 20 mm recirculation line.

- temporary rechlorination for early stages of development

- water model results indicate that the proposed watermain system can provide the required fire flows with acceptable maximum and minimum velocities.

    - Available fireflows 105 to 300 L/s
    - Required fireflows 75 L/s minimum, 300 L/s maximum
    - Minimum residual pressure 140 kPa at ground elevation (nominal node elevation) at MDD plus fire
    - Maximum Velocity 2.8 m/s at MDD plus fire
    - Minimum Velocity 0.03 m/s at NFD

Note that minimum velocities fall slightly below 0.15 m/s on several loops, however, the resulting water temperatures do not fall below freezing due to the short length of loops. A minimum return water temperature of approximately 2°C can be maintained at low demand conditions.

All watermain construction will be as per the City of Whitehorse Servicing Standards manual, latest edition. Watermains will be installed at a minimum 3.0 m bury to obvert, to provide adequate cover for thermal protection. Isolation valves and on-line hydrants will be installed.

2.5 Recirculation Analysis for the Water System

The ultimate water system consists of approximately 22,050 m of various pipe sized from 150 mm to 350 mm.

The water system layout and pipe sizing provides balanced system circulation flows without the need for balancing valves installed in the system, except at the pumphouse return loops.

The required recirculation flow to maintain a maximum 2°C heat loss is 80 L/s, assuming a 4°C supply temperature and 2°C return temperature.

A suggested circulation pump arrangement using a three-pump system (two duty, one – 50% standby), requires duty pumps with a capacity of 40 L/s @ 3.5 m TDH, or approximately 2.2 kW (3 hp). Pumps require discharge control valves, to sustain pump head during fire conditions. Only one pump is required for approximately 50% of the development. The second pump can be added as required by development staging.

2.5.1 Phase 1 and 2 Recirculation

Phase 1 and 2 can be adequately serviced with a partially constructed water system. The primary service loop could be constructed along the proposed arterial route, or routed through the future commercial core area depending on the demand for development type in the area. Either route option provides adequate recirculation and fire flow for Phase 1 and 2. A detail of the arterial route option is included with this brief.

Only one recirculation pump is required to provide adequate recirculation flows for the Phase 1 and 2 development loops. The amount of circulation is only marginally affected by the routing options.

2.6 Thermal Analysis for the Water System

The water system thermal analysis, assuming bare ductile iron mains, suggests a total system heat loss of approximately 665 kW.

Assuming 85% efficiency, the required boiler input capacity for the ultimate development will be approximately 800 kW.

A detailed thermal analysis for the development area was reviewed using the updated water model.

A minimum return recirculation temperature of 2°C can be maintained in the ultimate development with minimum night filling demand. As there is no flow through night fill demand in this area, the night fill demand was assumed to be minimal and modelled at a 0.1 demand factor.

The maximum heat load will only be required for a short time when ground temperatures reach the minimum low in the late winter. For the shoulder heating seasons in late fall and late spring, the heat load is reduced. Therefore a suggested boiler arrangement using a three-boiler system, two duty boilers at 50% capacity each, plus one standby @ 50% could provide more efficient heating. Only one duty boiler would operate for 75% of the time, with the second duty boiler operating only during the peak heat load period. Each boiler would have 400 kW input capacity.

Heat injection to the water system would be provided with an indirect heat loop with heat supply pump and temperature balancing valve to maintain a 4°C supply temperature at the pumphouse discharge.

2.6.1 Phase 1 and 2 Thermal Analysis

Phase 1 and 2 can be adequately serviced and freeze protected using a partially constructed water system. The return water temperatures using the partial system are slightly lower due to the longer pipe travel time, and reduced flow due to slightly higher head in the partial system.

2.7 Recirculation and Heating Pumphouse

A single recirculation and heating pumphouse can be constructed to service the entire development area, at the suggested location shown in the model outputs.

The suggested location accommodates three return loops to the pumphouse, to provide flexibility in development sequencing.

The pumphouse would incorporate the following components:

- two recirculation duty pumps and one standby pump (100% capacity)
    - recirc pump capacity is 2.2 kW (3 hp), 80 L/s @ 3.5 m TDH (65% overall efficiency assumed)
- two oil fired duty heating boilers and one standby boiler

  - boiler capacity is 400 kW input, 340 kW output (85% efficiency assumed)
  - each boiler is 50% of required maximum heat load for water system heating. Two duty boilers required for maximum heat load.

- An emergency generator capable of running two recirculation pumps and two duty boilers for maximum heat load requirements, plus building and control loads. A separate generator and electrical room is assumed to be required.

- Temporary rechlorination system (hypochlorite injection) for early stages of development.

- Space for system controls. A local control system with integration into the City's overall SCADA system is assumed.

- Pumphouse exterior design and elevations to fit into the primarily residential development area.

With regard to sustainability, a number of options were considered. Boilers as the heat source for freeze protection, could be replaced with other heat source options that may be available, including District heating system source if this proves feasible. A more detailed cost/benefit analysis is required once alternative heat sources are identified. In any case, a boiler system would likely be required as a back-up system to any alternative source, except perhaps a district heating system, which would have its own back-up. Solar heating is not likely an option for winter heating requirements. Waste heat from sewage is a possible option, but waste heat is not available from winter sewage; therefore would need to be stored in summer for use in winter season. This is not likely cost effective for water system heating only. Freeze protection heating would be required for both the short term and long term, as daily consumption is not sufficient to offset system heat losses.

2.7.1 Back Up Power Supply for Pumphouse

The pumphouse would have to be equipped with a backup power supply to maintain circulation and heating capabilities during power outages. A backup generator capable of running two recirculation pumps and two boilers, plus building and controls electrical loads would be required.

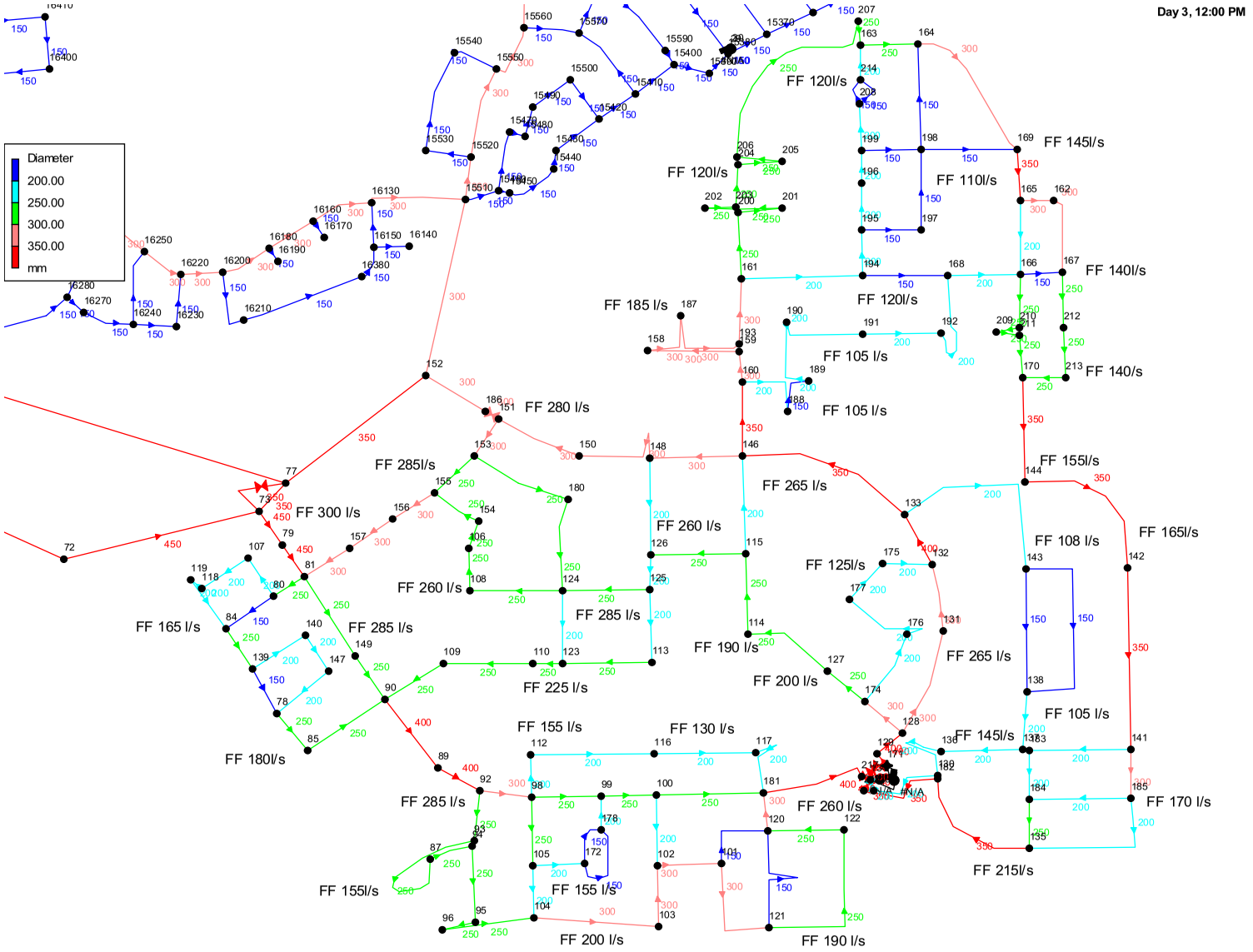
Initial sizing estimate for the generator is approximately 25 kW for the required pumping and boiler operation, plus control and building loads. Final sizing will be determined at the detailed design stage.

Depending on the location of other sewer infrastructure pumpstations, it may be possible to have a standby generator serve more than one facility.

2.8 Water Model Output Details (attached PDF Drawings)

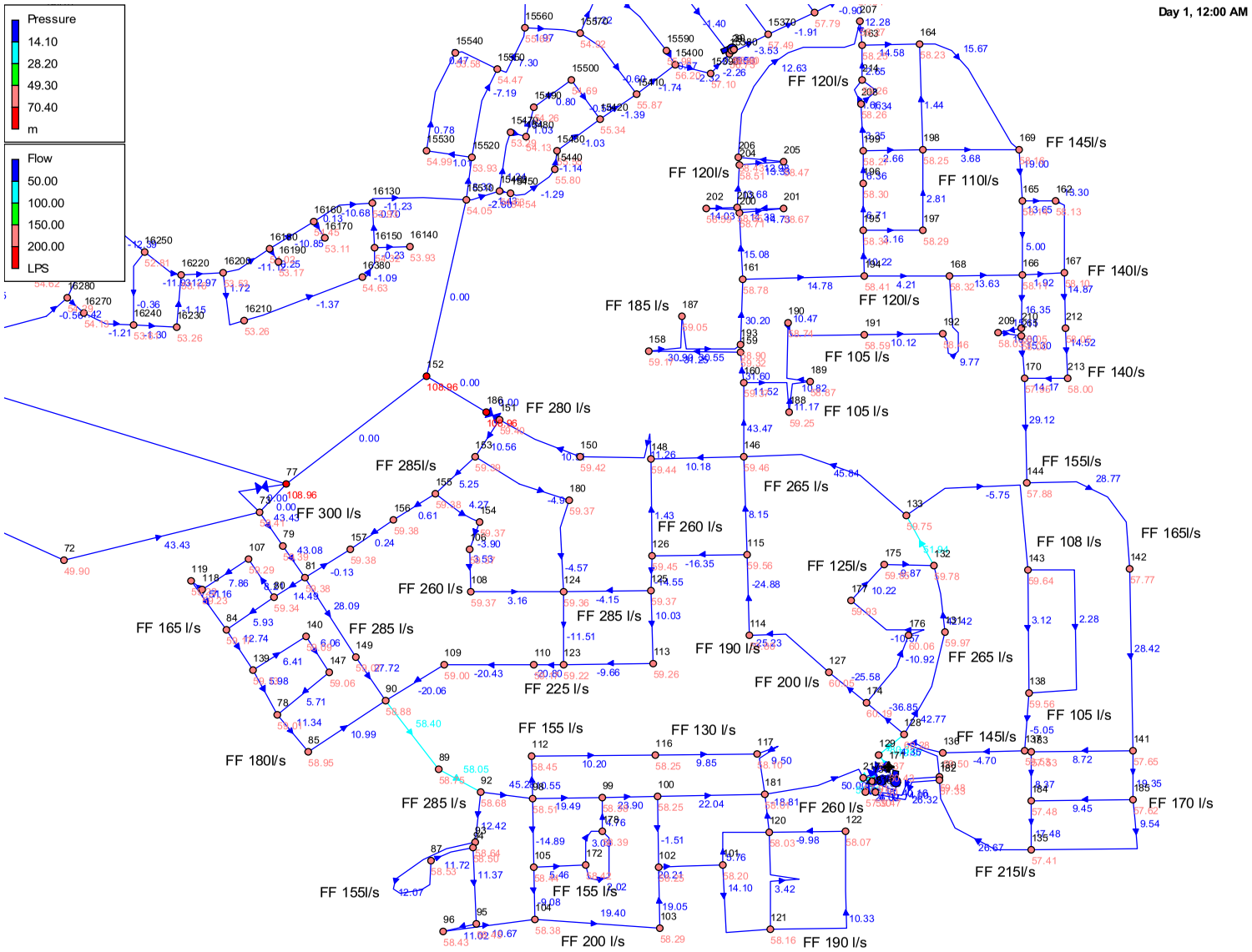
1. Water System Layout and Pipe Sizes
2. ADD Pressures and Flows
3. MDD Pressures and Flows
4. PHD Pressures and Flows
5. PHD Pressures and Velocities
6. MDD plus Available Fire Flows (Option 1 Fire Supply from McIntyre Creek)
7. ADD Temperatures and Velocities
8. NFD Temperatures and Velocities (no flow-through NFD)
9. NFD Temperatures and Velocities for Phase 1 and 2 only
10. Pumphouse Schematic Process Pipe Layout

Master Model_ex_Oct 2007_With Whistlebend



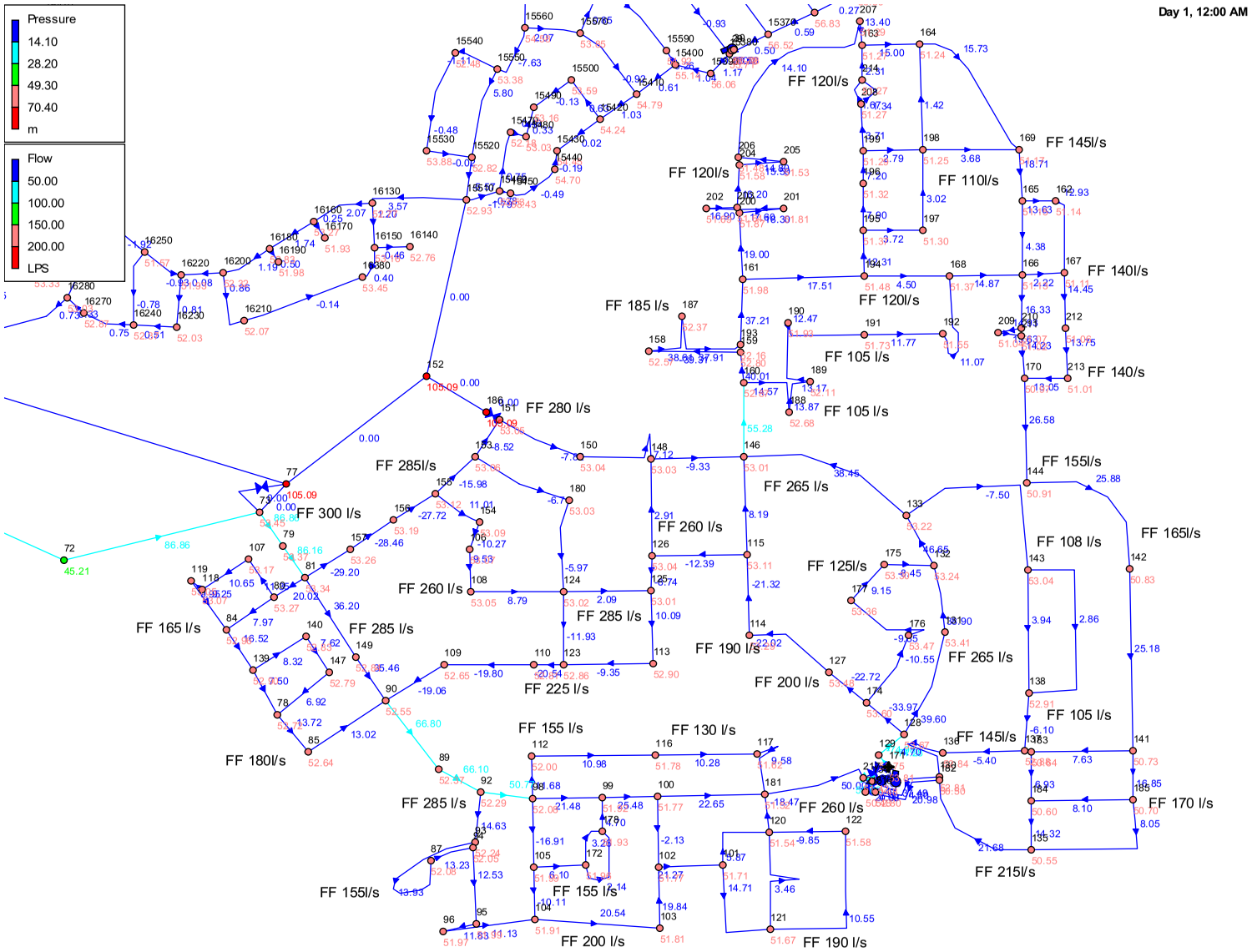
Whistlebend Predesign Water System_Layout and Pipe Sizes

Master Model_ex_Oct 2007_With Whistlebend



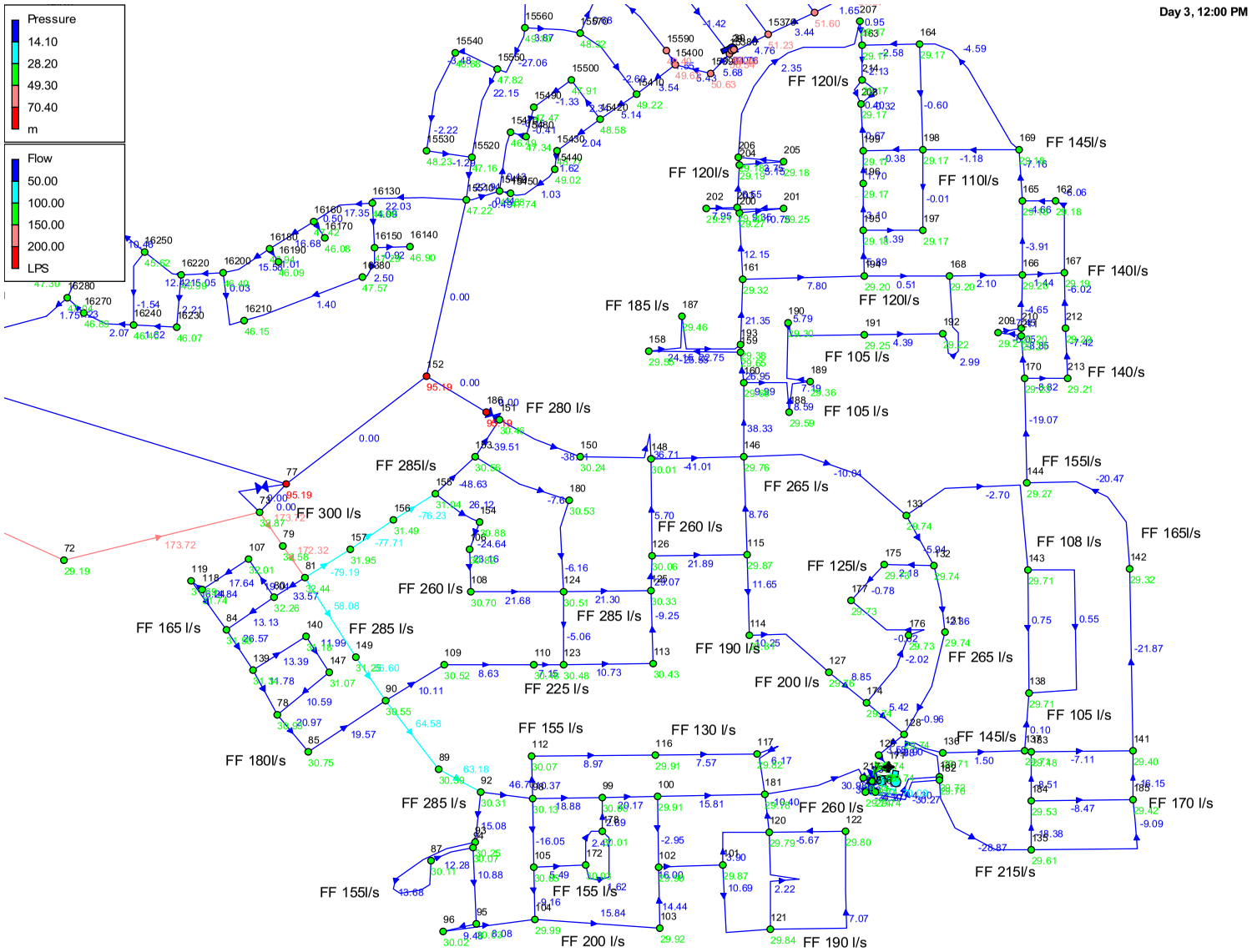
Whistlebend Predesign Water System_ADD Pressures and Flows

Master Model_ex_Oct 2007_With Whistlebend



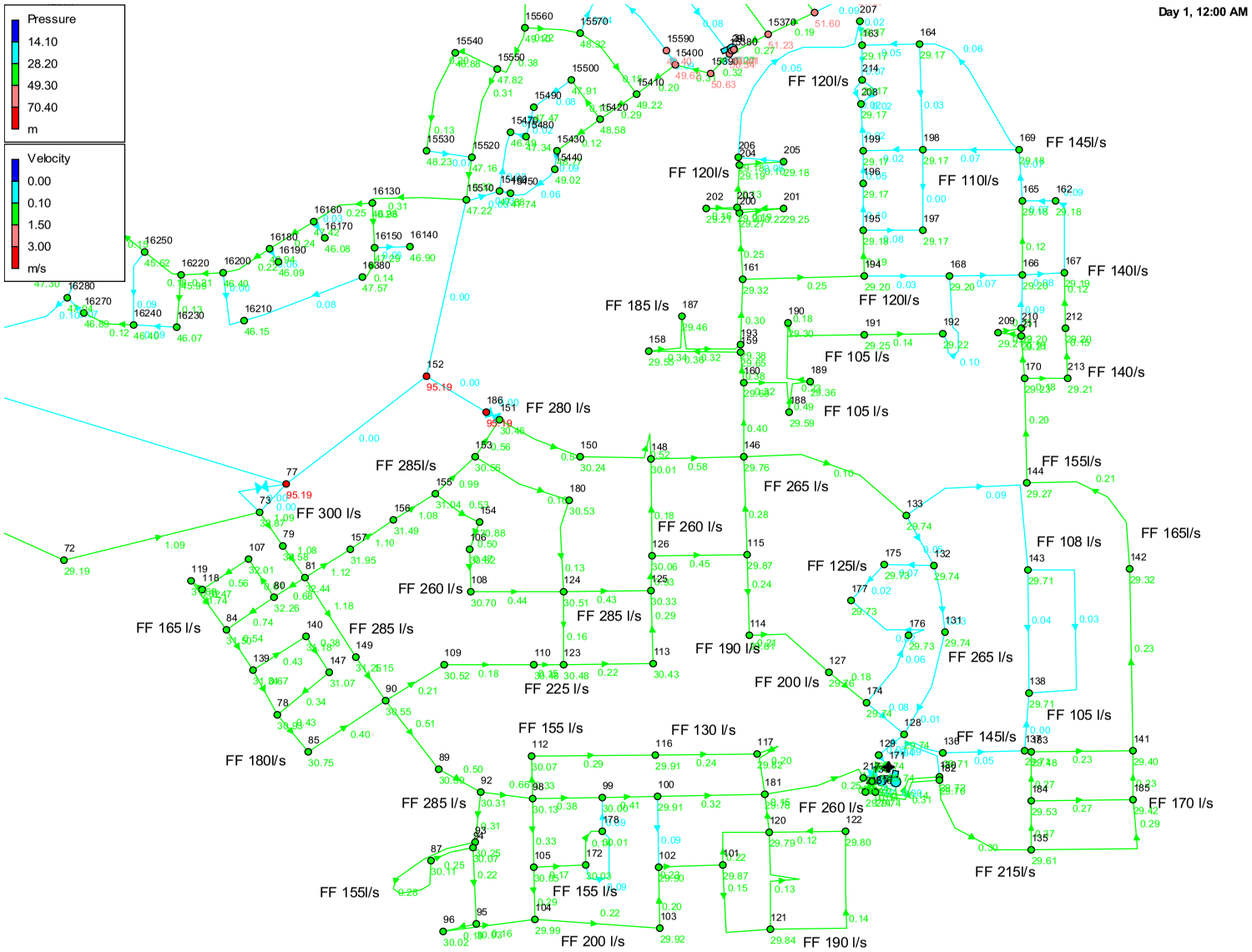
Whistlebend Predesign Water System_MDD Pressures and Flows

Master Model_ex_Oct 2007_With Whistlebend



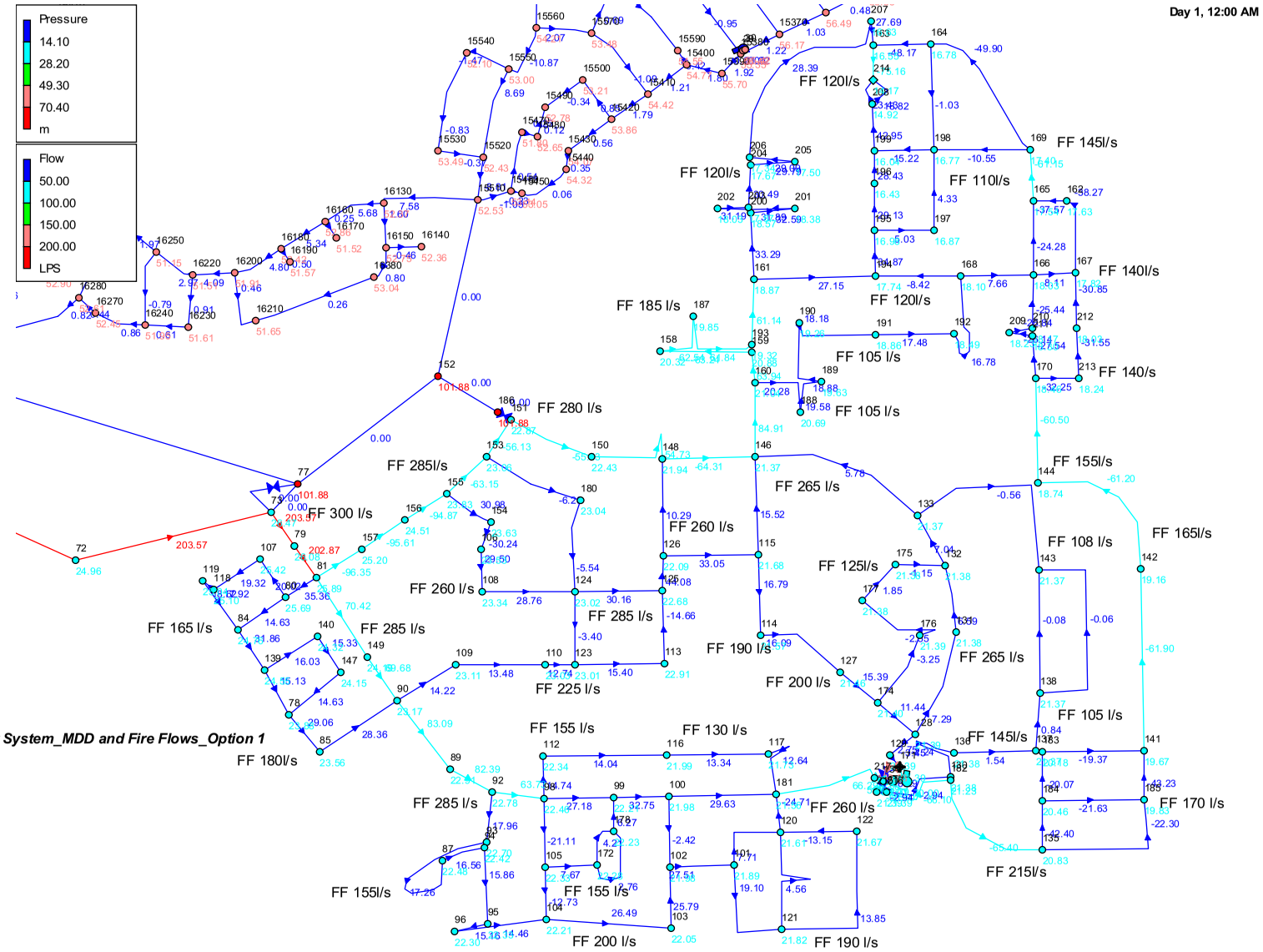
Whistlebend Predesign Water System_PHD Pressures and Flows

Master Model_ex_Oct 2007_With Whistlebend



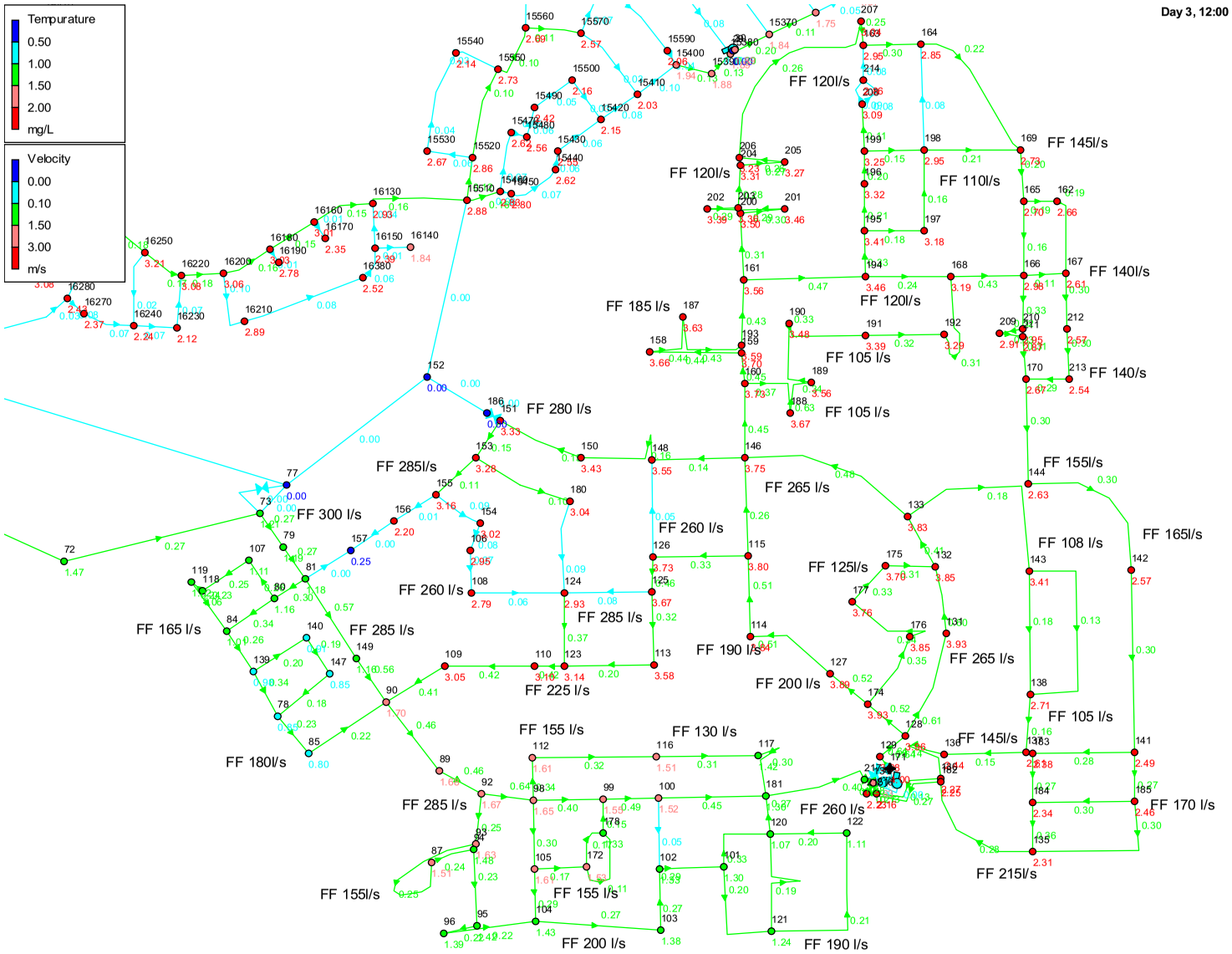
Whistlebend Predesign Water System_PHD Pressures and Velocities

Master Model_ex_Oct 2007_With Whistlebend



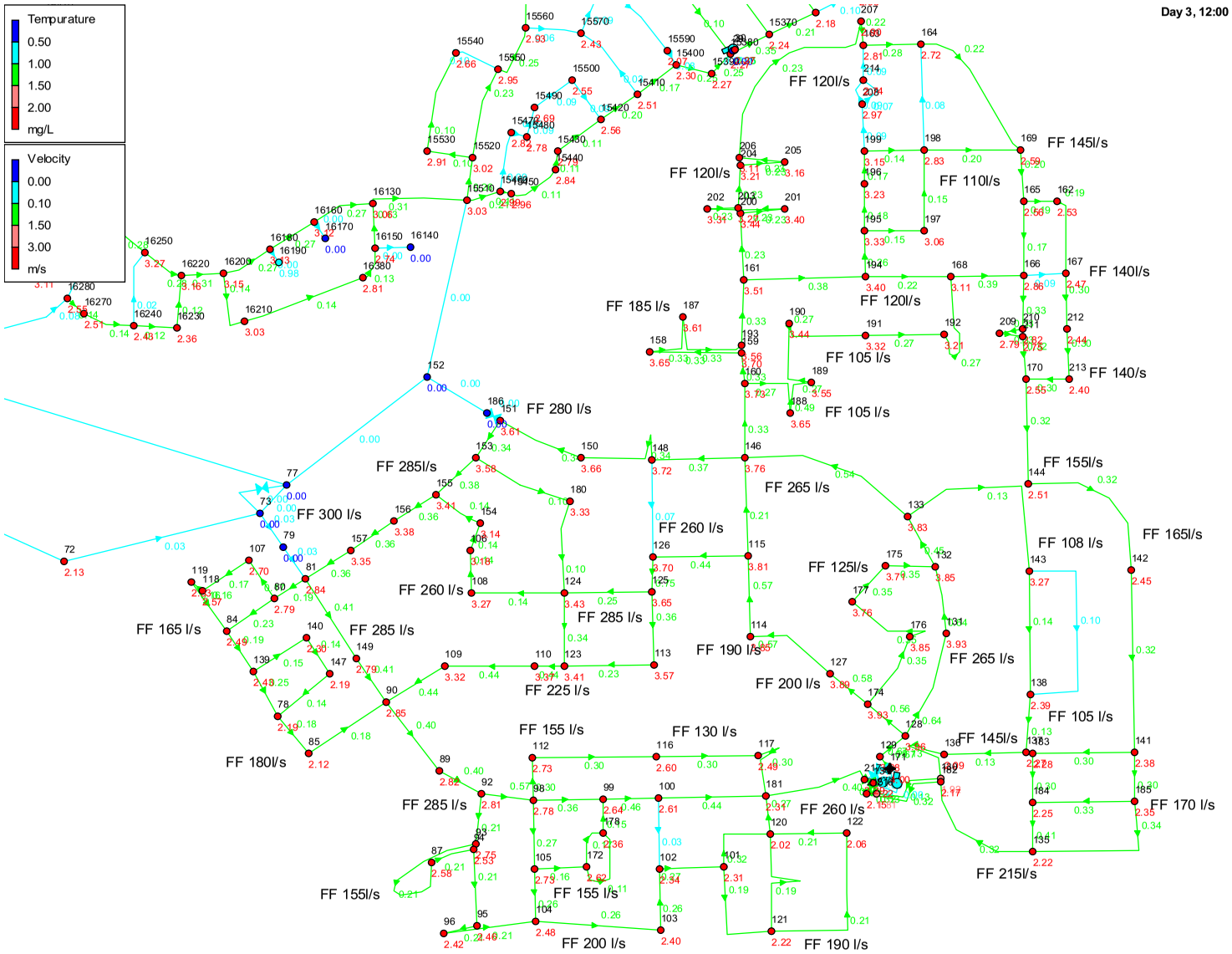
Whistlebend Predesign Water System_MDD and Fire Flows_Option 1

Master Model_ex_Oct 2007_With Whistlebend



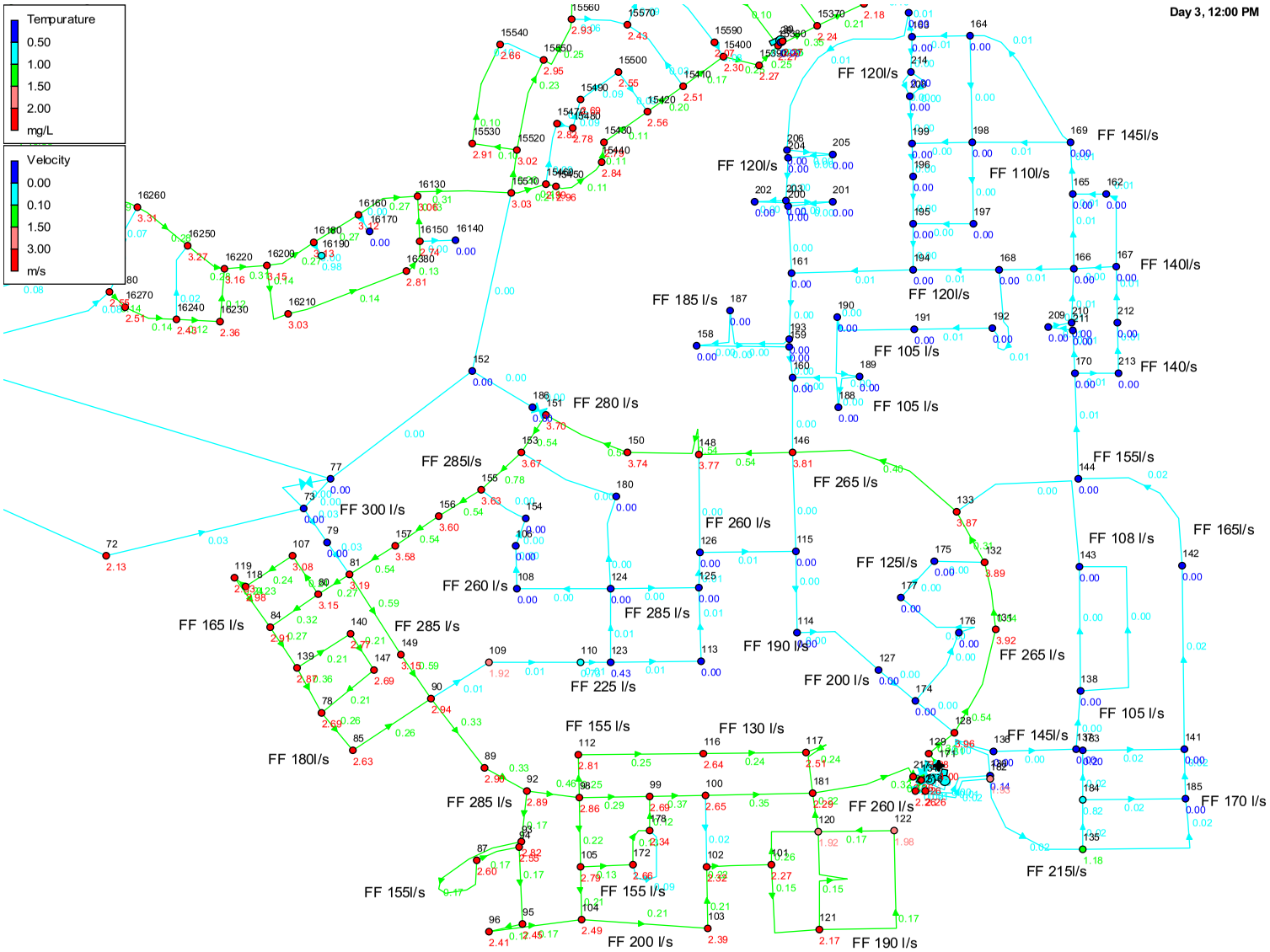
Whistlebend Predesign Water System_ADD Temperatures and Velocities

Master Model_ex_Oct 2007_With Whistlebend

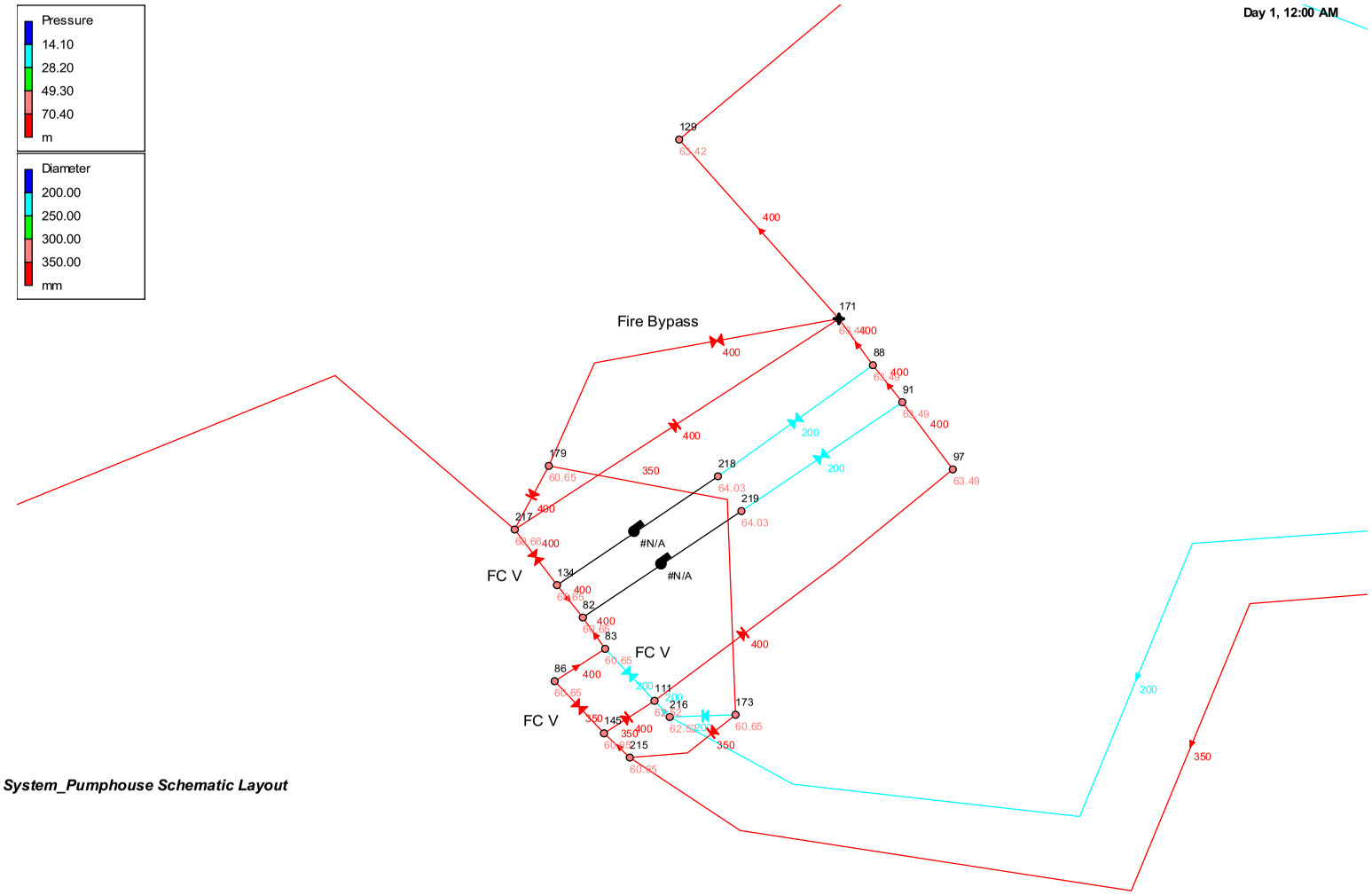


Whistlebend Predesign Water System_NFD Temperatures and Velocities

Master Model_ex_Oct 2007_With Whistlebend



Master Model_ex_Oct 2007_With Whistlebend



Whistlebend Predesign Water System_Pumphouse Schematic Layout

3. Wastewater Collection System

It is anticipated that the construction of the proposed residential development will occur in six phases depending on the market demand over a 20-year horizon. It is expected that the development will progress in phases from southeast to northwest as demand dictates. Phase 1 of construction is proposed to start in 2011.

3.1 Servicing Options

Three options for onsite sanitary sewage collection were developed for consideration:

- Option #1 involves construction of gravity sanitary sewers draining to a single pumpstation located approximately in the centre of the subdivision. The pumpstation will be sized for a peak flow of 110 L/s and will provide service for the ultimate residential development (approximately 7,800 people and a catchment area of 254 ha).

- Option #2 involves construction of gravity sanitary sewers and a pumpstation sized for a peak flow of approximately 85 L/s, which will provide service for approximately 5,900 people and a catchment area of 189 ha (Phase 1 to Phase 5). The construction of this pumpstation and the forcemain will occur during Phase 1 of development. A second pumpstation sized for a peak flow of approximately 35 L/s will be installed for Phase 6 of the development and will provide service for approximately 1,900 people and a catchment area of 65 ha (Phase 6 to Phase 8). Gravity sanitary sewers will be extended from the pumpstations to the phase boundaries as they progress.

- Option #3 involves construction of gravity sanitary sewer system and small lift stations for each phase of development, pumping to a main large pumpstation.

For all options the main pumpstation wet well would be built during Phase 1; however the pumps and controls would be upsized as required as the flows increase. The pumpstation would be operated in a duplex configuration initially but pre-piped for future triplex.

All options require provision of either low-pressure sewers or a small liftstation to service a low area in the northeast corner of the site. See Section 3.7 herein for details.

Note that at the time these options were identified and evaluated, eight phases of development were envisioned for this subdivision. Phasing was subsequently reduced to six, which reduces the cost of Option 3, but does not change its ranking in comparison to the other options.

3.2 Design Criteria to City of Whitehorse Servicing Standards Manual[1]

Design criteria for Whistle Bend Residential Subdivision:

- Manholes – maximum spacing between manholes is 110 m. Suitable separation will be provided from storm drainage swales.

- Sewer Main Sizing – a total of approximately 1,215 single family residential lots, 1,616 multi-family units and 169 mixed use units are proposed within the Whistle Bend Subdivision. Based on a residential

[1] City of Whitehorse Servicing Standards Manual, 2007- Section 2 –Construction Design Criteria, Sub-Section 2.4- Sanitary Sewer System

sewage design flow of 337 L/c/day, Harman's peaking factor and infiltration rate of 6,000 L/ha/day, sewer sizing required to service these flows will range from 200 mm diameter at the upper reaches of the collection system and increase to 400 mm diameter downstream. The per capita flow was reduced from 450 L/capita/day as specified in the City of Whitehorse Servicing Standards Manual to 337 L/capita/day as part of a water reduction strategy.

- Pipe sizing was selected based on the flow depth being equal to 75% of the pipe diameter during the peak hour design flow. The minimum pipe size for all residential gravity sewers to be 200mm diameter.

- Sewer Main Velocity – minimum velocity to be 0.7 m/s with a Manning's pipe roughness coefficient n of 0.013. Minimum pipe slopes for 200 mm piping to be 0.4% and for 300 mm and larger piping to be 0.3% to achieve self-cleansing. The pipe grade on each first upstream length of the pipe to be 0.6%.

- Depth of Bury –The minimum cover over the crown of the sanitary sewer mains to be 2.8 m. The sanitary sewer mains to be designed such that gravity drainage is possible from the finished basement level of all residential building lots.

- Alignment of Sewer Main – sanitary sewer main to be located within road right-of-way or green space corridor.

- Forcemain and Pumpstations –The pumpstation and forcemain will be sized based on the peak wastewater flow plus inflow/infiltration for the ultimate residential development. For Option 1 and 2 the pumps will be initially designed to accommodate a peak flow from Phase 1 and 2 of construction. Capacity will be added as required as new phases are built. This will be done via impeller changes, increases in motor size or change in pump model.

- The depth of the sanitary mains dictates the final pumpstation design. The exact pumpstation locations will be determined during preliminary design. Please refer to the assumptions below.

3.3 Design Assumptions

3.3.1 Option 1

In developing the conceptual sewer system, it was assumed that the entire Whistle Bend Subdivision would drain by gravity sewers to the proposed pumpstation.

Please refer to the attached Sketch 1 for the Conceptual Whistle Bend Wastewater collection system - Option 1.

Supplemental assumptions in generating the conceptual servicing and cost for Option 1 include:

- A single pumpstation will be required to service the entire estimated population of 7,800 people and a catchment area of 254 ha.

- The pumpstation will be a large facility and include building, a circular wet well, triplex submersible pumps for ultimate development (Flygt or similar), electrical/PLC/SCADA panels, ventilation and back-up power.

- The pumpstation will pump the sewage via a 300 mm diameter forcemain to the Porter Creek Flush Tank

- We have assumed open trench for the sanitary sewer mains installation with granular backfill.

3.3.2 Option 2

In developing the conceptual sewer system for Option 2, it was assumed that the entire residential development of the Whistle Bend Subdivision would drain by means of a gravity sewer system to the proposed two pumpstations.

Please refer to the attached Sketch 2 for the Conceptual Whistle Bend Wastewater collection system Option 2.

Supplemental assumptions in generating the conceptual servicing and cost for Option 2 include:

- Two pumpstations will be required:
    - A main pumpstation located within the centre area of the development will service approximately 5,900 people and a catchment area of 189 ha (Phase 1 to Phase 6). The pumpstation will be installed during phase 1 of construction.
    - A small pumpstation located on the west side of the development will service approximately 1,900 people and a catchment area of 65 ha (Phase 6 to Phase 8). The pumpstation will be installed during Phase 6 of the construction.
- Main pumpstation will be a larger facility and include building, wet well, duplex submersible pumps, electrical/PLC/SCADA panels, ventilation and back-up power. Forcemain conceptualized at 250 mm diameter.
- Smaller pumpstation will be a package type unit (Flygt or similar) with a smaller diameter forcemain discharge. Forcemain conceptualized at 150 mm diameter.
- Both pumpstations will pump sewage via forcemains to the Porter Creek Flush Tank.
- We have assumed open trench for the sanitary sewer mains installation with granular backfill.

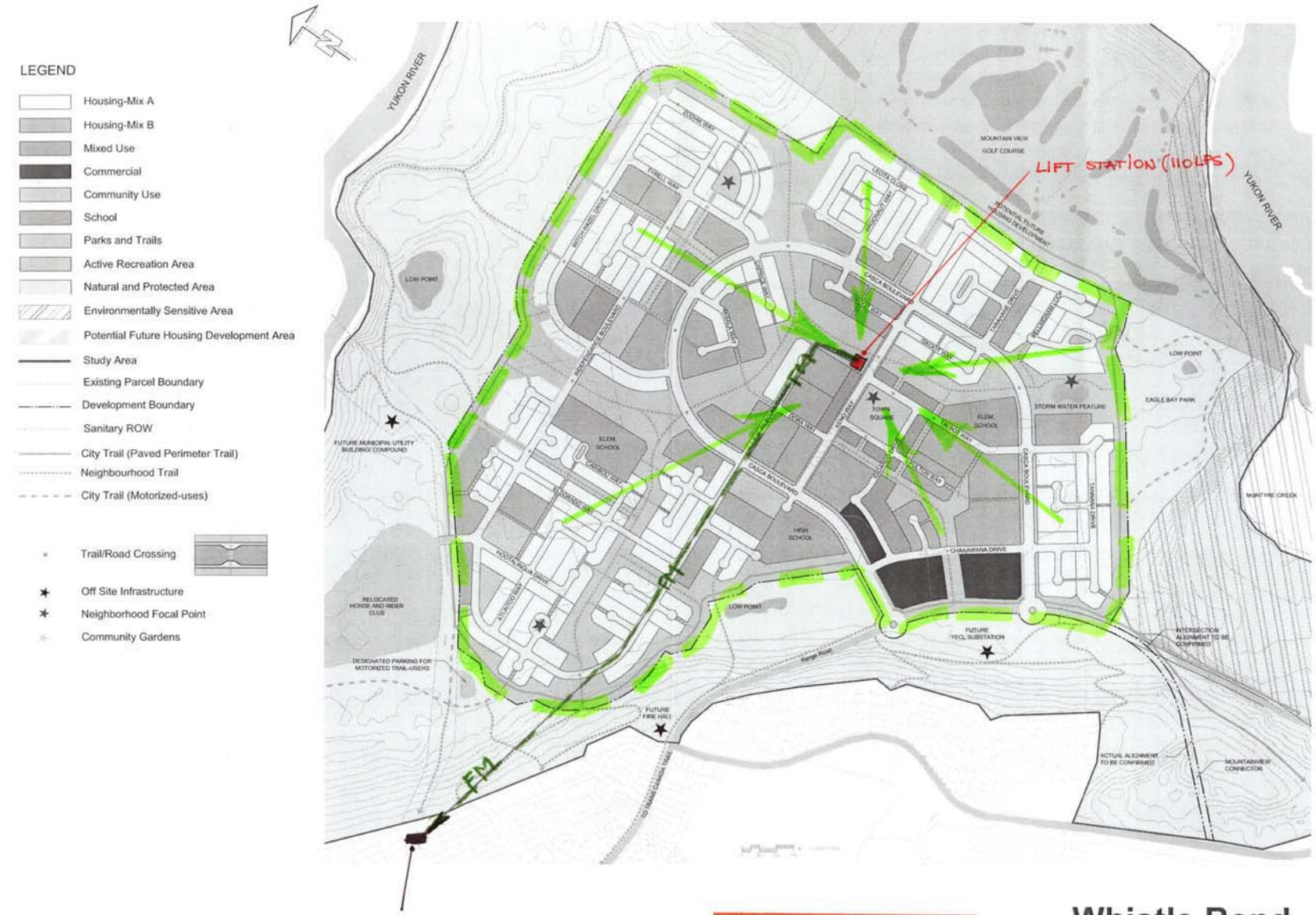
3.3.3 Option 3

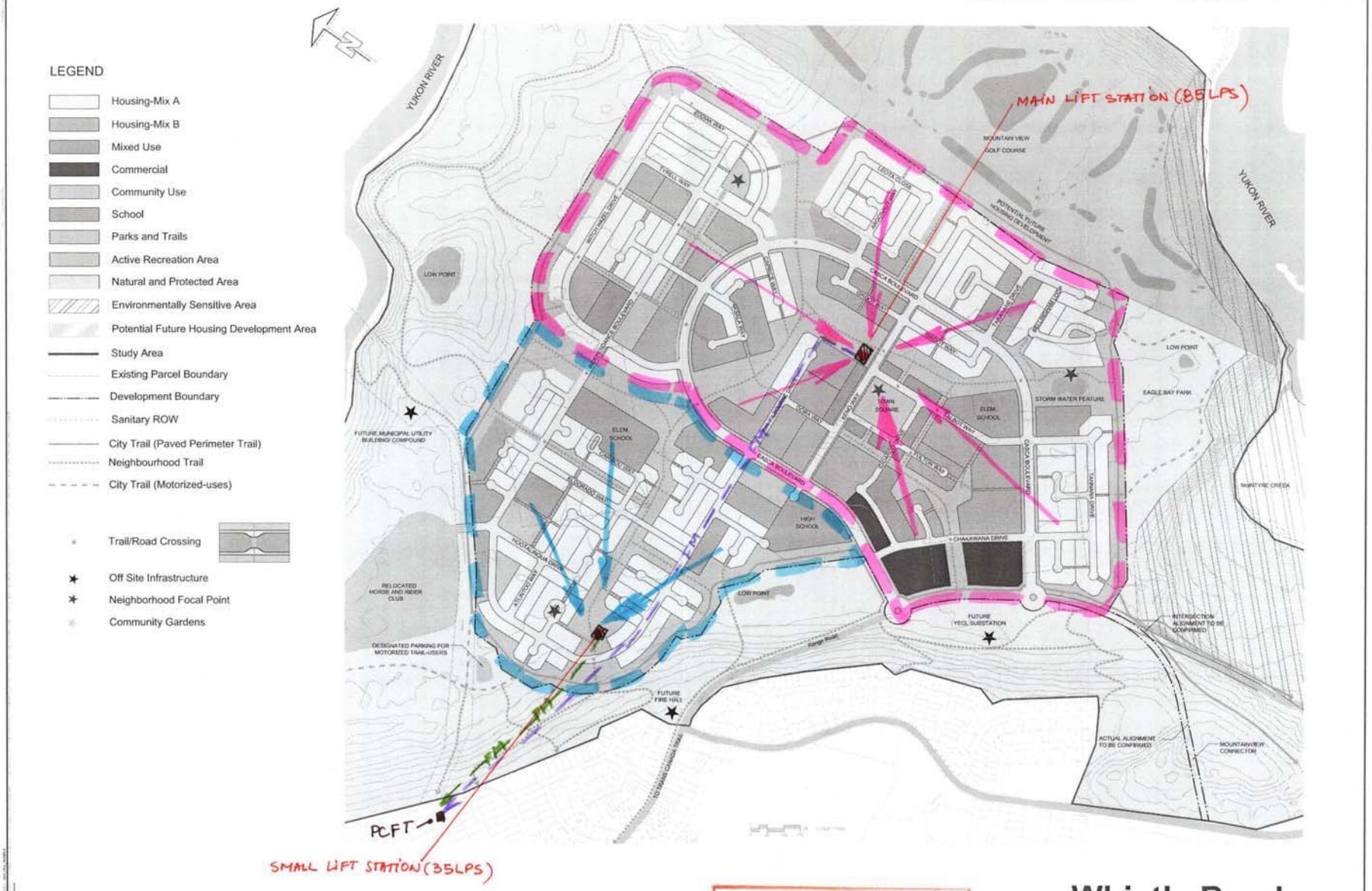
In developing the conceptual sewer system for Option 3 it was assumed that the entire residential development of the Whistle Bend Subdivision would drain by means of a gravity sewer system to small pumpstations installed within each phase of the development. Each pumpstation will pump sewage via forcemain to a main pumpstation located centrally in the development.

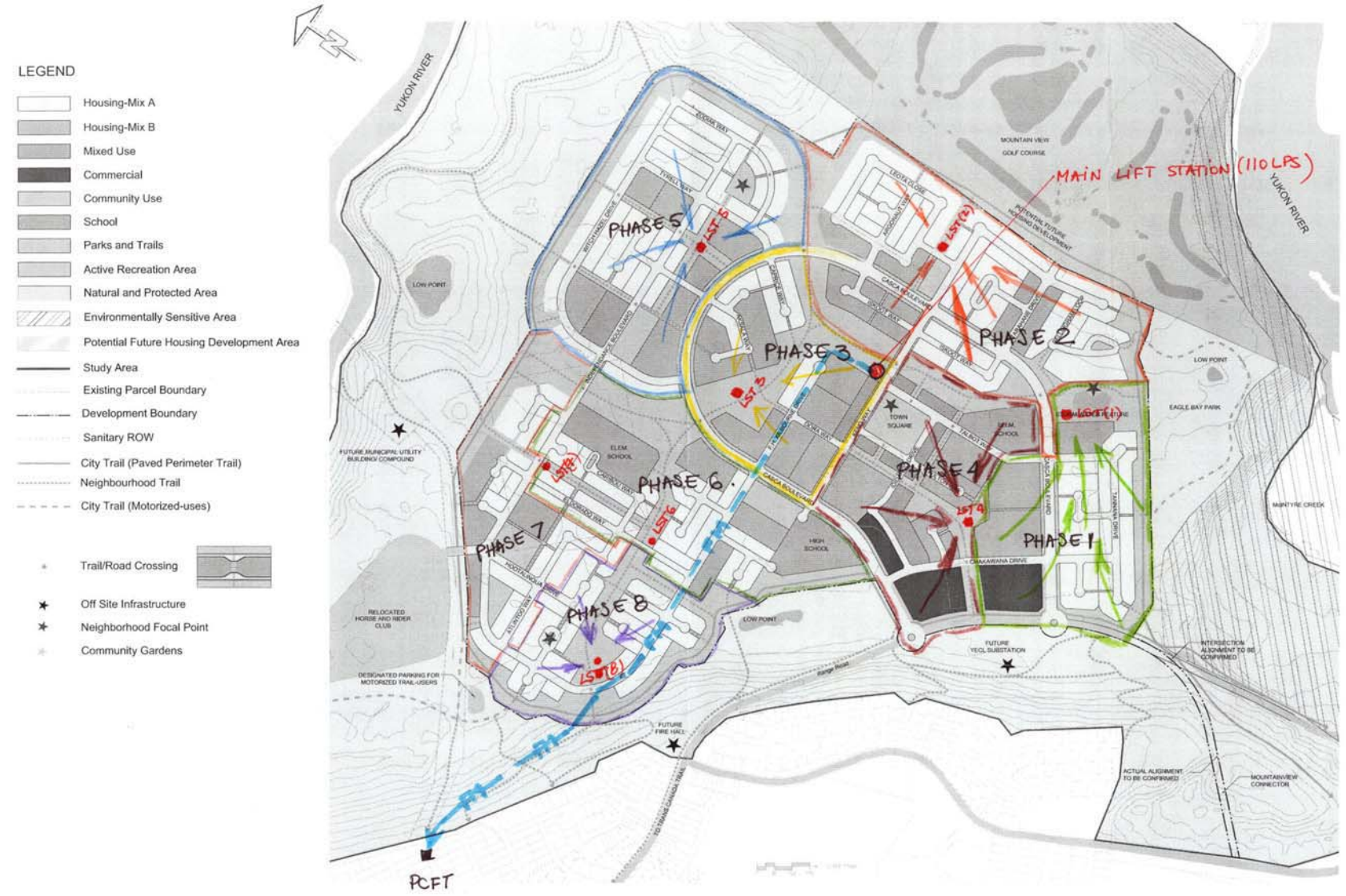
Please refer to the attached Sketch 3 for the Conceptual Whistle Bend Wastewater collection system Option 3.

Supplemental assumptions in generating the conceptual servicing and cost for Option 3 include:

- Eight pumpstations will be required. These pumpstations will be small package type units (Flygt or similar) with a smaller diameter forcemain discharge. Forcemain conceptualized at 150 mm diameter.
- A main pumpstation centrally located within the development will service the entire residential subdivision. The main pumpstation will have a similar configuration to Option 1.
- The main pumpstation will pump the sewage via a 300 mm diameter forcemain to the Porter Creek Flush Tank.


LEGEND
Housing-Mix A
Housing-Mix B
Mixed Use
Commercial
Community Use
School
Parks and Trails
Active Recreation Area
Natural and Protected Area
Environmentally Sensitive Area
Potential Future Housing Development Area
Study Area
Existing Parcel Boundary
Development Boundary
Sanitary ROW
City Trail (Paved Perimeter Trail)
Neighbourhood Trail
City Trail (Motorized-uses)
Trail/Road Crossing
Off Site Infrastructure
Neighborhood Focal Point
Community Gardens
YUKON RIVER
LIFT STATION (110 LPS)
FM
PCFT.
ON SITE WASTEWATER COLLECTION SYSTEM
OPTION 1
Whistle Bend
FINAL CONCEPT PLAN (Rev.6)
AECOM
Date: 09/02/12


LEGEND
Housing-Mix A
Housing-Mix B
Mixed Use
Commercial
Community Use
School
Parks and Trails
Active Recreation Area
Natural and Protected Area
Environmentally Sensitive Area
Potential Future Housing Development Area
Study Area
Existing Parcel Boundary
Development Boundary
Sanitary ROW
City Trail (Paved Perimeter Trail)
Neighbourhood Trail
City Trail (Motorized-uses)
Trail/Road Crossing
Off Site Infrastructure
Neighborhood Focal Point
Community Gardens
YUKON RIVER
MAIN LIFT STATION (85 LPS)
PCFT
SMALL LIFT STATION (35LPS)
ONSITE WASTEWATER COLLECTION SYSTEM
- OPTION 2 -
AECOM
Date: 09/02/12
Whistle Bend
FINAL CONCEPT PLAN (Rev.6)



AECOM

Date: 09/02/12

ON SITE WASTEWATER COLLECTION SYSTEM
~ OPTION 3 ~

Whistle Bend

FINAL CONCEPT PLAN (Rev.6)

3.4 Summary of Conceptual Costs

Based on the above noted design criteria and design assumptions, itemized quantity take-offs were completed for the project. A summary of the construction costs is presented below and the detailed itemized breakdowns are attached. Note that the costs are for comparison of options only and do not include engineering, construction services or contingency.

Option 1 – Summary of Conceptual Cost

Description	Costs
1: Gravity Sewers	$ 18,500,000
2: Pumpstation and forcemain	$ 3,400,000
Total Construction Cost – Option 1 (Excluding GST)	$ 21,900,000

Option 2 – Summary of Conceptual Cost

Description	Costs
1: Gravity Sewers	$ 15,500,000
2: Main pumpstation and forcemain	$ 2,700,000
3: Small pumpstation and forcemain	$ 800,000
Total Construction Cost - Option 2 (Excluding GST)	$ 19,000,000

Option 3 – Summary of Conceptual Cost

Description	Costs
1: Gravity Sewers	$ 15,100,000
2: Main pumpstation and forcemain	$ 3,400,000
3: Small pumpstations and forcemain	$ 5,200,000
Total Construction Cost - Option 3 (Excluding GST)	$ 23,700,000

City of Whitehorse
Whistle Bend Subdivison
On-site Wastewater Collection System
Option 1

March 17, 2009

	Description	Quantity	Unit	Unit Price	Estimated Cost
1	Sewage pumping station (110 LPS)	1	l.sum	$2,000,000	$2,000,000
2	Forcemain; 300 mm dia include trenching, bedding, backfilll	2,000	lin.m	$650	$1,300,000
3	Connection forcemain to PCTF	1	l.sum	$15,000	$15,000
4	Air Release Chambers	1	l.sum	$70,000	$70,000
5	Fittings (Allowance)	1	Allowance	$25,000	$25,000
6	Gravity sewers; 200 mm dia Pipe	16,260	lin.m	$150	$2,439,000
7	Gravity sewers; 300 mm dia Pipe	3,585	lin.m	$200	$717,000
8	Trench and backfill(3-4 m depth)	1,760	lin.m	$250	$440,000
9	Trench and backfill(4-5 m depth)	3,980	lin.m	$350	$1,393,000
10	Trench and backfill(5-6 m depth)	4,850	lin.m	$450	$2,182,500
11	Trench and backfill(6-7 m depth)	2,275	lin.m	$550	$1,251,250
12	Trench and backfill(7-8 m depth)	2,240	lin.m	$650	$1,456,000
13	Trench and backfill(8-9 m depth)	2,800	lin.m	$750	$2,100,000
14	Trench and backfill(9-10 m depth)	1,560	lin.m	$850	$1,326,000
15	Trench and backfill(10-11 m depth)	380	lin.m	$950	$361,000
16	Pipe installation	19,845	lin.m	$125	$2,480,625
17	Drain rock or pea gravel pipe bedding	19,845	lin.m	$25	$496,125
18	Manholes	180	each	$10,000	$1,800,000
Total Construction Cost					**$21,900,000**

Notes:

-Sizing and length of sewer infrastructure piping is conceptual and to be confirmed during detailed design.

-Sizing of lift stations and forcemains is conceptual and to be confirmed during detailed design.

City of Whitehorse
Whistle Bend Subdivison
On-site Wastewater Collection System
Option 2

	Description	Quantity	Unit	Unit Price	Estimated Cost
1	Main Sewage pumping station (85LPS)	1	l.sum	$1,500,000	$1,500,000
2	Small Sewage pumping station(35LPS)	1	l.sum	$350,000	$350,000
3	Forcemain; 250 mm dia include trenching, bedding, backfilll	2,000	lin.m	$550	$1,100,000
4	Forcemain; 150 mm diainclude trenching, bedding, backfilll	750	lin.m	$450	$337,500
5	Air Release Chambers	2	l.sum	$70,000	$140,000
6	Connection forcemain to PCTF	2	l.sum	$15,000	$30,000
7	Fittings	1	allowance	$25,000	$25,000
8	Gravity sewers; 200 mm dia Pipe	15,900	lin.m	$150	$2,385,000
9	Gravity sewers; 300 mm dia Pipe	3,300	lin.m	$200	$660,000
10	Trench and backfill(3-4 m depth)	4,000	lin.m	$250	$1,000,000
11	Trench and backfill(4-5 m depth)	5,800	lin.m	$350	$2,030,000
12	Trench and backfill(5-6 m depth)	5,700	lin.m	$450	$2,565,000
13	Trench and backfill(6-7 m depth)	3,400	lin.m	$550	$1,870,000
14	Trench and backfill(7-8 m depth)	400	lin.m	$650	$260,000
15	Pipe installation	19,200	lin.m	$125	$2,400,000
16	Drain rock or pea gravel pipe bedding	19,200	lin.m	$25	$480,000
17	Manholes	180	each	$10,000	$1,800,000
Total Construction Cost					**$19,000,000**

Notes:

-Sizing and length of sewer infrastructure piping is conceptual and to be confirmed during detailed design.

-Sizing of lift stations and forcemains is conceptual and to be confirmed during detailed design.

City of Whitehorse
Whistle Bend Subdivison
On-site Wastewater Collection System
Option 3

	Description	Quantity	Unit	Unit Price	Estimated Cost
1	Main Sewage pumping station (110LPS)	1	l.sum	$2,000,000	$2,000,000
2	Small Sewage pumping station(~15LPS)	8	l.sum	$250,000	$2,000,000
3	Forcemain; 300 mm dia include trenching, bedding, backfillll	2,000	lin.m	$650	$1,300,000
4	Forcemain; 150 mm diainclude trenching, bedding, backfillll	7,000	lin.m	$450	$3,150,000
5	Air Release Chambers	1	l.sum	$70,000	$70,000
6	Connection forcemain to PCTF	1	l.sum	$15,000	$15,000
7	Fittings	1	allowance	$25,000	$25,000
8	Gravity sewers; 200 mm dia Pipe	18,000	lin.m	$150	$2,700,000
9	Gravity sewers; 300 mm dia Pipe	1,600	lin.m	$200	$320,000
10	Trench and backfill(3-4 m depth)	4,000	lin.m	$250	$1,000,000
11	Trench and backfill(4-5 m depth)	8,500	lin.m	$350	$2,975,000
12	Trench and backfill(5-6 m depth)	5,700	lin.m	$450	$2,565,000
13	Trench and backfill(6-7 m depth)	1,400	lin.m	$550	$770,000
14	Pipe installation	19,600	lin.m	$125	$2,450,000
15	Drain rock or pea gravel pipe bedding	19,600	lin.m	$25	$490,000
16	Manholes	180	each	$10,000	$1,800,000
Total Construction Cost					**$23,700,000**

Notes:

-Sizing and length of sewer infrastructure piping is conceptual and to be confirmed during detailed design.

-Sizing of lift stations and forcemains is conceptual and to be confirmed during detailed design.

3.5 Recommendation

Option 2 is the preferred option for the wastewater collection system within Whistle Bend Residential development based on the following criteria:

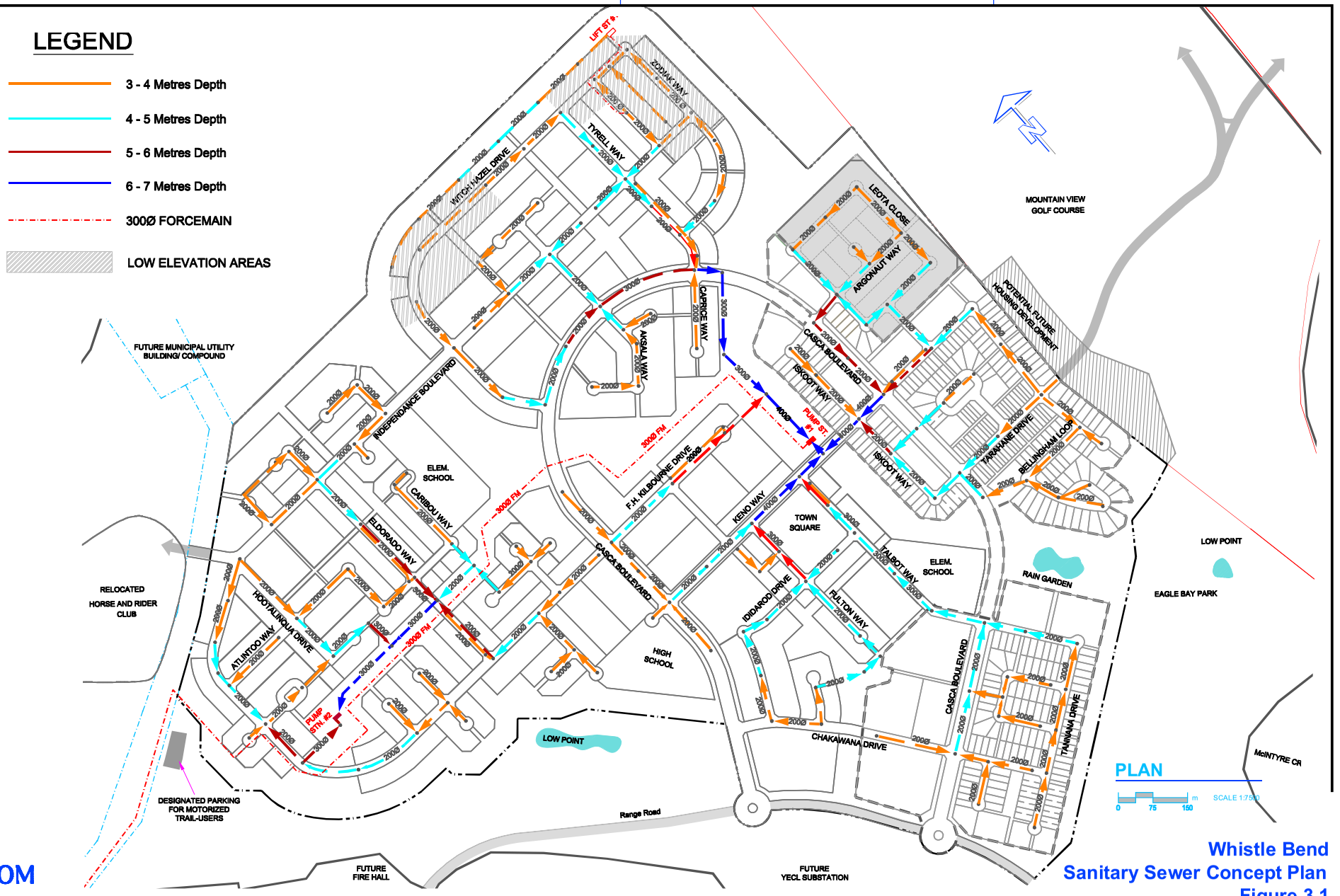
- Construction cost: this option has the lowest estimated capital cost based on feasibility level costing.
- Reduced depth of sewers over Option1.
- Savings in pumpstation operation and maintenance costs over Option 3.

3.6 Sanitary Sewer Layout

Figure 3.1 attached shows the proposed sanitary sewer layout for the selected Option 2.

This layout was developed to address the following criteria:

- The flat topography of the entire area that slopes very gently from south to northeast. The overall slope of the ground is approximately 0.5%, with some areas slightly steeper. The northeast corner of the subdivision is the local lowest spot (elevation 670 m), while the southeast corner is the highest spot (elevation 680 m).
- Based on the site topography for the northeast corner of the subdivision, Section 3.7 herein examines the options of a low-pressure sanitary system with individual grinder pumps compared to a gravity sewer system with a small liftstation.
- For overall planning purposes, the crown of the sanitary sewer at the start of each run is assumed to be 2.8 meters below the ground elevation.
- Minimum pipe slopes for the 200 mm piping to be 0.4%, the 300 mm piping to be 0.30% and for 400 mm piping to be 0.25%. The pipe grade on the first upstream length of each pipe to be 0.6% minimum.
- The depth of the sanitary mains dictates the final pumpstations designs.
- The sanitary sewer collection system will be located within road rights-of-way. Short lengths of parallel sanitary sewer collectors will be installed at 3-meter depth to pick up sanitary service connections in areas where the main sanitary sewer depth exceeds 5 meters. These parallel collectors will drop the sewage into the deeper trunks.
- The pumpstations will pump the sewage via forcemains to the existing Porter Creek Flush Tank. The forcemains will be located within subdivision green belt, below the connecting trails, aligned to minimize impact on trees.



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Whistle Bend
Sanitary Sewer Concept Plan
Figure 3.1

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3.7 Servicing of Low Area in Northeast Portion of Site

The northeast portion of the site (Phase 5 of 6) features two low sections; one at the northwest bend in Witch Hazel Drive and the other in the vicinity of the east end of Witch Hazel Drive and north end of Zodiac Way. To avoid excessive depth of the gravity sewer system coming from this area, we have investigated two optional methods of servicing this area. The total area of low topography is about 9 ha in size.

- Option 1 - Low pressure sanitary system
- Option 2 - Gravity sanitary sewer system and pumpstation

For the purpose of this estimate, a density of 22 units per hectare for single family (22 units/ha * 9 ha =198 units) was assumed.

Option 1 involves providing 198 homeowners with individual grinder pumps.. The pump units would be purchased under the construction contract and installed at the best possible location on each property.

The estimated construction cost of Option 1 (Class D) is $2,800,000 as presented below.

Cost Estimate Low Pressure System (Single family-density) – 198 Units

	Description	Quantity	Unit	Unit Price	Estimated Cost
1	75 mm or 100 mm dia. Low pressure FM	1,200	m	$150	$ 180,000
2	Sewer Service laterals LPFM	198	each	$650	$ 128,700
3	Inspection chamber at PL (include manhole, isolating and check valves)	198	each	$2,500	$ 495,000
4	Simplex Grinder pumpstation (installed)	198	each	$10,000	$1,980,000
5	Cleanout servicing the main LPFM (based on approximate spacing of 500 m)	3	each	$1,500	$ 4,500
6	Air relief valves	2	each	$5,000	$ 10,000
Total Cost Low Pressure System					$2,798,200
Cost Per User					$ 14,150

Option 2 involves providing 198 homeowners with a gravity sewer system draining to a small pumpstation (duplex with capacity of 15 L/s). This pumpstation will pump sewage into a higher gravity sewer flowing directly to the main pumpstation for the development.

The estimated construction cost of Option 2 (Class D) is $1,480,000 as presented below.

Cost Estimate Gravity Sewers and Liftstation – 198 Units

	Description	Quantity	Unit	Unit Price	Estimated Cost
1	200 mm dia. Gravity sanitary system	1,400	m	$150	$ 210,000
2	Manhole	10	each	$10,000	$ 100,000
3	Trench and backfill (3-4 m depth)	700	m	$250	$ 175,000
4	Trench and backfill (4-5 m depth)	400	m	$350	$ 140,000
5	Trench and backfill (5-6 m depth)	100	m	$450	$ 45,000
6	Forcemain (100 mm dia), depth 3 m	220	m	$400	$ 88,000
7	Pumpstation (15 L/s)	1	LS	$250,000	$ 250,000
8	Sewer service laterals (Gravity)	198	each	$1,250	$ 247,500
	Total Cost Gravity Sewer System and Liftstation				$1,255,500
	Cost Per User				$ 6,340

Advantages/ Disadvantages

Option	Advantages	Disadvantages
Low pressure system	- Homeowners will assume long term and maintenance costs for the system	- Higher construction cost - Power failure results in loss of sewer service - 198 pumpstation units (possible involvement of emergency assistance from the City).
Gravity Sewer System and Liftstation	- Lower construction cost - Gravity sewers require less operation and maintenance	- City will assume long term and maintenance cost for the system (liftstation and forcemain).

It is recommended that the gravity sewer and lift station option be chosen, based mainly on cost. It is also noted that if this area is ultimately developed as multi-family, the gravity sewer and lift station, Option 2, would be more suitable than Option 1.

3.8 Wastewater Pumpstation and Forcemain

The main wastewater pumpstation will be centrally located on the site in green space adjacent to Keno Way, as shown on the Sewer Concept Plan. It will be constructed as part of the Phase 1 infrastructure, and will handle almost all sewage pumping for Phases 1 to 5.

The smaller wastewater pumpstation will be located near the west end of Phase 6, and will handle all sewage from Phase 6 and a portion of the sewage from Phase 3. The need to include a portion of Phase 3 is due to the reduced number of proposed phases and adjustment of phase boundaries. This pumpstation will be a package unit with duplex pumps. It will have to be constructed as part of the Phase 3 infrastructure to service a portion of Phase 3.

The pumpstation will be custom-built to the application, including architectural design of the exterior to ensure it blends in with the surrounding neighbourhood.

The station will include dual inlet troughs with comminutors to grind up the sewage. The troughs will spill into a wet well, which will be pumped out by duplex submersible pumps in an adjacent dry well. The pump room will be piped for future triplex pumps as demands increase.

The ground floor will house electrical controls and hatches in one room and backup generator and fuel tank in the other room. Noise attenuation will be an important aspect of this design.

It is proposed that one 300 mm diameter forcemain be provided from the main pumpstation to the Porter Creek Flush Tank. The smaller pumpstation located in Phase 6 will share the same forcemain. In order to compensate for any hydraulic imbalance between concurrent pumpstation discharges, it is recommended that variable frequency drive units be fitted to the pumps. This will eliminate the need to provide controls to prevent concurrent discharges, thus eliminating the need to increase wet well sizes. The use of VFDs in pump starting will also reduce the required size of emergency generators.

The shared forcemain will be less expensive than two forcemains and will simplify the connection to the flush tank.

The possibility of using the emergency generators at this station to power the water recirculation and heating pumphouse was briefly examined. The water pumphouse will require considerably less backup power than the sewage pumpstation, and the 500 m separation between the two facilities could mean considerable line losses, so combining the backup power for these two facilities may not be cost effective. This should be analyzed further during detailed design when electrical loads are firmly established.

4. Stormwater Management

4.1 General

The proposed Whistle Bend development will be located on approximately 700 ha of land known as the Porter Creek Lower Bench. The stormwater management plan for this site is to adopt sustainable drainage principles in order to achieve the goal of no net increase of runoff from the completed development. To achieve this goal, the reduction of runoff will be a major aspect of site development of the municipal infrastructure.

4.2 Existing Conditions

The land is gently sloping towards the Yukon River. However, the site has an environmentally sensitive area to its south, a golf course to its east, a ridge and an existing road to its south. There is very gentle relief in the terrain, and no marked drainage gullies to the river. The reason for this is twofold: pervious soils, and gentle slopes. As well, the site is almost totally covered in coniferous vegetation. Review of borehole and test pit data in the EBA Engineering Consultants Ltd. Geotechnical report of August 2009 (see Appendix B), indicates that most of the site consists of a varying thickness of sand over glacio-lacustrine silt. Two areas, one in the middle of the site and the other in the northwest corner, are expected to have little or no sand cover. The sand, being uniformly graded, should be very permeable. The thickness of sand over about 80% of the site is expected to vary between 0.5 m and several metres thick.

The overall development site can be divided into eight discrete drainage basins, with five low spots which act as receiving points for runoff during spring thaw as well as during extreme precipitation events. These have been shown in Figure 4.1. The permeable sand areas probably absorb much of the rainfall runoff.

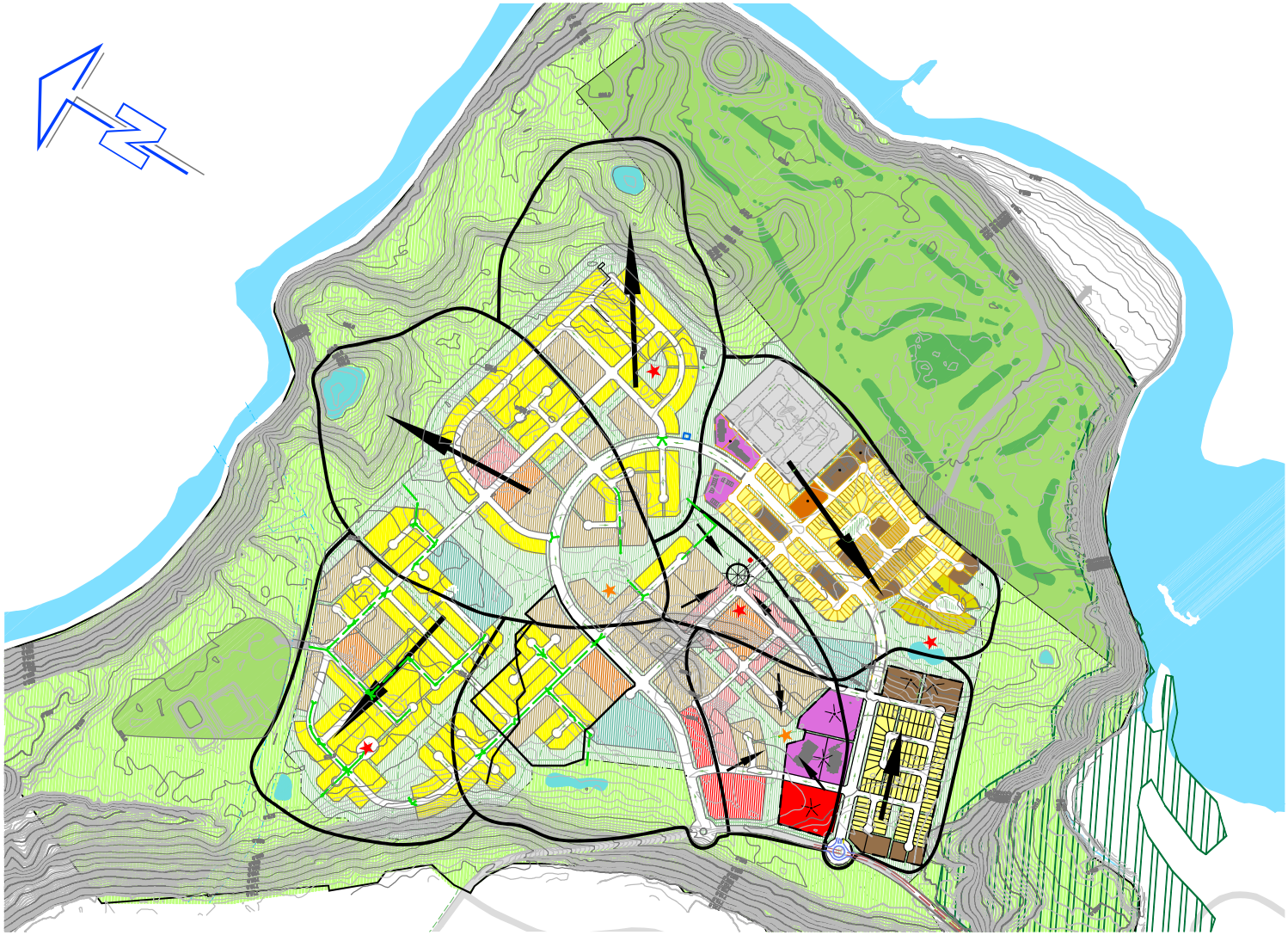
4.3 Proposed Drainage Basins

The overall drainage concept proposes to utilize existing drainage basins to service the completed development, to eliminate or minimize earthwork and regrading of the land. The existing low points will be designated and developed as the ultimate receiving points for the runoff. There will be no runoff from this development to the river.

4.4 Design Criteria

The overall stormwater management will be provided by both a major system as well as a minor system. The major system consists of surface routing the runoff through roads, rights-of-way, public utility lots, easements, reserves, and other public lands. The minor system consists of catchbasins, storm sewers, infiltration pits, and bio-swales. Other criteria are:

- The Rational Method will be used in the design of the storm sewer system, on the assumption that all the local drainage basins are less than 10 ha. For any basins larger than 10 ha, computer modelling should be considered.



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Whistle Bend
Overall Drainage Basins
Figure 4.1

The formula for the Rational Method is:

Q = CIA/360, where

Q = the quantity of runoff in cubic metres per second
I = the intensity of rainfall in millimetres per hour
A = the contribution area in hectares
C = the runoff coefficient

A five-year rainfall intensity event for the City shall be used for minor system design and a 100-year rainfall intensity event shall be used for major storm sewers and overall drainage system design. Time of concentration shall equal inlet time plus flow time with a maximum inlet time of 15 minutes.

The following runoff coefficients shall be used:

- Open space 0.15
- Residential 0.35
- Industrial 0.70
- Commercial 0.70
- Multiple Family 0.70
- Pavement 0.90

- To prevent ponding and stagnation in swales, the minimum velocity will be 1 m/s. Where runoff velocities in excess of 3 m/s are attained, special provisions shall be made to protect against erosion or impact.
- Pipe sizing shall be determined by using Manning's Formula. A maximum Manning's "n" of 0.013 for smooth walled storm pipe and "n" of 0.016 for concrete gutters and paved roads is to be used.
- Storm sewer mains shall be a minimum of 300 mm in diameter. Storm sewer main pipe shall conform to the City's material standard, which include:

  - Reinforced concrete pipe ASTM C76 / D655
  - CSP Ultraflow 2.0 mm CSPI No. 501-M
  - HDPE CGSB 41-GP-2Sm.

- Manholes shall be concrete as specified in City Standards Section 2.4.4. Floating manhole frames shall be used in all paved roadways.
- Catchbasin barrels with precast base and precast slab top shall be 600 mm inside diameter per City standard. If necessary for certain situations, large-diameter catchbasins could be employed.

4.5 Summary of Conceptual Design

The following design philosophy was kept in mind while conceptualizing the stormwater management for Whistle Bend:

- The existing drainage basins will largely be retained, to minimize earthwork quantities;
- The existing low spots would be utilized to retain the 100-year runoff;
- The treatment of the retention areas will be in the form of "Rain Gardens" and not as detention ponds, so that the vegetation around the area is preserved;
- Swales leading to the retention areas will be designed for minimal velocity, to discourage erosion. Excessive slopes will be countered with ditch-checks and stilling basins;
- Swales may be located in green corridors or in easements designed for this purpose. Swale runoff will be separated from sanitary sewers to minimize infiltration.

- No ponding will be allowed on the main arterial Casca Boulevard;
- An inlet time of 15 minutes maximum will be used for positioning the first catchbasin;
- No rooftop leaders will be allowed to connect to the storm sewers directly. They will be directed to the lawns and the runoff encouraged to infiltrate into the ground to avoid being picked up in the minor system;
- Perimeter drainage systems may be required for the foundations of homes in low permeability soil. Perimeter drains should not be allowed to discharge to storm sewers. Sump pumps discharging to rock pits in rear yards are recommended;
- Green rooftops should be encouraged in commercial areas;
- Commercial and multi-family developments should be encouraged to provide exfiltration pits, to decrease or, in some cases, eliminate runoff from the site, during a 5-year event;
- Shorter runs of storm sewer will be incorporated into the design, to maximize use of exfiltration pits, and avoid concentrating heavy flow;
- The detailed design will include measures to limit the chance of runoff infiltrating into sewer systems and trenches.

4.6 Overall Drainage Basins

The overall drainage basins identified in Figure 1 are as follows:

Area 1:	21.06	ha
Area 2:	47.87	ha
Area 3:	21.44	ha
Area 4:	12.45	ha
Area 5:	48.76	ha
Area 6:	68.57	ha
Area 7:	46.38	ha
Area 8:	40.72	ha

4.7 Conceptual and Preliminary Design

The overall stormwater management concept is shown in Figure 4.2. The Phase 1 conceptual design of the minor system as well as the major system is shown in Figure 4.3. The size of the storm sewers is a maximum 450 mm diameter.

The Phase 2 conceptual design is shown in Figure 4.4. The size of the storm sewer is again, not more than 450 mm diameter.

Also attached are typical details of the types of facilities proposed for this project.

4.8 Water Quality

The various systems mentioned above will also provide enhanced water quality for the runoff from the development. The addition of oil/grit separators at the select outlet locations may further enhance the runoff water quality. However, we do not anticipate the need for oil/grit separators throughout, as the recommended systems should achieve the same results. Also, the separators would become an additional City maintenance item.

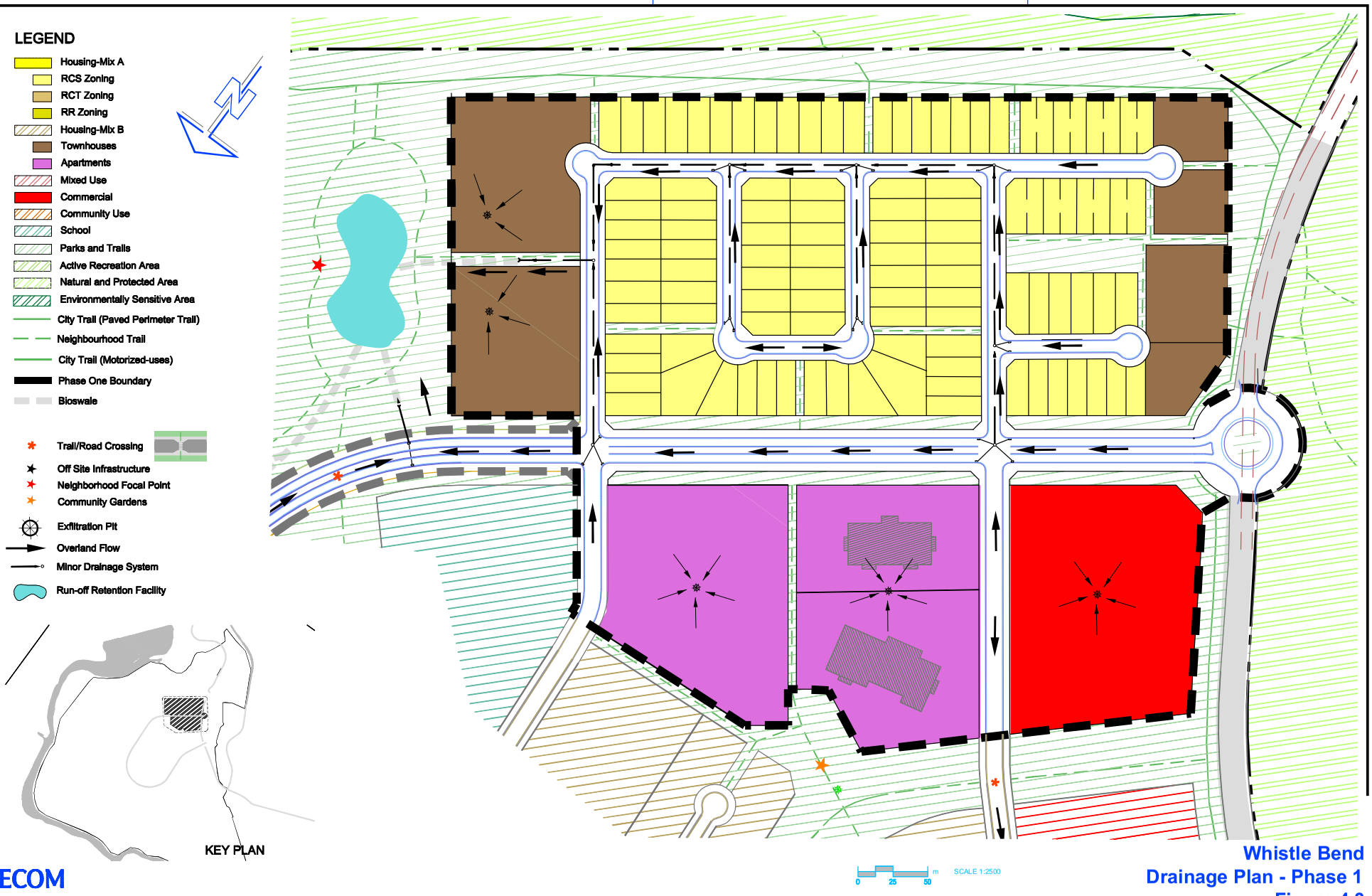


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Whistle Bend
Overall Stormwater Management Concept Plan
Figure 4.2



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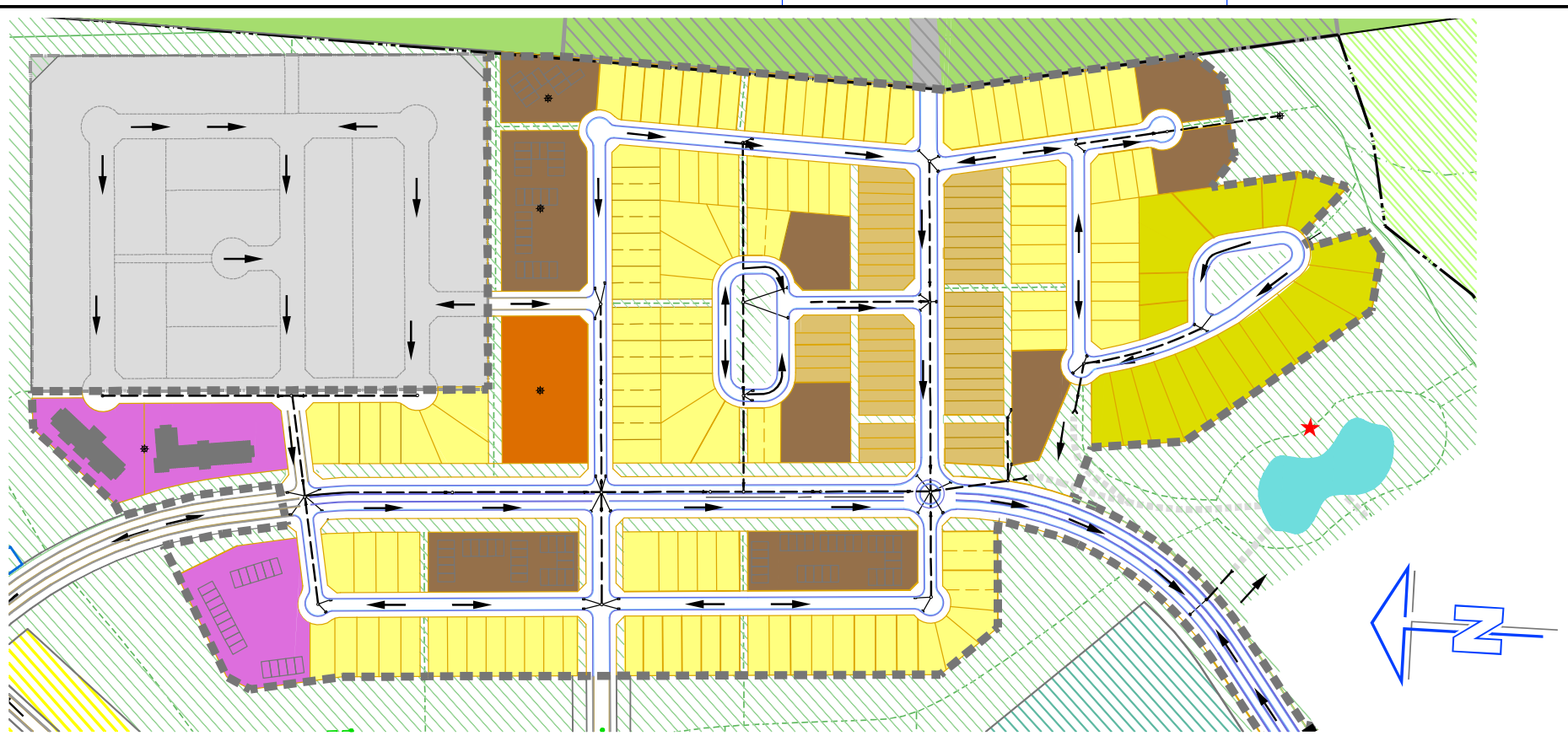
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Whistle Bend
Drainage Plan - Phase 1
Figure 4.3



LEGEND

- Housing-Mix A
- RCS Zoning
- RCT Zoning
- RR Zoning
- Housing-Mix B
- Townhouses
- Apartments
- Mixed Use
- Commercial
- Community Use
- School
- Parks and Trails
- Active Recreation Area
- Natural and Protected Area
- Environmentally Sensitive Area
- Potential Future Housing Development
- Phase Two Boundary
- City Trail (Paved Perimeter Trail)
- Neighbourhood Trail
- City Trail (Motorized-uses)
- Major Drainage Route
- Minor Drainage System
- Run-off Retention Facility
- Trail/Road Crossing
- Neighborhood Focal Point
- Exfiltration Pit
- Bioswale

KEY PLAN

SCALE 1:3000

0 30 60 m

AECOM

Whistle Bend
Drainage Plan - Phase 2
Figure 4.4

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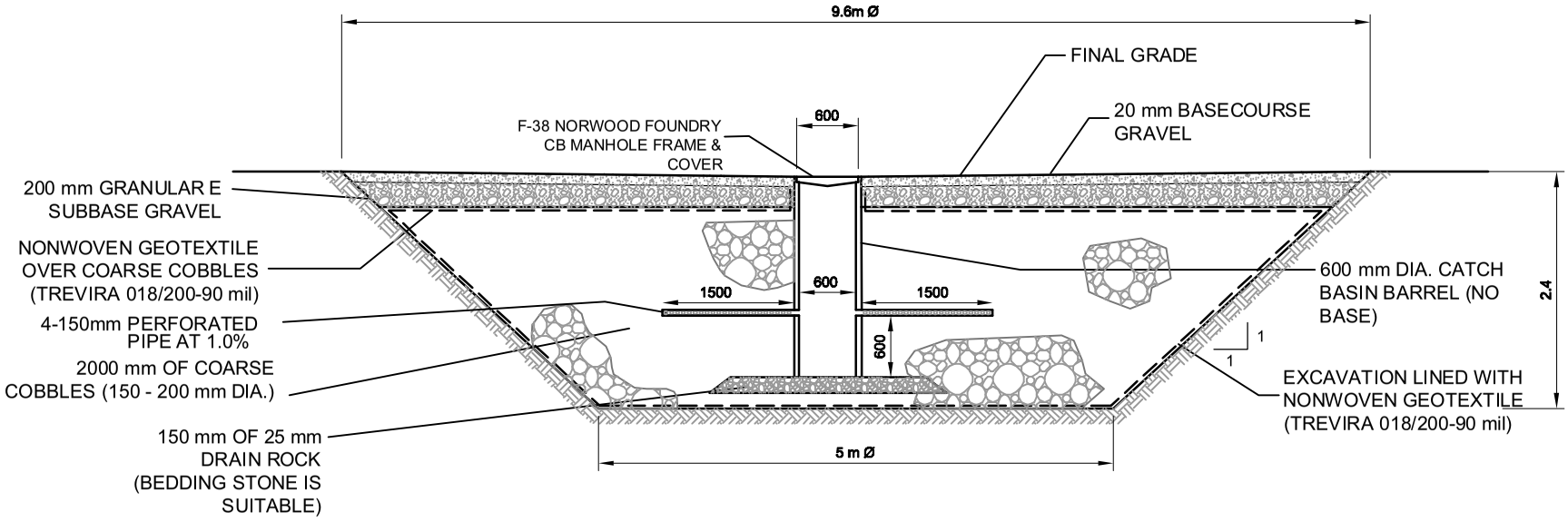
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EXFILTRATION PIT

SCALE: NTS

DESIGN - BASED ON NATIONAL PLUMBING CODE METHOD

DESIGNED FOR 15 MINUTE RAINFALL
ASSUME SOIL PERMEABILITY OF k= $1X10^{-4}$ cm/s (GRAVEL)
DESIGN IS SUITABLE FOR 4500 m^2 AREA

CONSTRUCTION NOTES

- PLACE COARSE ROCK TO WITHIN 150 mm OF BOTTOM OF CATCH BASIN BARREL. BARREL TO SIT ON 150 mm LAYER OF 25 mm DRAIN ROCK (BEDDING STONE)
- BACKFILL TO TOP OF BARREL WITH COARSE DRAIN ROCK AND COVER WITH NONWOVEN GEOTEXTILE AS INDICATED
- PLACE & COMPACT ROAD GRANULARS AND ASPHALT OR SELECT NATIVE MATERIAL AS SHOWN TO FINAL GRADE

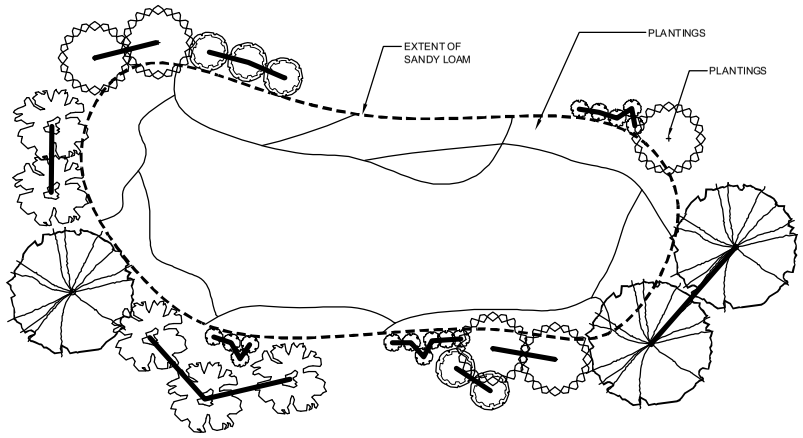
COMPACTION SPECIFICATIONS

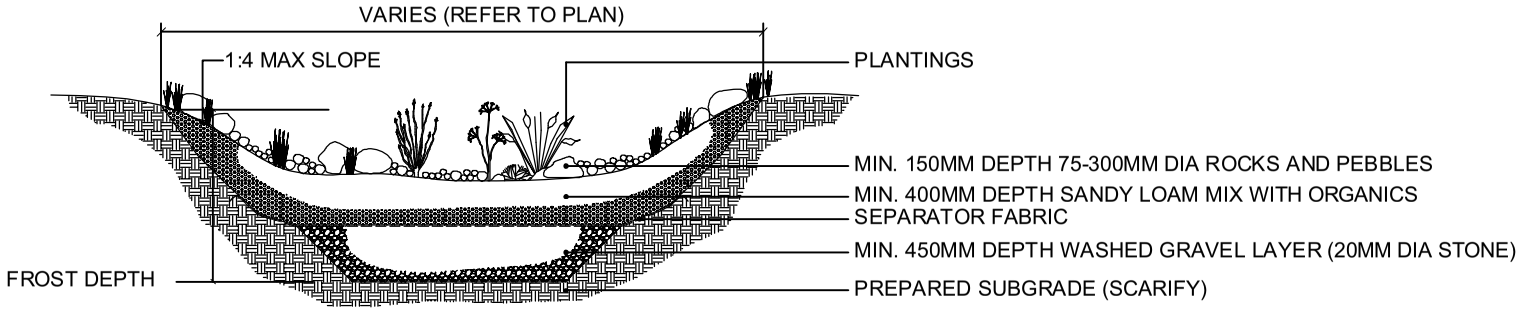
DRAIN ROCK & COBBLES- COMPACT BY MECHANICAL MEANS
SUBBASE GRANULAR - 98% of STANDARD PROCTOR MAXIMUM DRY DENSITY (SPMDD)
75 mm OF 20 mm CRUSHED BASECOURSE - 98% of SPMDD

AECOM

Whistle Bend
Exfiltration Pit
Figure 4.5

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RAIN GARDEN

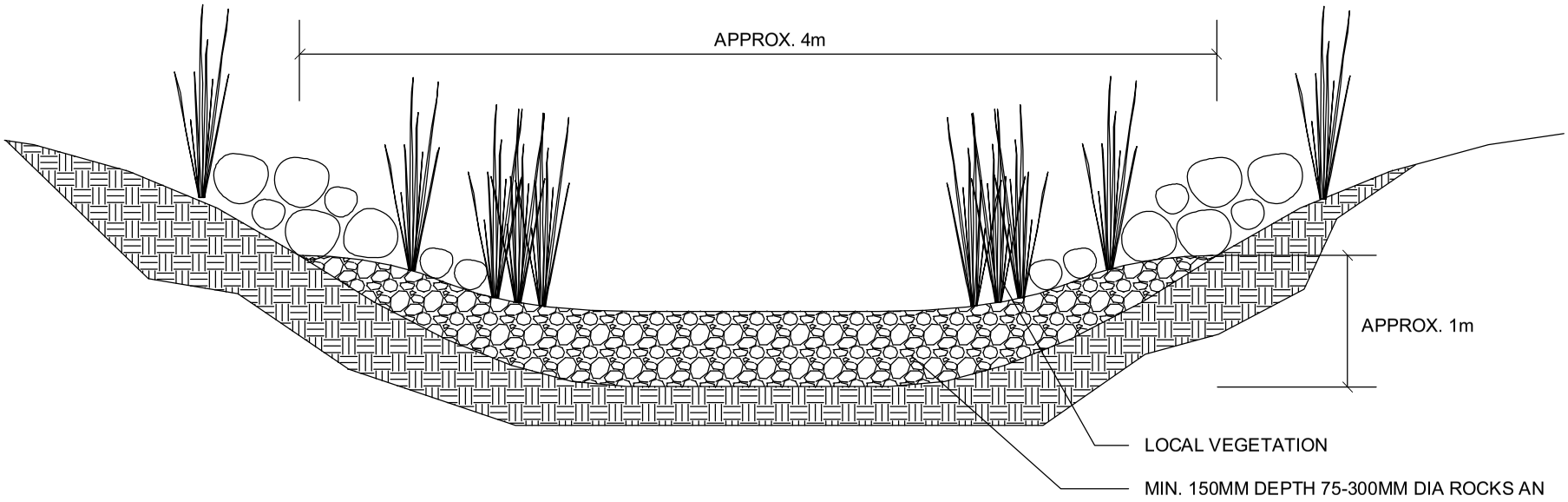
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Whistle Bend
RAIN GARDEN
Figure 4.6

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BIO SWALE

SCALE: NTS

AECOM

Whistle Bend
Bio Swale
Figure 4.7

5. Traffic Impact Analysis

5.1 Project Scope and Definition

The project is the development of the Whistle Bend Subdivision, bounded by the Yukon River to the north and east, Kwanlin Dun First Nation settlement lands to the southeast, McIntyre Creek and Range Road to the south, and the existing neighbourhood of Porter Creek and Mountainview Drive to the west. This traffic study forecasts traffic demands from Whistle Bend and recommends on-site road facilities to support them. It includes:

- Background traffic forecasts
- Proposed trip generation for the various land uses within the study area
- Intersection analysis including estimation of the anticipated capacity and Level of Service (LOS) of the proposed roads and intersections along Casca Boulevard corridor, as well as its connections to Range Road.

Road network and land use information to the end of Phase 2 was based on the Whistle Bend Phase 1 and Phase 2 Base Drawing (June 09, 2009). Road network and land use information at full development was based on the Whistle Bend Final Phasing Plan (February 05, 2009). Two horizon periods were selected for analysis, typifying conditions at Phase 2 completion and at full build-out.

5.2 Study Area

The study area, as shown in Figure 5.1, is defined as those land uses within the Whistle Bend Subdivision boundary which access the main road network via Range Road.

Figure 5.1 - Study Area and Traffic Zones



Source: Whistle Bend Phase 1 and Phase 2 Base Drawing (June 09, 2009)

5.3 Existing Traffic

Through traffic on Range Road was based on historic traffic count data[2] at the downstream intersection of Hickory Street and Wann Road and Range Road.

5.4 Future Background Traffic

An annual growth factor was not applied to existing through traffic on Range Road. At both Range Road connections to the development, future background traffic is considered to be the same as existing through traffic for the following reasons:

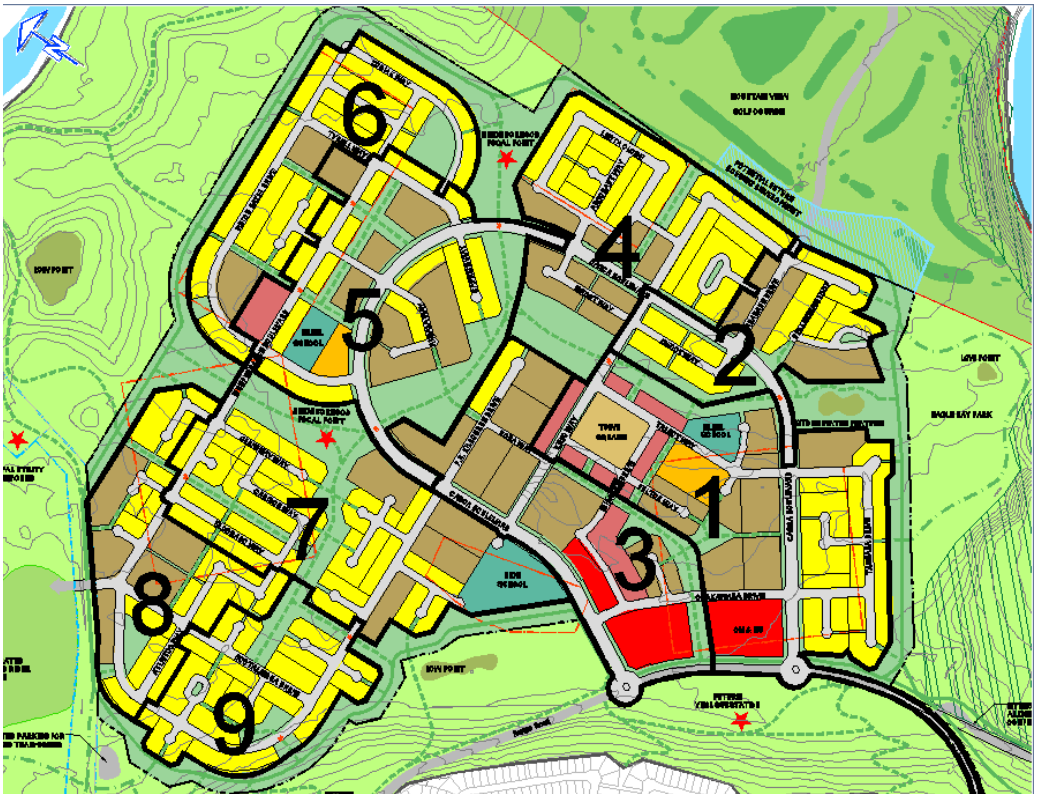
- Among the proposed new developments within the City in the medium to long term, Whistle Bend will be the largest future growth area and traffic generator. Without the development in Whistle Bend, the overall background traffic growth is relatively small.
- In addition, other future growth areas are at least 3 km from Whistle Bend. This part of Range Road is too remote to be part of the trip pattern for those areas. 3

[2] As per Traffic Count Inventory for the Porter Creek Bench Transport Network Impact Study (2008).
[3] These assumptions are based on the Porter Creek Bench Transport Network Impact Study (2008).

5.5 Future Development Traffic

The lands within the study area were divided into a series of nine traffic zones including residential, commercial, schools, community, and recreation uses as illustrated in Figure 5.2. (Note that the nine traffic zones were set up to match with the originally proposed development phases. Subsequent to the preparation of this traffic model, the number of development phase has been reduced to six.) The assumed land use types and input variables as obtained from project concept drawings are summarized in Tables 5.1 and 5.2 for residential and non-residential uses.

Figure 5.2 - Traffic Zones



The residential trip generation for each zone was calculated based on the number of dwelling units (illustrated Table 5.1) and the corresponding ITE trip generation equation for each land use.4 Two trip generation equations for residential land uses were used in this analysis:

- Land Use 210 Single-Family Detached Housing
- Land Use 231 Low-Rise Residential Condominium/Townhouse

[4] As per ITE 7th Edition Trip Generation

Table 5.1 - Residential Land Uses

-

Traffic Zone	Land Use Type	Area (ha)	Density	Dwelling Units		AM Peak Hour Trips		PM Peak Hour Trips	
				Phase 1+2	Full Build	Phase 1+2	Full Build	Phase 1+2	Full Build
1	Single Family	7.75	18units/ha	109	140	86	84	116	99
	Multi Family	7.39	40units/ha	295	296	210	214	230	196
	Mixed Use	2.37	35units/ha	0	83	0	42	0	55
2	Single Family	5.37	18units/ha	153	97	117	58	157	68
	Multi Family	3.43	40units/ha	251	137	171	99	196	91
	Mixed Use	0.00	35units/ha	0	0	0	0	0	0
3	Single Family	0.81	18units/ha		15		9		10
	Multi Family	9.32	40units/ha		373		270		247
	Mixed Use	1.40	35units/ha		49		25		32
4	Single Family	10.14	18units/ha		183		110		129
	Multi Family	4.55	40units/ha		182		132		121
	Mixed Use	0.00	35units/ha		0		0		0
5	Single Family	6.65	18units/ha		120		72		85
	Multi Family	6.75	40units/ha		270		195		179
	Mixed Use	1.13	35units/ha		40		20		26
6	Single Family	11.37	18units/ha		205		123		145
	Multi Family	1.97	40units/ha		79		57		52
	Mixed Use	0.00	35units/ha		0		0		0
7	Single Family	11.80	18units/ha		212		128		150
	Multi Family	4.49	40units/ha		180		130		119
	Mixed Use	0.00	35units/ha		0		0		0
8	Single Family	7.38	18units/ha		133		80		94
	Multi Family	5.06	40units/ha		202		146		134
	Mixed Use	0.00	35units/ha		0		0		0
9	Single Family	9.18	18units/ha		165		99		117
	Multi Family	0.00	40units/ha		0		0		0
	Mixed Use	0.00	35units/ha		0		0		0
	Total			808	3158	583	2092	699	2149

Trip generation for non-residential land uses was calculated by zone using independent variables (illustrated on Table 5.2) and the corresponding ITE Trip Generation equation and category for said land use. These included:

- For School land uses, trip equations for Land Use 520 Elementary School and Land Use 530 High School were used.
- For Parks and Trails, trip equation for Land Use 412 County Park was used.
- For Active Recreation land uses, trip equation for Land Use 430 Golf Course was used.

Table 5.2 - Non-Residential Land Uses

Traffic Zone	Land Use Type	Area (ha)	Input Variable			AM Peak Hour Trips		PM Peak Hour Trips	
			Phase 1+2	Full Build	Variable	Phase 1+2	Full Build	Phase 1+2	Full Build
1	Mixed Use	2.37	0	112	Gross Floor Area (1000 sq ft)	0	141	0	343
	Commercial Use	2.30	137	139	Gross Floor Area (1000 sq ft)	491	350	623	481
	School	2.35	0	332	Students	0	104	0	72
	Community Use	1.47	0	76	Gross Floor Area (1000 sq ft)	0	83	0	163
	Parks and Trails	7.81	0	19	Acres	0	0	0	1
2	Community Use	0.00	33	0	Gross Floor Area (1000 sq ft)	38	0	93	0
	Parks and Trails	7.81	0	19	Acres	0	0	0	1
3	Mixed Use	1.40		66	Gross Floor Area (1000 sq ft)		83		202
	Commercial Use	3.27		197	Gross Floor Area (1000 sq ft)		498		684
	Active Recreation	142.90	353	353	Acres	60	51	77	66
	Parks and Trails	7.81		19	Acres		0		1
4	Parks and Trails	7.81		19	Acres		0		1
5	Mixed Use	1.13		54	Gross Floor Area (1000 sq ft)		67		163
	School	3.28		464	Students		146		101
	Community Use	1.11		57	Gross Floor Area (1000 sq ft)		62		123
	Parks and Trails	7.81		19	Acres		0		1
6	Parks and Trails	7.81		19	Acres		0		1
7	School	2.84		747	Students		276		89
	Parks and Trails	7.81		19	Acres		0		1
8	Parks and Trails	7.81		19	Acres		0		1
Total	Mixed Use	4.90	0	232	Gross Floor Area (1000 sq ft)	0	292	0	709
Total	Commercial Use	5.57	137	336	Gross Floor Area (1000 sq ft)	491	848	623	1164
Total	School	8.47	0	1544	Students	0	527	0	262
Total	Community Use	2.58	33	133	Gross Floor Area (1000 sq ft)	38	145	93	285
Total	Active Recreation	142.90	353	353	Acres	60	51	77	66
Total	Parks and Trails	62.52	0	154	Acres	0	1	0	8

In the absence of a detailed site plan, a representative development mix was assumed for the mixed use, commercial and community land uses as follows:

Two trip generation equations were chosen to represent Mixed Use (Commercial) land uses:

- Land Use 750 Office Park (50% of Mixed Use lands)
- Land Use 815 Free-Standing Discount Store (50% of Mixed Use lands)

Three trip generation equations were chosen to represent Commercial Use land uses:

- Land Use 750 Office Park (33% of Commercial Use lands)
- Land Use 815 Free-Standing Discount Store (33% of Commercial Use lands)
- Land Use 814 Specialty Retail Centre (33% of Commercial Use lands)

Three trip generation equations were chosen to represent Community Use land uses:

- Land Use 495 Recreational Community Centre (33% of Community Use lands)
- Land Use 560 Church (33% of Community Use lands)
- Land Use 590 Library (33% of Community Use lands)

These trip generation equations were selected with reference to the land use descriptions in the Whistle Bend Concept Development and Community Consultation Summary Report (2009). Their selection was based on the availability of matching or closely matched land uses in the ITE Trip Generation handbook for both peak hours, the reliability of the equations, and the availability of information to derive the input variables.

Trip generation by zone is summarized by horizon year in Tables 5.3 and 5.4 for the AM and PM Peak hours.

Table 5.3 - Trip Generation – Phase 1+2

Traffic Zone	AM Peak Hour Trips Generated			PM Peak Hour Trips Generated		
	Total	Entering	Exiting	Total	Entering	Exiting
1	541	271	270	1122	536	586
2	279	82	197	383	216	167
Total Trips	819	353	467	1505	752	753

Table 5.4 - Trip Generation – Full Development

Traffic Zone	AM Peak Hour Trips Generated			PM Peak Hour Trips Generated		
	Total	Entering	Exiting	Total	Entering	Exiting
1	979	535	444	1754	816	937
2	158	39	118	160	96	64
3	849	476	373	1662	770	892
4	242	60	181	251	152	99
5	580	261	319	718	351	367
6	180	45	135	198	122	76
7	534	255	279	359	206	153
8	226	57	170	229	137	92
9	100	25	75	118	74	44
Total Trips	3847	1753	2094	5448	2724	2724

Trip distribution was developed based on forecast PM peak hour by directional split from the EMME transportation demand forecast model at the intersections of Range Road and Casca Boulevard.5 The majority of the trips generated by the development will travel in and out of the area via Range Road south, with a nominal percentage of trips traveling via Range Road north. Directional splits in the PM peak hour were obtained from the model, with the reverse direction assumed for the AM peak hour illustrated in Table 5.5.

[5] As per Porter Creek Bench Transport Network Impact Study (2008).

For modeling purposes, it has been assumed that all vehicular traffic generated within Whistle Bend leaves Whistle Bend, and all vehicular traffic headed to Whistle Bend comes from outside Whistle Bend. Being a sustainable community, we have assumed that internal trips will be non-vehicular (walk, pedal, etc.).

Table 5.5 - Trip Distribution

	AM Peak Hour		PM Peak Hour	
Directional Split	**Inbound**	**Outbound**	**Inbound**	**Outbound**
To/From Range Road north	21%	12%	12%	21%
To/From Range Road south	79%	88%	88%	79%

Trip assignment was accomplished by first allocating trips in each traffic zone to loading points, i.e. locations where traffic gains access to the network. There are a total of 20 loading points, each representing an access point where traffic loads onto the local cross street that intersects with Casca Boulevard. A "catchment area" is established for each loading point so that trips from the traffic zone level can be distributed to the loading point level depending on the geographical size and the land uses within the "catchment area". Two allocations were developed – one allocates trips that originate from or destined to Range Road north and one allocates trips that originate from or destined to Range Road south. The trips can then be assigned to the road network on the shortest distance path. This is accomplished by comparing the travel distance from each loading point to a common exit point on Range Road, and vice versa.

5.6 Road Network

Existing road network information was based on City of Whitehorse GIS obtained on June 8, 2009.

The proposed on-site road network at the end of Phase 2 was based on Whistle Bend Phase 1 and Phase 2 Base Drawing (June 09, 2009) and extends Casca Boulevard from Range Road (S) to Argonaut Way with intersections at Chakawana Drive, Talbot Way, Tarahane Drive, Keno Way S and Argonaut Way. The proposed on-site road network at full development was based on the Whistle Bend Final Phasing Plan (February 05, 2009), and includes the full road network.

The proposed basic road network identifies Casca Boulevard as a two-way arterial within a 30 m right-of-way. As a starting point, Casca Blvd was assumed to be a two-lane facility (one lane per direction), as this provides a more conservative approach to the provision of road capacity for vehicular movements only, without overbuild. If the single lanes are insufficient to handle the anticipated traffic demand, then additional laning could be accommodated within the existing RoW. All intersections on the Casca Boulevard corridor are unsignalized intersections with stop-controlled minor approaches, except for the intersection of Casca Boulevard and Tarahane Drive which is a single roundabout. Pavement widening on the major approaches separates left turning traffic and through traffic at each of the 10 stop-controlled intersections. The two Casca Boulevard connections to Range Road, as well as the intersection of Casca Boulevard and Tarahane Drive, are single roundabouts with single entrance and exit lane on all approaches. Peak hour traffic volumes for the two horizons are illustrated in Figures 5.3 to 5.6.

Figure 5.3 - AM Peak Hour Traffic Volumes – Phase 1 + 2

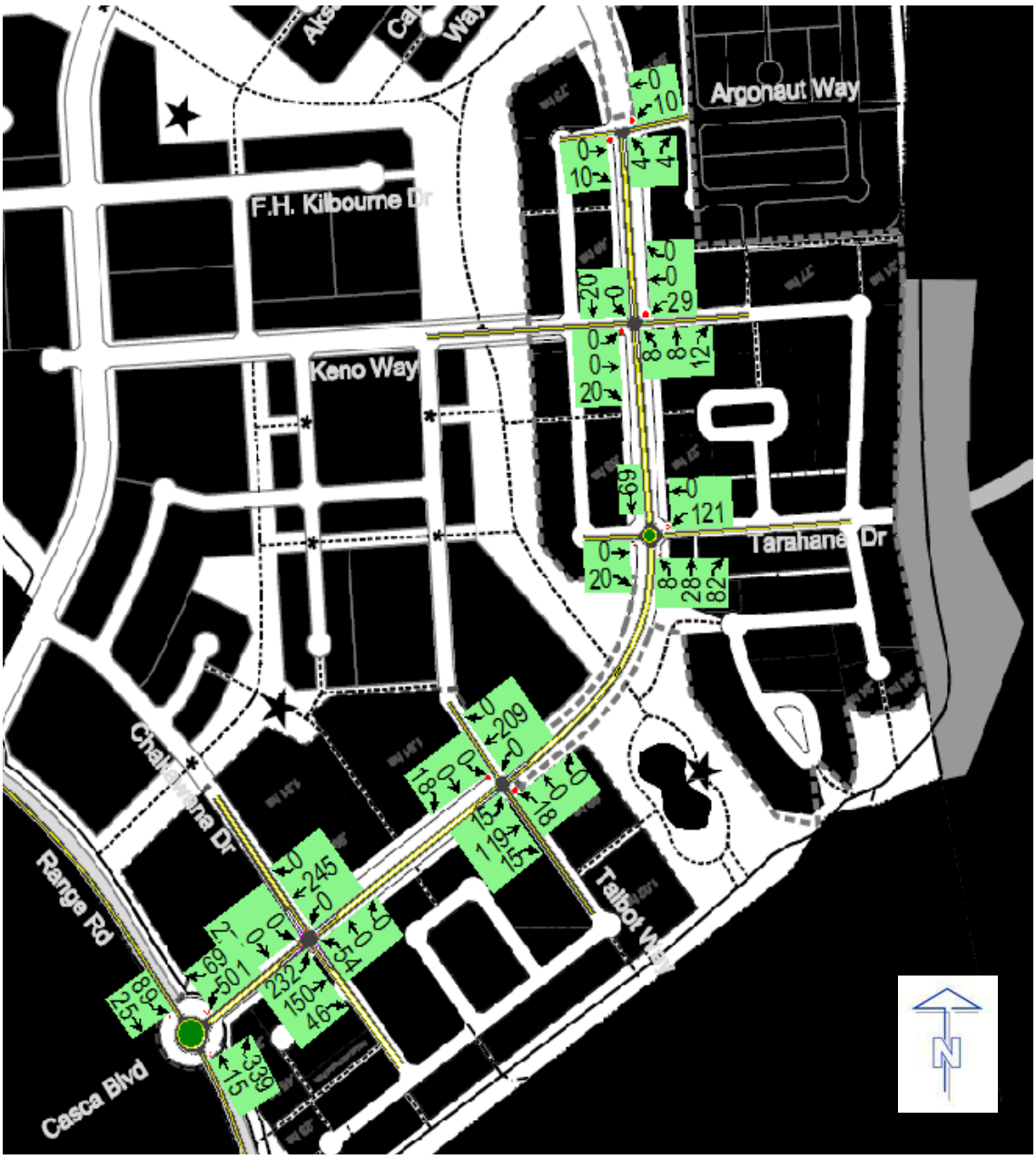


Figure 5.4 - PM Peak Hour Traffic Volumes – Phase 1 + 2

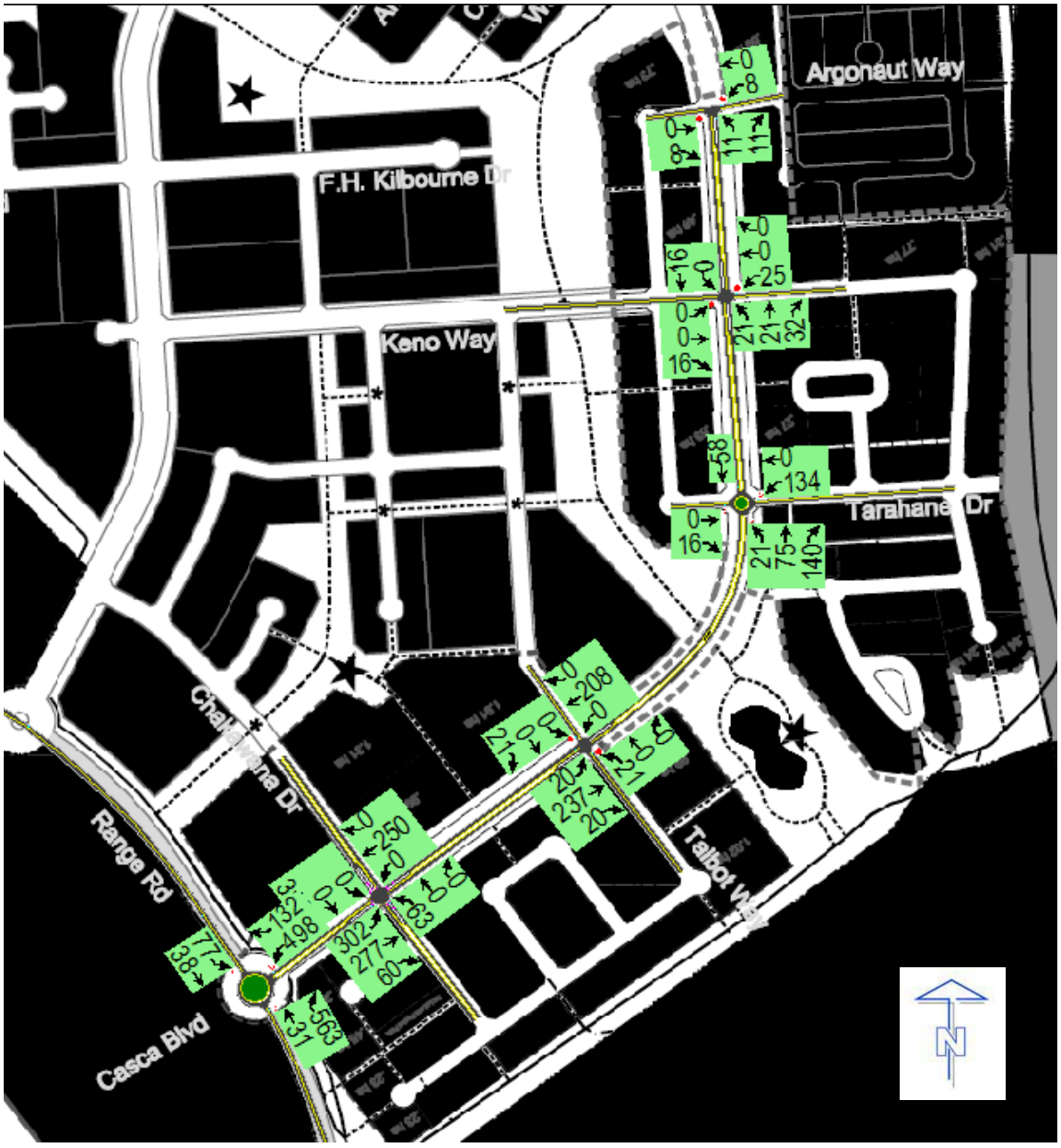


Figure 5.5 - AM Peak Hour Traffic Volumes – Full Build

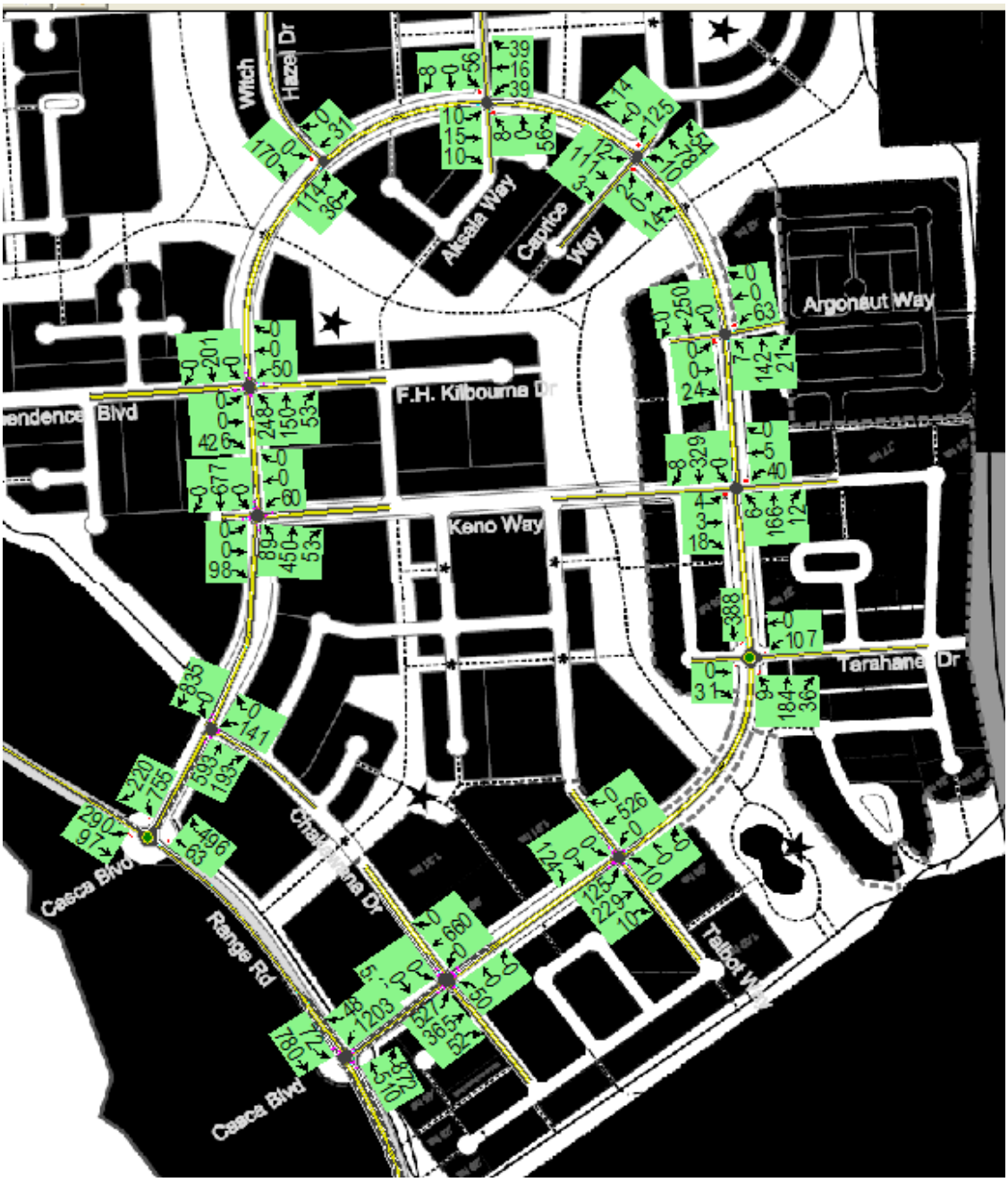


Figure 5.6 - PM Peak Hour Traffic Volumes – Full Build



5.7 Analysis Criteria

Computer micro-simulation software Synchro 7 was used for traffic analysis. Building upon the basic road network, any turning movement at a stop-controlled intersection that did not satisfy the threshold of Level-of-service (LOS) "C"6 was considered for road or intersection improvements. This was an iterative process where intersections were improved until they were LOS "C" or better in the following improvement sequences:

- Signalization
- Signal optimization and coordination
- Geometric Improvements

Building upon the basic road network, any approach at a single roundabout that did not satisfy the threshold volume-to-capacity (v/c) ratio of 0.85 was considered for roundabout improvements. The following improvement sequences were tested in an iterative process until the approach met v/c ratio of 0.85 or better:

- The addition of a bypass lane
- Double roundabout
- Signalization
- Signal optimization and coordination
- Geometric Improvement

5.8 Scenarios Analyzed

Four scenarios were selected for analysis as follows:

- Scenario Phase 1+2 Basic: representing future traffic volumes (background plus development) on the proposed basic road network at the end of Phase 2.
- Scenario Phase 1+2 Recommended: representing future traffic volumes (background plus development) on the proposed basic road network including recommended improvements at the end of Phase 2.
- Scenario Full Build Basic: representing future traffic volumes (background plus development) on the proposed basic road network at full build-out.
- Scenario Full Build Recommended: representing future traffic volumes (background plus development) on the proposed basic road network including recommended improvements at full build-out.

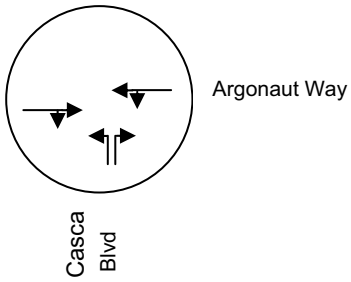
[6] LOS "C" is equivalent to 25 seconds of delay at an unsignalized intersection and 35 seconds of delay at a signalized intersection.

5.9 Traffic Analysis Results – Phase 1+2

HCM results for the two scenarios at the end of Phase 2 are illustrated in Tables 5.6 and 5.7 and summarized below at each intersection (travelling from North to South), with detailed results included in Appendix A:

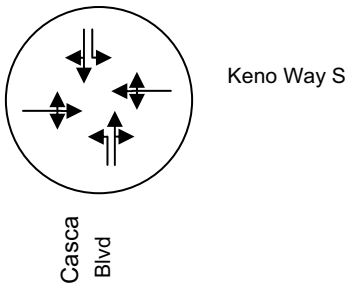
At Casca Boulevard/Argonaut Way:

- As a two way stop controlled (2WSC) intersection with basic laning, all approaches experience LOS "A" during both peak hours. The required laning to service Phase 2 traffic is illustrated as follows:



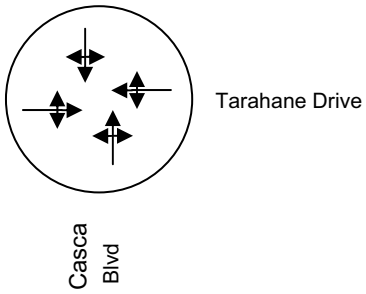
At Casca Boulevard/Keno Way S:

- As a 2WSC intersection with basic laning, all approaches experience LOS "A" during both peak hours. The required laning to service Phase 2 traffic is illustrated as follows:



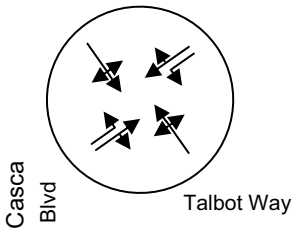
At Casca Boulevard/Tarahane Drive:

- As a single roundabout with single entrance and exit lanes, the highest volume-to-capacity ratio (v/c) at the roundabout is 0.2 for Casca northbound approach in the PM peak hour. Slightly lower v/c ratio is shown for the opposite approach in the AM peak hour. The required laning to service Phase 2 traffic is illustrated as follows:



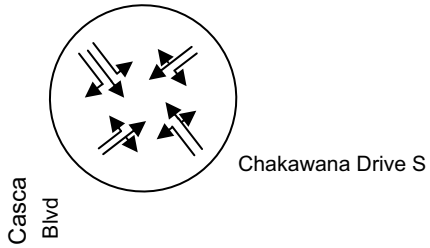
At Casca Boulevard/Talbot Way:

- As a 2WSC intersection with basic laning, the Casca approaches experience LOS "A" during both peak hours. The Talbot approaches experience LOS "B" or better during both peak hours. The required laning to service Phase 2 traffic is illustrated as follows:



At Casca Boulevard/Chakawana Drive S:

- As a two-way stop-controlled (2WSC) intersection with basic laning, the northbound approach from Chakawana operates at LOS "F" during both peak hours.
- After signalization, eastbound left turn advance phasing, and additional auxiliary turn lanes, all approaches experience LOS "B" or better during both peak hours.
- The required laning to service Phase 2 traffic is illustrated as follows:



At Range Road/Casca Boulevard S:

- As a single roundabout with single entrance and exit lanes, the highest v/c ratio at the roundabout is 0.6 for Range Road northbound approach and for Casca westbound approach in the PM peak hour. Slightly lower v/c ratios are shown for the same approaches in the AM peak hour. The required laning to service Phase 2 traffic is illustrated as follows:

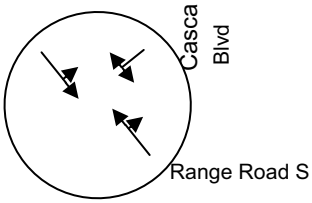


Table 5.6 – HCM Results – Phase 1 + 2 Basic (Unimproved) AM Peak Hour

Phase 1+2 Whistle Bend AM Peak Hour Background+Site																
ID	Description	Sig/Unsig	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Int Delay	Int LOS
1	Casca Blvd & Chakawana Dr (S)	Unsig	Casca Blvd						Chakawana Dr							
	Volume (vph)		232	150	46	0	245	0	54	0	0	0	0	270		
	V/C Ratio		0.2	0.1	0.1	0.0	0.2	0.2	0.8	0.8	0.8	0.4	0.4	0.4		
	Q-length (m) (95%)		5.9	0.0	0.0	0.0	0.0	0.0	28.8	28.8	28.8	14.5	14.5	14.5		
	Delay (s)		8.5	0.0	0.0	0.0	0.0	0.0	129.9	129.9	129.9	12.6	12.6	12.6		
	LOS		A	A	A	A	A	A	F	F	F	B	B	B		
	Approach Delay (s)			4.6			0.0			129.9			12.6			
	Approach LOS			A			A			F			B		12.4	B
2	Casca Blvd & Talbot Way	Unsig	Casca Blvd						Talbot Way							
	Volume (vph)		15	119	15	0	209	0	18	0	0	0	0	18		
	V/C Ratio		0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0		
	Q-length (m) (95%)		0.3	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.9	0.6	0.6	0.6		
	Delay (s)		7.7	0.0	0.0	0.0	0.0	0.0	12.0	12.0	12.0	9.5	9.5	9.5		
	LOS		A	A	A	A	A	A	B	B	B	A	A	A		
	Approach Delay (s)			0.8			0.0			12.0			9.5			
	Approach LOS			A			A			B			A		1.3	A
3	Casca Blvd & Tarahane Dr	Roundabt	Tarahane Dr						Casca Blvd							
	Volume (vph)		0	0	20	121	0	0	8	28	82	0	69	0		
	High V/C Ratio			0.0			0.1			0.1			0.1			
	Low V/C Ratio			0.0			0.1			0.1			0.1		n/a	n/a
4	Casca Blvd & Keno Way (S)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		0	0	20	29	0	0	8	8	12	0	20	0		
	V/C Ratio		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Q-length (m) (95%)		0.5	0.5	0.5	0.9	0.9	0.9	0.1	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		8.5	8.5	8.5	9.2	9.2	9.2	7.3	0.0	0.0	0.0	0.0	0.0		
	LOS		A	A	A	A	A	A	A	A	A	A	A	A		
	Approach Delay (s)			8.5			9.2			2.1			0.0			
	Approach LOS			A			A			A			A		5.1	A
5	Casca Blvd & Argonaut Way	Unsig	Argonaut Way						Casca Blvd							
	Volume (vph)			0	10	10	0		4		4					
	V/C Ratio			0.0	0.0	0.0	0.0		0.0		0.0					
	Q-length (m) (95%)			0.2	0.2	0.3	0.3		0.1		0.0					
	Delay (s)			8.3	8.3	8.7	8.7		7.2		0.0					
	LOS			A	A	A	A		A		A					
	Approach Delay (s)			8.3			8.7			3.6						
	Approach LOS			A			A			A					7.1	A
21	Range Rd & Casca Blvd (S)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)					501		69		15	339	89	25			
	High V/C Ratio						0.5			0.3			0.1			
	Low V/C Ratio						0.5			0.4			0.1		n/a	n/a

Table 5.6 – HCM Results – Phase 1 + 2 Basic (Unimproved) PM Peak Hour

Phase 1+2 Whistle Bend PM Peak Hour Background+Site															
ID	Description	Sig/Unsig	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Int Delay	Int LOS
1	Casca Blvd & Chakawana Dr (S)	Unsig	Casca Blvd						Chakawana Dr							
	Volume (vph)		302	277	60	0	250	0	63	0	0	0	0	316		
	V/C Ratio		0.3	0.2	0.2	0.0	0.2	0.2	1.8	1.8	1.8	0.5	0.5	0.5		
	Q-length (m) (95%)		8.3	0.0	0.0	0.0	0.0	0.0	58.8	58.8	58.8	18.9	18.9	18.9		
	Delay (s)		8.8	0.0	0.0	0.0	0.0	0.0	620.8	620.8	620.8	13.6	13.6	13.6		
	LOS		A	A	A	A	A	A	F	F	F	B	B	B		
	Approach Delay (s)			4.2			0.0			620.8			13.6			
	Approach LOS			A			A			F			B		36.3	E
2	Casca Blvd & Talbot Way	Unsig	Casca Blvd						Talbot Way							
	Volume (vph)		20	237	20	0	208	0	21	0	0	0	0	21		
	V/C Ratio		0.0	0.2	0.2	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0		
	Q-length (m) (95%)		0.4	0.0	0.0	0.0	0.0	0.0	1.4	1.4	1.4	0.7	0.7	0.7		
	Delay (s)		7.7	0.0	0.0	0.0	0.0	0.0	14.0	14.0	14.0	9.5	9.5	9.5		
	LOS		A	A	A	A	A	A	B	B	B	A	A	A		
	Approach Delay (s)			0.6			0.0			14.0			9.5			
	Approach LOS			A			A			B			A		1.2	A
3	Casca Blvd & Tarahane Dr	Roundabt	Tarahane Dr						Casca Blvd							
	Volume (vph)		0	0	16	134	0	0	21	75	140	0	58	0		
	High V/C Ratio			0.0			0.1			0.2			0.1			
	Low V/C Ratio			0.0			0.1			0.2			0.1		n/a	n/a
4	Casca Blvd & Keno Way (S)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		0	0	16	25	0	0	21	21	32	0	16	0		
	V/C Ratio		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Q-length (m) (95%)		0.4	0.4	0.4	0.8	0.8	0.8	0.3	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		8.4	8.4	8.4	9.5	9.5	9.5	7.3	0.0	0.0	0.0	0.0	0.0		
	LOS		A	A	A	A	A	A	A	A	A	A	A	A		
	Approach Delay (s)			8.4			9.5			2.1			0.0			
	Approach LOS			A			A			A			A		4.0	A
5	Casca Blvd & Argonaut Way	Unsig	Argonaut Way						Casca Blvd							
	Volume (vph)			0	8	8	0		11		11					
	V/C Ratio			0.0	0.0	0.0	0.0		0.0		0.0					
	Q-length (m) (95%)			0.2	0.2	0.2	0.2		0.2		0.0					
	Delay (s)			8.3	8.3	8.8	8.8		7.2		0.0					
	LOS			A	A	A	A		A		A					
	Approach Delay (s)			8.3			8.8			3.6						
	Approach LOS			A			A			A					5.7	A
21	Range Rd & Casca Blvd (S)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)					498		132		31	563	77	38			
	High V/C Ratio						0.5			0.5			0.1			
	Low V/C Ratio						0.6			0.6			0.2		n/a	n/a

Table 5.7 – HCM Results – Phase 1 + 2 Recommended AM Peak Hour

Phase 1+2 Whistle Bend AM Peak Hour Background+Site																
ID	Description	Sig/Unsig	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Int Delay	Int LOS
1	Casca Blvd & Chakawana Dr (S)	Sig	Casca Blvd						Chakawana Dr							
	Volume (vph)		232	150	46	0	245	0	54	0	0	0	0	270		
	V/C Ratio		0.4	0.2	0.2	0.0	0.5	0.5	0.4	0.0	0.0	0.0	0.0	0.1		
	Q-length (m) (95%)		24.5	17.5	17.5	0.0	41.3	41.3	11.5	0.0	0.0	0.0	0.0	6.6		
	Delay (s)		3.4	2.7	2.7	0.0	11.3	11.3	18.0	0.0	0.0	0.0	0.0	9.9		
	LOS		A	A	A	A	B	B	B	A	A	A	A	A		
	Approach Delay (s)			3.1			11.3			18.0			9.9			
	Approach LOS			A			B			B			A		7.8	A
2	Casca Blvd & Talbot Way	Unsig	Casca Blvd						Talbot Way							
	Volume (vph)		15	119	15	0	209	0	18	0	0	0	0	18		
	V/C Ratio		0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0		
	Q-length (m) (95%)		0.3	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.9	0.6	0.6	0.6		
	Delay (s)		7.7	0.0	0.0	0.0	0.0	0.0	12.0	12.0	12.0	9.5	9.5	9.5		
	LOS		A	A	A	A	A	A	B	B	B	A	A	A		
	Approach Delay (s)			0.8			0.0			12.0			9.5			
	Approach LOS			A			A			B			A		1.3	A
3	Casca Blvd & Tarahane Dr	Roundabt	Tarahane Dr						Casca Blvd							
	Volume (vph)		0	0	20	121	0	0	8	28	82	0	69	0		
	High V/C Ratio			0.0			0.1			0.1			0.1			
	Low V/C Ratio			0.0			0.1			0.1			0.1		n/a	n/a
4	Casca Blvd & Keno Way (S)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		0	0	20	29	0	0	8	8	12	0	20	0		
	V/C Ratio		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Q-length (m) (95%)		0.5	0.5	0.5	0.9	0.9	0.9	0.1	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		8.5	8.5	8.5	9.2	9.2	9.2	7.3	0.0	0.0	0.0	0.0	0.0		
	LOS		A	A	A	A	A	A	A	A	A	A	A	A		
	Approach Delay (s)			8.5			9.2			2.1			0.0			
	Approach LOS			A			A			A			A		5.1	A
5	Casca Blvd & Argonaut Way	Unsig	Argonaut Way						Casca Blvd							
	Volume (vph)			0	10	10	0		4		4					
	V/C Ratio			0.0	0.0	0.0	0.0		0.0		0.0					
	Q-length (m) (95%)			0.2	0.2	0.3	0.3		0.1		0.0					
	Delay (s)			8.3	8.3	8.7	8.7		7.2		0.0					
	LOS			A	A	A	A		A		A					
	Approach Delay (s)			8.3			8.7			3.6						
	Approach LOS			A			A			A					7.1	A
21	Range Rd & Casca Blvd (S)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)					501		69		15	339	89	25			
	High V/C Ratio						0.5			0.3			0.1			
	Low V/C Ratio						0.5			0.4			0.1		n/a	n/a

Table 5.7 – HCM Results – Phase 1 + 2 Recommended PM Peak Hour

Phase 1+2 Whistle Bend PM Peak Hour Background+Site																
ID	Description	Sig/Unsig	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Int Delay	Int LOS
1	Casca Blvd & Chakawana Dr (S)	Sig	Casca Blvd						Chakawana Dr							
	Volume (vph)		302	277	60	0	250	0	63	0	0	0	0	316		
	V/C Ratio		0.5	0.3	0.3	0.0	0.5	0.5	0.4	0.0	0.0	0.0	0.0	0.2		
	Q-length (m) (95%)		32.5	33.1	33.1	0.0	42.3	42.3	13.1	0.0	0.0	0.0	0.0	10.5		
	Delay (s)		4.5	3.6	3.6	0.0	12.6	12.6	17.2	0.0	0.0	0.0	0.0	9.4		
	LOS		A	A	A	A	B	B	B	A	A	A	A	A		
	Approach Delay (s)			4.0			12.6			17.2			9.4			
	Approach LOS			A			B			B			A		7.7	A
2	Casca Blvd & Talbot Way	Unsig	Casca Blvd						Talbot Way							
	Volume (vph)		20	237	20	0	208	0	21	0	0	0	0	21		
	V/C Ratio		0.0	0.2	0.2	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0		
	Q-length (m) (95%)		0.4	0.0	0.0	0.0	0.0	0.0	1.4	1.4	1.4	0.7	0.7	0.7		
	Delay (s)		7.7	0.0	0.0	0.0	0.0	0.0	14.0	14.0	14.0	9.5	9.5	9.5		
	LOS		A	A	A	A	A	A	B	B	B	A	A	A		
	Approach Delay (s)			0.6			0.0			14.0			9.5			
	Approach LOS			A			A			B			A		1.2	A
3	Casca Blvd & Tarahane Dr	Roundabt	Tarahane Dr						Casca Blvd							
	Volume (vph)		0	0	16	134	0	0	21	75	140	0	58	0		
	High V/C Ratio			0.0			0.1			0.2			0.1			
	Low V/C Ratio			0.0			0.1			0.2			0.1		n/a	n/a
4	Casca Blvd & Keno Way (S)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		0	0	16	25	0	0	21	21	32	0	16	0		
	V/C Ratio		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Q-length (m) (95%)		0.4	0.4	0.4	0.8	0.8	0.8	0.3	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		8.4	8.4	8.4	9.5	9.5	9.5	7.3	0.0	0.0	0.0	0.0	0.0		
	LOS		A	A	A	A	A	A	A	A	A	A	A	A		
	Approach Delay (s)			8.4			9.5			2.1			0.0			
	Approach LOS			A			A			A			A		4.0	A
5	Casca Blvd & Argonaut Way	Unsig	Argonaut Way						Casca Blvd							
	Volume (vph)			0	8	8	0		11		11					
	V/C Ratio			0.0	0.0	0.0	0.0		0.0		0.0					
	Q-length (m) (95%)			0.2	0.2	0.2	0.2		0.2		0.0					
	Delay (s)			8.3	8.3	8.8	8.8		7.2		0.0					
	LOS			A	A	A	A		A		A					
	Approach Delay (s)			8.3			8.8			3.6						
	Approach LOS			A			A			A					5.7	A
21	Range Rd & Casca Blvd (S)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)					498		132		31	563	77	38			
	High V/C Ratio						0.5			0.5			0.1			
	Low V/C Ratio						0.6			0.6			0.2		n/a	n/a

Peak hour volumes and recommended laning along the study corridor at the end of Phase 2 are illustrated in Figures 5.7 and 5.8 with improvements relative to the basic network highlighted in yellow (grey).

Figure 5.7 - AM Peak Hour Traffic Volumes and Laning – Phase 1 + 2 Recommended Network

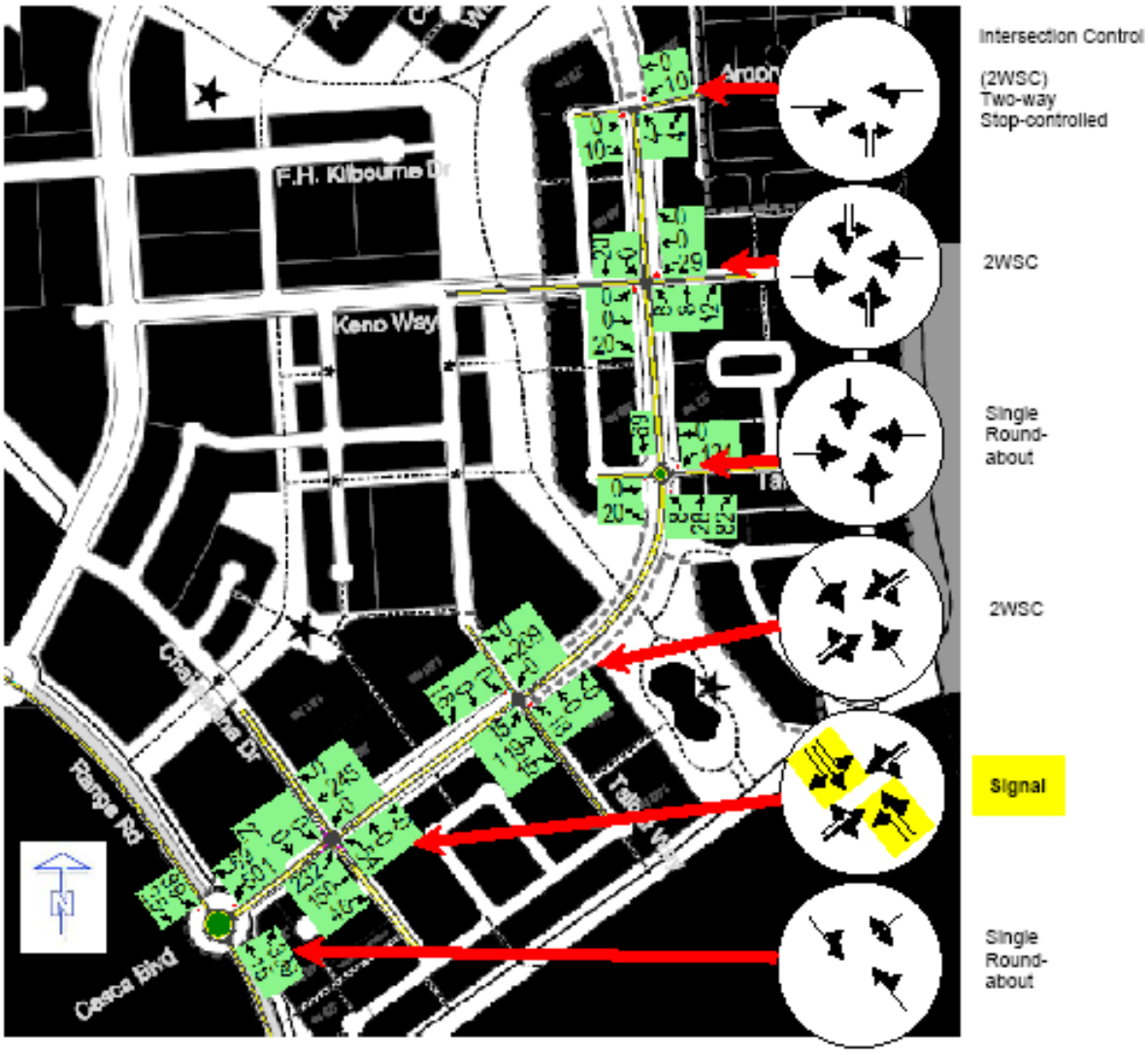
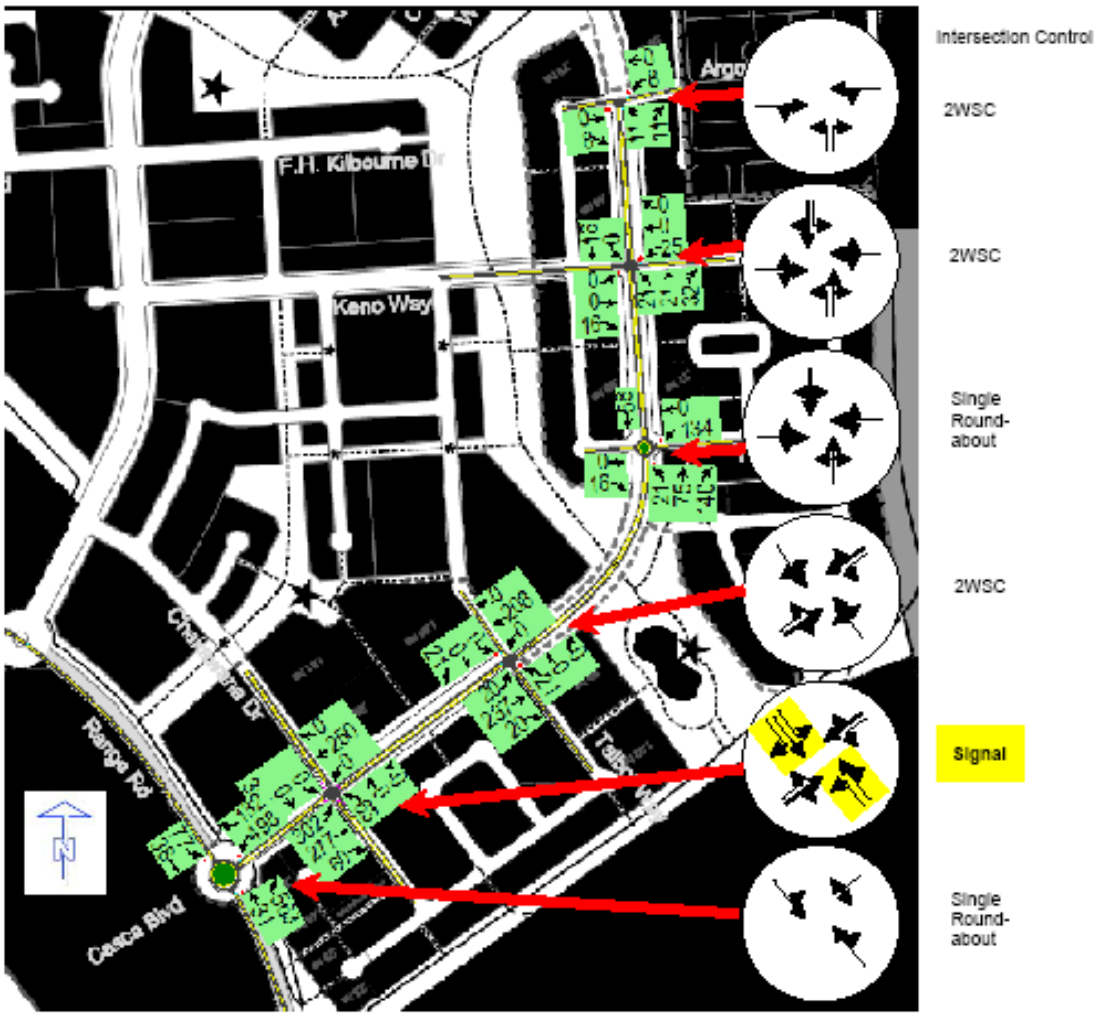


Figure 5.8 – PM Peak Hour Traffic Volumes and Laning – Phase 1 +2 Recommended Network



The recommended network at the end of Phase 2 is described as follows:

- Casca Boulevard (between Range Road S and Argonaut Way) as a single travel lane facility per direction with intersection widening would meet the traffic volume demand of the Phase 2 development.
- The intersection of Casca Boulevard and Chakawana Drive S is the only signalized intersection and advanced phasing is required for the eastbound left turn movement to the commercial developments on Chakawana Drive. The intersection has a 30m left turn lane on every approach and a 30 m southbound right turn lane from Chakawana to Casca Boulevard.
- Casca Boulevard at Talbot Way, Keno Way S, and Argonaut Way are two-way stop-controlled intersections each widened on the major approaches to separate left turning traffic and through traffic.
- Casca Boulevard at Range Road, and at Tarahane Drive are single roundabouts with single entrance and exit lanes on all approaches.

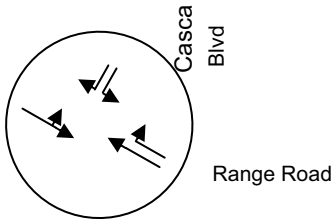
5.10 Traffic Analysis Results – Full Build

HCM results for the two scenarios at the full build-out are illustrated in Tables 5.8 and 5.9 and summarized below at each intersection with detailed results included in Appendix A. Traveling northwards along Casca Blvd starting at the northern entrance into the community, analysis results indicate the following:

At Range Road/Casca Boulevard N:

- As a single roundabout with single entrance and exit lanes, the highest v/c ratio at the roundabout is 1.0 for Casca westbound approach during both peak hours.

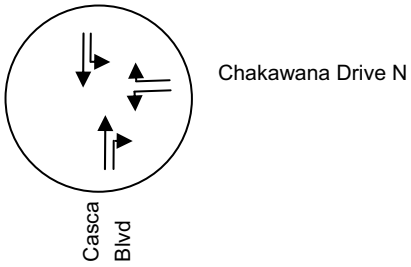
- After laning improvements with auxiliary right turn bypass lanes, the highest v/c ratio at the roundabout is 0.8 for Casca westbound approach in the AM peak hour. A relatively lower v/c ratio is shown for the same approach in the PM peak hour. The required laning to service Full build out traffic is illustrated as follows:



At Casca Boulevard/Chakawana Drive N:

- As a 2WSC intersection with basic laning, the northbound approach from Chakawana operates at LOS "F" during both peak hours.

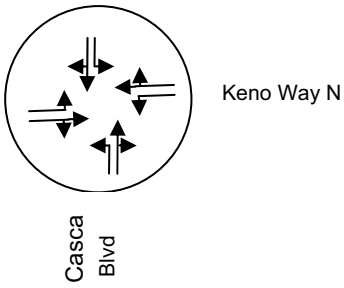
- After signalization and additional auxiliary turn lanes, the Casca approaches experience LOS "B" or better during both peak hours. The Chakawana approach experience LOS "C" during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:



At Casca Boulevard/Keno Way N:

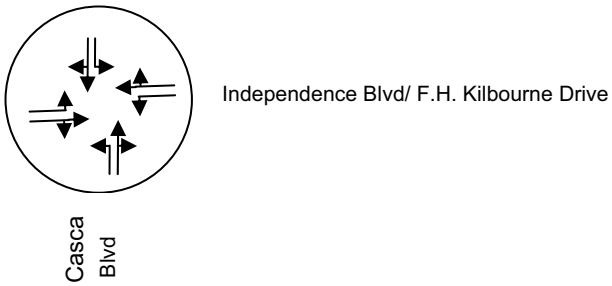
- As a 2WSC intersection with basic laning, the westbound approach from Keno operates at LOS "F" during both peak hours.

- After signalization and additional auxiliary turn lanes, the Casca approaches experience LOS "A" during both peak hours. The Keno approaches experience LOS "C" during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:



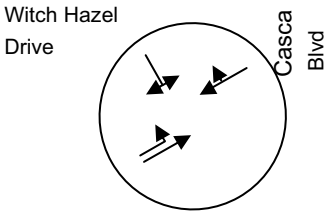
At Casca Boulevard/Independence Boulevard/F.H. Kilbourne Drive:

- As a 2WSC intersection with basic laning, the westbound approach from F.H. Kilbourne operates at LOS "F" during both peak hours.
- After signalization and additional auxiliary turn lanes, the Casca approaches experience LOS "A" during both peak hours. The Independence and F.H. Kilbourne approaches experience LOS "C" during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:



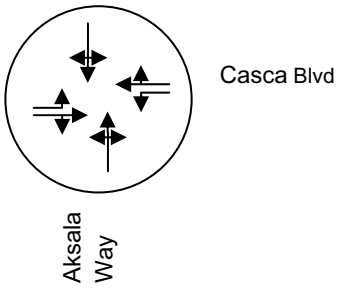
At Casca Boulevard/Witch Hazel Drive:

- As a 1WSC intersection with basic laning, all approaches experience LOS "A" during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:



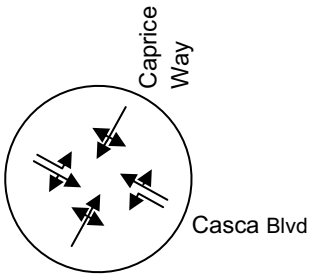
At Casca Boulevard/Aksala Way:

- As a 2WSC intersection with basic laning, the Casca approaches experience LOS "A" during both peak hours. The Aksala approaches experience LOS "B" or better during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:



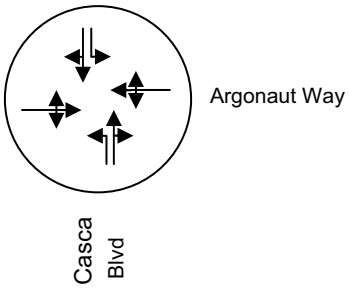
At Casca Boulevard/Caprice Way:

- As a 2WSC intersection with basic laning, the Casca approaches experience LOS “A” during both peak hours. The Caprice approaches experience LOS “B” or better during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:



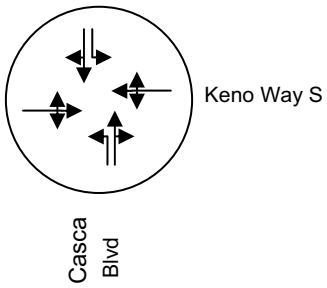
At Casca Boulevard/Argonaut Way:

- As a 2WSC intersection with basic laning, the Casca approaches experience LOS “A” during both peak hours. The Argonaut approaches experience LOS “B” or better during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:



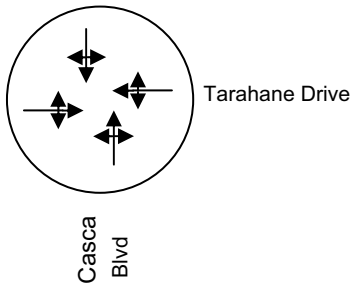
At Casca Boulevard/Keno Way S:

- As a 2WSC intersection with basic laning, the Casca approaches experience LOS “A” during both peak hours. The Keno approaches experience LOS “B” in the AM peak hour and LOS “C” in the PM peak hour. The required laning to service Full Build out traffic is illustrated as follows:



At Casca Boulevard/Tarahane Drive:

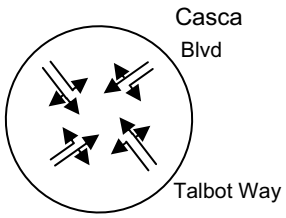
- As a single roundabout with single entrance and exit lanes, the highest v/c ratio at the roundabout is 0.5 for Casca northbound approach in the PM peak hour. A relatively lower v/c ratio is shown for the opposite approach in the AM peak hour. The required laning to service Full Build out traffic is illustrated as follows:



At Casca Boulevard/Talbot Way:

- As a 2WSC intersection with basic laning, the northbound approach from Talbot operates at LOS “E” and LOS “F” in the AM and PM peak hours respectively.

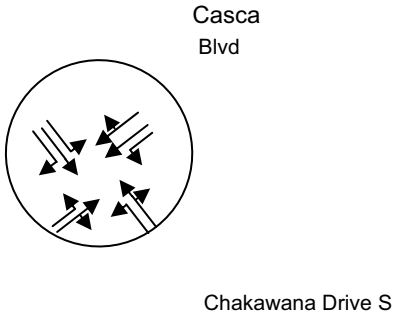
- After signalization and additional auxiliary turn lanes, the Casca approaches experience LOS “A” during both peak hours. The Talbot approaches experience LOS “C” during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:



At Casca Boulevard/Chakawana Drive S:

- With Phase 2 improvements (signalization and laning improvements), the westbound approach from Casca and the northbound approach from Chakawana experience LOS “D” during both peak hours at full build out.

- After the addition of a westbound through lane, increasing auxiliary lane storage lengths, and signal optimizations, all approaches experience LOS “C” or better during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:



At Range Road/Casca Boulevard S:

- As a single roundabout with single entrance and exit lanes, the intersection is not able to accommodate demand with the highest v/c ratio at the roundabout observed as 2.6 for the Casca westbound approach in the PM peak hour. Slightly lower v/c ratios were observed for the Range southbound approach in the AM peak hour. This suggests the need for greater capacity to accommodate the heavy flow of traffic using this entrance during both peaks at full build out.

- The next stage of control examined was a double roundabout with dual entrance and exit lanes. The highest v/c ratios for the approach still exceed 1.0 during both peak hours, suggesting signalization as a possible form of traffic control.

- With signalization, the addition of a northbound and a southbound through and auxiliary turn lanes, the Casca approach experiences LOS “B during both peak hours. The Range approaches experience LOS “C” or better during both peak hours. The required laning to service Full Build out traffic is illustrated as follows:

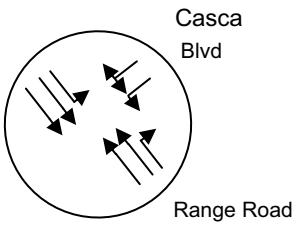


Table 5.8 – HCM Results – Full Build Basic (Unimproved) AM Peak Hour

100% Whistle Bend AM Peak Hour Background+Site																
ID	Description	Sig/Unsig	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Int Delay	Int LOS
1	Casca Blvd & Chakawana Dr (S)	Unsig	Casca Blvd						Chakawana Dr							
	Volume (vph)		527	365	52	0	660	0	50	0	0	0	0	542		
	V/C Ratio		0.7	0.3	0.3	0.0	0.4	0.4	Err	Err	Err	1.4	1.4	1.4		
	Q-length (m) (95%)		40.7	0.0	0.0	0.0	0.0	0.0	Err	Err	Err	227.0	227.0	227.0		
	Delay (s)		16.7	0.0	0.0	0.0	0.0	0.0	Err	Err	Err	214.6	214.6	214.6		
	LOS		C	A	A	A	A	A	F	F	F	F	F	F		
	Approach Delay (s)			9.3			0.0			Err			214.6			
	Approach LOS			A			A			F			F		Err	
2	Casca Blvd & Talbot Way	Unsig	Casca Blvd						Talbot Way							
	Volume (vph)		125	229	10	0	526	0	10	0	0	0	0	124		
	V/C Ratio		0.1	0.2	0.2	0.0	0.3	0.3	0.1	0.1	0.1	0.3	0.3	0.3		
	Q-length (m) (95%)		3.7	0.0	0.0	0.0	0.0	0.0	2.7	2.7	2.7	8.1	8.1	8.1		
	Delay (s)		9.1	0.0	0.0	0.0	0.0	0.0	43.9	43.9	43.9	14.2	14.2	14.2		
	LOS		A	A	A	A	A	A	E	E	E	B	B	B		
	Approach Delay (s)			3.1			0.0			43.9			14.2			
	Approach LOS			A			A			E			B		3.3	A
3	Casca Blvd & Tarahane Dr	Roundabt	Tarahane Dr						Casca Blvd							
	Volume (vph)		0	0	31	107	0	0	9	184	36	0	388	0		
	High V/C Ratio			0.0			0.1			0.2			0.3			
	Low V/C Ratio			0.1			0.1			0.2			0.4		n/a	n/a
4	Casca Blvd & Keno Way (S)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		4	3	18	40	5	0	6	166	12	0	329	8		
	V/C Ratio		0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.2	0.2		
	Q-length (m) (95%)		1.2	1.2	1.2	3.2	3.2	3.2	0.1	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		11.4	11.4	11.4	14.8	14.8	14.8	8.0	0.0	0.0	0.0	0.0	0.0		
	LOS		B	B	B	B	B	B	A	A	A	A	A	A		
	Approach Delay (s)			11.4			14.8			0.3			0.0			
	Approach LOS			B			B			A			A		1.7	A
5	Casca Blvd & Argonaut Way	Unsig	Argonaut Way						Casca Blvd							
	Volume (vph)		0	0	24	63	0	0	7	142	21	0	250	0		
	V/C Ratio		0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.2	0.2		
	Q-length (m) (95%)		0.8	0.8	0.8	3.9	3.9	3.9	0.1	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		9.8	9.8	9.8	13.7	13.7	13.7	7.8	0.0	0.0	0.0	0.0	0.0		
	LOS		A	A	A	B	B	B	A	A	A	A	A	A		
	Approach Delay (s)			9.8			13.7			0.3			0.0			
	Approach LOS			A			B			A			A		2.3	A
6	Casca Blvd & Caprice Way	Unsig	Casca Blvd						Caprice Way							
	Volume (vph)		12	111	3	10	78	54	2	0	14	125	0	14		
	V/C Ratio		0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.2	0.2	0.2		
	Q-length (m) (95%)		0.2	0.0	0.0	0.2	0.0	0.0	0.5	0.5	0.5	7.0	7.0	7.0		
	Delay (s)		7.5	0.0	0.0	7.5	0.0	0.0	9.1	9.1	9.1	12.1	12.1	12.1		
	LOS		A	A	A	A	A	A	A	A	A	B	B	B		
	Approach Delay (s)			0.7			0.5			9.1			12.1			
	Approach LOS			A			A			A			B		4.7	A
7	Casca Blvd & Aksala Way	Unsig	Casca Blvd						Aksala Way							
	Volume (vph)		10	15	10	39	16	39	8	0	56	56	0	8		
	V/C Ratio		0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1		
	Q-length (m) (95%)		0.2	0.0	0.0	0.7	0.0	0.0	1.8	1.8	1.8	2.6	2.6	2.6		
	Delay (s)		7.3	0.0	0.0	7.3	0.0	0.0	8.8	8.8	8.8	10.6	10.6	10.6		
	LOS		A	A	A	A	A	A	A	A	A	B	B	B		
	Approach Delay (s)			2.1			3.0			8.8			10.6			
	Approach LOS			A			A			A			B		6.2	A
8	Casca Blvd & Witch Hazel Dr	Unsig	Casca Blvd						Witch Hazel Dr							
	Volume (vph)		114	36			31	0				0		170		
	V/C Ratio		0.1	0.0			0.0	0.0				0.2		0.2		
	Q-length (m) (95%)		2.0	0.0			0.0	0.0				5.1		5.1		
	Delay (s)		7.5	0.0			0.0	0.0				9.2		9.2		
	LOS		A	A			A	A				A		A		
	Approach Delay (s)			5.7			0.0						9.2			
	Approach LOS			A			A						A		6.9	A
9	Casca Blvd & Independence Blvd	Unsig	Independence Blvd						Casca Blvd							
	Volume (vph)		0	0	426	50	0	0	248	150	53	0	201	0		
	V/C Ratio		0.6	0.6	0.6	1.3	1.3	1.3	0.2	0.1	0.1	0.0	0.1	0.1		
	Q-length (m) (95%)		28.4	28.4	28.4	42.0	42.0	42.0	5.9	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		14.8	14.8	14.8	366.9	366.9	366.9	8.3	0.0	0.0	0.0	0.0	0.0		
	LOS		B	B	B	F	F	F	A	A	A	A	A	A		
	Approach Delay (s)			14.8			366.9			4.6			0.0			
	Approach LOS			B			F			A			A		23.7	C
10	Casca Blvd & Keno Way (N)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		0	0	98	60	0	0	89	450	53	0	677	0		
	V/C Ratio		0.3	0.3	0.3	1.0	1.0	1.0	0.1	0.3	0.3	0.0	0.4	0.4		
	Q-length (m) (95%)		7.9	7.9	7.9	40.3	40.3	40.3	3.0	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		16.4	16.4	16.4	228.1	228.1	228.1	9.6	0.0	0.0	0.0	0.0	0.0		
	LOS		C	C	C	F	F	F	A	A	A	A	A	A		
	Approach Delay (s)			16.4			228.1			1.4			0.0			
	Approach LOS			C			F			A			A		11.3	B
11	Casca Blvd & Chakawana Dr (N)	Unsig	Casca Blvd						Chakawana Dr							
	Volume (vph)			593	193	0	835		141		0					
	V/C Ratio			0.5	0.5	0.0	0.5		1.5		1.5					
	Q-length (m) (95%)			0.0	0.0	0.0	0.0		88.9		88.9					
	Delay (s)			0.0	0.0	0.0	0.0		319.9		319.9					
	LOS			A	A	A	A		F		F					
	Approach Delay (s)			0.0			0.0			319.9						
	Approach LOS			A			A			F					25.6	D
21	Range Rd & Casca Blvd (S)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)					1203		48		510	872	72	780			
	High V/C Ratio						1.5			1.2			1.9			
	Low V/C Ratio						1.9			1.4			2.5		n/a	n/a
22	Casca Blvd & Casca Blvd (N)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)					755		220		63	496	290	97			
	High V/C Ratio						0.8			0.6			0.6			
	Low V/C Ratio						1.0			0.7			0.7		n/a	n/a

Table 5.8 – HCM Results – Full Build Basic (Unimproved) PM Peak Hour

100% Whistle Bend PM Peak Hour Background+Site																
ID	Description	Sig/Unsig	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Int Delay	Int LOS
1	Casca Blvd & Chakawana Dr (S)	Unsig	Casca Blvd						Chakawana Dr							
	Volume (vph)		712	659	67	0	541	0	74	0	0	0	0	738		
	V/C Ratio		0.8	0.5	0.5	0.0	0.4	0.4	Err	Err	Err	1.6	1.6	1.6		
	Q-length (m) (95%)		69.3	0.0	0.0	0.0	0.0	0.0	Err	Err	Err	353.4	353.4	353.4		
	Delay (s)		21.4	0.0	0.0	0.0	0.0	0.0	Err	Err	Err	297.4	297.4	297.4		
	LOS		C	A	A	A	A	A	F	F	F	F	F	F		
	Approach Delay (s)			10.6			0.0			Err			297.4			
	Approach LOS			B			A			F			F		Err	
2	Casca Blvd & Talbot Way	Unsig	Casca Blvd						Talbot Way							
	Volume (vph)		166	480	13	0	346	0	15	0	0	0	0	179		
	V/C Ratio		0.2	0.3	0.3	0.0	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3		
	Q-length (m) (95%)		4.3	0.0	0.0	0.0	0.0	0.0	6.7	6.7	6.7	9.5	9.5	9.5		
	Delay (s)		8.6	0.0	0.0	0.0	0.0	0.0	73.9	73.9	73.9	12.5	12.5	12.5		
	LOS		A	A	A	A	A	A	F	F	F	B	B	B		
	Approach Delay (s)			2.2			0.0			73.9			12.5			
	Approach LOS			A			A			F			B		4.0	A
3	Casca Blvd & Tarahane Dr	Roundabt	Tarahane Dr						Casca Blvd							
	Volume (vph)		0	0	15	58	0	0	25	366	88	0	273	0		
	High V/C Ratio			0.0			0.1			0.4			0.2			
	Low V/C Ratio			0.0			0.1			0.5			0.3		n/a	n/a
4	Casca Blvd & Keno Way (S)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		6	5	9	20	5	0	15	318	33	0	244	7		
	V/C Ratio		0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.2	0.2	0.0	0.2	0.2		
	Q-length (m) (95%)		1.1	1.1	1.1	1.9	1.9	1.9	0.3	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		12.7	12.7	12.7	15.7	15.7	15.7	7.8	0.0	0.0	0.0	0.0	0.0		
	LOS		B	B	B	C	C	C	A	A	A	A	A	A		
	Approach Delay (s)			12.7			15.7			0.3			0.0			
	Approach LOS			B			C			A			A		1.2	A
5	Casca Blvd & Argonaut Way	Unsig	Argonaut Way						Casca Blvd							
	Volume (vph)		0	0	12	35	0	0	20	251	53	0	205	0		
	V/C Ratio		0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.2	0.2	0.0	0.1	0.1		
	Q-length (m) (95%)		0.4	0.4	0.4	2.4	2.4	2.4	0.4	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		9.5	9.5	9.5	14.5	14.5	14.5	7.7	0.0	0.0	0.0	0.0	0.0		
	LOS		A	A	A	B	B	B	A	A	A	A	A	A		
	Approach Delay (s)			9.5			14.5			0.5			0.0			
	Approach LOS			A			B			A			A		1.3	A
6	Casca Blvd & Caprice Way	Unsig	Casca Blvd						Caprice Way							
	Volume (vph)		13	109	2	15	118	119	4	0	14	83	0	19		
	V/C Ratio		0.0	0.1	0.1	0.0	0.2	0.2	0.0	0.0	0.0	0.2	0.2	0.2		
	Q-length (m) (95%)		0.3	0.0	0.0	0.3	0.0	0.0	0.6	0.6	0.6	5.4	5.4	5.4		
	Delay (s)		7.8	0.0	0.0	7.5	0.0	0.0	9.4	9.4	9.4	12.4	12.4	12.4		
	LOS		A	A	A	A	A	A	A	A	A	B	B	B		
	Approach Delay (s)			0.8			0.4			9.4			12.4			
	Approach LOS			A			A			A			B		3.3	A
7	Casca Blvd & Aksala Way	Unsig	Casca Blvd						Aksala Way							
	Volume (vph)		8	15	8	59	22	59	14	0	54	54	0	14		
	V/C Ratio		0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
	Q-length (m) (95%)		0.1	0.0	0.0	1.0	0.0	0.0	2.0	2.0	2.0	2.9	2.9	2.9		
	Delay (s)		7.4	0.0	0.0	7.3	0.0	0.0	9.0	9.0	9.0	11.0	11.0	11.0		
	LOS		A	A	A	A	A	A	A	A	A	B	B	B		
	Approach Delay (s)			1.9			3.1			9.0			11.0			
	Approach LOS			A			A			A			B		6.0	A
8	Casca Blvd & Witch Hazel Dr	Unsig	Casca Blvd						Witch Hazel Dr							
	Volume (vph)		173	31			51	0				0		163		
	V/C Ratio		0.1	0.0			0.0	0.0				0.2		0.2		
	Q-length (m) (95%)		3.3	0.0			0.0	0.0				5.0		5.0		
	Delay (s)		7.6	0.0			0.0	0.0				9.3		9.3		
	LOS		A	A			A	A				A		A		
	Approach Delay (s)			6.5			0.0						9.3			
	Approach LOS			A			A						A		6.8	A
9	Casca Blvd & Independence Blvd	Unsig	Independence Blvd						Casca Blvd							
	Volume (vph)		0	0	235	72	0	0	345	205	64	0	215	0		
	V/C Ratio		0.3	0.3	0.3	1.4	1.4	1.4	0.3	0.2	0.2	0.0	0.1	0.1		
	Q-length (m) (95%)		10.8	10.8	10.8	56.6	56.6	56.6	9.2	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		11.5	11.5	11.5	394.0	394.0	394.0	8.7	0.0	0.0	0.0	0.0	0.0		
	LOS		B	B	B	F	F	F	A	A	A	A	A	A		
	Approach Delay (s)			11.5			394.0			4.9			0.0			
	Approach LOS			B			F			A			A		30.0	D
10	Casca Blvd & Keno Way (N)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		0	0	54	76	0	0	72	614	67	0	522	0		
	V/C Ratio		0.1	0.1	0.1	1.0	1.0	1.0	0.1	0.4	0.4	0.0	0.3	0.3		
	Q-length (m) (95%)		3.0	3.0	3.0	42.5	42.5	42.5	2.0	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		12.7	12.7	12.7	169.8	169.8	169.8	8.8	0.0	0.0	0.0	0.0	0.0		
	LOS		B	B	B	F	F	F	A	A	A	A	A	A		
	Approach Delay (s)			12.7			169.8			0.8			0.0			
	Approach LOS			B			F			A			A		10.1	B
11	Casca Blvd & Chakawana Dr (N)	Unsig	Casca Blvd						Chakawana Dr							
	Volume (vph)			753	182	0	651		267		0					
	V/C Ratio			0.6	0.6	0.0	0.4		2.6		2.6					
	Q-length (m) (95%)			0.0	0.0	0.0	0.0		212.3		212.3					
	Delay (s)			0.0	0.0	0.0	0.0		816.0		816.0					
	LOS			A	A	A	A		F		F					
	Approach Delay (s)			0.0			0.0			816.0						
	Approach LOS			A			A			F					117.6	F
21	Range Rd & Casca Blvd (S)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)					1249		104		739	1380	58	586			
	High V/C Ratio						2.0			1.8			1.5			
	Low V/C Ratio						2.6			2.1			2.0		n/a	n/a
22	Casca Blvd & Casca Blvd (N)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)					547		371		135	707	228	96			
	High V/C Ratio						0.8			0.8			0.4			
	Low V/C Ratio						1.0			1.0			0.5		n/a	n/a

Table 5.9 – HCM Results – Full Build Recommended AM Peak Hour

100% Whistle Bend AM Peak Hour Background+Site																
ID	Description	Sig/Unsig	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Int Delay	Int LOS
1	Casca Blvd & Chakawana Dr (S)	Sig	Casca Blvd						Chakawana Dr							
	Volume (vph)		527	365	52	0	660	0	50	0	0	0	0	542		
	V/C Ratio		0.8	0.3	0.3	0.0	0.7	0.7	0.4	0.0	0.0	0.0	0.0	0.7		
	Q-length (m) (95%)		#121.6	38.2	38.2	0.0	64.5	64.5	12.4	0.0	0.0	0.0	0.0	72.2		
	Delay (s)		13.8	2.8	2.8	0.0	23.4	23.4	26.1	0.0	0.0	0.0	0.0	14.6		
	LOS		B	A	A	A	C	C	C	A	A	A	A	B		
	Approach Delay (s)			9.0			23.4			26.1			14.6			
	Approach LOS			A			C			C			B		15.1	B
2	Casca Blvd & Talbot Way	Sig	Casca Blvd						Talbot Way							
	Volume (vph)		125	229	10	0	526	0	10	0	0	0	0	124		
	V/C Ratio		0.2	0.2	0.2	0.0	0.4	0.4	0.1	0.0	0.0	0.0	0.1	0.1		
	Q-length (m) (95%)		24.3	19.9	19.9	0.0	60.1	60.1	4.2	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		2.1	1.6	1.6	0.0	4.3	4.3	24.0	0.0	0.0	0.0	24.0	24.0		
	LOS		A	A	A	A	A	A	C	A	A	A	C	C		
	Approach Delay (s)			1.7			4.3			24.0			24.0			
	Approach LOS			A			A			C			C		6.0	A
3	Casca Blvd & Tarahane Dr	Roundabt	Tarahane Dr						Casca Blvd							
	Volume (vph)		0	0	31	107	0	0	9	184	36	0	388	0		
	High V/C Ratio			0.0			0.1			0.2			0.3			
	Low V/C Ratio			0.1			0.1			0.2			0.4		n/a	n/a
4	Casca Blvd & Keno Way (S)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		4	3	18	40	5	0	6	166	12	0	329	8		
	V/C Ratio		0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.2	0.2		
	Q-length (m) (95%)		1.2	1.2	1.2	3.2	3.2	3.2	0.1	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		11.4	11.4	11.4	14.8	14.8	14.8	8.0	0.0	0.0	0.0	0.0	0.0		
	LOS		B	B	B	B	B	B	A	A	A	A	A	A		
	Approach Delay (s)			11.4			14.8			0.3			0.0			
	Approach LOS			B			B			A			A		1.7	A
5	Casca Blvd & Argonaut Way	Unsig	Argonaut Way						Casca Blvd							
	Volume (vph)		0	0	24	63	0	0	7	142	21	0	250	0		
	V/C Ratio		0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.2	0.2		
	Q-length (m) (95%)		0.8	0.8	0.8	3.9	3.9	3.9	0.1	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		9.8	9.8	9.8	13.7	13.7	13.7	7.8	0.0	0.0	0.0	0.0	0.0		
	LOS		A	A	A	B	B	B	A	A	A	A	A	A		
	Approach Delay (s)			9.8			13.7			0.3			0.0			
	Approach LOS			A			B			A			A		2.3	A
6	Casca Blvd & Caprice Way	Unsig	Casca Blvd						Caprice Way							
	Volume (vph)		12	111	3	10	78	54	2	0	14	125	0	14		
	V/C Ratio		0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.2	0.2	0.2		
	Q-length (m) (95%)		0.2	0.0	0.0	0.2	0.0	0.0	0.5	0.5	0.5	7.0	7.0	7.0		
	Delay (s)		7.5	0.0	0.0	7.5	0.0	0.0	9.1	9.1	9.1	12.1	12.1	12.1		
	LOS		A	A	A	A	A	A	A	A	A	B	B	B		
	Approach Delay (s)			0.7			0.5			9.1			12.1			
	Approach LOS			A			A			A			B		4.7	A
7	Casca Blvd & Aksala Way	Unsig	Casca Blvd						Aksala Way							
	Volume (vph)		10	15	10	39	16	39	8	0	56	56	0	8		
	V/C Ratio		0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1		
	Q-length (m) (95%)		0.2	0.0	0.0	0.7	0.0	0.0	1.8	1.8	1.8	2.6	2.6	2.6		
	Delay (s)		7.3	0.0	0.0	7.3	0.0	0.0	8.8	8.8	8.8	10.6	10.6	10.6		
	LOS		A	A	A	A	A	A	A	A	A	B	B	B		
	Approach Delay (s)			2.1			3.0			8.8			10.6			
	Approach LOS			A			A			A			B		6.2	A
8	Casca Blvd & Witch Hazel Dr	Unsig	Casca Blvd						Witch Hazel Dr							
	Volume (vph)		114	36			31	0				0		170		
	V/C Ratio		0.1	0.0			0.0	0.0				0.2		0.2		
	Q-length (m) (95%)		2.0	0.0			0.0	0.0				5.1		5.1		
	Delay (s)		7.5	0.0			0.0	0.0				9.2		9.2		
	LOS		A	A			A	A				A		A		
	Approach Delay (s)			5.7			0.0						9.2			
	Approach LOS			A			A						A		6.9	A
9	Casca Blvd & Independence Blvd	Sig	Independence Blvd						Casca Blvd							
	Volume (vph)		0	0	426	50	0	0	248	150	53	0	201	0		
	V/C Ratio		0.0	0.3	0.3	0.5	0.0	0.0	0.3	0.2	0.2	0.0	0.2	0.2		
	Q-length (m) (95%)		0.0	1.9	1.9	15.4	0.0	0.0	15.3	3.7	3.7	0.0	24.1	24.1		
	Delay (s)		0.0	25.4	25.4	29.4	0.0	0.0	3.3	2.2	2.2	0.0	4.4	4.4		
	LOS		A	C	C	C	A	A	A	A	A	A	A	A		
	Approach Delay (s)			25.4			29.4			2.8			4.4			
	Approach LOS			C			C			A			A		12.8	B
10	Casca Blvd & Keno Way (N)	Sig	Keno Way						Casca Blvd							
	Volume (vph)		0	0	98	60	0	0	89	450	53	0	677	0		
	V/C Ratio		0.0	0.1	0.1	0.4	0.0	0.0	0.2	0.4	0.4	0.0	0.5	0.5		
	Q-length (m) (95%)		0.0	0.0	0.0	17.3	0.0	0.0	18.9	71.9	71.9	0.0	73.1	73.1		
	Delay (s)		0.0	27.4	27.4	30.1	0.0	0.0	5.1	5.8	5.8	0.0	4.8	4.8		
	LOS		A	C	C	C	A	A	A	A	A	A	A	A		
	Approach Delay (s)			27.4			30.1			5.7			4.8			
	Approach LOS			C			C			A			A		7.8	A
11	Casca Blvd & Chakawana Dr (N)	Sig	Casca Blvd						Chakawana Dr							
	Volume (vph)			593	193	0	835		141		0					
	V/C Ratio			0.5	0.1	0.0	0.7		0.6		0.0					
	Q-length (m) (95%)			68.6	6.5	0.0	46.0		34.1		0.0					
	Delay (s)			4.6	3.3	0.0	5.4		32.6		0.0					
	LOS			A	A	A	A		C		A					
	Approach Delay (s)			4.3			5.4			32.6						
	Approach LOS			A			A			C					7.1	A
21	Range Rd & Casca Blvd (S)	Sig	Casca Blvd						Range Rd							
	Volume (vph)						1203		48		510	872	72	780		
	V/C Ratio						0.8		0.8		0.5	0.6	0.4	0.8		
	Q-length (m) (95%)						50.4		50.4		40.0	0.0	18.1	64.4		
	Delay (s)						10.0		10.0		17.8	1.9	17.9	23.0		
	LOS						B		B		B	A	B	C		
	Approach Delay (s)						10.0				7.7			22.6		
	Approach LOS						B				A			C	12.2	B
22	Range Rd & Casca Blvd (N)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)						755		220		63	496	290	97		
	High V/C Ratio							0.6			0.1			0.6		
	Low V/C Ratio							0.8			0.1			0.7	n/a	n/a

Table 5.9 – HCM Results – Full Build Recommended PM Peak Hour

100% Whistle Bend PM Peak Hour Background+Site																
ID	Description	Sig/Unsig	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Int Delay	Int LOS
1	Casca Blvd & Chakawana Dr (S)	Sig	Casca Blvd						Chakawana Dr							
	Volume (vph)		712	659	67	0	541	0	74	0	0	0	0	738		
	V/C Ratio		0.9	0.6	0.6	0.0	0.8	0.8	0.5	0.0	0.0	0.0	0.0	0.8		
	Q-length (m) (95%)		m#117.8	m61.7	m61.7	0.0	52.2	52.2	16.8	0.0	0.0	0.0	0.0	#147.2		
	Delay (s)		14.7	4.5	4.5	0.0	27.8	27.8	27.1	0.0	0.0	0.0	0.0	16.0		
	LOS		B	A	A	A	C	C	C	A	A	A	A	B		
	Approach Delay (s)			9.6			27.8			27.1			16.0			
	Approach LOS			A			C			C			B		15.3	B
2	Casca Blvd & Talbot Way	Sig	Casca Blvd						Talbot Way							
	Volume (vph)		166	480	13	0	346	0	15	0	0	0	0	179		
	V/C Ratio		0.3	0.4	0.4	0.0	0.3	0.3	0.1	0.0	0.0	0.0	0.1	0.1		
	Q-length (m) (95%)		3.2	11.2	11.2	0.0	35.3	35.3	5.4	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		1.8	2.2	2.2	0.0	3.5	3.5	23.3	0.0	0.0	0.0	23.2	23.2		
	LOS		A	A	A	A	A	A	C	A	A	A	C	C		
	Approach Delay (s)			2.1			3.5			23.3			23.2			
	Approach LOS			A			A			C			C		5.9	A
3	Casca Blvd & Tarahane Dr	Roundabt	Tarahane Dr						Casca Blvd							
	Volume (vph)		0	0	15	58	0	0	25	366	88	0	273	0		
	High V/C Ratio			0.0			0.1			0.4			0.2			
	Low V/C Ratio			0.0			0.1			0.5			0.3		n/a	n/a
4	Casca Blvd & Keno Way (S)	Unsig	Keno Way						Casca Blvd							
	Volume (vph)		6	5	9	20	5	0	15	318	33	0	244	7		
	V/C Ratio		0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.2	0.2	0.0	0.2	0.2		
	Q-length (m) (95%)		1.1	1.1	1.1	1.9	1.9	1.9	0.3	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		12.7	12.7	12.7	15.7	15.7	15.7	7.8	0.0	0.0	0.0	0.0	0.0		
	LOS		B	B	B	C	C	C	A	A	A	A	A	A		
	Approach Delay (s)			12.7			15.7			0.3			0.0			
	Approach LOS			B			C			A			A		1.2	A
5	Casca Blvd & Argonaut Way	Unsig	Argonaut Way						Casca Blvd							
	Volume (vph)		0	0	12	35	0	0	20	251	53	0	205	0		
	V/C Ratio		0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.2	0.2	0.0	0.1	0.1		
	Q-length (m) (95%)		0.4	0.4	0.4	2.4	2.4	2.4	0.4	0.0	0.0	0.0	0.0	0.0		
	Delay (s)		9.5	9.5	9.5	14.5	14.5	14.5	7.7	0.0	0.0	0.0	0.0	0.0		
	LOS		A	A	A	B	B	B	A	A	A	A	A	A		
	Approach Delay (s)			9.5			14.5			0.5			0.0			
	Approach LOS			A			B			A			A		1.3	A
6	Casca Blvd & Caprice Way	Unsig	Casca Blvd						Caprice Way							
	Volume (vph)		13	109	2	15	118	119	4	0	14	83	0	19		
	V/C Ratio		0.0	0.1	0.1	0.0	0.2	0.2	0.0	0.0	0.0	0.2	0.2	0.2		
	Q-length (m) (95%)		0.3	0.0	0.0	0.3	0.0	0.0	0.6	0.6	0.6	5.4	5.4	5.4		
	Delay (s)		7.8	0.0	0.0	7.5	0.0	0.0	9.4	9.4	9.4	12.4	12.4	12.4		
	LOS		A	A	A	A	A	A	A	A	A	B	B	B		
	Approach Delay (s)			0.8			0.4			9.4			12.4			
	Approach LOS			A			A			A			B		3.3	A
7	Casca Blvd & Aksala Way	Unsig	Casca Blvd						Aksala Way							
	Volume (vph)		8	15	8	59	22	59	14	0	54	54	0	14		
	V/C Ratio		0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
	Q-length (m) (95%)		0.1	0.0	0.0	1.0	0.0	0.0	2.0	2.0	2.0	2.9	2.9	2.9		
	Delay (s)		7.4	0.0	0.0	7.3	0.0	0.0	9.0	9.0	9.0	11.0	11.0	11.0		
	LOS		A	A	A	A	A	A	A	A	A	B	B	B		
	Approach Delay (s)			1.9			3.1			9.0			11.0			
	Approach LOS			A			A			A			B		6.0	A
8	Casca Blvd & Witch Hazel Dr	Unsig	Casca Blvd						Witch Hazel Dr							
	Volume (vph)		173	31			51	0				0		163		
	V/C Ratio		0.1	0.0			0.0	0.0				0.2		0.2		
	Q-length (m) (95%)		3.3	0.0			0.0	0.0				5.0		5.0		
	Delay (s)		7.6	0.0			0.0	0.0				9.3		9.3		
	LOS		A	A			A	A				A		A		
	Approach Delay (s)			6.5			0.0						9.3			
	Approach LOS			A			A						A		6.8	A
9	Casca Blvd & Independence Blvd	Sig	Independence Blvd						Casca Blvd							
	Volume (vph)		0	0	235	72	0	0	345	205	64	0	215	0		
	V/C Ratio		0.0	0.2	0.2	0.6	0.0	0.0	0.5	0.2	0.2	0.0	0.2	0.2		
	Q-length (m) (95%)		0.0	0.0	0.0	18.6	0.0	0.0	0.4	0.0	0.0	0.0	21.6	21.6		
	Delay (s)		0.0	21.4	21.4	28.7	0.0	0.0	2.9	1.1	1.1	0.0	4.0	4.0		
	LOS		A	C	C	C	A	A	A	A	A	A	A	A		
	Approach Delay (s)			21.4			28.7			2.1			4.0			
	Approach LOS			C			C			A			A		8.1	A
10	Casca Blvd & Keno Way (N)	Sig	Keno Way						Casca Blvd							
	Volume (vph)		0	0	54	76	0	0	72	614	67	0	522	0		
	V/C Ratio		0.0	0.0	0.0	0.5	0.0	0.0	0.1	0.6	0.6	0.0	0.4	0.4		
	Q-length (m) (95%)		0.0	0.0	0.0	17.4	0.0	0.0	m0.1	0	0	0.0	43.2	43.2		
	Delay (s)		0.0	23.5	23.5	27.5	0.0	0.0	1.0	1.9	1.9	0.0	3.0	3.0		
	LOS		A	C	C	C	A	A	A	A	A	A	A	A		
	Approach Delay (s)			23.5			27.5			1.8			3.0			
	Approach LOS			C			C			A			A		4.5	A
11	Casca Blvd & Chakawana Dr (N)	Sig	Casca Blvd						Chakawana Dr							
	Volume (vph)			753	182	0	651		267		0					
	V/C Ratio			0.7	0.1	0.0	0.6		0.7		0.0					
	Q-length (m) (95%)			107.5	6.9	0.0	109.6		52.4		0.0					
	Delay (s)			12.2	5.4	0.0	9.8		27.9		0.0					
	LOS			B	A	A	A		C		A					
	Approach Delay (s)			10.9			9.8			27.9						
	Approach LOS			B			A			C					13.0	B
21	Range Rd & Casca Blvd (S)	Sig	Casca Blvd						Range Rd							
	Volume (vph)					1249		104		739	1380	58	586			
	V/C Ratio					0.8		0.8		0.8	1.0	0.5	0.6			
	Q-length (m) (95%)					m68.4		m68.4		62.2	#63.8	#20.8	47.7			
	Delay (s)					12.3		12.3		24.4	17.8	22.2	20.2			
	LOS					B		B		C	B	C	C			
	Approach Delay (s)					12.3				20.1			20.4			
	Approach LOS					B				C			C		17.6	B
22	Range Rd & Casca Blvd (N)	Roundabt	Casca Blvd						Range Rd							
	Volume (vph)					547		371		135	707	228	96			
	High V/C Ratio						0.5			0.1			0.4			
	Low V/C Ratio						0.6			0.2			0.5		n/a	n/a

Peak hour volumes and recommended laning along the study corridor at the end of Phase 2 are illustrated in Figures 5.9 and 5.10 with improvements relative to the basic network highlighted in yellow (grey).

Figure 5.9 – AM Peak Hour Traffic Volumes and Laning – Full Build Recommended

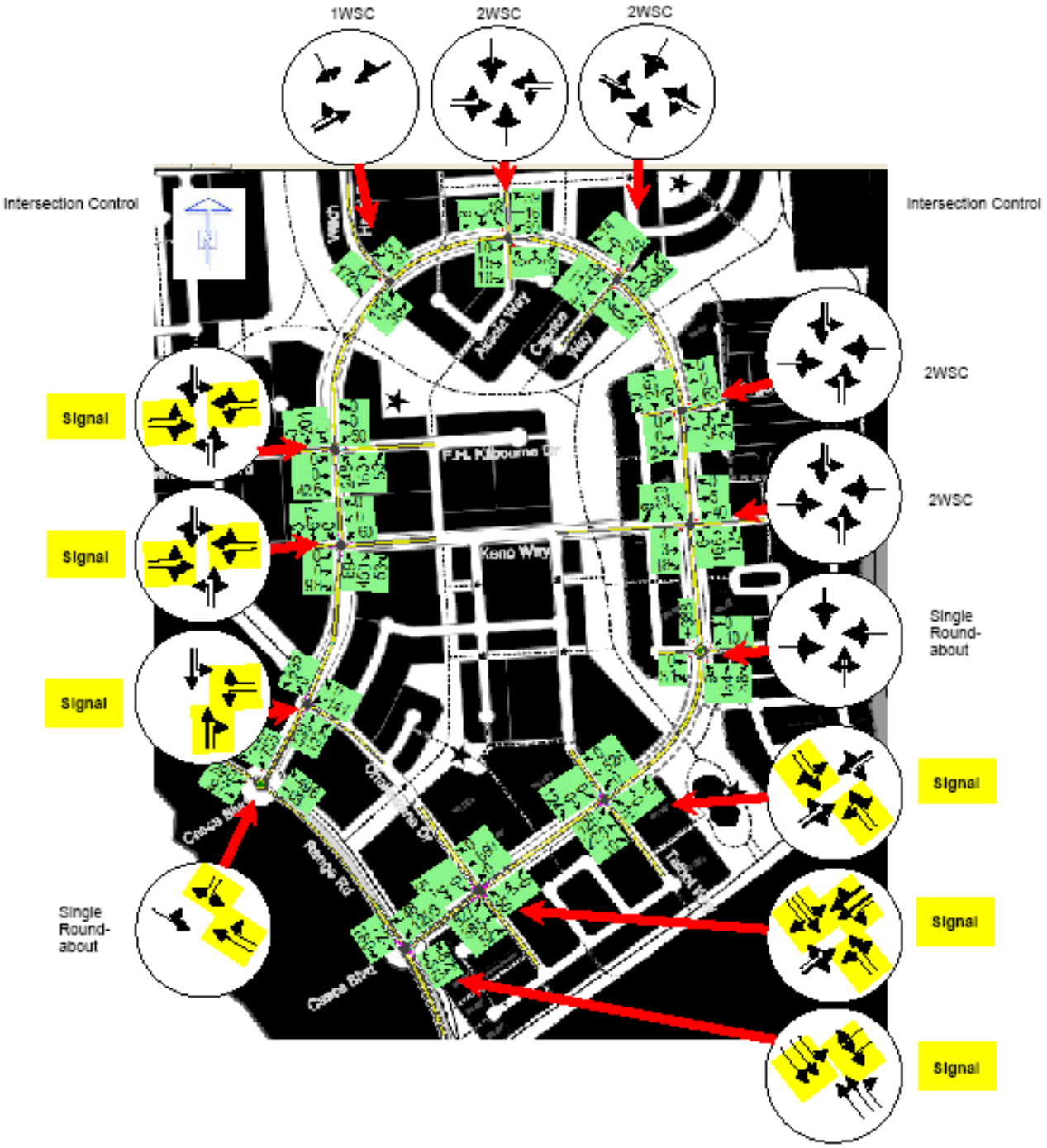
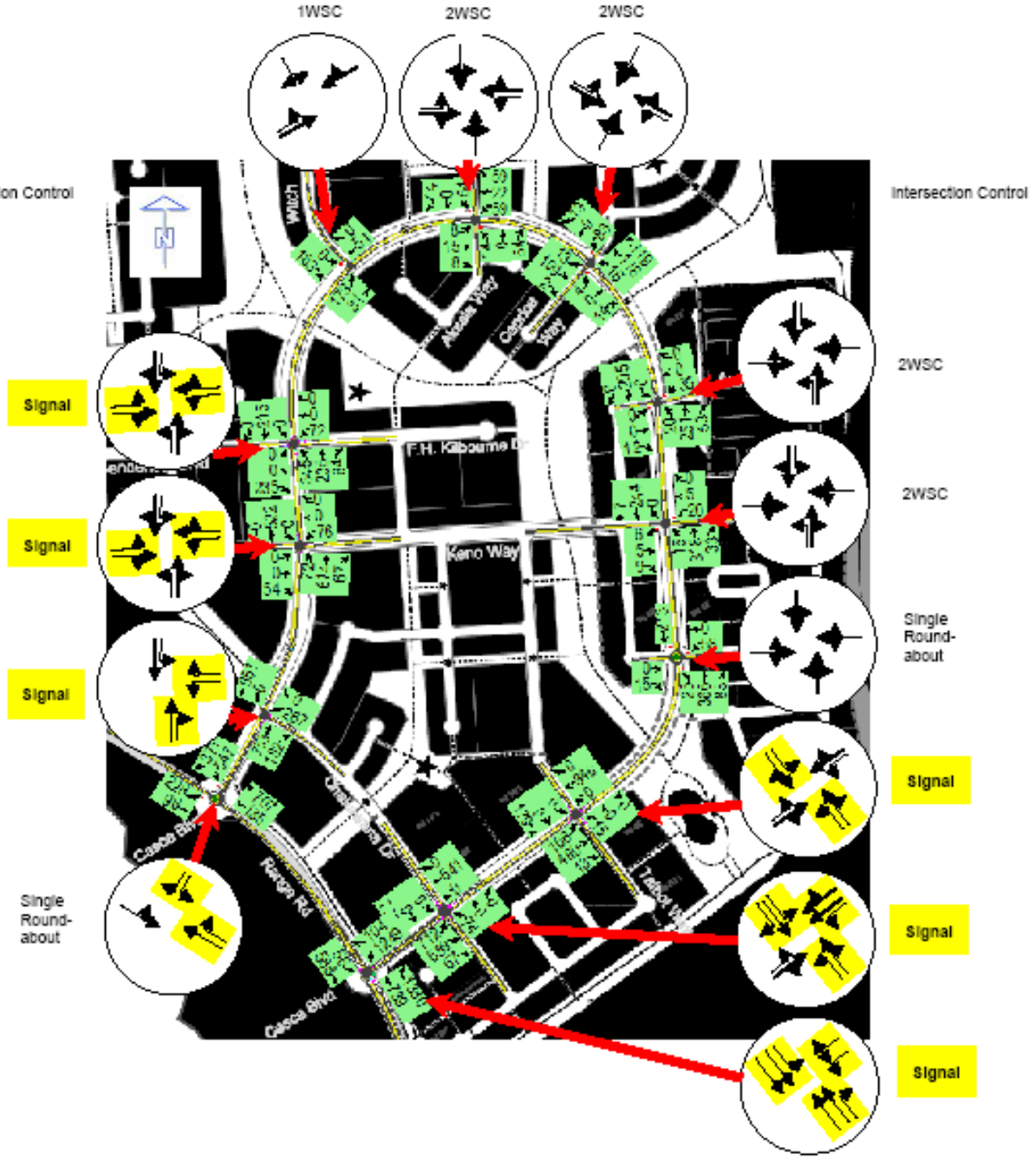


Figure 5.10 – PM Peak Hour Traffic Volumes and Laning – Full Build Recommended



Laning and storage length requirements around the area of the Range Road-Casca Boulevard connections are more complex and do not correspond to the minimum 30m storage lengths. These areas are better illustrated in Figures 5.11 and 5.12. The recommended network at full build-out is described as below.

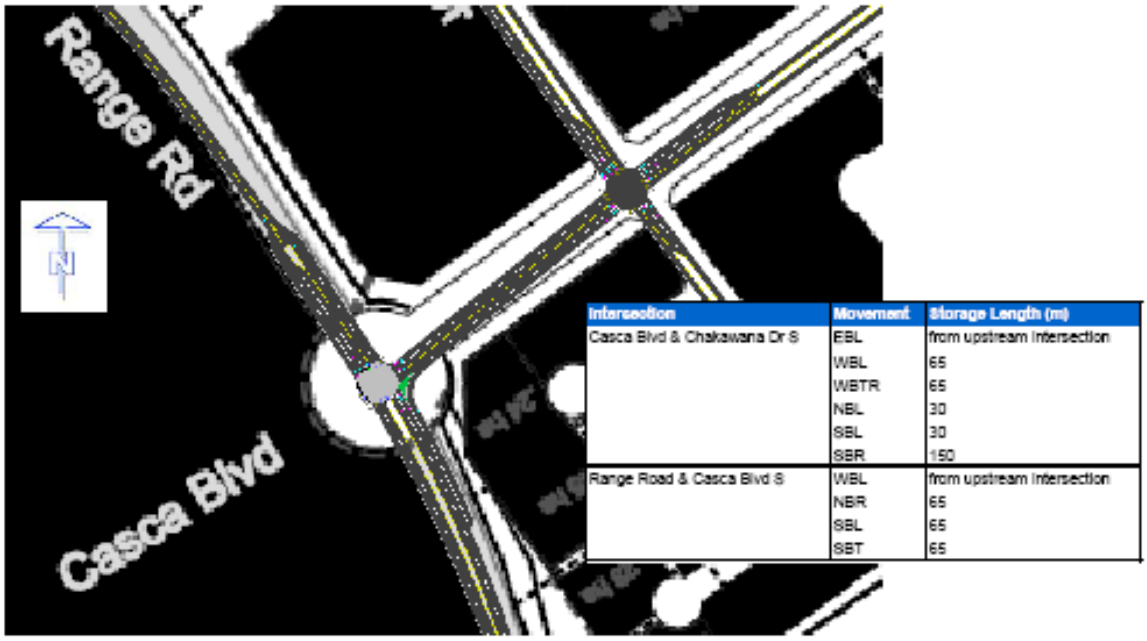
In general, the laning requirement for Casca Boulevard at full build-out is:

- One lane per direction between Chakawana Drive N and Chakawana Drive S
- Two lanes eastbound and one lane westbound between Range Road N and Chakawana Drive N
- Two lanes per direction between Range Road S and Chakawana Drive S

At Range Road/Casca Boulevard S (signalized)

- Laning and storage length requirements are illustrated in Figure 5.11.

Figure 5.11 – Recommended Laning at the South Connection to Range Road – Full Build



Intersection	Movement	Storage Length (m)
Casca Blvd & Chakawana Dr S	EBL	from upstream intersection
	WBL	65
	WBTR	65
	NBL	30
	SBL	30
	SBR	150
Range Road & Casca Blvd S	WBL	from upstream intersection
	NBR	65
	SBL	65
	SBT	65

At Casca Boulevard/Chakawana Drive S (signalized)

- Advanced phasing is required for the eastbound left turn movement to the commercial developments on Chakawana Drive.
- Laning and storage length requirements are illustrated in Figure 5.11.

At Casca Boulevard/Talbot Way (signalized)

- A 30m left turn lane on every approach.

At Casca Boulevard/Tarahane Drive (single roundabout)

- Single entrance exit lanes on all approaches.

For the following stop controlled intersections, pavement widened on the major approaches to separate left turning traffic and through traffic is recommended:

- Casca Boulevard/Keno Way S

At Casca Boulevard/Argonaut Way

- Pavement widened on the major approaches to separate left turning traffic and through traffic

At Casca Boulevard/Caprice Way

- Pavement widened on the major approaches to separate left turning traffic and through traffic

At Casca Boulevard/Aksala Way

- Pavement widened on the major approaches to separate left turning traffic and through traffic.

At Casca Boulevard/Witch Hazel Drive

- Pavement widened on the major approaches to separate left turning traffic and through traffic.

At Casca Boulevard/Independence Boulevard/F.H. Kilbourne Drive (signalized)

- A 30m left turn lane on every approach.

At Casca Boulevard/Keno Way N (signalized)

- Laning and storage length requirements are illustrated in Figure 5.12.

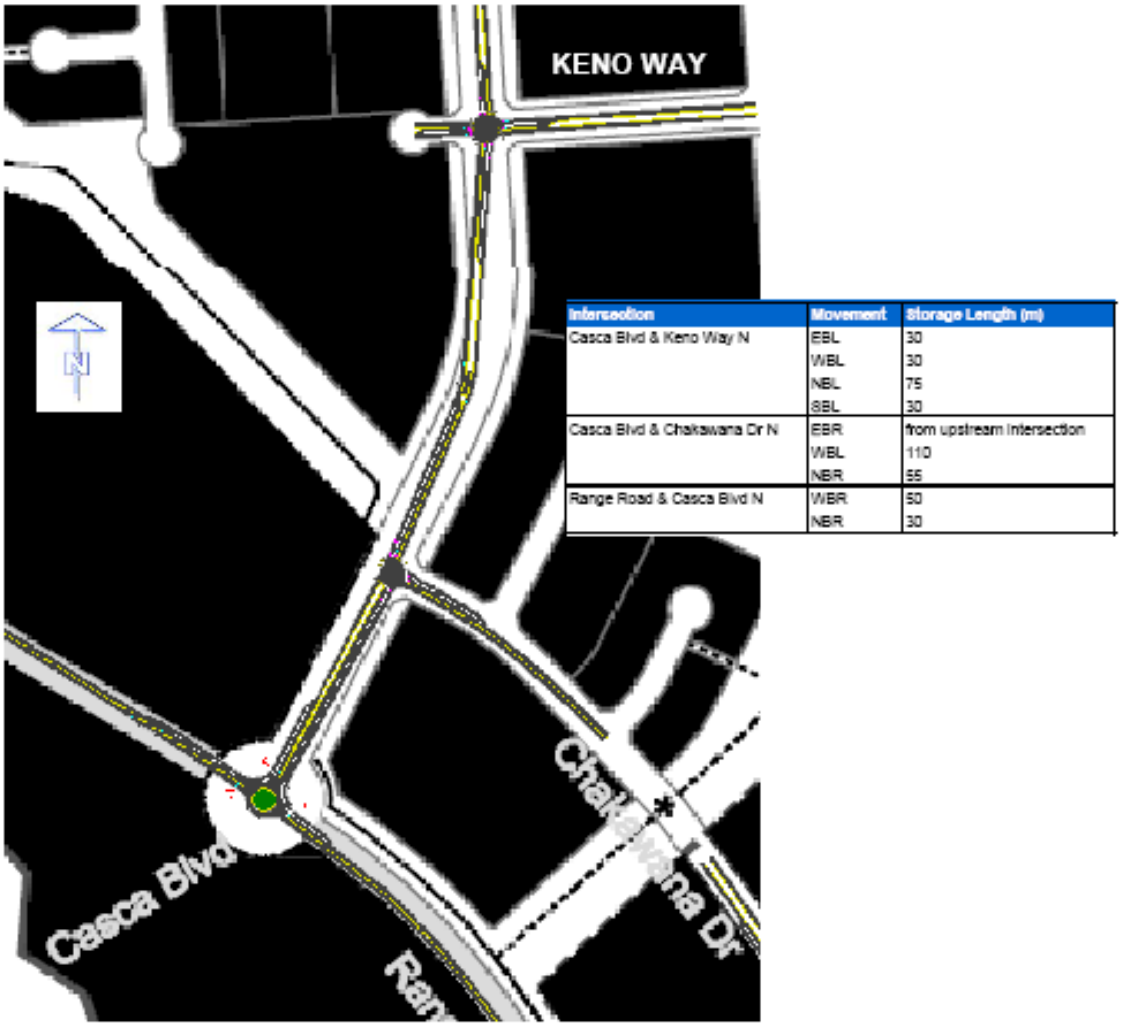
At Casca Boulevard/Chakawana Drive N (signalized)

- Laning and storage length requirements are illustrated in Figure 5.12.

At Range Road/Casca Boulevard N (single roundabout)

- Single bypass lanes for the northbound right turn movement into Whistle Bend and the westbound right turn movement out of Whistle Bend.
- Laning and storage length requirements are illustrated in Figure 5.12.

Figure 5.12 – Landing at the North Connection to Range Road – Full Build Recommended



5.11 Functional Classification of Roadways

Roadways within the City of Whitehorse are classified into three basics categories based on their function and use. The functional road hierarchy provides a foundation for a coherent and consistent approach to managing the road network, providing for the safe, effective and efficient movement of people and goods. The hierarchy provides a continuum between primarily providing access vs. the accommodation of through traffic.

Within the Whistle Bend neighborhood, the following classes of roadways are proposed:

- Local
- Collector
- Arterial

Local roadways function to provide direct access to properties. They are generally low speed (max 50 km/h) facilities in residential areas, with parking permitted within the 8.0 m travel way. Local roads connect to other local roads or collectors, but generally not to arterials.

In Phases 1 and 2, the following facilities would be expected to function as local roads within Whistle Bend:

- Aksala Place (renamed Tannana Place)
- Aksala Drive (renamed Tannana Drive* [assumed])
- Dora Crescent
- Bellingham Place (renamed Bellingham Loop)
- Eldorado Place (presently unnamed)
- Skookum Place (renamed Tarahane Place)
- Keno Way
- Iskoot Crescent (renamed Iskoot Way)

Collector roadways have the dual purpose of providing access to abutting properties as well as providing for through traffic movement. Their primary purpose is to distribute traffic within the community, by providing a link between local and arterial roads. Collector roads would generally operate with posted speeds of 50 km/h. Within the proposed 22 m RoW, dual sidewalks are proposed in support of the active transportation and sustainable focus of the community Cycling can be encouraged within the 11.5 m travel way through on-street (i.e., signed) bicycling facilities. Within Whistle Bend, we anticipate the following roads to function as collectors for Phase 1 and 2:

- Tarahane Way (renamed Chakawana Drive)
- Olive May Way (renamed Talbot Way)
- Skookum Drive (renamed Tarahane Drive)

Arterials are the highest class of roadways proposed for the neighbourhood. They are developed to accommodate the movement of traffic, with direct access to adjacent properties discouraged. Connections for arterials are intended to be limited to connection with other arterials or with collector roadways. In Whistle Bend, the arterial facilities support the alternative mode focus of the development with dual separated sidewalks, bicycle lanes, and provision for public transit. The posted speed would be limited to maximum 60km/h; however, 50 kph would also be acceptable. Casca Boulevard is anticipated to be the sole arterial within the community, connecting to the entrance and exit points along Range Road.

The functional hierarchy of the road network within Whistle Bend provides for a coherent and consistent approach to managing the road network. It provides for the appropriate and safe use of roads by all users, by reflecting the needs, priorities and function of each facility within the network. To this end, the proposed road network meets the requirements laid out in the Citywide Transportation Study (2005), with retaining a sustainable and active transportation focus.

5.12 Safety

An elementary school is proposed to be located in the northern quadrant of the proposed Casca Boulevard and Talbot Way intersection. Based on traffic analysis, signals are not recommended at the end of Phase 2 but are recommended at full build-out. While this elementary school is proposed to be built subsequent to Phase 2, signalization of the intersection is recommended from a pedestrian safety standpoint as soon as the school comes into service.

A secondary school is proposed for the western quadrant of the proposed Casca Boulevard and Keno Way intersection. Based on future traffic volumes, a signal is recommended at full build-out. From a pedestrian safety standpoint, this intersection should also be signalized concurrent to opening of the school.

With the sustainable community concept in mind, pedestrian actuated signals may be considered at the following locations to promote pedestrian safety and other modes of transportation:

- On Independence Boulevard adjacent to the proposed elementary school.
- On Casca Boulevard adjacent to transit stops.
- Near Town Square and nearby mixed use commercials.
- On Casca Boulevard at trail connections.

5.13 Transit Service Review

Bus service in the City of Whitehorse is provided by Whitehorse Transit for conventional transit services. Currently, Route 5 Takhini – College – CGC which operates on a 35-minute headway in the peak hours, runs on Range Road to the south of the proposed development. To service the population in Whistle Bend in the short term, route extension to the Casca Boulevard roundabout or the Tarahane Drive roundabout should be considered. If that is the case, these roundabouts must be designed to allow for such turning movements to be made by a bus. In the long term, there should be consideration for a new bus route dedicated to Whistle Bend which runs on the entire Casca Boulevard corridor. To accommodate increasing transit demand, it is anticipated that this bus route will run at a shorter headway than the current standard of 35 minutes. This is an important and sustainable feature of the subdivision to promote and encourage public transit in the new development.

5.14 Summary

To assess the impacts of the new development in Whistle Bend, four scenarios were developed. Two scenarios define the traffic conditions at the end of Phase 2; two scenarios define the traffic conditions at full build-out. Key findings of the traffic analysis include:

- Analysis shows requirements for the installation of signals at the intersection of Casca Boulevard and Chakawana Drive S to accommodate Phase 2 traffic demand.
- Laning requirement of Casca Boulevard suggests one lane per direction with intersection widening to accommodate Phase 2.
- Analysis shows both single roundabouts at the intersection of Range Road and Casca Boulevard N, and the intersection of Casca Boulevard and Tarahane Drive operate well at full build-out.
- However, a double roundabout at the intersection of Range Road and Casca Boulevard S will operate at a v/c ratio exceeding 1.0 at full build-out, suggesting the need for a signal at this location.
- At full build out, our analysis Casca Boulevard at Talbot Way, at Independence Boulevard/F.H. Kilbourne Drive, at Keno Way N, and at Chakawana Drive N. This does not preclude the use of roundabouts at these locations as a more sustainable option.
- Laning requirement of Casca Boulevard at full build-out suggests:
    - One lane per direction between Chakawana Drive N and Chakawana Drive S
    - Two lanes eastbound and one lane westbound between Range Road N and Chakawana Drive N
    - Two lanes per direction between Range Road S and Chakawana Drive S.
- Detailed laning and storage length requirements under full build-out conditions are illustrated in Figures 5.8 to 5.11.
- Intersection operations at the Casca Boulevard corridor indicate that with recommended improvements, all intersections operate at LOS “C” or better for all turning movements during both AM and PM, peak hours under full build-out conditions. All roundabouts operate at v/c ratio of 0.85 or less for all approaches during both peak hours under full build-out conditions.

6. Road Cross Sections

This section presents the proposed road cross-sections for this development. Figure 6.1 shows the proposed local road design within an 18 m wide road allowance. Figure 6.2 shows the proposed collector road design within a 22 m wide road allowance. Figure 6.3 shows the proposed arterial (major collector) road design within a 30 m road allowance with 10 m wide green corridors on each side.

The proposed road sections take into account sustainable planning objectives, Whitehorse servicing standards, recent land development projects (Copper Ridge, Takhini), and comments received from the City on the draft report.

6.1 Local Roads

The design of surface works is similar to the Whitehorse standard for this road class, except the asphalt width is slightly narrower and sidewalks are proposed on both sides of the street, per Copper Ridge development.

For the underground servicing, power/telecom ducts are centred 1 m off the curb and the watermain is on the opposite side of the road centre line. Sanitary and storm sewers are in the same trench with 1 m centre to centre separation, as suggested by the City following review of the draft report. With a vertical separation of over a metre between the sanitary and storm, future open cut repair of the sanitary sewer means the storm sewer would have to be supported. However, repairs of this type will be infrequent, and the initial cost savings will be significant. A 3 m centre to centre separation is provided between the storm sewer and the watermain to meet health requirements.

In accordance with the Servicing Standards Manual, street lighting is provided on one side of the road at 2.50 m offset from the front of the curb.

Allowance has been provided in the boulevard for future district heating requirements.

6.2 Collector Roads

The design of surface works is similar to the Whitehorse standard for this road class, except that separated sidewalks are shown on both sides of the road.

Lighting is shown on one side of the road with the pole located behind the sidewalk, 4.80 m offset from the front of the curb; or as an option, in front of the sidewalk, 2.50 m offset from the front of the curb.

Underground services are arranged similarly to the local road section, except with a wider separation between the power/telecom and the sanitary sewer.

Allowances have been provided in both boulevards for future district heating requirements.

6.3 Arterial Roads

The design of surface works is customized to this project. A divided road is proposed, with a 6.0 m wide median, which provides space for opposing left turn lanes where required, plus a refuge space for vehicles pulling out from side streets. The driving surface width of 5.5 m in both directions provides space for bicycle lanes. No dedicated bus pull-outs are provided, but the width of asphalt is sufficient for vehicles to pass stopped buses.

If right turn lanes are required in the future, they can be added by relocating the right side curb to suit.

Lighting is shown on both sides of the road with the poles located behind the sidewalks, 4.70 m offset from the front of the curb; or as an option, in front of the sidewalk, 2.50 m offset from the front of the curb.

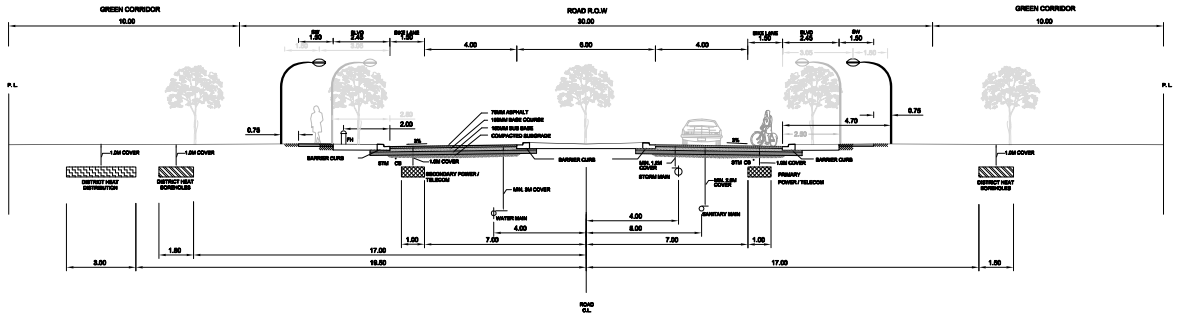
Underground services are arranged similarly to the collector road standard, except with a wider separation between the storm sewer and the watermain. Also an additional space is provided for secondary power/telecom, if necessary.

Landscaping trees are provided in the median and both boulevards. It is our understanding that existing trees in the green corridors will remain to the extent possible. Allowances have also been provided in each of the green corridors for future district heating requirements.

6.4 Options

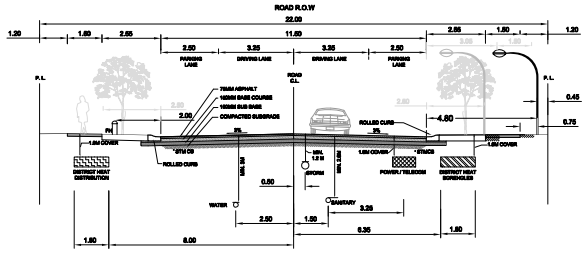
Following review of the draft cross sections, the City offered several suggestions of modifications or refinements that should be considered during detailed design, such as:

- Street lights in the centre median of arterial roads, in particular for the left-turn lanes
- Decorative lighting on local roads
- Boulevards and separate sidewalks on some local roads, space permitting.



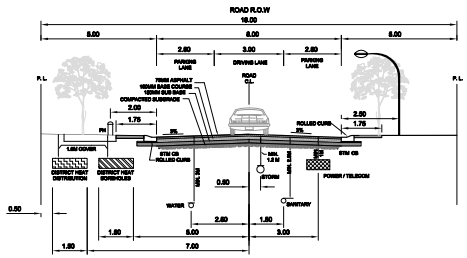
ARTERIAL ROAD

0 1 2 3 m SCALE 1:100



COLLECTOR ROAD

0 1 2 3 m SCALE 1:100



LOCAL ROAD

0 1 2 3 m SCALE 1:100

PLOT: 09/11/09 2:56:19 PM
A1 SIZE 59.39" x 33.11" (594mm x 841mm)
ISSUED A
ACCOUNT E NAME: 2501-04U00_SUC-FD13_RX.dwg Saved By: brenes
This drawing is the property of AECOM. Use of it for any purpose other than that for which it was prepared is prohibited. AECOM accepts no responsibility for any use of this drawing for any purpose other than that for which it was prepared and no responsibility whatsoever for any use made of it by others. Any use which a third party makes of this drawing is the responsibility of such third party. Such third party agrees that AECOM shall not be responsible for any loss or damage caused by use of this drawing by such third party. Any such third party use is without liability to AECOM and such third party shall indemnify AECOM for all loss or damage resulting therefrom. Any person using this drawing for any purpose agrees to the foregoing.

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Whistle Bend
Typical Cross Sections
Figure 6.1

7. Cost Estimates

7.1 Cost Estimate Summary – Onsite Servicing

The total cost of development of all phases of the onsite work, including contingencies and engineering, but excluding Heiland and Ta'an sections, is $117,330,000. Class C Cost Estimates have been prepared for Phases 1 and 2 of the proposed development. The estimates are summarized as follows:

Phase 1

1.	Water Distribution System	$4,753,000
2.	Wastewater Collection and Disposal	4,613,900
3.	Stormwater Management	600,500
4	Landscaping	
5.	Transportation	4,856,600
6.	Hydro/Cable/Tel	2,247,000
	Subtotal	**$17,071,000**
	Mobilization	150,000
	Contingency and Estimating Allowance (+15%)	2,583,200
	Subtotal	**$19,804,200**
	Engineering (+15%)	2,970,600
	Total	**$22,774,800**
	Rounded Total	**$22,770,000**

Phase 2

1.	Water Distribution System	$2,298,000
2.	Wastewater Collection and Disposal	2,076,500
3.	Stormwater Management	986,900
4.	Transportation	7,402,900
5.	Hydro/Cable/Tel	2,061,000
	Subtotal	**$14,825,300**
	Mobilization	130,000
	Contingency and Estimating Allowance (+15%)	2,243,300
	Subtotal	**$17,198,600**
	Engineering (+15%)	2,579,800
	Total	**$19,778,400**
	Rounded Total	**$19,780,000**

Class D cost estimates have been prepared for Phases 3 through 6 of the proposed development. The estimates are summarized as follows:

Phase 3

1.	Water Distribution System	$2,031,700
2.	Wastewater Collection and Disposal	2,763,800
3.	Stormwater Management	611,500
4.	Transportation	7,003,400
5.	Hydro/Cable/Tel	2,523,000
	Subtotal	**$14,933,400**
	Mobilization	140,000
	Contingency and Estimating Allowance (+25%)	3,768,400
	Subtotal	**$18,841,800**
	Engineering (+15%)	2,826,200
	Total	**$21,670,000**
	Rounded Total	**$21,670,000**

Phase 4

1.	Water Distribution System	$1,128,300
2.	Wastewater Collection and Disposal	933,200
3.	Stormwater Management	689,000
4.	Transportation	6,708,400
5.	Hydro/Cable/Tel	1,002,000
	Subtotal	**$10,460,900**
	Mobilization	100,000
	Contingency and Estimating Allowance (+25%)	2,640,200
	Subtotal	**$13,201,100**
	Engineering (+15%)	1,980,200
	Total	**$15,181,300**
	Rounded Total	**$15,180,000**

Phase 5

1.	Water Distribution System	$1,114,100
2.	Wastewater Collection and Disposal	1,006,800
3.	Stormwater Management	537,400
4.	Transportation	2,931,400
5.	Hydro/Cable/Tel	930,000
	Subtotal	**$6,519,700**
	Mobilization	65,000
	Contingency and Estimating Allowance (+25%)	1,646,200
	Subtotal	**$8,230,900**
	Engineering (+15%)	1,234,600
	Total	**$9,465,500**
	Rounded total	**$9,470,000**

Phase 6

1.	Water Distribution System	$3,530,000
2.	Wastewater Collection and Disposal	3,167,000
3.	Stormwater Management	967,500
4.	Landscaping	
5	Transportation	9,361,900
6.	Hydro/Cable/Tel	2,604,000
	Subtotal	**$19,630,400**
	Mobilization	165,000
	Contingency and Estimating Allowance (+25%)	4,948,900
	Subtotal	**$24,744,300**
	Engineering (+15%)	3,711,600
	Total	**$28,455,900**
	Rounded Total	**$28,460,000**

Detailed breakdowns of the above costs are provided in the previously submitted Cost Summary Report.

Note that the above costs do not include the cost of servicing the Heiland or Ta'an lands in Phase 2 and Phase 5. These costs are summarized below as Class D estimates. Detailed breakdowns are also included in the Cost Summary Report.

Heiland

1.	Water Distribution System	$ 945,300
2.	Wastewater Collection and Disposal	603,900
3.	Stormwater Management	512,100
4.	Transportation	1,951,200
5.	Hydro/Cable/Tel	624,000
	Subtotal	$4,636,500
	Mobilization	50,000
	Contingency and Estimating Allowance (+25%)	1,171,600
	Subtotal	$5,858,100
	Engineering (+15%)	878,700
	Total	$6,736,800
	Rounded Total	$6,740,000

Ta'an

1.	Water Distribution System	$1,720,900
2.	Wastewater Collection and Disposal	1,530,400
3.	Stormwater Management	476,700
4.	Transportation	4,481,400
5.	Hydro/Cable/Tel	1,671,000
	Subtotal	**$9,880,400**
	Mobilization	100,000
	Contingency and Estimating Allowance (+25%)	2,495,100
	Subtotal	**$12,475,500**
	Engineering (+15%)	1,871,300
	Total	**$14,346,800**
	Rounded Total	**$14,350,000**

The cost estimates include a 15% contingency and estimating allowance for Class C design. The basic unit prices are, for the most part, derived from 2008 budget prices provided by Quest Engineering Ltd. Recent land development projects in Whitehorse have been awarded to out-of-town contractors at substantially lower prices. We have continued to use the Quest 2008 budget prices for these estimates, assuming that prices will return to near Whitehorse normal costs in the near future. The basic unit prices in the estimate are thus considered to be conservative on the high side. In conjunction with good quantity take-offs from the preliminary design drawings, a 15% contingency and estimating allowance is considered appropriate for all Class C estimates.

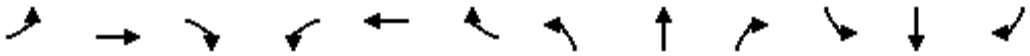
We have not attempted to estimate an escalation factor for future years, since we have no expertise in economic forecasting. We have reviewed the historical increases in Consumer Price Index for Whitehorse. (We were unable to find any records relating to construction cost index.) The Consumer Price Index indicates average inflation of less than 2% per year from 1998 to 2008. In 2007 and 2008, inflation was somewhat higher than average, at 2.5% and 3.6%, respectively.

Exclusions from the above estimates are as follows:

1. GST
2. Escalation after 2009
3. Land and legal costs, legal survey
4. Environmental site clean-up costs, if any.
5. Costs due to detailed design changes
6. Winter work.

Appendix A

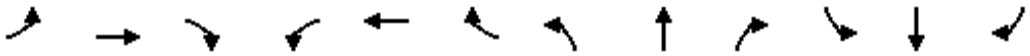
Appendix A:
Synchro HCM Results



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	232	150	46	0	245	0	54	0	0	0	0	270
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	252	163	50	0	266	0	59	0	0	0	0	293
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	266			213			1252	959	188	934	984	266
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	266			213			1252	959	188	934	984	266
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	80			100			25	100	100	100	100	62
cM capacity (veh/h)	1280			1369			79	208	859	211	201	765

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	252	213	0	266	59	293
Volume Left	252	0	0	0	59	0
Volume Right	0	50	0	0	0	293
cSH	1280	1700	1700	1700	79	765
Volume to Capacity	0.20	0.13	0.00	0.16	0.75	0.38
Queue Length 95th (m)	5.9	0.0	0.0	0.0	28.8	14.5
Control Delay (s)	8.5	0.0	0.0	0.0	129.9	12.6
Lane LOS	A				F	B
Approach Delay (s)	4.6		0.0		129.9	12.6
Approach LOS					F	B

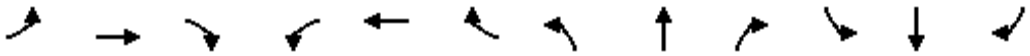
Intersection Summary			
Average Delay	12.4		
Intersection Capacity Utilization	59.1%	ICU Level of Service	B
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	15	119	15	0	209	0	18	0	0	0	0	18
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	16	129	16	0	227	0	20	0	0	0	0	20
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	227			146			417	397	138	389	405	227
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	227			146			417	397	138	389	405	227
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			100			96	100	100	100	100	98
cM capacity (veh/h)	1353			1449			532	537	916	568	531	817

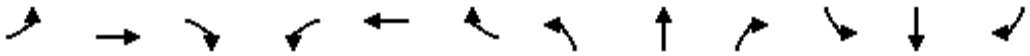
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	16	146	0	227	20	20
Volume Left	16	0	0	0	20	0
Volume Right	0	16	0	0	0	20
cSH	1353	1700	1700	1700	532	817
Volume to Capacity	0.01	0.09	0.00	0.13	0.04	0.02
Queue Length 95th (m)	0.3	0.0	0.0	0.0	0.9	0.6
Control Delay (s)	7.7	0.0	0.0	0.0	12.0	9.5
Lane LOS	A				B	A
Approach Delay (s)	0.8		0.0		12.0	9.5
Approach LOS					B	A

Intersection Summary				
Average Delay	1.3			
Intersection Capacity Utilization	26.8%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	0	20	121	0	0	8	28	82	0	69	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	22	132	0	0	9	30	89	0	75	0
Approach Volume (veh/h)		22			132			128			75	
Crossing Volume (veh/h)		207			39			0			140	
High Capacity (veh/h)		1178			1343			1385			1241	
High v/c (veh/h)		0.02			0.10			0.09			0.06	
Low Capacity (veh/h)		974			1123			1161			1031	
Low v/c (veh/h)		0.02			0.12			0.11			0.07	

Intersection Summary					
Maximum v/c High	0.10				
Maximum v/c Low	0.12				
Intersection Capacity Utilization	33.7%	ICU Level of Service		A	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	20	29	0	0	8	8	12	0	20	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	22	32	0	0	9	9	13	0	22	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	48	61	22	76	54	15	22			22		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	48	61	22	76	54	15	22			22		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	98	96	100	100	99			100		
cM capacity (veh/h)	954	829	1061	896	836	1070	1607			1607		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	22	32	9	22	0	22
Volume Left	0	32	9	0	0	0
Volume Right	22	0	0	13	0	0
cSH	1061	896	1607	1700	1700	1700
Volume to Capacity	0.02	0.04	0.01	0.01	0.00	0.01
Queue Length 95th (m)	0.5	0.9	0.1	0.0	0.0	0.0
Control Delay (s)	8.5	9.2	7.3	0.0	0.0	0.0
Lane LOS	A	A	A			
Approach Delay (s)	8.5	9.2	2.1		0.0	
Approach LOS	A	A				

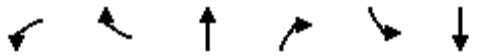
Intersection Summary				
Average Delay	5.1			
Intersection Capacity Utilization	21.6%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	0	10	10	0	4	4
Sign Control	Stop			Stop	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	11	11	0	4	4
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	13	0	20	9	0	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	13	0	20	9	0	
tC, single (s)	6.5	6.2	7.1	6.5	4.1	
tC, 2 stage (s)						
tF (s)	4.0	3.3	3.5	4.0	2.2	
p0 queue free %	100	99	99	100	100	
cM capacity (veh/h)	883	1091	987	888	1636	

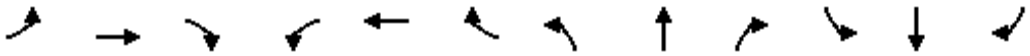
Direction, Lane #	EB 1	WB 1	NB 1	NB 2
Volume Total	11	11	4	4
Volume Left	0	11	4	0
Volume Right	11	0	0	4
cSH	1091	987	1636	1700
Volume to Capacity	0.01	0.01	0.00	0.00
Queue Length 95th (m)	0.2	0.3	0.1	0.0
Control Delay (s)	8.3	8.7	7.2	0.0
Lane LOS	A	A	A	
Approach Delay (s)	8.3	8.7	3.6	
Approach LOS	A	A		

Intersection Summary				
Average Delay	7.1			
Intersection Capacity Utilization	17.2%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized						
Volume (veh/h)	501	69	15	339	89	25
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	545	75	16	368	97	27
Approach Volume (veh/h)	620		385			124
Crossing Volume (veh/h)	16		97			545
High Capacity (veh/h)	1367		1284			901
High v/c (veh/h)	0.45		0.30			0.14
Low Capacity (veh/h)	1145		1070			725
Low v/c (veh/h)	0.54		0.36			0.17

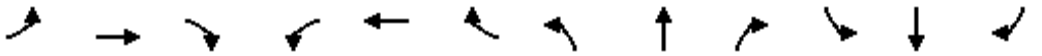
Intersection Summary				
Maximum v/c High	0.45			
Maximum v/c Low	0.54			
Intersection Capacity Utilization	70.0%	ICU Level of Service		C



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	302	277	60	0	250	0	63	0	0	0	0	316
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	328	301	65	0	272	0	68	0	0	0	0	343
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	272			366			1605	1262	334	1229	1295	272
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	272			366			1605	1262	334	1229	1295	272
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	74			100			0	100	100	100	100	55
cM capacity (veh/h)	1274			1203			38	127	713	125	122	760

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	328	366	0	272	68	343
Volume Left	328	0	0	0	68	0
Volume Right	0	65	0	0	0	343
cSH	1274	1700	1700	1700	38	760
Volume to Capacity	0.26	0.22	0.00	0.16	1.82	0.45
Queue Length 95th (m)	8.3	0.0	0.0	0.0	58.8	18.9
Control Delay (s)	8.8	0.0	0.0	0.0	620.8	13.6
Lane LOS	A				F	B
Approach Delay (s)	4.2		0.0		620.8	13.6
Approach LOS					F	B

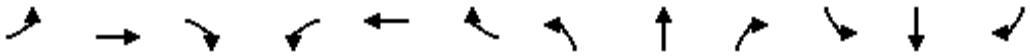
Intersection Summary			
Average Delay	36.3		
Intersection Capacity Utilization	66.3%	ICU Level of Service	C
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	20	237	20	0	208	0	21	0	0	0	0	21
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	22	258	22	0	226	0	23	0	0	0	0	23
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	226			279			561	538	268	527	549	226
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	226			279			561	538	268	527	549	226
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	98			100			95	100	100	100	100	97
cM capacity (veh/h)	1354			1295			424	445	775	459	439	818

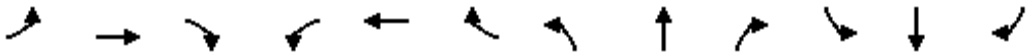
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	22	279	0	226	23	23
Volume Left	22	0	0	0	23	0
Volume Right	0	22	0	0	0	23
cSH	1354	1700	1700	1700	424	818
Volume to Capacity	0.02	0.16	0.00	0.13	0.05	0.03
Queue Length 95th (m)	0.4	0.0	0.0	0.0	1.4	0.7
Control Delay (s)	7.7	0.0	0.0	0.0	14.0	9.5
Lane LOS	A				B	A
Approach Delay (s)	0.6		0.0		14.0	9.5
Approach LOS					B	A

Intersection Summary				
Average Delay	1.2			
Intersection Capacity Utilization	31.1%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	0	16	134	0	0	21	75	140	0	58	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	17	146	0	0	23	82	152	0	63	0
Approach Volume (veh/h)		17			146			257			63	
Crossing Volume (veh/h)		209			104			0			168	
High Capacity (veh/h)		1176			1276			1385			1214	
High v/c (veh/h)		0.01			0.11			0.19			0.05	
Low Capacity (veh/h)		972			1063			1161			1006	
Low v/c (veh/h)		0.02			0.14			0.22			0.06	

Intersection Summary				
Maximum v/c High	0.19			
Maximum v/c Low	0.22			
Intersection Capacity Utilization	41.1%	ICU Level of Service	A	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	16	25	0	0	21	21	32	0	16	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	17	27	0	0	23	23	35	0	17	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	86	121	17	121	103	40	17			58		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	86	121	17	121	103	40	17			58		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	98	97	100	100	99			100		
cM capacity (veh/h)	895	762	1067	836	779	1037	1613			1560		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	17	27	23	58	0	17
Volume Left	0	27	23	0	0	0
Volume Right	17	0	0	35	0	0
cSH	1067	836	1613	1700	1700	1700
Volume to Capacity	0.02	0.03	0.01	0.03	0.00	0.01
Queue Length 95th (m)	0.4	0.8	0.3	0.0	0.0	0.0
Control Delay (s)	8.4	9.5	7.3	0.0	0.0	0.0
Lane LOS	A	A	A			
Approach Delay (s)	8.4	9.5	2.1		0.0	
Approach LOS	A	A				

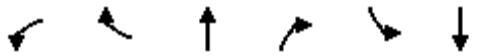
Intersection Summary				
Average Delay	4.0			
Intersection Capacity Utilization	22.5%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	0	8	8	0	11	11
Sign Control	Stop			Stop	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	9	9	0	12	12
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	36	0	33	24	0	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	36	0	33	24	0	
tC, single (s)	6.5	6.2	7.1	6.5	4.1	
tC, 2 stage (s)						
tF (s)	4.0	3.3	3.5	4.0	2.2	
p0 queue free %	100	99	99	100	99	
cM capacity (veh/h)	854	1091	967	867	1636	

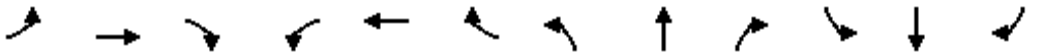
Direction, Lane #	EB 1	WB 1	NB 1	NB 2
Volume Total	9	9	12	12
Volume Left	0	9	12	0
Volume Right	9	0	0	12
cSH	1091	967	1636	1700
Volume to Capacity	0.01	0.01	0.01	0.01
Queue Length 95th (m)	0.2	0.2	0.2	0.0
Control Delay (s)	8.3	8.8	7.2	0.0
Lane LOS	A	A	A	
Approach Delay (s)	8.3	8.8	3.6	
Approach LOS	A	A		

Intersection Summary			
Average Delay	5.7		
Intersection Capacity Utilization	16.6%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized						
Volume (veh/h)	498	132	31	563	77	38
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	541	143	34	612	84	41
Approach Volume (veh/h)	685		646			125
Crossing Volume (veh/h)	34		84			541
High Capacity (veh/h)	1349		1297			903
High v/c (veh/h)	0.51		0.50			0.14
Low Capacity (veh/h)	1129		1082			728
Low v/c (veh/h)	0.61		0.60			0.17

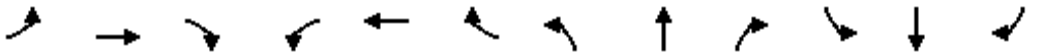
Intersection Summary				
Maximum v/c High		0.51		
Maximum v/c Low		0.61		
Intersection Capacity Utilization		88.3%	ICU Level of Service	E



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	232	150	46	0	245	0	54	0	0	0	0	270
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0			5.0		5.0					5.0
Lane Util. Factor	1.00	1.00			1.00		1.00					1.00
Frt	1.00	0.96			1.00		1.00					0.85
Flt Protected	0.95	1.00			1.00		0.95					1.00
Satd. Flow (prot)	1719	1833			1900		1805					1538
Flt Permitted	0.42	1.00			1.00		1.00					1.00
Satd. Flow (perm)	762	1833			1900		1900					1538
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	252	163	50	0	266	0	59	0	0	0	0	293
RTOR Reduction (vph)	0	14	0	0	0	0	0	0	0	0	0	204
Lane Group Flow (vph)	252	199	0	0	266	0	59	0	0	0	0	89
Heavy Vehicles (%)	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
Turn Type	pm+pt			Perm			Perm			Perm		pm+ov
Protected Phases	5	2			6			8			4	5
Permitted Phases	2			6			8			4		4
Actuated Green, G (s)	25.5	25.5			12.1		3.4					11.8
Effective Green, g (s)	25.5	25.5			12.1		3.4					11.8
Actuated g/C Ratio	0.66	0.66			0.31		0.09					0.30
Clearance Time (s)	5.0	5.0			5.0		5.0					5.0
Vehicle Extension (s)	3.0	3.0			3.0		3.0					3.0
Lane Grp Cap (vph)	706	1202			591		166					664
v/s Ratio Prot	c0.08	0.11			c0.14							0.03
v/s Ratio Perm	0.16						c0.03					0.03
v/c Ratio	0.36	0.17			0.45		0.36					0.13
Uniform Delay, d1	3.1	2.6			10.7		16.7					9.8
Progression Factor	1.00	1.00			1.00		1.00					1.00
Incremental Delay, d2	0.3	0.1			0.5		1.3					0.1
Delay (s)	3.4	2.7			11.3		18.0					9.9
Level of Service	A	A			B		B					A
Approach Delay (s)		3.1			11.3			18.0			9.9	
Approach LOS		A			B			B			A	

Intersection Summary			
HCM Average Control Delay	7.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	38.9	Sum of lost time (s)	15.0
Intersection Capacity Utilization	45.4%	ICU Level of Service	A
Analysis Period (min)	15		

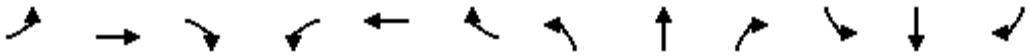
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	15	119	15	0	209	0	18	0	0	0	0	18
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	16	129	16	0	227	0	20	0	0	0	0	20
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		289										
pX, platoon unblocked												
vC, conflicting volume	227			146			417	397	138	389	405	227
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	227			146			417	397	138	389	405	227
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			100			96	100	100	100	100	98
cM capacity (veh/h)	1353			1449			532	537	916	568	531	817

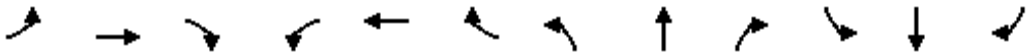
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	16	146	0	227	20	20
Volume Left	16	0	0	0	20	0
Volume Right	0	16	0	0	0	20
cSH	1353	1700	1700	1700	532	817
Volume to Capacity	0.01	0.09	0.00	0.13	0.04	0.02
Queue Length 95th (m)	0.3	0.0	0.0	0.0	0.9	0.6
Control Delay (s)	7.7	0.0	0.0	0.0	12.0	9.5
Lane LOS	A				B	A
Approach Delay (s)	0.8		0.0		12.0	9.5
Approach LOS					B	A

Intersection Summary				
Average Delay	1.3			
Intersection Capacity Utilization	26.8%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	0	20	121	0	0	8	28	82	0	69	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	22	132	0	0	9	30	89	0	75	0
Approach Volume (veh/h)		22			132			128			75	
Crossing Volume (veh/h)		207			39			0			140	
High Capacity (veh/h)		1178			1343			1385			1241	
High v/c (veh/h)		0.02			0.10			0.09			0.06	
Low Capacity (veh/h)		974			1123			1161			1031	
Low v/c (veh/h)		0.02			0.12			0.11			0.07	

Intersection Summary					
Maximum v/c High	0.10				
Maximum v/c Low	0.12				
Intersection Capacity Utilization	33.7%	ICU Level of Service		A	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	20	29	0	0	8	8	12	0	20	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	22	32	0	0	9	9	13	0	22	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	48	61	22	76	54	15	22			22		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	48	61	22	76	54	15	22			22		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	98	96	100	100	99			100		
cM capacity (veh/h)	954	829	1061	896	836	1070	1607			1607		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	22	32	9	22	0	22
Volume Left	0	32	9	0	0	0
Volume Right	22	0	0	13	0	0
cSH	1061	896	1607	1700	1700	1700
Volume to Capacity	0.02	0.04	0.01	0.01	0.00	0.01
Queue Length 95th (m)	0.5	0.9	0.1	0.0	0.0	0.0
Control Delay (s)	8.5	9.2	7.3	0.0	0.0	0.0
Lane LOS	A	A	A			
Approach Delay (s)	8.5	9.2	2.1		0.0	
Approach LOS	A	A				

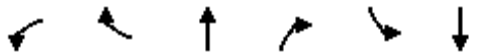
Intersection Summary				
Average Delay	5.1			
Intersection Capacity Utilization	21.6%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	0	10	10	0	4	4
Sign Control	Stop			Stop	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	11	11	0	4	4
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	13	0	20	9	0	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	13	0	20	9	0	
tC, single (s)	6.5	6.2	7.1	6.5	4.1	
tC, 2 stage (s)						
tF (s)	4.0	3.3	3.5	4.0	2.2	
p0 queue free %	100	99	99	100	100	
cM capacity (veh/h)	883	1091	987	888	1636	

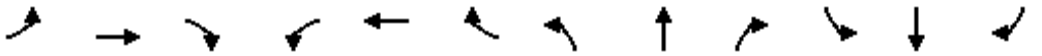
Direction, Lane #	EB 1	WB 1	NB 1	NB 2
Volume Total	11	11	4	4
Volume Left	0	11	4	0
Volume Right	11	0	0	4
cSH	1091	987	1636	1700
Volume to Capacity	0.01	0.01	0.00	0.00
Queue Length 95th (m)	0.2	0.3	0.1	0.0
Control Delay (s)	8.3	8.7	7.2	0.0
Lane LOS	A	A	A	
Approach Delay (s)	8.3	8.7	3.6	
Approach LOS	A	A		

Intersection Summary				
Average Delay	7.1			
Intersection Capacity Utilization	17.2%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized						
Volume (veh/h)	501	69	15	339	89	25
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	545	75	16	368	97	27
Approach Volume (veh/h)	620		385			124
Crossing Volume (veh/h)	16		97			545
High Capacity (veh/h)	1367		1284			901
High v/c (veh/h)	0.45		0.30			0.14
Low Capacity (veh/h)	1145		1070			725
Low v/c (veh/h)	0.54		0.36			0.17

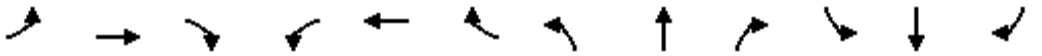
Intersection Summary				
Maximum v/c High	0.45			
Maximum v/c Low	0.54			
Intersection Capacity Utilization	70.0%	ICU Level of Service		C



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	302	277	60	0	250	0	63	0	0	0	0	316
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0			5.0		5.0					5.0
Lane Util. Factor	1.00	1.00			1.00		1.00					1.00
Frt	1.00	0.97			1.00		1.00					0.85
Flt Protected	0.95	1.00			1.00		0.95					1.00
Satd. Flow (prot)	1719	1849			1900		1805					1538
Flt Permitted	0.41	1.00			1.00		0.80					1.00
Satd. Flow (perm)	741	1849			1900		1520					1538
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	328	301	65	0	272	0	68	0	0	0	0	343
RTOR Reduction (vph)	0	11	0	0	0	0	0	0	0	0	0	215
Lane Group Flow (vph)	328	355	0	0	272	0	68	0	0	0	0	128
Heavy Vehicles (%)	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
Turn Type	pm+pt			Perm			Perm			Perm		pm+ov
Protected Phases	5	2			6			8			4	5
Permitted Phases	2			6			8			4		4
Actuated Green, G (s)	25.1	25.1			11.5		5.0					13.6
Effective Green, g (s)	25.1	25.1			11.5		5.0					13.6
Actuated g/C Ratio	0.63	0.63			0.29		0.12					0.34
Clearance Time (s)	5.0	5.0			5.0		5.0					5.0
Vehicle Extension (s)	3.0	3.0			3.0		3.0					3.0
Lane Grp Cap (vph)	674	1157			545		190					713
v/s Ratio Prot	c0.10	0.19			0.14							0.04
v/s Ratio Perm	c0.20						c0.04					0.04
v/c Ratio	0.49	0.31			0.50		0.36					0.18
Uniform Delay, d1	3.9	3.5			11.9		16.1					9.3
Progression Factor	1.00	1.00			1.00		1.00					1.00
Incremental Delay, d2	0.6	0.2			0.7		1.2					0.1
Delay (s)	4.5	3.6			12.6		17.2					9.4
Level of Service	A	A			B		B					A
Approach Delay (s)		4.0			12.6			17.2			9.4	
Approach LOS		A			B			B			A	

Intersection Summary			
HCM Average Control Delay	7.7	HCM Level of Service	A
HCM Volume to Capacity ratio	0.44		
Actuated Cycle Length (s)	40.1	Sum of lost time (s)	10.0
Intersection Capacity Utilization	48.7%	ICU Level of Service	A
Analysis Period (min)	15		

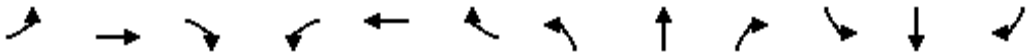
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	20	237	20	0	208	0	21	0	0	0	0	21
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	22	258	22	0	226	0	23	0	0	0	0	23
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		289										
pX, platoon unblocked												
vC, conflicting volume	226			279			561	538	268	527	549	226
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	226			279			561	538	268	527	549	226
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	98			100			95	100	100	100	100	97
cM capacity (veh/h)	1354			1295			424	445	775	459	439	818

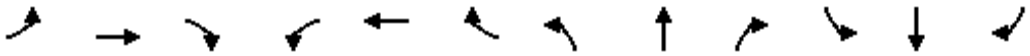
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	22	279	0	226	23	23
Volume Left	22	0	0	0	23	0
Volume Right	0	22	0	0	0	23
cSH	1354	1700	1700	1700	424	818
Volume to Capacity	0.02	0.16	0.00	0.13	0.05	0.03
Queue Length 95th (m)	0.4	0.0	0.0	0.0	1.4	0.7
Control Delay (s)	7.7	0.0	0.0	0.0	14.0	9.5
Lane LOS	A				B	A
Approach Delay (s)	0.6		0.0		14.0	9.5
Approach LOS					B	A

Intersection Summary				
Average Delay	1.2			
Intersection Capacity Utilization	31.1%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	0	16	134	0	0	21	75	140	0	58	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	17	146	0	0	23	82	152	0	63	0
Approach Volume (veh/h)		17			146			257			63	
Crossing Volume (veh/h)		209			104			0			168	
High Capacity (veh/h)		1176			1276			1385			1214	
High v/c (veh/h)		0.01			0.11			0.19			0.05	
Low Capacity (veh/h)		972			1063			1161			1006	
Low v/c (veh/h)		0.02			0.14			0.22			0.06	

Intersection Summary				
Maximum v/c High	0.19			
Maximum v/c Low	0.22			
Intersection Capacity Utilization	41.1%	ICU Level of Service	A	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	16	25	0	0	21	21	32	0	16	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	17	27	0	0	23	23	35	0	17	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	86	121	17	121	103	40	17			58		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	86	121	17	121	103	40	17			58		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	98	97	100	100	99			100		
cM capacity (veh/h)	895	762	1067	836	779	1037	1613			1560		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	17	27	23	58	0	17
Volume Left	0	27	23	0	0	0
Volume Right	17	0	0	35	0	0
cSH	1067	836	1613	1700	1700	1700
Volume to Capacity	0.02	0.03	0.01	0.03	0.00	0.01
Queue Length 95th (m)	0.4	0.8	0.3	0.0	0.0	0.0
Control Delay (s)	8.4	9.5	7.3	0.0	0.0	0.0
Lane LOS	A	A	A			
Approach Delay (s)	8.4	9.5	2.1		0.0	
Approach LOS	A	A				

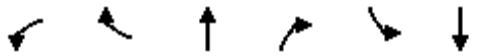
Intersection Summary				
Average Delay	4.0			
Intersection Capacity Utilization	22.5%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	0	8	8	0	11	11
Sign Control	Stop			Stop	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	9	9	0	12	12
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	36	0	33	24	0	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	36	0	33	24	0	
tC, single (s)	6.5	6.2	7.1	6.5	4.1	
tC, 2 stage (s)						
tF (s)	4.0	3.3	3.5	4.0	2.2	
p0 queue free %	100	99	99	100	99	
cM capacity (veh/h)	854	1091	967	867	1636	

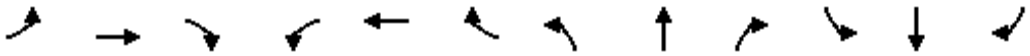
Direction, Lane #	EB 1	WB 1	NB 1	NB 2
Volume Total	9	9	12	12
Volume Left	0	9	12	0
Volume Right	9	0	0	12
cSH	1091	967	1636	1700
Volume to Capacity	0.01	0.01	0.01	0.01
Queue Length 95th (m)	0.2	0.2	0.2	0.0
Control Delay (s)	8.3	8.8	7.2	0.0
Lane LOS	A	A	A	
Approach Delay (s)	8.3	8.8	3.6	
Approach LOS	A	A		

Intersection Summary			
Average Delay	5.7		
Intersection Capacity Utilization	16.6%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized						
Volume (veh/h)	498	132	31	563	77	38
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	541	143	34	612	84	41
Approach Volume (veh/h)	685		646			125
Crossing Volume (veh/h)	34		84			541
High Capacity (veh/h)	1349		1297			903
High v/c (veh/h)	0.51		0.50			0.14
Low Capacity (veh/h)	1129		1082			728
Low v/c (veh/h)	0.61		0.60			0.17

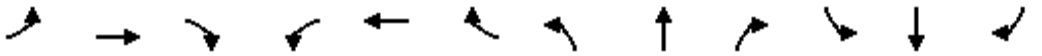
Intersection Summary				
Maximum v/c High		0.51		
Maximum v/c Low		0.61		
Intersection Capacity Utilization		88.3%	ICU Level of Service	E



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	527	365	52	0	660	0	50	0	0	0	0	542
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	573	397	57	0	717	0	54	0	0	0	0	589
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	717			453			2877	2288	425	2260	2316	717
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	717			453			2877	2288	425	2260	2316	717
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	34			100			0	100	100	100	100	0
cM capacity (veh/h)	870			1118			0	14	634	14	13	424

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	573	453	0	717	54	589
Volume Left	573	0	0	0	54	0
Volume Right	0	57	0	0	0	589
cSH	870	1700	1700	1700	0	424
Volume to Capacity	0.66	0.27	0.00	0.42	Err	1.39
Queue Length 95th (m)	40.7	0.0	0.0	0.0	Err	227.0
Control Delay (s)	16.7	0.0	0.0	0.0	Err	214.6
Lane LOS	C				F	F
Approach Delay (s)	9.3		0.0		Err	214.6
Approach LOS					F	F

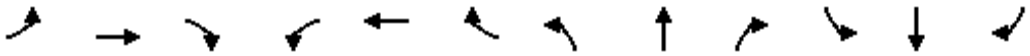
Intersection Summary				
Average Delay	Err			
Intersection Capacity Utilization	114.2%	ICU Level of Service	H	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	125	229	10	0	526	0	10	0	0	0	0	124
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	136	249	11	0	572	0	11	0	0	0	0	135
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	572			260			1233	1098	254	1092	1103	572
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	572			260			1233	1098	254	1092	1103	572
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	87			100			89	100	100	100	100	74
cM capacity (veh/h)	1011			1316			103	186	789	174	184	524

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	136	260	0	572	11	135
Volume Left	136	0	0	0	11	0
Volume Right	0	11	0	0	0	135
cSH	1011	1700	1700	1700	103	524
Volume to Capacity	0.13	0.15	0.00	0.34	0.11	0.26
Queue Length 95th (m)	3.7	0.0	0.0	0.0	2.7	8.1
Control Delay (s)	9.1	0.0	0.0	0.0	43.9	14.2
Lane LOS	A				E	B
Approach Delay (s)	3.1		0.0		43.9	14.2
Approach LOS					E	B

Intersection Summary				
Average Delay	3.3			
Intersection Capacity Utilization	52.9%	ICU Level of Service		A
Analysis Period (min)	15			



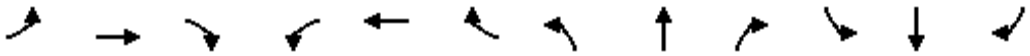
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	0	31	107	0	0	9	184	36	0	388	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	34	116	0	0	10	200	39	0	422	0
Approach Volume (veh/h)		34			116			249			422	
Crossing Volume (veh/h)		538			210			0			126	
High Capacity (veh/h)		905			1175			1385			1255	
High v/c (veh/h)		0.04			0.10			0.18			0.34	
Low Capacity (veh/h)		730			971			1161			1043	
Low v/c (veh/h)		0.05			0.12			0.21			0.40	

Intersection Summary				
Maximum v/c High	0.34			
Maximum v/c Low	0.40			
Intersection Capacity Utilization	39.7%	ICU Level of Service	A	

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	4	3	18	40	5	0	6	166	12	0	329	8
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	4	3	20	43	5	0	7	180	13	0	358	9
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	558	568	362	579	566	187	366			193		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	558	568	362	579	566	187	366			193		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	99	99	97	89	99	100	99			100		
cM capacity (veh/h)	437	433	687	413	434	860	1203			1392		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	27	49	7	193	0	366
Volume Left	4	43	7	0	0	0
Volume Right	20	0	0	13	0	9
cSH	591	415	1203	1700	1700	1700
Volume to Capacity	0.05	0.12	0.01	0.11	0.00	0.22
Queue Length 95th (m)	1.2	3.2	0.1	0.0	0.0	0.0
Control Delay (s)	11.4	14.8	8.0	0.0	0.0	0.0
Lane LOS	B	B	A			
Approach Delay (s)	11.4	14.8	0.3		0.0	
Approach LOS	B	B				

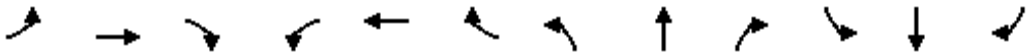
Intersection Summary				
Average Delay	1.7			
Intersection Capacity Utilization	33.6%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	24	63	0	0	7	142	21	0	250	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	26	68	0	0	8	154	23	0	272	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	441	464	272	479	453	166	272			177		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	441	464	272	479	453	166	272			177		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	97	86	100	100	99			100		
cM capacity (veh/h)	527	495	772	481	503	884	1303			1411		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	26	68	8	177	0	272
Volume Left	0	68	8	0	0	0
Volume Right	26	0	0	23	0	0
cSH	772	481	1303	1700	1700	1700
Volume to Capacity	0.03	0.14	0.01	0.10	0.00	0.16
Queue Length 95th (m)	0.8	3.9	0.1	0.0	0.0	0.0
Control Delay (s)	9.8	13.7	7.8	0.0	0.0	0.0
Lane LOS	A	B	A			
Approach Delay (s)	9.8	13.7	0.3		0.0	
Approach LOS	A	B				

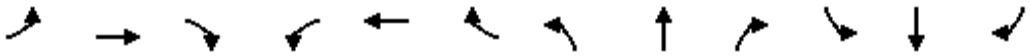
Intersection Summary				
Average Delay	2.3			
Intersection Capacity Utilization	30.0%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	12	111	3	10	78	54	2	0	14	125	0	14
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	13	121	3	11	85	59	2	0	15	136	0	15
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	143			124			270	314	122	298	286	114
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	143			124			270	314	122	298	286	114
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			99			100	100	98	79	100	98
cM capacity (veh/h)	1451			1475			667	595	934	640	617	944

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	13	124	11	143	17	151
Volume Left	13	0	11	0	2	136
Volume Right	0	3	0	59	15	15
cSH	1451	1700	1475	1700	890	661
Volume to Capacity	0.01	0.07	0.01	0.08	0.02	0.23
Queue Length 95th (m)	0.2	0.0	0.2	0.0	0.5	7.0
Control Delay (s)	7.5	0.0	7.5	0.0	9.1	12.1
Lane LOS	A		A		A	B
Approach Delay (s)	0.7		0.5		9.1	12.1
Approach LOS					A	B

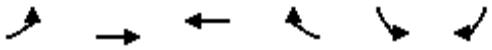
Intersection Summary				
Average Delay	4.7			
Intersection Capacity Utilization	31.1%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	10	15	10	39	16	39	8	0	56	56	0	8
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	11	16	11	42	17	42	9	0	61	61	0	9
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	60			27			154	188	22	222	172	39
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	60			27			154	188	22	222	172	39
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			97			99	100	94	91	100	99
cM capacity (veh/h)	1557			1600			790	687	1061	678	700	1039

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	11	27	42	60	70	70
Volume Left	11	0	42	0	9	61
Volume Right	0	11	0	42	61	9
cSH	1557	1700	1600	1700	1018	709
Volume to Capacity	0.01	0.02	0.03	0.04	0.07	0.10
Queue Length 95th (m)	0.2	0.0	0.7	0.0	1.8	2.6
Control Delay (s)	7.3	0.0	7.3	0.0	8.8	10.6
Lane LOS	A		A		A	B
Approach Delay (s)	2.1		3.0		8.8	10.6
Approach LOS					A	B

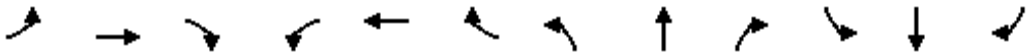
Intersection Summary				
Average Delay	6.2			
Intersection Capacity Utilization	25.8%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	114	36	31	0	0	170
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	124	39	34	0	0	185
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	34				321	34
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	34				321	34
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	92				100	82
cM capacity (veh/h)	1591				624	1045

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	124	39	34	185
Volume Left	124	0	0	0
Volume Right	0	0	0	185
cSH	1591	1700	1700	1045
Volume to Capacity	0.08	0.02	0.02	0.18
Queue Length 95th (m)	2.0	0.0	0.0	5.1
Control Delay (s)	7.5	0.0	0.0	9.2
Lane LOS	A			A
Approach Delay (s)	5.7		0.0	9.2
Approach LOS				A

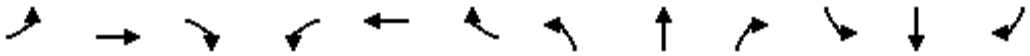
Intersection Summary			
Average Delay	6.9		
Intersection Capacity Utilization	30.2%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	426	50	0	0	248	150	53	0	201	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	463	54	0	0	270	163	58	0	218	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	921	978	218	1412	949	192	218			221		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	921	978	218	1412	949	192	218			221		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	44	0	100	100	80			100		
cM capacity (veh/h)	215	202	826	43	210	855	1363			1360		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	463	54	270	221	0	218
Volume Left	0	54	270	0	0	0
Volume Right	463	0	0	58	0	0
cSH	826	43	1363	1700	1700	1700
Volume to Capacity	0.56	1.25	0.20	0.13	0.00	0.13
Queue Length 95th (m)	28.4	42.0	5.9	0.0	0.0	0.0
Control Delay (s)	14.8	366.9	8.3	0.0	0.0	0.0
Lane LOS	B	F	A			
Approach Delay (s)	14.8	366.9	4.6		0.0	
Approach LOS	B	F				

Intersection Summary				
Average Delay	23.7			
Intersection Capacity Utilization	67.4%	ICU Level of Service	C	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	98	60	0	0	89	450	53	0	677	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	107	65	0	0	97	489	58	0	736	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	1418	1476	736	1554	1447	518	736			547		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1418	1476	736	1554	1447	518	736			547		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	75	0	100	100	89			100		
cM capacity (veh/h)	106	113	422	64	118	562	879			1033		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	107	65	97	547	0	736
Volume Left	0	65	97	0	0	0
Volume Right	107	0	0	58	0	0
cSH	422	64	879	1700	1700	1700
Volume to Capacity	0.25	1.02	0.11	0.32	0.00	0.43
Queue Length 95th (m)	7.9	40.3	3.0	0.0	0.0	0.0
Control Delay (s)	16.4	228.1	9.6	0.0	0.0	0.0
Lane LOS	C	F	A			
Approach Delay (s)	16.4	228.1	1.4		0.0	
Approach LOS	C	F				

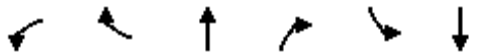
Intersection Summary				
Average Delay	11.3			
Intersection Capacity Utilization	60.6%	ICU Level of Service	B	
Analysis Period (min)	15			



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	593	193	0	835	141	0
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	645	210	0	908	153	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			854		1657	749
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			854		1657	749
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			100		0	100
cM capacity (veh/h)			794		106	415

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	854	0	908	153
Volume Left	0	0	0	153
Volume Right	210	0	0	0
cSH	1700	1700	1700	106
Volume to Capacity	0.50	0.00	0.53	1.45
Queue Length 95th (m)	0.0	0.0	0.0	88.9
Control Delay (s)	0.0	0.0	0.0	319.9
Lane LOS				F
Approach Delay (s)	0.0	0.0		319.9
Approach LOS				F

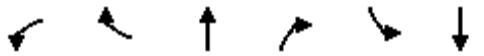
Intersection Summary			
Average Delay	25.6		
Intersection Capacity Utilization	58.4%	ICU Level of Service	B
Analysis Period (min)	15		



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized						
Volume (veh/h)	1203	48	510	872	72	780
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1308	52	554	948	78	848
Approach Volume (veh/h)	1360		1502			926
Crossing Volume (veh/h)	554		78			1308#
High Capacity (veh/h)	894		1303			483
High v/c (veh/h)	1.52		1.15			1.92
Low Capacity (veh/h)	719		1087			364
Low v/c (veh/h)	1.89		1.38			2.54

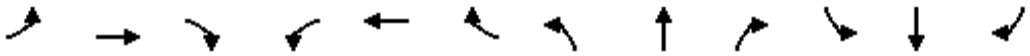
Intersection Summary			
Maximum v/c High	1.92		
Maximum v/c Low	2.54		
Intersection Capacity Utilization	177.0%	ICU Level of Service	H

Crossing flow exceeds 1200, method is not applicable



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized						
Volume (veh/h)	755	220	63	496	290	97
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	821	239	68	539	315	105
Approach Volume (veh/h)	1060		608			421
Crossing Volume (veh/h)	68		315			821
High Capacity (veh/h)	1313		1081			721
High v/c (veh/h)	0.81		0.56			0.58
Low Capacity (veh/h)	1096		886			568
Low v/c (veh/h)	0.97		0.69			0.74

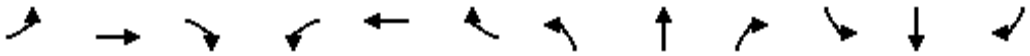
Intersection Summary			
Maximum v/c High	0.81		
Maximum v/c Low	0.97		
Intersection Capacity Utilization	120.4%	ICU Level of Service	H



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	712	659	67	0	541	0	74	0	0	0	0	738
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	774	716	73	0	588	0	80	0	0	0	0	802
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	588			789			3691	2889	753	2852	2925	588
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	588			789			3691	2889	753	2852	2925	588
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	20			100			0	100	100	100	100	0
cM capacity (veh/h)	972			840			0	3	413	4	3	503

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	774	789	0	588	80	802
Volume Left	774	0	0	0	80	0
Volume Right	0	73	0	0	0	802
cSH	972	1700	1700	1700	0	503
Volume to Capacity	0.80	0.46	0.00	0.35	Err	1.59
Queue Length 95th (m)	69.3	0.0	0.0	0.0	Err	353.4
Control Delay (s)	21.4	0.0	0.0	0.0	Err	297.4
Lane LOS	C				F	F
Approach Delay (s)	10.6		0.0		Err	297.4
Approach LOS					F	F

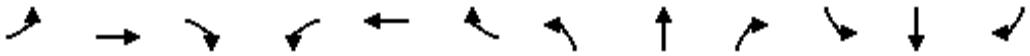
Intersection Summary			
Average Delay	Err		
Intersection Capacity Utilization	131.0%	ICU Level of Service	H
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	166	480	13	0	346	0	15	0	0	0	0	179
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	180	522	14	0	376	0	16	0	0	0	0	195
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	376			536			1460	1266	529	1259	1273	376
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	376			536			1460	1266	529	1259	1273	376
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	85			100			76	100	100	100	100	71
cM capacity (veh/h)	1193			1042			68	145	554	132	143	675

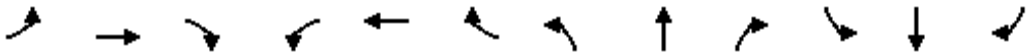
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	180	536	0	376	16	195
Volume Left	180	0	0	0	16	0
Volume Right	0	14	0	0	0	195
cSH	1193	1700	1700	1700	68	675
Volume to Capacity	0.15	0.32	0.00	0.22	0.24	0.29
Queue Length 95th (m)	4.3	0.0	0.0	0.0	6.7	9.5
Control Delay (s)	8.6	0.0	0.0	0.0	73.9	12.5
Lane LOS	A				F	B
Approach Delay (s)	2.2		0.0		73.9	12.5
Approach LOS					F	B

Intersection Summary				
Average Delay	4.0			
Intersection Capacity Utilization	51.8%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	0	15	58	0	0	25	366	88	0	273	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	16	63	0	0	27	398	96	0	297	0
Approach Volume (veh/h)		16			63			521			297	
Crossing Volume (veh/h)		360			425			0			90	
High Capacity (veh/h)		1044			991			1385			1291	
High v/c (veh/h)		0.02			0.06			0.38			0.23	
Low Capacity (veh/h)		853			806			1161			1076	
Low v/c (veh/h)		0.02			0.08			0.45			0.28	

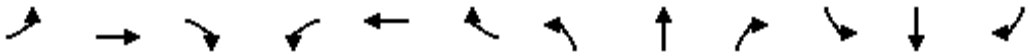
Intersection Summary				
Maximum v/c High	0.38			
Maximum v/c Low	0.45			
Intersection Capacity Utilization	60.2%	ICU Level of Service	B	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	6	5	9	20	5	0	15	318	33	0	244	7
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	7	5	10	22	5	0	16	346	36	0	265	8
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	650	683	269	674	669	364	273			382		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	650	683	269	674	669	364	273			382		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	98	99	99	94	99	100	99			100		
cM capacity (veh/h)	377	369	775	359	376	686	1302			1188		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	22	27	16	382	0	273
Volume Left	7	22	16	0	0	0
Volume Right	10	0	0	36	0	8
cSH	487	362	1302	1700	1700	1700
Volume to Capacity	0.04	0.08	0.01	0.22	0.00	0.16
Queue Length 95th (m)	1.1	1.9	0.3	0.0	0.0	0.0
Control Delay (s)	12.7	15.7	7.8	0.0	0.0	0.0
Lane LOS	B	C	A			
Approach Delay (s)	12.7	15.7	0.3		0.0	
Approach LOS	B	C				

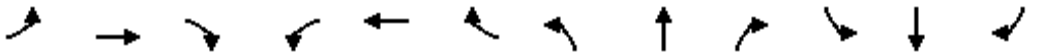
Intersection Summary				
Average Delay	1.2			
Intersection Capacity Utilization	28.7%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	12	35	0	0	20	251	53	0	205	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	13	38	0	0	22	273	58	0	223	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	539	597	223	581	568	302	223			330		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	539	597	223	581	568	302	223			330		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	98	91	100	100	98			100		
cM capacity (veh/h)	451	412	822	416	428	743	1358			1240		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	13	38	22	330	0	223
Volume Left	0	38	22	0	0	0
Volume Right	13	0	0	58	0	0
cSH	822	416	1358	1700	1700	1700
Volume to Capacity	0.02	0.09	0.02	0.19	0.00	0.13
Queue Length 95th (m)	0.4	2.4	0.4	0.0	0.0	0.0
Control Delay (s)	9.5	14.5	7.7	0.0	0.0	0.0
Lane LOS	A	B	A			
Approach Delay (s)	9.5	14.5	0.5		0.0	
Approach LOS	A	B				

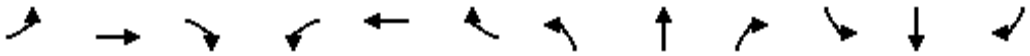
Intersection Summary				
Average Delay	1.3			
Intersection Capacity Utilization	31.9%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	13	109	2	15	118	119	4	0	14	83	0	19
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	14	118	2	16	128	129	4	0	15	90	0	21
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	258			121			329	438	120	388	374	193
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	258			121			329	438	120	388	374	193
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			99			99	100	98	84	100	98
cM capacity (veh/h)	1319			1480			603	504	937	556	547	854

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	14	121	16	258	20	111
Volume Left	14	0	16	0	4	90
Volume Right	0	2	0	129	15	21
cSH	1319	1700	1480	1700	834	595
Volume to Capacity	0.01	0.07	0.01	0.15	0.02	0.19
Queue Length 95th (m)	0.3	0.0	0.3	0.0	0.6	5.4
Control Delay (s)	7.8	0.0	7.5	0.0	9.4	12.4
Lane LOS	A		A		A	B
Approach Delay (s)	0.8		0.4		9.4	12.4
Approach LOS					A	B

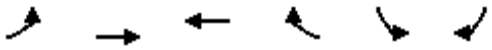
Intersection Summary				
Average Delay	3.3			
Intersection Capacity Utilization	32.6%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	8	15	8	59	22	59	14	0	54	54	0	14
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	9	16	9	64	24	64	15	0	59	59	0	15
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	88			25			205	254	21	277	227	56
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	88			25			205	254	21	277	227	56
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			96			98	100	94	91	100	99
cM capacity (veh/h)	1520			1603			719	623	1063	620	645	1016

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	9	25	64	88	74	74
Volume Left	9	0	64	0	15	59
Volume Right	0	9	0	64	59	15
cSH	1520	1700	1603	1700	968	674
Volume to Capacity	0.01	0.01	0.04	0.05	0.08	0.11
Queue Length 95th (m)	0.1	0.0	1.0	0.0	2.0	2.9
Control Delay (s)	7.4	0.0	7.3	0.0	9.0	11.0
Lane LOS	A		A		A	B
Approach Delay (s)	1.9		3.1		9.0	11.0
Approach LOS					A	B

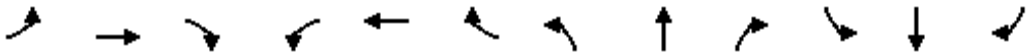
Intersection Summary				
Average Delay	6.0			
Intersection Capacity Utilization	27.1%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	173	31	51	0	0	163
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	188	34	55	0	0	177
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	55				465	55
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	55				465	55
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	88				100	83
cM capacity (veh/h)	1562				492	1017

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	188	34	55	177
Volume Left	188	0	0	0
Volume Right	0	0	0	177
cSH	1562	1700	1700	1017
Volume to Capacity	0.12	0.02	0.03	0.17
Queue Length 95th (m)	3.3	0.0	0.0	5.0
Control Delay (s)	7.6	0.0	0.0	9.3
Lane LOS	A			A
Approach Delay (s)	6.5		0.0	9.3
Approach LOS				A

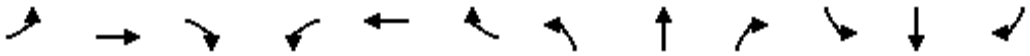
Intersection Summary			
Average Delay	6.8		
Intersection Capacity Utilization	33.0%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	235	72	0	0	345	205	64	0	215	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	255	78	0	0	375	223	70	0	234	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	1207	1276	234	1497	1241	258	234			292		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1207	1276	234	1497	1241	258	234			292		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	68	0	100	100	72			100		
cM capacity (veh/h)	127	121	810	55	127	786	1346			1281		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	255	78	375	292	0	234
Volume Left	0	78	375	0	0	0
Volume Right	255	0	0	70	0	0
cSH	810	55	1346	1700	1700	1700
Volume to Capacity	0.32	1.43	0.28	0.17	0.00	0.14
Queue Length 95th (m)	10.8	56.6	9.2	0.0	0.0	0.0
Control Delay (s)	11.5	394.0	8.7	0.0	0.0	0.0
Lane LOS	B	F	A			
Approach Delay (s)	11.5	394.0	4.9		0.0	
Approach LOS	B	F				

Intersection Summary				
Average Delay	30.0			
Intersection Capacity Utilization	62.3%	ICU Level of Service	B	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	54	76	0	0	72	614	67	0	522	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	59	83	0	0	78	667	73	0	567	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	1391	1464	567	1486	1428	704	567			740		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1391	1464	567	1486	1428	704	567			740		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	89	5	100	100	92			100		
cM capacity (veh/h)	114	120	527	87	126	441	1015			876		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	59	83	78	740	0	567
Volume Left	0	83	78	0	0	0
Volume Right	59	0	0	73	0	0
cSH	527	87	1015	1700	1700	1700
Volume to Capacity	0.11	0.95	0.08	0.44	0.00	0.33
Queue Length 95th (m)	3.0	42.5	2.0	0.0	0.0	0.0
Control Delay (s)	12.7	169.8	8.8	0.0	0.0	0.0
Lane LOS	B	F	A			
Approach Delay (s)	12.7	169.8	0.8		0.0	
Approach LOS	B	F				

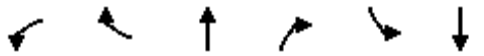
Intersection Summary				
Average Delay	10.1			
Intersection Capacity Utilization	60.6%	ICU Level of Service	B	
Analysis Period (min)	15			



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	753	182	0	651	267	0
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	818	198	0	708	290	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			1016		1625	917
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			1016		1625	917
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			100		0	100
cM capacity (veh/h)			690		111	332

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	1016	0	708	290
Volume Left	0	0	0	290
Volume Right	198	0	0	0
cSH	1700	1700	1700	111
Volume to Capacity	0.60	0.00	0.42	2.62
Queue Length 95th (m)	0.0	0.0	0.0	212.3
Control Delay (s)	0.0	0.0	0.0	816.0
Lane LOS				F
Approach Delay (s)	0.0	0.0		816.0
Approach LOS				F

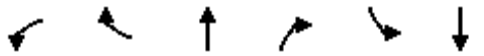
Intersection Summary			
Average Delay	117.6		
Intersection Capacity Utilization	72.1%	ICU Level of Service	C
Analysis Period (min)	15		



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized						
Volume (veh/h)	1249	104	739	1380	58	586
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1358	113	803	1500	63	637
Approach Volume (veh/h)	1471		2303			700
Crossing Volume (veh/h)	803		63			1358#
High Capacity (veh/h)	731		1318			463
High v/c (veh/h)	2.01		1.75			1.51
Low Capacity (veh/h)	576		1101			348
Low v/c (veh/h)	2.55		2.09			2.01

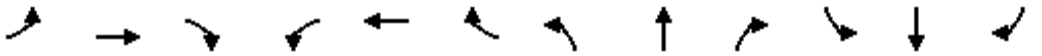
Intersection Summary			
Maximum v/c High	2.01		
Maximum v/c Low	2.55		
Intersection Capacity Utilization	205.8%	ICU Level of Service	H

Crossing flow exceeds 1200, method is not applicable



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized						
Volume (veh/h)	547	371	135	707	228	96
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	595	403	147	768	248	104
Approach Volume (veh/h)	998		915			352
Crossing Volume (veh/h)	147		248			595
High Capacity (veh/h)	1235		1140			865
High v/c (veh/h)	0.81		0.80			0.41
Low Capacity (veh/h)	1025		940			694
Low v/c (veh/h)	0.97		0.97			0.51

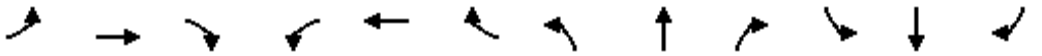
Intersection Summary			
Maximum v/c High	0.81		
Maximum v/c Low	0.97		
Intersection Capacity Utilization	131.4%	ICU Level of Service	H



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	527	365	52	0	660	0	50	0	0	0	0	542
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0			5.0		5.0					5.0
Lane Util. Factor	1.00	1.00			0.95		1.00					1.00
Frt	1.00	0.98			1.00		1.00					0.85
Flt Protected	0.95	1.00			1.00		0.95					1.00
Satd. Flow (prot)	1719	1864			3610		1805					1538
Flt Permitted	0.18	1.00			1.00		0.76					1.00
Satd. Flow (perm)	331	1864			3610		1439					1538
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	573	397	57	0	717	0	54	0	0	0	0	589
RTOR Reduction (vph)	0	6	0	0	0	0	0	0	0	0	0	15
Lane Group Flow (vph)	573	449	0	0	717	0	54	0	0	0	0	574
Heavy Vehicles (%)	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
Turn Type	pm+pt			Perm			Perm			Perm		pm+ov
Protected Phases	5	2			6			8			4	5
Permitted Phases	2			6			8			4		4
Actuated Green, G (s)	43.5	43.5			16.9		6.5					28.1
Effective Green, g (s)	43.5	43.5			16.9		6.5					28.1
Actuated g/C Ratio	0.72	0.72			0.28		0.11					0.47
Clearance Time (s)	5.0	5.0			5.0		5.0					5.0
Vehicle Extension (s)	3.0	3.0			3.0		3.0					3.0
Lane Grp Cap (vph)	740	1351			1017		156					848
v/s Ratio Prot	c0.28	0.24			0.20							c0.24
v/s Ratio Perm	c0.28						0.04					0.13
v/c Ratio	0.77	0.33			0.71		0.35					0.68
Uniform Delay, d1	10.5	3.0			19.3		24.8					12.4
Progression Factor	0.93	0.90			1.01		1.00					1.00
Incremental Delay, d2	4.1	0.1			3.9		1.3					2.2
Delay (s)	13.8	2.8			23.4		26.1					14.6
Level of Service	B	A			C		C					B
Approach Delay (s)		9.0			23.4			26.1			14.6	
Approach LOS		A			C			C			B	

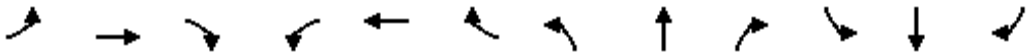
Intersection Summary			
HCM Average Control Delay	15.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	67.6%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	125	229	10	0	526	0	10	0	0	0	0	124
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0			5.0		5.0				5.0	
Lane Util. Factor	1.00	1.00			1.00		1.00				1.00	
Frt	1.00	0.99			1.00		1.00				0.85	
Flt Protected	0.95	1.00			1.00		0.95				1.00	
Satd. Flow (prot)	1805	1888			1900		1805				1615	
Flt Permitted	0.42	1.00			1.00		0.67				1.00	
Satd. Flow (perm)	798	1888			1900		1274				1615	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	136	249	11	0	572	0	11	0	0	0	0	135
RTOR Reduction (vph)	0	2	0	0	0	0	0	0	0	0	120	0
Lane Group Flow (vph)	136	258	0	0	572	0	11	0	0	0	15	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	43.2	43.2			43.2		6.8				6.8	
Effective Green, g (s)	43.2	43.2			43.2		6.8				6.8	
Actuated g/C Ratio	0.72	0.72			0.72		0.11				0.11	
Clearance Time (s)	5.0	5.0			5.0		5.0				5.0	
Vehicle Extension (s)	3.0	3.0			3.0		3.0				3.0	
Lane Grp Cap (vph)	575	1359			1368		144				183	
v/s Ratio Prot		0.14			c0.30						c0.01	
v/s Ratio Perm	0.17						0.01					
v/c Ratio	0.24	0.19			0.42		0.08				0.08	
Uniform Delay, d1	2.8	2.7			3.4		23.8				23.8	
Progression Factor	0.65	0.55			1.00		1.00				1.00	
Incremental Delay, d2	0.2	0.1			0.9		0.2				0.2	
Delay (s)	2.1	1.6			4.3		24.0				24.0	
Level of Service	A	A			A		C				C	
Approach Delay (s)		1.7			4.3			24.0			24.0	
Approach LOS		A			A			C			C	

Intersection Summary			
HCM Average Control Delay	6.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	55.4%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



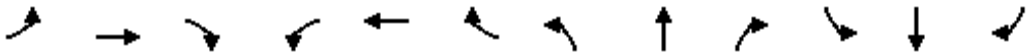
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	0	31	107	0	0	9	184	36	0	388	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	34	116	0	0	10	200	39	0	422	0
Approach Volume (veh/h)		34			116			249			422	
Crossing Volume (veh/h)		538			210			0			126	
High Capacity (veh/h)		905			1175			1385			1255	
High v/c (veh/h)		0.04			0.10			0.18			0.34	
Low Capacity (veh/h)		730			971			1161			1043	
Low v/c (veh/h)		0.05			0.12			0.21			0.40	

Intersection Summary				
Maximum v/c High	0.34			
Maximum v/c Low	0.40			
Intersection Capacity Utilization	39.7%	ICU Level of Service	A	

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	4	3	18	40	5	0	6	166	12	0	329	8
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	4	3	20	43	5	0	7	180	13	0	358	9
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	558	568	362	579	566	187	366			193		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	558	568	362	579	566	187	366			193		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	99	99	97	89	99	100	99			100		
cM capacity (veh/h)	437	433	687	413	434	860	1203			1392		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	27	49	7	193	0	366
Volume Left	4	43	7	0	0	0
Volume Right	20	0	0	13	0	9
cSH	591	415	1203	1700	1700	1700
Volume to Capacity	0.05	0.12	0.01	0.11	0.00	0.22
Queue Length 95th (m)	1.2	3.2	0.1	0.0	0.0	0.0
Control Delay (s)	11.4	14.8	8.0	0.0	0.0	0.0
Lane LOS	B	B	A			
Approach Delay (s)	11.4	14.8	0.3		0.0	
Approach LOS	B	B				

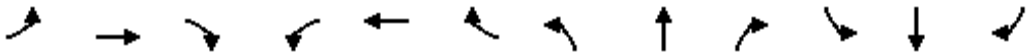
Intersection Summary				
Average Delay	1.7			
Intersection Capacity Utilization	33.6%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	24	63	0	0	7	142	21	0	250	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	26	68	0	0	8	154	23	0	272	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	441	464	272	479	453	166	272			177		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	441	464	272	479	453	166	272			177		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	97	86	100	100	99			100		
cM capacity (veh/h)	527	495	772	481	503	884	1303			1411		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	26	68	8	177	0	272
Volume Left	0	68	8	0	0	0
Volume Right	26	0	0	23	0	0
cSH	772	481	1303	1700	1700	1700
Volume to Capacity	0.03	0.14	0.01	0.10	0.00	0.16
Queue Length 95th (m)	0.8	3.9	0.1	0.0	0.0	0.0
Control Delay (s)	9.8	13.7	7.8	0.0	0.0	0.0
Lane LOS	A	B	A			
Approach Delay (s)	9.8	13.7	0.3		0.0	
Approach LOS	A	B				

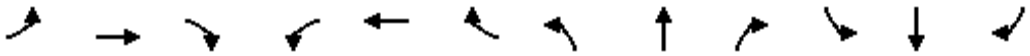
Intersection Summary				
Average Delay	2.3			
Intersection Capacity Utilization	30.0%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	12	111	3	10	78	54	2	0	14	125	0	14
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	13	121	3	11	85	59	2	0	15	136	0	15
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	143			124			270	314	122	298	286	114
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	143			124			270	314	122	298	286	114
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			99			100	100	98	79	100	98
cM capacity (veh/h)	1451			1475			667	595	934	640	617	944

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	13	124	11	143	17	151
Volume Left	13	0	11	0	2	136
Volume Right	0	3	0	59	15	15
cSH	1451	1700	1475	1700	890	661
Volume to Capacity	0.01	0.07	0.01	0.08	0.02	0.23
Queue Length 95th (m)	0.2	0.0	0.2	0.0	0.5	7.0
Control Delay (s)	7.5	0.0	7.5	0.0	9.1	12.1
Lane LOS	A		A		A	B
Approach Delay (s)	0.7		0.5		9.1	12.1
Approach LOS					A	B

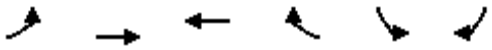
Intersection Summary				
Average Delay	4.7			
Intersection Capacity Utilization	31.1%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	10	15	10	39	16	39	8	0	56	56	0	8
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	11	16	11	42	17	42	9	0	61	61	0	9
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	60			27			154	188	22	222	172	39
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	60			27			154	188	22	222	172	39
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			97			99	100	94	91	100	99
cM capacity (veh/h)	1557			1600			790	687	1061	678	700	1039

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	11	27	42	60	70	70
Volume Left	11	0	42	0	9	61
Volume Right	0	11	0	42	61	9
cSH	1557	1700	1600	1700	1018	709
Volume to Capacity	0.01	0.02	0.03	0.04	0.07	0.10
Queue Length 95th (m)	0.2	0.0	0.7	0.0	1.8	2.6
Control Delay (s)	7.3	0.0	7.3	0.0	8.8	10.6
Lane LOS	A		A		A	B
Approach Delay (s)	2.1		3.0		8.8	10.6
Approach LOS					A	B

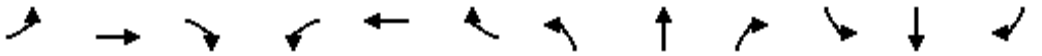
Intersection Summary				
Average Delay	6.2			
Intersection Capacity Utilization	25.8%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	114	36	31	0	0	170
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	124	39	34	0	0	185
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)		344				
pX, platoon unblocked						
vC, conflicting volume	34				321	34
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	34				321	34
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	92				100	82
cM capacity (veh/h)	1591				624	1045

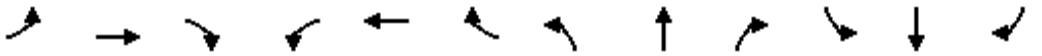
Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	124	39	34	185
Volume Left	124	0	0	0
Volume Right	0	0	0	185
cSH	1591	1700	1700	1045
Volume to Capacity	0.08	0.02	0.02	0.18
Queue Length 95th (m)	2.0	0.0	0.0	5.1
Control Delay (s)	7.5	0.0	0.0	9.2
Lane LOS	A			A
Approach Delay (s)	5.7		0.0	9.2
Approach LOS				A

Intersection Summary			
Average Delay	6.9		
Intersection Capacity Utilization	30.2%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	426	50	0	0	248	150	53	0	201	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0		5.0			5.0	5.0			5.0	
Lane Util. Factor		1.00		1.00			1.00	1.00			1.00	
Frt		0.85		1.00			1.00	0.96			1.00	
Flt Protected		1.00		0.95			0.95	1.00			1.00	
Satd. Flow (prot)		1615		1805			1805	1825			1900	
Flt Permitted		1.00		0.32			0.62	1.00			1.00	
Satd. Flow (perm)		1615		603			1182	1825			1900	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	463	54	0	0	270	163	58	0	218	0
RTOR Reduction (vph)	0	380	0	0	0	0	0	12	0	0	0	0
Lane Group Flow (vph)	0	83	0	54	0	0	270	209	0	0	218	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		12.6		12.6			47.4	47.4			47.4	
Effective Green, g (s)		12.6		12.6			47.4	47.4			47.4	
Actuated g/C Ratio		0.18		0.18			0.68	0.68			0.68	
Clearance Time (s)		5.0		5.0			5.0	5.0			5.0	
Vehicle Extension (s)		3.0		3.0			3.0	3.0			3.0	
Lane Grp Cap (vph)		291		109			800	1236			1287	
v/s Ratio Prot		0.05						0.11			0.11	
v/s Ratio Perm				c0.09			c0.23					
v/c Ratio		0.29		0.50			0.34	0.17			0.17	
Uniform Delay, d1		24.8		25.8			4.7	4.1			4.1	
Progression Factor		1.00		1.00			0.64	0.52			1.00	
Incremental Delay, d2		0.5		3.5			0.2	0.1			0.3	
Delay (s)		25.4		29.4			3.3	2.2			4.4	
Level of Service		C		C			A	A			A	
Approach Delay (s)		25.4			29.4			2.8			4.4	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	12.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	70.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	98	60	0	0	89	450	53	0	677	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0		5.0			5.0	5.0			5.0	
Lane Util. Factor		1.00		1.00			1.00	1.00			1.00	
Frt		0.85		1.00			1.00	0.98			1.00	
Flt Protected		1.00		0.95			0.95	1.00			1.00	
Satd. Flow (prot)		1615		1805			1805	1870			1900	
Flt Permitted		1.00		0.69			0.33	1.00			1.00	
Satd. Flow (perm)		1615		1307			622	1870			1900	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	107	65	0	0	97	489	58	0	736	0
RTOR Reduction (vph)	0	94	0	0	0	0	0	4	0	0	0	0
Lane Group Flow (vph)	0	13	0	65	0	0	97	543	0	0	736	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		8.5		8.5			51.5	51.5			51.5	
Effective Green, g (s)		8.5		8.5			51.5	51.5			51.5	
Actuated g/C Ratio		0.12		0.12			0.74	0.74			0.74	
Clearance Time (s)		5.0		5.0			5.0	5.0			5.0	
Vehicle Extension (s)		3.0		3.0			3.0	3.0			3.0	
Lane Grp Cap (vph)		196		159			458	1376			1398	
v/s Ratio Prot		0.01						0.29			c0.39	
v/s Ratio Perm				c0.05			0.16					
v/c Ratio		0.07		0.41			0.21	0.39			0.53	
Uniform Delay, d1		27.2		28.4			2.9	3.4			4.0	
Progression Factor		1.00		1.00			1.69	1.62			0.86	
Incremental Delay, d2		0.1		1.7			0.2	0.2			1.3	
Delay (s)		27.4		30.1			5.1	5.8			4.8	
Level of Service		C		C			A	A			A	
Approach Delay (s)		27.4			30.1			5.7			4.8	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	7.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	63.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	593	193	0	835	141	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	
Lane Util. Factor	1.00	1.00		1.00	1.00	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	1.00	1.00		1.00	0.95	
Satd. Flow (prot)	1900	1538		1900	1719	
Flt Permitted	1.00	1.00		1.00	0.95	
Satd. Flow (perm)	1900	1538		1900	1719	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	645	210	0	908	153	0
RTOR Reduction (vph)	0	60	0	0	0	0
Lane Group Flow (vph)	645	150	0	908	153	0
Heavy Vehicles (%)	0%	5%	0%	0%	5%	0%
Turn Type		Perm	Perm			Perm
Protected Phases	2			6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	49.9	49.9		49.9	10.1	
Effective Green, g (s)	49.9	49.9		49.9	10.1	
Actuated g/C Ratio	0.71	0.71		0.71	0.14	
Clearance Time (s)	5.0	5.0		5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1354	1096		1354	248	
v/s Ratio Prot	0.34			c0.48	c0.09	
v/s Ratio Perm		0.10				
v/c Ratio	0.48	0.14		0.67	0.62	
Uniform Delay, d1	4.4	3.2		5.5	28.1	
Progression Factor	1.00	1.00		0.53	1.00	
Incremental Delay, d2	0.3	0.1		2.4	4.5	
Delay (s)	4.6	3.3		5.4	32.6	
Level of Service	A	A		A	C	
Approach Delay (s)	4.3			5.4	32.6	
Approach LOS	A			A	C	

Intersection Summary			
HCM Average Control Delay	7.1	HCM Level of Service	A
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	60.1%	ICU Level of Service	B
Analysis Period (min)	15		

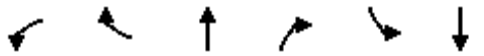
c Critical Lane Group



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	1203	48	510	872	72	780
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0	4.0	5.0	5.0
Lane Util. Factor	0.97		0.95	1.00	1.00	0.95
Frt	0.99		1.00	0.85	1.00	1.00
Flt Protected	0.95		1.00	1.00	0.95	1.00
Satd. Flow (prot)	3330		3610	1538	1719	3610
Flt Permitted	0.95		1.00	1.00	0.37	1.00
Satd. Flow (perm)	3330		3610	1538	665	3610
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	1308	52	554	948	78	848
RTOR Reduction (vph)	5	0	0	0	0	0
Lane Group Flow (vph)	1355	0	554	948	78	848
Heavy Vehicles (%)	5%	5%	0%	5%	5%	0%
Turn Type				Free	Perm	
Protected Phases	8		2			6
Permitted Phases				Free	6	
Actuated Green, G (s)	32.0		18.0	60.0	18.0	18.0
Effective Green, g (s)	32.0		18.0	60.0	18.0	18.0
Actuated g/C Ratio	0.53		0.30	1.00	0.30	0.30
Clearance Time (s)	5.0		5.0		5.0	5.0
Vehicle Extension (s)	3.0		3.0		3.0	3.0
Lane Grp Cap (vph)	1776		1083	1538	200	1083
v/s Ratio Prot	c0.41		0.15			0.23
v/s Ratio Perm				c0.62	0.12	
v/c Ratio	0.76		0.51	0.62	0.39	0.78
Uniform Delay, d1	11.0		17.4	0.0	16.6	19.2
Progression Factor	0.69		1.00	1.00	1.00	1.00
Incremental Delay, d2	2.4		0.4	1.9	1.3	3.8
Delay (s)	10.0		17.8	1.9	17.9	23.0
Level of Service	B		B	A	B	C
Approach Delay (s)	10.0		7.7			22.6
Approach LOS	B		A			C

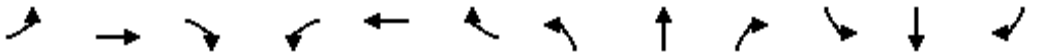
Intersection Summary			
HCM Average Control Delay	12.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	5.0
Intersection Capacity Utilization	66.4%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized		Yes		Yes		
Volume (veh/h)	755	220	63	496	290	97
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	821	239	68	539	315	105
Approach Volume (veh/h)	821		68			421
Crossing Volume (veh/h)	68		315			821
High Capacity (veh/h)	1313		1081			721
High v/c (veh/h)	0.63		0.06			0.58
Low Capacity (veh/h)	1096		886			568
Low v/c (veh/h)	0.75		0.08			0.74

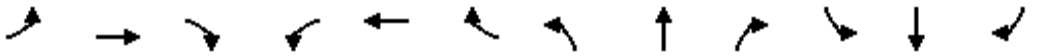
Intersection Summary			
Maximum v/c High	0.63		
Maximum v/c Low	0.75		
Intersection Capacity Utilization	76.3%	ICU Level of Service	D



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	712	659	67	0	541	0	74	0	0	0	0	738
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0			5.0		5.0					5.0
Lane Util. Factor	1.00	1.00			0.95		1.00					1.00
Frt	1.00	0.99			1.00		1.00					0.85
Flt Protected	0.95	1.00			1.00		0.95					1.00
Satd. Flow (prot)	1719	1874			3610		1805					1538
Flt Permitted	0.23	1.00			1.00		0.76					1.00
Satd. Flow (perm)	418	1874			3610		1439					1538
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	774	716	73	0	588	0	80	0	0	0	0	802
RTOR Reduction (vph)	0	4	0	0	0	0	0	0	0	0	0	26
Lane Group Flow (vph)	774	785	0	0	588	0	80	0	0	0	0	776
Heavy Vehicles (%)	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
Turn Type	pm+pt			Perm			Perm			Perm		pm+ov
Protected Phases	5	2			6			8			4	5
Permitted Phases	2			6			8			4		4
Actuated Green, G (s)	43.1	43.1			12.3		6.9					32.7
Effective Green, g (s)	43.1	43.1			12.3		6.9					32.7
Actuated g/C Ratio	0.72	0.72			0.20		0.12					0.55
Clearance Time (s)	5.0	5.0			5.0		5.0					5.0
Vehicle Extension (s)	3.0	3.0			3.0		3.0					3.0
Lane Grp Cap (vph)	860	1346			740		165					966
v/s Ratio Prot	c0.39	0.42			0.16							c0.35
v/s Ratio Perm	c0.26						0.06					0.16
v/c Ratio	0.90	0.58			0.79		0.48					0.80
Uniform Delay, d1	10.8	4.1			22.7		24.9					11.0
Progression Factor	0.95	0.96			0.97		1.00					1.00
Incremental Delay, d2	4.5	0.6			5.8		2.2					4.9
Delay (s)	14.7	4.5			27.8		27.1					16.0
Level of Service	B	A			C		C					B
Approach Delay (s)		9.6			27.8			27.1			16.0	
Approach LOS		A			C			C			B	

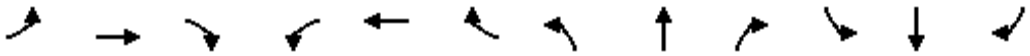
Intersection Summary			
HCM Average Control Delay	15.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.89		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	77.3%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



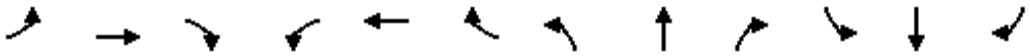
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	166	480	13	0	346	0	15	0	0	0	0	179
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0			5.0		5.0				5.0	
Lane Util. Factor	1.00	1.00			1.00		1.00				1.00	
Frt	1.00	1.00			1.00		1.00				0.85	
Flt Protected	0.95	1.00			1.00		0.95				1.00	
Satd. Flow (prot)	1805	1893			1900		1805				1615	
Flt Permitted	0.54	1.00			1.00		0.53				1.00	
Satd. Flow (perm)	1023	1893			1900		1008				1615	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	180	522	14	0	376	0	16	0	0	0	0	195
RTOR Reduction (vph)	0	1	0	0	0	0	0	0	0	0	169	0
Lane Group Flow (vph)	180	535	0	0	376	0	16	0	0	0	26	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	42.0	42.0			42.0		8.0				8.0	
Effective Green, g (s)	42.0	42.0			42.0		8.0				8.0	
Actuated g/C Ratio	0.70	0.70			0.70		0.13				0.13	
Clearance Time (s)	5.0	5.0			5.0		5.0				5.0	
Vehicle Extension (s)	3.0	3.0			3.0		3.0				3.0	
Lane Grp Cap (vph)	716	1325			1330		134				215	
v/s Ratio Prot		c0.28			0.20						c0.02	
v/s Ratio Perm	0.18						0.02					
v/c Ratio	0.25	0.40			0.28		0.12				0.12	
Uniform Delay, d1	3.3	3.8			3.4		22.9				22.9	
Progression Factor	0.32	0.38			1.00		1.00				1.00	
Incremental Delay, d2	0.7	0.8			0.1		0.4				0.3	
Delay (s)	1.8	2.2			3.5		23.3				23.2	
Level of Service	A	A			A		C				C	
Approach Delay (s)		2.1			3.5			23.3			23.2	
Approach LOS		A			A			C			C	

Intersection Summary			
HCM Average Control Delay	5.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.36		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	54.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Right Turn Channelized												
Volume (veh/h)	0	0	15	58	0	0	25	366	88	0	273	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	16	63	0	0	27	398	96	0	297	0
Approach Volume (veh/h)		16			63			521			297	
Crossing Volume (veh/h)		360			425			0			90	
High Capacity (veh/h)		1044			991			1385			1291	
High v/c (veh/h)		0.02			0.06			0.38			0.23	
Low Capacity (veh/h)		853			806			1161			1076	
Low v/c (veh/h)		0.02			0.08			0.45			0.28	

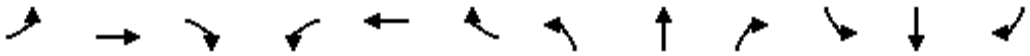
Intersection Summary				
Maximum v/c High	0.38			
Maximum v/c Low	0.45			
Intersection Capacity Utilization	60.2%	ICU Level of Service	B	



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	6	5	9	20	5	0	15	318	33	0	244	7
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	7	5	10	22	5	0	16	346	36	0	265	8
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	650	683	269	674	669	364	273			382		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	650	683	269	674	669	364	273			382		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	98	99	99	94	99	100	99			100		
cM capacity (veh/h)	377	369	775	359	376	686	1302			1188		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	22	27	16	382	0	273
Volume Left	7	22	16	0	0	0
Volume Right	10	0	0	36	0	8
cSH	487	362	1302	1700	1700	1700
Volume to Capacity	0.04	0.08	0.01	0.22	0.00	0.16
Queue Length 95th (m)	1.1	1.9	0.3	0.0	0.0	0.0
Control Delay (s)	12.7	15.7	7.8	0.0	0.0	0.0
Lane LOS	B	C	A			
Approach Delay (s)	12.7	15.7	0.3		0.0	
Approach LOS	B	C				

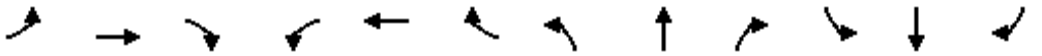
Intersection Summary				
Average Delay	1.2			
Intersection Capacity Utilization	28.7%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	12	35	0	0	20	251	53	0	205	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	13	38	0	0	22	273	58	0	223	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	539	597	223	581	568	302	223			330		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	539	597	223	581	568	302	223			330		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	98	91	100	100	98			100		
cM capacity (veh/h)	451	412	822	416	428	743	1358			1240		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	13	38	22	330	0	223
Volume Left	0	38	22	0	0	0
Volume Right	13	0	0	58	0	0
cSH	822	416	1358	1700	1700	1700
Volume to Capacity	0.02	0.09	0.02	0.19	0.00	0.13
Queue Length 95th (m)	0.4	2.4	0.4	0.0	0.0	0.0
Control Delay (s)	9.5	14.5	7.7	0.0	0.0	0.0
Lane LOS	A	B	A			
Approach Delay (s)	9.5	14.5	0.5		0.0	
Approach LOS	A	B				

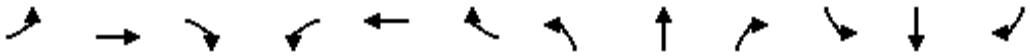
Intersection Summary				
Average Delay	1.3			
Intersection Capacity Utilization	31.9%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	13	109	2	15	118	119	4	0	14	83	0	19
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	14	118	2	16	128	129	4	0	15	90	0	21
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	258			121			329	438	120	388	374	193
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	258			121			329	438	120	388	374	193
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			99			99	100	98	84	100	98
cM capacity (veh/h)	1319			1480			603	504	937	556	547	854

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	14	121	16	258	20	111
Volume Left	14	0	16	0	4	90
Volume Right	0	2	0	129	15	21
cSH	1319	1700	1480	1700	834	595
Volume to Capacity	0.01	0.07	0.01	0.15	0.02	0.19
Queue Length 95th (m)	0.3	0.0	0.3	0.0	0.6	5.4
Control Delay (s)	7.8	0.0	7.5	0.0	9.4	12.4
Lane LOS	A		A		A	B
Approach Delay (s)	0.8		0.4		9.4	12.4
Approach LOS					A	B

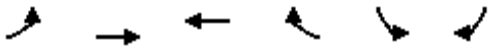
Intersection Summary				
Average Delay	3.3			
Intersection Capacity Utilization	32.6%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	8	15	8	59	22	59	14	0	54	54	0	14
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	9	16	9	64	24	64	15	0	59	59	0	15
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	88			25			205	254	21	277	227	56
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	88			25			205	254	21	277	227	56
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			96			98	100	94	91	100	99
cM capacity (veh/h)	1520			1603			719	623	1063	620	645	1016

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	9	25	64	88	74	74
Volume Left	9	0	64	0	15	59
Volume Right	0	9	0	64	59	15
cSH	1520	1700	1603	1700	968	674
Volume to Capacity	0.01	0.01	0.04	0.05	0.08	0.11
Queue Length 95th (m)	0.1	0.0	1.0	0.0	2.0	2.9
Control Delay (s)	7.4	0.0	7.3	0.0	9.0	11.0
Lane LOS	A		A		A	B
Approach Delay (s)	1.9		3.1		9.0	11.0
Approach LOS					A	B

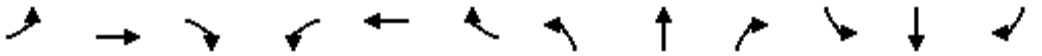
Intersection Summary				
Average Delay	6.0			
Intersection Capacity Utilization	27.1%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	173	31	51	0	0	163
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	188	34	55	0	0	177
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)		344				
pX, platoon unblocked						
vC, conflicting volume	55				465	55
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	55				465	55
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	88				100	83
cM capacity (veh/h)	1562				492	1017

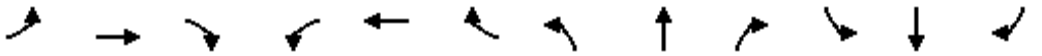
Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	188	34	55	177
Volume Left	188	0	0	0
Volume Right	0	0	0	177
cSH	1562	1700	1700	1017
Volume to Capacity	0.12	0.02	0.03	0.17
Queue Length 95th (m)	3.3	0.0	0.0	5.0
Control Delay (s)	7.6	0.0	0.0	9.3
Lane LOS	A			A
Approach Delay (s)	6.5		0.0	9.3
Approach LOS				A

Intersection Summary			
Average Delay	6.8		
Intersection Capacity Utilization	33.0%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	235	72	0	0	345	205	64	0	215	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0		5.0			5.0	5.0			5.0	
Lane Util. Factor		1.00		1.00			1.00	1.00			1.00	
Frt		0.85		1.00			1.00	0.96			1.00	
Flt Protected		1.00		0.95			0.95	1.00			1.00	
Satd. Flow (prot)		1615		1805			1805	1832			1900	
Flt Permitted		1.00		0.41			0.61	1.00			1.00	
Satd. Flow (perm)		1615		787			1165	1832			1900	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	255	78	0	0	375	223	70	0	234	0
RTOR Reduction (vph)	0	211	0	0	0	0	0	15	0	0	0	0
Lane Group Flow (vph)	0	44	0	78	0	0	375	278	0	0	234	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		10.3		10.3			39.7	39.7			39.7	
Effective Green, g (s)		10.3		10.3			39.7	39.7			39.7	
Actuated g/C Ratio		0.17		0.17			0.66	0.66			0.66	
Clearance Time (s)		5.0		5.0			5.0	5.0			5.0	
Vehicle Extension (s)		3.0		3.0			3.0	3.0			3.0	
Lane Grp Cap (vph)		277		135			771	1212			1257	
v/s Ratio Prot		0.03						0.15			0.12	
v/s Ratio Perm				c0.10			c0.32					
v/c Ratio		0.16		0.58			0.49	0.23			0.19	
Uniform Delay, d1		21.2		22.9			5.1	4.0			3.9	
Progression Factor		1.00		1.00			0.18	0.17			1.00	
Incremental Delay, d2		0.3		5.9			1.9	0.4			0.1	
Delay (s)		21.4		28.7			2.9	1.1			4.0	
Level of Service		C		C			A	A			A	
Approach Delay (s)		21.4			28.7			2.1			4.0	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	8.1	HCM Level of Service	A
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	65.6%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	54	76	0	0	72	614	67	0	522	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0		5.0			5.0	5.0			5.0	
Lane Util. Factor		1.00		1.00			1.00	1.00			1.00	
Frt		0.85		1.00			1.00	0.99			1.00	
Flt Protected		1.00		0.95			0.95	1.00			1.00	
Satd. Flow (prot)		1615		1805			1805	1872			1900	
Flt Permitted		1.00		0.72			0.42	1.00			1.00	
Satd. Flow (perm)		1615		1365			800	1872			1900	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	59	83	0	0	78	667	73	0	567	0
RTOR Reduction (vph)	0	52	0	0	0	0	0	4	0	0	0	0
Lane Group Flow (vph)	0	7	0	83	0	0	78	736	0	0	567	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		7.1		7.1			42.9	42.9			42.9	
Effective Green, g (s)		7.1		7.1			42.9	42.9			42.9	
Actuated g/C Ratio		0.12		0.12			0.72	0.72			0.72	
Clearance Time (s)		5.0		5.0			5.0	5.0			5.0	
Vehicle Extension (s)		3.0		3.0			3.0	3.0			3.0	
Lane Grp Cap (vph)		191		162			572	1338			1359	
v/s Ratio Prot		0.00						c0.39			0.30	
v/s Ratio Perm				c0.06			0.10					
v/c Ratio		0.04		0.51			0.14	0.55			0.42	
Uniform Delay, d1		23.4		24.8			2.7	4.0			3.5	
Progression Factor		1.00		1.00			0.24	0.18			0.80	
Incremental Delay, d2		0.1		2.7			0.3	1.1			0.2	
Delay (s)		23.5		27.5			1.0	1.9			3.0	
Level of Service		C		C			A	A			A	
Approach Delay (s)		23.5			27.5			1.8			3.0	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	4.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	63.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	753	182	0	651	267	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	
Lane Util. Factor	1.00	1.00		1.00	1.00	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	1.00	1.00		1.00	0.95	
Satd. Flow (prot)	1900	1538		1900	1719	
Flt Permitted	1.00	1.00		1.00	0.95	
Satd. Flow (perm)	1900	1538		1900	1719	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	818	198	0	708	290	0
RTOR Reduction (vph)	0	79	0	0	0	0
Lane Group Flow (vph)	818	119	0	708	290	0
Heavy Vehicles (%)	0%	5%	0%	0%	5%	0%
Turn Type		Perm	Perm			Perm
Protected Phases	2			6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	36.1	36.1		36.1	13.9	
Effective Green, g (s)	36.1	36.1		36.1	13.9	
Actuated g/C Ratio	0.60	0.60		0.60	0.23	
Clearance Time (s)	5.0	5.0		5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1143	925		1143	398	
v/s Ratio Prot	c0.43			0.37	c0.17	
v/s Ratio Perm		0.08				
v/c Ratio	0.72	0.13		0.62	0.73	
Uniform Delay, d1	8.4	5.2		7.6	21.3	
Progression Factor	1.00	1.00		1.16	1.00	
Incremental Delay, d2	3.8	0.3		1.0	6.5	
Delay (s)	12.2	5.4		9.8	27.9	
Level of Service	B	A		A	C	
Approach Delay (s)	10.9			9.8	27.9	
Approach LOS	B			A	C	

Intersection Summary			
HCM Average Control Delay	12.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	62.8%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	1249	104	739	1380	58	586
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0	4.0	5.0	5.0
Lane Util. Factor	0.97		0.95	1.00	1.00	0.95
Frt	0.99		1.00	0.85	1.00	1.00
Flt Protected	0.96		1.00	1.00	0.95	1.00
Satd. Flow (prot)	3317		3610	1538	1719	3610
Flt Permitted	0.96		1.00	1.00	0.24	1.00
Satd. Flow (perm)	3317		3610	1538	431	3610
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	1358	113	803	1500	63	637
RTOR Reduction (vph)	10	0	0	0	0	0
Lane Group Flow (vph)	1461	0	803	1500	63	637
Heavy Vehicles (%)	5%	5%	0%	5%	5%	0%
Turn Type				Free	Perm	
Protected Phases	8		2			6
Permitted Phases				Free	6	
Actuated Green, G (s)	33.2		16.8	60.0	16.8	16.8
Effective Green, g (s)	33.2		16.8	60.0	16.8	16.8
Actuated g/C Ratio	0.55		0.28	1.00	0.28	0.28
Clearance Time (s)	5.0		5.0		5.0	5.0
Vehicle Extension (s)	3.0		3.0		3.0	3.0
Lane Grp Cap (vph)	1835		1011	1538	121	1011
v/s Ratio Prot	0.44		0.22			0.18
v/s Ratio Perm				c0.98	0.15	
v/c Ratio	0.80		0.79	0.98	0.52	0.63
Uniform Delay, d1	10.7		20.0	0.0	18.2	18.9
Progression Factor	0.91		1.00	1.00	1.00	1.00
Incremental Delay, d2	2.5		4.4	17.8	4.0	1.3
Delay (s)	12.3		24.4	17.8	22.2	20.2
Level of Service	B		C	B	C	C
Approach Delay (s)	12.3		20.1			20.4
Approach LOS	B		C			C

Intersection Summary			
HCM Average Control Delay	17.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.98		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	0.0
Intersection Capacity Utilization	75.2%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Right Turn Channelized		Yes		Yes		
Volume (veh/h)	547	371	135	707	228	96
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	595	403	147	768	248	104
Approach Volume (veh/h)	595		147			352
Crossing Volume (veh/h)	147		248			595
High Capacity (veh/h)	1235		1140			865
High v/c (veh/h)	0.48		0.13			0.41
Low Capacity (veh/h)	1025		940			694
Low v/c (veh/h)	0.58		0.16			0.51

Intersection Summary				
Maximum v/c High	0.48			
Maximum v/c Low	0.58			
Intersection Capacity Utilization	68.1%	ICU Level of Service		C

AECOM

Appendix B

Appendix B:
Geotechnical Report by EBA Engineering Consultants Ltd.

N.B. The Geotechnical Report can be found in *Appendix C* of *Whistle Bend Master Concept Plan VOLUME 1: Background Planning & Implementation.*

3.0 WHISTLE BEND SUBDIVISION COST ESTIMATE SUMMARY

City of Whitehorse

Whistle Bend Subdivision
Cost Estimate Summary

Prepared by:

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Project Number:

2501-040

23 December, 2009

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23 December, 2009 Project Number: 2504-040 (4.0)

Wayne Tuck, P.Eng.
City Engineer
City of Whitehorse
Municipal Services Building
4210 - 4th Avenue
Whitehorse, YT Y1A 1C2

Dear Wayne:

Re: Whistle Bend Subdivision – Cost Estimate Summary

We are pleased to submit this (revised) final cost estimate summary for proposed onsite and offsite work in connection with the Whistle Bend subdivision.

Class C estimates have been provided for the "front-end" offsite works, and Phases 1 and 2 of the onsite works. Class D estimates are provided for the remainder of the work to build-out, including both offsite and onsite. Executive summaries prepared for the onsite and offsite works provide brief explanations of the scope of work. Detailed information is provided in the comprehensive onsite and offsite servicing reports.

Please advise as to the number of bound copies you would like to receive of this document.

Sincerely,
AECOM Canada Ltd.



Ron Akehurst, P.Eng.
Manager, Municipal Infrastructure
Community Infrastructure
Ron.Akehurst@aecom.com

RA/bl

Encl.

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1. Introduction

The following report presents Executive Summaries and cost summaries for onsite and offsite services associated with the development of the proposed Whistle Bend subdivision. The Executive Summaries are based on Executive Summaries prepared for the Onsite Servicing Report and the Offsite Servicing Report.

The final Onsite Servicing Report is being submitted simultaneously with this final Cost Summary Report.

The final Offsite Servicing Report was submitted and accepted by the City previously, on March 23, 2009. The Offsite Servicing Report included Order-Of-Magnitude costs which have been updated and improved to Class C for the purpose of this report. Some of these updates have significant effects on the cost estimate, notably the reduced target population of the subdivision (7,800 vs. 10,000 originally), which affects the scope of offsite transportation improvements attributable to Whistle Bend development, and the preliminary design level of detail applied to all offsite infrastructure.

2. Executive Summary – Onsite Servicing

2.1 Water Supply and Distribution

The onsite water system has been designed by Quest Engineering Group of Whitehorse, based on criteria consistent with other large development areas in the city, and consists of a series of parallel looped watermains of various sizes to balance the flow through the parallel loops.

A detailed water system analysis has been completed by Quest using the City of Whitehorse EPA Net water model. The model was reviewed and updated to include the proposed new water system infrastructure and recirculation pumphouse requirements for the Whistle Bend development.

The following water demand design criteria are used in the water model:

Total serviced population	10,000 persons*
Residential demand	375 L/capita/day
Total average daily demand	3,750,000 L/day
Average demand rate	43.4 L/s
Maximum day demand rate	2 x ADD
Peak hour demand rate	4 x ADD
Night fill demand rate	0.1 x ADD (no flow through)
Node demand for model	0.35 L/s (ADD)

* Note that the design population of 10,000 for this development has been superseded as a result of the planning process, and reduced to 7,800. This reduction does not affect the sizing of proposed water distribution plant, since the determining factor is fire flow, which is not affected by the reduced population.

Recommended onsite water system improvements include:

- Installation of a new 350, 300, 250, 200 and 150 mm looped watermain system in the proposed expansion area, with forced circulation provided from a new circulation pumpstation. Watermain construction will be completed as staged development.
- A supply trunkmain will be constructed following the proposed main collector roadway. From this primary trunkmain, parallel loops can be constructed for phased development as required.
- A single recirculation and heating pumphouse can be located on the main trunkmain loop, such that a single pumphouse can provide recirculation and heating for the entire development.

- Three return loops will tie back to the recirculation pumphouse. Each loop will have a flow control valve to balance return flows at the pumphouse as required for the phased development.
- The pumphouse will have a common return suction header, and a common discharge header.
- A one-way bypass and fire flow bypass valve will connect the suction and discharge headers to allow bi-directional flow through the pumphouse for fire conditions, to increase available fire flows while minimizing distribution pipe sizes.
- Fire hydrants will be installed at regularly spaced intervals to provide 75 m radius coverage for all residential lots and 45 m radius coverage for all commercial lots.
- Insulated service stubs will be provided to each lot:
  - Minimum residential service to be 20 mm, insulated and impedance heat traced, or insulated recirculating services with 25 supply/20 return.
  - Minimum commercial services to be 50 mm supply with 20 mm recirculation line.
- Water model results indicate that the proposed watermain system can provide the required fire flows with acceptable maximum and minimum velocities:
  - Available fire flows: 105 to 300 L/s
  - Required fire flows: 75 L/s minimum, 300 L/s maximum
  - Minimum residual pressure: 140 kPa at ground elevation (nominal mode elevation) at MDD plus fire
  - Maximum velocity: 2.8 m/s at MDD plus fire
  - Minimum velocity: 0.03 m/s at NFD

All watermain construction will be as per the City of Whitehorse Servicing Standards manual, latest edition. Watermains will be installed at a minimum 3.0 m bury to obvert, to provide adequate cover for thermal protection. Isolation valves and on-line hydrants will be installed.

2.2 Wastewater Collection and Disposal

Several scenarios for wastewater collection and pumping were examined in this study. The chosen option involves construction of a gravity sanitary sewer system and a pumpstation sized for a peak flow of approximately 85 L/s, which will provide service for approximately 5,900 people and a catchment area of 189 ha (Phase 1 to Phase 5). The construction of this pumpstation and forcemain will occur during Phase 1 of development. A second pumpstation sized for a peak flow of approximately 35 L/s will be installed during Phase 3 of the development, and will provide service for approximately 1,900 people and a catchment area of 65 ha, consisting of a portion of Phase 3 and all of Phase 6. Gravity sanitary lines will be extended from the pumpstations to the phase boundaries as they progress.

The main pumpstation wet well will be built during Phase 1, however, the pumps and controls will be upsized as required as the flows increase. The pumpstation will be operated in a duplex configuration initially, but pre-piped for future triplex. The main pumpstation will include a building, a wet well, duplex submersible pumps, variable frequency drives, electrical/PLC/SCADA panels, ventilation and back-up power. The forcemain will be 300 mm diameter.

The smaller pumpstation will be a small package type unit (Flygt or similar) with a smaller diameter forcemain discharge. This forcemain will connect to the forcemain from the larger pumpstation.

Both pumpstations will pump sewage via a common forcemain to the Porter Creek Flush Tank. In conjunction with the single forcemain, it is recommended that the pumps in both stations be equipped with variable frequency drives.

The northeast and northwest corners of Phase 5 are lower in elevation to the point where gravity flow to the boundary of the phase is not feasible due to excessive depth. The use of pressure sewers and individual grinder pumps for this area was compared to gravity sewers and a small liftstation in the northeast corner. The liftstation option was found to be considerably less expensive, so this option has been chosen.

Design criteria will be in accordance with the City of Whitehorse Servicing Standards Manual, as follows:

- **Manholes** – maximum spacing 110 m.
- **Sewer Main Sizing** – 200 mm (minimum) to 400 mm, according to design flows.
- **Sewer Main Velocity** – minimum velocity to be 0.7 m/s with a Manning's pipe roughness coefficient n of 0.013. Minimum pipe slopes for 200 mm piping to be 0.4% and for 300mm piping to be 0.3% to achieve self-cleansing. The pipe grade on the first upstream length of each pipe is to be 0.6% minimum.
- **Depth of Bury** – the minimum cover will be 2.8 m. The sanitary sewer mains are to be designed such that gravity drainage is possible from the finished basement level of all residential building lots. The maximum depth of bury will be 6 m. To facilitate future maintenance of service connections where the sewer main is deeper than 5 m, a parallel local collection sewer will be installed at an approximate depth of 3 m.

2.3 Stormwater Management

The proposed development will adopt sustainable stormwater management principles in achieving the goal of no net increase in post-development water runoff.

The overall drainage concept proposes to retain existing drainage basins after development, to eliminate or minimize earthwork and re-grading of the land. The existing low points will be designated and developed as the ultimate receiving points for the runoff. There will be no runoff from this development to the river. Where these receiving points occur within the urban landscape, rain garden landscaping will be designed. Bio-swales will convey runoff to the receiving ponds and rain gardens, where appropriate.

The stormwater management system will consist of a major system and a minor system. The major system will be capable of handling a 100-year storm event, and will consist of surface routing the runoff through roads, rights-of-way, public utility lots, easements, reserves, and other public lands. The minor system will be capable of handling a 5-year storm event, and will consist of catchbasins, storm sewers, exfiltration pits, and bio-swales. Overflows from the minor system will be diverted to the major system.

Storm flows were analyzed by the Rational Method. Pipe sizing, determined by Manning's formula, indicates the minimum pipe size of 450 mm CSP pipe is suitable for all installations in Phases 1 and 2 of this development. Figure 1 of Appendix 5 of the onsite servicing report identifies seven subcatchments for this development and associated ponding areas and exfiltration pits that will serve as the disposal areas for runoff from the subcatchments.

In addition to the ponding areas, the system will include bio-swales and rain gardens to enhance water quality. Roof drainage will generally be allowed to infiltrate on the individual lots to reduce runoff quantities.

2.4 Transportation

Roads in the Whistle Bend subdivision will be designed in accordance with City of Whitehorse standards. Right-of-way concepts include:

- 18 m right-of-way for 8 m wide local road
- 22 m right-of-way for 11.5 m collector road
- 30 m right-of-way and two 10 m green corridors for arterial roads.

The Onsite Servicing report contains a detailed report on the onsite traffic model results. This model is based on an approximate population of 8,000 for the development at build-out. A brief description of the principal road and traffic elements resulting from the model analysis is presented herein.

Casca Boulevard will be the main arterial road within a 30-m wide right-of-way. Casca Boulevard will be built initially as a two-lane road with bike lanes and centre median. This ROW width will allow for future expansion to four lanes as traffic volumes warrant. This ROW will also be flanked by 10-m wide green space corridors on each side. Casca Boulevard will loop through the site and connect to Range Road in two locations. These intersections will be single-lane roundabouts initially. At build-out, the southerly Casca/ Range intersection will require signalization, or possibly a double roundabout..

Signalized intersections are required at Casca/Chakawana by the end of Phase 2, and at four other locations on Casca Boulevard at build-out of the subdivision.

The road design cross sections will be in accordance with recommendations presented in EBA Engineering Consultants Ltd. report of August 2009. Consistent with the City's Servicing Standards Manual, the EBA report recommends that no frost-susceptible (silt) material should be permitted within 1.7 m of the road surface. Figure 2 of the geotechnical report shows the extent of areas expected to have less than 1.5 m of sand over the frost-susceptible silt. This figure indicates a large portion of the site will require a deep granular subbase layer to prevent frost damage to the roads.

The site plan also indicates an extensive trail network within green space corridors. Trails will typically be 3 m wide with gravel surfacing on the internal trails and asphalt surfacing on the external (City) trail.

2.5 Cost Estimate Summary – Onsite Servicing

The total cost of development of all phases of the onsite work, including contingencies and engineering, but excluding Heiland and Ta'an sections, is $117,330,000. Class C Cost Estimates have been prepared for Phases 1 and 2 of the proposed development. The estimates are summarized as follows:

Phase 1

1.	Water Distribution System	$4,753,000
2.	Wastewater Collection and Disposal	4,613,900
3.	Stormwater Management	600,500
4	Landscaping	
5.	Transportation	4,856,600
6.	Hydro/Cable/Tel	2,247,000
	Subtotal	**$17,071,000**
	Mobilization	150,000
	Contingency and Estimating Allowance (+15%)	2,583,200
	Subtotal	**$19,804,200**
	Engineering (+15%)	2,970,600
	Total	**$22,774,800**
	Rounded Total	**$22,770,000**

Phase 2

1.	Water Distribution System	$2,298,000
2.	Wastewater Collection and Disposal	2,076,500
3.	Stormwater Management	986,900
4.	Transportation	7,402,900
5.	Hydro/Cable/Tel	2,061,000
	Subtotal	**$14,825,300**
	Mobilization	130,000
	Contingency and Estimating Allowance (+15%)	2,243,300
	Subtotal	**$17,198,600**
	Engineering (+15%)	2,579,800
	Total	**$19,778,400**
	Rounded Total	**$19,780,000**

Class D cost estimates have been prepared for Phases 3 through 6 of the proposed development. The estimate is summarized as follows:

Phase 3

1.	Water Distribution System	$2,031,700
2.	Wastewater Collection and Disposal	2,763,800
3.	Stormwater Management	611,500
4.	Transportation	7,003,400
5.	Hydro/Cable/Tel	2,523,000
	Subtotal	**$14,933,400**
	Mobilization	140,000
	Contingency and Estimating Allowance (+25%)	3,768,400
	Subtotal	**$18,841,800**
	Engineering (+15%)	2,826,200
	Total	**$21,670,000**
	Rounded Total	**$21,670,000**

Phase 4

1.	Water Distribution System	$1,128,300
2.	Wastewater Collection and Disposal	933,200
3.	Stormwater Management	689,000
4.	Transportation	6,708,400
5.	Hydro/Cable/Tel	1,002,000
	Subtotal	**$10,460,900**
	Mobilization	100,000
	Contingency and Estimating Allowance (+25%)	2,640,200
	Subtotal	**$13,201,100**
	Engineering (+15%)	1,980,200
	Total	**$15,181,300**
	Rounded Total	**$15,180,000**

Phase 5

1.	Water Distribution System	$1,114,100
2.	Wastewater Collection and Disposal	1,006,800
3.	Stormwater Management	537,400
4.	Transportation	2,931,400
5.	Hydro/Cable/Tel	930,000
	Subtotal	**$6,519,700**
	Mobilization	65,000
	Contingency and Estimating Allowance (+25%)	1,646,200
	Subtotal	**$8,230,900**
	Engineering (+15%)	1,234,600
	Total	**$9,465,500**
	Rounded total	**$9,470,000**

Phase 6

1.	Water Distribution System	$3,530,000
2.	Wastewater Collection and Disposal	3,167,000
3.	Stormwater Management	967,500
4.	Landscaping	
5	Transportation	9,361,900
6.	Hydro/Cable/Tel	2,604,000
	Subtotal	**$19,630,400**
	Mobilization	165,000
	Contingency and Estimating Allowance (+25%)	4,948,900
	Subtotal	**$24,744,300**
	Engineering (+15%)	3,711,600
	Total	**$28,455,900**
	Rounded Total	**$28,460,000**

Detailed breakdowns of the above costs are attached.

Note that the above costs do not include the cost of servicing the Heiland or Ta'an lands in Phase 2 and Phase 5. These costs are summarized below as Class D estimates. Detailed breakdowns are also appended.

Heiland

1.	Water Distribution System	$ 945,300
2.	Wastewater Collection and Disposal	603,900
3.	Stormwater Management	512,100
4.	Transportation	1,951,200
5.	Hydro/Cable/Tel	624,000
	Subtotal	**$4,636,500**
	Mobilization	50,000
	Contingency and Estimating Allowance (+25%)	1,171,600
	Subtotal	**$5,858,100**
	Engineering (+15%)	878,700
	Total	**$6,736,800**
	Rounded Total	**$6,740,000**

Ta'an

1.	Water Distribution System	$1,720,900
2.	Wastewater Collection and Disposal	1,530,400
3.	Stormwater Management	476,700
4.	Transportation	4,481,400
5.	Hydro/Cable/Tel	1,671,000
	Subtotal	**$9,880,400**
	Mobilization	100,000
	Contingency and Estimating Allowance (+25%)	2,495,100
	Subtotal	**$12,475,500**
	Engineering (+15%)	1,871,300
	Total	**$14,346,800**
	Rounded Total	**$14,350,000**

The cost estimates include a 15% contingency and estimating allowance for Class C design. The basic unit prices are, for the most part, derived from 2008 budget prices provided by Quest Engineering Ltd. Recent land development projects in Whitehorse have been awarded to out-of-town contractors at substantially lower prices. We have continued to use the Quest 2008 budget prices for these estimates, assuming that prices will return to near Whitehorse normal costs in the near future. The basic unit prices in the estimate are thus considered to be conservative on the high side. In conjunction with good quantity take-offs from the preliminary design drawings, a 15% contingency and estimating allowance is considered appropriate for all Class C estimates.

We have not attempted to estimate an escalation factor for future years, since we have no expertise in economic forecasting. We have reviewed the historical increases in Consumer Price Index for Whitehorse. (We were unable to find any records relating to construction cost index.) The Consumer Price Index indicates average inflation of less than 2% per year from 1998 to 2008. In 2007 and 2008, inflation was somewhat higher than average, at 2.5% and 3.6%, respectively.

Exclusions from the above estimates are as follows:

1. GST
2. Escalation after 2009
3. Land and legal costs, legal survey
4. Environmental site clean-up costs, if any.
5. Costs due to detailed design changes
6. Winter work.

3. Executive Summary – Offsite Servicing

This report serves as an initial background analysis for offsite servicing and its impact on the proposed new Whistle Bend development situated on the lower Porter Creek Bench in Whitehorse. It forms part of a larger planning and engineering study to generate an overall land use and subdivision plan to guide future development of this approximately 730 ha area in the City. In designing for the future, a focus on sustainability forms an integral component of the work.

3.1 Water Supply and Distribution

The off-site servicing assessment has adopted a target average water consumption rate of 375 L/capita/day (lpcd), which is less than the current City target of 500 lpcd and significantly lower than the current actual consumption of 690 lpcd in Porter Creek. While this may 'push the envelope' somewhat, this target should be achievable with the use of low-flow fixtures and appliances, metering and other water use reduction strategies. The target is also in line with the current national average rate. Flow analyses for both water and wastewater were based on phasing in the reduced rate over the initial 50% build-out of the development starting with the current City target of 500 lpcd.

Various scenarios were modelled and analyzed to determine the optimal option for providing water to the proposed development. The option of a separate and dedicated water supply system for Whistle Bend was eliminated due to cost. A further option of providing a separate fire supply system utilizing a river intake or a well was also assessed, but found to not be feasible from a cost perspective.

The off-site water system infrastructure upgrades recommendations, phased over the build-out of the development are as follows:

0% Build-Out (Front End):

- Extend the existing 350 mm trunk main on Range Road with a 450 mm main to Whistle Bend (supply from Service Area 2). This provides the peak domestic flows for the ultimate build-out but fire flow of only up to 150 L/s for the first 5 years. The adequacy of this fire flow will depend on the nature of the development. 150 L/s is adequate for the assumed residential development in the first phases of development, but additional fire flow capacity will be required once commercial/institutional development begins. Ultimate fire flow requirements up to 300 L/s are assumed for the built-out development.

- Add 2 new 5,000 m^3 cells to the Valleyview Reservoir. The ultimate increase in storage is estimated to be 15,000 m^3. Adding the additional storage in phases is recommended due to uncertainties with the rate of development in other parts of the Valleyview service area. See Appendix B for pre-design brief and cost estimate.

25% to 50% Build-Out:

- Add a 350 mm trunk main from McIntyre Creek (Service Area 3) to provide adequate fire flow. This will also provide domestic service to the proposed Porter Creek "D" development. If this other development does not move forward, this item may be eliminated.

- If Porter Creek D is not developed, add a 300 mm connection from Wann Road to Whistle Bend to provide additional fire flow.

- Add a new 6,000 m^3 cell to the Porter Creek Reservoir. (Note: the timing of this upgrade is impacted by the demand for additional development in the existing Porter Creek and Alaska Highway commercial areas, and therefore the City may wish to accelerate this upgrade if capital funding is available.)

50% to 75% Build-Out:

- Add another pump to the Two Mile Hill Booster pumphouse
- Add one more 5,000 m3 cell to the Valleyview Reservoir

3.2 Wastewater Collection and Disposal

The sanitary flows from Whistle Bend are to be transported to the City lagoons on the north side of the Yukon River. The City lagoons and headworks have adequate capacity to handle the additional flows from Whistle Bend. The Porter Creek flush tank (PCFT) and gravity force main have adequate excess capacity to handle the additional flows up to the 75% development horizon. Various options were analyzed, and it is recommended to construct a major pumpstation and a second, smaller pumpstation in the development area that will pump directly to the flush tank at Porter Creek via separate forcemains. Flows from the development will be collected within the various phases by gravity sewers or low-pressure sewers feeding into the pumpstations. After the 75% horizon, or when the gravity main is near capacity, some twinning of the gravity force main will be required to increase hydraulic capacity. Delaying this work until the twinning is actually required will be optimal from a present value perspective. The twinning requirement may be delayed further or even eliminated if the ultimate build-out of the existing Porter Creek catchment area is not achieved, or if the per capita flows are reduced even further than targeted.

The off-site wastewater system infrastructure upgrade recommendations are as follows:

0% Build-Out (Front End):

- Construct the major Whistle Bend sanitary pumpstation (85 L/s at 45 m TDH) and a 300 mm forcemain to the PCFT

75% Build-Out: PCFT Gravity Main at Capacity for Peak Wet Weather Flows

- Construct the second Whistle Bend sanitary pumpstation (35 L/s) and a 150 mm forcemain to the PCFT.
- Twin approximately 500 m of the 450 mm gravity force main by constructing 200 m of new main and connecting the spare river crossing (300 m)
- Option to abandon the flush tank control valve by leaving it open.

3.3 Stormwater Management

Recommended drainage strategies are based on Alberta standards and are practical for the unique conditions of the North. The intent is to achieve a post development zero net increase in runoff from the site and be supportive of sustainability principles. Generally, the Whistle Bend site has favourable drainage characteristics, and strategies incorporating infiltration can be utilized to reduce the runoff from the development and roadways by about 50% and 30%, respectively. Minor and major systems will still be required to handle the additional runoff which will be directed via piped systems and swales to detention facilities. These systems will also serve as a back-up to the infiltration systems that will be affected when the ground is frozen and snowmelt has to be conveyed away from the site. Options for detention include the

potholes at the north end of the site and the golf course to the east. Smaller detention ponds that are designed to infiltrate can also be built in each development phase. Water quality enhancement will also be provided with these systems.

3.4 Transportation

Offsite transportation impacts have also been investigated. Primarily access into the neighbourhood will be from a new major entrance at the intersection of Whistle Bend Connector (called Whistle Bend Drive) and Mountainview Drive, at a location that ties into the future extension road proposed to service the Pine Street Extension to Alaska Highway. Initially, Whistle Bend Drive will be a two-lane road; however, the entire 40 m wide right-of-way will be prepared for the ultimate 4-lane road, including retaining walls. The retaining wall system recommended for this application is an MSE (mechanically-stabilized earth) wall, which utilizes tie-backs into the retained fill or embankment, and a suitable wall facing system. The intersection at Mountainview Drive will initially be stop sign controlled, and then signalized when the TAC signal warrants are met (estimated at 50% build-out).

With the progressive build-out of Whistle Bend, the adjacent street network will require upgrading and improvements. Mountainview Drive, which links the new community with downtown Whitehorse, will need to be widened to a four-lane cross section between Range Road and the proposed Whistle Bend Drive. Initial review of the roadway width requirements (based on a TAC classification of UCU-70 and City Standards for a major collector street) is approximately 17 m width based on maintaining two travel lanes of 3.5 m plus on-road bicycle lanes of 1.5 m and no on-street parking per direction. The existing right-of-way (ROW) of Mountainview between Tliingit Road and 12th Avenue (based on cadastral information) is in the order of 60 m plus, and is likely sufficient to accommodate the proposed widening of the Mountainview corridor. Intersection improvements including geometric upgrades, signalization and signal optimization, will be required at Mountainview Drive and Range Road, at Quartz Road and Industrial Road, Two Mile Hill and Industrial Road, and at Quartz Road and Chilkoot Way. Transit improvements will also be required to service the additional demand. These improvements may include the extension of existing transit lines (i.e. Transit Line 5: Takhini – College - CGC), increases in frequency to 10- and 20-minutes headway, and new transit service (Transit Line 7: Downtown – Whistle Bend - Porter Creek). Transit services are explored further in the design concepts as a way of embracing sustainable transportation alternatives.

The entrance to the subdivision at the intersection of Whistle Bend Drive and Casca Boulevard is initially proposed to be a single-lane roundabout. It is intended that this intersection be expanded to a double roundabout as the subdivision approaches build-out. The traffic model indicates the possibility that a double roundabout may not provide an adequate level of service. It is noted, however, that the traffic model O/D data may not adequately reflect future commercial uses within the subdivision that may tend to reduce the number of offsite trips, thereby reducing pressure on the Casca/Whistle Bend Drive intersection. It is therefore recommended to continue to plan on a double roundabout at this location, and monitor the situation in the future.

To connect the new neighbourhood with downtown, a new bike trail is proposed which combines an on-road bike lane with an off-road trail. The off-road section is proposed as a 3-m wide asphalt trail connecting between Range Road and 170 m west of McIntyre Creek, and Mountainview Drive. The on-road sections are alongside Mountainview Drive from McIntyre Creek crossing to the southerly intersection with Range Road, and on Range Road from 170 m west of McIntyre Creek to the subdivision. This section of Range Road could be functionally downgraded to service cyclists and Transit.

In conjunction with the installation of the new 450 mm trunk main along Range Road, the road in the vicinity of the McIntyre Creek crossing will be improved with respect to grade and width. By installing the new watermain in the road embankment fill across the creek, environmental impacts on the creek will be

minimized, the higher road embankment will improve the grade of the road, and the existing narrow crossing can be widened to match the rest of the road.

3.5 Cost Estimate Summary – Offsite Servicing

Table 1 summarizes all expected project-related offsite costs, including contingency allowance and engineering (total $46,874,000). Class "C" estimates for the proposed front-end offsite servicing are provided in the table. Class C estimates include 15% contingency allowance and 15% engineering. Table 1 also includes Class "D cost estimates for future work tied into 25%, 50%, 75% and 100% build-out of the subdivision. Cost breakdowns for the above are also attached. Note that the Class D cost breakdowns include 25% contingency/estimating allowance and 15% engineering.

The transportation model includes a sensitivity analysis based on 75% build-out of the subdivision. Since the model was based on 10,000 population, the 75% scenario also simulates 7,500 population, which is close to the 7,800 population now assumed as the ultimate population of the development. Therefore, the projects listed as required at 75% build-out in the transportation will probably not be required until near build-out (100%). Also, the projects listed at 100% in the transportation study, including additional four-laning on Mountainview Drive and intersection improvements at Hamilton Boulevard/Arkell Access road, will not be triggered by the Whistle Bend development, and are therefore not included in the estimate .

The costs shown in Table 1 for offsite wastewater collection and disposal relate only to the offsite portion of the forcemain and twinning of PCFT main. Pumpstation and onsite portions of forcemain costs are presented in the Onsite Servicing section of this report.

The cost estimates include a 15% contingency and estimating allowance for Class C design. The basic unit prices are, for the most part, derived from 2008 budget prices provided by Quest Engineering Ltd. Recent land development projects in Whitehorse have been awarded to out-of-town contractors at substantially lower prices. We have continued to use the Quest 2008 budget prices for these estimates, assuming that prices will return to near Whitehorse normal costs in the near future. The basic unit prices in the estimate are thus considered to be conservative on the high side. In conjunction with good quantity take-offs from the preliminary design drawings, a 15% contingency and estimating allowance is considered appropriate for all Class C estimates.

We have not attempted to estimate an escalation factor for future years, since we have no expertise in economic forecasting. We have reviewed the historical increases in Consumer Price Index for Whitehorse. (We were unable to find any records relating to construction cost index.) The Consumer Price Index indicates average inflation of less than 2% per year from 1998 to 2008. In 2007 and 2008, inflation was somewhat higher than average, at 2.5% and 3.6%, respectively.

Exclusions from the above estimates are as follows:

1. GST
2. Escalation after 2009
3. Land and legal costs, legal survey
4. Environmental site clean-up costs, if any.
5. Costs due to detailed design changes
6. Winter work
7. Power and Tel costs.

Table 1 – Summary of Offsite Costs

% Build-Out	Service	Item	Cost
Front End (0%)	Water	Range Road Trunk Main	$3,540,000
		Valleyview Reservoir (2 cells)	$6,063,000
	Sanitary	Forcemain – 300 mm diameter	$738,000
	Roads*	Industrial Road/Two Mile Hill Signalization	$50,000
		Range Road/Two Mile Hill Geometric Improvements	$50,000
		Whistle Bend Drive	$7,089,000
	Bike Trail	Bike Trail (Whistle Bend - Mountainview Dr)	$716,000
	Power		not available
	Telecom		not available
		Class C Estimate - Subtotal Front End (0% Build-out)	**$18,246,000**
25%	Water	None	$0
	Sanitary	None	$0
	Roads	Pine Street Extension	$6,910,000
	Power		not available
	Telecom		not available
		Class D Estimate - Subtotal 25% Build-out	**$6,910,000**
50%	Water	Porter Creek D extension (Whistle Bend share)	$664,000
		Porter Creek Reservoir (1 cell)	$3,638,000
	Sanitary	None	$0
	Roads	Alaska Highway Connector	$5,660,000
		Whistle Bend Drive – 4-lane widening	$2,010,000
		Mountainview Drive/Whistle Bend Drive Intersection geometrics and signalization	$1,970,000
		Mountainview Drive Corridor Intersection improvements	$200,000
		Downtown Intersection improvements	$330,000
	Power		not available
	Telecom		not available
		Class D Estimate - Subtotal 50% Build-out	**$14,472,000**
75%	Water	Valleyview Reservoir (1 cell)	$3,032,000
		Two Mile Booster Station	$500,000
	Sanitary	Twin section of PCFT main	$184,000
	Power		not available
	Roads:	Mountainview Drive – 4-laning (Range Road – Whistle Bend Drive)	3,330,000
		Mountainview Drive intersection improvements	200,000
	Telecom		not available
		Class D Estimate - Subtotal 75% Build-out	**$7,246,000**
100%	Water	None	$0
	Sanitary	None	$0
	Roads	None	$0
	Power		not available
	Telecom		not available
		Class D Estimate - Subtotal 100% Build-out	**$0**

Appendix A

Appendix A:
Cost Estimate Details

Whistle Bend Subdivision Class C Cost Estimate - Phase 1

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.1	Trenching/Backfilling	l.m	5556	$200.00	$1,111,200.00
1.2	150Ø PVC/ DI MAIN	l.m	220	$100.00	$22,000.00
1.3	200Ø PVC/ DI MAIN	l.m	732	$125.00	$91,500.00
1.4	250Ø PVC/ DI MAIN	l.m	1311	$150.00	$196,650.00
1.5	300Ø PVC/ DI MAIN	l.m	1235	$175.00	$216,125.00
1.6	350Ø PVC/ DI MAIN	l.m	354	$230.00	$81,420.00
1.7	400Ø PVC/ DI MAIN	l.m	674	$300.00	$202,200.00
1.8	Hydrant	ea.	16	$7,500.00	$120,000.00
1.9	150mm Valves	ea.	5	$2,000.00	$10,000.00
1.1	200mm Valves	ea.	4	$2,500.00	$10,000.00
1.11	250mm Valves	ea.	10	$3,000.00	$30,000.00
1.12	300mm Valves	ea.	12	$3,500.00	$42,000.00
1.13	350mm Valves	ea.	2	$5,000.00	$10,000.00
1.14	400mm Valves	ea.	6	$6,000.00	$36,000.00
1.15	Connect to existing	ea.	1	$5,000.00	$5,000.00
1.16	Misc fittings	ea.	0	$1,500.00	$0.00
1.17	Flushing, chlorination and testing	l.m	2235	$20.00	$44,700.00
1.18	Water service - large diameter	l.m	100	$125.00	$12,500.00
1.19	Water service - small diameter	l.m	1110	$125.00	$138,750.00
1.20	Water Service Tie in to main large dia.	ea.	10	$2,500.00	$25,000.00
1.21	Water Service Tie in to main small dia.	ea.	111	$500.00	$55,500.00
1.22	Water Recirculation and Heating Pumphouse	lump Sum	1	$2,292,500.00	$2,292,500.00
				Subtotal Phase 1 Water Distribution	***$4,753,045.00***

	Wastewater Collection and Disposal				
2.1	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	5511	$200.00	$1,102,200.00
2.2	Trenching/Backfilling - Sanitary (4-5m deep)	l.m	487	$250.00	$121,750.00
2.3	Trenching/Backfilling - Sanitary (5-6m deep)	l.m	0	$300.00	$0.00
2.4	Trenching/Backfilling - Sanitary (6-7m deep)	l.m	0	$350.00	$0.00
2.5	200Ø PVC main	l.m	1715	$100.00	$171,500.00
2.6	300Ø PVC main	l.m	0	$150.00	$0.00
2.7	400Ø PVC main	l.m	24	$200.00	$4,800.00
2.8	100Ø Low Pressure sewer	l.m	0	$300.00	$0.00
2.9	150Ø PVC Forcemain	l.m	0	$100.00	$0.00
2.10	300Ø PVC Forcemain	l.m	2374	$550.00	$1,305,700.00
2.11	Sanitary manhole	ea.	24	$7,500.00	$180,000.00
2.12	Connect to existing sanitary system	ea.	1	$5,000.00	$5,000.00
2.13	TV inspection and testing	l.m	4780	$15.00	$71,700.00
2.14	Sewer Lift Station	ea.	1	$1,500,000.00	$1,500,000.00
2.15	Sewer Service 100-150mm Bare	l.m	1210	$75.00	$90,750.00
2.16	Sewer Service 100-150mm Insulated	l.m	0	$175.00	$0.00
2.17	Sewer main tie in to main, saddle or in-line tee	ea.	121	$500.00	$60,500.00
				Subtotal Phase 1 Wastewater Collection and Disposal	***$4,613,900.00***

	Stormwater Management				
3.1	Trenching/Backfilling - Storm	l.m	1013	$150.00	$151,950.00
3.2	450Ø CSP Storm Main	l.m	1013	$125.00	$126,625.00
3.3	Storm manhole 1200 dia.	ea.	3	$7,500.00	$22,500.00
3.4	Catchbasin 600mm c/w 10m lead and trench/backfill	ea.	16	$5,000.00	$80,000.00
3.5	Catchbasin manhole	ea.	7	$7,500.00	$52,500.00
3.6	Exfiltration Pit	ea.	6	$10,000.00	$60,000.00
3.7	Connect to existing storm main	ea.	0	$2,500.00	$0.00
3.8	Outfalls c/w rip rap erosion control	ea.	0	$5,000.00	$0.00
3.9	Bio-swale	l.m	17	$150.00	$2,550.00
3.10	Detention Pond Excavation	m3	4358	$9.00	$39,222.00
3.11	Detention Pond Landscaping	lump Sum	1	$50,000.00	$50,000.00
3.12	TV inspection and testing	l.m	1013	$15.00	$15,195.00
				Subtotal Phase 1 Stormwater Management	***$600,542.00***

Whistle Bend Subdivision Class C Cost Estimate - Phase 1

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Transportation				
4.1	Clearing	Sq. m	54100	$1.00	$54,100.00
4.2	Grubbing and Stripping (topsoil)	Sq. m	54100	$2.00	$108,200.00
4.3	Excavation and replace with pit run (roads or utilities	Cu.m	18132	$30.00	$543,960.00
4.4	subgrade preparation	Sq. m	24974	$2.50	$62,435.00
4.5	sub-base (80mm, 300mm thick, pit run)	Sq. m	24974	$12.00	$299,688.00
4.6	Base (20mm, 150mm Thick)	Sq. m	24974	$10.00	$249,740.00
4.7	75mm AC Surface	Sq. m	20611	$35.00	$721,385.00
4.8	Boulevard Restoration	Sq. m	16830	$15.00	$252,450.00
4.9	Curb, rolled or barrier	l.m	4824	$100.00	$482,400.00
4.10	Separate Sidewalk	Sq. m	6144	$125.00	$768,000.00
4.11	Street Lights	ea.	50	$5,000.00	$250,000.00
4.12	Signalised Intersection @ Chakewana Dr/ Casca Blvd	ls	1	$250,000.00	$250,000.00
4.13	Signs and Pavement Marking	lump Sum	1	$20,000.00	$20,000.00
4.14	Trails - Gravel 3m Wide	l.m	1137	$37.50	$42,637.50
4.15	Trails - Paved 3m Wide	l.m	1118	$127.50	$142,545.00
4.16	Boulevard Trees @7m Cntrs both sides of road and medians)	ea.	609	$1,000.00	$609,000.00
				Subtotal Phase 1 Transportation	***$4,856,540.50***
	Shallow Utilities				
	Power, Telephone, Cable (Single)	ea.	109	$6,000.00	$654,000.00
	Power, Telephone, Cable (Multi - per unit)	ea.	531	$3,000.00	$1,593,000.00
				Subtotal Shallow Utilities	***$2,247,000.00***
				Subtotal	**$17,071,027.50**
				Mobilization	**$150,000.00**
				Contingency & Estimating Allowance (15%)	**$2,583,154.13**
				Subtotal	**$19,804,181.63**
				Engineering (15%)	**$2,970,627.24**
				Grand Total	**$22,774,808.87**

Whistle Bend Subdivision Class C Cost Estimate - Water Recirculation and Heating Pumphouse

Date: October 20th, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.2	Site Clearing and Preparation	ha.	0.5	$25,000	$12,500.00
1.3	Excavation and base preparation	lump Sum	1	$10,000	$10,000.00
1.1	Site Services for water / sewer	lump Sum	1	$10,000	$10,000.00
1.4	Site Services, electrical/communication	lump Sum	1	$10,000	$10,000.00
1.5	Site Services, fencing	m	300	$100	$30,000.00
1.6	Building Foundation and Structure	sq. ft	3000	$250	$750,000.00
1.7	Standby Generator and switch gear	lump Sum	1	$200,000	$200,000.00
1.8	Boiler Heating System, 3 units	ea.	3	$25,000	$75,000.00
1.9	Recirc Pump units, 3 units	ea.	3	$15,000	$45,000.00
1.1	Process Piping	lump Sum	1	$100,000	$100,000.00
1.11	Fuel Oil System	lump Sum	1	$50,000	$50,000.00
1.12	Building Heat and Ventilation Systems	lump Sum	1	$100,000	$100,000.00
1.13	Builidng plumbing	lump Sum	1	$25,000	$25,000.00
1.14	Building Electrical Systems	lump Sum	1	$400,000	$400,000.00
1.15	Instrumentation and Controls	lump Sum	1	$250,000	$250,000.00
1.16	Chlorination System and controls	lump Sum	1	$25,000	$25,000.00
1.17	Commissioning	lump Sum	1	$50,000	$50,000.00
1.18	Maintenance Manuals	lump Sum	1	$25,000	$25,000.00
1.19	Miscellaneous, permits, asbuilts	lump Sum	1	$50,000	$50,000.00
1.20	Mob / Demob	lump Sum	1	$50,000	$50,000.00
1.21	Site Surfacing and landscaping	lump Sum	1	$25,000	$25,000.00
				Subtotal Water Distribution	***$2,292,500***
				Contingency & Estimating Allowance (15%)	**$343,875**
				Subtotal	**$2,636,375**
				Engineering (15%)	**$395,456**
				Grand Total	**$3,031,831**

Note: Estimate is based on recent comparison with Selkirk Water System Pumphouse, 2008 Tender

Whistle Bend Subdivision Class C Cost Estimate - Phase 2

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.1	Trenching/Backfilling	l.m	5270	$200.00	$1,054,000.00
1.2	150Ø PVC/ DI MAIN	l.m	255	$100.00	$25,500.00
1.3	200Ø PVC/ DI MAIN	l.m	1041	$125.00	$130,125.00
1.4	250Ø PVC/ DI MAIN	l.m	1022	$150.00	$153,300.00
1.5	300Ø PVC/ DI MAIN	l.m	375	$175.00	$65,625.00
1.6	350Ø PVC/ DI MAIN	l.m	0	$230.00	$0.00
1.7	400Ø PVC/ DI MAIN	l.m	287	$300.00	$86,100.00
1.8	Hydrant	ea.	26	$7,500.00	$195,000.00
1.9	150mm Valves	ea.	2	$2,000.00	$4,000.00
1.1	200mm Valves	ea.	10	$2,500.00	$25,000.00
1.11	250mm Valves	ea.	9	$3,000.00	$27,000.00
1.12	300mm Valves	ea.	5	$3,500.00	$17,500.00
1.13	350mm Valves	ea.	0	$5,000.00	$0.00
1.14	400mm Valves	ea.	2	$6,000.00	$12,000.00
1.15	Connect to existing	ea.	6	$500.00	$3,000.00
1.16	Misc fittings	ea.		$1,500.00	$0.00
1.17	Flushing, chlorination and testing	l.m	3654	$20.00	$73,080.00
1.18	Water service - large diameter	l.m	130	$125.00	$16,250.00
1.19	Water service - small diameter	l.m	2160	$125.00	$270,000.00
1.20	Water Service Tie in to main large dia.	ea.	13	$2,500.00	$32,500.00
1.21	Water Service Tie in to main small dia.	ea.	216	$500.00	$108,000.00
				Subtotal Phase 2 Water Distribution	***$2,297,980.00***
	Wastewater Collection and Disposal				
2.1	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	4535	$200.00	$907,000.00
2.2	Trenching/Backfilling - Sanitary (4-5m deep)	l.m	215	$250.00	$53,750.00
2.3	Trenching/Backfilling - Sanitary (5-6m deep)	l.m	727	$300.00	$218,100.00
2.4	Trenching/Backfilling - Sanitary (6-7m deep)	l.m	0	$350.00	$0.00
2.5	200Ø PVC main	l.m	2616	$100.00	$261,600.00
2.6	300Ø PVC main	l.m	394	$150.00	$59,100.00
2.7	400Ø PVC main	l.m	177	$200.00	$35,400.00
2.8	100Ø Low Pressure sewer	l.m	0	$300.00	$0.00
2.9	150Ø PVC Forcemain	l.m	0	$100.00	$0.00
2.10	300Ø PVC Forcemain	l.m	0	$150.00	$0.00
2.11	Sanitary manhole	ea.	27	$7,500.00	$202,500.00
2.12	Connect to existing sanitary system	ea.	1	$5,000.00	$5,000.00
2.13	TV inspection and testing	l.m	3187	$15.00	$47,805.00
2.14	Sewer Service 100-150mm Bare	l.m	2290	$75.00	$171,750.00
2.15	Sewer Service 100-150mm Insulated	l.m		$175.00	$0.00
2.16	Sewer main tie in to main, saddle or in-line tee	ea.	229	$500.00	$114,500.00
				Subtotal Phase 2 Wastewater Collection and Disposal	***$2,076,505.00***
	Stormwater Management				
3.1	Trenching/Backfilling - Storm	l.m	1818	$150.00	$272,700.00
3.2	450Ø CSP Storm Main	l.m	1818	$125.00	$227,250.00
3.3	Storm manhole 1200 dia.	ea.	14	$7,500.00	$105,000.00
3.4	Catchbasin 600mm c/w 10m lead and trench/backfill	ea.	36	$5,000.00	$180,000.00
3.5	Catchbasin manhole	ea.	0	$7,500.00	$0.00
3.6	Exfiltration Pit	ea.	10	$10,000.00	$100,000.00
3.7	Connect to existing storm main	ea.	0	$2,500.00	$0.00
3.8	Outfalls c/w rip rap erosion control	ea.	0	$5,000.00	$0.00
3.9	Bio-swale	l.m	498	$150.00	$74,700.00
3.10	TV inspection and testing	l.m	1818	$15.00	$27,270.00
				Subtotal Phase 2 Stormwater Management	***$986,920.00***

Whistle Bend Subdivision Class C Cost Estimate - Phase 2

Date: November 3rd, 2009

4.1	**Transportation**				
4.2	Clearing	Sq. m	73448	$1.00	$73,448.00
4.3	Grubbing and Stripping (topsoil)	Sq. m	73448	$2.00	$146,896.00
4.4	Excavation and replace with pit run (roads or utilities	Cu.m	16169	$30.00	$485,070.00
4.5	subgrade preparation	Sq. m	39761	$2.50	$99,402.50
4.6	sub-base (80mm, 300mm thick, pit run)	Sq. m	39761	$12.00	$477,132.00
4.7	Base (20mm, 150mm Thick)	Sq. m	39761	$10.00	$397,610.00
4.8	75mm AC Surface	Sq. m	32320	$35.00	$1,131,200.00
4.9	Boulevard Restoration	Sq. m	29343	$15.00	$440,145.00
4.10	Curb, rolled or barrier	l.m	8493	$100.00	$849,300.00
4.11	Separate Sidewalk	Sq. m	10509	$125.00	$1,313,625.00
4.12	Street Lights	ea.	85	$5,000.00	$425,000.00
4.13	Roundabout at Keno Way	ls	1	$250,000.00	$250,000.00
4.14	Signs and Pavement Marking	lump Sum	1	$20,000.00	$20,000.00
4.15	Trails - Gravel 3m Wide	l.m	1576	$37.50	$59,100.00
4.16	Trails - Paved 3m Wide	l.m	1404	$127.50	$179,010.00
4.17	Boulevard Trees @7m Cntrs both sides of road and medians)	ea.	1056	$1,000.00	$1,056,000.00
				Subtotal Phase 2 Transportation	***$7,402,938.50***

	Shallow Utilities				
	Power, Telephone, Cable (Single)	ea.	207	$6,000.00	$1,242,000.00
	Power, Telephone, Cable (Multi - per unit)	ea.	273	$3,000.00	$819,000.00
				Subtotal Shallow Utilities	***$2,061,000.00***
				Subtotal	**$14,825,343.50**
				Mobilization	**$130,000.00**
				Contingency & Estimating Allowance (15%)	**$2,243,301.53**
				Subtotal	**$17,198,645.03**
				Engineering (15%)	**$2,579,796.75**
				Grand Total	**$19,778,441.78**

Whistle Bend Subdivision Class D Cost Estimate - Phase 3

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.1	Trenching/Backfilling	l.m	4370	$200.00	$874,000.00
1.2	150Ø PVC/ DI MAIN	l.m	0	$100.00	$0.00
1.3	200Ø PVC/ DI MAIN	l.m	1036	$125.00	$129,500.00
1.4	250Ø PVC/ DI MAIN	l.m	712	$150.00	$106,800.00
1.5	300Ø PVC/ DI MAIN	l.m	869	$175.00	$152,075.00
1.6	350Ø PVC/ DI MAIN	l.m	123	$230.00	$28,290.00
1.7	400Ø PVC/ DI MAIN	l.m	0	$300.00	$0.00
1.8	Hydrant	ea.	28	$7,500.00	$210,000.00
1.9	150mm Valves	ea.	0	$2,000.00	$0.00
1.1	200mm Valves	ea.	17	$2,500.00	$42,500.00
1.11	250mm Valves	ea.	4	$3,000.00	$12,000.00
1.12	300mm Valves	ea.	11	$3,500.00	$38,500.00
1.13	350mm Valves	ea.	3	$5,000.00	$15,000.00
1.14	400mm Valves	ea.	3	$6,000.00	$18,000.00
1.15	Connect to existing	ea.	3	$5,000.00	$15,000.00
1.16	Misc fittings	ea.		$1,500.00	$0.00
1.17	Flushing, chlorination and testing	l.m	3941	$20.00	$78,820.00
1.18	Water service - large diameter	l.m	130	$125.00	$16,250.00
1.19	Water service - small diameter	l.m	1500	$125.00	$187,500.00
1.20	Water Service Tie in to main large dia.	ea.	13	$2,500.00	$32,500.00
1.21	Water Service Tie in to main small dia.	ea.	150	$500.00	$75,000.00
				Subtotal Water Distribution	***$2,031,735.00***

	Wastewater Collection and Disposal				
2.1	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	5122	$200.00	$1,024,400.00
2.2	Trenching/Backfilling - Sanitary (4-5m deep)	l.m	557	$250.00	$139,250.00
2.3	Trenching/Backfilling - Sanitary (5-6m deep)	l.m	520	$300.00	$156,000.00
2.4	Trenching/Backfilling - Sanitary (6-7m deep)	l.m	547	$350.00	$191,450.00
2.5	200Ø PVC main	l.m	2729	$100.00	$272,900.00
2.6	300Ø PVC main	l.m	747	$150.00	$112,050.00
2.7	400Ø PVC main	l.m	0	$200.00	$0.00
2.8	100Ø Low Pressure sewer	l.m	0	$300.00	$0.00
2.9	150Ø PVC Forcemain	l.m	20	$450.00	$9,000.00
2.10	300Ø PVC Forcemain	l.m	0	$150.00	$0.00
2.11	Sanitary manhole	ea.	30	$7,500.00	$225,000.00
2.14	Sewer Lift Station	ea.	1.0	$350,000.00	$350,000.00
2.12	Connect to existing sanitary system	ea.	2	$500.00	$1,000.00
2.13	TV inspection and testing	l.m	5266	$15.00	$78,990.00
2.14	Sewer Service 100-150mm Bare	l.m	1630	$75.00	$122,250.00
2.15	Sewer Service 100-150mm Insulated	l.m	0	$175.00	$0.00
2.16	Sewer main tie in to main, saddle or in-line tee	ea.	163	$500.00	$81,500.00
				Subtotal Wastewater Collection and Disposal	***$2,763,790.00***

	Stormwater Management				
3.1	Trenching/Backfilling - Storm	l.m	1100	$150.00	$165,000.00
3.2	450Ø CSP Storm Main	l.m	1100	$125.00	$137,500.00
3.3	Storm manhole 1200 dia.	ea.	15	$7,500.00	$112,500.00
3.4	Catchbasin 600mm c/w 10m lead and trench/backfill	ea.	26	$5,000.00	$130,000.00
3.5	Catchbasin manhole	ea.	0	$7,500.00	$0.00
3.6	Exfiltration Pit	ea.	5	$10,000.00	$50,000.00
3.7	Connect to existing storm main	ea.	0	$2,500.00	$0.00
3.8	Outfalls c/w rip rap erosion control	ea.	0	$5,000.00	$0.00
3.9	Bio-swale	l.m	0	$150.00	$0.00
3.10	TV inspection and testing	l.m	1100	$15.00	$16,500.00
				Subtotal Stormwater Management	***$611,500.00***

Whistle Bend Subdivision Class D Cost Estimate - Phase 3

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Transportation				
4.1	Clearing	Sq. m	87897.0	$1.00	$87,897.00
4.2	Grubbing and Stripping (topsoil)	Sq. m	87897.0	$2.00	$175,794.00
4.3	Excavation and replace with pit run (roads or utilities	Cu.m	22075.0	$30.00	$662,250.00
4.4	subgrade preparation	Sq. m	41094.0	$2.50	$102,735.00
4.5	sub-base (80mm, 300mm thick, pit run)	Sq. m	41094.0	$12.00	$493,128.00
4.6	Base (20mm, 150mm Thick)	Sq. m	41094.0	$10.00	$410,940.00
4.7	75mm AC Surface	Sq. m	33017.0	$35.00	$1,155,595.00
4.8	Boulevard Restoration	Sq. m	23174.0	$15.00	$347,610.00
4.9	Curb, rolled or barrier	l.m	8454.0	$100.00	$845,400.00
4.10	Separate Sidewalk	Sq. m	9550.0	$125.00	$1,193,750.00
4.11	Street Lights	ea.	85.0	$5,000.00	$425,000.00
4.12	Signs and Pavement Marking	lump Sum	1	$20,000.00	$20,000.00
4.13	Trails - Gravel 3m Wide	l.m	1570	$37.50	$58,875.00
4.14	Trails - Paved 3m Wide	l.m	168	$127.50	$21,420.00
4.15	Boulevard Trees @7m Cntrs both sides of road and medians)	ea.	1003	$1,000.00	$1,003,000.00
				Subtotal Transportation	***$7,003,394.00***

	Shallow Utilities				
	Power, Telephone, Cable (Single)	ea.	150	$6,000.00	$900,000.00
	Power, Telephone, Cable (Multi - per unit)	ea.	541	$3,000.00	$1,623,000.00
				Subtotal Shallow Utilities	***$2,523,000.00***
				Subtotal	**$14,933,419.00**
				Mobilization	***$140,000.00***
				Contingency & Estimating Allowance (25%)	**$3,768,354.75**
				Subtotal	**$18,841,773.75**
				Engineering (15%)	**$2,826,266.06**
				Grand Total	**$21,668,039.81**

Whistle Bend Subdivision Class D Cost Estimate - Phase 4

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.1	Trenching/Backfilling	l.m	2420.0	$200.00	$484,000.00
1.2	150Ø PVC/ DI MAIN	l.m	0.0	$100.00	$0.00
1.3	200Ø PVC/ DI MAIN	l.m	760.0	$125.00	$95,000.00
1.4	250Ø PVC/ DI MAIN	l.m	1440.0	$150.00	$216,000.00
1.5	300Ø PVC/ DI MAIN	l.m	60.0	$175.00	$10,500.00
1.6	350Ø PVC/ DI MAIN	l.m	0.0	$230.00	$0.00
1.7	400Ø PVC/ DI MAIN	l.m	0.0	$300.00	$0.00
1.8	Hydrant	ea.	20.0	$7,500.00	$150,000.00
1.9	150mm Valves	ea.	0	$2,000.00	$0.00
1.1	200mm Valves	ea.	5	$2,500.00	$12,500.00
1.11	250mm Valves	ea.	7	$3,000.00	$21,000.00
1.12	300mm Valves	ea.	2	$3,500.00	$7,000.00
1.13	350mm Valves	ea.	0	$5,000.00	$0.00
1.14	400mm Valves	ea.	0	$6,000.00	$0.00
1.15	Connect to existing	ea.	3	$5,000.00	$15,000.00
1.16	Misc fittings	ea.		$1,500.00	$0.00
1.17	Flushing, chlorination and testing	l.m	2862.0	$20.00	$57,240.00
1.18	Water service - large diameter	l.m	160.0	$125.00	$20,000.00
1.19	Water service - small diameter	l.m	0.0	$125.00	$0.00
1.20	Water Service Tie in to main large dia.	ea.	16	$2,500.00	$40,000.00
1.21	Water Service Tie in to main small dia.	ea.	0	$500.00	$0.00
				Subtotal Phase 4 Water Distribution	***$1,128,240.00***

	Wastewater Collection and Disposal				
2.1	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	742.0	$200.00	$148,400.00
2.2	Trenching/Backfilling - Sanitary (4-5m deep)	l.m	982.0	$250.00	$245,500.00
2.3	Trenching/Backfilling - Sanitary (5-6m deep)	l.m	311.0	$300.00	$93,300.00
2.4	Trenching/Backfilling - Sanitary (6-7m deep)	l.m		$350.00	$0.00
2.5	200Ø PVC main	l.m	1726.0	$100.00	$172,600.00
2.6	300Ø PVC main	l.m	0.0	$150.00	$0.00
2.7	400Ø PVC main	l.m	149.0	$200.00	$29,800.00
2.8	100Ø Low Pressure sewer	l.m	0.0	$300.00	$0.00
2.9	150Ø PVC Forcemain	l.m	0.0	$100.00	$0.00
2.10	300Ø PVC Forcemain	l.m	0.0	$150.00	$0.00
2.11	Sanitary manhole	ea.	26.0	$7,500.00	$195,000.00
2.12	Connect to existing sanitary system	ea.	1.0	$500.00	$500.00
2.13	TV inspection and testing	l.m	1875.0	$15.00	$28,125.00
2.14	Sewer Service 100-150mm Bare	l.m	160.0	$75.00	$12,000.00
2.15	Sewer Service 100-150mm Insulated	l.m	0	$175.00	$0.00
2.16	Sewer main tie in to main, saddle or in-line tee	ea.	16	$500.00	$8,000.00
				Subtotal Phase 4 Wastewater Collection and Disposal	***$933,225.00***

	Stormwater Management				
3.1	Trenching/Backfilling - Storm	l.m	1298.0	$150.00	$194,700.00
3.2	450Ø CSP Storm Main	l.m	1298.0	$125.00	$162,250.00
3.3	Storm manhole 1200 dia.	ea.	11.0	$7,500.00	$82,500.00
3.4	Catchbasin 600mm c/w 10m lead and trench/backfill	ea.	20.0	$5,000.00	$100,000.00
3.5	Catchbasin manhole	ea.	0.0	$7,500.00	$0.00
3.6	Exfiltration Pit	ea.	2.0	$10,000.00	$20,000.00
3.7	Connect to existing storm main	ea.	0.0	$2,500.00	$0.00
3.8	Outfalls c/w rip rap erosion control	ea.	1.0	$5,000.00	$5,000.00
3.9	Bio-swale	l.m	38	$150.00	$5,700.00
3.10	Detention Pond Excavation	m3	5490	$9.00	$49,410.00
3.11	Detention Pond Landscaping	lump Sum	1	$50,000.00	$50,000.00
3.12	TV inspection and testing	l.m	1298.0	$15.00	$19,470.00
				Subtotal Phase 4 Stormwater Management	***$689,030.00***

Whistle Bend Subdivision Class D Cost Estimate - Phase 4

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Transportation				
4.1	Clearing	Sq. m	31908.0	$1.00	$31,908.00
4.2	Grubbing and Stripping (topsoil)	Sq. m	31908.0	$2.00	$63,816.00
4.3	Excavation and replace with pit run (roads or utilities	Cu.m	19523.0	$30.00	$585,690.00
4.4	subgrade preparation	Sq. m	32230.0	$2.50	$80,575.00
4.5	sub-base (80mm, 300mm thick, pit run)	Sq. m	32230.0	$12.00	$386,760.00
4.6	Base (20mm, 150mm Thick)	Sq. m	32230.0	$10.00	$322,300.00
4.7	75mm AC Surface	Sq. m	26722.0	$35.00	$935,270.00
4.8	Boulevard Restoration	Sq. m	20824.0	$15.00	$312,360.00
4.9	Curb, rolled or barrier	l.m	6130.0	$100.00	$613,000.00
4.10	Separate Sidewalk	Sq. m	7987.0	$125.00	$998,375.00
4.11	Street Lights	ea.	61.0	$5,000.00	$305,000.00
4.12	Signs and Pavement Marking	lump Sum	1	$20,000.00	$20,000.00
4.13	Trails - Gravel 3m Wide	l.m	1764	$37.50	$66,150.00
4.14	Trails - Paved 3m Wide	l.m	645	$127.50	$82,237.50
4.15	Roundabout at Range Rd & Casca Blvd (North)	ea.	1.0	$250,000.00	$250,000.00
4.15	Signalized Intersections at Talbot Way	ea.	1.0	$250,000.00	$250,000.00
4.17	Signalized Intersections at Keno Way	ea.	1.0	$250,000.00	$250,000.00
4.16	Boulevard Trees @7m Cntrs both sides of road and medians)	ea.	770	$1,000.00	$770,000.00
4.17	Sports field including excavation, surface restoration and irrigation	lump Sum	1	$385,000.00	$385,000.00
				Subtotal Phase 4 Transportation	***$6,708,441.50***

	Shallow Utilities				
	Power, Telephone, Cable (Single)	ea.	0	$6,000.00	$0.00
	Power, Telephone, Cable (Multi - per unit)	ea.	334	$3,000.00	$1,002,000.00
				Subtotal Shallow Utilities	***$1,002,000.00***
				Subtotal	**$10,460,936.50**
				Mobilization	***$100,000.00***
				Contingency & Estimating Allowance (25%)	**$2,640,234.13**
				Subtotal	**$13,201,170.63**
				Engineering (15%)	**$1,980,175.59**
				Grand Total	**$15,181,346.22**

Whistle Bend Subdivision Class D Cost Estimate - Phase 5

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.1	Trenching/Backfilling	l.m	2648.0	$200.00	$529,600.00
1.2	150Ø PVC/ DI MAIN	l.m	0.0	$100.00	$0.00
1.3	200Ø PVC/ DI MAIN	l.m	903.0	$125.00	$112,875.00
1.4	250Ø PVC/ DI MAIN	l.m	99.0	$150.00	$14,850.00
1.5	300Ø PVC/ DI MAIN	l.m	104.0	$175.00	$18,200.00
1.6	350Ø PVC/ DI MAIN	l.m	662.0	$230.00	$152,260.00
1.7	400Ø PVC/ DI MAIN	l.m	0.0	$300.00	$0.00
1.8	Hydrant	ea.	6.0	$7,500.00	$45,000.00
1.9	150mm Valves	ea.	1.0	$2,000.00	$2,000.00
1.1	200mm Valves	ea.	4.0	$2,500.00	$10,000.00
1.11	250mm Valves	ea.	1.0	$3,000.00	$3,000.00
1.12	300mm Valves	ea.	2.0	$3,500.00	$7,000.00
1.13	350mm Valves	ea.	3.0	$5,000.00	$15,000.00
1.14	400mm Valves	ea.	0.0	$6,000.00	$0.00
1.15	Connect to existing	ea.	1.0	$5,000.00	$5,000.00
1.16	Misc fittings	ea.		$1,500.00	$0.00
1.17	Flushing, chlorination and testing	l.m	1768.0	$20.00	$35,360.00
1.18	Water service - large diameter	l.m	50.0	$125.00	$6,250.00
1.19	Water service - small diameter	l.m	830.0	$125.00	$103,750.00
1.20	Water Service Tie in to main large dia.	ea.	5.0	$2,500.00	$12,500.00
1.21	Water Service Tie in to main small dia.	ea.	83.0	$500.00	$41,500.00
				Subtotal Phase 5 Water Distribution	***$1,114,145.00***

	Wastewater Collection and Disposal				
2.1	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	2002.0	$200.00	$400,400.00
2.2	Trenching/Backfilling - Sanitary (4-5m deep)	l.m	110.0	$250.00	$27,500.00
2.3	Trenching/Backfilling - Sanitary (5-6m deep)	l.m	212.0	$300.00	$63,600.00
2.4	Trenching/Backfilling - Sanitary (6-7m deep)	l.m		$350.00	$0.00
2.5	200Ø PVC main	l.m	1444.0	$100.00	$144,400.00
2.6	300Ø PVC main	l.m	0.0	$150.00	$0.00
2.7	400Ø PVC main	l.m	0.0	$200.00	$0.00
2.8	100Ø Low Pressure sewer	l.m	0.0	$300.00	$0.00
2.9	150Ø PVC Forcemain	l.m	75.0	$450.00	$33,750.00
2.10	300Ø PVC Forcemain	l.m	0.0	$150.00	$0.00
2.12	Sewer Lift Station (cost Shared with Ta'an)	ea.	0.35	$350,000.00	$122,500.00
2.11	Sanitary manhole	ea.	11.0	$7,500.00	$82,500.00
2.12	Connect to existing sanitary system	ea.	1.0	$500.00	$500.00
2.13	TV inspection and testing	l.m	1444.0	$15.00	$21,660.00
2.14	Sewer Service 100-150mm Bare	l.m	880.0	$75.00	$66,000.00
2.15	Sewer Service 100-150mm Insulated	l.m	0	$175.00	$0.00
2.16	Sewer main tie in to main, saddle or in-line tee	ea.	88.0	$500.00	$44,000.00
				Subtotal Phase 5 Wastewater Collection and Disposal	***$1,006,810.00***

	Stormwater Management				
3.1	Trenching/Backfilling - Storm	l.m	1183.0	$150.00	$177,450.00
3.2	450Ø CSP Storm Main	l.m	1183.0	$125.00	$147,875.00
3.3	Storm manhole 1200 dia.	ea.	6.0	$7,500.00	$45,000.00
3.4	Catchbasin 600mm c/w 10m lead and trench/backfill	ea.	13.0	$5,000.00	$65,000.00
3.5	Catchbasin manhole	ea.	0.0	$7,500.00	$0.00
3.6	Exfiltration Pit	ea.	2.0	$10,000.00	$20,000.00
3.7	Connect to existing storm main	ea.	0.0	$2,500.00	$0.00
3.8	Outfalls c/w rip rap erosion control	ea.	2.0	$5,000.00	$10,000.00
3.9	Bio-swale	l.m	363	$150.00	$54,450.00
3.10	TV inspection and testing	l.m	1173.0	$15.00	$17,595.00
				Subtotal Phase 5 Stormwater Management	***$537,370.00***

Whistle Bend Subdivision Class D Cost Estimate - Phase 5

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Transportation				
4.1	Clearing	Sq. m	26842.0	$1.00	$26,842.00
4.2	Grubbing and Stripping (topsoil)	Sq. m	26842.0	$2.00	$53,684.00
4.3	Excavation and replace with pit run (roads or utilities	Cu.m	12951.0	$30.00	$388,530.00
4.4	subgrade preparation	Sq. m	15506.0	$2.50	$38,765.00
4.5	sub-base (80mm, 300mm thick, pit run)	Sq. m	15506.0	$12.00	$186,072.00
4.6	Base (20mm, 150mm Thick)	Sq. m	15506.0	$10.00	$155,060.00
4.7	75mm AC Surface	Sq. m	13264.0	$35.00	$464,240.00
4.8	Boulevard Restoration	Sq. m	8496.0	$15.00	$127,440.00
4.9	Curb, rolled or barrier	l.m	2638.0	$100.00	$263,800.00
4.10	Separate Sidewalk	Sq. m	4092.0	$125.00	$511,500.00
4.11	Street Lights	ea.	26.0	$5,000.00	$130,000.00
4.12	Signs and Pavement Marking	lump Sum	1	$10,000.00	$10,000.00
4.13	Trails - Gravel 3m Wide	l.m	1414	$37.50	$53,025.00
4.14	Trails - Paved 3m Wide	l.m	1337	$127.50	$170,467.50
4.15	Boulevard Trees @7m Cntrs both sides of road and medians)	ea.	352	$1,000.00	$352,000.00
				Subtotal Phase 5 Transportation	***$2,931,425.50***

	Shallow Utilities				
	Power, Telephone, Cable (Single)	ea.	83.0	$6,000.00	$498,000.00
	Power, Telephone, Cable (Multi - per unit)	ea.	144	$3,000.00	$432,000.00
				Subtotal Shallow Utilities	***$930,000.00***

Subtotal	**$6,519,750.50**
Mobilization	***$65,000.00***
Contingency & Estimating Allowance (25%)	**$1,646,187.63**
Subtotal	**$8,230,938.13**
Engineering (15%)	**$1,234,640.72**
Grand Total	**$9,465,578.84**

Whistle Bend Subdivision Class D Cost Estimate - Phase 6

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.1	Trenching/Backfilling	l.m	8525.0	$200.00	$1,705,000.00
1.2	150Ø PVC/ DI MAIN	l.m	1139.0	$100.00	$113,900.00
1.3	200Ø PVC/ DI MAIN	l.m	1262.0	$125.00	$157,750.00
1.4	250Ø PVC/ DI MAIN	l.m	1915.0	$150.00	$287,250.00
1.5	300Ø PVC/ DI MAIN	l.m	517.0	$175.00	$90,475.00
1.6	350Ø PVC/ DI MAIN	l.m	92.0	$230.00	$21,160.00
1.7	400Ø PVC/ DI MAIN	l.m	0.0	$300.00	$0.00
1.8	Hydrant	ea.	35.0	$7,500.00	$262,500.00
1.9	150mm Valves	ea.	4.0	$2,000.00	$8,000.00
1.1	200mm Valves	ea.	14.0	$2,500.00	$35,000.00
1.11	250mm Valves	ea.	22.0	$3,000.00	$66,000.00
1.12	300mm Valves	ea.	5.0	$3,500.00	$17,500.00
1.13	350mm Valves	ea.	1.0	$5,000.00	$5,000.00
1.14	400mm Valves	ea.	0.0	$6,000.00	$0.00
1.15	Connect to existing	ea.	4.0	$5,000.00	$20,000.00
1.16	Misc fittings	ea.		$1,500.00	$0.00
1.17	Flushing, chlorination and testing	l.m	4925.0	$20.00	$98,500.00
1.18	Water service - large diameter	l.m	60.0	$125.00	$7,500.00
1.19	Water service - small diameter	l.m	3540.0	$125.00	$442,500.00
1.20	Water Service Tie in to main large dia.	ea.	6.0	$2,500.00	$15,000.00
1.21	Water Service Tie in to main small dia.	ea.	354.0	$500.00	$177,000.00
				Subtotal Phase 6 Water Distribution	***$3,530,035.00***

	Wastewater Collection and Disposal				
2.1	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	6580.0	$200.00	$1,316,000.00
2.2	Trenching/Backfilling - Sanitary (4-5m deep)	l.m	1050.0	$250.00	$262,500.00
2.3	Trenching/Backfilling - Sanitary (5-6m deep)	l.m	749.0	$300.00	$224,700.00
2.4	Trenching/Backfilling - Sanitary (6-7m deep)	l.m	150.0	$350.00	$52,500.00
2.5	200Ø PVC main	l.m	4211.0	$100.00	$421,100.00
2.6	300Ø PVC main	l.m	450.0	$150.00	$67,500.00
2.7	400Ø PVC main	l.m	0.0	$200.00	$0.00
2.8	100Ø Low Pressure sewer	l.m	0.0	$300.00	$0.00
2.9	150Ø PVC Forcemain	l.m	0.0	$450.00	$0.00
2.10	300Ø PVC Forcemain	l.m	0.0	$150.00	$0.00
2.11	Sanitary manhole	ea.	40.0	$7,500.00	$300,000.00
2.13	Connect to existing sanitary system	ea.	2.0	$500.00	$1,000.00
2.14	TV inspection and testing	l.m	4779.0	$15.00	$71,685.00
2.15	Sewer Service 100-150mm Bare	l.m	3600.0	$75.00	$270,000.00
2.16	Sewer Service 100-150mm Insulated	l.m	0	$175.00	$0.00
2.17	Sewer main tie in to main, saddle or in-line tee	ea.	360.0	$500.00	$180,000.00
				Subtotal Phase 6 Wastewater Collection and Disposal	***$3,166,985.00***

	Stormwater Management				
3.1	Trenching/Backfilling - Storm	l.m	2112.0	$150.00	$316,800.00
3.2	450Ø CSP Storm Main	l.m	2112.0	$125.00	$264,000.00
3.3	Storm manhole 1200 dia.	ea.	22.0	$7,500.00	$165,000.00
3.4	Catchbasin 600mm c/w 10m lead and trench/backfill	ea.	25.0	$5,000.00	$125,000.00
3.5	Catchbasin manhole	ea.	5.0	$7,500.00	$37,500.00
3.6	Exfiltration Pit	ea.	2.0	$10,000.00	$20,000.00
3.7	Connect to existing storm main	ea.	1.0	$2,500.00	$2,500.00
3.8	Outfalls c/w rip rap erosion control	ea.	1.0	$5,000.00	$5,000.00
3.9	Bio-swale	l.m	0	$150.00	$0.00
3.10	TV inspection and testing	l.m	2112.0	$15.00	$31,680.00
				Subtotal Phase 6 Stormwater Management	***$967,480.00***

Whistle Bend Subdivision Class D Cost Estimate - Phase 6

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Transportation				
4.1	Clearing	Sq. m	34786.0	$1.00	$34,786.00
4.2	Grubbing and Stripping (topsoil)	Sq. m	34786.0	$2.00	$69,572.00
4.3	Excavation and replace with pit run (roads or utilities	Cu.m	55253.0	$30.00	$1,657,590.00
4.4	subgrade preparation	Sq. m	48148.0	$2.50	$120,370.00
4.5	sub-base (80mm, 300mm thick, pit run)	Sq. m	48148.0	$12.00	$577,776.00
4.6	Base (20mm, 150mm Thick)	Sq. m	48148.0	$10.00	$481,480.00
4.7	75mm AC Surface	Sq. m	40654.0	$35.00	$1,422,890.00
4.8	Boulevard Restoration	Sq. m	25094.0	$15.00	$376,410.00
4.9	Curb, rolled or barrier	l.m	7768.0	$100.00	$776,800.00
4.10	Separate Sidewalk	Sq. m	12259.0	$125.00	$1,532,375.00
4.11	Street Lights	ea.	80.0	$5,000.00	$400,000.00
4.12	Signs and Pavement Marking	lump Sum	1	$20,000.00	$20,000.00
4.13	Trails - Gravel 3m Wide	l.m	3401	$37.50	$127,537.50
4.14	Trails - Paved 3m Wide	l.m	1791	$127.50	$228,352.50
4.16	Signalized Intersections at F.H Kilbourne Dr	ea.	1.0	$250,000.00	$250,000.00
4.18	Signalized Intersections at Chakewana Dr (north)	ea.	1.0	$250,000.00	$250,000.00
4.19	Boulevard Trees @7m Cntrs both sides of road and medians)	ea.	1036	$1,000.00	$1,036,000.00
				Subtotal Phase 6 Transportation	***$9,361,939.00***
	Shallow Utilities				
	Power, Telephone, Cable (Single)	ea.	354.0	$6,000.00	$2,124,000.00
	Power, Telephone, Cable (Multi - per unit)	ea.	160	$3,000.00	$480,000.00
				Subtotal Shallow Utilities	***$2,604,000.00***
				Subtotal	**$19,630,439.00**
				Mobilization	***$165,000.00***
				Contingency & Estimating Allowance (25%)	**$4,948,859.75**
				Subtotal	**$24,744,298.75**
				Engineering (15%)	**$3,711,644.81**
				Grand Total	**$28,455,943.56**

Whistle Bend Subdivision Class D Cost Estimate - Heiland First Nation Development

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.1	Trenching/Backfilling	l.m	2237	$200.00	$447,400.00
1.2	150Ø PVC/ DI MAIN	l.m	457	$100.00	$45,700.00
1.3	200Ø PVC/ DI MAIN	l.m	0	$125.00	$0.00
1.4	250Ø PVC/ DI MAIN	l.m	469	$150.00	$70,350.00
1.5	300Ø PVC/ DI MAIN	l.m	271	$175.00	$47,425.00
1.6	350Ø PVC/ DI MAIN	l.m	0	$230.00	$0.00
1.7	400Ø PVC/ DI MAIN	l.m	0	$300.00	$0.00
1.8	Hydrant	ea.	12	$7,500.00	$90,000.00
1.9	150mm Valves	ea.	6	$2,000.00	$12,000.00
1.1	200mm Valves	ea.	0	$2,500.00	$0.00
1.11	250mm Valves	ea.	5	$3,000.00	$15,000.00
1.12	300mm Valves	ea.	3	$3,500.00	$10,500.00
1.13	350mm Valves	ea.	0	$5,000.00	$0.00
1.14	400mm Valves	ea.	0	$6,000.00	$0.00
1.15	Connect to existing	ea.	2	$500.00	$1,000.00
1.16	Misc fittings	ea.	0	$1,500.00	$0.00
1.17	Flushing, chlorination and testing	l.m	1197	$20.00	$23,940.00
1.18	Water service - large diameter	l.m	0	$125.00	$0.00
1.19	Water service - small diameter	l.m	1040	$125.00	$130,000.00
1.20	Water Service Tie in to main large dia.	ea.	0	$2,500.00	$0.00
1.21	Water Service Tie in to main small dia.	ea.	104	$500.00	$52,000.00
				Subtotal Water Distribution	***$945,315.00***

	Wastewater Collection and Disposal				
2.1	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	580	$200.00	$116,000.00
2.2	Trenching/Backfilling - Sanitary (4-5m deep)	l.m	565	$250.00	$141,250.00
2.3	Trenching/Backfilling - Sanitary (5-6m deep)	l.m		$300.00	$0.00
2.4	Trenching/Backfilling - Sanitary (6-7m deep)	l.m		$350.00	$0.00
2.5	200Ø PVC main	l.m	1145	$100.00	$114,500.00
2.6	300Ø PVC main	l.m		$150.00	$0.00
2.7	400Ø PVC main	l.m		$200.00	$0.00
2.8	100Ø Low Pressure sewer	l.m		$300.00	$0.00
2.9	150Ø PVC Forcemain	l.m		$100.00	$0.00
2.10	300Ø PVC Forcemain	l.m		$150.00	$0.00
2.11	Sanitary manhole	ea.	10	$7,500.00	$75,000.00
2.12	Connect to existing sanitary system	ea.	2	$5,000.00	$10,000.00
2.13	TV inspection and testing	l.m	1145	$15.00	$17,175.00
2.14	Sewer Service 100-150mm Bare	l.m	1040	$75.00	$78,000.00
2.15	Sewer Service 100-150mm Insulated	l.m		$175.00	$0.00
2.16	Sewer main tie in to main, saddle or in-line tee	ea.	104	$500.00	$52,000.00
				SubtotalWastewater Collection and Disposal	***$603,925.00***

	Stormwater Management				
3.1	Trenching/Backfilling - Storm	l.m	1145	$150.00	$171,750.00
3.2	450Ø CSP Storm Main	l.m	1145	$125.00	$143,125.00
3.3	Storm manhole 1200 dia.	ea.	10	$7,500.00	$75,000.00
3.4	Catchbasin 600mm c/w 10m lead and trench/backfill	ea.	20	$5,000.00	$100,000.00
3.5	Catchbasin manhole	ea.	0	$7,500.00	$0.00
3.6	Exfiltration Pit	ea.	0	$10,000.00	$0.00
3.7	Connect to existing storm main	ea.	2	$2,500.00	$5,000.00
3.8	Outfalls c/w rip rap erosion control	ea.	0	$5,000.00	$0.00
3.9	Bio-swale	l.m	0	$150.00	$0.00
3.10	TV inspection and testing	l.m	1145	$15.00	$17,175.00
				Subtotal Stormwater Management	***$512,050.00***

Whistle Bend Subdivision Class D Cost Estimate - Heiland First Nation Development

Date: November 3rd, 2009

4.1	**Transportation**				
4.2	Clearing	Sq. m	20610	$1.00	$20,610.00
4.3	Grubbing and Stripping (topsoil)	Sq. m	20610	$2.00	$41,220.00
4.4	Excavation and replace with pit run (roads or utilities	Cu.m	2889	$30.00	$86,670.00
4.5	subgrade preparation	Sq. m	11106	$2.50	$27,765.00
4.6	sub-base (80mm, 300mm thick, pit run)	Sq. m	11106	$12.00	$133,272.00
4.7	Base (20mm, 150mm Thick)	Sq. m	11106	$10.00	$111,060.00
4.8	75mm AC Surface	Sq. m	9160	$35.00	$320,600.00
4.9	Boulevard Restoration	Sq. m	7442	$15.00	$111,630.00
4.10	Curb, rolled or barrier	l.m	2290	$100.00	$229,000.00
4.11	Separate Sidewalk	Sq. m	3435	$125.00	$429,375.00
4.12	Street Lights	ea.	23	$5,000.00	$115,000.00
4.14	Signs and Pavement Marking	lump Sum	1	$20,000.00	$20,000.00
4.15	Trails - Gravel 3m Wide	l.m	0	$37.50	$0.00
4.16	Trails - Paved 3m Wide	l.m	0	$127.50	$0.00
4.17	Boulevard Trees @7m Cntrs both sides of road and medians)	ea.	305	$1,000.00	$305,000.00
				Subtotal Transportation	***$1,951,202.00***

	Shallow Utilities				
	Power, Telephone, Cable (Single)	ea.	104	$6,000.00	$624,000.00
	Power, Telephone, Cable (Multi - per unit)	ea.		$3,000.00	$0.00
				Subtotal Shallow Utilities	***$624,000.00***
				Subtotal	**$4,636,492.00**
				Mobilization	**$50,000.00**
				Contingency & Estimating Allowance (25%)	**$1,171,623.00**
				Subtotal	**$5,858,115.00**
				Engineering (15%)	**$878,717.25**
				Grand Total	**$6,736,832.25**

Whistle Bend Subdivision Class D Cost Estimate - Ta'an First Nation Development

Date: November 3rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.1	Trenching/Backfilling	l.m	4213	$200.00	$842,600.00
1.2	150Ø PVC/ DI MAIN	l.m	872	$100.00	$87,200.00
1.3	200Ø PVC/ DI MAIN	l.m	689	$125.00	$86,125.00
1.4	250Ø PVC/ DI MAIN	l.m		$150.00	$0.00
1.5	300Ø PVC/ DI MAIN	l.m		$175.00	$0.00
1.6	350Ø PVC/ DI MAIN	l.m	542	$230.00	$124,660.00
1.7	400Ø PVC/ DI MAIN	l.m		$300.00	$0.00
1.8	Hydrant	ea.	22	$7,500.00	$165,000.00
1.9	150mm Valves	ea.	5	$2,000.00	$10,000.00
1.1	200mm Valves	ea.	7	$2,500.00	$17,500.00
1.11	250mm Valves	ea.		$3,000.00	$0.00
1.12	300mm Valves	ea.		$3,500.00	$0.00
1.13	350mm Valves	ea.	5	$5,000.00	$25,000.00
1.14	400mm Valves	ea.		$6,000.00	$0.00
1.15	Connect to existing	ea.	4	$500.00	$2,000.00
1.16	Misc fittings	ea.		$1,500.00	$0.00
1.17	Flushing, chlorination and testing	l.m	2193	$20.00	$43,860.00
1.18	Water service - large diameter	l.m	40	$125.00	$5,000.00
1.19	Water service - small diameter	l.m	1980	$125.00	$247,500.00
1.20	Water Service Tie in to main large dia.	ea.	4	$2,500.00	$10,000.00
1.21	Water Service Tie in to main small dia.	ea.	109	$500.00	$54,500.00
				Subtotal Water Distribution	***$1,720,945.00***

	Wastewater Collection and Disposal				
2.1	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	1388	$200.00	$277,600.00
2.2	Trenching/Backfilling - Sanitary (4-5m deep)	l.m	1114	$250.00	$278,500.00
2.3	Trenching/Backfilling - Sanitary (5-6m deep)	l.m	0	$300.00	$0.00
2.4	Trenching/Backfilling - Sanitary (6-7m deep)	l.m	0	$350.00	$0.00
2.5	200Ø PVC main	l.m	2502	$100.00	$250,200.00
2.6	300Ø PVC main	l.m	0	$150.00	$0.00
2.7	400Ø PVC main	l.m	0	$200.00	$0.00
2.8	100Ø Low Pressure sewer	l.m	0	$300.00	$0.00
2.9	150Ø PVC Forcemain	l.m	150	$450.00	$67,500.00
2.10	300Ø PVC Forcemain	l.m	0	$150.00	$0.00
2.11	Sanitary manhole	ea.	18	$7,500.00	$135,000.00
2.12	Sewer Lift Station (cost shared with Phase 5)	ea.	0.65	$350,000.00	$227,500.00
2.12	Connect to existing sanitary system	ea.	2	$5,000.00	$10,000.00
2.13	TV inspection and testing	l.m	2107	$15.00	$31,605.00
2.14	Sewer Service 100-150mm Bare	l.m	2020	$75.00	$151,500.00
2.15	Sewer Service 100-150mm Insulated	l.m		$175.00	$0.00
2.16	Sewer main tie in to main, saddle or in-line tee	ea.	202	$500.00	$101,000.00
				SubtotalWastewater Collection and Disposal	***$1,530,405.00***

	Stormwater Management				
3.1	Trenching/Backfilling - Storm	l.m	988	$150.00	$148,200.00
3.2	450Ø CSP Storm Main	l.m	988	$125.00	$123,500.00
3.3	Storm manhole 1200 dia.	ea.	10	$7,500.00	$75,000.00
3.4	Catchbasin 600mm c/w 10m lead and trench/backfill	ea.	22	$5,000.00	$110,000.00
3.5	Catchbasin manhole	ea.	0	$7,500.00	$0.00
3.6	Exfiltration Pit	ea.	0	$10,000.00	$0.00
3.7	Connect to existing storm main	ea.	2	$2,500.00	$5,000.00
3.8	Outfalls c/w rip rap erosion control	ea.	0	$5,000.00	$0.00
3.9	Bio-swale	l.m	0	$150.00	$0.00
3.10	TV inspection and testing	l.m	998	$15.00	$14,970.00
				Subtotal Stormwater Management	***$476,670.00***

Whistle Bend Subdivision Class D Cost Estimate - Ta'an First Nation Development

Date: November 3rd, 2009

4.1	**Transportation**				
4.2	Clearing	Sq. m	43588	$1.00	$43,588.00
4.3	Grubbing and Stripping (topsoil)	Sq. m	43588	$2.00	$87,176.00
4.4	Excavation and replace with pit run (roads or utilities	Cu.m	24189	$30.00	$725,670.00
4.5	subgrade preparation	Sq. m	25156	$2.50	$62,890.00
4.6	sub-base (80mm, 300mm thick, pit run)	Sq. m	25156	$12.00	$301,872.00
4.7	Base (20mm, 150mm Thick)	Sq. m	25156	$10.00	$251,560.00
4.8	75mm AC Surface	Sq. m	21508	$35.00	$752,780.00
4.9	Boulevard Restoration	Sq. m	13825	$15.00	$207,375.00
4.10	Curb, rolled or barrier	l.m	4292	$100.00	$429,200.00
4.11	Separate Sidewalk	Sq. m	6438	$125.00	$804,750.00
4.12	Street Lights	ea.	42	$5,000.00	$210,000.00
4.14	Signs and Pavement Marking	lump Sum	1	$10,000.00	$10,000.00
4.15	Trails - Gravel 3m Wide	l.m	600	$37.50	$22,500.00
4.16	Trails - Paved 3m Wide	l.m		$127.50	$0.00
4.17	Boulevard Trees @7m Cntrs both sides of road and medians)	ea.	572	$1,000.00	$572,000.00
				Subtotal Transportation	***$4,481,361.00***

	Shallow Utilities				
	Power, Telephone, Cable (Single)	ea.	198	$6,000.00	$1,188,000.00
	Power, Telephone, Cable (Multi - per unit)	ea.	161	$3,000.00	$483,000.00
				Subtotal Shallow Utilities	***$1,671,000.00***

Subtotal	**$9,880,381.00**
Mobilization	**$100,000.00**
Contingency & Estimating Allowance (25%)	**$2,495,095.25**
Subtotal	**$12,475,476.25**
Engineering (15%)	**$1,871,321.44**
Grand Total	**$14,346,797.69**

Whistle Bend Subdivision Class C Cost Estimate - Range Road Trunk Watermain

Date: December 22nd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Water Distribution System				
1.2	450mm Dia DI, bare, un-restrained	l.m	1600	$225.00	$360,000.00
1.3	450mm Dia DI, bare, restrained	l.m	800	$275.00	$220,000.00
1.1	Trenching/Backfilling	l.m	2400	$250.00	$600,000.00
1.4	Pipe installation, unrestrained	l.m	1600	$125.00	$200,000.00
1.5	Pipe installation, restrained	l.m	800	$175.00	$140,000.00
1.6	Drain Rock or pea gravel pipe bedding	l.m	2400	$25.00	$60,000.00
1.7	Common Excavation and Pregrading allowance	Cu.m	1000	$10.00	$10,000.00
1.8	Hydrant and Hydrant Tee assembly	ea.	2	$7,500.00	$15,000.00
1.9	Watermain Fittings 450mm	ea.	10	$3,500.00	$35,000.00
1.1	Butterfly valves and valve boxes, 450mm	ea.	4	$4,000.00	$16,000.00
1.11	Concrete filled bollards	ea.	8	$500.00	$4,000.00
1.12	Surface Restoration, subgrade prep	sq. m	5000	$4.00	$20,000.00
1.13	Base (20mm, 150mm Thick)	Sq. m	15000	$10.00	$150,000.00
1.14	Surface Restoration, 20mm BST surface course	Sq. m	11000	$12.00	$132,000.00
1.15	Clearing and Grubbing	Sq. m	24000	$5.00	$120,000.00
1.16	Tie to Existing Watermains	ea.	1	$5,000.00	$5,000.00
1.17	450mm Dia saddles and mainstops	l.m	2	$500.00	$1,000.00
1.18	Flushing, chlorination	lump Sum	1	$25,000.00	$25,000.00
1.19	Pressure testing	lump Sum	1	$12,500.00	$12,500.00
1.20	Rock excavation	Cu.m	50	$100.00	$5,000.00
1.21	Install trench plug	ea.	8	$500.00	$4,000.00
1.17	PRV bypass allowance	lump Sum	1	$150,000.00	$150,000.00
				Subtotal Water Distribution	***$2,284,500.00***

	McIntyre Creek Culvert and Road Widening				
2.1	Erosion Control	Lump Sum	1.0	$ 20,000.00	$ 20,000.00
2.2	Common excavation , including off-site disposal	Cu.m	75	$ 30.00	$ 2,250.00
2.3	Culvert demolition and disposal	Lump Sum	1	$ 5,000.00	$ 5,000.00
2.4	Imported Fill, (from Whitslebend connector) including compaction	Cu.m	8045	$ 10.00	$ 80,450.00
2.5	Base (20mm, 150mm Thick)	Sq. m	1260	$10.00	$12,600.00
2.6	20mm BST paving - (4.5m wide)	Sq. m	1260	$ 12.00	$ 15,120.00
2.7	Pipe insulation at creek crossing	Lump sum	1	*$ 5,000.00*	$ 5,000.00
2.8	4572 x 1422 CSP Arched Culvert	Metre	36	$ 4,500.00	$ 162,000.00
2.9	End walls – concrete	Each	2	$ 10,000.00	$ 20,000.00
2.10	Guard Rail	Metre	60	*$ 300.00*	$ 18,000.00
2.11	Mitigation of fish habitat - allowance	Lump Sum	1	$ 30,000.00	$ 30,000.00
				Subtotal Creek Crossing	***$370,420.00***
				Subtotal	**$2,654,920.00**
				Mobilization	***$25,000.00***
				Contingency & Estimating Allowance (15%)	**$398,238.00**
				Subtotal	**$3,078,158.00**
				Engineering (15%)	**$461,723.70**
				Grand Total	**$3,539,881.70**

Whistle Bend Subdivision Off-Site Waste Water Collection and Disposal

Date: November 3rd, 2009

Wastewater Collection and Disposal @ 0% Class C Estimate

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
	Wastewater Collection and Disposal @ 0%				
1.1	Clearing, Grubbing and disposal allowance	Sq. m	2500.0	$5.00	$12,500.00
1.2	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	661.0	$200.00	$132,200.00
1.3	300Ø PVC Forcemain	l.m	661.0	$550.00	$363,550.00
1.4	Connect to existing PCFT c/w chamber and valving	lump Sum	1.0	$30,000.00	$30,000.00
1.5	TV inspection and testing	l.m	661.0	$15.00	$9,915.00

Subtotal Off-Site Wastewater Collection and Disposal @ 0%	**$548,165.00**
Mobilization	**$10,000.00**
Contingency & Estimating Allowance (15%)	**$83,724.75**
Subtotal	**$641,889.75**
Engineering (15%)	**$96,283.46**
Total Off Site Wastewater Collection and Disposal @ 0%	**$738,173.21**

Wastewater Collection and Disposal @ 75% Class D Estimate

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
2.2	Trenching/Backfilling - Sanitary (3-4m deep)	l.m	200.0	$200.00	$40,000.00
2.4	450Ø HDPE Gravity Forcemain	l.m	200.0	$375.00	$75,000.00
2.6	TV inspection and testing	l.m	200.0	$15.00	$3,000.00

Subtotal Off-Site Wastewater Collection and Disposal @ 75%	**$118,000.00**
Mobilization	**$10,000.00**
Contingency & Estimating Allowance (25%)	**$32,000.00**
Sub Total	**$160,000.00**
Engineering (15%)	**$24,000.00**
Total Off Site Wastewater Collection and Disposal @ 75%	**$184,000.00**
Grand Total Off Site Wastewater Servicing	**$922,173.21**

Whistle Bend Subdivision Class C Cost Estimate - Whistlebend Drive

Initial 2 Lane Connection from Casca Blvd to Mountain View Road*

Date: December 22nd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
4.1	Clearing	Sq. m	47375.0	$1.00	$47,375.00
4.2	Grubbing and Stripping (topsoil)	Sq. m	47375.0	$2.00	$94,750.00
4.3	Excavate and place material on site Including Compaction	Cu.m	79123.0	$9.00	$712,107.00
4.4	Excavation and Dispose off site	Cu.m	28298.0	$15.00	$424,470.00
4.6	Geofabric at subgrade in poor soil area	Sq. m	1900.0	$15.00	$28,500.00
4.7	Subgrade preparation	Sq. m	16165.0	$2.50	$40,412.50
4.8	Sub-base (80mm, 300mm thick, pit run)	Sq. m	16165.0	$12.00	$193,980.00
4.11	Base (20mm, 150mm Thick)	Sq. m	16165.0	$10.00	$161,650.00
4.12	100 mm AC Surface	Sq. m	15604.0	$45.00	$702,180.00
4.18	Retaining walls	Sq. m	2050.0	$1,000.00	$2,050,000.00
4.19	Fence on top of Retaining walls	m	800.0	$50.00	$40,000.00
4.20	Guard Rail	m	950.0	$300.00	$285,000.00
4.21	Street Lights	ea.	44.0	$5,000.00	$220,000.00
4.22	Signs and Pavement Marking	lump Sum	1	$10,000.00	$10,000.00
4.23	Single Lane Roundabout at Casca Blvd	ea.	1.0	$250,000.00	$250,000.00

Subtotal	***$5,260,424.50***
Mobilization	***$100,000.00***
Contingency & Estimating Allowance (15%)	**$804,063.68**
Subtotal	**$6,164,488.18**
Engineering (15%)	**$924,673.23**
Grand Total	**$7,089,161.40**

* Cost estimate includes realignment of Range Road/ Whistlebend Drive intersection

Whistle Bend Subdivision Class C Cost Estimate - Proposed Bike Trail

Date: October 23rd, 2009

Item	Description	Unit of Measure	Quantity	Unit Price ($)	Amount
1	Clearing and grubbing	Sq.m.	10000	$2.00	$20,000
2	Stripping, 250 mm depth	Sq.m.	8015	$2.00	$16,030
3	Borrow (Type D Fill)	cu.m.	9500	$20.00	$190,000
6	Subgrade Preparation (200 mm Depth)	Sq.m.	7460	$2.50	$18,650
7	Compacted Gravel (80 mm, 200 Depth)	Sq.m.	7370	$10.00	$73,700
	50mm Asphalt Surface	Sq.m.	5025	$30.00	$150,750
15	Signs and Posts	each	5.00	$500.00	$2,500
19	Guard Rails/barriers	m	500.00	$100.00	$50,000
20	Miscellaneous Drainage (inlets/outlets etc.)	1.00	LS	$10,000.00	$10,000
				Subtotal Bike Trail	***$531,630.00***
				Mobilization	**$10,000.00**
				Contingency & Estimating Allowance (15%)	**$81,244.50**
				Sub Total	**$622,874.50**
				Engineering (15%)	**$93,431.18**
				Grand Total	**$716,305.68**

Assumptions and Notes:

1 Please refer to Drawing: CTF001RC.dwg for conceptual alignment and grades and typical sections

2 The unit rates are based on unit costs by Quest Engineering for the City of Whitehorse. The shaded unit costs are derived from the B.C. MoT Construction and Rehabilitation Cost Guide.

3 The estimate does not include any property acquisition costs or environmental mitigation costs.

Whistle Bend Offsite Water Servicing
Open cut Installation with 350 DI pipe, Mountainview Drive Crossing
Porter Creek D Extension - 2800 linear metres, restrained joints for 400 linear metres

Item	Description	Unit	Unit Rate	Quantity	Total
1	pipe, 350 mm DI, bare, un-restrained	l.m.	$200.00	2400	$480,000.00
	pipe, 350 mm DI, restrained joints	l.m.	$225.00	400	$90,000.00
2	Trench and Backfill, 3 - 4 m depth	l.m.	$250.00	2800	$700,000.00
3	pipe installation, unrestrained	l.m.	$100.00	2400	$240,000.00
	pipe installation, restrained	l.m.	$150.00	400	$60,000.00
4	drain rock or pea gravel pipe bedding	l.m.	$25.00	2800	$70,000.00
5	common excavation and pregrading allowance	cu.m.	$10.00	5000	$50,000.00
6	Hydrants and Hydrant tee assembly	each	$7,500.00	2	$15,000.00
7	Watermain fittings, 350 mm	each	$3,000.00	10	$30,000.00
8	Butterfly valves and valve boxes, 350 mm	each	$3,500.00	4	$14,000.00
9	Concrete Filled Bollards	each	$500.00	8	$4,000.00
10	Surface restoration, subgrade prep	sq.m.	$4.00	0	$0.00
11	Surface restoration, surface course	sq.m.	$10.00	0	$0.00
12	Clearing, grubbing and disposal allowance	sq.m.	$5.00	45000	$225,000.00
13	Tie to Existing Watermains	each	$5,000.00	2	$10,000.00
14	350 Saddles and Mainstops	each	$500.00	2	$1,000.00
15	Flushing and Chlorinating	lump sum	$25,000.00	1	$25,000.00
16	Pressure Testing	lump sum	$12,500.00	1	$12,500.00
17	Rock Excavation and waste (provisional)	cu.m.	$100.00	50	$5,000.00
18	Install trench plugs	each	$500.00	4	$2,000.00
19	PRV bypass vault allowance	lump sum	$150,000.00	1	$150,000.00
20	Road crossing allowance, Mountainview Drive	lump sum	$100,000.00	1	$100,000.00
21	Mobilization / Demobilization	lump sum	$25,000.00	1	$25,000.00
				Subtotal	**$2,308,500.00**
				Contingencies @ 25% for Class D Estimate	**$577,125.00**
				Subtotal	**$2,885,625.00**
				Engineering @ 15%	**$432,843.75**
				Total	**$3,318,468.75**
				Note: Approximately 80% recoverable with Porter Creek D Development	**-------**
				Portion attributable to Whistle Bend	**$663,693.75**

Whistle Bend Subdivision - Reservoir Expansions

1. Class C Estimate: 10,000 m^3 Addition to Valleyview Reservoir

Basic Cost – structure, excavation/backfill, valving, internal piping $400/$m^3$ capacity		$4,000,000
Additional Items		
- Bedrock excavation – assumed volume - 1400 m^3 @ $250		350,000
- Roofing system – insulation and membrane – 2250 m^2 @ $70		157,500
- Heating system – Furnace		8,000
- 300 mm ductwork, 80 m @ $60 + $3,200		8,000
- Exterior header pipe/modifications – 350 mm dia. 170 m @ $360		61,200
	Subtotal	**$4,584,700**
	Contingency and Estimating Allowance (+15%)	687,705
	Subtotal	**$5,272,405**
	Engineering (+15%)	790,860
	Total	**$6,063,000**

2. Class D Estimate: Future 5,000 m^3 Addition to Valleyview Reservoir

50% of cost of (1) above	**$3,032,000**

3. Class D Estimate: Future 6,000 m^3 Addition to Porter Creek Reservoir

60% of cost of (1) above	**$3,638,000**

Appendix B

Appendix B:
Reservoir Expansions

Valleyview Reservoir Pre-Design Brief

1. Site Analysis

The water supply analysis for this project calls for expansion of the existing 5,330 m^3 reservoir as follows:

Two – 5,000 m^3 cells @ 0% build-out
One – 5,000 m^3 cell @ 50% to 75% build-out

The area available for expansion is north of the existing reservoir. In order to construct the new cells to the same floor and roof elevations as the existing, and to minimize impact on the existing ski trail system, it is recommended that the three new cells be constructed roughly in line with the existing cells (see Figure 1). One section of the ski trail will need to be realigned to accommodate the reservoir expansion. The contours of the site are such that the fill embankment on the east side of the reservoir will be up to 7 m high. The reason for this relatively high embankment is that the bench the existing reservoir sites on tapers out to the north, such that the proposed new cells will be built into a 4 hor.:1 vert. side slope.

The site is generally treed with gravelly soil. An existing borehole associated with the original reservoir design, just north of the parking lot, indicates bedrock at 2.5 m depth. Under the existing reservoir, the depth to bedrock is 6 to 7 m. The geotechnical engineers were unable to perform additional boreholes due to site access difficulties. At an underside of floor design elevation of 753.0, it is likely that bedrock will be encountered in the vicinity of the existing borehole. The extent of shallow bedrock is not known. We have thus assumed a bedrock quantity and included an allowance for rock excavation in our estimate.

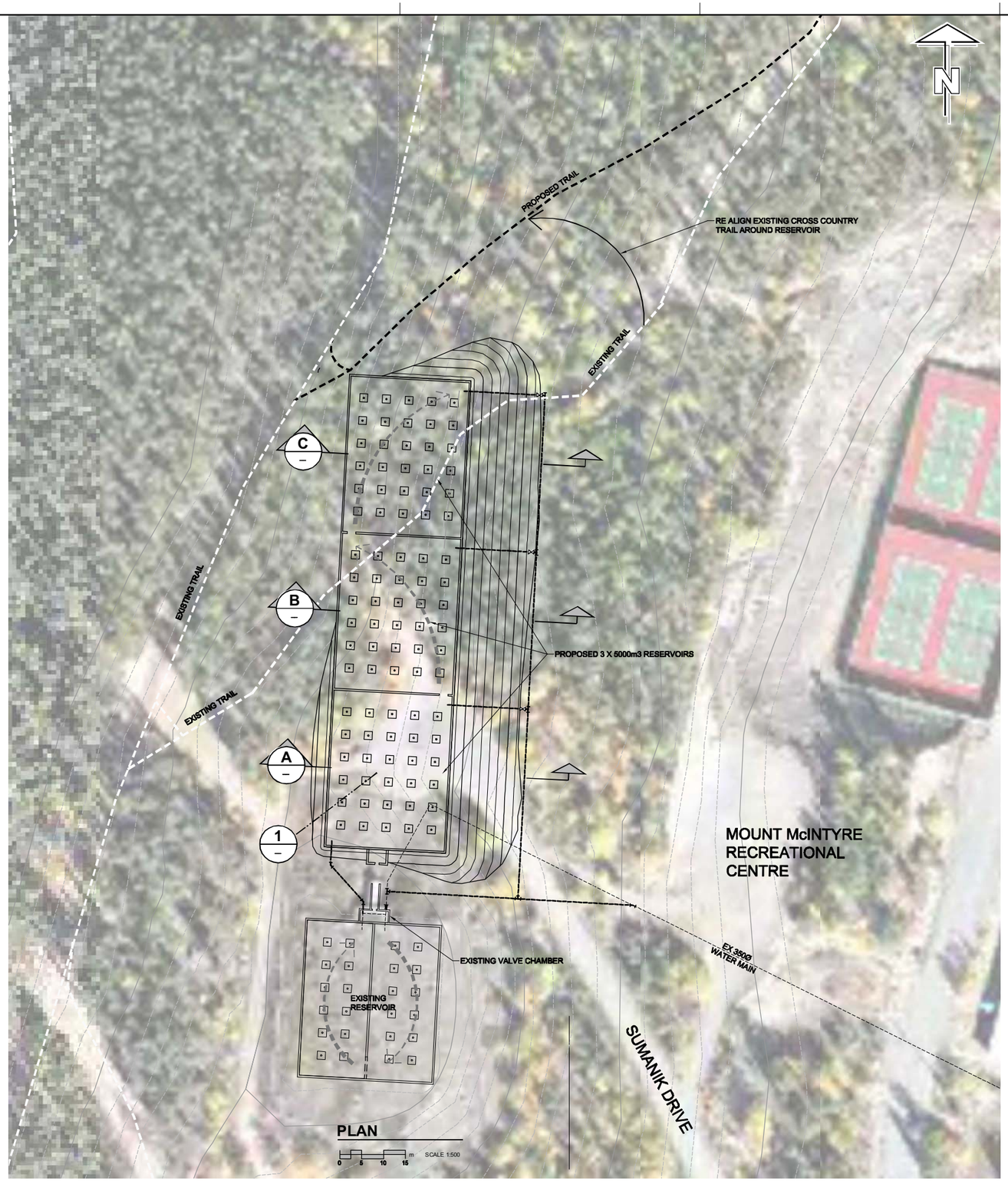
The existing parking lot will be covered by the proposed reservoir addition. It is proposed that an existing cleared area, which may be presently used for parking associated with the ski trails and McIntyre Recreation Complex, be utilized as parking for reservoir maintenance purposes. This parking area is located about 30 m beyond the toe of the proposed reservoir embankment fill.

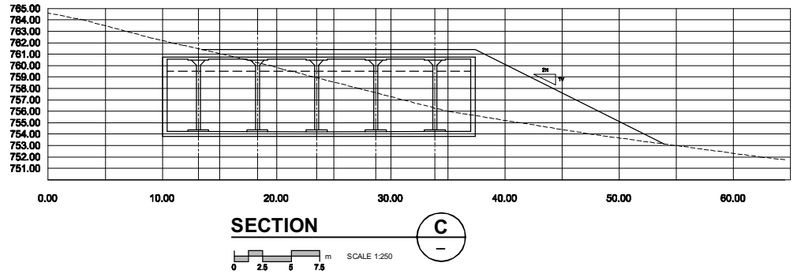
2. Piping and Circulation

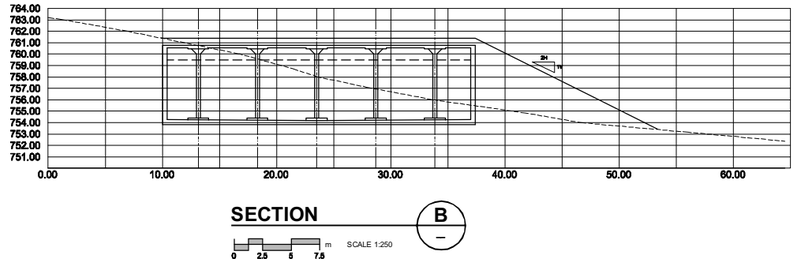
The existing two-cell reservoir has no interconnection piping between the two cells. Each cell is fed separately from the supply main through a single pipe which acts as the inlet and outlet for each cell. Although these cells are each relatively small, there is the potential for “dead spots” due to poor circulation, which could affect water quality.

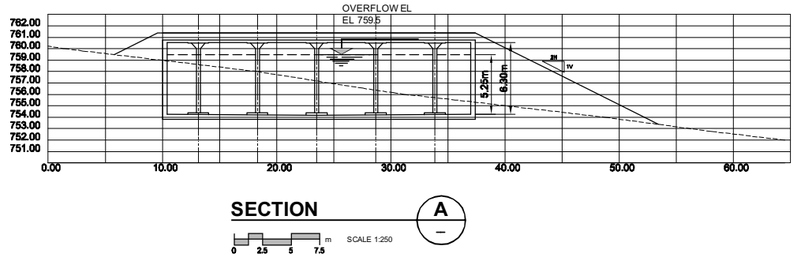
It is proposed that the existing and proposed reservoir cells be served by a 350 mm dia. header, teed off the incoming supply line to feed the five cells in series. This will allow the water to flow through the cells from south to north. The cell interconnection pipes will be oriented to enhance circulation within each cell and thus minimize the potential for dead spots, and sized to minimize the hydraulic losses between the cells. In order to integrate the existing reservoir cells into this arrangement, the existing in/out feed pipes can be converted to “in only” for one cell and “out only” for the other cell. An interconnection pipe will be added into the south end of the existing cell dividing wall. The outlet pipe from the existing reservoir will connect to the new reservoir cell immediately to the north. Note that the hydraulic capacity of the existing inlet and outlet pipes will have to be verified during detailed design. Valving will be arranged so any cell can be taken out of service temporarily, as necessary. This arrangement is shown in Figure 1.

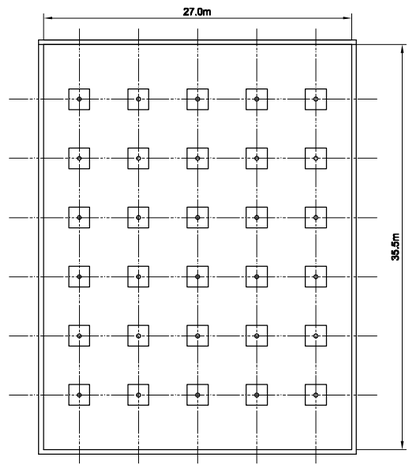
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City of Whitehorse
Whistle Bend Development

Valley View Reservoir Expansion
Preliminary Design
Figure 1

AECOM

3. Structural Arrangement

The first two new reservoir cells will be constructed independently from the existing reservoir, as shown. This will eliminate any potential structural influence of one structure upon the other, separate the footings, and allow the existing valve chamber structure to be modified for continued use. The third new cell to be added in the future should also be structurally separated from the second new cell.

The presence of bedrock within the footprint of the new cells will require special considerations during removal to ensure no damage occurs to the existing reservoir. Removal of rock by mechanical means, i.e. hoe ram or equivalent, is preferred over blasting. Any blasting that is necessary will have to be carefully controlled and monitored.

The new reservoir cells will be similar structurally to the existing cells. The floor slab will be separated from any bedrock surface by a granular/sand cushion to allow for unrestricted expansion and contraction of the floor slab. Design should be in accordance with ACI 350 guidelines.

The roof will be protected by a roofing system consisting of insulation, roofing membranes and earth cover. The City may wish to investigate the condition of the roofing membranes above the existing reservoir, if they haven't already been replaced. The original reservoir was built in 1965.

4. Other Considerations

A heating system for the air space above water level is included in the existing reservoir. A similar system may need to be installed to protect the new reservoir cells. Heaters will also be added to new valve chambers where necessary.

5. Reservoir Expansions Cost Estimates

5.1 Class C Estimate: 10,000 m^3 Addition to Valleyview Reservoir

Basic Cost – structure, excavation/backfill, valving, internal piping $400/$m^3$ capacity		$4,000,000
Additional Items		
- Bedrock excavation – assumed volume - 1400 m^3 @ $250		350,000
- Roofing system – insulation and membrane – 2250 m^2 @ $70		157,500
- Heating system – Furnace		8,000
- 300 mm ductwork, 80 m @ $60 + $3,200		8,000
- Exterior header pipe/modifications – 350 mm dia. 170 m @ $360		61,200
	Subtotal	**$4,584,700**
	Contingency and Estimating Allowance (+15%)	687,705
	Subtotal	**$5,272,405**
	Engineering (+15%)	790,860
	Total	**$6,063,000**

5.2 Class D Estimate: Future 5,000 m^3 Addition to Valleyview Reservoir

50% of cost of (1) above	**$3,032,000**

5.3 Class D Estimate: Future 6,000 m^3 Addition to Porter Creek Reservoir

60% of cost of (1) above	**$3,638,000**

4.0 OFF-SITE PRELIMINARY DESIGN DRAWINGS

AECOM
200 – 415 Gorge Road East
Victoria, BC, Canada V8T 2W1
www.aecom.com

250 475 6355 tel
250 475 6388 fax

23 December, 2009

Project No: 2501-040 [60113945 0200]

Wayne Tuck, P.Eng.
City Engineer
City of Whitehorse
Municipal Services Building
4210 - 4th Avenue
Whitehorse, YT Y1A 1C2

Dear Wayne:

Re: Whistle Bend Offsite Predesign Drawings

This letter is in response to Christine Benedek's letter of 3 December, 2009, providing comments on the preliminary design drawings. As mentioned in the City's letter, a number of the comments will be dealt with during detailed design. Other comments have been dealt with in the attached revised drawings.

Title page revisions have been made as requested.

General

- This change has not been made in the reports and drawings at this time. It would make sense for Yukon Government to combine the offsite portion with the onsite for the design and construction contract.
- Outline revised to include storm pond site.
- Insert A has been identified.

Whistle Bend Drive

- Right-turn deceleration and right-turn merge lanes are warranted and included in the cost estimate at the 50% build-out stage.
- Future watermain added.
- Right-of-way width revised to 70 m. Retaining wall design and cost estimate also revised.

- Guide rail has been added, including cost estimate, in Cost Estimate Summary report.
- Range Road connection realigned as suggested.

Bike Trail

- These details will be added during detailed design phase.
- McIntyre Creek culverts added.
- Extraneous lines have been deleted from this drawing. Range Road is not proposed to be relocated.

Range Road Trunk Watermain

- Watermain alignment adjusted in the vicinity of Whistle Bend Drive.
- Suggested watermain alignment adjustments have been made.
- Alignment adjusted as suggested.
- Alignment adjusted to boulevard area, except where the main crosses the creek.
- Fire hydrant added.
- Valves have been spaced at approximately 1,000m apart. If more are wanted, they can be added during detailed design.
- Our survey information is not complete at this time. This information will be added during detailed design.
- Typical cross sections have not been added at this time due to lack of survey information. These will be included in the detailed design drawings.
- A much larger CSP arch culvert with open bottom is now proposed. Negotiations with DFO will occur during detailed design.
- Concrete chamber noted on the drawings, and will be added to the detailed design.
- Pipe sections can be insulated as suggested. We prefer the board insulation shown in any case to increase the effective separation of the main from the top of the culvert.
- Guide rails will be extended as suggested.

Reservoir Expansion Plans

- We think this is the best way to promote circulation of the reservoir contents.
- Agreed. Valved opening added to west end of cell dividing wall.

- Freeze protection will be looked at in more detail during detailed design. The outlet pipe from Cell A could be valved at the edge of the reservoir to eliminate stagnant water/freezing water in the pipe. Freeze protection, i.e. a small heater, will probably be required in the new chamber.

- Rock removal will be required for Cells A and B, and Cell C should be blasted at the same time.

- Access Road and turning area added to site plan.

- Future valves will not be installed.

- Flowmeters are not proposed at this time.

Sewage Forcemain Connection to Flush Tank

- Forcemain route revised as suggested. This will be coordinated with YECL power alignment, which will be confirmed during detailed design.

- Macerators are proposed for the sewage pumpstation.

Thank you for your comments.

Sincerely,
AECOM Canada Ltd.



Ron Akehurst, P.Eng.
Manager, Municipal Infrastructure
Ron.Akehurst@aecom.com

RA/bl
Attch.

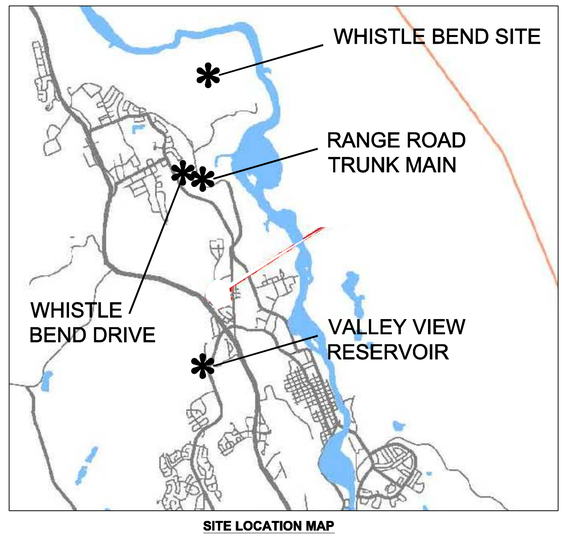
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City Of Whitehorse
Pre-Design For Whistle Bend

Off Site Works

LIST OF PROJECT DRAWINGS

CITY No.	DRAWING TITLE	CONSULTANT'S No.
	Cover Sheet	01-C-0100
201	Overall Plan	01-C-1100
202	Whistle Bend Drive Plan & Profile	01-C-1101
203	Bike Trail - Range Road to Mountain View Drive	01-C-1102
204	Range Road Trunk Main - Key Plan	01-C-1103
205	Range Road Trunk Main Plan & Profile Sheet 1 of 4	01-C-1104
206	Range Road Trunk Main Plan & Profile Sheet 2 of 4	01-C-1105
207	Range Road Trunk Main Plan & Profile Sheet 3 of 4	01-C-1106
208	Range Road Trunk Main Plan & Profile Sheet 4 of 4	01-C-1107
209	Range Road Trunk Main McIntyre Creek Crossing	01-C-1108
210	Valley View Reservoir Expansion	01-C-1109
211	Off Site Sanitary Forcemain	01-C-1110



SITE LOCATION MAP
N.T.S.

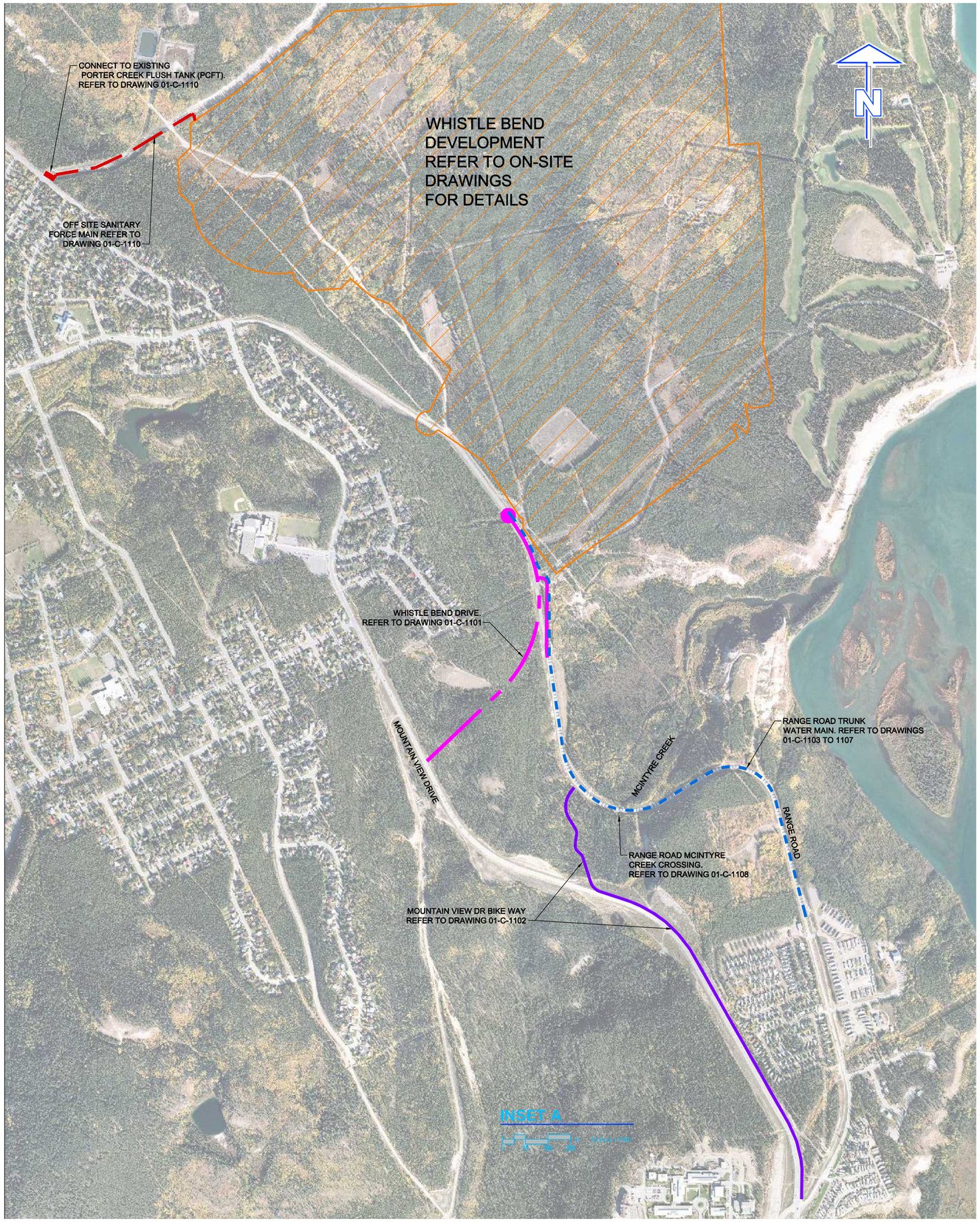
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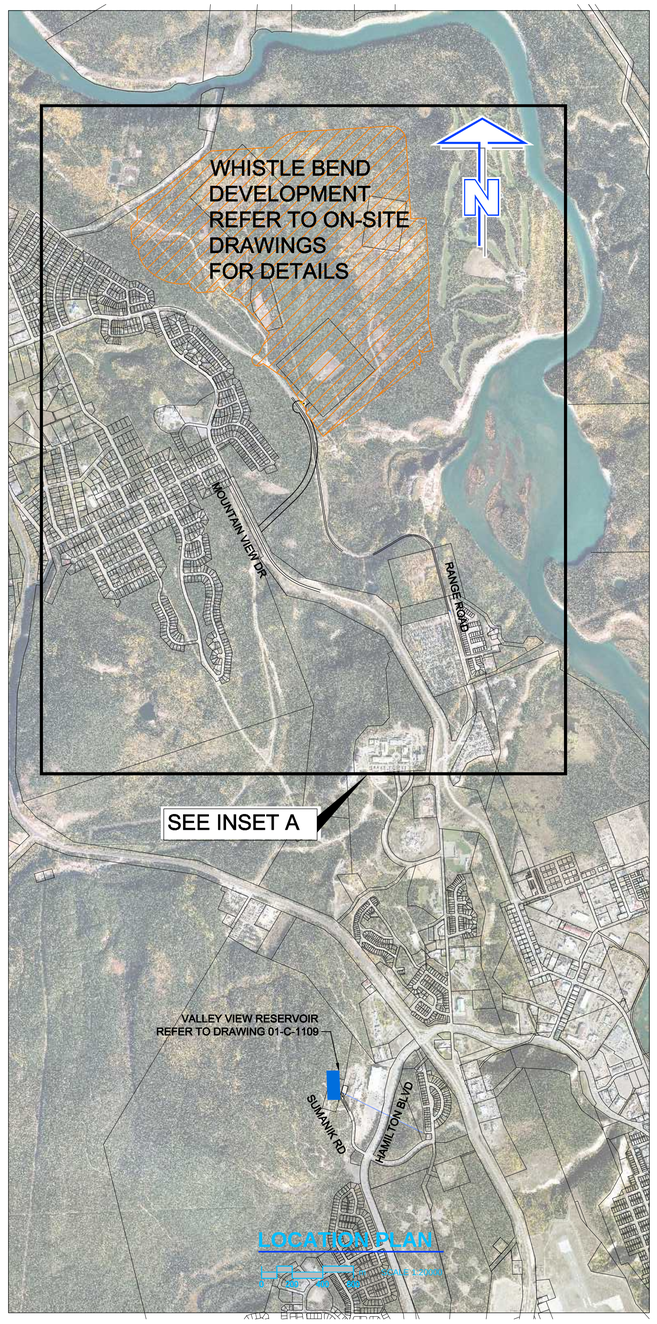
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REFERENCE DRAWINGS

GENERAL NOTES

NO.	DATE	ENG.	DESCRIPTION
B	DEC 18 2009	RA	REVISED PRELIMINARY DESIGN
A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

AECOM

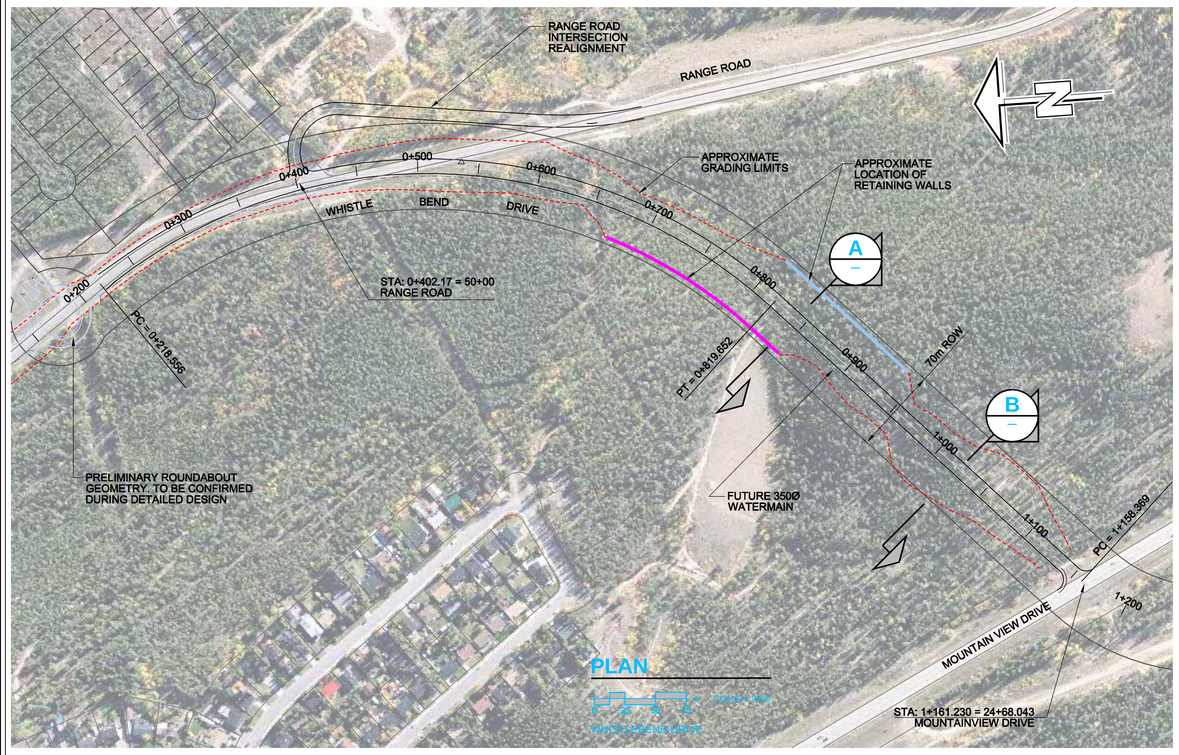
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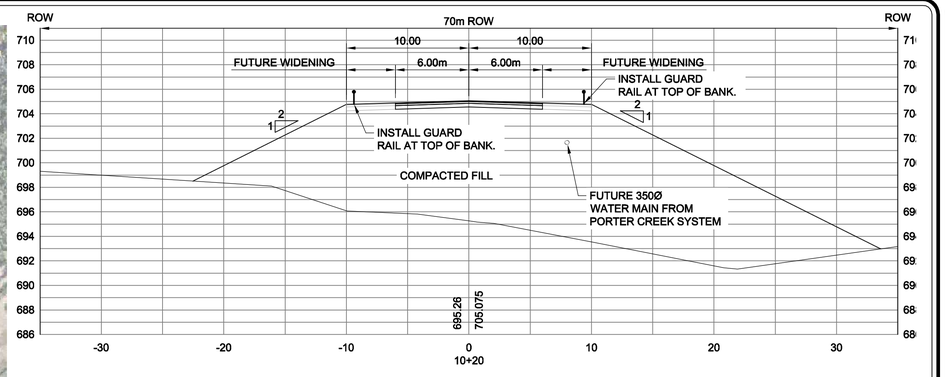
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DATE	NOV 10 2009
CHECKED	PT
P. ENG. SEAL	
APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR.	1:1000
VER.	

PRE-DESIGN FOR WHISTLE BEND
OFF SITE WORKS
PHASE 1

OVERALL PLAN

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-1100
CITY DWG. No.	201
REV.	B

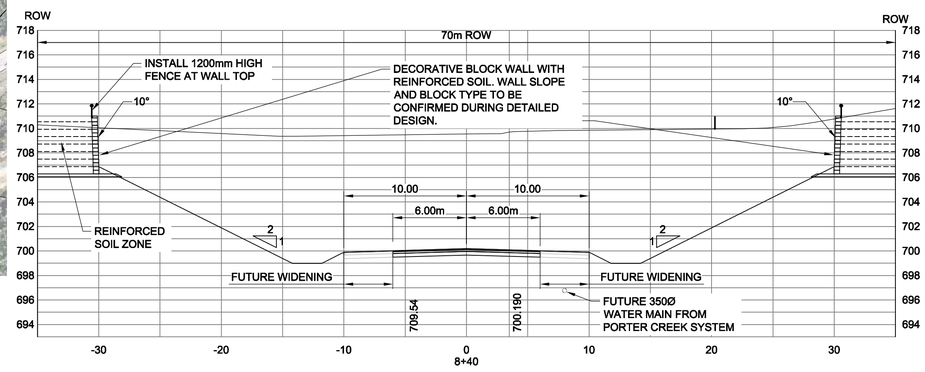




SECTION B

0 2.5 5 7.5 m SCALE 1:250

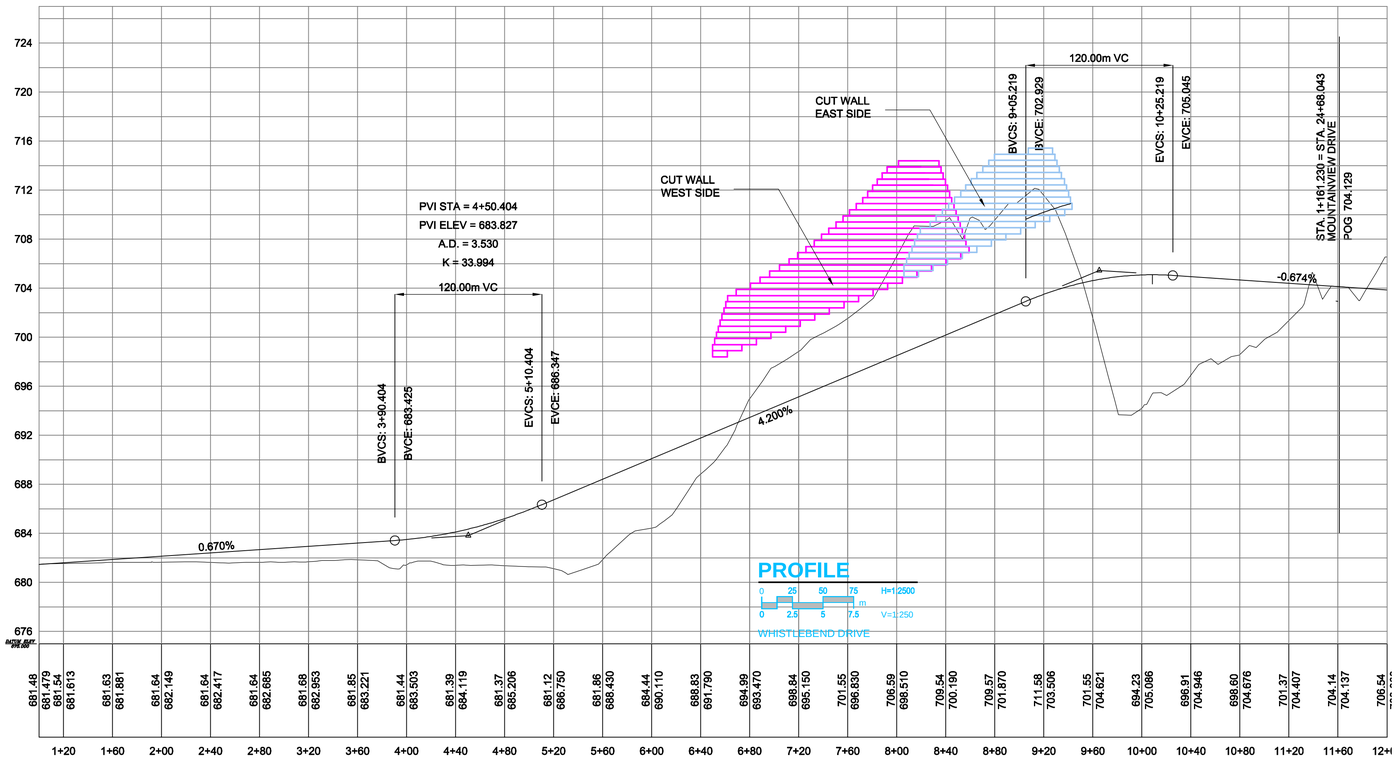
TYPICAL FILL WALL



SECTION A

0 2.5 5 7.5 m SCALE 1:250

TYPICAL CUT WALL



PROFILE

0 25 50 75 H=1:2500 m

0 2.5 5 7.5 V=1:250

WHISTLEBEND DRIVE

REFERENCE DRAWINGS

GENERAL NOTES

NO.	DATE	ENG.	DESCRIPTION
B	DEC 18 2009	RA	REVISED PRELIMINARY DESIGN REVIEW
A	NOV 06 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

AECOM

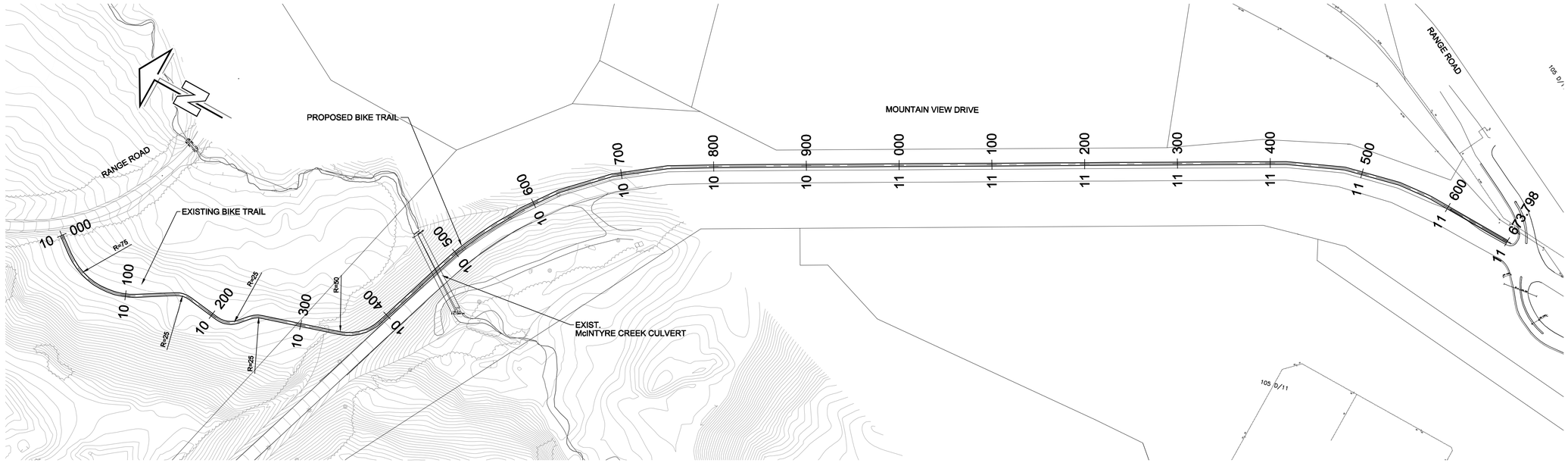
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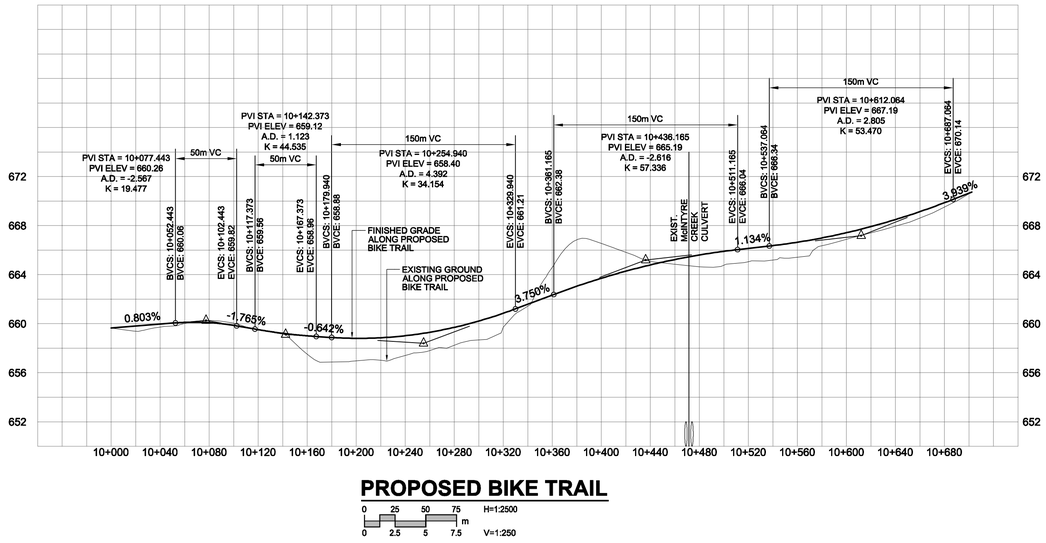
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DRAWN	MW
DATE	NOV 10 2009
CHECKED	PT
P. ENG. SEAL	
APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR. VER.	

PRE-DESIGN FOR WHISTLE BEND
OFF SITE WORKS
PHASE 1

WHISTLE BEND DRIVE

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-1101
CITY DWG. No.	202
REV.	B

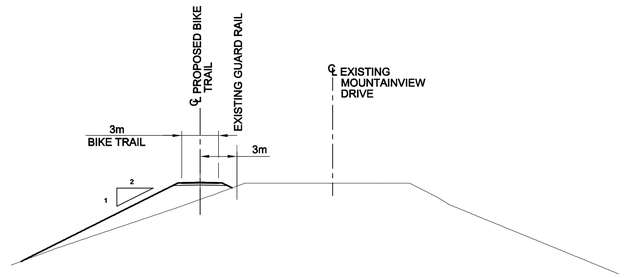




PROPOSED BIKE TRAIL

0 25 50 75 m H=1:2500

0 2.5 5 7.5 V=1:250



TYPICAL SECTION

0 2.5 5 7.5 m SCALE 1:250

NOTES:

1. BIKE TRAIL PAVEMENT STRUCTURE TO BE CONFIRMED.
2. DRAINAGE DETAILS FOR THE FILL SECTION (e.g. PERMEABLE LAYERS) ALONG MOUNTAINVIEW DRIVE TO BE CONFIRMED.

REFERENCE DRAWINGS

GENERAL NOTES

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APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR.	AS SHOWN
VER.	

PRE-DESIGN FOR WHISTLE BEND

OFF SITE WORKS

PHASE 1

BIKE TRAIL

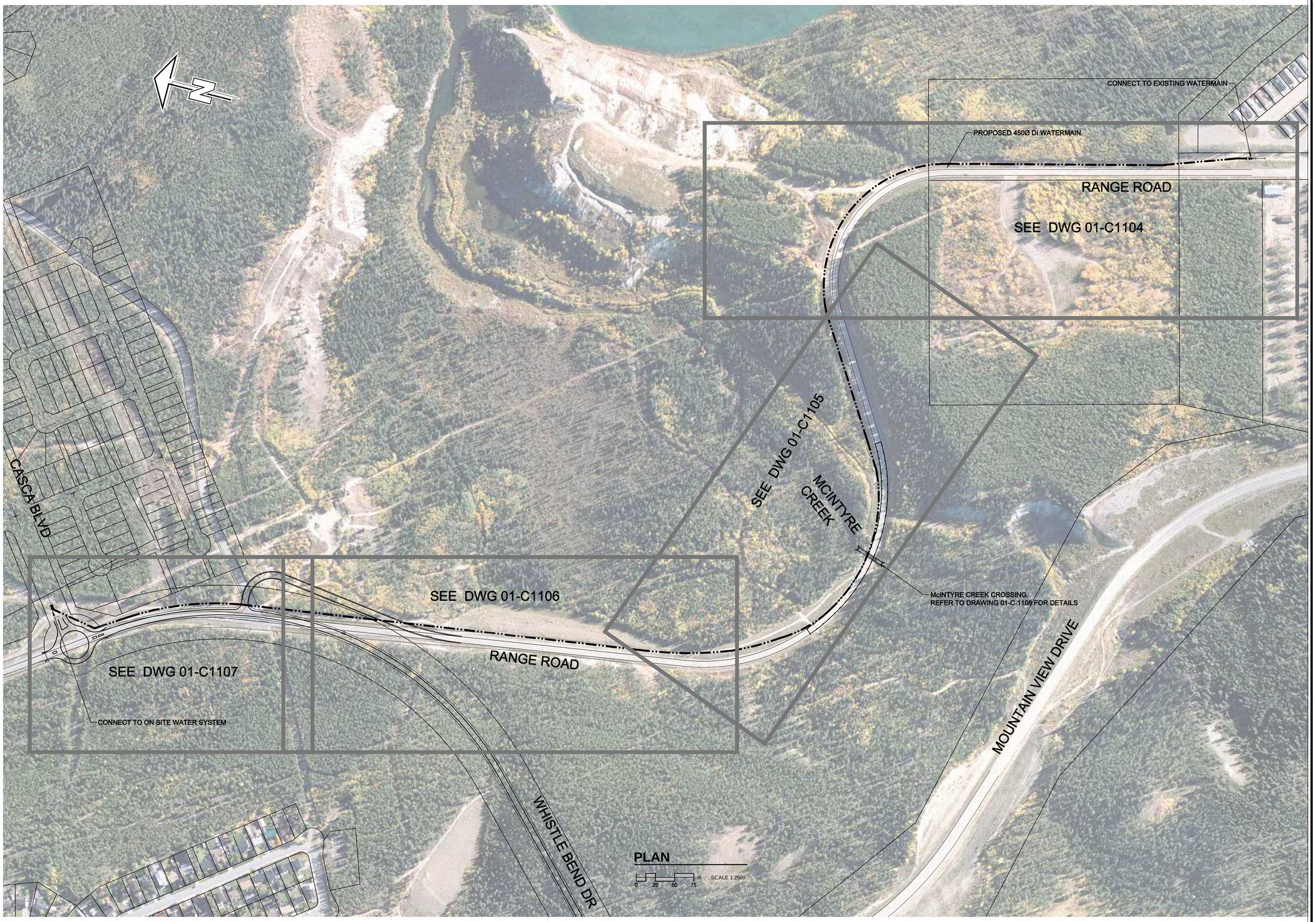
SHEET OF

CONSULTANT DWG. No.

2501-040-00_01-C-1102

CITY DWG. No. 203

REV. B



REFERENCE DRAWINGS

GENERAL NOTES

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DATE	NOV 10 2009
CHECKED	PT
P. ENG. SEAL	
APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR.	AS SHOWN
VER.	

PRE-DESIGN FOR WHISTLE BEND
OFF-SITE WORKS
PHASE 1

RANGE ROAD TRUNK MAIN
KEY PLAN

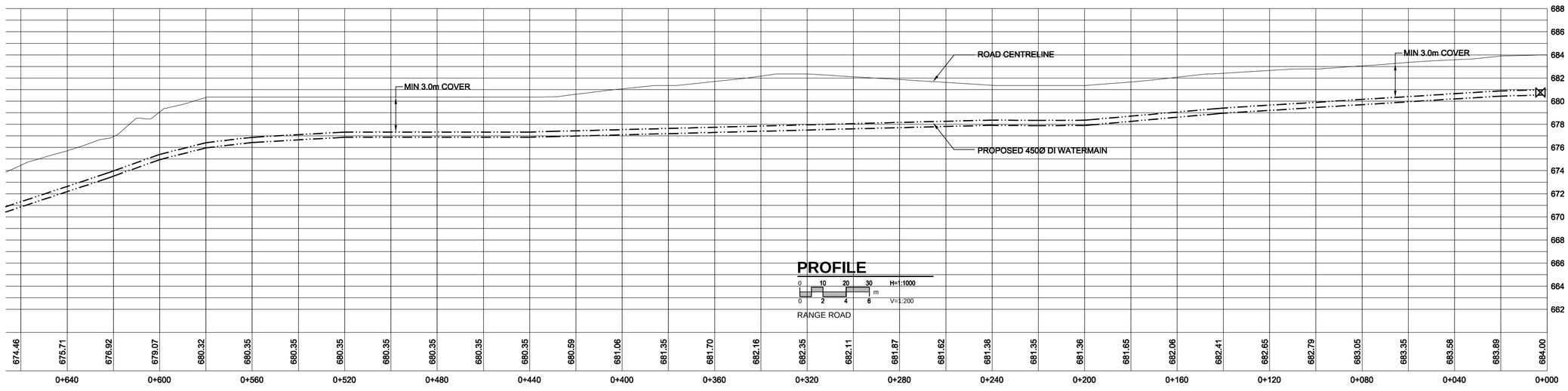
SHEET OF

CONSULTANT DWG. No.
2501-040-00_01-C-1103

CITY DWG. No. 204

REV. B





REFERENCE DRAWINGS

GENERAL NOTES

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A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

AECOM

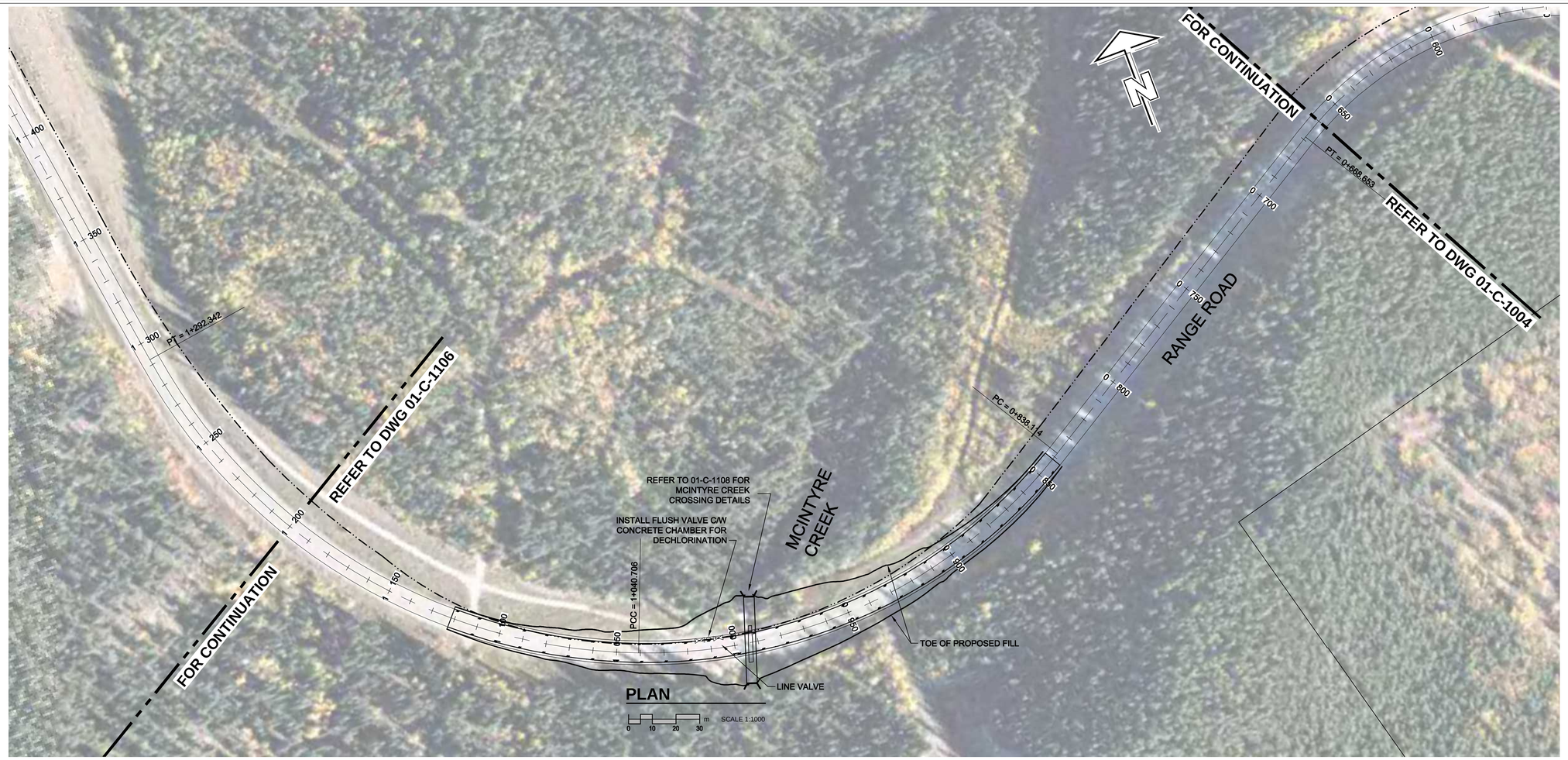
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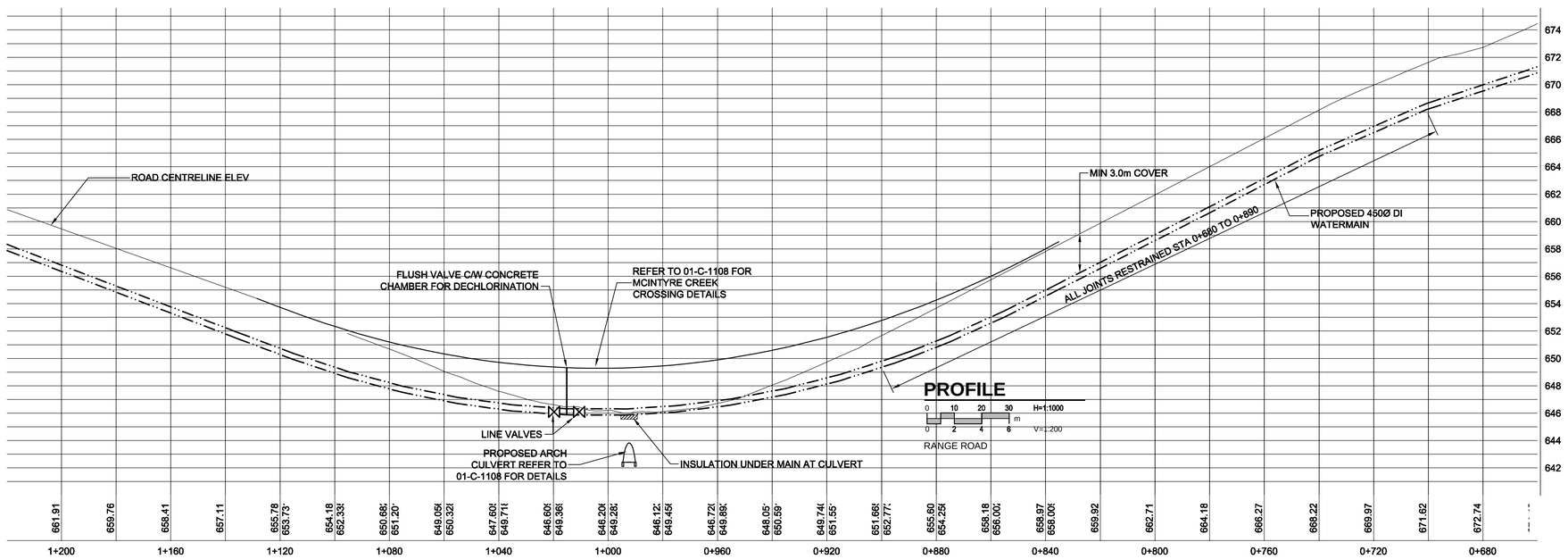
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P. ENG. SEAL
APP'D BY CONSULTANT DATE
APP'D BY CITY DATE
SCALE:
HOR. 1:1000
VER.

PRE-DESIGN FOR WHISTLE BEND
OFF SITE WORKS
PHASE 1

RANGE ROAD TRUNK MAIN
PLAN AND PROFILE
SHEET 1 OF 4

SHEET OF
CONSULTANT DWG. No. 2501-040-00_01-C-1104
CITY DWG. No. 205
REV. B





REFERENCE DRAWINGS

GENERAL NOTES

NO.	DATE	ENG.	DESCRIPTION
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A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

AECOM

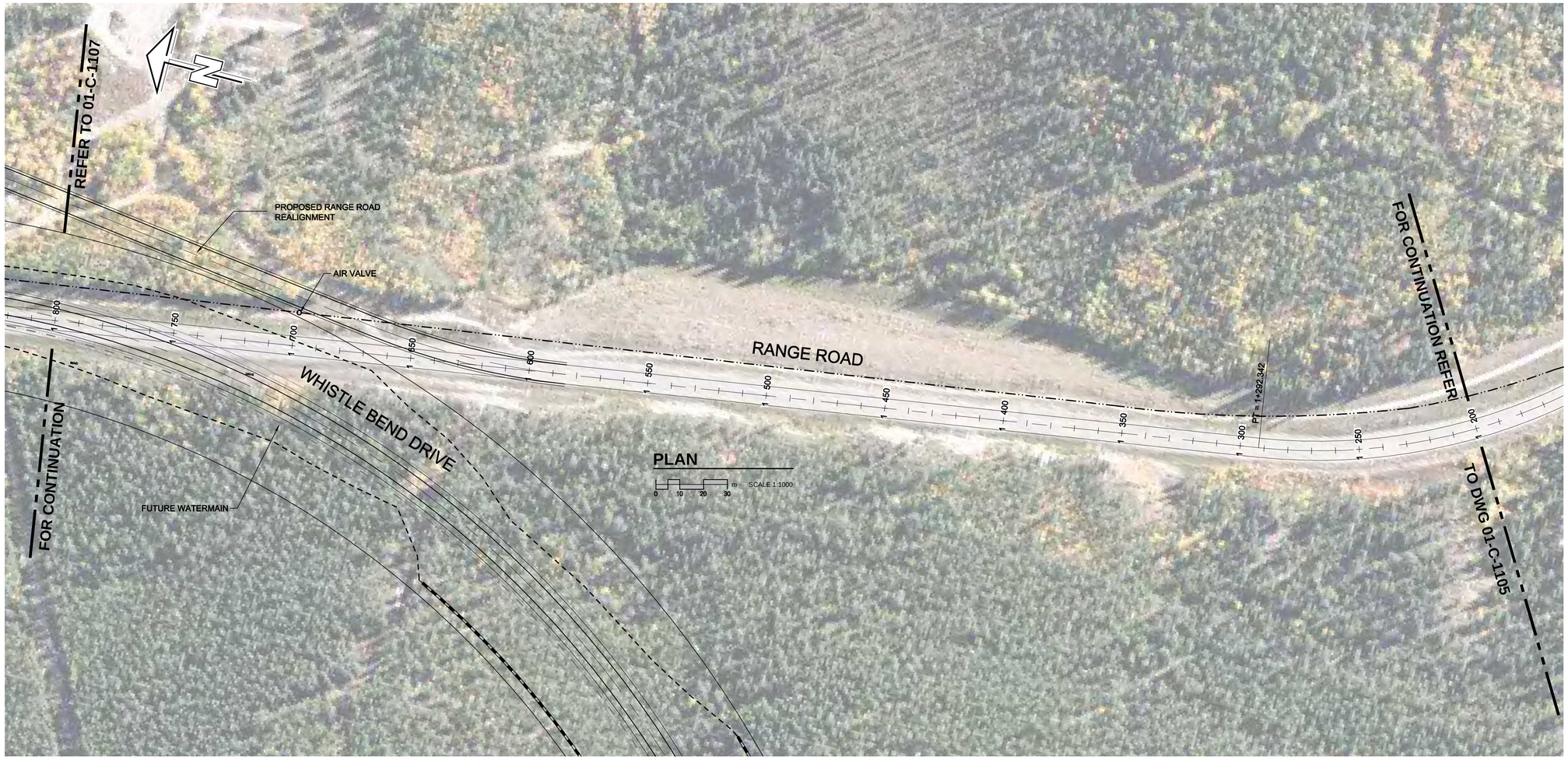
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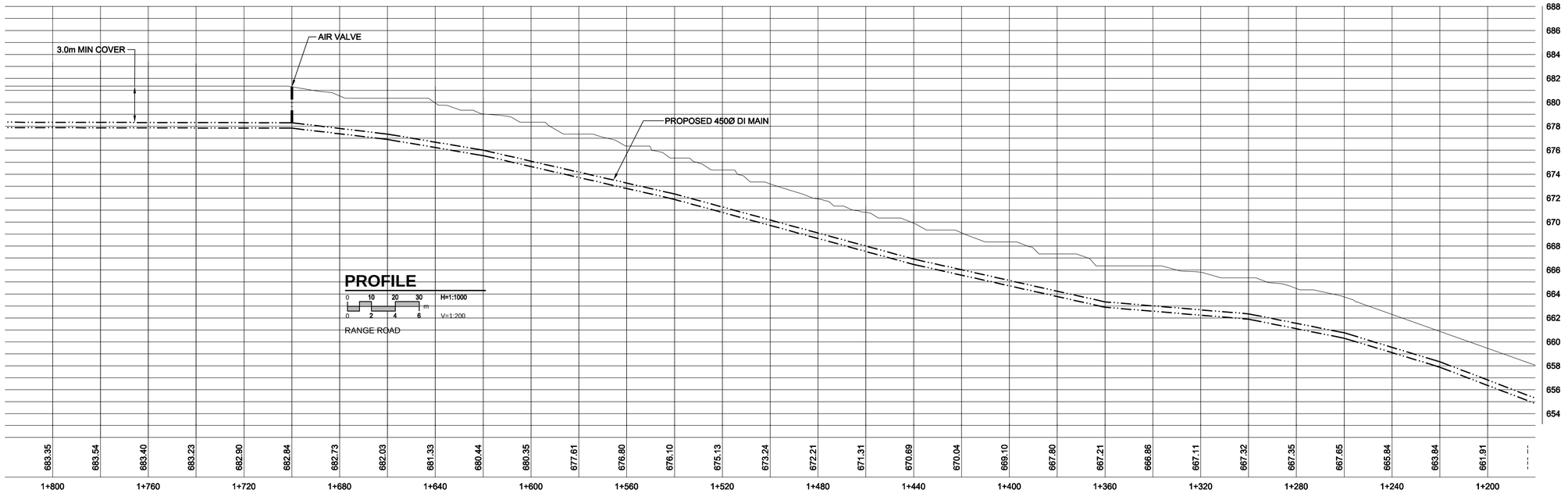
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CHECKED: PT
P. ENG. SEAL
APP'D BY CONSULTANT DATE
APP'D BY CITY DATE
SCALE:
HOR. 1:1000
VER.

PRE-DESIGN FOR WHISTLE BEND
OFF SITE WORKS
PHASE 1

RANGE ROAD TRUNK MAIN
PLAN AND PROFILE
SHEET 2 OF 4

SHEET OF
CONSULTANT DWG. No. 2501-040-00_01-C-1105
CITY DWG. No. 206
REV. B





REFERENCE DRAWINGS

GENERAL NOTES

NO.	DATE	ENG.	DESCRIPTION
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A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

AECOM

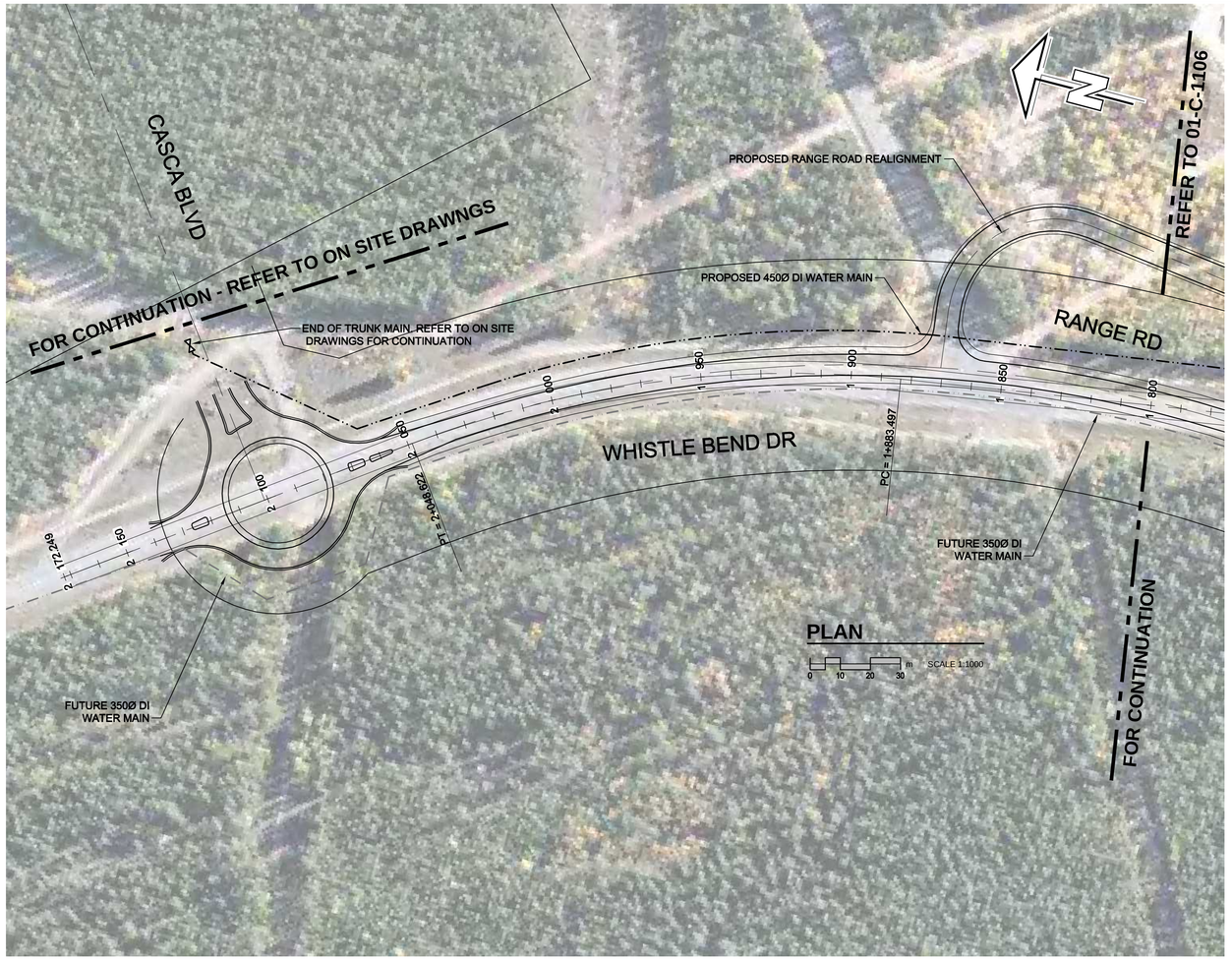
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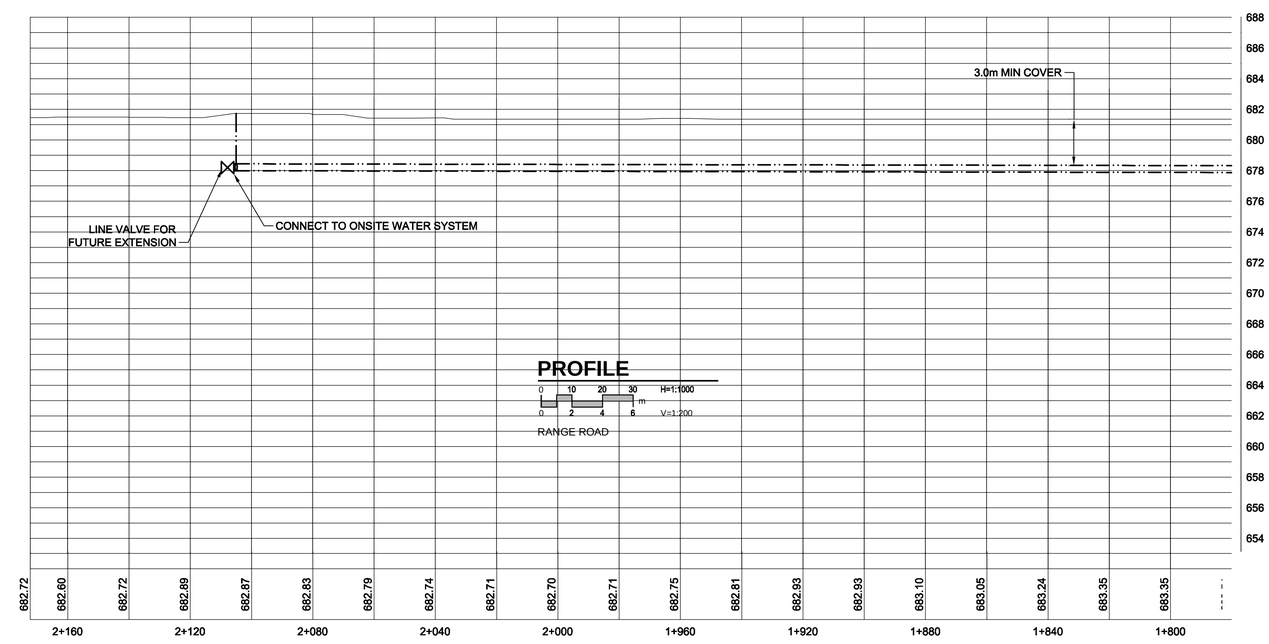
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DATE	NOV 10 2009
CHECKED	PT
P. ENG. SEAL	
APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR.	1:1000
VER.	

PRE-DESIGN FOR WHISTLE BEND
OFF SITE WORKS
PHASE 1

RANGE ROAD TRUNK MAIN
PLAN AND PROFILE
SHEET 3 OF 4

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-1106
CITY DWG. No.	207
REV.	B





REFERENCE DRAWINGS

GENERAL NOTES

NO.	DATE	ENG.	DESCRIPTION
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DATE	NOV 10 2009
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APP'D BY CITY	DATE
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VER.	

PRE-DESIGN FOR WHISTLE BEND
OFF SITE WORKS
PHASE 1

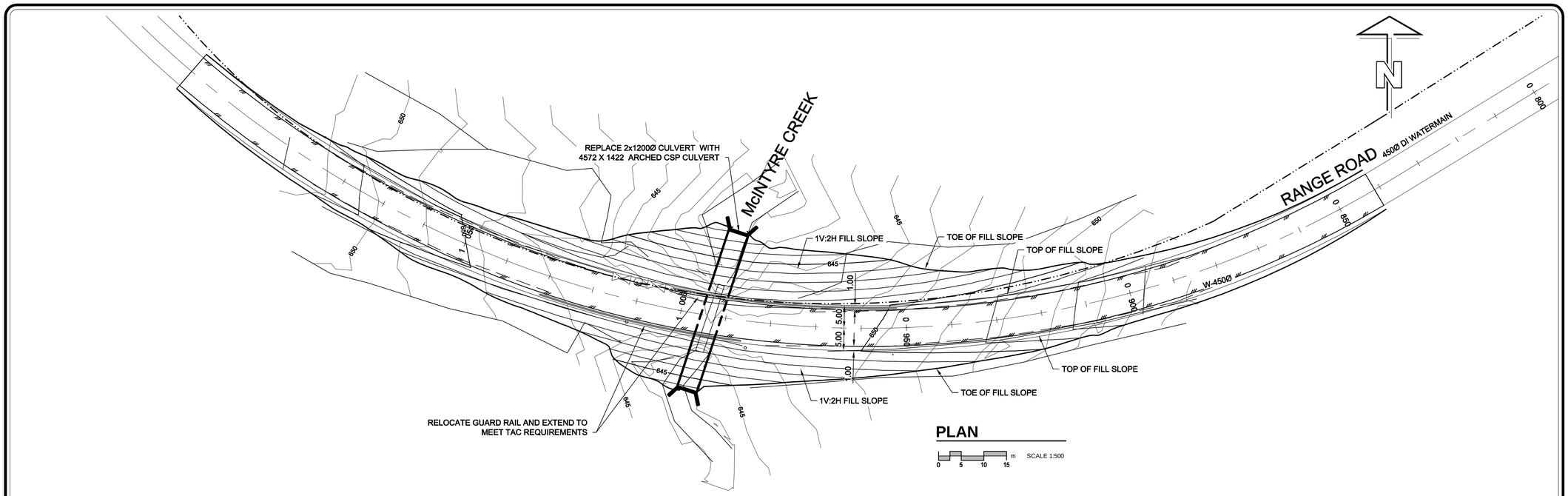
RANGE ROAD TRUNK MAIN
PLAN AND PROFILE
SHEET 4 OF 4

SHEET OF

CONSULTANT DWG. No.
2501-040-00_01-C-1107

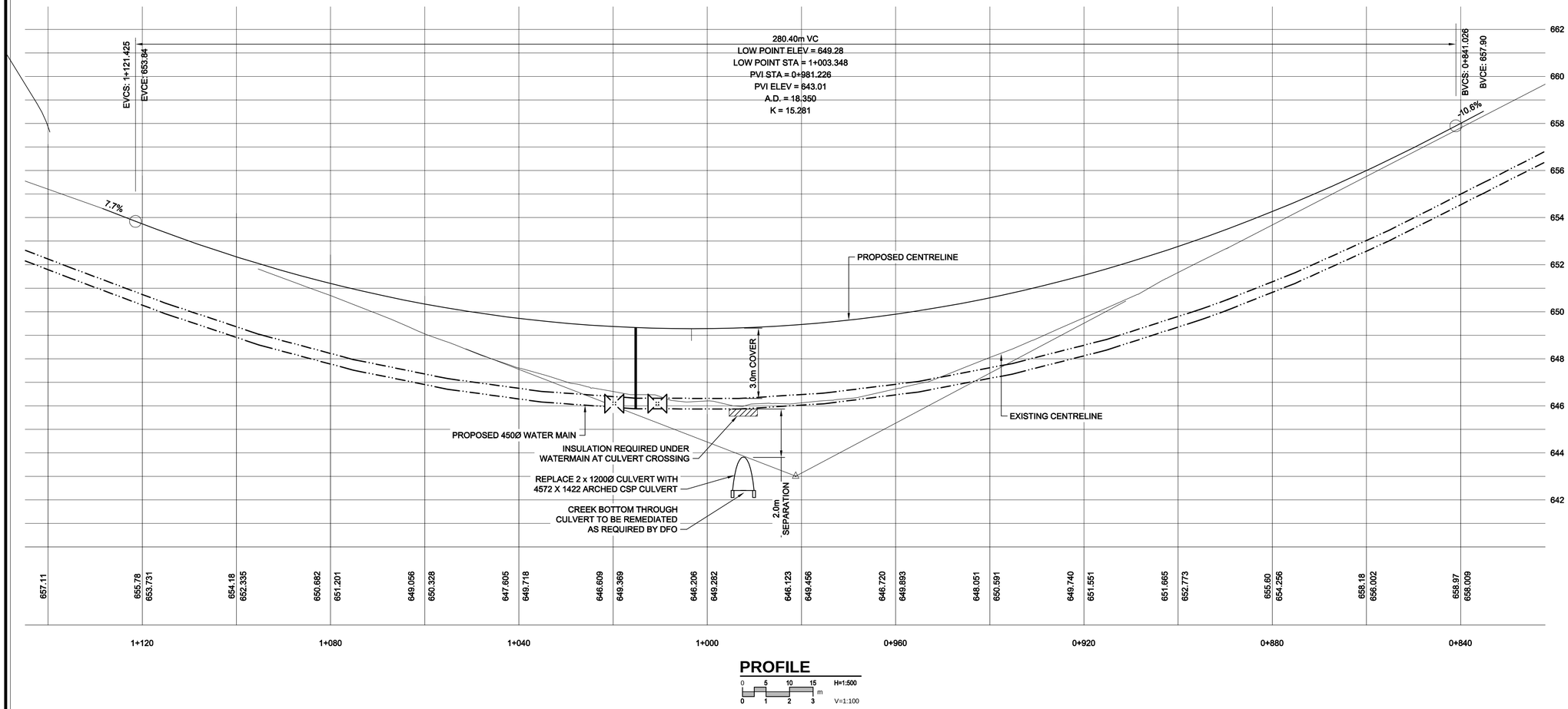
CITY DWG. No. 208

REV. B



PLAN

0 5 10 15 m SCALE 1:500



PROFILE

0 5 10 15 H=1:500

0 1 2 3 m V=1:100

REFERENCE DRAWINGS

GENERAL NOTES

NO.	DATE	ENG.	DESCRIPTION
B	DEC 10 2009	RA	REVISED PRELIMINARY DESIGN
A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

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APP'D BY CITY DATE
SCALE:
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VER.

PRE-DESIGN FOR WHISTLE BEND
OFF SITE WORKS
PHASE 1

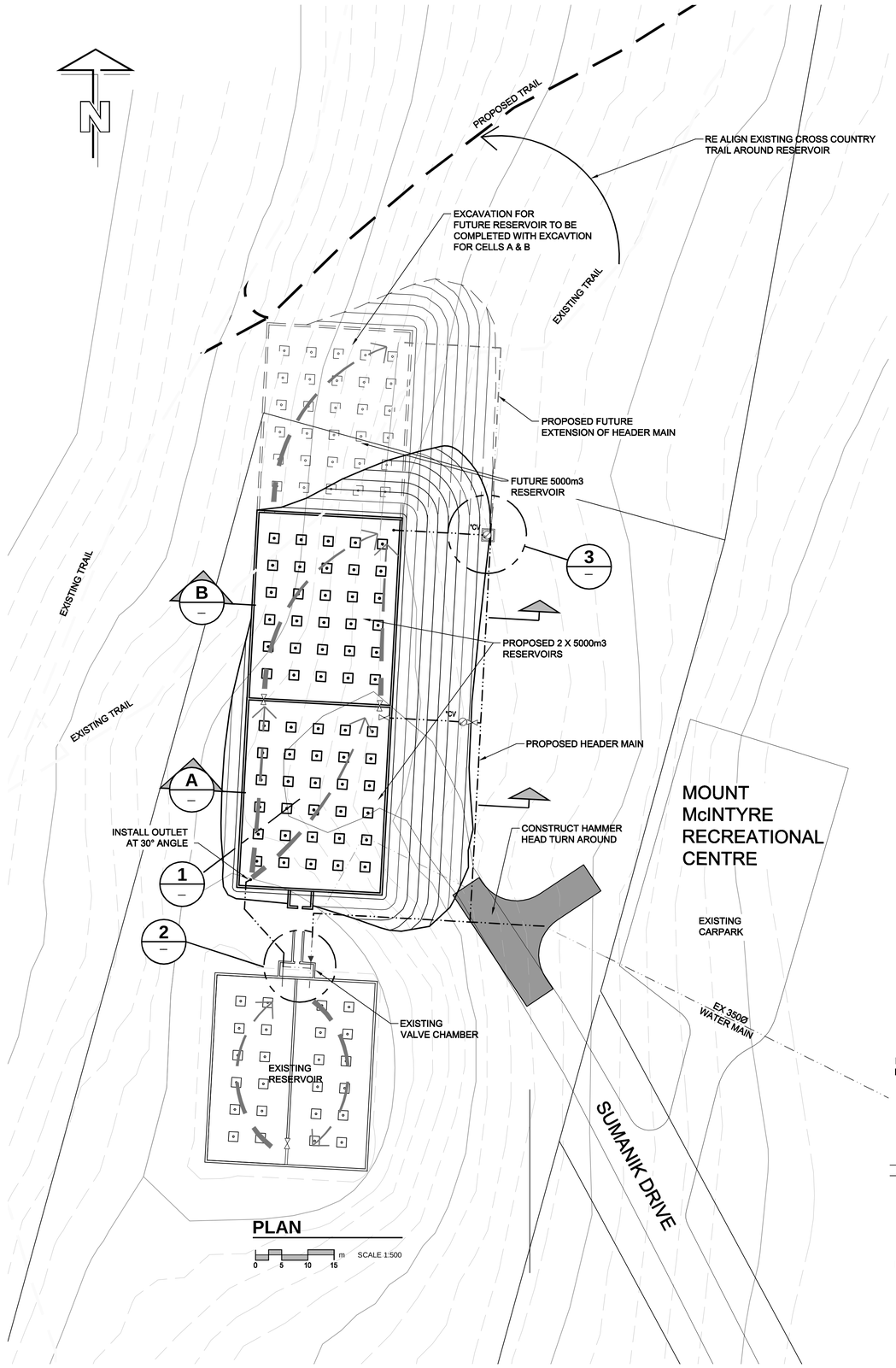
RANGE ROAD TRUNK MAIN
McINTYRE CREEK CROSSING

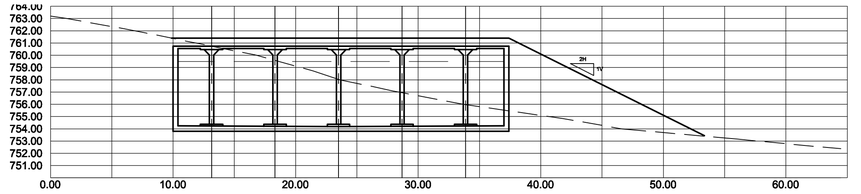
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CONSULTANT DWG. No.
2501-040-00_01-C-1108

CITY DWG. No. 209

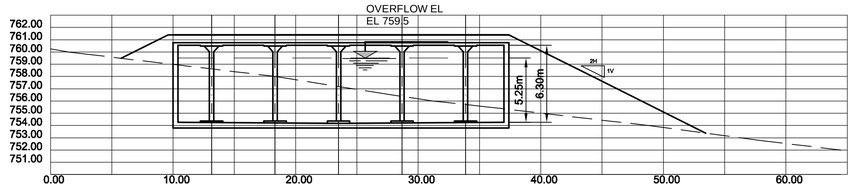
REV. B





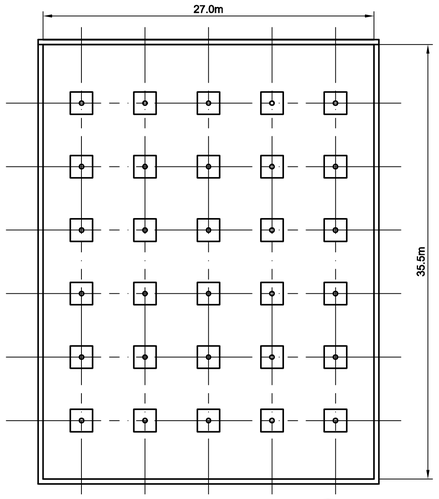
SECTION B

0 2.5 5 7.5 m SCALE 1:250



SECTION A

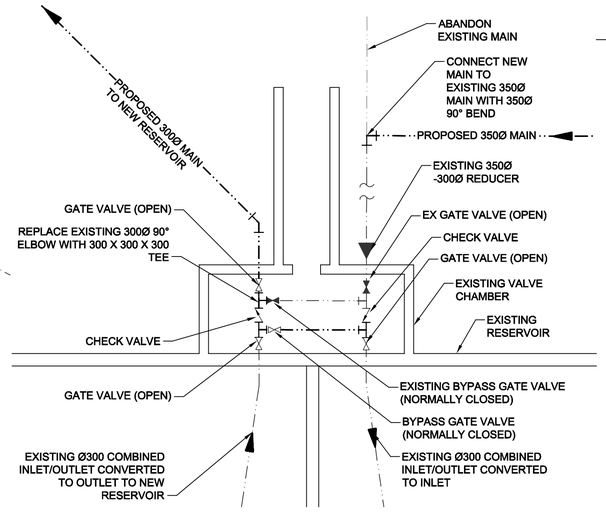
0 2.5 5 7.5 m SCALE 1:250



DETAIL 1

0 2.5 5 7.5 m SCALE 1:250

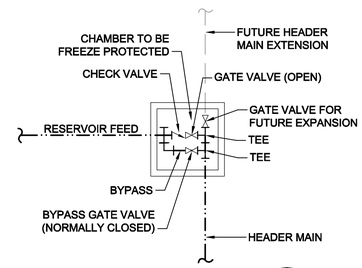
TYPICAL 5000m3 RESERVOIR CELL



DETAIL 2

0 1 2 3 m SCALE 1:100

MODIFICATION TO EXISTING VALVE CHAMBER



DETAIL 3

0 1 2 3 m SCALE 1:100

VALVE CHAMBER

REFERENCE DRAWINGS

GENERAL NOTES

NO.	DATE	ENG.	DESCRIPTION
B	DEC 10 2009	RA	REVISED PRELIMINARY DESIGN
A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

AECOM

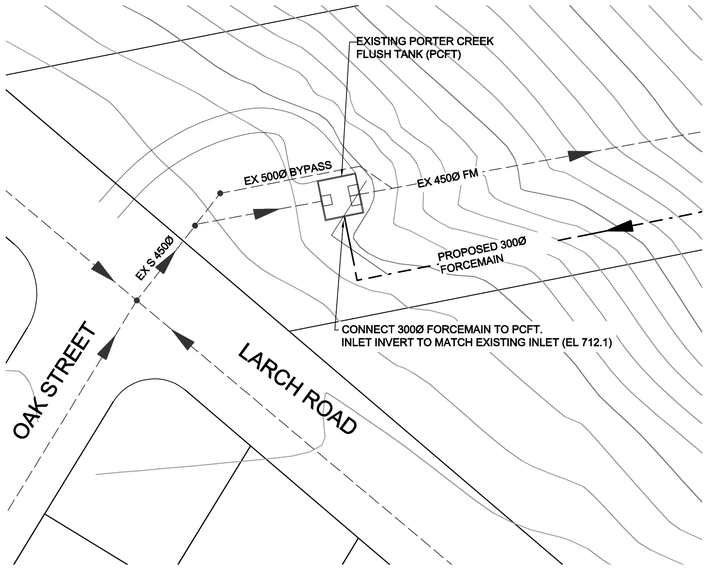
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APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR.	AS SHOWN
VER.	

PRE-DESIGN FOR WHISTLE BEND
OFF SITE WORKS
PHASE 1

VALLEY VIEW RESERVOIR EXPANSION
PRELIMINARY DESIGN

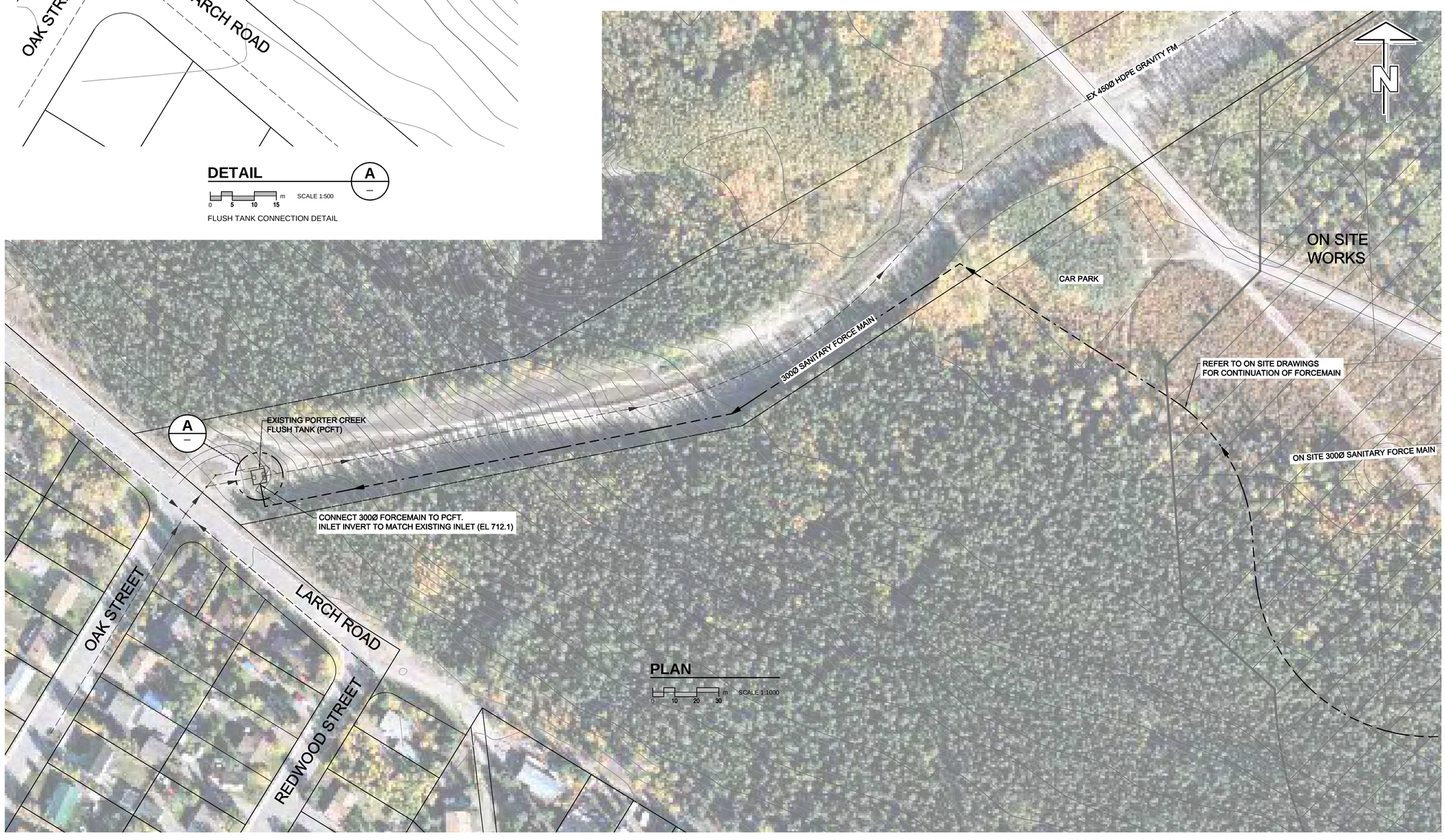
SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-1109
CITY DWG. No.	210
REV.	B



DETAIL A

0 5 10 15 m SCALE 1:500

FLUSH TANK CONNECTION DETAIL



PLAN

0 10 20 30 m SCALE 1:1000

REFERENCE DRAWINGS

GENERAL NOTES

NO.	DATE	ENG.	DESCRIPTION
B	DEC 10 2009	RA	REVISED PRELIMINARY DESIGN
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DESIGN	RA
DRAWN	MW
DATE	NOV 10 2009
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APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR.	AS SHOWN
VER.	

PRE-DESIGN FOR WHISTLE BEND
OFF SITE WORKS
PHASE 1

SANITARY FORCE MAIN

SHEET OF

CONSULTANT DWG. No.
2501-040-00_01-C-1110

CITY DWG. No. 211

REV. B

5.0 ON-SITE PRELIMINARY DESIGN DRAWINGS

AECOM
200 – 415 Gorge Road East
Victoria, BC, Canada V8T 2W1
www.aecom.com

250 475 6355 tel
250 475 6388 fax

23 December, 2009

Project No: 2501-040 [60113945 0200]

Wayne Tuck, P.Eng.
City Engineer
City of Whitehorse
Municipal Services Building
4210 - 4th Avenue
Whitehorse, YT Y1A 1C2

Dear Wayne:

Re: Whistle Bend Onsite Predesign Drawings

This letter is in response to Christine Benedek's letter of 3 December, 2009, providing comments on the preliminary design drawings. As mentioned in the City's letter, a number of the comments will be dealt with during detailed design. Other comments have been dealt with in the attached revised drawings.

Title page revisions have been made as requested.

Overall Plan

- It is our understanding that the hatched area on the golf course property is a possible future private development area. The idea of realigning the east property line has been suggested to the Yukon Government.
- Existing roadways have been added.
- The approximate location of the proposed power station has been shown. There are no plans of the power and telephone distribution, except for the typical cross sections.
- The alignment of the sanitary forcemain has been adjusted as suggested.
- Legend clarified and labels added.
- The future watermain from Mountainview via Whistle Bend Drive has been added.

Drawing 102

- Agreed re: clearing and grading
- Servicing of this area will have to be dealt with during detailed design in consultation with Yukon Government.
- The proposed relocation of a PUL on Tannana will be dealt with during detailed design in consultation with Yukon Government.
- Watermain alignment adjusted around proposed roundabout.
- Fire hydrants will be added during detailed design.
- Acknowledged.
- Agreed, the roundabout should be constructed in Phase 1. Another advantage of doing it now is that traffic will not have to be detoured in the future.
- Notations of boundary lines have been clarified.
- Acknowledged.

Drawing 103

- Agreed. This is a detailed design item. Manholes may have to be enlarged or added.
- If shallow sewer is to be realigned as suggested, then it would probably not be advantageous to install it at the same time as the deep sewer, since it would be in a separate trench.
- Agreed re: Tarahane roundabout. This is a detailed design item.

Drawing 104

- Agreed. This should be adjusted as part of the detailed design.
- We had assumed that longer service connections could be installed here. However, this area is quite flat and could result in extra sewer depth. Whitehorse servicing standards should also be reviewed during detailed design. We have shown an additional length of sewer on the drawing.

Drawing 105

- Locations of the pumpstations are flexible to some degree. We have pointed out the benefit of combining the emergency power for both facilities in one location in our proposal to Yukon Government, provided feasibility can be demonstrated.

Drawing 108

- According to the water model, this is correct. The model shows a proposed loop connecting into both ends of the 250 mm diameter section.

Thank you for your comments.

Sincerely,
AECOM Canada Ltd.



Ron Akehurst, P.Eng.
Manager, Municipal Infrastructure
Ron.Akehurst@aecom.com

RA/bl
Attch.

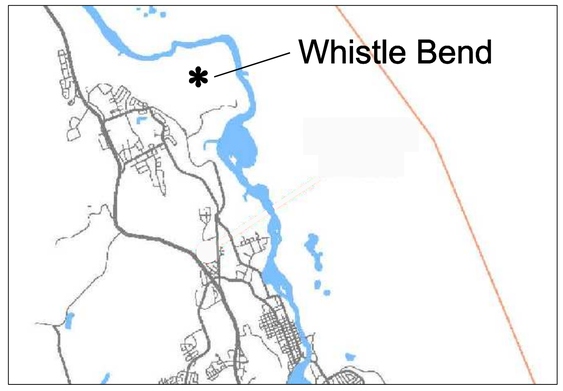
City of Whitehorse
Pre-Design For Whistle Bend

Infrastructure Pre-Design
On Site Works

LIST OF PROJECT DRAWINGS

CITY No.	DRAWING TITLE	CONSULTANT'S No.
	Cover Sheet	01-C-0000
101	Legend and Index Plan	01-C-0001
102	Phase One Infrastructure	01-C-0002
103	Phase One Infrasturcture	01-C-0003
104	Phase Two Infrastructure	01-C-0004
105	Phase Two Infrastructure	01-C-0005
106	Phase One Infrastructure	01-C-0006
107	Phase One Infrastructure	01-C-0007
108	Phase One Infrastructure	01-C-0008
109	Phase One - Sanitary Forcemain	01-C-0009
110	Phase One - Sanitary Forcemain	01-C-0010

CITY No.	DRAWING TITLE	CONSULTANT'S No.
401	Water Recirculating Pump House	01-C-4001
402	Sanitary Pump Station	01-C-4002



SITE LOCATION MAP
N.T.S.

Issued For Preliminary Design

Issue Date: **09/12/23**

AECOM

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISIOI
2501-040-00	01-C-0000	B



PLAN

0 40 80 120 m SCALE 1:4000

LEGEND

PROPOSED (PLAN)

- PROPOSED CENTERLINE
- PROPOSED PROPERTY LINE
- PROPOSED CURB
- PROPOSED ROLLED CURB
- PROPOSED VERGE
- PROPOSED EDGE OF ASPHALT
- PROPOSED BIOSWALE
- PROPOSED STORM SEWER
- PROPOSED WATER
- PROPOSED SANITARY SEWER
- 3-4m DEPTH (SANITARY SEWER)
- 4-5m DEPTH (SANITARY SEWER)
- 5-6m DEPTH (SANITARY SEWER)
- 6-7m DEPTH (SANITARY SEWER)
- SANITARY FORCEMAIN
- PHASE BOUNDARY
- TRAILS
- PROPOSED INFILTRATION PIT
- PROPOSED MANHOLE
- PROPOSED CATCHBASIN MANHOLE
- PROPOSED CATCHBASIN AND LEAD
- PROPOSED OUTFALL
- PROPOSED HYDRANT
- PROPOSED VALVE
- APPROX. LOCATION OF SUBSTATION
- EXISTING POWER POLE

REFERENCE DRAWINGS

GENERAL NOTES

NO.	DATE	ENG.	DESCRIPTION
B	DEC 23 2009	RA	REVISED PRELIMINARY DESIGN
A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

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P. ENG. SEAL	
APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR.	1:4000
VER.	

PRE-DESIGN FOR
WHISTLE BEND
PHASE ONE & TWO

INFRASTRUCTURE PRE-DESIGN
OVERALL PLAN

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-0001
CITY DWG. No.	101
REV.	B

TANNANA DRIVE

S - 200 Ø
W - 250 Ø
W - 150 Ø
W - 200 Ø
W - 400 Ø
W - 450 Ø

BIO-SWALE

RAIN GARDEN / STORM
DETENTION POND (0.4 ha)
WITH LANDSCAPING

TALBOT WAY

CHAKWANA DRIVE

FUTURE 350Ø TRUNK MAIN

RANGE ROAD

RANGE ROAD
TRUNK MAIN

PHASE 1
DEVELOPMENT
BOUNDARY

PHASE 2
DEVELOPMENT
BOUNDARY

PHASE 4
DEVELOPMENT
BOUNDARY

CASCA BOULEVARD

CONNECT TO RANGE ROAD TRUNK MAIN

CONTINUED DWG 01-C-0004

CONTINUED DWG 01-C-0003

CONTINUED DWG 01-C-0008

PHASE1
DEVELOPMENT
BOUNDARY

PHASE 4
DEVELOPMENT
BOUNDARY

PHASE1
DEVELOPMENT
BOUNDARY

PHASE 4
DEVELOPMENT
BOUNDARY

PLAN

0 10 20 30 m SCALE 1:1000

REFERENCE DRAWINGS

GENERAL NOTES

1. HYDRANT AND MANHOLE LOCATIONS ARE PRELIMINARY. EXACT LOCATOINS TO BE DETERMINED AT DETAILED DESIGN STAGE.
2. ALL STORM MAINS TO BE 450Ø CSP.
3. SANITARY MAIN DEPTHS INDICATED AS FOLLOWS:
   - 3 - 4 m DEPTH
   - 4 - 5 m DEPTH
   - 5 - 6 m DEPTH
   - 6 - 7 m DEPTH

NO.	DATE	ENG.	DESCRIPTION
B	DEC 23 2009	RA	REVISED PRELIMINARY DESIGN
A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

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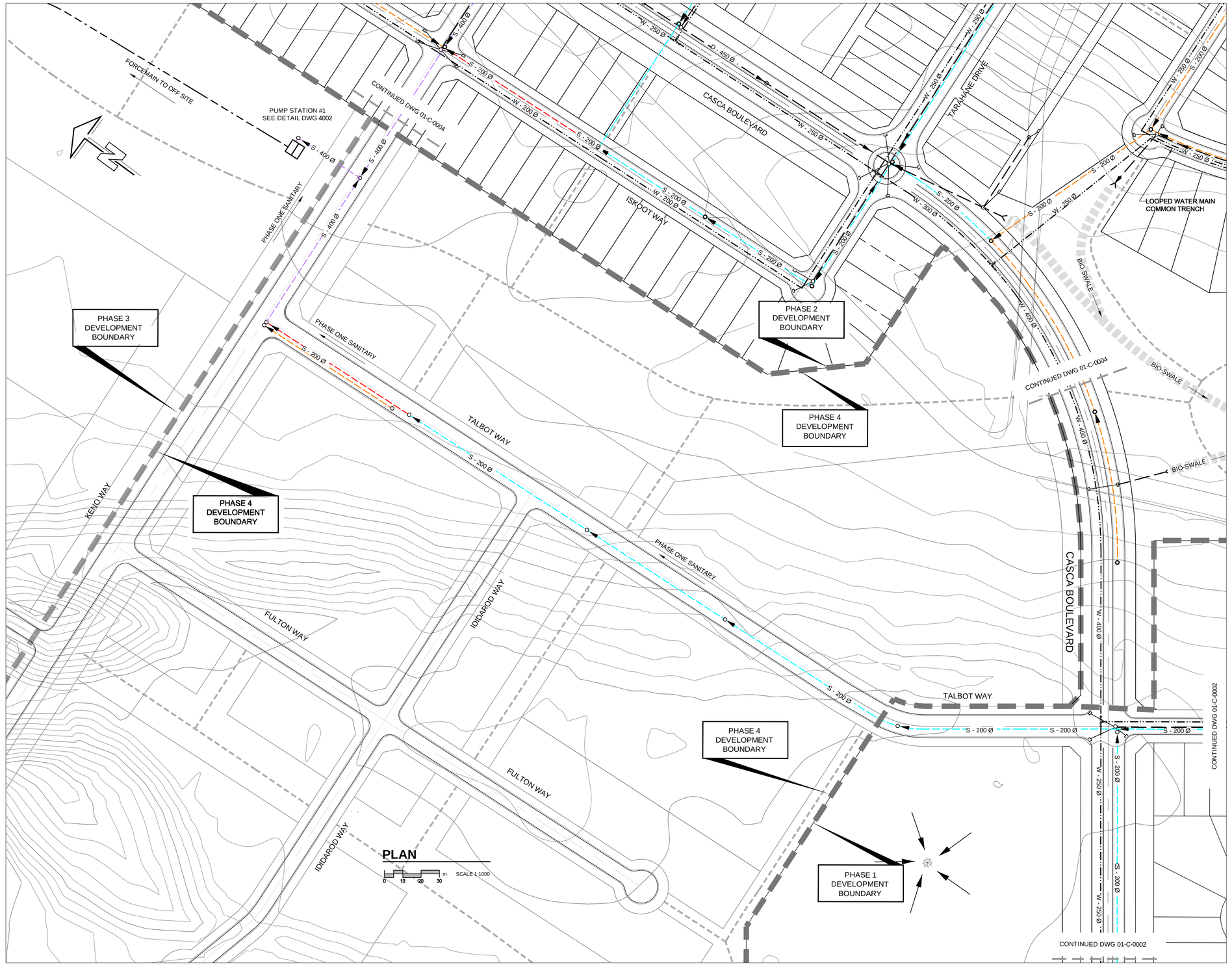
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APP'D BY CITY — DATE
SCALE:
HOR. 1:1000
VER.

PRE-DESIGN FOR
WHISTLE BEND
PHASE ONE

INFRASTRUCTURE PRE-DESIGN

SHEET OF
CONSULTANT DWG. No.
2501-040-00_01-C-0002
CITY DWG. No. 102
REV. B



REFERENCE DRAWINGS

GENERAL NOTES

1. HYDRANT AND MANHOLE LOCATIONS ARE PRELIMINARY. EXACT LOCATIOINS TO BE DETERMINED AT DETAILED DESIGN STAGE.
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- **5 - 6 m DEPTH**
- **6 - 7 m DEPTH**

NO.	DATE	ENG.	DESCRIPTION
B	DEC 22 2009	RA	REVISED PRELIMINARY DESIGN
A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

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APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR.	1:1000
VER.	

PRE-DESIGN FOR
WHISTLE BEND
PHASE ONE

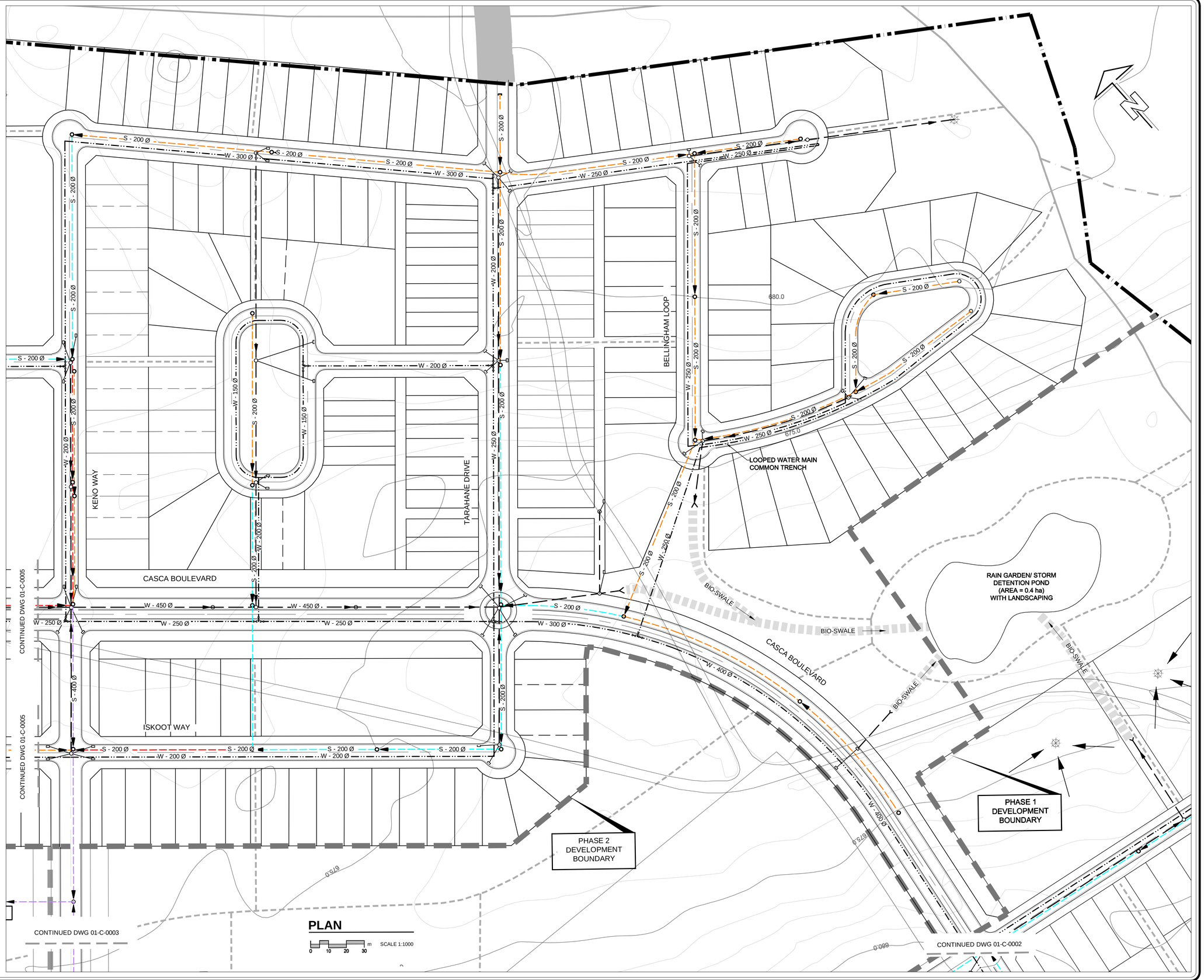
INFRASTRUCTURE PRE-DESIGN

SHEET OF

CONSULTANT DWG. No.
2501-040-00_01-C-0003

CITY DWG. No.
103

REV.
B



REFERENCE DRAWINGS

GENERAL NOTES

1. HYDRANT AND MANHOLE LOCATIONS ARE PRELIMINARY. EXACT LOCATIOINS TO BE DETERMINED AT DETAILED DESIGN STAGE.
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REVISIONS & ISSUES

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APP'D BY CITY	DATE
SCALE: HOR.	1:1000
VER.	

PRE-DESIGN FOR
WHISTLE BEND
PHASE TWO

INFRASTRUCTURE PRE-DESIGN

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-0004
CITY DWG. No.	104
REV.	B

HEILAND LAND

PHASE 5 DEVELOPMENT BOUNDARY

PHASE 2 H DEVELOPMENT BOUNDARY

PHASE 2 DEVELOPMENT BOUNDARY

PHASE 3 DEVELOPMENT BOUNDARY

PHASE 2 DEVELOPMENT BOUNDARY

PHASE 5 DEVELOPMENT BOUNDARY

PHASE 3 DEVELOPMENT BOUNDARY

WATER RECIRCULATION PUMP STATION # 1 (SEE DETAIL DWG 4001)

PHASE 1 WATER

W - 300 Ø

W - 400 Ø

CASCA BOULEVARD

TYRELL WAY

CAPRICE WAY

KENO WAY

ISKOOT WAY

S - 200 Ø

W - 250 Ø

W - 200 Ø

CONTINUED DWG 01-C-0004

CONTINUED DWG 01-C-0006

SANITARY FORCEMAIN CONTINUES ON DWG 01-C-0006

PUMP STATION # 1 (SEE DETAIL DWGS 4002)

300 Ø FORCE MAIN

6150

PLAN

0 10 20 30 m SCALE 1:1000

REFERENCE DRAWINGS

GENERAL NOTES

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REVISIONS & ISSUES

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APP'D BY CITY	DATE
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PRE-DESIGN FOR
WHISTLE BEND
PHASE TWO

INFRASTRUCTURE PRE-DESIGN

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-0005
CITY DWG. No.	105
REV.	B

CASCA BOULVARD

W - 300 Ø

PHASE 1 WATER

W - 400 Ø

W - 350 Ø

AKSALA WAY

PHASE 5
DEVELOPMENT
BOUNDARY

PHASE 3
DEVELOPMENT
BOUNDARY

WATER RECIRCULATION
PUMP STATION
(SEE DETAIL DWGS 4001)

CAPRICE WAY

CONTINUED DWG 01-C-0005

SANITARY FORCEMAIN
CONTINUES ON DWG 01-C-0009

PHASE 1 - 300Ø SFM

CONTINUED DWG 01-C-0007

PHASE 3
DEVELOPMENT
BOUNDARY

PHASE 2
DEVELOPMENT
BOUNDARY

SANITARY FORCEMAIN
CONTINUES ON DWG 01-C-0005

PLAN

m 0 10 20 30 SCALE 1:1000

REFERENCE DRAWINGS

GENERAL NOTES

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APP'D BY CITY	DATE
SCALE: HOR.	1:1000
VER.	

PRE-DESIGN FOR
WHISTLE BEND
PHASE ONE

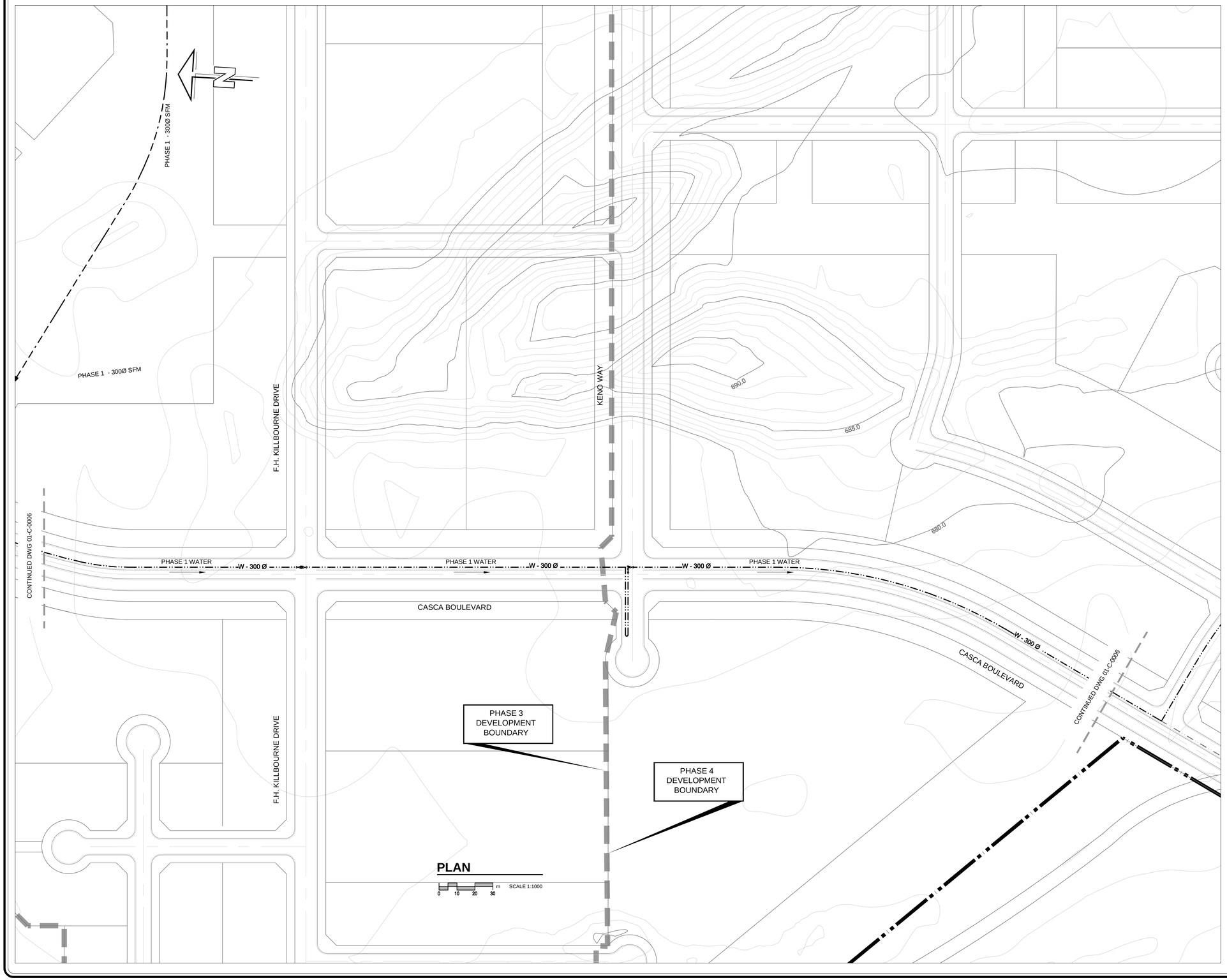
INFRASTRUCTURE PRE-DESIGN

SHEET OF

CONSULTANT DWG. No.
2501-040-00_01-C-0006

CITY DWG. No. 106

REV. B



REFERENCE DRAWINGS

GENERAL NOTES

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   - **6 - 7 m DEPTH**

NO.	DATE	ENG.	DESCRIPTION
B	DEC 23 2009	RA	REVISED PRELIMINARY DESIGN
A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

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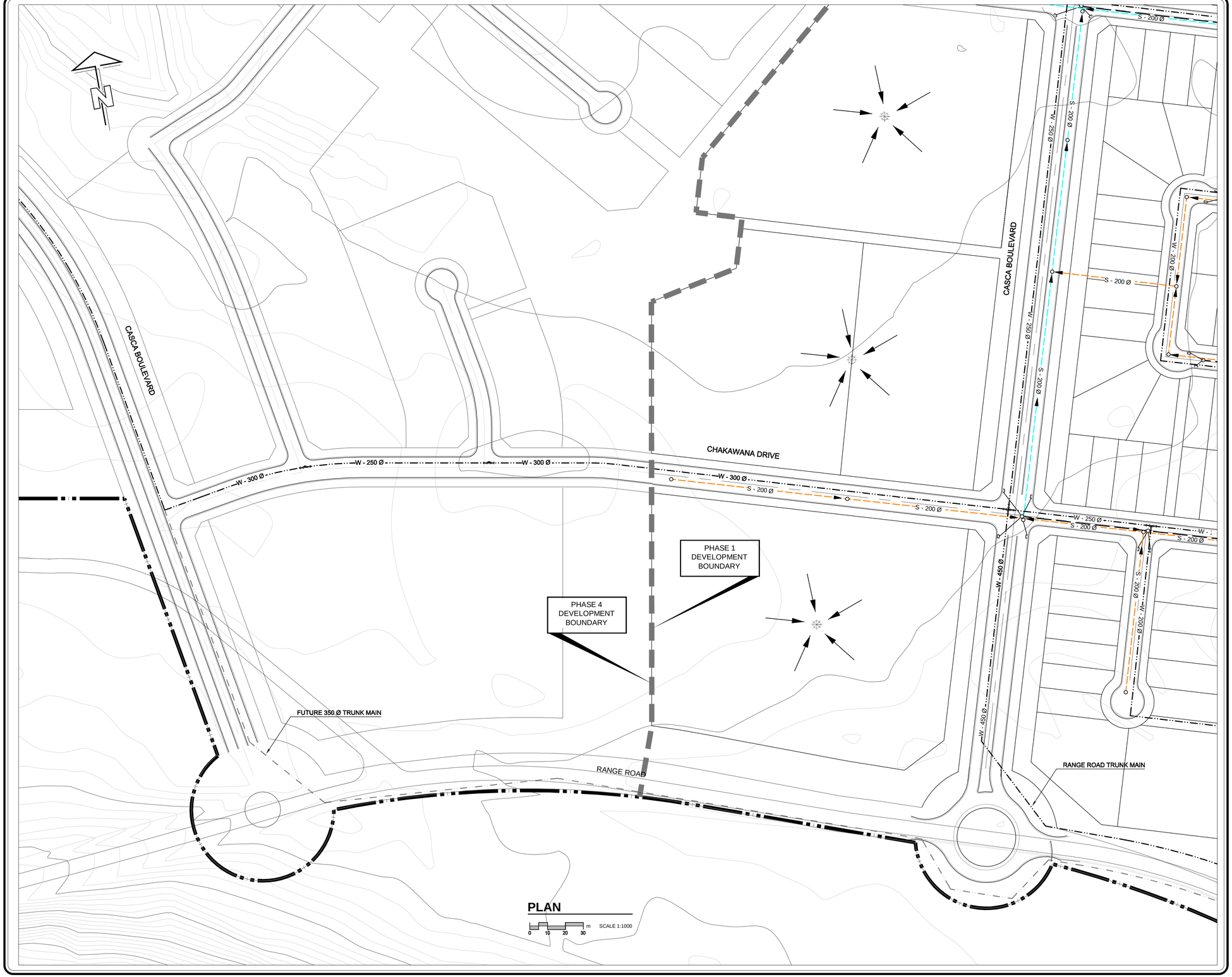
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APP'D BY CITY	DATE
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VER.	

PRE-DESIGN FOR
WHISTLE BEND
PHASE ONE

INFRASTRUCTURE PRE-DESIGN

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-0007
CITY DWG. No.	107
REV.	B



REFERENCE DRAWINGS

GENERAL NOTES

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NO.	DATE	ENG.	DESCRIPTION
B	DEC 28 2009	RA	REVISED PRELIMINARY DESIGN
A	NOV 10 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

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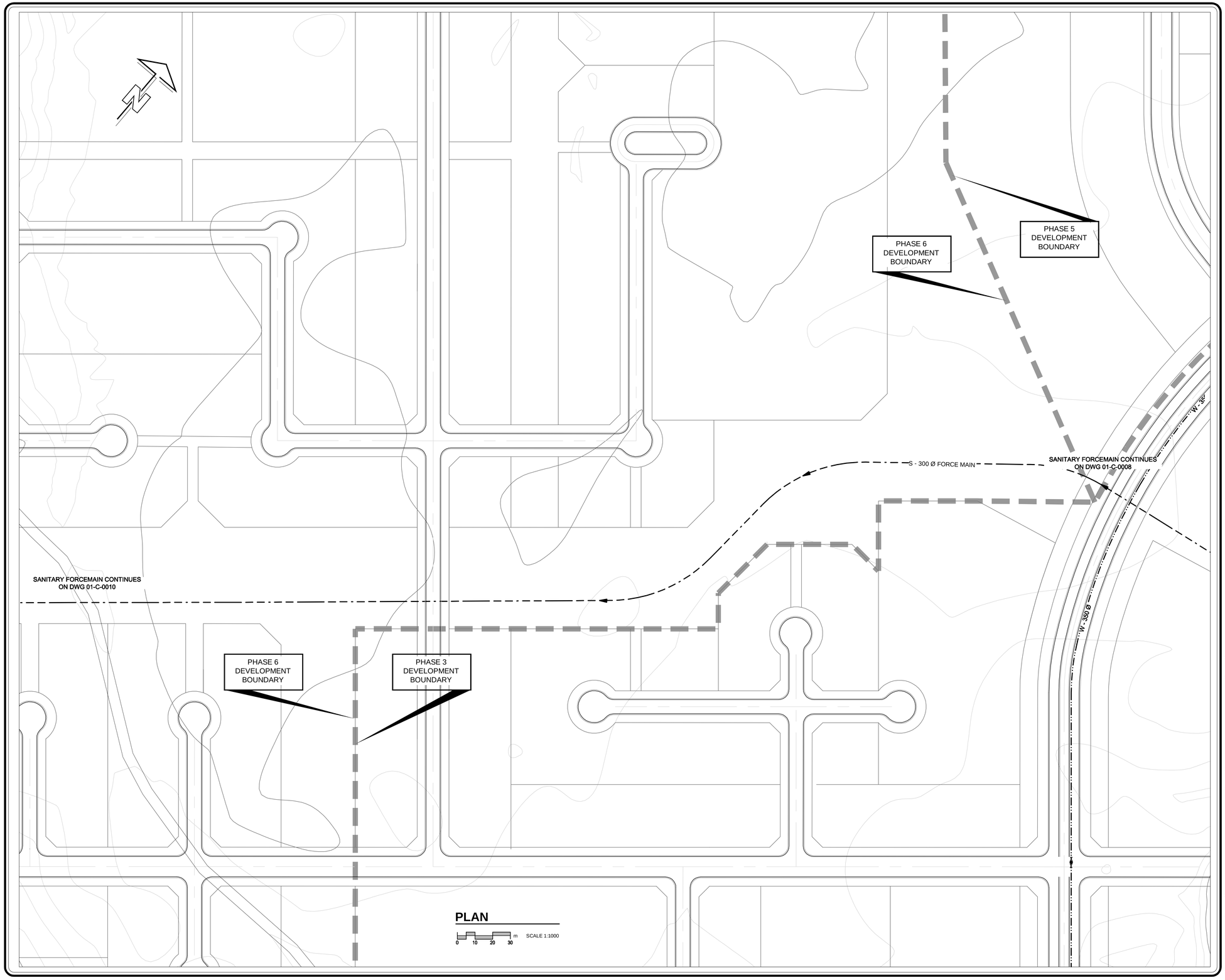
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APP'D BY CITY	DATE
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VER.	

PRE-DESIGN FOR
WHISTLE BEND
PHASE ONE

INFRASTRUCTURE PRE-DESIGN

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-0008
CITY DWG. No.	108
REV.	B



REFERENCE DRAWINGS

GENERAL NOTES

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REVISIONS & ISSUES

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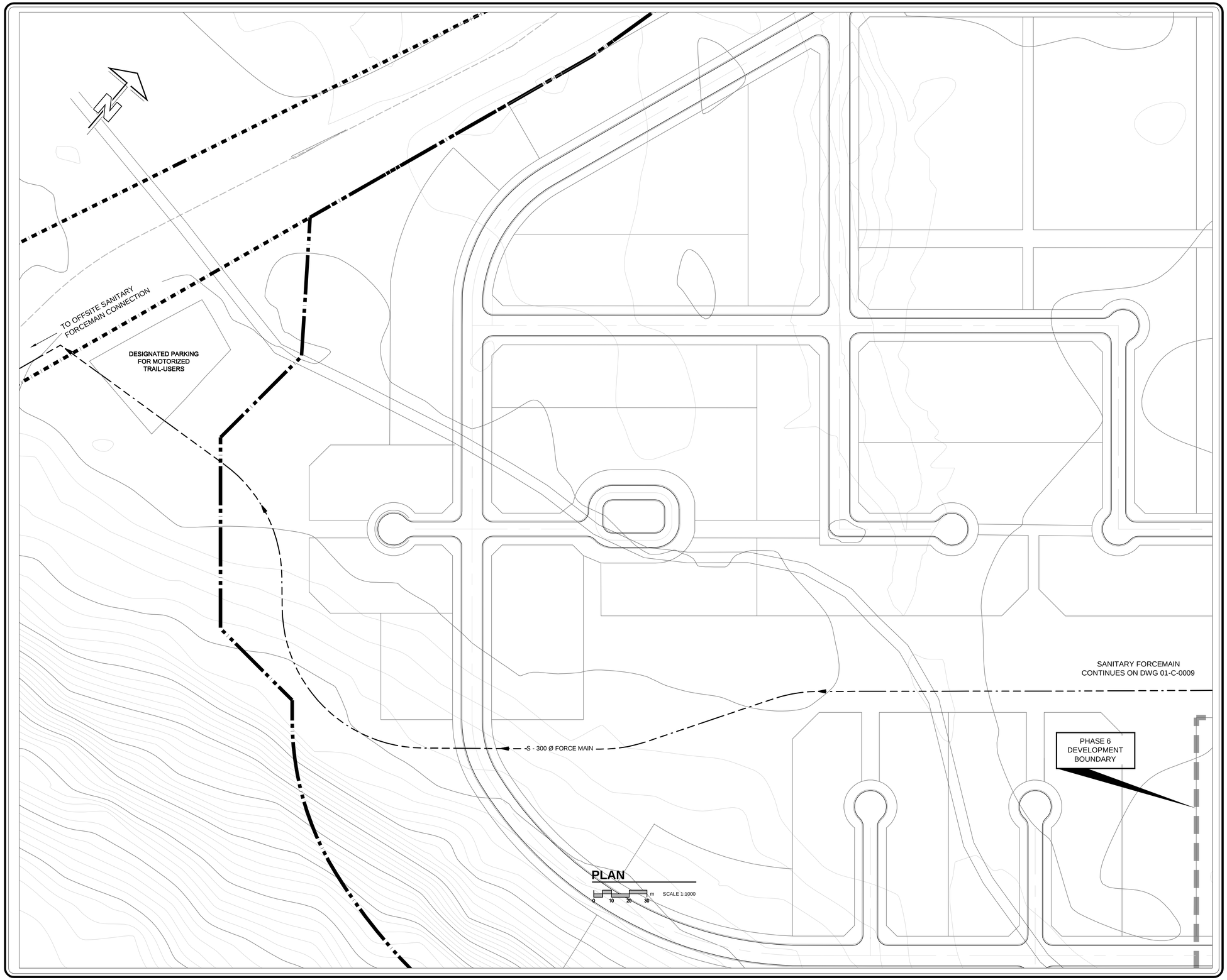
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SCALE: HOR.	1:1000
VER.	

PRE-DESIGN FOR
WHISTLE BEND
PHASE ONE

INFRASTRUCTURE PRE-DESIGN

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-0009
CITY DWG. No.	109
REV.	B



REFERENCE DRAWINGS

GENERAL NOTES

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NO.	DATE	ENG.	DESCRIPTION
B	DES 23 2009	RA	REVISED PRELIMINARY DESIGN
A	NOV 06 2009	RA	PRELIMINARY DESIGN REVIEW

REVISIONS & ISSUES

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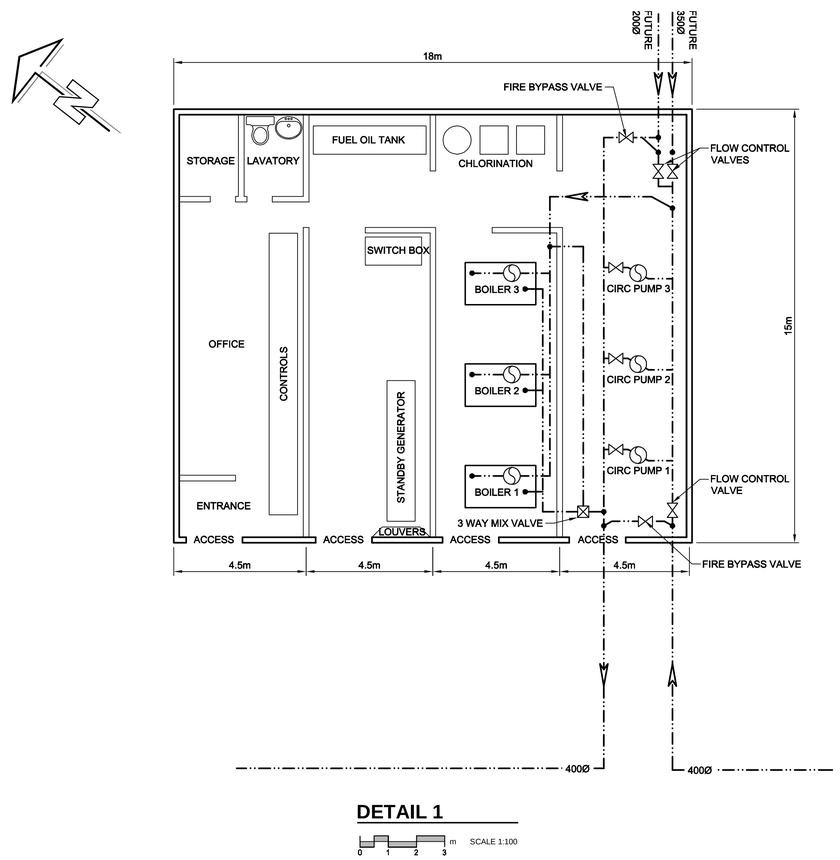
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VER.	

PRE-DESIGN FOR
WHISTLE BEND
PHASE ONE

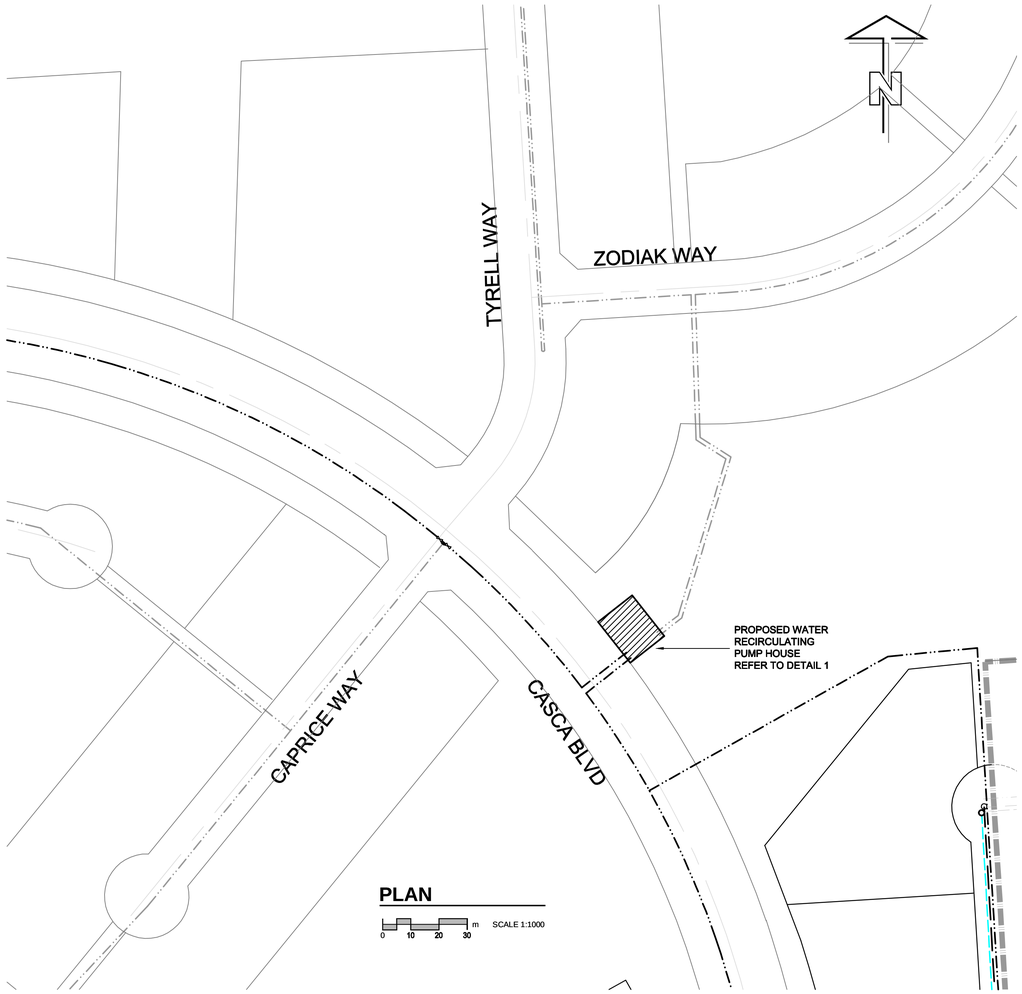
INFRASTRUCTURE PRE-DESIGN

SHEET	OF
CONSULTANT DWG. No.	2501-040-00_01-C-0010
CITY DWG. No.	110
REV.	B



DETAIL 1

0 1 2 3 m SCALE 1:100



PLAN

0 10 20 30 m SCALE 1:1000

REFERENCE DRAWINGS

GENERAL NOTES

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DESIGN	RA
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DATE	NOV 10 2009
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P. ENG. SEAL	
APP'D BY CONSULTANT	DATE
APP'D BY CITY	DATE
SCALE: HOR.	1:1000
VER.	

PRE-DESIGN FOR
WHISTLE BEND
PHASE 1 AND 2

INFRASTRUCTURE PRE-DESIGN
WATER RECIRCULATING PUMP HOUSE

SHEET OF

CONSULTANT DWG. No.
2501-040-00_01-C-4001

CITY DWG. No. 401

REV. B

