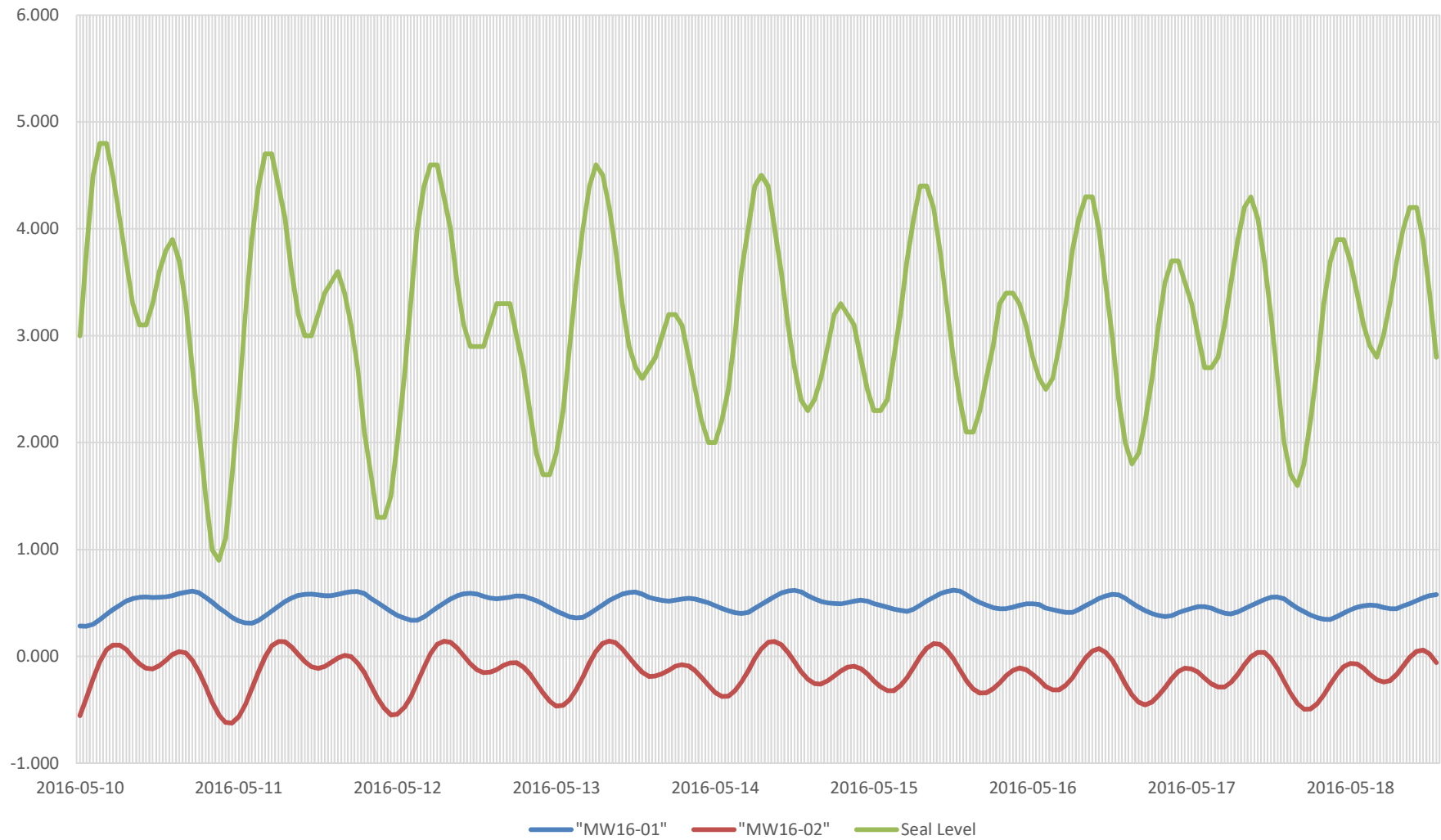
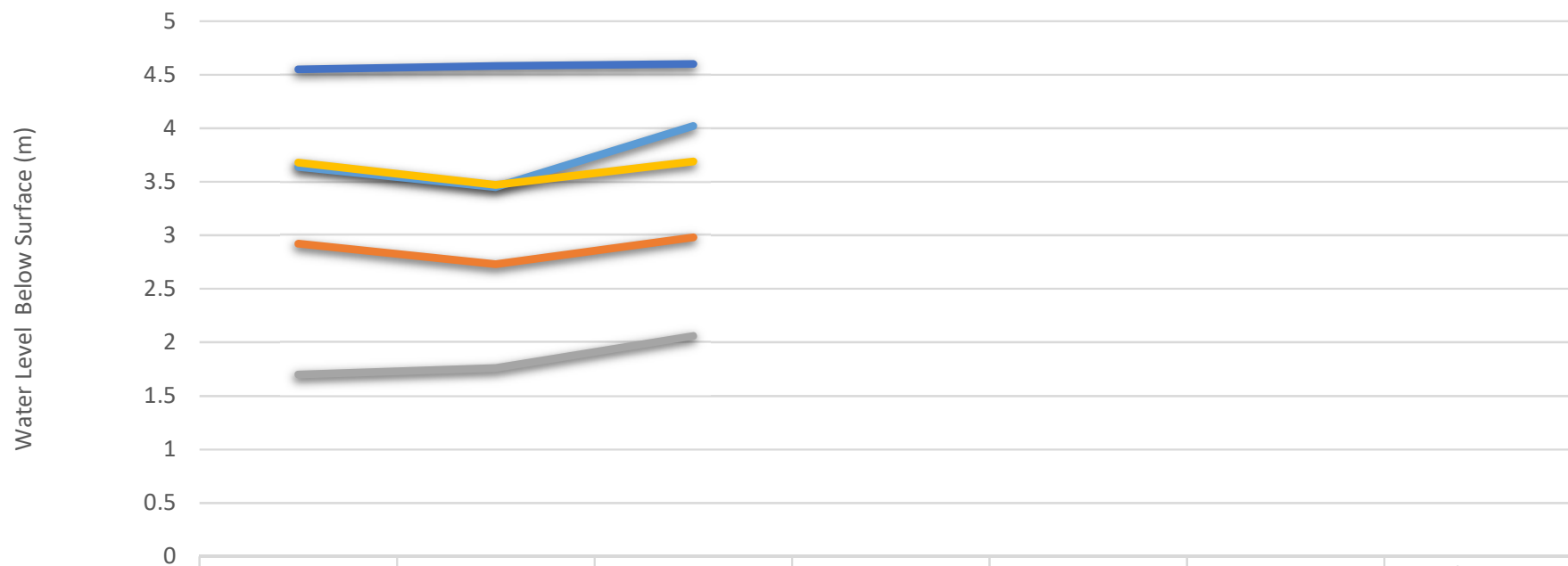


APPENDIX C – GROUNDWATER MONITORING WELL DATA

Britannia Tidal Fluctuations



Britannia South Water Monitoring



	6th May 2016	10th May 2016	19th May 2016	15th June 2016	1st July 2016	30th July 2016	15th August 2016
MW16-01	3.64	3.45	4.02				
MW16-02	2.92	2.73	2.98				
MW16-03	1.7	1.76	2.06				
MW16-04	3.68	3.47	3.69				
MW16-05	4.55	4.58	4.6				



#1-38920 Queens Way
Squamish, BC V8B 0K8
604-898-1093

Tigerbay Development Corporation
27154 Sea to Sky Highway 99
Britannia Beach, BC, V0N 1J0

April 28, 2020
File: 1181

Attention: Tony Petricevic

**RE: DRAFT Geotechnical Recommendations Report, Proposed Wave Garden Structure,
Britannia Beach South Development, Britannia Beach BC**

1.0 INTRODUCTION

We understand that Tigerbay Development Corporation is proposing to develop an area of land south of the existing Britannia Beach mine and town site. It is proposed to construct a comprehensive development which is expected to include townhouses, apartments, hotels, commercial and community facilities, camping areas, parking structures and an outdoor wave garden.

SFA Geotechnical Inc. (SFA) originally provided preliminary recommendations for the comprehensive development in our report dated April 15, 2019. SFA has now been requested to provide further detailed geotechnical recommendations specific to the proposed wave garden as outlined in the geotechnical brief prepared by Coffman Engineers dated January 29, 2020 and further to our proposal dated February 27, 2020.

SFA completed additional geotechnical investigation in the vicinity of the wave garden. This report summarizes the results of our investigation of the soil and groundwater conditions encountered and also references the results of past geotechnical investigations. The results of geotechnical lab testing are also presented. This report provides geotechnical recommendations for design consideration by the planning, design, and consulting teams.

This report has been prepared exclusively for Tigerbay Development Corporation and for the use of others within their design and construction team, however it remains the property of SFA Geotechnical Inc.

2.0 SITE DESCRIPTION

The proposed development site is located immediately south of the Britannia Beach town site approximately 10 km southwest of Squamish. The site is bounded by the Britannia Beach mine complex to the north, a BC Hydro Transmission Line right-of-way to the east, Highway 99 to the south, and Highway 99 and Howe Sound to the west. The site is irregular in shape, is up to 1,500 m long north to south and 700 m east-west and has an area of 780,000 square metres. The site is a former gravel pit which has been mined heavily.

The location of the proposed wave garden is in the northwest portion of the development site. The northern portion of the proposed wave garden is generally flat and is gravel covered. The southern third is hummocky and is vegetated with small trees and bushes. A wetland/creek is present near the southern edge of the wave garden.

3.0 SITE INVESTIGATION

SFA conducted a geotechnical investigation on March 27, 2020. The investigation included five solid-stem auger test holes supplemented with dynamic cone penetration test (DCPT) soundings. The auger test holes were advanced to depths of 9.0 m below grade. The soils were logged in the field and samples were collected for

Taicheng Development Corporation South Britannia Project Britannia Beach, BC

Archaeological Overview Assessment

Submitted to:

Taicheng Development Corporation
West Vancouver, BC

Submitted by:

AMEC Environment & Infrastructure
a division of AMEC Americas Limited
Burnaby, BC

AMEC Project No. VE12405

Revision Log

Version	Date Issued	Description
1.0	31 October 2012	Draft report to Taicheng Development Corporation for review
1.1	1 November 2012	Comments back from Folio Hotel and Resort Architecture; report revised
1.2	9 November 2012	Final report to Taicheng Development Corporations (via Folio Hotel and Resort Architecture)

IMPORTANT NOTICE

This report was prepared exclusively for Taicheng Development Corporation by AMEC Environment & Infrastructure, a wholly owned subsidiary of AMEC Americas Limited. The quality of information, conclusions and estimates contained herein are consistent with the level of effort involved in AMEC services and based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used only by Taicheng Development Corporation, subject to the terms and conditions of its contract with AMEC. Any use of, or reliance on, this report by any third party is at that party's sole risk.

Abbreviations and Acronyms

Abbreviation	Definition
AOA	Archaeological Overview Assessment
AMEC	AMEC Environment & Infrastructure
BC	British Columbia
CMT	Culturally Modified Tree
ha	hectare
km	kilometre
m	metre

Executive Summary

An archaeological overview assessment was carried out by AMEC Environment & Infrastructure for the South Britannia Project, immediately south of Britannia Beach, on the east side of Howe Sound, B.C., for Taicheng Development Corporation.

The assessment concluded that there are no known archaeological sites on the subject properties. However, based on the results of the archaeological overview assessment there are properties within the South Britannia Project that have the potential for archaeological sites. In addition, information on cultural heritage resources (traditional places and land use) is available for several locations along the shoreline of Howe Sound within the development properties and remnants of the historic community of Minaty Bay may be present on the subject properties. Therefore, there is potential for developments within some of the subject properties to affect as yet undiscovered buried archaeological remains. To address these potential effects, it is recommended that:

- Subject properties assessed as having low-to-moderate or moderate-to-high archaeological potential: District Lot 1889, REM District Lot 2009, District Lot 1970 Group 1, District Lot 5208, District Lot 5210, District Lot 2617, District Lot 3717, District Lot 1583, District Lot 4005, District Lot 4008, District Lot 4012, and District Lot 2933; be subject to an Archaeological Impact Assessment (AIA) prior to development of these lots.
- No AIA is recommended for subject properties assessed as having low archaeological potential: East ½ District Lot 1981, Lot A Except: Part Dedicated Road On Plan BCP25632 – District Lot 2001 & 7053, Parcel 1 (Reference Plan 4878) of District Lot 2001, Lot A Except: part Dedicated Road on Plan BCP286651, District Lots 1583, 2001, 7934 Plan 21567, Parcel 1 (Reference Plan 4878) of District Lot 1583, Except Part On Plan 21576.

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1. Introduction

This report describes the results of an archaeological overview assessment (AOA) undertaken in August – November 2012 by AMEC Environment & Infrastructure (AMEC) at the request of Folio Hotel And Resort Architecture on behalf of the proponent, Taicheng Development Corporation, for 16 properties (collectively known as the South Britannia Project) immediately south of Britannia Beach, British Columbia (BC) (Figures 1 & 2; Table 1).

The objective of the assessment was to determine the potential effects of development within the subject properties on cultural heritage resources and determine if follow-up actions are required. Specific impacts from development activities were not assessed, as there are no detailed development plans currently available.

The 16 subject properties cover a total area of approximately 237.5 hectares (ha) south of Britannia Beach along the east shore of Howe Sound and include the abandoned community of Minaty Bay. The South Britannia Project extends from Britannia Beach south along the east shore of Howe Sound for approximately 2.7 kilometres (km) and extends inland for approximately 1.5 km (Figures 2 & 3). Currently no existing developments are situated on the South Britannia Properties though portions of the subject properties have been affected by industrial activities (aggregate mining) and residential settlement.

Table 1. South Britannia Project Properites

Legal Description	PID/PIN	Area (ha)
District Lot 1889 Group 1 New Westminster District	010-025-782	2.6
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	2.3
REM District Lot 4009	010-025-634	5.5
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	4.7
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	18.7
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	4.2
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	15.3

Table 1. South Britannia Project Properites

Legal Description	PID/PIN	Area (ha)
District Lot 5208, Group 1, New Westminster District	015-825-663	9.8
District Lot 5210, Group 1, New Westminster District	015-825-680	5.6
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	1.3
District Lot 2617 Group 1 New Westminster District	010-025-677	14.8
District Lot 3717	015-896-170	18.2
District Lot 1583 Group 1 New Westminster District	010-026-151	49.1
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	22.8
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	20.9
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on Plan LMP17053	010-025-774	20.8
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	20.9

2. Protection of Archaeological Resources in British Columbia

In British Columbia, most archaeological sites are attributable to settlement and resource use by First Nations' people, and if they pre-date AD 1846, are automatically protected from damage, desecration, alteration, or excavation by the *Heritage Conservation Act* (RSBC 1996, Chap. 187). Some sites are protected through designation as "Provincial Heritage Sites" under Section 9 of the *Heritage Conservation Act (HCA)*, or through automatic protection under Section 13 by virtue of particular historic or archaeological values. Sites automatically protected under Section 13 include:

- archaeological sites occupied or used before AD 1846;
- rock art with historical or archaeological value;
- burial places with historical or archaeological value;

- heritage shipwrecks or aircraft wrecks; and
- archaeological sites of unknown age, with a reasonable possibility of having been occupied or used before AD 1846.

Protected sites may be located on public or private land, and may not be altered (changed in any manner) without a permit issued under Sections 12 or 14 of the *HCA*. Additionally, archaeological sites of Aboriginal origin may be subject to interpretations of the Supreme Court of Canada decision in *Delgamuukw* vs. British Columbia (1997), regarding the fiduciary responsibility of provincial governments for protecting cultural heritage.

3. Objectives

To assist with the management of archaeological sites, the Archaeology Branch issued the *British Columbia Archaeological Impact Assessment Guidelines* (Archaeology Branch 1998). These *Guidelines* identify several kinds of archaeological assessments that may be undertaken in response to proposed developments, with the kind of assessment dependent on the stage of development design and the types of archaeological information required. The purpose of an overview assessment, based on the *Guidelines*, is to:

- identify lands that have the potential to contain archaeological resources, within the subject properties;
- identify potential conflicts between archaeological resources and the proposed development; and
- recommend additional studies or other measures to protect archaeological resources, if required.

Archaeological potential is defined as the capability of a landscape (or landform) for having supported the kinds of traditional activities in the past which would have resulted in the formation (and preservation) of archaeological remains. Potential ratings do not predict the probability of sites, but identify lands that should be examined by archaeologists in advance of development projects. Some kinds of traditional activities did not result in the formation of physical remains, and such activities usually cannot be considered in the context of an assessment of archaeological potential.

No heritage inspection permit was required for the assessment of archaeological resources for the South Britannia Project. Additional archaeological studies such as an archaeological impact assessment will require a Heritage Inspection Permit as defined in the *Heritage Conservation Act* (RSBC 1996, Chap. 187).

4. Archaeological Potential Assessment

The assessment of archaeological resource potential was based upon a consideration of the locations of documented archaeological sites, ethnographic and historic information, and topographical and biophysical characteristics that favourably influence the distribution of

archaeological sites. Because archaeological site locations are often correlated with particular micro-environmental attributes, the presence or absence of these variables can be used to identify lands with greater or lesser archaeological potential. The environmental variables considered for this overview study included:

- modern vegetation/forest cover;
- proximity to documented archaeological resources;
- presence of traditional resources (e.g., stone suitable for flaking, economic plants);
- proximity to aquatic features (e.g., streams, wetlands, open water);
- aspect (i.e., wind or solar exposure based on direction of slope);
- presence of fine-textured sediments and soil drainage quality;
- current understanding of traditional resource use and settlement by Aboriginal people;
- environmental settings of documented archaeological sites in the area; and
- integrity of the modern landscape as a reflection of historic land use practices.

5. Methods

The archaeological overview assessment included:

- background research, involving a review of regional historic, ethnographic, and archaeological literature describing research in the Howe Sound - Squamish area generally and Britannia Beach locality specifically;
- A search of the Provincial Heritage Register maintained by the Archaeology Branch of the Ministry of Forests, Lands and Natural Resource Operations, for recorded archaeological and historical sites in the vicinity of the development properties;
- A review of historic aerial photos of the immediate area obtained from the Department of Geography at the University of British Columbia, for information on historic land use and landscape integrity;
- A review of biological, topographical, and hydrological information for the subject properties provided by proponent;
- A brief field inspection of the subject properties, from Highway #99 and along the shoreline, to assess landscape integrity and potential for archaeological sites; this inspection was carried out on October 25, 2012; and
- Preparing this report on the results of the assessment.

The background research involved a review of archaeological reports and other literature in the AMEC library. Sources consulted are provided in Section 10 (References Cited). In addition, the *Archaeological Overview Assessment of the Squamish Forest District* (Millennia Research 1997) was reviewed online via RAAD. The background review sought general information on pre-Contact archaeology, traditional land use practices by First Nations' people in this area, and historic land-use and occupancy of the Britannia Beach locality.

In addition, a brief field reconnaissance was undertaken to take contextual photographs of the subject properties and evaluate the potential for archaeological sites based on the biophysical characteristics of the proposed development area visible from Highway #99. The reconnaissance took place on October 25, 2012, and was conducted by D. Geordie Howe (AMEC). The subject properties were visually inspected from Highway #99 for terrain features, drainage and disturbance factors.

6. Archaeological Overview Background Results

6.1 Study Area and Biophysical Setting

The proposed South Britannia Development Project is located on the east side of Howe Sound in the Southern Pacific Ranges Ecoregion, Pacific Ranges Ecoregion, of the Coast and Mountains Ecoprovince (Demarchi 2011). The topography of the project area is moderately to steeply sloping and rises from Howe Sound to approximately 365 m above sea level along its eastern boundary. Locations within the development properties that are relatively flat are the result of historic land altering activities. Two creeks, Thistle Creek and Daisy Creek, flow west through the development draining into Howe Sound. Another drainage, South Creek, is located immediately south of the south boundary of the development.

No archaeological sites are registered within the Provincial Heritage Register for the subject properties. Lands within the subject properties have not been subject to archaeological study previously and little archaeological work adjacent to the project area has occurred.

6.2 Modern Vegetation

The Project area is situated within the Submaritime variant, Very Wet Maritime Subzone of the Coastal Western Hemlock Zone (CWHvm1) (Ministry of Forests Research Branch 1994; Pojar et al. 1991). This zone is distinguished by the presence of low-lying moist areas interspersed between high elevation, well-drained, dry settings. The CWHvm1 subzone is characteristic of windward montane slopes up to 650 m asl, and has cool summers and mild wet winters with relatively little snow. Zonal sites are typically dominated by western hemlock and true fir (*Abies* spp.) with western redcedar (Green and Klinka 1994), while red alder is dominant on recently-disturbed sites.

Historic mineral exploration and mining, aggregate extraction, railroad and highway development, residential development, and timber harvesting within the South Britannia subject properties have altered natural vegetation patterns at this locality. Historic land altering activities have occurred in the project locality since the early 1900s and has been extensive. Natural regeneration consists mainly of western hemlock, western redcedar, and red alder with an understory comprised of salal, huckleberry, and salmonberry.

6.3 Geology

The Project area is situated in coastal mountainous terrain comprised of rocks attributable to the Coast Plutonic Complex (Roddick et al. 1979). The geology of the northern portion of the development area is typified by the Britannia Formation (slate) or basic, fragmental and massive volcanic or Jurassic porphyritic quartz diorite of the Coast Range Batholithic rocks for the southern portion (James 1929; Journeay and Monger 1994). Lower elevations south from Britannia Beach to Daisy Creek consist of recent alluvium and glacial drift, glacial till, and colluvium (Armstrong 1990; Mathews 1975). Quartz diorite is a coarsely-textured rock that would not have been an attractive lithic raw material for pre-Contact stone-tool makers. Although alluvial sediments are present in the low-elevation, the majority of lands affected by the Project display an upper organic layer comprised of acidic humus which is often present to a depth of 40 cm depth below surface, overlying either gravels or bedrock. The acidic sediments are often poorly drained or moist, and are not ideal for preserving organic archaeological remains (e.g., bone, wood).

6.4 Ethnographic Background

From European contact to the present, the South Britannia Project locality has been the traditional territory of the Squamish Nation (or *skxwú'mish7úlh* in their own language) and the Tsleil-Waututh Nation, who speak different, but related languages that make up the Central Coast Salish linguistic family.

Suttles (1990) provides the most recent summary of Coast Salish culture in the Central Strait of Georgia region. Barnett (1955), Hill-Tout (1978), and Suttles (1987) are additional sources that are frequently cited.

Traditional Coast Salish society was characterized by a semi-sedentary lifestyle dependent upon fishing, gathering, and hunting for subsistence. The society was stratified and three classes of people were usually present; a large upper class, a smaller lower class, and a very small class of slaves. The primary socio-economic unit of Coast Salish society was the house group, each consisting of one or more extended families occupying a single plank house. Residence was usually with the man's family ("patrilocal"), while descent was reckoned bilaterally. Each house group owned its house, rights to resource harvesting sites, and ritual property including ancestral names, legends, songs and dances. Rights to these properties were acquired through inheritance and were normally held by the most important members of the household.

Coast Salish villages were usually comprised of one or more houses. Leadership was provided by a "council" of *siyam*, made up of the most respected family heads in the village. The prestige of the *siyam* was based on inherited social position and demonstrated abilities of leadership. Each village was linked through ties of marriage and kinship with other villages to form a social network without distinct boundaries. Marriages arranged between socially equal families in different villages helped to establish a co-operative system for resource procurement, including shared access to specific resource locations and shared labour.

Traditional population and settlement were contingent upon the availability and distribution of seasonally available food resources. These resources would have included anadromous (i.e., sea-run) fish (including coho and chum salmon, steelhead, and minor amounts of coastal cutthroat trout) in the permanent streams emptying into Howe Sound. Herring were taken for their roe, and rockfish, lingcod, and bottom fish such as flatfishes were also of considerable importance to the Coast Salish people. Intertidal marine resources such as clams and mussels were an important part of the diet, and the discarded shells of these creatures are among the principal constituents of coastal archaeological sites today.

Sea mammals were taken by specially-trained hunters, and included harbour porpoises, hair and harbour seals, and sea lions; the Pasley Island group south of Keats Island was especially renowned for sea lion hunting. Land mammals such as deer, elk, and bears were hunted, and mountain goats were a highly-prized specialty of Squamish hunters. Small game and fur-bearing mammals, including beaver, muskrat, otters, and mink, were hunted or trapped from aquatic settings, while other species like marmots were taken in montane, parkland environments. The broad foreshore on the western side of lower Howe Sound would have been important habitat for waterfowl such as ducks and geese.

Numerous plant resources were utilized, including (i) red and yellow cedar trees for timber and bark, and other tree species for firewood and medicinal purposes; (ii) terrestrial plants such as chokecherries, huckleberries, blueberries, and deerberries, were used for food; (iii) aquatic plants such as cranberries and wapato, were also used for food, and cat-tails, for mat-weaving; and (iv) medicinal and edible-root plants in forested and wetland environments. Turner (1975, 1979) provides detailed descriptions of the traditional uses of plants by First Nations' peoples in this region, while Bouchard and Kennedy (1976a, 1976b) provide specific information about utilization of terrestrial and marine food resources by Squamish people.

In addition to economic pursuits, individuals pursued spirit quests throughout their communities' territory, to acquire powerful or helpful spirits. Frequently overlooked by archaeologists, spirit-quest sites leave little trace of their presence, in comparison to resource exploitation sites like shellfish harvesting camps or forest utilization sites.

It is important to note that not all aspects of traditional First Nations' cultures are recorded in the anthropological and ethnohistoric literature. Additional knowledge of traditional culture and lifeways still exists in many contemporary First Nations' communities. Furthermore, Aboriginal societies underwent significant changes as a result of their contact with Europeans, and some cultural aspects reported in the literature may not accurately reflect that culture prior to contact.

6.5 Archaeological Background

An archaeological site is a location containing physical evidence of past human activity in the form of artifacts or cultural features. Artifacts are human-made or modified objects, such as stone and bone tools, ceremonial objects, and fire-altered rocks. Cultural features are

modifications to the landscape or objects which cannot be moved without altering them, such as burials, culturally modified trees (CMTs), rock art, cabins and structures, trails and roads, and the remains of industrial activities.

The age at which artifacts and features become an “archaeological site” is arbitrary, and can be defined according to particular research or management objectives. Those sites that clearly post-date the arrival of Europeans or are documented by written records are called “historic archaeological sites”.

Archaeological sites are numbered according to the Borden Site Designation Scheme (Borden 1952) used throughout Canada. This scheme is based on the maps of the National Topographic System and uses latitude and longitude to indicate a site location within 10'. The four alternating upper and lower case letters (e.g., DjRt) designate a unique 10' latitude by 10' longitude “Borden Unit.” Sites are numbered sequentially within a Borden Unit based (usually) on their date of discovery (i.e., DjRt-2 would be the second site recorded in the DjRt Borden Unit).

General syntheses of Pacific Northwest archaeology in British Columbia include Ames and Mashner (1999), Borden (1970, 1975), Carlson (1983), Fladmark (1982), Matson and Coupland (1995) and Mitchell (1990). Regional archaeological survey reports reviewed for this AOA include Arcas (1995, 1998, 2000, 2002, 2003), Bussey (1982, 1990), May and Lucs (1976), and Winram (1975). Archaeological excavation reports include Arcas (1995) and Reimer (2011). A general archaeological overview for the Squamish Forest District was also reviewed for this study (Millennia Research 1997. Historic sources included Armitage (1997) and Town (2010).

6.5.1 Archaeological Site Types

An archaeological site is defined as a location containing physical evidence of past human activity in the form of artifacts or features. Typical sites in the Project locality and Howe Sound region can include one or more of the following:

- **Middens**, most often situated near marine shorelines, are deposits of mollusc shell, fire-altered rocks, charcoal, and faunal remains (butchered mammal, bird, and fish bones), representing the locations of village sites or resource harvesting camps. Middens in the upper reach of Howe Sound and inland along major rivers have a lower frequency of shellfish remains in a matrix of black anthropogenic loam.
- **Artifact scatters** are comprised of clusters of (usually) stone artifacts, including expedient or formed tools and the waste products of tool manufacture (debitage). Most artifact scatters represent transitory use of the landscape, and are often associated with the exploitation of particular resources.
- **Burial places** are locations where First Nation communities interred their dead, commonly within village middens, but also throughout their territories for individuals who expired away from permanent village sites. In more recent times, the dead were interred above ground at special locations such as bedrock overhangs or earthen mounds.

- **Rock art** sites are locations of non-portable Aboriginal art, either painted (pictographs) or pecked into stone (petroglyphs). Rock art sites are typically found on bedrock outcrops or large boulders, usually along steep shorelines or at locations of strong spiritual significance to First Nations people.
- **Fish traps/weirs** are found on river bars or in creeks and streams supporting runs of sea-run salmonids and other fishes.
- **Wetsites** are found in permanently saturated or waterlogged locations, which allow preservation of organic materials (including wooden artifacts) that would otherwise decay rapidly.
- **Forest utilization sites** consist of one or more culturally modified trees (CMTs), which are trees that have been intentionally altered by First Nations' people. Coastal CMTs are of two basic types: bark-stripped trees and aboriginally-logged trees (Archaeology Branch 2001). The former result from bark collecting, whereas the latter were produced during timber procurement. Aboriginally-logged trees can be divided into different types, including: logged stumps of various kinds, standing test hole trees, plank-stripped trees, plank-stripped logs, and canoe blanks. The majority of CMTs will occur within 500 m of the coastline or a major watercourse, on well-drained, level ground to hillsides, and in old-growth forest stands containing straight-grained cedar trees.
- **Historic Sites:** Post-Contact remains, including artifacts, structures, and features associated with Euro-Canadian or Asian-Canadian settlement and land use.

6.5.2 Overview of Regional Prehistory

The development locality is situated within the Northwest Coast Culture Area, which encompasses the west coast of North America from southeastern Alaska to southern Oregon (Ames and Maschner 1999; Matson and Coupland 1995). Archaeologists have defined a sequence of pre-Contact cultures in this area, based on site investigations in Howe Sound and Burrard Inlet, the Fraser Valley, the east coast of Vancouver Island and southern Gulf Islands, and in Whatcom County and on the San Juan Islands in Washington State. Recent summaries of regional prehistory are Ames and Maschner (1999), Matson and Coupland (1995), Mitchell (1990), and Moss (2011). Researchers have noted continuities in the reliance on marine resources, woodworking technology, ceremonialism, status, and the acquisition of wealth. Based on diagnostic artifact types and technologies, as well as inferred economic, social and other cultural traits, five distinct cultural periods are identified:

- Lithic or Old Cordilleran (ca. 8,500 - 5,000 years Before Present or B.P.);
- Charles (ca. 6,500 - 3,200 B.P.);
- Locarno Beach (ca. 3,200 - 2,400 B.P.);
- Marpole (ca. 2,400 - 1,600 B.P.); and
- Strait of Georgia (ca. 1,600 - 200 B.P.).

6.5.2.1 Archaeological Research near Squamish

Parts of the Howe Sound and the Squamish River valley have been inspected by archaeologists since the early 20th century. The earliest archaeological investigations near Squamish were initiated at the turn of the century by Charles Hill-Tout (1978); later, Harlan Smith (1907) investigated a pictograph at Furry Creek. Since that time, numerous archaeological surveys have been conducted in the area, often in the form of assessments for proposed forestry, road, residential-commercial, and other developments (e.g., Arcas Consulting Archeologists 1998, 2000, 2002, 2003; Golder Associates (2004); May and Lucs 1976; Quirolo and Ham 1990; Reimer 2011; Winram 1975). Of particular note are several studies for BC Hydro transmission lines to the Cheekye substation that examined several route options in the study area (Bussey 1982, 1990). These studies and others have resulted in the identification of approximately 25 archaeological sites in the northern Howe Sound region.

The distribution and frequency of known sites is not necessarily believed to be representative of the archaeological resources in the area as a whole. Archaeological inventories and impact assessment surveys have, by and large, been restricted to development locations, and large landscape units have not been examined systematically.

6.5.2.2 Archaeological Sites near the South Britannia Project

At the time this AOA was undertaken, no archaeological sites had been recorded within the proposed development properties. A search of the Provincial Heritage Register database indicated that seven documented archaeological sites are situated within 8 km of the Project (Figure 1):

- the nearest recorded archaeological site to the subject properties is DjRt-2, a pictograph site, located approximately 2.7 km south at Furry Creek
- the next nearest site is DjRt-10, another pictograph site near Browning Lake approximately 3.4 km north

Additional archaeological sites within 10 km of the development include:

- DjRt-7 (a lithic scatter on the beach) approximately 5.3 km north-northwest
- DjRt-5, a lithic scatter on Defense Islands 6.6 km south-southwest
- DjRt-6, a midden site at Potlatch Creek, located 8.6 km southwest; respectively of the development properties.
- DkRs-6 is situated near the mouth of the Stawamus River on Mamquam Blind Channel, approximately 9.0 km north-northeast of the development. This site is the traditional village of *Stawamus* and has been subject to archaeological investigations for the Squamish Nation (Arcas 1995)

- DkRs-10 is located approximately 9.1 km northeast of the Project within the Olesen Creek drainage, and is a rock shelter/lithic scatter situated in an alpine setting.

The closest archaeological sites north of the Project are situated approximately 3.4 km north-northwest of the Mamquam River (DkRs-9, isolated find) and on the west side of the Squamish River, opposite the mouth of the Mamquam River (DkRs-5, historic cemetery). Additional archaeological sites are present along the banks of the Squamish and Cheakamus River and south along the shore of Howe Sound. The majority of sites located within 8 km of the proposed development are located in one of two environmental settings: 1) low-elevation locations along Howe Sound and the Squamish River; or 2) in the subalpine zone in the local mountains.

One historic site, the Britannia Beach National Historic Site (DjRt-11 – Britannia Mines Concentrator), is situated immediately north of the northern boundary of the subject property and was designated a National Historic Site in 1987.

7. Archaeological Overview Assessment Results

The archaeological overview assessment of the subject properties observed that the terrain within the subject properties is generally well-drained, reaching their highest elevation along the eastern and southern margins, with relatively level or undulating terrain backed by moderate to steeply sloping terrain. Vegetation varies from sparse in relatively open gravel fields to dense re-growth consisting of western hemlock, western redcedar, and some Douglas-fir. Two southeast-northwest trending creeks (Thistle and Daisy) run through the central portion of the subject properties, and based on an historical aerial photo review it appears that they were rechanneled during the operations of the various aggregate pits (Figure 3; Table 2).

Based on the historic airphoto review, extensive deforestation or ground altering activities have occurred within the majority of the properties: However, some properties adjacent to or in proximity to Howe Sound and/or Thistle and Daisy Creeks, with minimum to moderate historic disturbance, are assessed as having low-to-moderate or moderate-to-high archaeological potential (Figures 2 & 3; Table 2).

Given the extent of previous disturbance observed during the historic airphoto review, the possibility of as-yet undiscovered archaeological sites is considered to be low within the remaining lots of the Britannia South properties.

Second or third growth western redcedar is present within the forested portions of the subject properties. Western redcedar was an important source of bark and wood for First Nations people in the past, and cedar bark continues to be collected for ritual and other purposes. Western redcedar exhibiting physical modifications such as scars from bark-stripping, are called CMTs. Based on the forest clearing observed within the subject properties during the review of historic airphotos and the site visit, it is unlikely that CMTs would be present within the subject properties, except for the point of land within District Lot 2925 extending into Howe Sound, which appears to still retain large trees.

Historic aerial photo review: A review of historic aerial photographs, obtained from the Geographic Information Centre at the University of British Columbia, was undertaken to assess the intensity of past land-altering activities within the subject properties. Various land-altering activities have occurred within the South Britannia Project area over the last 106 years including: the development and operations of the Britannia Mine, aggregate extraction operations, construction of the Pacific Great Eastern Railway (subsequently BC Rail and now CN Rail); construction of residential and mining buildings including the community of Minaty Bay; road building, including the Sea To Sky Highway (Highway #99), and intensive logging and vegetation clearing associated with the above activities. For a detailed review of land-altering activities observed during the historic aerial review see *Appendix A*.

First Nation traditional use: The development property lies within the traditional territory of the Squamish Nation and the Tsleil-Waututh Nation. The Squamish Nation has reserves around Howe Sound and in the Squamish River valley and the Tsleil-Waututh Nation reserves are in Burrard Inlet and Indian Arm.

An early source for Squamish land use for the study area is *Conversations With Khahtsahlano 1932 -1954* by Major J.S. Matthews (1955). During those years, Matthews, who was archivist for the City of Vancouver, conducted extensive interviews with Chief Khatsahlano. The beach within the subject properties is referred to as *Huey-qwah-lahun* by Chief Khahtsahlano, and he goes on to add that it was:

“A good, sheltered bay with gravel beach and creek, a mile south of Britannia Beach. A dozen or more small cottages—shacks—ranged in a row along the shore between an extensive grove of alders and the water. The exact location of *Huey-qwah-lahun* (meaning: “A lot of little trout”) is where the creek empties into the sea. Immediately to the south is a small knoll. It is on D.L. 2925.” (1955:427).

Randy Bouchard and Dorothy Kennedy in their *Squamish Indian Band Land Use And Occupancy Study* (1986) prepared for the Squamish Nation state that the general name for Britannia Beach was *Shisháyu7áy* though they go on to say that some Squamish specifically locate this name at the mouth of Daisy Creek (Bouchard and Kennedy 1986:259). One of Bouchard and Kennedy’s major Squamish sources, Louis Miranda, noted that the mouth of Daisy Creek was a good camping spot (1986:259) and he also pointed out that people did not fish in Daisy Creek (1986:259). In addition, Louis Miranda also mentioned that “shacks” used to be near the mouth of the creek (Bouchard and Kennedy 1986:259).

Currently, along the Sea To Sky Highway (Highway #99), roadside kiosks and signs provide the Cultural Journey Sea-To-Sky Highway Route (Squamish Lilwat Cultural Centre). One such sign identifies Britannia Creek as *Shisháyu7áy*.

Archaeological Sites: No archaeological sites have been identified and recorded for the South Britannia Project. However, archaeological sites have been identified in similar environments elsewhere for the Howe Sound – Squamish area.

Historic heritage sites and properties: One historic heritage resource, the Britannia Beach National Historic Site (DjRt-11 – Britannia Mines Concentrator), is situated immediately to the north of the subject property and was designated a National Historic Site in 1988.

Britannia Beach Mine

The original copper claim was discovered in 1888 by Dr. Alex Forbes and by 1905 was in operation as the Britannia Mining and Smelting Company. Eventually the operations consisted of four adjoining mines and associated mills. Two communities formed in association with the mine operations, the town site at Britannia Beach (or the Beach) and further up the valley at Tunnel Camp and later Mount Sheer (Billwiller 1946; Engineering & Mining Journal 1915; Rickard 1916; Ramsey 1967). Various owners operated the mine over its years of operation until it finally closed in 1974. The following year the BC Museum of Mining opened and the mines were declared a National Historic Site in 1988 (Ramsey 1967; Town 2000, 2012).

Minaty Bay

Information on the community of Minaty Bay (situated within District Lot 1583 and shown on Figure 1 (from the National Topographic mapsheet Squamish 93G/11 Edition 2) is extremely sparse. Ramsey mentions that “around 1925 settlement began at Minaty Bay...At first the only way to get to the Bay was by boat...A trail was ultimately put in the Beach to allow the isolated Minaty Bay residents to join in the social activities which went on at the Beach and at the Townsite...In 1944 a road was put in and supplies were brought in by company truck” (Ramsey 1967:127). The Britannia Beach Sheet (Map 199A) accompanying James’ *Britannia Beach Map-area, British Columbia* (1929) dating to 1925 shows no structures or other features at Minaty Bay. A pipeline, providing water from Furry Creek to Britannia Beach, is shown at the eastern boundary of the recent alluvium and glacial drift deposits paralleling the western limit of the Britannia Formation.

Florida Ann Town, in her book *The Lively Ghost of Howe Sound* (2000), provides some additional information on Minaty Bay, as she lived “outside of Britannia Beach, at Minetta (sic) Bay, right on the water” from the late 1940s to the 1960s (Town 2012:8).

“In the mid-thirties, a group of workers banded together and threatened to walk out if the company could not find living quarters for their families and let them enjoy more normal lives. The men were given their pick of sites around Minaty Bay. There were responsible for clearing the land, and for building their homes. The company co-operated to the extent of providing materials (although their cost was deducted from the men’s pay cheques) but did not provide assistance with construction. They also charged a \$1 per month fee for land usage. Presumably, this arrangement would prevent residents from claiming squatter’s rights on the land”. (Town 2000:79)

Town goes on to add that with the construction of the PGE and then the highway (Highway #99) “Some Beach houses, especially those in the Minaty Bay area, were torn down, others moved” (Town 2000:109). A photograph in Ramsey’s *Britannia: The Story of A Mine* (1967:134) shows numerous houses along the waterfront at Minaty Bay in 1966. However, by the early 1990s little remained of the community of Minaty Bay.

Table 2. South Britannia Project Properties AOA Results

Legal Description	PID/PIN	Landscape Integrity - Rationale
District Lot 1889 Group 1 New Westminster District	010-025-782	Moderate historic disturbance except for northern portion; potential for CMTs and habitation sites (rock shelters) in northern portion
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	Moderate to intensive historic disturbance; low potential for archaeological sites
REM District Lot 4009	010-025-634	Moderate to intensive historic disturbance to south half of lot; potential for CMTs and habitation sites (rock shelters) in northern portion
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	Moderate to intensive historic disturbance; low potential for archaeological sites; see Photos 1, 2, & 3
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	Moderate to intensive historic disturbance to south half of lot; potential for CMTs and habitation sites (rock shelters) in northern portion; see Photos 1, 2, 3, & 4
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	Intensive historic disturbance; low potential for archaeological sites
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	Intensive historic disturbance; low potential for archaeological sites
District Lot 5208, Group 1, New Westminster District	015-825-663	Moderate historic disturbance; shoreline property; potential for archaeological sites (intertidal and along shoreline)
District Lot 5210, Group 1, New Westminster District	015-825-680	Moderate historic disturbance; shoreline property; potential for

Table 2. South Britannia Project Properties AOA Results

Legal Description	PID/PIN	Landscape Integrity - Rationale
		archaeological sites (intertidal and along shoreline)
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	Intensive historic disturbance; low potential for archaeological sites; see Photo 4
District Lot 2617 Group 1 New Westminster District	010-025-677	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs, habitation/rock shelters) in undisturbed contexts within northern portion
District Lot 3717	015-896-170	Minor to moderate historic disturbance to lot; potential for archaeological sites (CMTs, habitation/rock shelters); Thistle Creek and Daisy Creek flow through lot
District Lot 1583 Group 1 New Westminster District	010-026-151	Intensive historic disturbance to majority of lot; used as aggregate quarry and Minaty Bay townsite; low to moderate potential for archaeological sites in undisturbed locations and/or forested locations within lot and along shoreline; see Photo 5
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	Minor to moderate historic disturbance to lot; potential for archaeological sites (CMTs and habitation/rock shelters); Daisy Creek flows through portion of lot
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs and habitation/rock shelters) in northeastern portion of lot
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on	010-025-774	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs and

Table 2. South Britannia Project Properties AOA Results

Legal Description	PID/PIN	Landscape Integrity - Rationale
Plan LMP17053		habitation/rock shelters) in undisturbed portions of lot
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs and habitation/rock shelters) in undisturbed portions of lot

8. Conclusions and Recommendations

There are no known archaeological sites identified on the subject properties. However, based on the results of the archaeological overview assessment there are properties within the South Britannia Project that have the potential for archaeological sites. In addition, information on cultural heritage resources (traditional places and land use) is available for several locations along the shoreline of Howe Sound within the development properties and remnants of the historic community of Minaty Bay may also be present on the subject properties. Therefore, there is potential for development within some of the subject properties to affect as yet undiscovered buried archaeological remains (Table 3). To address these potential effects, it is recommended that:

- Subject properties assessed as having low-to-moderate or moderate-to-high archaeological potential: District Lot 1889, REM District Lot 4009, District Lot 1970 Group 1, District Lot 5208, District Lot 5210, District Lot 2617, District Lot 3717, District Lot 1583, District Lot 4005, District Lot 4008, District Lot 4012, and District Lot 2933; be subject to an Archaeological Impact Assessment (AIA) prior to development of these lots.
- No AIA is recommended for subject properties assessed as having low archaeological potential: East ½ District Lot 1981, Lot A Except: Part Dedicated Road On Plan BCP25632 – District Lot 2001 & 7053, Parcel 1 (Reference Plan 4878) of District Lot 2001, Lot A Except: part Dedicated Road on Plan BCP286651, District Lots 1583, 2001, 7034 Plan 21567, Parcel 1 (Reference Plan 4878) of District Lot 1583, Except Part On Plan 21576.

Table 3. South Britannia Project Properties AOA Recommendations

Legal Description	PID/PIN	AOA Result (Archaeological Site Potential)	Recommendation
District Lot 1889 Group 1 New Westminster District	010-025-782	Low to moderate potential	AIA
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	Low potential	No further archaeological work
REM District Lot 4009	010-025-634	Low to moderate potential	AIA
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	Low potential	No further archaeological work
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	Low to moderate potential	AIA
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	Low potential	No further archaeological work
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	Low potential	No further archaeological work
District Lot 5208, Group 1, New Westminster District	015-825-663	Moderate to high potential	AIA
District Lot 5210, Group 1, New Westminster District	015-825-680	Moderate to high potential	AIA
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	Low potential	No further archaeological work
District Lot 2617 Group 1 New Westminster District	010-025-677	Low to moderate potential	AIA

Table 3. South Britannia Project Properties AOA Recommendations

Legal Description	PID/PIN	AOA Result (Archaeological Site Potential)	Recommendation
District Lot 3717	015-896-170	Low to moderate potential	AIA
District Lot 1583 Group 1 New Westminster District	010-026-151	Moderate to high potential	AIA
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	Low to moderate potential	AIA
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	Low to moderate potential	AIA
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on Plan LMP17053	010-025-774	Low to moderate potential	AIA
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	Low to moderate potential	AIA

9. Limitations and Closure

Information on archaeological resources and resource potential in the subject properties presented in this report are based on a time-limited review of relevant documents, a search of relevant databases housing recorded sites-specific data, an historical aerial photograph review, and a brief field visit on October 25, 2012. Efforts were made to verify the accuracy of the data produced or provided by others and extracted from the literature and databases.

This assessment of archaeological potential is based on current understanding of the distribution of archaeological resources (sites and artifacts) in the general project area. AMEC acknowledges that knowledge and understanding of the archaeological record continues to evolve, and that ideas about site locations and distribution may change over time.

The findings and conclusions documented in this report have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care customarily exercised by archaeological professionals currently practising under similar conditions in this region. This study was conducted without prejudice to First Nations' treaty negotiations, Aboriginal rights, or Aboriginal title. Participation by Aboriginal communities in this study does not indicate support of the proposed development by those communities.

We trust that this report has provided you with the information you require. If you have any questions or comments, please contact Geordie Howe at (604) 295-6182.

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10. References Cited

- Ames, K., and H. Maschner
1999 *Peoples of the Northwest Coast: Their Archaeology and Prehistory*. Thames & Hudson Ltd., London.
- Arcas Consulting Archeologists
1995 *Archaeological Investigations in Traditional Squamish Territory 1989-1992. (Permits 1990-32 and 1990-89)*. Report on file, Archaeology Branch, Victoria, B.C.
- 1998 *Squamish Forest District Woodlots: Archaeological Impact Assessments Final Report. (Permit 1997-340)*. Report on file, Archaeology Branch, Victoria, B.C.
- 2000 *Garibaldi At Squamish Squamish, B.C. Archaeological Overview Assessment. (Squamish Nation Archaeological Investigation Permit #98-0027)*. Report on file, Archaeology Branch, Victoria, B.C.
- 2002 *Garibaldi At Squamish Ski Report Archaeological Impact Assessment Preliminary Results. (Heritage Inspection Permit 2000-317)*. Report on file, Archaeology Branch, Victoria, B.C.
- 2003 *Squamish Forest District Archaeological Assessments In 2002 Permit Report. (Heritage Inspection Permit 2002-028 and Squamish Nation Archaeological Investigation Permit #02-0079)*. Report prepared for the Ministry of Forests – Squamish Forest District and the Evans Lake Forest Education Society. Report on file, Archaeology Branch, Victoria, B.C.
- Archaeology Branch
1998 *British Columbia Archaeological Impact Assessment Guidelines [3rd revised edition]*. Ministry of Small Business, Tourism and Culture, Archaeology Branch, Victoria, B.C.
- 2001 *Culturally Modified Trees of British Columbia: A Handbook for the Identification and Recording of Culturally Modified Trees [version 2.0]*. Archaeology Branch and Resources Inventory Committee, Province of British Columbia. Available on the Internet at <http://www.for.gov.bc.ca/ric>.
- Armitage, D.
1997 *Around the Sound: A History of Howe Sound-Whistler*. Harbour Publishing, Madeira Park, B.C.
- Armstrong, J.E.
1990 *Vancouver Geology*. Cordilleran Section, Geological Survey of Canada, Vancouver, B.C.
- Backus, H.F.
1969 *Tomboy Pride*. A Woman's Personal Account of Life in Mining Camps of the West Pruett, Boulder, Co.
- Barnett, H.G.
1955 *The Coast Salish of British Columbia*. University of Oregon, Eugene (reprinted 1975 by Greenwood Press Publishers, Westport, Connecticut).
- Billwiller, P.W.
1946 No. 8 Shaft, Britannia Mines. *Western Miner* 19:42-54.

Borden, C.E.

- 1952 A uniform site designation scheme for Canada. *Anthropology in British Columbia* 3: 44-48.
- 1970 Cultural History of the Fraser River-Delta Region: An Outline. In *Archaeology of British Columbia, New Discoveries*, edited by R.L. Carlson. B.C. Studies, Special Issue 6-7:95-112.
- 1975 *Origins and Development of Early Northwest Coast Culture to about 3000 BC*. National Museum of Man Mercury Series, Archaeological Survey of Canada, Paper No. 45. Ottawa, Ontario.

Bouchard, R. And D. Kennedy

- 1986 *Squamish Indian Band land Use And Occupancy Study*. Prepared for the Squamish Nation, on file with the Squamish Nation, North Vancouver, B.C.
- 1976a *Knowledge and Usage of Land Mammals, Birds, Insects, Reptiles and Amphibians by the Squamish Indian People of British Columbia*. Report on file at B.C. Indian Language Project, Victoria, B.C.
- 1976b *Knowledge and Usage of Fish, Beach Foods, and Marine Mammals by the Squamish Indian People of British Columbia*. Report on file at B.C. Indian Language Project, Victoria, B.C.

Bussey, J.

- 1982 *Stage II Heritage Resource Impact Assessment B.C. Hydro and Power Authority Kelly - Cheekeye Transmission Line Project*. (Heritage Inspection Permit 1982-0006). Report on file, Archaeology Branch, Victoria, B.C.
- 1990 *Heritage Resource Update: Proposed Kelly Lake/Cheekeye 500 kV Transmission Line*. (Heritage Inspection Permit 1989-38). Points West Heritage Consulting Ltd. Report on file, Archaeology Branch, Victoria, B.C.

Carlson, R.L.

- 1983 Prehistory of the Northwest Coast. In *Indian Art Traditions of the Northwest Coast*, edited by R.L. Carlson, pp. 13-31. Archaeology Press, Simon Fraser University, Burnaby, B.C.

Demarchi, D.A.

- 2011 *The British Columbia Ecoregion Classification. Third Edition*. Ecosystem Information Section, Ministry of the Environment, Province of British Columbia. Victoria. Available at: <http://www.env.gov.bc.ca/ecology/ecoregions/>; accessed October 5, 2012.

Engineering & Mining Journal

- 1915 Fatal Snowslide at Britannia Copper Co.'s Mines – Special Correspondence. *The Engineering & Mining Journal*, 99(14):628.

Fladmark, K.R.

- 1982 An introduction to the prehistory of British Columbia. *Canadian Journal of Archaeology* 6:95-156.

Friesen, D.E.

- 1980 *Heritage Resource Assessment of the Proposed Westcoast Transmission Company Limited Vancouver Island Gas Pipeline Williams Lake to Comox and Squamish Lateral*. (Ministerial Order 1980-0001). Report on file, Archaeology Branch, Victoria. B.C.

Golder Associates

2004 *Archaeological Impact Assessment For The Sea-to-Sky Highway Improvement Project Heritage Inspection Permit 2003-111 Squamish Nation Permit 03-001*. Report on file, Archaeology Branch, Victoria, B.C.

Green, R.N., and K. Klinka

1994 *A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region*. Ministry of Forests, Land Management Handbook No. 28. Victoria, B.C.

Hill-Tout, C.

1978 *The Salish People: The Contribution of Charles Hill-Tout, Volume III: The Mainland Halkomelem*, edited by Ralph Maud. Talonbooks, Vancouver, B.C.

James, H.T.

1929 *Britannia Beach Map-area, British Columbia*. Geological Survey, Canada Department of Mines, Ottawa, Ontario, Ontario.

Journeyay, J.M., and J.W.H. Monger

1994 *Geology and Crustal Structure of the Southern Coast and Intermontane Belts, Southern Canadian Cordillera, British Columbia [map]*. Geological Survey of Canada, Open File. Ottawa, Ontario.

Mathews, W.H.

1975 *Garibaldi Geology*. Geological Association of Canada, Vancouver, B.C.

Matson, R.G. and G. Coupland

1995 *Prehistory of the Northwest Coast*. Academic Press, San Diego, California.

May, J. and S. Lucs

1976 *South Coast Regional Survey: Vancouver Island and the Lower Fraser Valley*. Report on file, Heritage Resource Centre, Ministry of Community, Aboriginal & Women's Services Victoria, B.C.

Millennia Research Ltd.

1997 *Archaeological Overview Assessment of the Squamish Forest District*. Squamish Forest District, Ministry of Forests, Squamish, B.C.

Mitchell, D.H.

1990 Prehistory of the Coast of Southern British Columbia and Northern Washington. In *Handbook of North American Indians, Volume 7, Northwest Coast*, edited by W. Suttles, pp.340-358. Smithsonian Institution, Washington, D.C.

Ministry of Forests, Research Branch

1994 *Biogeoclimatic Units of the Vancouver Forest Region: Map Sheet 5 of 6, Southern Vancouver Island -Sunshine Coast*. Ministry of Forests, Research Branch, Victoria, B.C.

Moss, M. L.

2011 *Northwest Coast Archaeology as Deep History*. SAA Press. Washington, D.C.

Mullan, M.

2012 *Britannia – The Story of A British Columbia Mine – from Mining Resource to Heritage Resource*. Ministry of Energy, Mines and Natural Gas and Responsible for Housing. Available at: <http://www.empr.gov.bc.ca/MINING/GEOSCIENCE/PUBLICATIONSCATALOGUE/OPENFILES/1992/1992-19/Pages/Britannia.aspx>; accessed October 5, 2012.

Pojar, J., K. Klinka, and D. Demarchi

1991a Coastal Western Hemlock Zone. In *Ecosystems of British Columbia* edited by D. Meidinger and J. Pojar, pp. 95-112. Ministry of Forests, Research Branch, Special Report Series 6, Victoria, B.C.

Quirolo, M.M., and L. Ham

1990 *Archaeological Resource Overview of the Furry Creek Delta, Howe Sound, British Columbia*. Report on file, Culture Department Library, Ministry of Small Business, Tourism and Culture, Victoria, B.C.

Ramsey, B.

2004 *Britannia: Story of a Mine*. Second Edition. Trafford Publishing. Victoria, B.C.

Reimer, R. (Yumks)

2011 *The Mountains And Rocks Are Forever: Lithics And Landscapes of Skwxwú7mesh Uxwumixw Territory*. Unpublished Ph.D. Dissertation, Department of Archaeology, Simon Fraser University, Burnaby, B.C.

Richard, T.A.

1916 The Britannia Mine and Mill. *Mining And Scientific Press* 112:693-700.

Roddick, J.A., J.E. Muller and A.V. Okulitch

1979 *Fraser River, British Columbia - Washington, Sheet 92 [map]*. Geological Survey of Canada, Map 1386A. Ottawa, Ontario.

Suttles, W.

1955 Squamish Ethnographic Notes. *Anthropology in British Columbia Memoir* Nos. 2 & 3, University of British Columbia, Vancouver, B.C.

1987 *Coast Salish Essays*. Talonbooks, Vancouver & University of Washington Press, Seattle, Washington.

1990 Central Coast Salish. In *Handbook of North American Indians, Volume 7, Northwest Coast*, edited by W. Suttles, pp.453-475. Smithsonian Institution, Washington, D.C.

Smith, H.I.

1907 Archaeology of the Gulf of Georgia and Puget Sound. *Publications of the Jesup North Pacific Expedition* 2(6); *Memoirs of the American Museum of Natural History*. 4(6):303-441, New York, New York.

Squamish Lilwat Cultural Centre

2012 *Cultural Journey Sea-to-Sky Highway Route – Connecting People And Communities Along The Way*. Available at: <http://www.slcc.ca/cultural-journey>; accessed: October 25, 2012.

Town, F.A.

2000 *The Lively Ghost of Howe Sound*. Bookus Press, Port Coquitlam, B.C.

2010 *Before The Road Came*. Smashwords. Available at:
<http://www.smashwords.com/books/view/15962>; accessed October 5, 2012.

Turner, N.J.

1975 *Food Plants of British Columbia Indians: Part I – Coastal Peoples*. British Columbia Provincial Museum, Handbook No.34. Victoria, B.C.

Turner, N.J.

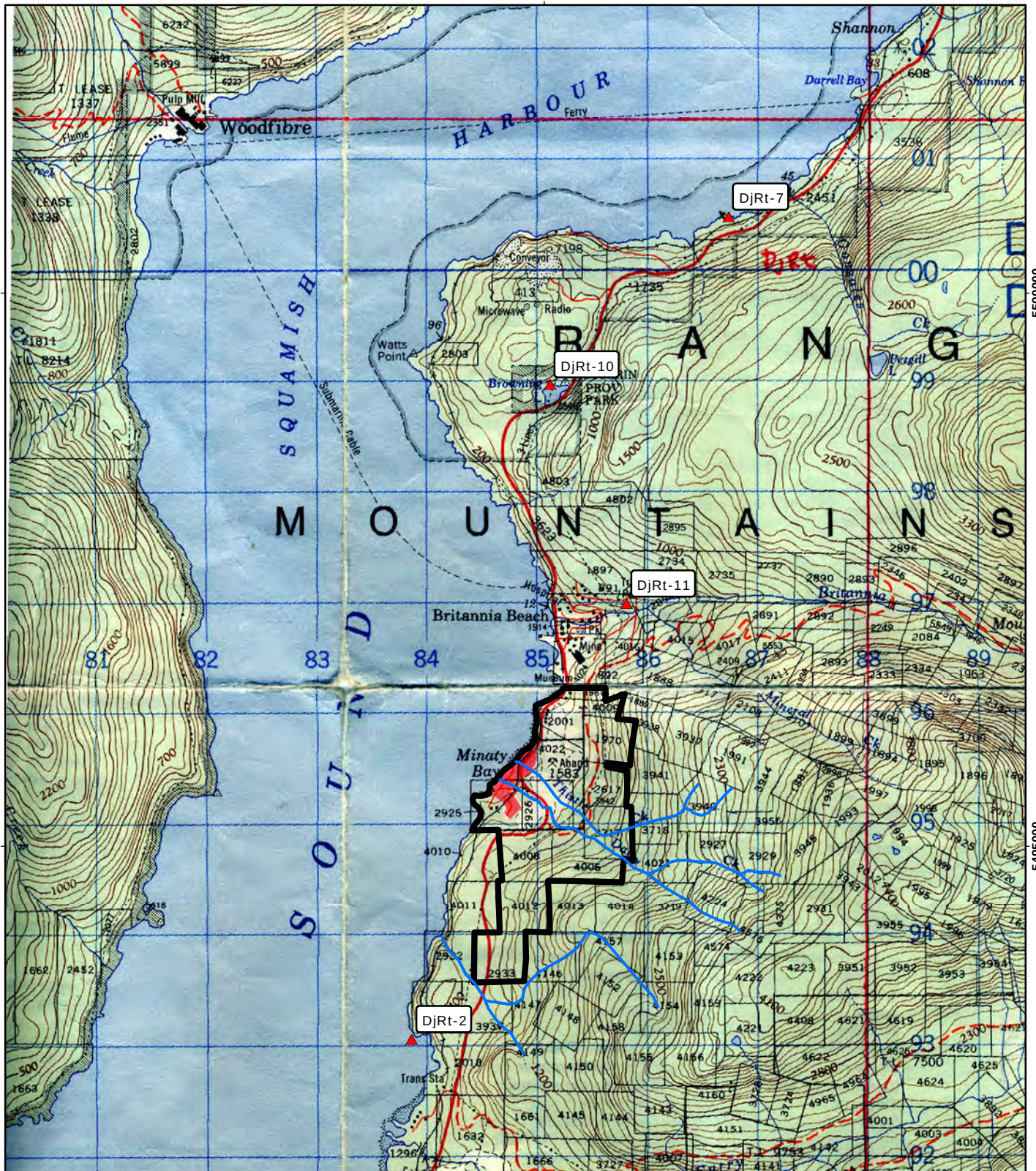
1979 *Plants in British Columbia Indian Technology*. British Columbia Provincial Museum, Handbook No.38. Victoria, .B.C.

Winram, P.

1975 *A Report on the Howe Sound Archaeology Survey*. [Permit # 1975-011]. Report on file, Archaeology Branch, Victoria B.C.

FIGURES

485000



485000

Legend

- South Britannia Subject Properties
- ▲ Archaeological Site
- River

Reference

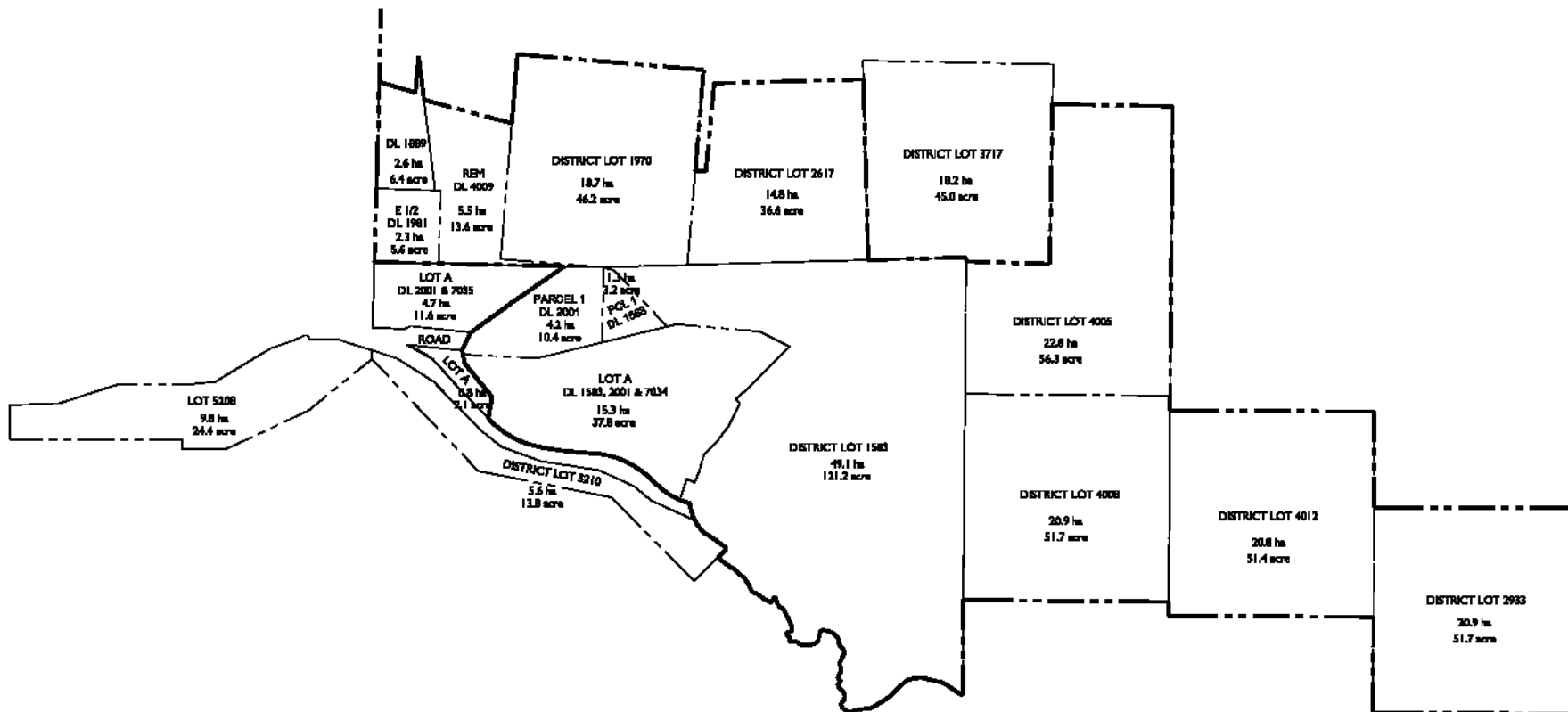
NTS Mapsheet 92G/11



1 0.5 0 1 km
Scale: 1:50,000

Location of South Britannia Project and nearby Archaeological Sites

CLIENT: Taiching Development Corporation		PROJECT: South Britannia Project AOA
DATE: Nov 08, 2012	ANALYST: AO'S	Figure 1
JOB No: VE12405	QA/QC: GH	
PROJECTION: UTM Zone 10	DATUM: NAD83	



1:15,000



FOLIO Hotel and Resort Architecture SOUTH BRITANNIA MASTERPLAN

Legend

--- South Britannia Subject Properties



Reference

Basemap: from Taiching Development Corporation

South Britannia Project - Development Property Information

CLIENT: Taiching Development Corporation		PROJECT: South Britannia
DATE: Nov 8, 2012	ANALYST: AO'S	Figure 2
JOB No: VE12405	QA/QC: GH	
PROJECTION: UTM Zone 10	DATUM: NAD83	



K:\Drafting\12 Drafting\VE12405\Data\Britannia Fig3.cdr



Legend

 South Britannia Subject Properties



Reference

Basemap: from Taiching Development Corporation

South Britannia Project - Development Property

CLIENT: Taiching Development Corporation		PROJECT: South Britannia
DATE: Nov 7, 2012	ANALYST: AO'S	Figure 3 
JOB No: VE12405	QA/QC: GH	
PROJECTION: UTM Zone 10	DATUM: NAD83	

PHOTOGRAPHS



Photo 2. Panorama view of South Britannia Project. View ESE across District Lot 2001;
Highway #99 on left and right side of photo.



Photo 2 View ESE across District Lot 2001.



Photo 3. View SE across District Lot 2001 and 1583.



Photo 4. View SE across Highway #99 across District Lot 1583 with District Lots 3717 and 4005 along ridgeline.



Photo 5. View SW along shoreline of Howe Sound towards Minaty Bay and District Lot 2925.

APPENDIX A

Historical Aerial Photograph Review

Appendix A. Summary of observations from historic airphoto review of South Britannia Development.				
Date	Flight	Frames	Altitude	Subject Property Observations
1947	BC 398	109	High Oblique	Oblique view east across Howe Sound to Britannia Creek drainage. Hydro transmission line visible inland of Britannia Beach; pipe line (water) from Furry Creek to Britannia Beach Mine and mine site visible. Pacific Great Eastern Railway (subsequently BC Rail, now CN Rail) line not yet constructed. Majority of South Britannia development area covered in vegetation (forest type not identifiable). Road connecting Britannia Beach to Minaty Bay visible; roads from water inland to transmission line visible; evidence of community of Minaty Bay visible; knoll in DL 2925 wooded
	BC 398	110		
1947	BC 398	111	High Oblique	Oblique view east across Howe Sound to Britannia Creek drainage. Hydro transmission line visible inland of Britannia Beach; pipe line (water) from Furry Creek to Britannia Beach Mine and mine site visible. Pacific Great Eastern Railway (subsequently BC Rail, now CN Rail) line not yet constructed. Majority of development covered in vegetation (forest type not identifiable). Road connecting Britannia Beach to Minaty Bay visible; roads from water inland to transmission line visible; evidence of community of Minaty Bay visible; knoll in DL 2925 wooded
	BC 398	112		
1951	Energy, Mines & Resources Canada A 13250	153	Very High	Hydro transmission line visible inland of Britannia Beach; pipe line (water) from Furry Creek to Britannia Beach Mine and mine site visible. Pacific Great Eastern Railway line not yet constructed. Majority of development covered in vegetation (forest type not identifiable). Roads from water inland to transmission line visible; evidence of community of Minaty Bay visible; knoll in DL 2925 wooded
1957	BC 2349	4	Low	Pacific Great Eastern Railway line visible. Majority of development covered in vegetation (forest type not identifiable). Aggregate operations visible in Parcel 1 DL 2001, north side of Lot A DL 1583, 2001 & 7034. Forest cover within south half of Lot A DL 1583, 2001 & 7034 showing clearing in progress. Additional aggregate operation north side of DL 1583, (now west of Highway #99). Highway #99 visible south of Britannia Beach to southern limit of development property. No evidence of logging inland of highway or transmission line. Community of Minaty Bay well established; knoll in DL 2925 wooded
	BC 2349	5		
	BC 2349	6		
	BC 2349	7		
	BC 2349	65		
	BC 2349	66		
	BC 2349	67		
	BC 2349	68		
1969	BC 5342	035	High	Highway #99 constructed. Aggregate operations now very extensive: visible in Parcel 1 DL 2001, all of Lot A DL 1583, 2001 & 7034, PCL 1 DL 1583 and northern

Appendix A. Summary of observations from historic airphoto review of South Britannia Development.				
Date	Flight	Frames	Altitude	Subject Property Observations
	BC 5342	036		portion of DL 1583. Only remnant of forest cover present within DL 1583 north of community of Minaty Bay – remainder is either lands associated with the community of Minaty Bay or aggregate operations. Trees becoming reestablished along Minaty Bay community roads. Rest of development property still covered in forest but forest service roads visible inland (eastern portion of development property); knoll in DL 2925 wooded
	BC 5342	037		
1969	BC 7202	057	Low	Highway #99 constructed. Aggregate operations now very extensive (maximum extent): visible in Parcel 1 DL 2001, all of Lot A DL 1583, 2001 & 7034, PCL 1 DL 1583 and northern portion of DL 1583. Small settling pond visible in Lot A DL 1583, 2001 & 7034 –western portion near Highway #99. Only remnant of forest cover within DL 1583 north of Minaty Bay – remainder is either lands associated with the community of Minaty Bay or aggregate operations. Trees becoming re-established along Minty Bay community roads. Evidence of logging inland within DL 1870, 2617, 3717, 4005, and 4008Rest of development property still covered in forest but forest service roads visible inland (eastern portion of development property); knoll in DL 2925 wooded
	BC 7202	058		
	BC 7202	137		
	BC 7202	138		
	BC 7202	139		
	BC 7202	140		
1974	BC 7558	158	Low	Aggregate operations extensive: visible in Parcel 1 DL 2001, all of Lot A DL 1583, 2001 & 7034, PCL 1 DL 1583 and northern portion of DL 1583. Settling pond has expanded and is now quite large adjacent to Highway #99. Community of Minaty Bay still present. No evidence of new logging visible; knoll in DL 2925 wooded
	BC 7558	159		
1982	BC 82 058	60	High	Trees now covering majority of aggregate pit – operations abandoned. Settling pond no longer present. Streets of Minaty Bay still visible but no buildings present. No evidence of new logging visible – development property becoming reforested; knoll in DL 2925 wooded.
	BC 82 058	61		
	BC 82 058	62		
	BC 82 058	63		
1982	BC 82 060	130	Very High	Trees now covering majority of aggregate pit – operations abandoned. Settling pond no longer present. Streets of Minaty Bay still visible but no buildings present. No evidence of new logging visible – development property becoming reforested; knoll in DL 2925 wooded.
	BC 82 060	131		
	BC 82 060	132		
	BC 82 061	133		
1990	30 BC B90020	25	Very High	A large portion of the aggregate pit has been cleared of vegetation (alder removed). Settling pond no longer present. Southern portion of DL 1583 (south of Highway #99) cleared of vegetation. Forest (alder) covers community of Minaty Bay – roads no longer visible. Various locations within development properties have been cleared of vegetation; knoll in DL 2925 wooded.
	30 BC B90020	26		
	30 BC B90020	27		
	30 BC B90020	40		
	30 BC B90020	41		

Appendix A. Summary of observations from historic airphoto review of South Britannia Development.				
Date	Flight	Frames	Altitude	Subject Property Observations
	30 BC B90020	42		
1994 colour	30 BC C94122	078	Low	The aggregate pit is starting to revegetate. Settling pond no longer present. Southern portion of DL 1583 (south of Highway #99) cleared of vegetation in 1990 is revegetated. Forest (alder) covers community of Minaty Bay – roads no longer visible. Various locations within development properties cleared of vegetation in 1990 regrowing; knoll in DL 2925 wooded.
	30 BC C94122	079		
	30 BC C94122	080		
	30 BC C94122	195		
	30 BC C94122	196		
	30 BC C94122	197		
2004 colour	SRS 6935	79	Very High	The aggregate pit is starting to revegetate though some new clearing appears. Forest (alder) covers community of Minaty Bay – roads no longer visible. Various locations within development properties cleared of vegetation in 1990 regrowing. Most of development property revegetated; knoll in DL 2925 wooded
	SRS 6935	80		
	SRS 6935	81		

laboratory testing. The location of the test holes are shown on our drawing 1181-1 and the detailed test hole logs are included in Appendix A. Lab testing results are included in Appendix B.

The site was also previously investigated a number of times by others. The investigations included the following:

- The excavation of 34 test pits on June 29th and 30th 2015. The test pits were excavated throughout the site to help determine the overall shallow soil conditions.
- Four test holes, and two cone penetration test (CPT) soundings were completed on July 16th and 17th 2015 to help identify the deeper stratigraphy and assess the liquefaction potential of the subsurface soils.
- The excavation of 15 additional test pits on March 21 and 25, 2016.
- Three monitoring wells were installed on July 17th, 2015 and five monitoring wells on May 6, 2016, to help evaluate the influence of the tides on the groundwater level below the site as well as to help determine the seasonal variability of the groundwater level.

The locations of historic test pit, test hole, monitoring well and CPT locations are shown on our drawing 1181-2 included following the text of this report. The relevant test hole logs specific to the wave garden site are included in Appendix C.

4.0 SUBSURFACE CONDITIONS

4.1 Published Surficial Geology

The Geological Survey of British Columbia describes the surficial geology as alluvial fan sediments that are very poorly sorted, dominantly sand and gravel sediment that form at the base of slopes. These sediments overly glaciomarine terrace sediments comprising stratified massive sand and gravel deposits and stratified proglacial deltaic sediments consisting of dominantly sand and gravel with minor silt and clay, locally up to 10m thick, over glaciomarine silt and clay.

4.2 Soil Conditions

In general, the soil profile noted from the surface downwards at our test holes consists of compact to very dense sand and gravel fill over native sand and gravel deposits. A detailed description of the soils encountered is provided below.

Fill

The site is generally overlain by 0.5 to 1.4 m of granular fill generally consisting of cobbly sand and gravel. The fill is inferred to consist of reworked native material. A thin layer of topsoil was found to overlie the fill on the southern portion of the site. Some woody debris was noted within the fill in test pits TP15-05, 06, 07 and 11.

Sand & Gravel

The fill was found to be underlain by dense native deposits consisting of sand or sand and gravel with varying amounts of cobbles. The sand was found to be medium to coarse grained with trace silt.

4.3 Groundwater Conditions

Two groundwater monitoring wells were installed as part of our scope of work to allow for future groundwater monitoring. The groundwater table was measured at approximately 3.4 to 3.9 m below grade during our investigation.

The groundwater table is expected to fluctuate with generally higher levels following periods of extended precipitation and to be tidally influenced.

Data loggers have been placed in the two new groundwater monitoring wells as well as two previously installed wells on the site. The data loggers will allow for continuous monitoring of the groundwater table specific to the wave garden site and its variability. SFA will periodically collect the data and measure water levels in accordance with our proposal.

Following the collection and interpretation of the ground water data we will prepare a summary report under separate cover.

4.3 Laboratory Testing

Laboratory testing was completed on select samples. Testing included grain size distribution, soluble sulphate and corrosion potential testing. A summary of the results is below. Detailed testing results are included in Appendix B.

4.3.1 Grain Size Distribution

The sieve testing for grain size distribution was completed on samples TH20-02, 03, 04 and 05 at depths ranging from 0.9 to 2.1 m below grade. The testing indicated the soils generally consisted of gravelly sand with trace amounts of silt.

4.3.2 Corrosion Potential

The corrosion potential test was completed on a sample from TH20-05 at a depth of 0.9 m. The testing indicates the overall corrosion potential is low.

4.3.3 Soluble Sulphate Testing

Soluble sulphate testing was completed on samples obtained from TH20-02 at 2.1 m depth and from TH20-05 at 0.9 m depth. The samples were found to have 0.01 – 0.02% soluble sulphate and therefore the degree of exposure is considered low.

4.4 Expansion Potential

The soils encountered consist of variable granular soils which are not considered susceptible to expansion.

5.0 DISCUSSION

5.1 General Comments

In general, the soil conditions consist of 0.5 to 1.4 m of variable granular fill materials with trace organics overlying dense native sand and gravel deposits.

Based on our review of the preliminary design drawings for the wave garden dated January 28, 2020, included in the geotechnical design brief, we understand that the top of the plinth will be approximately 3.5 m below the final surrounding grade. Therefore, we expect the underside of the plinths foundations to be approximately 4.0 m below final grade. We understand that the final grade of the structure has not been decided and will be determined based on flood construction level (FCL) and the design ground water table. We expect that the underside of the structure will be located above the design ground water table and that the top of the structure will be above the FCL.

Due to the wave garden's size and sensitivity tolerance to differential settlement, we recommend that the existing fill be removed to expose the native sand and gravel deposits prior to placement of any additional fill if/where

required. We expect that the wave garden can be supported on conventional reinforced concrete foundations bearing on the native granular deposits or engineered fill placed and compacted under review of SFA.

Provided the geotechnical consideration above are addressed as described below, we are of the opinion that the project is feasible from a geotechnical standpoint.

5.2 Seismic Considerations

The site is located in a seismically active zone. Therefore, earthquakes and their impact on the development must be considered.

5.2.1 Seismic Hazard

The seismic provisions in 2018 British Columbia Building Code (2018 BCBC) are adopted from the 2015 National Building Code (NBC) which states that the intent of seismic design is to protect the life and safety of building occupants and the general public as the building responds to strong ground shaking.

For design purposes, the 2015 NBC strong ground shaking is defined in terms of the mean ground motion amplitude having a probability of exceedance 2% in 50 years which equates to a 1 in 2,475 hazard.

5.2.2 Liquefaction Potential

It is generally accepted that loose to compact sand and non-plastic silt are prone to liquefaction or strain softening during cyclic loading caused by large earthquakes. Once liquefaction has been triggered, experience has shown that permanent vertical and horizontal ground movements may be experienced. The strength reduction caused by soil liquefaction can cause a substantial reduction in load carrying capacity which may lead to foundation punching failure. Once liquefaction is triggered, significant, permanent, vertical, and horizontal movements may be experienced.

For our analysis, we have relied on the 2015 National Building Code interpolated Seismic Hazard Values from Natural Resources Canada, which indicate that the peak ground acceleration (PGA) at this location is 0.29g (where g is the acceleration of gravity) for the 1 in 2,475 design ground motion event.

Based on our findings and CPT sounds the underlying soils are not considered susceptible to liquefaction triggering.

5.3 Geological Hazards

We understand that the site is subject to potential geological hazards such as coastal flood hazard from the Howe Sound as well as debris flow hazard from the creeks which run through the property.

SFA has not been engaged to review the geological hazards at the site. However, we can prepare a hazard review upon request.

6.0 DESIGN RECOMMENDATIONS

6.1 Site Preparation

6.1.1 Site Stripping

Prior to construction, all existing vegetation, topsoil, and existing fill should be removed within the construction areas to expose a subgrade consisting of native sand and gravel. Based on our test holes we estimate that the minimum stripping depth will range from 0.5 to 1.4 m on the site.

Site stripping should extend beyond the outer edge of foundations by a distance equal to the total thickness of fill required in. For example, if 1 meter of fill is to be placed below foundations then stripping should extend a minimum distance of 1 meter beyond the outside edge.

Regardless we recommend that site preparation extend a minimum of 1.5 m outside of the structure.

6.1.2 Temporary Excavations

We understand that the excavation depth required for the wave garden has not yet been confirmed. We expect that the majority of the excavation work will be completed above the water table, however, depending on the final design some excavation beneath the water table may be required.

We expect that the site can be readily excavated using standard excavating equipment. Temporary slopes can be designed at a maximum slope of 1.5H:1V within the compact to very dense sands to sand and gravels where above the water table. Dewatering will be required to allow for excavations below the water table. Regardless, temporary excavations should be reviewed by a geotechnical engineer or as required by WorkSafe BC temporary excavation guidelines.

6.1.3 Temporary Dewatering

Temporary dewatering would be required if excavation beneath the groundwater table is proposed. We expect that sump and pump techniques would likely provide a sufficient level of dewatering where the water table is at or slightly below the required excavation depth. Sumps should be installed such that the local water table is lowered to at least 0.6 m below foundation level to help reduce the potential for subgrade instability or heave.

The temporary dewatering recommendations should be reviewed once design elevations are known.

6.1.4 Compaction

We recommend that the stripped subgrade be well compacted using a large ride-on vibratory roller. The compacted subgrade must be reviewed by SFA prior to placement of any fill material or foundation formwork.

6.1.5 Engineered Fill

Following the recommended site stripping and compaction, engineered fill may be required beneath foundations. In the context of this report “engineered fill” is defined as sand to sand and gravel, compacted in maximum 300 mm loose lifts to a minimum of 95% of the ASTM D1557 (Modified Proctor) maximum dry density at a moisture content that is within 2% of optimum for compaction.

6.1.6 Re-use of Existing Fill

We expect that the majority of the excavated granular fills or native sands and gravels will be suitable for use as engineered fill provided that the materials are free of any organic’s materials.

Any excavated fill materials containing organics and other deleterious materials should not be re-used as engineered fill.

6.2 Foundations

6.2.1 Bearing Capacity

Following the recommended site preparation, the subgrade soil would be considered suitable to support conventional spread foundations at serviceability limit state (SLS) bearing pressure of up to 125 kPa and a factored ultimate limit state (ULS) of 250 kPa for foundations supported on native soils or engineered fill.

6.2.2 Settlement of Foundations

Post-construction settlements of less than 25 mm are expected with differential settlements less than 1 in 300.

6.2.3 Frost Protection

Foundations should be buried a minimum of 450 mm below the surface for frost protection.

6.2.4 Seismic Design of Foundations

The site is generally underlain by dense sand and gravel. We recommend that any structural design consider the site classification “Site Class C”, in accordance with Table 4.1.8.4.A. of the 2018 British Columbia Building Code (BCBC) for design purposes.

6.3 Slab-on-Grade

All grade supported concrete slab should be underlain by a minimum of 150 mm of 19 mm clear crushed gravel, to prevent moisture from accumulating below the slab, placed over compacted “engineered fill” or native granular soils as described in this report. The gravel should be compacted in place.

6.4 Lateral Pressures on Foundation/Retaining Walls

We recommend that any below grade foundation walls or retaining walls be designed using the following earth pressures:

1. Static: $P_a = 5.4 \cdot H$
Where;
 P_a = Lateral earth pressure due to static loading (kPa), triangular distribution;
 H = Wall height (m).
2. Seismic: $P_e = 2.7 \cdot H$
Where;
 P_e = Earth induced earth pressure (kPa), inverted triangular distribution;
 H = Wall height (m).

We assume that foundation/retaining walls will be backfilled with free draining material and that the walls would be fully drained. These lateral pressures are based upon unfactored soil parameters and are considered to be unfactored loads. Any additional surcharge loads located near the foundation walls should be added to the earth pressures given.

6.5 Wave Garden Drainage Recommendations

We understand that the wave garden will require periodical draining for maintenance. We recommend that the design of the wave garden include for 0.3 m of 19 mm clear crushed gravel beneath the pool and that permanent sump pumps be included in the mechanical design to lower the water table locally in order to allow the soil around the pool to be drained. The mechanical design should allow for lowering the groundwater table a minimum 0.6 m below the underside of the pool. SFA should review these recommendations once a design ground water level is known and the wave garden elevation has been set

6.7 Hardscaping

We anticipate that the existing granular fill materials would be suitable for subgrade support for any hardscaping or exterior flatwork. However, the subgrade should be stripped of organics and the existing granular fill should be compacted in place with a large vibratory roller and reviewed by SFA prior to any additional fill placement.

7.0 FIELD REVIEWS

As is normally required for Municipal Letts of Assurance, SFA Geotechnical Inc. should be asked to carry out sufficient field reviews during construction to ensure that the Geotechnical Design recommendation contained within this report have been adequately communicated to the design team and the contractors implanting the design. These field reviews are not carried out for the benefit of the contractors and therefore do not in any way effect the contractor's obligations to perform under the terms of their contract.

It is the contractor's responsibility to advise SFA Geotechnical Inc. (a minimum of 24 hours in advance) that a field review is required. Geotechnical field reviews are normally required at the time of the following:

- | | |
|------------------|---|
| 1. Stripping | Review of stripped subgrade prior to any fill placement |
| 2. Compaction | Review of compacted subgrade prior to filling |
| 3. Filling | Review of any engineering fill used to raise grades |
| 4. Subgrade | Review of prepared foundation subgrade |
| 5. Slab-on-grade | Review of slab-on-grade preparation |

8.0 CLOSURE

This report is prepared solely for use by our client and their design team for this project as described to the general standards of similar work for similar projects in this area and no other warranty of any kind is expressed or implied. SFA Geotechnical Inc. accepts no responsibility for any other use of this report.

We are pleased to assist you with this project, and we trust this information is helpful and sufficient for your purposes at this time. However, please do not hesitate to call the undersigned if you should require any clarification or additional details.

Yours truly,
SFA Geotechnical Inc.

Reviewed by:

DRAFT

DRAFT

Jessica Gagne, P.Eng.
Project Engineer

Steven Fofonoff, M.Eng., P.Eng.
Principal



SFA GEOTECHNICAL ENGINEERING	SFA GEOTECHNICAL INC 1 - 38920 QUEENS WAY SQUAMISH, BC V8B 0K8 604 898 1093	PROPOSED WAVEGARDEN SOUTH BRITANNIA BEACH, BC 2020 TEST HOLE PLAN VIEW	DRAWN BY: WG REVIEWED BY: SF DATE: APRIL 24, 2020 SCALE: AS SHOWN	REVISION NO.: DESCRIPTION DATE	JOB NO: 1181 DRAWING NO: 1181-01

2020 Test Hole Logs
TH20-01 to TH20-05

Test Hole Log: TH20-01

Project No.: 1181

Project: Proposed Wavegarden

Client: Tigerbay Development Corporation

Location: Britannia Beach, BC



#1 - 38920 Queens Way
Squamish, BC V8B 0K8
604-898-1093
www.sfaengineering.ca

Depth	Soil Profile		Elevation	Dynamic Cone Penetration Resistance (blows/0.3m)	Water Content (%)	Groundwater/Well	Remarks
	Strata	Description					
0		Ground Surface	4.0				
0.5		Topsoil brown, topsoil with some grass		27			
1.0		SAND and GRAVEL cobbly sand and gravel, medium grained, light brown to grey, dense, dry	3.0	41			
1.5				17			
2.0			2.0	20			
2.5				28			
3.0		SAND and GRAVEL coarse grained sand with fine gravel, grey, dense, becomes wet at approximately 3.6 m,	1.0	36			
3.5				26			
4.0			0.0	13			
4.5				13			
5.0		low recovery below 4.5 m,	-1.0	26			
5.5				14			
6.0			-2.0	13			
6.5				26			
7.0		very difficult drilling below 7 m	-3.0				
7.5							
8.0			-4.0				
8.5							
9.0			-5.0				

Date of Drilling: March 27, 2020

Rig Type: Auger

Logged By: WG

Datum: Geodetic

Page: 1 of 1

Test Hole Log: TH20-02 (MW20-01)

Project No.: 1181

Project: Proposed Wavegarden

Client: Tigerbay Development Corporation

Location: Britannia Beach, BC



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Depth	Soil Profile		Elevation	Dynamic Cone Penetration Resistance (blows/0.3m)	Water Content (%)	Groundwater/Well	Remarks
	Strata	Description					
0		Ground Surface	4.0				
1		Topsoil brown, topsoil with some grass	3.0				
2		SAND and GRAVEL cobbly sand and gravel, large rocks suspected, grey-brown, compact to dense, dry	2.0	>50			
3		SAND and GRAVEL sand and gravel, trace to some cobbles throughout with more at the top and again with depth, becomes moist at 2.0 m,	1.0				
4		wet at 3.9 m, little recovery below 4 m	0.0				
5		very difficult drilling from 4.8 to 5.5 m	-1.0				
6			-2.0				
7			-3.0				
8			-4.0				
9			-5.0				

Date of Drilling: March 27, 2020

Rig Type: Auger

Logged By: WG

Datum: Geodetic

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Test Hole Log: TH20-03

Project No.: 1181

Project: Proposed Wavegarden

Client: Tigerbay Development Corporation

Location: Britannia Beach, BC



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Depth	Soil Profile		Dynamic Cone Penetration Resistance (blows/0.3m)	Water Content (%)	Groundwater/Well	Remarks
	Strata	Description				
0		Ground Surface	4.0			
1		SAND and GRAVEL sand and gravel with some cobble, coarse grained, grey, dense, dry,	>50			
2						
3		becomes wet at 3.4 m				
4						
5						
6						
7						
8						
9						

Date of Drilling: March 27, 2020

Rig Type: Auger

Logged By: WG

Datum: Geodetic

Page: 1 of 1

Test Hole Log: TH20-04 (MW20-02)

Project No.: 1181

Project: Proposed Wavegarden

Client: Tigerbay Development Corporation

Location: Britannia Beach, BC



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Depth	Soil Profile		Elevation	Dynamic Cone Penetration Resistance (blows/0.3m)	Water Content (%)	Groundwater/Well	Remarks
	Strata	Description					
0		Ground Surface	4.0				
1		SAND and GRAVEL (Fill) cobbly sand and gravel fill, rounded to sub-rounded cobble and gravel, dense, very difficult to drill, wet at the surface with standing water	3.0				
2		SAND (Fill) sand with trace to some gravel fill, medium grained, brown, dense, moist	2.0	>50			
3		SAND and GRAVEL sand and gravel fill, medium grained, brown, dense, moist	1.0				
4		SAND and GRAVEL coarse grained, grey, dense, becomes wet at 3.4 m	0.0				
5			-1.0				
6			-2.0				
7			-3.0				
8			-4.0				
9			-5.0				

Date of Drilling: March 27, 2020

Rig Type: Auger

Logged By: WG

Datum: Geodetic

Page: 1 of 1

Test Hole Log: TH20-05

Project No.: 1181

Project: Proposed Wavegarden

Client: Tigerbay Development Corporation

Location: Britannia Beach, BC



#1 - 38920 Queens Way
Squamish, BC V8B 0K8
604-898-1093
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Depth	Soil Profile		Dynamic Cone Penetration Resistance (blows/0.3m)	Water Content (%)	Groundwater/Well	Remarks
	Strata	Description				
0		Ground Surface	3.7			
1		SAND and GRAVEL (Fill) medium to coarse grained sand with some gravel, light brown, compact to dense, dry	17			
2		SAND and GRAVEL sand and gravel, medium to coarse grained, brown, dense, dry	27			
3		SAND and GRAVEL SAND and GRAVEL - grey, very coarse grained, fine gravel, some rounded cobble up to 90 mm, wet at 3.7 m and little recovery with depth below the water table	>50			
4			>50			
5			>50			
6						
7						
8						
9						

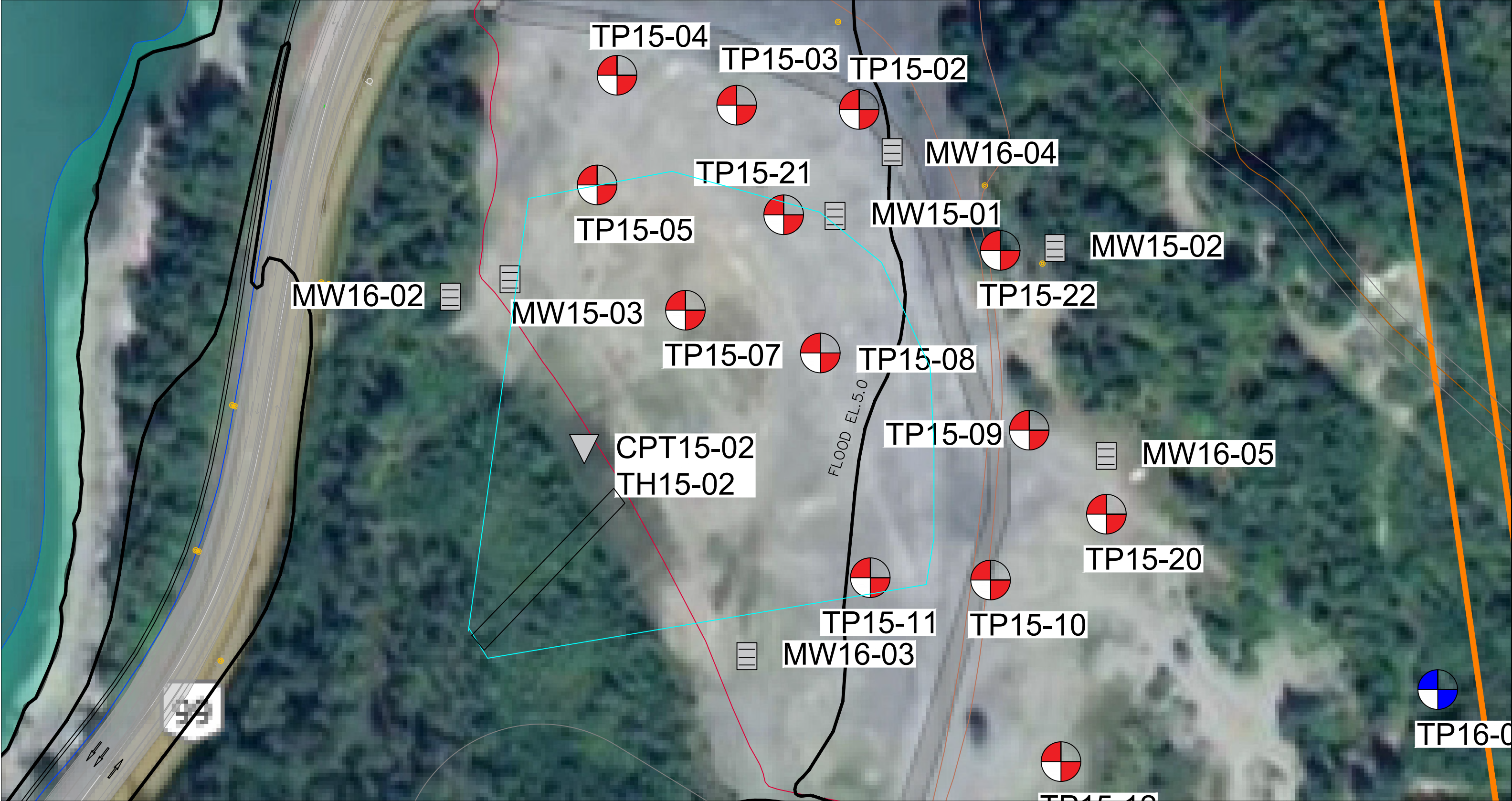
Date of Drilling: March 27, 2020

Rig Type: Auger

Logged By: WG

Datum: Geodetic

Page: 1 of 1



SFA GEOTECHNICAL ENGINEERING	SFA GEOTECHNICAL INC 1 - 38920 QUEENS WAY SQUAMISH, BC V8B 0K8 604 898 1093	PROPOSED WAVEGARDEN SOUTH BRITANNIA BEACH, BC 2020 TEST HOLE PLAN VIEW	DRAWN BY: WG REVIEWED BY: SF DATE: APRIL 24, 2020 SCALE: AS SHOWN	REVISION NO.:	DESCRIPTION	DATE	JOB NO: 1181 DRAWING NO: 1181-02

2015 Test Pit Logs
TP15-01 to TP15-34

Test Pit Log: TP15-05

File: 13088

Project: Britannia Beach South Development

Client: Taicheng Development Corp.

Site Location: Britannia Beach, BC

GeoPacific Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	Groundwater	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (ft)			
0		Ground Surface	0.0			
1		Sand and Gravel FILL With sub-round cobbles, dry, brown, with organics (woody debris)	2.0			
2		Sand and Gravel Coarse sand and sub-angular gravel, some sub-round cobbles, dry, grey				
3						
4						
5						
6		6.5' boulders observed				
7						
8						
9		9' becomes wet				
10		10' groundwater observed	10.5			
11		End of Test Pit				
12						
13						
14						
15						

Logged: AB
Method: Excavator
Date: 2015-06-29

Datum:
Figure Number:
Page: 1 of 1

Test Pit Log: TP15-06

File: 13088

Project: Britannia Beach South Development

Client: Taicheng Development Corp.

Site Location: Britannia Beach, BC

GeoPacific

Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	Groundwater	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (ft)			
0		Ground Surface	0.0			
1		Sand and Gravel FILL With sub-round cobbles, dry, brown, some organics (woody debris)				
2						
3						
4		Sand with Gravel Coarse Sand with sub-round gravel, some rounded cobbles, dry, grey				
5						
6						
7						
8						
9		9' becomes wet				
10		10.5' groundwater observed				
11			11.0			
12		End of Test Pit				
13						
14						
15						

Logged: AB

Method: Excavator

Date: 2015-06-29

Datum:

Figure Number:

Page: 1 of 1

Test Pit Log: TP15-07

File: 13088

Project: Britannia Beach South Development

Client: Taicheng Development Corp.

Site Location: Britannia Beach, BC

GeoPacific

Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	Groundwater	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (ft)			
0		Ground Surface	0.0			
1		Sand and Gravel FILL With some sub-round cobbles and trace angular cobbles, dry, brown, trace organics (rootlets)	2.0			
2		Sand and Gravel Coarse sand and rounded gravel, dry, grey				
3						
4						
5						
6						
7		7.5' becomes moist				
8						
9		9.5' becomes wet				
10			10.5			
11		End of Test Pit				
12						
13						
14						
15						

Logged: AB

Method: Excavator

Date: 2015-06-29

Datum:

Figure Number:

Page: 1 of 1

Test Pit Log: TP15-08

File: 13088

Project: Britannia Beach South Development

Client: Taicheng Development Corp.

Site Location: Britannia Beach, BC

GeoPacific Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	Groundwater	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (ft)			
0		Ground Surface	0.0			
1		Sand and Gravel FILL Rounded cobbles, trace silt, dry, brown, some organics (rootlets)				
2		3.5' interbedded grey silt layer				
3						
4			4.5			
5		Sand Coarse sand with some sub-rounded gravel, dry, grey				
6						
7			7.0			
8		Sand and Gravel Coarse sand and sub-rounded gravel, dry to moist, grey				
9						
10			10.0			
11		End of Test Pit				
12						
13						
14						
15						

Logged: AB
Method: Excavator
Date: 2015-06-29

Datum:
Figure Number:
Page: 1 of 1

Test Pit Log: TP15-09

File: 13088

Project: Britannia Beach South Development

Client: Taicheng Development Corp.

Site Location: Britannia Beach, BC

GeoPacific

Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	Groundwater	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (ft)			
0		Ground Surface	0.0			
1		Gravel FILL Sub-round, sandy, dry, brown	1.5			
2		Sand and Gravel FILL Rounded cobbles, dry, brown	2.5			
3		Sand and Gravel Coarse sand and sub-round gravel, dry, grey				
4						
5						
6						
7		7.5' gravel becomes sub-angular				
8						
9			9.0			
10		End of Test Pit				
11						
12						
13						
14						
15						

Logged: AB

Method: Excavator

Date: 2015-06-29

Datum:

Figure Number:

Page: 1 of 1

Test Pit Log: TP15-10

File: 13088

Project: Britannia Beach South Development

Client: Taicheng Development Corp.

Site Location: Britannia Beach, BC

GeoPacific
Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	Groundwater	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (ft)			
0		Ground Surface	0.0			
1		Sand and Gravel FILL Sub-angular to angular, some rounded cobbles, very dense, dry, brown	2.0			
2		Sand Medium to coarse, some sub-angular gravel, rounded cobbles in upper 6", dry, grey				
3		3.5' interbedded gravel layer				
4						
5						
6						
7						
8			8.0			
9		Sand and Gravel Medium-coarse sand and sub-angular gravel, dry to moist, grey	9.5			
10		End of Test Pit				
11						
12						
13						
14						
15						

Logged: AB
Method: Excavator
Date: 2015-06-29

Datum:
Figure Number:
Page: 1 of 1

Test Pit Log: TP15-11

File: 13088

Project: Britannia Beach South Development

Client: Taicheng Development Corp.

Site Location: Britannia Beach, BC

GeoPacific

Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	Groundwater	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (ft)			
0		Ground Surface	0.0			
1		Sand and Gravel FILL Sub-angular, dry, brown, organics (woody debris) Interbedded silt layer	2.0			
2		Sand and Gravel Coarse sand and sub-angular gravel, dry, grey-brown				
3		8' interbedded silt, dry, black				
4			9.0			
5		End of Test Pit				
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Logged: AB

Method: Excavator

Date: 2015-06-29

Datum:

Figure Number:

Page: 1 of 1

Test Pit Log: TP15-21

File: 13088

Project: Britannia Beach South Development

Client: Taicheng Development Corp.

Site Location: Britannia Beach, BC

GeoPacific

Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	Groundwater	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (ft)			
0		Ground Surface	0.0			
1		Sand and Gravel FILL Dry, brown				
2		2' Interbedded silt layer, dry, brown-orange				
3						
4			4.0			
5		Sand and Gravel Coarse sand and sub-round gravel, dry to moist, grey				
6						
7						
8		9' Interbedded brown gravel layer				
9						
10		11' becomes wet				
11		12' groundwater observed				
12			13.0			
13		End of Test Pit				
14						
15						

Logged: AB

Method: Excavator

Date: 2015-06-29

Datum:

Figure Number:

Page: 1 of 1

Test Pit Log: TP15-22

File: 13088

Project: Britannia Beach South Development

Client: Taicheng Development Corp.

Site Location: Britannia Beach, BC

GeoPacific Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	Groundwater	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (ft)			
0		Ground Surface	0.0			
1		Topsoil With sand and gravel, dry, brown, organics	1.0			
2		Sand and Gravel Coarse sand and sub-round gravel, some sub-angular cobbles, dry to moist, grey				
3						
4						
5						
6						
7						
8						
9						
10						
11		12.5' becomes wet				
12		13.5' groundwater observed				
13						
14			14.0			
15		End of Test Pit				

Logged: AB

Method: Excavator

Date: 2015-06-29

Datum:

Figure Number:

Page: 1 of 1

2015 Monitoring Wells
MW15-01 to MW15-03

Test Hole Log: MW15-01

File: 13088

Project: BRITANNIA BEACH SOUTH DEVELOPMENT

Client: TAICHENG DEVELOPMENT CORP.

Site Location: BRITANNIA BEACH, BC

GeoPacific
Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	DCPT (blows per foot) 10 20 30 40	Groundwater / Well	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)				
0		Ground Surface					
0.0		Sand and gravel compact to dense SAND and GRAVEL, trace silt, gravel <40 mm, brown, slightly moist	0.0				1" PVC monitoring well; Solid from 0.0m to 1.5m Screened from 1.5m to 6.0m Bentonite from 0.0m to 1.2m Filter sand from 1.2m to 6.0m 3.04 m observed water table depth in well: (17-Jul-2015 @14:15)
0.9		Sand and gravel dense coarse SAND and GRAVEL, some cobbles, gravel <50 mm, brown, moist becomes wet @ 2.5 m	0.9				
3.4		Sand and gravel very dense cobbly SAND and GRAVEL, gravel <80 mm, grey, moist to wet	3.4				
5.2		Gravel very dense sandy GRAVEL, some cobbles, coarse grained sand, gravel <40 mm, grey, wet	5.2				
6.1		End of Borehole	6.1				
7							

Logged: ZH

Method: Hollow stem auger

Date: 17-Jul-2015

Datum: Ground elevation

Figure Number: A.05

Page: 1 of 1

Test Hole Log: MW15-02

File: 13088

Project: BRITANNIA BEACH SOUTH DEVELOPMENT

Client: TAICHENG DEVELOPMENT CORP.

Site Location: BRITANNIA BEACH, BC

GeoPacific
Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	DCPT (blows per foot) 10 20 30 40	Groundwater / Well	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)				
0		Ground Surface	0.0				
1		Sand and gravel dense coarse SAND and GRAVEL, trace cobbles, gravel <50 mm, brown, dry	0.0				
2							
3							
4							
5							
6							
7							
8							
9							
10							
11		Sand and gravel dense coarse SAND and GRAVEL, some cobbles, gravel <80 mm, brown, moist to wet	3.0				
12							
13							
14		becomes very dense @ 4.0 m					
15							
16							
17							
18							
19							
20							
21		Sand dense gravelly SAND, trace cobbles, gravel <40 mm, grey, moist to wet	6.1				
22							
23		Sand and gravel dense to very dense cobbly SAND and GRAVEL, gravel <60 mm, grey, moist to wet	6.7				
24							
25							
26							
27							
28							
29							
30							
31		End of Borehole	9.1				
32							

Logged: ZH

Method: Hollow stem auger

Date: 17-Jul-2015

Datum: Ground elevation

Figure Number: A.06

Page: 1 of 1

Test Hole Log: MW15-03

File: 13088

Project: BRITANNIA BEACH SOUTH DEVELOPMENT

Client: TAICHENG DEVELOPMENT CORP.

Site Location: BRITANNIA BEACH, BC

GeoPacific
Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	DCPT (blows per foot) 10 20 30 40	Groundwater / Well	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)				
0		Ground Surface	0.0				
1		Sand and gravel dense cobbly SAND and GRAVEL, gravel <80 mm, brown, dry	1.5				
2		Sand and gravel dense coarse SAND and GRAVEL, trace cobbles, gravel <50 mm, greyish brown, moist	2.7				
3		Sand dense gravelly SAND, trace cobbles, gravel <50 mm, grey-brown, moist to wet	4.9				
4		Sand and gravel dense to very dense coarse SAND and GRAVEL, trace cobbles, gravel <30 mm, grey, moist to wet	9.1				
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							

Logged: ZH

Method: Hollow stem auger

Date: 17-Jul-2015

Datum: Ground elevation

Figure Number: A.07

Page: 1 of 1

2016 Monitoring Wells
MW16-01 to MW16-05

Test Hole Log: MW16-02

File: 13088

Project: South Britannia Development

Client: Taicheng Development Corporation

Site Location: South Britannia Beach, Squamish, BC



215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Groundwater / Well	Water Level Monitoring Data	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)			
0 ft 0 m		Ground Surface	5.0		Installation = 2.92m (06/05/2016)	Standpipe - concrete cap. Native sand and Gravel Fill to 5ft Bentonite Sealed from 5-10ft Screened with Sand packing 10-20ft
1		Sand and Gravel (Fill)	0.0			
2						
3			4.1			
4		Sand and Gravel (Native)	0.9			
5		Dense coarse (angular) sand - damp				
6						
7						
8						
9						
10						
11		Wet from 11ft				
12						
13						
14						
15						
16						
17						
18						
19						
20			-1.1			
21		End of Borehole	6.1			
22						
23						
24						
25						

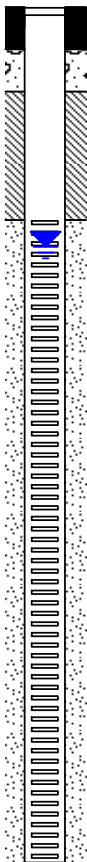
Logged: LVDM
Method: Hollow Stem Auger
Date: 6th May 2016

Datum:
Figure Number:
Page: 1 of 1

Site Location: South Britannia Beach, Squamish, BC



215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Groundwater / Well	Water Level Monitoring Data	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)			
0		Ground Surface	5.0		Installation - 1.70m (06/05/2016)	Flush Mount & Picket. Native sand and Gravel Fill to 2ft Bentonite Sealed from 2-5ft

Logged: LVDM
Method: Hollow Stem Auger
Date: 6th May 2016

Datum:
Figure Number:
Page: 1 of 1

2015 Test Hole Logs
TH15-01 to TH15-04

Test Hole Log: TH15-02 (CPT15-02)

File: 13088

Project: BRITANNIA BEACH SOUTH DEVELOPMENT

Client: TAICHENG DEVELOPMENT CORP.

Site Location: BRITANNIA BEACH, BC

GeoPacific
Consultants Ltd.

215 - 1200 West 73rd Avenue, Vancouver, BC, V6P 6G5
Tel: 604-439-0922 Fax: 604-439-9189

INFERRED PROFILE				Moisture Content (%)	DCPT (blows per foot) 10 20 30 40	Groundwater / Well	Remarks
Depth	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)				
0		Ground Surface					
1		Sand and gravel [FILL] dense cobbly SAND and GRAVEL fill, gravel <90 mm, brown, slightly moist	0.9				DCPT refusal @ 0.5 m
2		Sand and gravel dense coarse SAND and GRAVEL, gravel <60 mm, some cobbles, brown, slightly moist		2.8			
3				6.4			
4		Sand and gravel dense to very dense coarse SAND and GRAVEL, gravel <60 mm, trace cobbles, brown, moist	3.7				3.4 m estimated water table depth
5							Drilled out to 4.6 m to complete DCPT sounding
6		becomes gravelly from 6.0 m to 10.5 m					DCPT refusal @ 4.9 m
7				16.2			
8							
9				16.6			
10							
11							
12				15.2			
13							
14							
15			15.2				
		End of Borehole					

Logged: ZH

Method: Solid stem auger

Date: 16-Jul-2015

Datum: Ground elevation

Figure Number: A.02

Page: 1 of 1

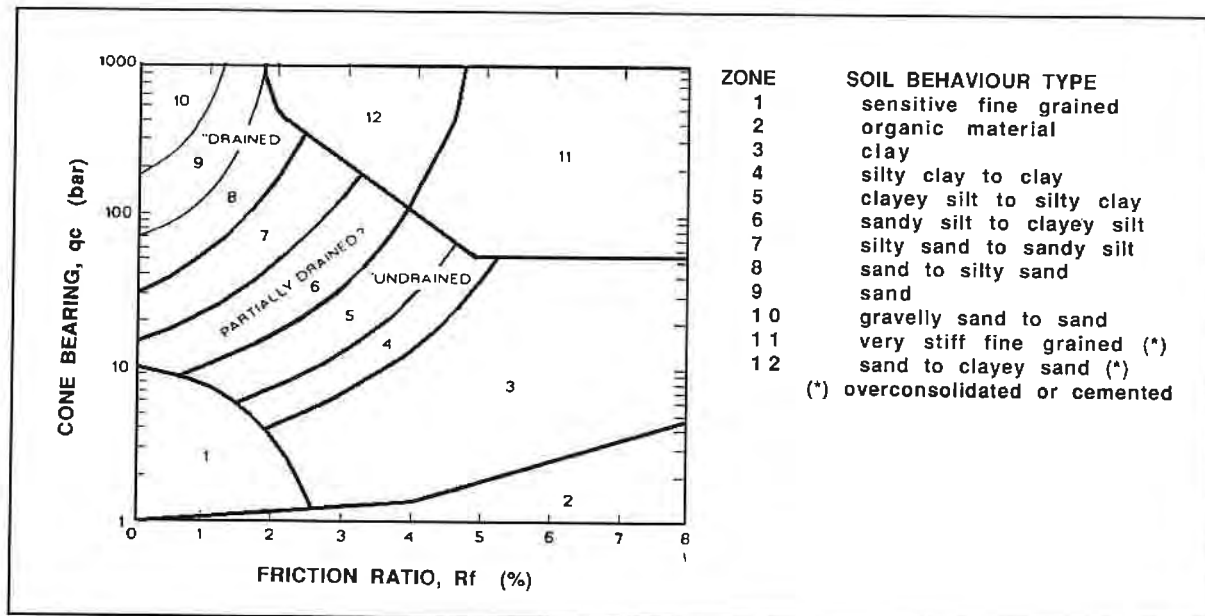
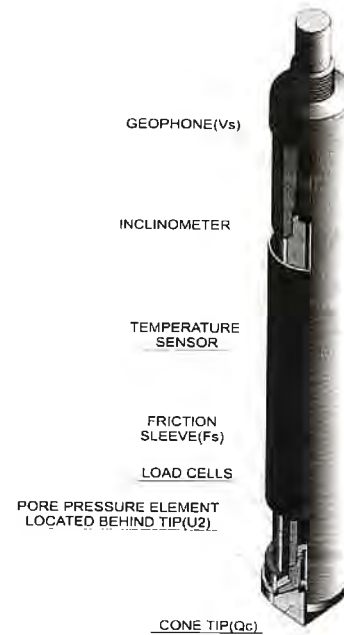
APPENDIX B - ELECTRONIC CONE PENETRATION RESULTS

The system used is owned and operated by GeoPacific and employs a 35.7 mm diameter cone that records tip resistance, sleeve friction, dynamic pore pressure, inclination and temperature at 5 cm intervals on a digital computer system. The system is a Hogentogler electronic cone system and the cone used was a 10 ton cone with pore pressure element located behind the tip and in front of the sleeve as shown on the adjacent figure.

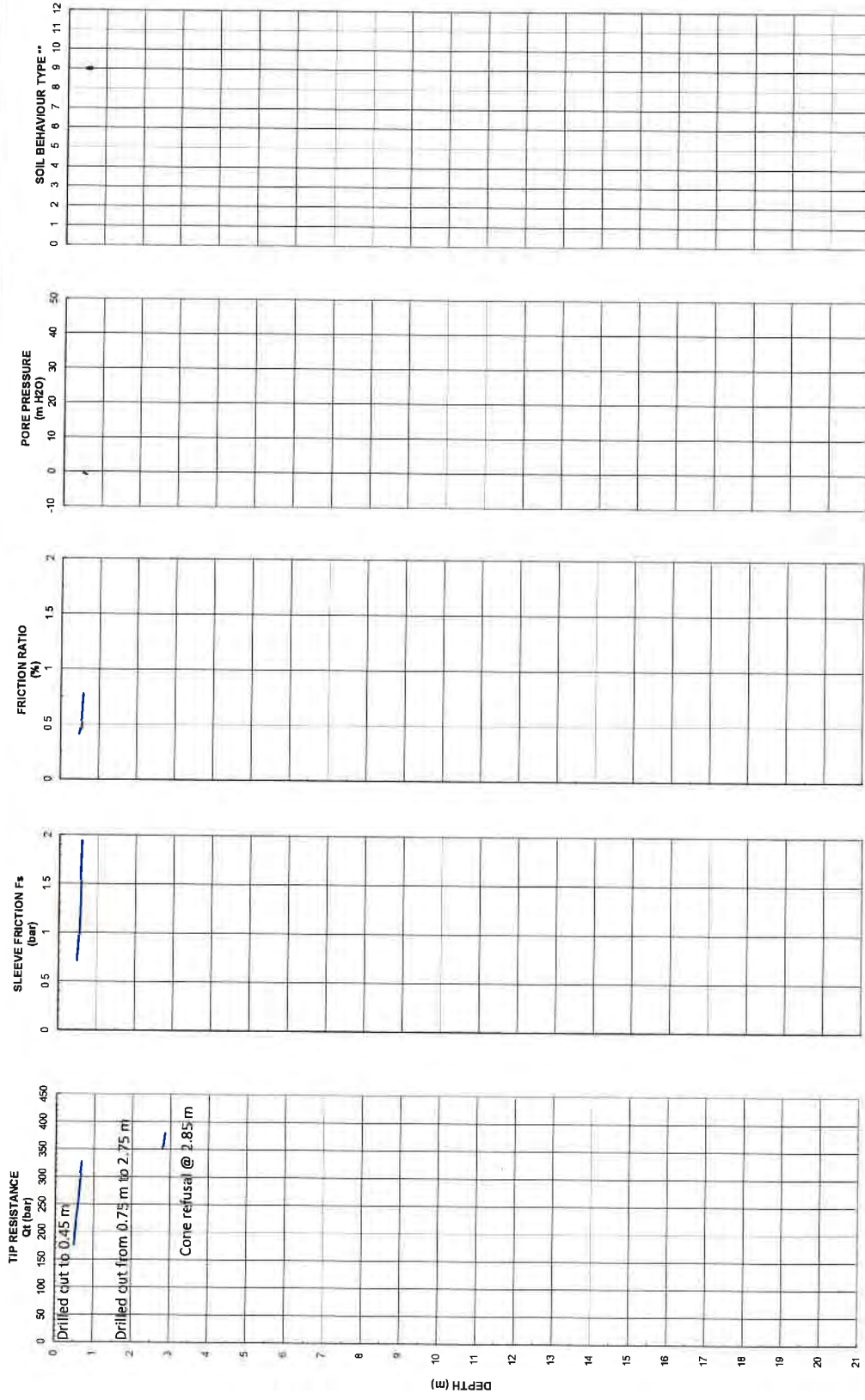
In addition to the capabilities described above, the cone can be stopped at specified depths and dissipation tests carried out. These dissipation tests can be used to determine the groundwater pressures at the specified depth. This is very useful for identifying artesian pressures within specific layers below the ground surface.

Interpretation of the cone penetration test results are carried out by computer using the interpretation chart presented below by Robertson¹. Raw data collected by the field computer includes tip resistance, sleeve friction and pore pressure. The tip resistance is corrected for water pressure and the friction ratio is calculated as the ratio of the sleeve friction on the side of the cone to the corrected tip resistance expressed as a percent. These two parameters are used to determine the soil behaviour type as shown in the chart below. The interpreted soil type may be different from other classification systems such as the Unified Soil Classification that is based upon grain size and plasticity.

Electronic Cone Penetrometer



	16-Jul-15	TAICHENG DEVELOPMENT CORPORATION BRITANNIA BEACH, BRITANNIA BEACH	GeoPacific Project #: 13088 Figure: B.02
Sounding: CPT15-02	Figure: B.02		



- ** Based on Robertson et. al 1986
- | | | |
|-----------------------------|----------------------------|----------------------------|
| 1 Sensitive Fine Grained | 7 Silty Sand to Sandy Silt | 10 Gravely Sand to Sand |
| 2 Organic Material | 8 Sand to Silty Sand | 11 Very Stiff Fine Grained |
| 3 Clay | 9 Sand | 12 Sand to Clayey Sand |
| 4 Silty Clay to Clay | | |
| 5 Clayey Silt to Silty Clay | | |
| 6 Sandy Silt to Clayey Silt | | |

APPENDIX C - INTERPRETED PARAMETERS

The following charts plot the Standard Penetration Test (SPT) values and the undrained strength of fine grained soils based upon generally accepted correlations. The methods of correlation are presented below.

STANDARD PENETRATION TEST CORRELATION

The Standard Penetration Test $N_{(60)}$ value is related to the cone tip resistance through a Q_c/N ratio that depends upon the mean grain size of the soil particles. The soil type is determined from the interpretation described in Appendix B and the data of Table C.1 below is used to calculate the value of $N_{(60)}$.

Table C.1. Tabulated $Q_c/N_{(60)}$ Ratios for Interpreted Soil Types

Soil Type	Q_c/N Ratio
Organic soil - Peat	1.0
Sensitive Fine Grained	2.0
Clay	1.0
Silty Clay to Clay	1.5
Clayey Silt to Silty Clay	2.0
Silt	2.5
Silty Sand to Sandy Silt	3.0
Clean Sand to Silty Sand	4.0
Clean Sand	5.0
Gravelly Sand to Sand	6.0
Very Stiff Fine Grained	1.0
Sand to Clayey Sand	2.0

The $Q_c/N_{(60)}$ ratio is based upon the published work of Robertson (1985)². The values of N are corrected for overburden pressure in accordance with the correction suggested by Liao and Whitman using a factor of 0.5. Where the correction is of the form:

$$N_1 = \sigma^{0.5} * N$$

All calculations are carried out by computer using the software program CPTint.exe developed by UBC Civil Engineering Department. The results of the interpretation are presented on the following Figures.

UNDRAINED SHEAR STRENGTH CORRELATION

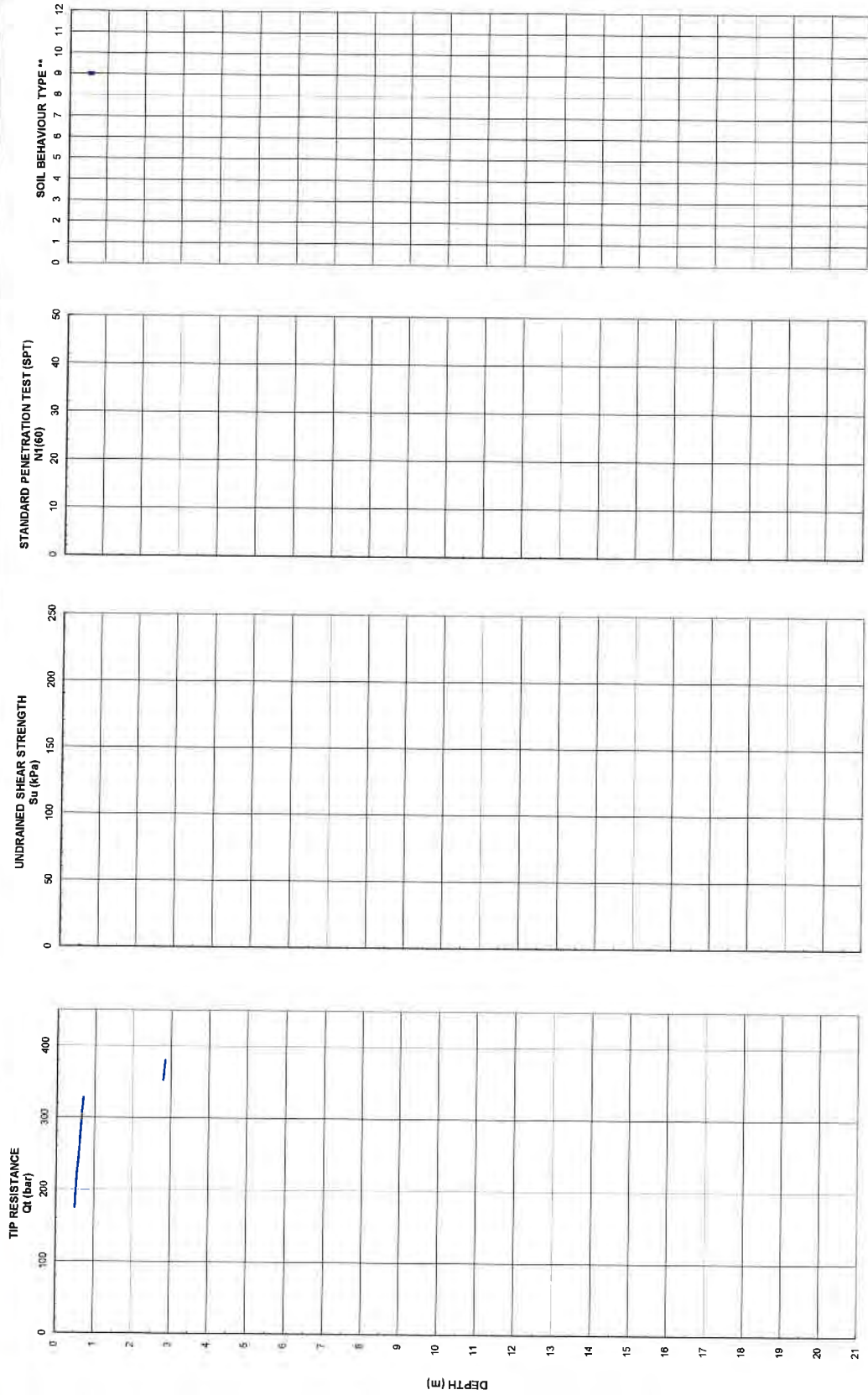
It is generally accepted that there is a correlation between undrained shear strength of clay and the tip resistance as determined from the cone penetration testing. Generally the correlation is of the form:

$$S_u = \frac{(q_c - \sigma_v)}{N_k}$$

where q_c = cone tip resistance, σ = in situ total stress, N_k = cone constant

The undrained shear strength of the clay has been calculated using the cone tip resistance and an N_k factor of 12.5. All calculations have been carried out automatically using the program CPTint.exe. The results are presented on the Figures following.

	16-Jul-15	TAICHENG DEVELOPMENT CORPORATION BRITANNIA BEACH, BRITANNIA BEACH	GeoPacific Project #: 13088 Figure: C.02
	Sounding: CPT15-02		



Nkt=12.5

** Based on Robertson et. al 1986

- | | | | |
|--------------------------|-----------------------------|----------------------------|----------------------------|
| 1 Sensitive Fine Grained | 4 Silty Clay to Clay | 7 Silty Sand to Sandy Silt | 10 Gravelly Sand to Sand |
| 2 Organic Material | 5 Clayey Silt to Silty Clay | 8 Sand to Silty Sand | 11 Very Stiff Fine Grained |
| 3 Clay | 6 Sandy Silt to Clayey Silt | 9 Sand | 12 Sand to Clayey Sand |

APPENDIX D - LIQUEFACTION ANALYSIS

Assessment of the liquefaction potential of the ground has been determined by the Cone Penetration Test (CPT). The method of analysis is presented in the following sections.

FACTOR OF SAFETY AGAINST LIQUEFACTION

The factor of safety against liquefaction calculated here is the ratio of the cyclic resistance of the soil (CRR) to the cyclic stresses induced by the design earthquake (CSR). Where the ratio of CRR/CSR is greater than unity the soils ability to resist cyclic stresses is greater than the cyclic stresses induced by the earthquake and liquefaction will be unlikely. Where the CRR/CSR is less than unity then liquefaction could occur. This ratio is presented as the FOS Against Liquefaction on the following charts. Calculation of the factor of safety is based on Seed (1984)⁶ that determines the CRR from the normalized Standard Penetration Test $N_{1(60)}$ value and the percentage silt content. The value of the cyclic stress ratio has been calculated based on peak horizontal ground acceleration of 0.35g during the 2012 British Columbia Building Code design earthquake, which is consistent with our experience in this area.

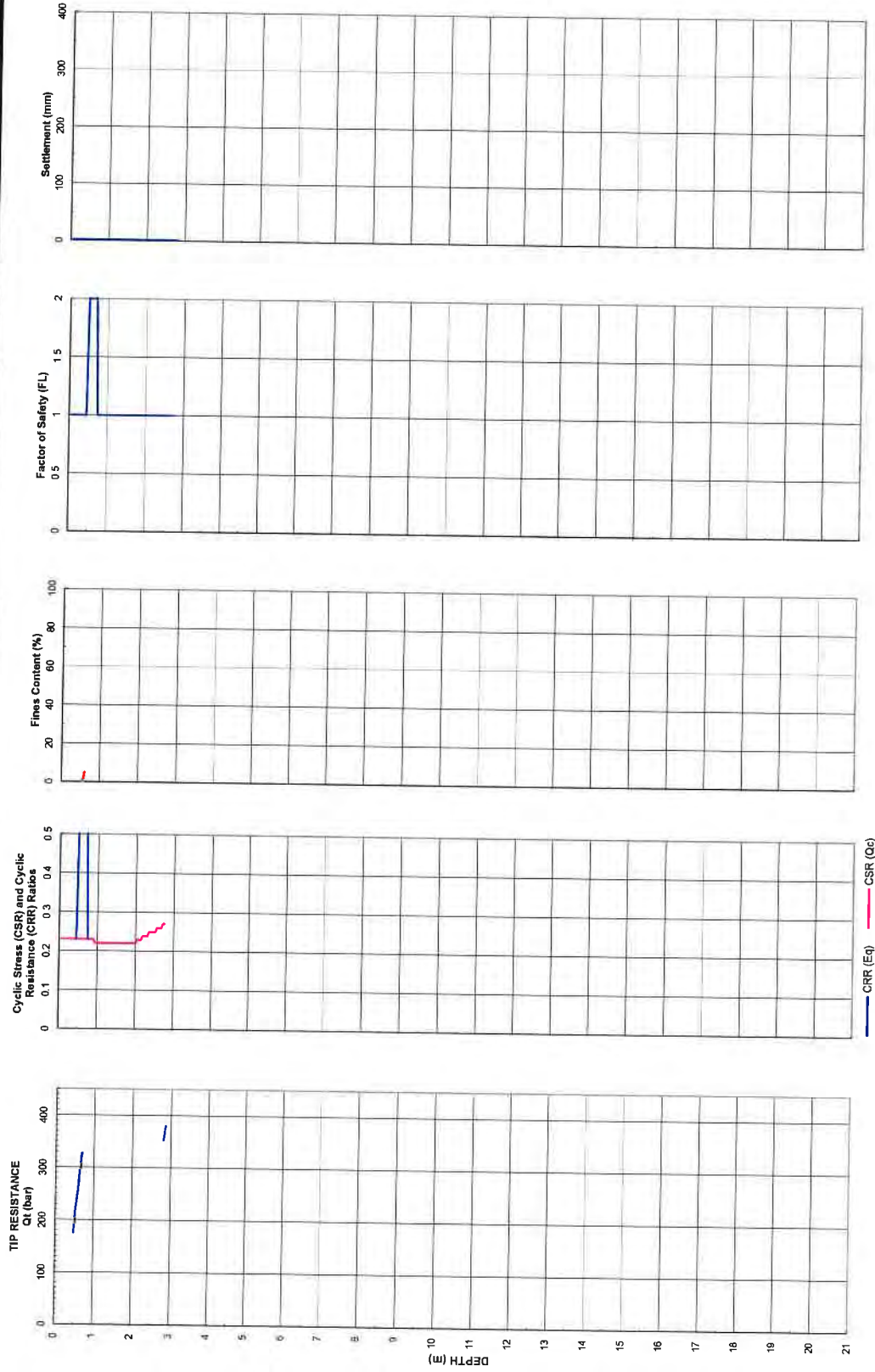
SEISMIC INDUCED SETTLEMENT

In the event of a significant earthquake, settlement of the ground surface could occur as a result of densification of the looser soil layers as a result of liquefaction or due to the expulsion of sand in the form of sand dykes or sills from beneath the site. Tokimatsu and Seed (1987)⁷ suggest a method of analysis for estimating vertical settlements as a result of earthquake induced accelerations. In this method the normalized standard penetration blow counts ($N_{1(60)}$) is compared with the cyclic stress ratio for the induced earthquake to determine the volumetric strain resulting from the earthquake shaking. The volumetric strain is assumed to result in only vertical settlement. The vertical settlement is summed for each depth at which settlement is predicted to occur and accumulated from the bottom of the test hole. The results are presented on the following charts labelled as Settlement.

⁶ Seed, H.B., K. Tokimatsu, L.F. Harder, and R.M. Chung, 1984, "The Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations", Report No. UBC/EERC-84/15, Earthquake Engineering Research Center, University of California, Berkeley.

⁷ Tokimatsu, K.A.M. and Seed, H.B., 1987. "Evaluation of Settlement in Sands Due to Earthquake Shaking", Journal of Geotechnical Engineering, ASCE, Vol. 113, No. 8, pp. 861-878

	16-Jul-15	TAICHENG DEVELOPMENT CORPORATION	GeoPacific Project #: 13088
	Sounding: CPT15-02	BRITANNIA BEACH, BRITANNIA BEACH	Figure: D.02



Liquefaction Interpretation ran with PGA = 0.35g

8 ARCHAEOLOGICAL

This section contains two documents: the Architectural Overview Assessment and the subsequent Archaeological Site Inventory and Impact Assessment prepare by AMEC. The assessments conclude that “No archaeological resources or sites were identified during the course of the Architectural Impact Assessment”. They do recommend that “Taicheng work with local stakeholders to preserve or record elements of local mining history which will be impacted by development”. This recommendation aligns with the social and marketing interests of the development team and will be pursued.

8.1 2012 11 00 Archaeological Overview Assessment (AMEC)

Taicheng Development Corporation South Britannia Project Britannia Beach, BC

Archaeological Overview Assessment

Submitted to:

Taicheng Development Corporation
West Vancouver, BC

Submitted by:

AMEC Environment & Infrastructure
a division of AMEC Americas Limited
Burnaby, BC

AMEC Project No. VE12405

Revision Log

Version	Date Issued	Description
1.0	31 October 2012	Draft report to Taicheng Development Corporation for review
1.1	1 November 2012	Comments back from Folio Hotel and Resort Architecture; report revised
1.2	9 November 2012	Final report to Taicheng Development Corporations (via Folio Hotel and Resort Architecture)

IMPORTANT NOTICE

This report was prepared exclusively for Taicheng Development Corporation by AMEC Environment & Infrastructure, a wholly owned subsidiary of AMEC Americas Limited. The quality of information, conclusions and estimates contained herein are consistent with the level of effort involved in AMEC services and based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used only by Taicheng Development Corporation, subject to the terms and conditions of its contract with AMEC. Any use of, or reliance on, this report by any third party is at that party's sole risk.

Abbreviations and Acronyms

Abbreviation	Definition
AOA	Archaeological Overview Assessment
AMEC	AMEC Environment & Infrastructure
BC	British Columbia
CMT	Culturally Modified Tree
ha	hectare
km	kilometre
m	metre

Executive Summary

An archaeological overview assessment was carried out by AMEC Environment & Infrastructure for the South Britannia Project, immediately south of Britannia Beach, on the east side of Howe Sound, B.C., for Taicheng Development Corporation.

The assessment concluded that there are no known archaeological sites on the subject properties. However, based on the results of the archaeological overview assessment there are properties within the South Britannia Project that have the potential for archaeological sites. In addition, information on cultural heritage resources (traditional places and land use) is available for several locations along the shoreline of Howe Sound within the development properties and remnants of the historic community of Minaty Bay may be present on the subject properties. Therefore, there is potential for developments within some of the subject properties to affect as yet undiscovered buried archaeological remains. To address these potential effects, it is recommended that:

- Subject properties assessed as having low-to-moderate or moderate-to-high archaeological potential: District Lot 1889, REM District Lot 2009, District Lot 1970 Group 1, District Lot 5208, District Lot 5210, District Lot 2617, District Lot 3717, District Lot 1583, District Lot 4005, District Lot 4008, District Lot 4012, and District Lot 2933; be subject to an Archaeological Impact Assessment (AIA) prior to development of these lots.
- No AIA is recommended for subject properties assessed as having low archaeological potential: East ½ District Lot 1981, Lot A Except: Part Dedicated Road On Plan BCP25632 – District Lot 2001 & 7053, Parcel 1 (Reference Plan 4878) of District Lot 2001, Lot A Except: part Dedicated Road on Plan BCP286651, District Lots 1583, 2001, 7934 Plan 21567, Parcel 1 (Reference Plan 4878) of District Lot 1583, Except Part On Plan 21576.

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1. Introduction

This report describes the results of an archaeological overview assessment (AOA) undertaken in August – November 2012 by AMEC Environment & Infrastructure (AMEC) at the request of Folio Hotel And Resort Architecture on behalf of the proponent, Taicheng Development Corporation, for 16 properties (collectively known as the South Britannia Project) immediately south of Britannia Beach, British Columbia (BC) (Figures 1 & 2; Table 1).

The objective of the assessment was to determine the potential effects of development within the subject properties on cultural heritage resources and determine if follow-up actions are required. Specific impacts from development activities were not assessed, as there are no detailed development plans currently available.

The 16 subject properties cover a total area of approximately 237.5 hectares (ha) south of Britannia Beach along the east shore of Howe Sound and include the abandoned community of Minaty Bay. The South Britannia Project extends from Britannia Beach south along the east shore of Howe Sound for approximately 2.7 kilometres (km) and extends inland for approximately 1.5 km (Figures 2 & 3). Currently no existing developments are situated on the South Britannia Properties though portions of the subject properties have been affected by industrial activities (aggregate mining) and residential settlement.

Table 1. South Britannia Project Properites

Legal Description	PID/PIN	Area (ha)
District Lot 1889 Group 1 New Westminster District	010-025-782	2.6
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	2.3
REM District Lot 4009	010-025-634	5.5
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	4.7
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	18.7
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	4.2
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	15.3

Table 1. South Britannia Project Properites

Legal Description	PID/PIN	Area (ha)
District Lot 5208, Group 1, New Westminster District	015-825-663	9.8
District Lot 5210, Group 1, New Westminster District	015-825-680	5.6
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	1.3
District Lot 2617 Group 1 New Westminster District	010-025-677	14.8
District Lot 3717	015-896-170	18.2
District Lot 1583 Group 1 New Westminster District	010-026-151	49.1
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	22.8
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	20.9
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on Plan LMP17053	010-025-774	20.8
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	20.9

2. Protection of Archaeological Resources in British Columbia

In British Columbia, most archaeological sites are attributable to settlement and resource use by First Nations' people, and if they pre-date AD 1846, are automatically protected from damage, desecration, alteration, or excavation by the *Heritage Conservation Act* (RSBC 1996, Chap. 187). Some sites are protected through designation as "Provincial Heritage Sites" under Section 9 of the *Heritage Conservation Act (HCA)*, or through automatic protection under Section 13 by virtue of particular historic or archaeological values. Sites automatically protected under Section 13 include:

- archaeological sites occupied or used before AD 1846;
- rock art with historical or archaeological value;
- burial places with historical or archaeological value;

- heritage shipwrecks or aircraft wrecks; and
- archaeological sites of unknown age, with a reasonable possibility of having been occupied or used before AD 1846.

Protected sites may be located on public or private land, and may not be altered (changed in any manner) without a permit issued under Sections 12 or 14 of the *HCA*. Additionally, archaeological sites of Aboriginal origin may be subject to interpretations of the Supreme Court of Canada decision in *Delgamuukw* vs. British Columbia (1997), regarding the fiduciary responsibility of provincial governments for protecting cultural heritage.

3. Objectives

To assist with the management of archaeological sites, the Archaeology Branch issued the *British Columbia Archaeological Impact Assessment Guidelines* (Archaeology Branch 1998). These *Guidelines* identify several kinds of archaeological assessments that may be undertaken in response to proposed developments, with the kind of assessment dependent on the stage of development design and the types of archaeological information required. The purpose of an overview assessment, based on the *Guidelines*, is to:

- identify lands that have the potential to contain archaeological resources, within the subject properties;
- identify potential conflicts between archaeological resources and the proposed development; and
- recommend additional studies or other measures to protect archaeological resources, if required.

Archaeological potential is defined as the capability of a landscape (or landform) for having supported the kinds of traditional activities in the past which would have resulted in the formation (and preservation) of archaeological remains. Potential ratings do not predict the probability of sites, but identify lands that should be examined by archaeologists in advance of development projects. Some kinds of traditional activities did not result in the formation of physical remains, and such activities usually cannot be considered in the context of an assessment of archaeological potential.

No heritage inspection permit was required for the assessment of archaeological resources for the South Britannia Project. Additional archaeological studies such as an archaeological impact assessment will require a Heritage Inspection Permit as defined in the *Heritage Conservation Act* (RSBC 1996, Chap. 187).

4. Archaeological Potential Assessment

The assessment of archaeological resource potential was based upon a consideration of the locations of documented archaeological sites, ethnographic and historic information, and topographical and biophysical characteristics that favourably influence the distribution of

archaeological sites. Because archaeological site locations are often correlated with particular micro-environmental attributes, the presence or absence of these variables can be used to identify lands with greater or lesser archaeological potential. The environmental variables considered for this overview study included:

- modern vegetation/forest cover;
- proximity to documented archaeological resources;
- presence of traditional resources (e.g., stone suitable for flaking, economic plants);
- proximity to aquatic features (e.g., streams, wetlands, open water);
- aspect (i.e., wind or solar exposure based on direction of slope);
- presence of fine-textured sediments and soil drainage quality;
- current understanding of traditional resource use and settlement by Aboriginal people;
- environmental settings of documented archaeological sites in the area; and
- integrity of the modern landscape as a reflection of historic land use practices.

5. Methods

The archaeological overview assessment included:

- background research, involving a review of regional historic, ethnographic, and archaeological literature describing research in the Howe Sound - Squamish area generally and Britannia Beach locality specifically;
- A search of the Provincial Heritage Register maintained by the Archaeology Branch of the Ministry of Forests, Lands and Natural Resource Operations, for recorded archaeological and historical sites in the vicinity of the development properties;
- A review of historic aerial photos of the immediate area obtained from the Department of Geography at the University of British Columbia, for information on historic land use and landscape integrity;
- A review of biological, topographical, and hydrological information for the subject properties provided by proponent;
- A brief field inspection of the subject properties, from Highway #99 and along the shoreline, to assess landscape integrity and potential for archaeological sites; this inspection was carried out on October 25, 2012; and
- Preparing this report on the results of the assessment.

The background research involved a review of archaeological reports and other literature in the AMEC library. Sources consulted are provided in Section 10 (References Cited). In addition, the *Archaeological Overview Assessment of the Squamish Forest District* (Millennia Research 1997) was reviewed online via RAAD. The background review sought general information on pre-Contact archaeology, traditional land use practices by First Nations' people in this area, and historic land-use and occupancy of the Britannia Beach locality.

In addition, a brief field reconnaissance was undertaken to take contextual photographs of the subject properties and evaluate the potential for archaeological sites based on the biophysical characteristics of the proposed development area visible from Highway #99. The reconnaissance took place on October 25, 2012, and was conducted by D. Geordie Howe (AMEC). The subject properties were visually inspected from Highway #99 for terrain features, drainage and disturbance factors.

6. Archaeological Overview Background Results

6.1 Study Area and Biophysical Setting

The proposed South Britannia Development Project is located on the east side of Howe Sound in the Southern Pacific Ranges Ecoregion, Pacific Ranges Ecoregion, of the Coast and Mountains Ecoprovince (Demarchi 2011). The topography of the project area is moderately to steeply sloping and rises from Howe Sound to approximately 365 m above sea level along its eastern boundary. Locations within the development properties that are relatively flat are the result of historic land altering activities. Two creeks, Thistle Creek and Daisy Creek, flow west through the development draining into Howe Sound. Another drainage, South Creek, is located immediately south of the south boundary of the development.

No archaeological sites are registered within the Provincial Heritage Register for the subject properties. Lands within the subject properties have not been subject to archaeological study previously and little archaeological work adjacent to the project area has occurred.

6.2 Modern Vegetation

The Project area is situated within the Submaritime variant, Very Wet Maritime Subzone of the Coastal Western Hemlock Zone (CWHvm1) (Ministry of Forests Research Branch 1994; Pojar et al. 1991). This zone is distinguished by the presence of low-lying moist areas interspersed between high elevation, well-drained, dry settings. The CWHvm1 subzone is characteristic of windward montane slopes up to 650 m asl, and has cool summers and mild wet winters with relatively little snow. Zonal sites are typically dominated by western hemlock and true fir (*Abies* spp.) with western redcedar (Green and Klinka 1994), while red alder is dominant on recently-disturbed sites.

Historic mineral exploration and mining, aggregate extraction, railroad and highway development, residential development, and timber harvesting within the South Britannia subject properties have altered natural vegetation patterns at this locality. Historic land altering activities have occurred in the project locality since the early 1900s and has been extensive. Natural regeneration consists mainly of western hemlock, western redcedar, and red alder with an understory comprised of salal, huckleberry, and salmonberry.

6.3 Geology

The Project area is situated in coastal mountainous terrain comprised of rocks attributable to the Coast Plutonic Complex (Roddick et al. 1979). The geology of the northern portion of the development area is typified by the Britannia Formation (slate) or basic, fragmental and massive volcanic or Jurassic porphyritic quartz diorite of the Coast Range Batholithic rocks for the southern portion (James 1929; Journeay and Monger 1994). Lower elevations south from Britannia Beach to Daisy Creek consist of recent alluvium and glacial drift, glacial till, and colluvium (Armstrong 1990; Mathews 1975). Quartz diorite is a coarsely-textured rock that would not have been an attractive lithic raw material for pre-Contact stone-tool makers. Although alluvial sediments are present in the low-elevation, the majority of lands affected by the Project display an upper organic layer comprised of acidic humus which is often present to a depth of 40 cm depth below surface, overlying either gravels or bedrock. The acidic sediments are often poorly drained or moist, and are not ideal for preserving organic archaeological remains (e.g., bone, wood).

6.4 Ethnographic Background

From European contact to the present, the South Britannia Project locality has been the traditional territory of the Squamish Nation (or *skxwú'mish7úlh* in their own language) and the Tsleil-Waututh Nation, who speak different, but related languages that make up the Central Coast Salish linguistic family.

Suttles (1990) provides the most recent summary of Coast Salish culture in the Central Strait of Georgia region. Barnett (1955), Hill-Tout (1978), and Suttles (1987) are additional sources that are frequently cited.

Traditional Coast Salish society was characterized by a semi-sedentary lifestyle dependent upon fishing, gathering, and hunting for subsistence. The society was stratified and three classes of people were usually present; a large upper class, a smaller lower class, and a very small class of slaves. The primary socio-economic unit of Coast Salish society was the house group, each consisting of one or more extended families occupying a single plank house. Residence was usually with the man's family ("patrilocal"), while descent was reckoned bilaterally. Each house group owned its house, rights to resource harvesting sites, and ritual property including ancestral names, legends, songs and dances. Rights to these properties were acquired through inheritance and were normally held by the most important members of the household.

Coast Salish villages were usually comprised of one or more houses. Leadership was provided by a "council" of *siyam*, made up of the most respected family heads in the village. The prestige of the *siyam* was based on inherited social position and demonstrated abilities of leadership. Each village was linked through ties of marriage and kinship with other villages to form a social network without distinct boundaries. Marriages arranged between socially equal families in different villages helped to establish a co-operative system for resource procurement, including shared access to specific resource locations and shared labour.

Traditional population and settlement were contingent upon the availability and distribution of seasonally available food resources. These resources would have included anadromous (i.e., sea-run) fish (including coho and chum salmon, steelhead, and minor amounts of coastal cutthroat trout) in the permanent streams emptying into Howe Sound. Herring were taken for their roe, and rockfish, lingcod, and bottom fish such as flatfishes were also of considerable importance to the Coast Salish people. Intertidal marine resources such as clams and mussels were an important part of the diet, and the discarded shells of these creatures are among the principal constituents of coastal archaeological sites today.

Sea mammals were taken by specially-trained hunters, and included harbour porpoises, hair and harbour seals, and sea lions; the Pasley Island group south of Keats Island was especially renowned for sea lion hunting. Land mammals such as deer, elk, and bears were hunted, and mountain goats were a highly-prized specialty of Squamish hunters. Small game and fur-bearing mammals, including beaver, muskrat, otters, and mink, were hunted or trapped from aquatic settings, while other species like marmots were taken in montane, parkland environments. The broad foreshore on the western side of lower Howe Sound would have been important habitat for waterfowl such as ducks and geese.

Numerous plant resources were utilized, including (i) red and yellow cedar trees for timber and bark, and other tree species for firewood and medicinal purposes; (ii) terrestrial plants such as chokecherries, huckleberries, blueberries, and deerberries, were used for food; (iii) aquatic plants such as cranberries and wapato, were also used for food, and cat-tails, for mat-weaving; and (iv) medicinal and edible-root plants in forested and wetland environments. Turner (1975, 1979) provides detailed descriptions of the traditional uses of plants by First Nations' peoples in this region, while Bouchard and Kennedy (1976a, 1976b) provide specific information about utilization of terrestrial and marine food resources by Squamish people.

In addition to economic pursuits, individuals pursued spirit quests throughout their communities' territory, to acquire powerful or helpful spirits. Frequently overlooked by archaeologists, spirit-quest sites leave little trace of their presence, in comparison to resource exploitation sites like shellfish harvesting camps or forest utilization sites.

It is important to note that not all aspects of traditional First Nations' cultures are recorded in the anthropological and ethnohistoric literature. Additional knowledge of traditional culture and lifeways still exists in many contemporary First Nations' communities. Furthermore, Aboriginal societies underwent significant changes as a result of their contact with Europeans, and some cultural aspects reported in the literature may not accurately reflect that culture prior to contact.

6.5 Archaeological Background

An archaeological site is a location containing physical evidence of past human activity in the form of artifacts or cultural features. Artifacts are human-made or modified objects, such as stone and bone tools, ceremonial objects, and fire-altered rocks. Cultural features are

modifications to the landscape or objects which cannot be moved without altering them, such as burials, culturally modified trees (CMTs), rock art, cabins and structures, trails and roads, and the remains of industrial activities.

The age at which artifacts and features become an “archaeological site” is arbitrary, and can be defined according to particular research or management objectives. Those sites that clearly post-date the arrival of Europeans or are documented by written records are called “historic archaeological sites”.

Archaeological sites are numbered according to the Borden Site Designation Scheme (Borden 1952) used throughout Canada. This scheme is based on the maps of the National Topographic System and uses latitude and longitude to indicate a site location within 10'. The four alternating upper and lower case letters (e.g., DjRt) designate a unique 10' latitude by 10' longitude “Borden Unit.” Sites are numbered sequentially within a Borden Unit based (usually) on their date of discovery (i.e., DjRt-2 would be the second site recorded in the DjRt Borden Unit).

General syntheses of Pacific Northwest archaeology in British Columbia include Ames and Mashner (1999), Borden (1970, 1975), Carlson (1983), Fladmark (1982), Matson and Coupland (1995) and Mitchell (1990). Regional archaeological survey reports reviewed for this AOA include Arcas (1995, 1998, 2000, 2002, 2003), Bussey (1982, 1990), May and Lucs (1976), and Winram (1975). Archaeological excavation reports include Arcas (1995) and Reimer (2011). A general archaeological overview for the Squamish Forest District was also reviewed for this study (Millennia Research 1997. Historic sources included Armitage (1997) and Town (2010).

6.5.1 Archaeological Site Types

An archaeological site is defined as a location containing physical evidence of past human activity in the form of artifacts or features. Typical sites in the Project locality and Howe Sound region can include one or more of the following:

- **Middens**, most often situated near marine shorelines, are deposits of mollusc shell, fire-altered rocks, charcoal, and faunal remains (butchered mammal, bird, and fish bones), representing the locations of village sites or resource harvesting camps. Middens in the upper reach of Howe Sound and inland along major rivers have a lower frequency of shellfish remains in a matrix of black anthropogenic loam.
- **Artifact scatters** are comprised of clusters of (usually) stone artifacts, including expedient or formed tools and the waste products of tool manufacture (debitage). Most artifact scatters represent transitory use of the landscape, and are often associated with the exploitation of particular resources.
- **Burial places** are locations where First Nation communities interred their dead, commonly within village middens, but also throughout their territories for individuals who expired away from permanent village sites. In more recent times, the dead were interred above ground at special locations such as bedrock overhangs or earthen mounds.

- **Rock art** sites are locations of non-portable Aboriginal art, either painted (pictographs) or pecked into stone (petroglyphs). Rock art sites are typically found on bedrock outcrops or large boulders, usually along steep shorelines or at locations of strong spiritual significance to First Nations people.
- **Fish traps/weirs** are found on river bars or in creeks and streams supporting runs of sea-run salmonids and other fishes.
- **Wetsites** are found in permanently saturated or waterlogged locations, which allow preservation of organic materials (including wooden artifacts) that would otherwise decay rapidly.
- **Forest utilization sites** consist of one or more culturally modified trees (CMTs), which are trees that have been intentionally altered by First Nations' people. Coastal CMTs are of two basic types: bark-stripped trees and aboriginally-logged trees (Archaeology Branch 2001). The former result from bark collecting, whereas the latter were produced during timber procurement. Aboriginally-logged trees can be divided into different types, including: logged stumps of various kinds, standing test hole trees, plank-stripped trees, plank-stripped logs, and canoe blanks. The majority of CMTs will occur within 500 m of the coastline or a major watercourse, on well-drained, level ground to hillsides, and in old-growth forest stands containing straight-grained cedar trees.
- **Historic Sites:** Post-Contact remains, including artifacts, structures, and features associated with Euro-Canadian or Asian-Canadian settlement and land use.

6.5.2 Overview of Regional Prehistory

The development locality is situated within the Northwest Coast Culture Area, which encompasses the west coast of North America from southeastern Alaska to southern Oregon (Ames and Maschner 1999; Matson and Coupland 1995). Archaeologists have defined a sequence of pre-Contact cultures in this area, based on site investigations in Howe Sound and Burrard Inlet, the Fraser Valley, the east coast of Vancouver Island and southern Gulf Islands, and in Whatcom County and on the San Juan Islands in Washington State. Recent summaries of regional prehistory are Ames and Maschner (1999), Matson and Coupland (1995), Mitchell (1990), and Moss (2011). Researchers have noted continuities in the reliance on marine resources, woodworking technology, ceremonialism, status, and the acquisition of wealth. Based on diagnostic artifact types and technologies, as well as inferred economic, social and other cultural traits, five distinct cultural periods are identified:

- Lithic or Old Cordilleran (ca. 8,500 - 5,000 years Before Present or B.P.);
- Charles (ca. 6,500 - 3,200 B.P.);
- Locarno Beach (ca. 3,200 - 2,400 B.P.);
- Marpole (ca. 2,400 - 1,600 B.P.); and
- Strait of Georgia (ca. 1,600 - 200 B.P.).

6.5.2.1 Archaeological Research near Squamish

Parts of the Howe Sound and the Squamish River valley have been inspected by archaeologists since the early 20th century. The earliest archaeological investigations near Squamish were initiated at the turn of the century by Charles Hill-Tout (1978); later, Harlan Smith (1907) investigated a pictograph at Furry Creek. Since that time, numerous archaeological surveys have been conducted in the area, often in the form of assessments for proposed forestry, road, residential-commercial, and other developments (e.g., Arcas Consulting Archeologists 1998, 2000, 2002, 2003; Golder Associates (2004); May and Lucs 1976; Quirolo and Ham 1990; Reimer 2011; Winram 1975). Of particular note are several studies for BC Hydro transmission lines to the Cheekye substation that examined several route options in the study area (Bussey 1982, 1990). These studies and others have resulted in the identification of approximately 25 archaeological sites in the northern Howe Sound region.

The distribution and frequency of known sites is not necessarily believed to be representative of the archaeological resources in the area as a whole. Archaeological inventories and impact assessment surveys have, by and large, been restricted to development locations, and large landscape units have not been examined systematically.

6.5.2.2 Archaeological Sites near the South Britannia Project

At the time this AOA was undertaken, no archaeological sites had been recorded within the proposed development properties. A search of the Provincial Heritage Register database indicated that seven documented archaeological sites are situated within 8 km of the Project (Figure 1):

- the nearest recorded archaeological site to the subject properties is DjRt-2, a pictograph site, located approximately 2.7 km south at Furry Creek
- the next nearest site is DjRt-10, another pictograph site near Browning Lake approximately 3.4 km north

Additional archaeological sites within 10 km of the development include:

- DjRt-7 (a lithic scatter on the beach) approximately 5.3 km north-northwest
- DjRt-5, a lithic scatter on Defense Islands 6.6 km south-southwest
- DjRt-6, a midden site at Potlatch Creek, located 8.6 km southwest; respectively of the development properties.
- DkRs-6 is situated near the mouth of the Stawamus River on Mamquam Blind Channel, approximately 9.0 km north-northeast of the development. This site is the traditional village of *Stawamus* and has been subject to archaeological investigations for the Squamish Nation (Arcas 1995)

- DkRs-10 is located approximately 9.1 km northeast of the Project within the Olesen Creek drainage, and is a rock shelter/lithic scatter situated in an alpine setting.

The closest archaeological sites north of the Project are situated approximately 3.4 km north-northwest of the Mamquam River (DkRs-9, isolated find) and on the west side of the Squamish River, opposite the mouth of the Mamquam River (DkRs-5, historic cemetery). Additional archaeological sites are present along the banks of the Squamish and Cheakamus River and south along the shore of Howe Sound. The majority of sites located within 8 km of the proposed development are located in one of two environmental settings: 1) low-elevation locations along Howe Sound and the Squamish River; or 2) in the subalpine zone in the local mountains.

One historic site, the Britannia Beach National Historic Site (DjRt-11 – Britannia Mines Concentrator), is situated immediately north of the northern boundary of the subject property and was designated a National Historic Site in 1987.

7. Archaeological Overview Assessment Results

The archaeological overview assessment of the subject properties observed that the terrain within the subject properties is generally well-drained, reaching their highest elevation along the eastern and southern margins, with relatively level or undulating terrain backed by moderate to steeply sloping terrain. Vegetation varies from sparse in relatively open gravel fields to dense re-growth consisting of western hemlock, western redcedar, and some Douglas-fir. Two southeast-northwest trending creeks (Thistle and Daisy) run through the central portion of the subject properties, and based on an historical aerial photo review it appears that they were rechanneled during the operations of the various aggregate pits (Figure 3; Table 2).

Based on the historic airphoto review, extensive deforestation or ground altering activities have occurred within the majority of the properties: However, some properties adjacent to or in proximity to Howe Sound and/or Thistle and Daisy Creeks, with minimum to moderate historic disturbance, are assessed as having low-to-moderate or moderate-to-high archaeological potential (Figures 2 & 3; Table 2).

Given the extent of previous disturbance observed during the historic airphoto review, the possibility of as-yet undiscovered archaeological sites is considered to be low within the remaining lots of the Britannia South properties.

Second or third growth western redcedar is present within the forested portions of the subject properties. Western redcedar was an important source of bark and wood for First Nations people in the past, and cedar bark continues to be collected for ritual and other purposes. Western redcedar exhibiting physical modifications such as scars from bark-stripping, are called CMTs. Based on the forest clearing observed within the subject properties during the review of historic airphotos and the site visit, it is unlikely that CMTs would be present within the subject properties, except for the point of land within District Lot 2925 extending into Howe Sound, which appears to still retain large trees.

Historic aerial photo review: A review of historic aerial photographs, obtained from the Geographic Information Centre at the University of British Columbia, was undertaken to assess the intensity of past land-altering activities within the subject properties. Various land-altering activities have occurred within the South Britannia Project area over the last 106 years including: the development and operations of the Britannia Mine, aggregate extraction operations, construction of the Pacific Great Eastern Railway (subsequently BC Rail and now CN Rail); construction of residential and mining buildings including the community of Minaty Bay; road building, including the Sea To Sky Highway (Highway #99), and intensive logging and vegetation clearing associated with the above activities. For a detailed review of land-altering activities observed during the historic aerial review see *Appendix A*.

First Nation traditional use: The development property lies within the traditional territory of the Squamish Nation and the Tsleil-Waututh Nation. The Squamish Nation has reserves around Howe Sound and in the Squamish River valley and the Tsleil-Waututh Nation reserves are in Burrard Inlet and Indian Arm.

An early source for Squamish land use for the study area is *Conversations With Khahtsahlano 1932 -1954* by Major J.S. Matthews (1955). During those years, Matthews, who was archivist for the City of Vancouver, conducted extensive interviews with Chief Khatsahlano. The beach within the subject properties is referred to as *Huey-qwah-lahun* by Chief Khahtsahlano, and he goes on to add that it was:

“A good, sheltered bay with gravel beach and creek, a mile south of Britannia Beach. A dozen or more small cottages—shacks—ranged in a row along the shore between an extensive grove of alders and the water. The exact location of *Huey-qwah-lahun* (meaning: “A lot of little trout”) is where the creek empties into the sea. Immediately to the south is a small knoll. It is on D.L. 2925.” (1955:427).

Randy Bouchard and Dorothy Kennedy in their *Squamish Indian Band Land Use And Occupancy Study* (1986) prepared for the Squamish Nation state that the general name for Britannia Beach was *Shisháyu7áy* though they go on to say that some Squamish specifically locate this name at the mouth of Daisy Creek (Bouchard and Kennedy 1986:259). One of Bouchard and Kennedy’s major Squamish sources, Louis Miranda, noted that the mouth of Daisy Creek was a good camping spot (1986:259) and he also pointed out that people did not fish in Daisy Creek (1986:259). In addition, Louis Miranda also mentioned that “shacks” used to be near the mouth of the creek (Bouchard and Kennedy 1986:259).

Currently, along the Sea To Sky Highway (Highway #99), roadside kiosks and signs provide the Cultural Journey Sea-To-Sky Highway Route (Squamish Lilwat Cultural Centre). One such sign identifies Britannia Creek as *Shisháyu7áy*.

Archaeological Sites: No archaeological sites have been identified and recorded for the South Britannia Project. However, archaeological sites have been identified in similar environments elsewhere for the Howe Sound – Squamish area.

Historic heritage sites and properties: One historic heritage resource, the Britannia Beach National Historic Site (DjRt-11 – Britannia Mines Concentrator), is situated immediately to the north of the subject property and was designated a National Historic Site in 1988.

Britannia Beach Mine

The original copper claim was discovered in 1888 by Dr. Alex Forbes and by 1905 was in operation as the Britannia Mining and Smelting Company. Eventually the operations consisted of four adjoining mines and associated mills. Two communities formed in association with the mine operations, the town site at Britannia Beach (or the Beach) and further up the valley at Tunnel Camp and later Mount Sheer (Billwiller 1946; Engineering & Mining Journal 1915; Rickard 1916; Ramsey 1967). Various owners operated the mine over its years of operation until it finally closed in 1974. The following year the BC Museum of Mining opened and the mines were declared a National Historic Site in 1988 (Ramsey 1967; Town 2000, 2012).

Minaty Bay

Information on the community of Minaty Bay (situated within District Lot 1583 and shown on Figure 1 (from the National Topographic mapsheet Squamish 93G/11 Edition 2) is extremely sparse. Ramsey mentions that “around 1925 settlement began at Minaty Bay...At first the only way to get to the Bay was by boat...A trail was ultimately put in the Beach to allow the isolated Minaty Bay residents to join in the social activities which went on at the Beach and at the Townsite...In 1944 a road was put in and supplies were brought in by company truck” (Ramsey 1967:127). The Britannia Beach Sheet (Map 199A) accompanying James’ *Britannia Beach Map-area, British Columbia* (1929) dating to 1925 shows no structures or other features at Minaty Bay. A pipeline, providing water from Furry Creek to Britannia Beach, is shown at the eastern boundary of the recent alluvium and glacial drift deposits paralleling the western limit of the Britannia Formation.

Florida Ann Town, in her book *The Lively Ghost of Howe Sound* (2000), provides some additional information on Minaty Bay, as she lived “outside of Britannia Beach, at Minetta (sic) Bay, right on the water” from the late 1940s to the 1960s (Town 2012:8).

“In the mid-thirties, a group of workers banded together and threatened to walk out if the company could not find living quarters for their families and let them enjoy more normal lives. The men were given their pick of sites around Minaty Bay. There were responsible for clearing the land, and for building their homes. The company co-operated to the extent of providing materials (although their cost was deducted from the men’s pay cheques) but did not provide assistance with construction. They also charged a \$1 per month fee for land usage. Presumably, this arrangement would prevent residents from claiming squatter’s rights on the land”. (Town 2000:79)

Town goes on to add that with the construction of the PGE and then the highway (Highway #99) “Some Beach houses, especially those in the Minaty Bay area, were torn down, others moved” (Town 2000:109). A photograph in Ramsey’s *Britannia: The Story of A Mine* (1967:134) shows numerous houses along the waterfront at Minaty Bay in 1966. However, by the early 1990s little remained of the community of Minaty Bay.

Table 2. South Britannia Project Properties AOA Results

Legal Description	PID/PIN	Landscape Integrity - Rationale
District Lot 1889 Group 1 New Westminster District	010-025-782	Moderate historic disturbance except for northern portion; potential for CMTs and habitation sites (rock shelters) in northern portion
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	Moderate to intensive historic disturbance; low potential for archaeological sites
REM District Lot 4009	010-025-634	Moderate to intensive historic disturbance to south half of lot; potential for CMTs and habitation sites (rock shelters) in northern portion
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	Moderate to intensive historic disturbance; low potential for archaeological sites; see Photos 1, 2, & 3
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	Moderate to intensive historic disturbance to south half of lot; potential for CMTs and habitation sites (rock shelters) in northern portion; see Photos 1, 2, 3, & 4
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	Intensive historic disturbance; low potential for archaeological sites
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	Intensive historic disturbance; low potential for archaeological sites
District Lot 5208, Group 1, New Westminster District	015-825-663	Moderate historic disturbance; shoreline property; potential for archaeological sites (intertidal and along shoreline)
District Lot 5210, Group 1, New Westminster District	015-825-680	Moderate historic disturbance; shoreline property; potential for

Table 2. South Britannia Project Properties AOA Results

Legal Description	PID/PIN	Landscape Integrity - Rationale
		archaeological sites (intertidal and along shoreline)
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	Intensive historic disturbance; low potential for archaeological sites; see Photo 4
District Lot 2617 Group 1 New Westminster District	010-025-677	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs, habitation/rock shelters) in undisturbed contexts within northern portion
District Lot 3717	015-896-170	Minor to moderate historic disturbance to lot; potential for archaeological sites (CMTs, habitation/rock shelters); Thistle Creek and Daisy Creek flow through lot
District Lot 1583 Group 1 New Westminster District	010-026-151	Intensive historic disturbance to majority of lot; used as aggregate quarry and Minaty Bay townsite; low to moderate potential for archaeological sites in undisturbed locations and/or forested locations within lot and along shoreline; see Photo 5
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	Minor to moderate historic disturbance to lot; potential for archaeological sites (CMTs and habitation/rock shelters); Daisy Creek flows through portion of lot
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs and habitation/rock shelters) in northeastern portion of lot
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on	010-025-774	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs and

Table 2. South Britannia Project Properties AOA Results

Legal Description	PID/PIN	Landscape Integrity - Rationale
Plan LMP17053		habitation/rock shelters) in undisturbed portions of lot
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs and habitation/rock shelters) in undisturbed portions of lot

8. Conclusions and Recommendations

There are no known archaeological sites identified on the subject properties. However, based on the results of the archaeological overview assessment there are properties within the South Britannia Project that have the potential for archaeological sites. In addition, information on cultural heritage resources (traditional places and land use) is available for several locations along the shoreline of Howe Sound within the development properties and remnants of the historic community of Minaty Bay may also be present on the subject properties. Therefore, there is potential for development within some of the subject properties to affect as yet undiscovered buried archaeological remains (Table 3). To address these potential effects, it is recommended that:

- Subject properties assessed as having low-to-moderate or moderate-to-high archaeological potential: District Lot 1889, REM District Lot 4009, District Lot 1970 Group 1, District Lot 5208, District Lot 5210, District Lot 2617, District Lot 3717, District Lot 1583, District Lot 4005, District Lot 4008, District Lot 4012, and District Lot 2933; be subject to an Archaeological Impact Assessment (AIA) prior to development of these lots.
- No AIA is recommended for subject properties assessed as having low archaeological potential: East ½ District Lot 1981, Lot A Except: Part Dedicated Road On Plan BCP25632 – District Lot 2001 & 7053, Parcel 1 (Reference Plan 4878) of District Lot 2001, Lot A Except: part Dedicated Road on Plan BCP286651, District Lots 1583, 2001, 7034 Plan 21567, Parcel 1 (Reference Plan 4878) of District Lot 1583, Except Part On Plan 21576.

Table 3. South Britannia Project Properties AOA Recommendations

Legal Description	PID/PIN	AOA Result (Archaeological Site Potential)	Recommendation
District Lot 1889 Group 1 New Westminster District	010-025-782	Low to moderate potential	AIA
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	Low potential	No further archaeological work
REM District Lot 4009	010-025-634	Low to moderate potential	AIA
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	Low potential	No further archaeological work
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	Low to moderate potential	AIA
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	Low potential	No further archaeological work
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	Low potential	No further archaeological work
District Lot 5208, Group 1, New Westminster District	015-825-663	Moderate to high potential	AIA
District Lot 5210, Group 1, New Westminster District	015-825-680	Moderate to high potential	AIA
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	Low potential	No further archaeological work
District Lot 2617 Group 1 New Westminster District	010-025-677	Low to moderate potential	AIA

Table 3. South Britannia Project Properties AOA Recommendations

Legal Description	PID/PIN	AOA Result (Archaeological Site Potential)	Recommendation
District Lot 3717	015-896-170	Low to moderate potential	AIA
District Lot 1583 Group 1 New Westminster District	010-026-151	Moderate to high potential	AIA
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	Low to moderate potential	AIA
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	Low to moderate potential	AIA
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on Plan LMP17053	010-025-774	Low to moderate potential	AIA
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	Low to moderate potential	AIA

9. Limitations and Closure

Information on archaeological resources and resource potential in the subject properties presented in this report are based on a time-limited review of relevant documents, a search of relevant databases housing recorded sites-specific data, an historical aerial photograph review, and a brief field visit on October 25, 2012. Efforts were made to verify the accuracy of the data produced or provided by others and extracted from the literature and databases.

This assessment of archaeological potential is based on current understanding of the distribution of archaeological resources (sites and artifacts) in the general project area. AMEC acknowledges that knowledge and understanding of the archaeological record continues to evolve, and that ideas about site locations and distribution may change over time.

The findings and conclusions documented in this report have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care customarily exercised by archaeological professionals currently practising under similar conditions in this region. This study was conducted without prejudice to First Nations' treaty negotiations, Aboriginal rights, or Aboriginal title. Participation by Aboriginal communities in this study does not indicate support of the proposed development by those communities.

We trust that this report has provided you with the information you require. If you have any questions or comments, please contact Geordie Howe at (604) 295-6182.

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10. References Cited

- Ames, K., and H. Maschner
1999 *Peoples of the Northwest Coast: Their Archaeology and Prehistory*. Thames & Hudson Ltd., London.
- Arcas Consulting Archeologists
1995 *Archaeological Investigations in Traditional Squamish Territory 1989-1992. (Permits 1990-32 and 1990-89)*. Report on file, Archaeology Branch, Victoria, B.C.
- 1998 *Squamish Forest District Woodlots: Archaeological Impact Assessments Final Report. (Permit 1997-340)*. Report on file, Archaeology Branch, Victoria, B.C.
- 2000 *Garibaldi At Squamish Squamish, B.C. Archaeological Overview Assessment. (Squamish Nation Archaeological Investigation Permit #98-0027)*. Report on file, Archaeology Branch, Victoria, B.C.
- 2002 *Garibaldi At Squamish Ski Report Archaeological Impact Assessment Preliminary Results. (Heritage Inspection Permit 2000-317)*. Report on file, Archaeology Branch, Victoria, B.C.
- 2003 *Squamish Forest District Archaeological Assessments In 2002 Permit Report. (Heritage Inspection Permit 2002-028 and Squamish Nation Archaeological Investigation Permit #02-0079)*. Report prepared for the Ministry of Forests – Squamish Forest District and the Evans Lake Forest Education Society. Report on file, Archaeology Branch, Victoria, B.C.
- Archaeology Branch
1998 *British Columbia Archaeological Impact Assessment Guidelines [3rd revised edition]*. Ministry of Small Business, Tourism and Culture, Archaeology Branch, Victoria, B.C.
- 2001 *Culturally Modified Trees of British Columbia: A Handbook for the Identification and Recording of Culturally Modified Trees [version 2.0]*. Archaeology Branch and Resources Inventory Committee, Province of British Columbia. Available on the Internet at <http://www.for.gov.bc.ca/ric>.
- Armitage, D.
1997 *Around the Sound: A History of Howe Sound-Whistler*. Harbour Publishing, Madeira Park, B.C.
- Armstrong, J.E.
1990 *Vancouver Geology*. Cordilleran Section, Geological Survey of Canada, Vancouver, B.C.
- Backus, H.F.
1969 *Tomboy Pride*. A Woman's Personal Account of Life in Mining Camps of the West Pruett, Boulder, Co.
- Barnett, H.G.
1955 *The Coast Salish of British Columbia*. University of Oregon, Eugene (reprinted 1975 by Greenwood Press Publishers, Westport, Connecticut).
- Billwiller, P.W.
1946 No. 8 Shaft, Britannia Mines. *Western Miner* 19:42-54.

Borden, C.E.

- 1952 A uniform site designation scheme for Canada. *Anthropology in British Columbia* 3: 44-48.
- 1970 Cultural History of the Fraser River-Delta Region: An Outline. In *Archaeology of British Columbia, New Discoveries*, edited by R.L. Carlson. B.C. Studies, Special Issue 6-7:95-112.
- 1975 *Origins and Development of Early Northwest Coast Culture to about 3000 BC*. National Museum of Man Mercury Series, Archaeological Survey of Canada, Paper No. 45. Ottawa, Ontario.

Bouchard, R. And D. Kennedy

- 1986 *Squamish Indian Band land Use And Occupancy Study*. Prepared for the Squamish Nation, on file with the Squamish Nation, North Vancouver, B.C.
- 1976a *Knowledge and Usage of Land Mammals, Birds, Insects, Reptiles and Amphibians by the Squamish Indian People of British Columbia*. Report on file at B.C. Indian Language Project, Victoria, B.C.
- 1976b *Knowledge and Usage of Fish, Beach Foods, and Marine Mammals by the Squamish Indian People of British Columbia*. Report on file at B.C. Indian Language Project, Victoria, B.C.

Bussey, J.

- 1982 *Stage II Heritage Resource Impact Assessment B.C. Hydro and Power Authority Kelly - Cheekeye Transmission Line Project*. (Heritage Inspection Permit 1982-0006). Report on file, Archaeology Branch, Victoria, B.C.
- 1990 *Heritage Resource Update: Proposed Kelly Lake/Cheekeye 500 kV Transmission Line*. (Heritage Inspection Permit 1989-38). Points West Heritage Consulting Ltd. Report on file, Archaeology Branch, Victoria, B.C.

Carlson, R.L.

- 1983 Prehistory of the Northwest Coast. In *Indian Art Traditions of the Northwest Coast*, edited by R.L. Carlson, pp. 13-31. Archaeology Press, Simon Fraser University, Burnaby, B.C.

Demarchi, D.A.

- 2011 *The British Columbia Ecoregion Classification. Third Edition*. Ecosystem Information Section, Ministry of the Environment, Province of British Columbia. Victoria. Available at: <http://www.env.gov.bc.ca/ecology/ecoregions/>; accessed October 5, 2012.

Engineering & Mining Journal

- 1915 Fatal Snowslide at Britannia Copper Co.'s Mines – Special Correspondence. *The Engineering & Mining Journal*, 99(14):628.

Fladmark, K.R.

- 1982 An introduction to the prehistory of British Columbia. *Canadian Journal of Archaeology* 6:95-156.

Friesen, D.E.

- 1980 *Heritage Resource Assessment of the Proposed Westcoast Transmission Company Limited Vancouver Island Gas Pipeline Williams Lake to Comox and Squamish Lateral*. (Ministerial Order 1980-0001). Report on file, Archaeology Branch, Victoria. B.C.

Golder Associates

2004 *Archaeological Impact Assessment For The Sea-to-Sky Highway Improvement Project Heritage Inspection Permit 2003-111 Squamish Nation Permit 03-001*. Report on file, Archaeology Branch, Victoria, B.C.

Green, R.N., and K. Klinka

1994 *A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region*. Ministry of Forests, Land Management Handbook No. 28. Victoria, B.C.

Hill-Tout, C.

1978 *The Salish People: The Contribution of Charles Hill-Tout, Volume III: The Mainland Halkomelem*, edited by Ralph Maud. Talonbooks, Vancouver, B.C.

James, H.T.

1929 *Britannia Beach Map-area, British Columbia*. Geological Survey, Canada Department of Mines, Ottawa, Ontario, Ontario.

Journeyay, J.M., and J.W.H. Monger

1994 *Geology and Crustal Structure of the Southern Coast and Intermontane Belts, Southern Canadian Cordillera, British Columbia [map]*. Geological Survey of Canada, Open File. Ottawa, Ontario.

Mathews, W.H.

1975 *Garibaldi Geology*. Geological Association of Canada, Vancouver, B.C.

Matson, R.G. and G. Coupland

1995 *Prehistory of the Northwest Coast*. Academic Press, San Diego, California.

May, J. and S. Lucs

1976 *South Coast Regional Survey: Vancouver Island and the Lower Fraser Valley*. Report on file, Heritage Resource Centre, Ministry of Community, Aboriginal & Women's Services Victoria, B.C.

Millennia Research Ltd.

1997 *Archaeological Overview Assessment of the Squamish Forest District*. Squamish Forest District, Ministry of Forests, Squamish, B.C.

Mitchell, D.H.

1990 Prehistory of the Coast of Southern British Columbia and Northern Washington. In *Handbook of North American Indians, Volume 7, Northwest Coast*, edited by W. Suttles, pp.340-358. Smithsonian Institution, Washington, D.C.

Ministry of Forests, Research Branch

1994 *Biogeoclimatic Units of the Vancouver Forest Region: Map Sheet 5 of 6, Southern Vancouver Island -Sunshine Coast*. Ministry of Forests, Research Branch, Victoria, B.C.

Moss, M. L.

2011 *Northwest Coast Archaeology as Deep History*. SAA Press. Washington, D.C.

Mullan, M.

2012 *Britannia – The Story of A British Columbia Mine – from Mining Resource to Heritage Resource*. Ministry of Energy, Mines and Natural Gas and Responsible for Housing. Available at: <http://www.empr.gov.bc.ca/MINING/GEOSCIENCE/PUBLICATIONSCATALOGUE/OPENFILES/1992/1992-19/Pages/Britannia.aspx>; accessed October 5, 2012.

Pojar, J., K. Klinka, and D. Demarchi

1991a Coastal Western Hemlock Zone. In *Ecosystems of British Columbia* edited by D. Meidinger and J. Pojar, pp. 95-112. Ministry of Forests, Research Branch, Special Report Series 6, Victoria, B.C.

Quirolo, M.M., and L. Ham

1990 *Archaeological Resource Overview of the Furry Creek Delta, Howe Sound, British Columbia*. Report on file, Culture Department Library, Ministry of Small Business, Tourism and Culture, Victoria, B.C.

Ramsey, B.

2004 *Britannia: Story of a Mine*. Second Edition. Trafford Publishing. Victoria, B.C.

Reimer, R. (Yumks)

2011 *The Mountains And Rocks Are Forever: Lithics And Landscapes of Skwxwú7mesh Uxwumixw Territory*. Unpublished Ph.D. Dissertation, Department of Archaeology, Simon Fraser University, Burnaby, B.C.

Richard, T.A.

1916 The Britannia Mine and Mill. *Mining And Scientific Press* 112:693-700.

Roddick, J.A., J.E. Muller and A.V. Okulitch

1979 *Fraser River, British Columbia - Washington, Sheet 92 [map]*. Geological Survey of Canada, Map 1386A. Ottawa, Ontario.

Suttles, W.

1955 Squamish Ethnographic Notes. *Anthropology in British Columbia Memoir* Nos. 2 & 3, University of British Columbia, Vancouver, B.C.

1987 *Coast Salish Essays*. Talonbooks, Vancouver & University of Washington Press, Seattle, Washington.

1990 Central Coast Salish. In *Handbook of North American Indians, Volume 7, Northwest Coast*, edited by W. Suttles, pp.453-475. Smithsonian Institution, Washington, D.C.

Smith, H.I.

1907 Archaeology of the Gulf of Georgia and Puget Sound. *Publications of the Jesup North Pacific Expedition* 2(6); *Memoirs of the American Museum of Natural History*. 4(6):303-441, New York, New York.

Squamish Lilwat Cultural Centre

2012 *Cultural Journey Sea-to-Sky Highway Route – Connecting People And Communities Along The Way*. Available at: <http://www.slcc.ca/cultural-journey>; accessed: October 25, 2012.

Town, F.A.

2000 *The Lively Ghost of Howe Sound*. Bookus Press, Port Coquitlam, B.C.

2010 *Before The Road Came*. Smashwords. Available at:
<http://www.smashwords.com/books/view/15962>; accessed October 5, 2012.

Turner, N.J.

1975 *Food Plants of British Columbia Indians: Part I – Coastal Peoples*. British Columbia Provincial Museum, Handbook No.34. Victoria, B.C.

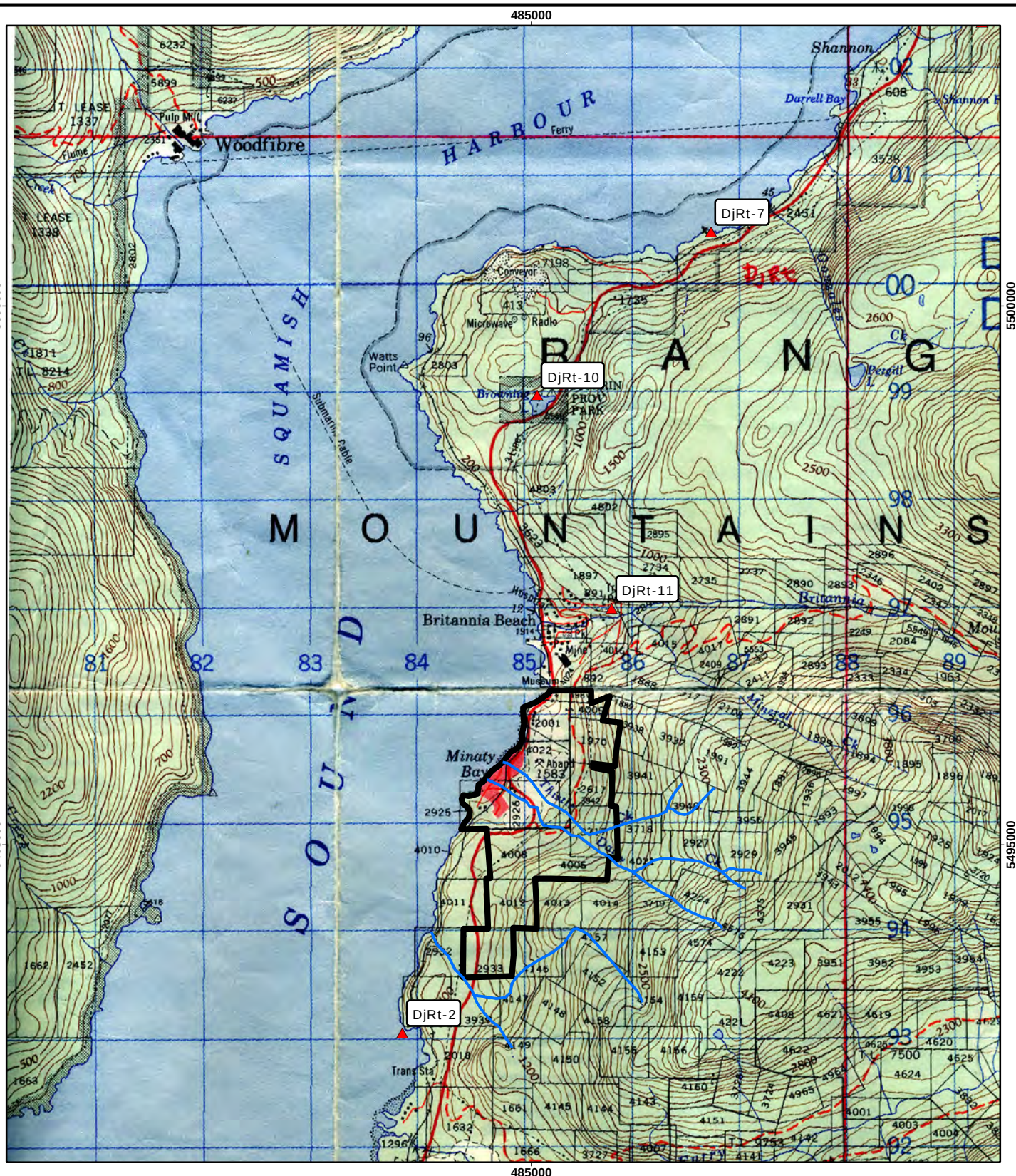
Turner, N.J.

1979 *Plants in British Columbia Indian Technology*. British Columbia Provincial Museum, Handbook No.38. Victoria, .B.C.

Winram, P.

1975 *A Report on the Howe Sound Archaeology Survey*. [Permit # 1975-011]. Report on file, Archaeology Branch, Victoria B.C.

FIGURES

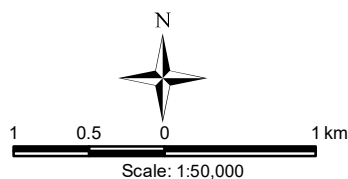


Legend

- South Britannia Subject Properties
- ▲ Archaeological Site
- River

Reference

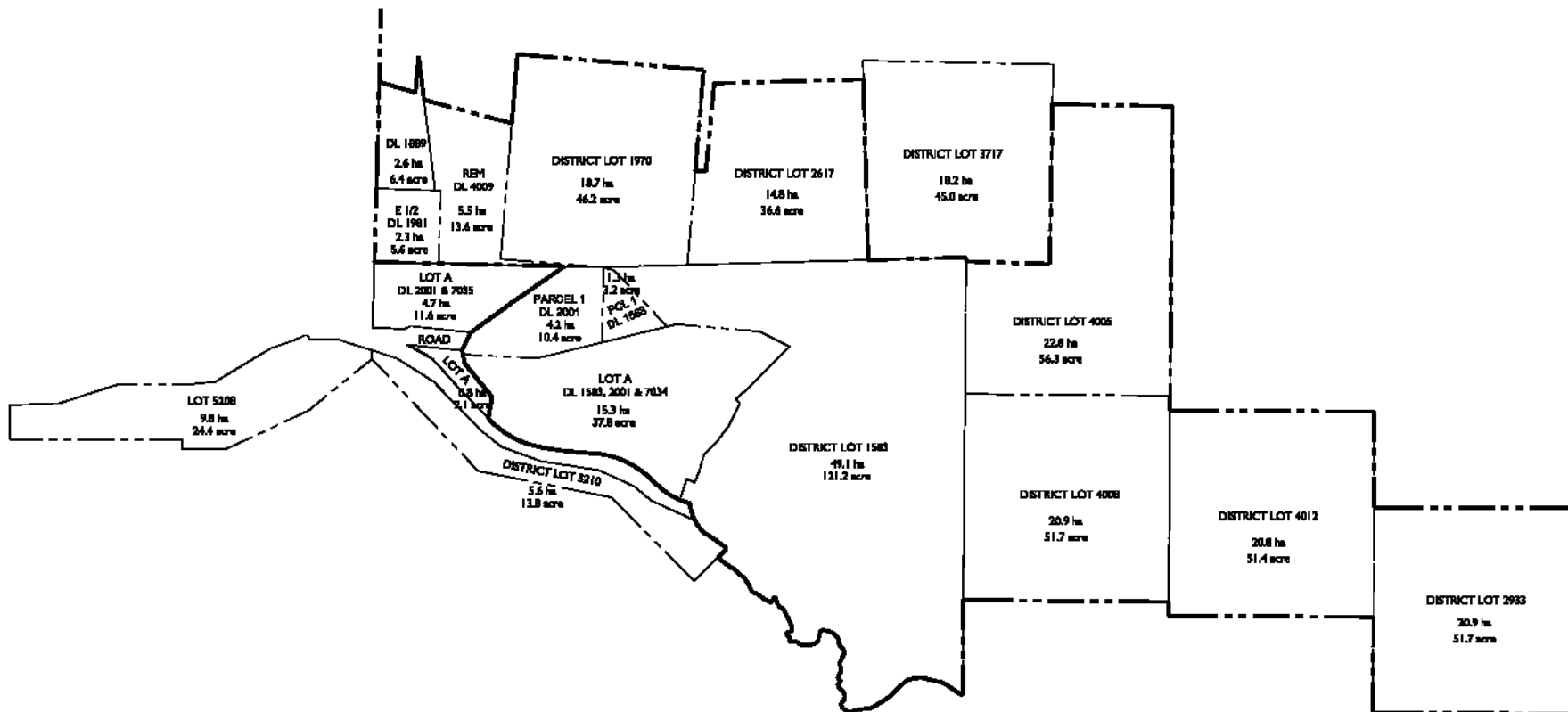
NTS Mapsheet 92G/11



Location of South Britannia Project and nearby Archaeological Sites

CLIENT: Taiching Development Corporation		PROJECT: South Britannia Project AOA
DATE: Nov 08, 2012	ANALYST: AO'S	Figure 1
JOB No: VE12405	QA/QC: GH	
PROJECTION: UTM Zone 10	DATUM: NAD83	





1:15,000



FOLIO Hotel and Resort Architecture SOUTH BRITANNIA MASTERPLAN

Legend

--- South Britannia Subject Properties



Reference

Basemap: from Taiching Development Corporation

South Britannia Project - Development Property Information

CLIENT: Taiching Development Corporation		PROJECT: South Britannia
DATE: Nov 8, 2012	ANALYST: AO'S	Figure 2
JOB No: VE12405	QA/QC: GH	
PROJECTION: UTM Zone 10	DATUM: NAD83	



K:\Drafting\12 Drafting\VE12405\Data\Britannia Fig3.cdr



Legend

 South Britannia Subject Properties



Reference

Basemap: from Taiching Development Corporation

South Britannia Project - Development Property

CLIENT: Taiching Development Corporation		PROJECT: South Britannia
DATE: Nov 7, 2012	ANALYST: AO'S	Figure 3 
JOB No: VE12405	QA/QC: GH	
PROJECTION: UTM Zone 10	DATUM: NAD83	

PHOTOGRAPHS



Photo 2. Panorama view of South Britannia Project. View ESE across District Lot 2001;
Highway #99 on left and right side of photo.



Photo 2 View ESE across District Lot 2001.



Photo 3. View SE across District Lot 2001 and 1583.



Photo 4. View SE across Highway #99 across District Lot 1583 with District Lots 3717 and 4005 along ridgeline.



Photo 5. View SW along shoreline of Howe Sound towards Minaty Bay and District Lot 2925.

APPENDIX A

Historical Aerial Photograph Review

Appendix A. Summary of observations from historic airphoto review of South Britannia Development.				
Date	Flight	Frames	Altitude	Subject Property Observations
1947	BC 398	109	High Oblique	Oblique view east across Howe Sound to Britannia Creek drainage. Hydro transmission line visible inland of Britannia Beach; pipe line (water) from Furry Creek to Britannia Beach Mine and mine site visible. Pacific Great Eastern Railway (subsequently BC Rail, now CN Rail) line not yet constructed. Majority of South Britannia development area covered in vegetation (forest type not identifiable). Road connecting Britannia Beach to Minaty Bay visible; roads from water inland to transmission line visible; evidence of community of Minaty Bay visible; knoll in DL 2925 wooded
	BC 398	110		
1947	BC 398	111	High Oblique	Oblique view east across Howe Sound to Britannia Creek drainage. Hydro transmission line visible inland of Britannia Beach; pipe line (water) from Furry Creek to Britannia Beach Mine and mine site visible. Pacific Great Eastern Railway (subsequently BC Rail, now CN Rail) line not yet constructed. Majority of development covered in vegetation (forest type not identifiable). Road connecting Britannia Beach to Minaty Bay visible; roads from water inland to transmission line visible; evidence of community of Minaty Bay visible; knoll in DL 2925 wooded
	BC 398	112		
1951	Energy, Mines & Resources Canada A 13250	153	Very High	Hydro transmission line visible inland of Britannia Beach; pipe line (water) from Furry Creek to Britannia Beach Mine and mine site visible. Pacific Great Eastern Railway line not yet constructed. Majority of development covered in vegetation (forest type not identifiable). Roads from water inland to transmission line visible; evidence of community of Minaty Bay visible; knoll in DL 2925 wooded
1957	BC 2349	4	Low	Pacific Great Eastern Railway line visible. Majority of development covered in vegetation (forest type not identifiable). Aggregate operations visible in Parcel 1 DL 2001, north side of Lot A DL 1583, 2001 & 7034. Forest cover within south half of Lot A DL 1583, 2001 & 7034 showing clearing in progress. Additional aggregate operation north side of DL 1583, (now west of Highway #99). Highway #99 visible south of Britannia Beach to southern limit of development property. No evidence of logging inland of highway or transmission line. Community of Minaty Bay well established; knoll in DL 2925 wooded
	BC 2349	5		
	BC 2349	6		
	BC 2349	7		
	BC 2349	65		
	BC 2349	66		
	BC 2349	67		
	BC 2349	68		
1969	BC 5342	035	High	Highway #99 constructed. Aggregate operations now very extensive: visible in Parcel 1 DL 2001, all of Lot A DL 1583, 2001 & 7034, PCL 1 DL 1583 and northern

Appendix A. Summary of observations from historic airphoto review of South Britannia Development.				
Date	Flight	Frames	Altitude	Subject Property Observations
	BC 5342	036		portion of DL 1583. Only remnant of forest cover present within DL 1583 north of community of Minaty Bay – remainder is either lands associated with the community of Minaty Bay or aggregate operations. Trees becoming reestablished along Minaty Bay community roads. Rest of development property still covered in forest but forest service roads visible inland (eastern portion of development property); knoll in DL 2925 wooded
	BC 5342	037		
1969	BC 7202	057	Low	Highway #99 constructed. Aggregate operations now very extensive (maximum extent): visible in Parcel 1 DL 2001, all of Lot A DL 1583, 2001 & 7034, PCL 1 DL 1583 and northern portion of DL 1583. Small settling pond visible in Lot A DL 1583, 2001 & 7034 –western portion near Highway #99. Only remnant of forest cover within DL 1583 north of Minaty Bay – remainder is either lands associated with the community of Minaty Bay or aggregate operations. Trees becoming re-established along Minty Bay community roads. Evidence of logging inland within DL 1870, 2617, 3717, 4005, and 4008Rest of development property still covered in forest but forest service roads visible inland (eastern portion of development property); knoll in DL 2925 wooded
	BC 7202	058		
	BC 7202	137		
	BC 7202	138		
	BC 7202	139		
	BC 7202	140		
1974	BC 7558	158	Low	Aggregate operations extensive: visible in Parcel 1 DL 2001, all of Lot A DL 1583, 2001 & 7034, PCL 1 DL 1583 and northern portion of DL 1583. Settling pond has expanded and is now quite large adjacent to Highway #99. Community of Minaty Bay still present. No evidence of new logging visible; knoll in DL 2925 wooded
	BC 7558	159		
1982	BC 82 058	60	High	Trees now covering majority of aggregate pit – operations abandoned. Settling pond no longer present. Streets of Minaty Bay still visible but no buildings present. No evidence of new logging visible – development property becoming reforested; knoll in DL 2925 wooded.
	BC 82 058	61		
	BC 82 058	62		
	BC 82 058	63		
1982	BC 82 060	130	Very High	Trees now covering majority of aggregate pit – operations abandoned. Settling pond no longer present. Streets of Minaty Bay still visible but no buildings present. No evidence of new logging visible – development property becoming reforested; knoll in DL 2925 wooded.
	BC 82 060	131		
	BC 82 060	132		
	BC 82 061	133		
1990	30 BC B90020	25	Very High	A large portion of the aggregate pit has been cleared of vegetation (alder removed). Settling pond no longer present. Southern portion of DL 1583 (south of Highway #99) cleared of vegetation. Forest (alder) covers community of Minaty Bay – roads no longer visible. Various locations within development properties have been cleared of vegetation; knoll in DL 2925 wooded.
	30 BC B90020	26		
	30 BC B90020	27		
	30 BC B90020	40		
	30 BC B90020	41		

Appendix A. Summary of observations from historic airphoto review of South Britannia Development.				
Date	Flight	Frames	Altitude	Subject Property Observations
	30 BC B90020	42		
1994 colour	30 BC C94122	078	Low	The aggregate pit is starting to revegetate. Settling pond no longer present. Southern portion of DL 1583 (south of Highway #99) cleared of vegetation in 1990 is revegetated. Forest (alder) covers community of Minaty Bay – roads no longer visible. Various locations within development properties cleared of vegetation in 1990 regrowing; knoll in DL 2925 wooded.
	30 BC C94122	079		
	30 BC C94122	080		
	30 BC C94122	195		
	30 BC C94122	196		
	30 BC C94122	197		
2004 colour	SRS 6935	79	Very High	The aggregate pit is starting to revegetate though some new clearing appears. Forest (alder) covers community of Minaty Bay – roads no longer visible. Various locations within development properties cleared of vegetation in 1990 regrowing. Most of development property revegetated; knoll in DL 2925 wooded
	SRS 6935	80		
	SRS 6935	81		

**8.2 2014 02 00 Archaeological Site Inventory and Impact
Assessment (AMEC)**



TAICHENG DEVELOPMENT CORPORATION

SOUTH BRITANNIA PROJECT

BRITANNIA BEACH, B.C.

ARCHAEOLOGICAL SITE INVENTORY AND IMPACT

ASSESSMENT

HERITAGE INSPECTION PERMIT #2013-134

Taicheng Development Corporation

South Britannia Project

Britannia Beach, B.C.

Archaeological Site Inventory and Impact Assessment Heritage Inspection Permit #2013-134

February 2014

Submitted to:
ARCHAEOLOGY BRANCH
Ministry of Forests, Lands and Natural Resource Operations
Victoria, B.C.

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Executive Summary

This report describes the results of an archaeological site inventory and impact assessment (AIA) undertaken in September 2013 by AMEC Environment & Infrastructure (AMEC) at the request of Taicheng Development Corporation. The AIA addresses 17 properties (collectively known as the South Britannia Project; the Project) immediately south of Britannia Beach, British Columbia (B.C.). The 17 subject properties cover a total area of 237.5 hectares (ha), extend south from Britannia Beach along the east shore of Howe Sound, and include the abandoned community of Minaty Bay.

The purpose of the impact assessment was to:

- Identify and evaluate archaeological resources within the project area,
- Identify and assess all impacts on archaeological resources which might result from the project, and
- Recommend viable alternatives for managing unavoidable adverse impacts.

No archaeological resources or sites were identified during the course of the AIA. In addition, no landforms with archaeological potential were identified or tested, as all lands surveyed were observed to be very steep, rocky with no sedimentation, or previously disturbed. Areas which may have previously had archaeological potential – in particular the Howe Sound shoreline and along Thistle and Daisy Creeks – had been heavily impacted by historic industrial development. The shoreline along Minaty Bay has also been completely modified and built up in the past for both industrial (mining and shipping) and residential purposes. Creek margins at higher elevations are rocky and steep, with no sedimentation while those at lower elevations flow through lands substantially altered due to historic activities or flow through channels created from historical alterations.

The remnants of several historic era structures were identified and recorded during the AIA. These structures are associated with historic mining and residential development. Identified structures were: the waterline that previously piped water from Furry Creek to the Britannia Mine and an associated water control valve, a mine shaft and associated entrance pit, as well as several historic building and outbuilding foundations at Minaty Bay. These structures are not protected by the *Heritage Conservation Act*.

It is recommended that:

1. No further archaeological work be required for the South Britannia Project, as long as the project footprint is not redesigned to include lands beyond those covered by the AIA.
2. Taicheng Development Corporation work with local stakeholders to preserve or record elements of local mining history which will be impacted by development.

3. In the event that unanticipated suspected subsurface or surface archaeological remains are encountered during ;land-altering activities associated with project development, all ground disturbance in the immediate vicinity be suspended at once and the Archaeology Branch and appropriate First Nations are promptly informed regarding the particulars of the archaeological resources encountered and the extent of the impacts. If suspected culturally modified trees are encountered, clearing activities should also be halted until a qualified archaeologist can be consulted.

DRAFT

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1.0 INTRODUCTION

This report describes the results of an archaeological site inventory and impact assessment (AIA) undertaken in September, 2013 by AMEC Environment & Infrastructure (AMEC) at the request of Taicheng Development Corporation. The AIA addresses 17 properties (collectively known as the South Britannia Project; the Project) immediately south of Britannia Beach, British Columbia (BC) (Figures 1 and 2; Table 1).

The objective of the assessment was to identify and evaluate archaeological sites within the development area, and assess impacts to any identified sites by Project development activities. Specific development impacts were not assessed, as detailed development plans are not currently available.

The 17 subject properties cover a total area of 237.5 hectares (ha), extend south from Britannia Beach along the east shore of Howe Sound, and include the abandoned community of Minaty Bay. From Britannia Beach, the South Britannia Project extends south along Howe Sound for approximately 2.7 kilometres (km), and extends inland for approximately 1.5 km (Figures 1 and 2). Limited structures exist on the South Britannia properties, but portions of the Project area have been affected by industrial activities (aggregate mining), residential settlement, forestry resource use, as well as transportation (CN Rail line, Highway #99) corridors and hydroelectric transmission line corridors.

Table 1. South Britannia Project Properties

Legal Description	PID/PIN	Area (ha)
District Lot 1889 Group 1 New Westminster District	010-025-782	2.6
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	2.3
REM District Lot 4009	010-025-634	5.5
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	4.7
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	18.7
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	4.2
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	15.3
District Lot 5208, Group 1, New Westminster District	015-825-663	9.8

Legal Description	PID/PIN	Area (ha)
District Lot 5210, Group 1, New Westminster District	015-825-680	5.6
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	1.3
District Lot 2617 Group 1 New Westminster District	010-025-677	14.8
District Lot 3717	015-896-170	18.2
District Lot 1583 Group 1 New Westminster District	010-026-151	49.1
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	22.8
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	20.9
District Lot 4012, Group 1 New Westminster District Except Portions Dedicated Road on Plan LMP17053	010-025-774	20.8
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Road on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	20.9

1.1 Protection of Archaeological Resources in British Columbia

Most archaeological sites in B.C. are attributable to settlement and resource use by Aboriginal people. If these pre-date 1846 AD they are automatically protected from damage, desecration, alteration, or excavation by the *Heritage Conservation Act (HCA)* (RSBC 1996; Chap. 187). Some sites are protected through a designation as "Provincial Heritage Sites" under section 9 of the *HCA* or through automatic protection under section 13 by virtue of particular historic or archaeological value, including:

- Archaeological sites occupied or used before 1846 AD,
- Rock art with historical or archaeological value,
- Burial places with historical or archaeological value,
- Heritage shipwrecks or aircraft wrecks, and

- Archaeological sites of unknown age, with a reasonable possibility of having been occupied or used before 1846 AD.

Protected sites may be located on public or private land and may not be altered (i.e., changed in any manner) without a permit issued under Sections 12 or 14 of the *HCA*. Archaeological sites of Aboriginal origin may also be subject to interpretations of the Supreme Court of Canada decision in *Delgamuukw vs. British Columbia* (1997), regarding the fiduciary responsibility of provincial governments for protecting cultural heritage.

1.2 Objectives

The Archaeology Branch issued the *British Columbia Archaeological Impact Assessment Guidelines* (Archaeology Branch 1998) to assist with the management of archaeological sites in the province. The *Guidelines* identify the kinds of assessments that may be undertaken in response to proposed developments, with the specific assessment dependent on the stage of development design and type of archaeological information required. The purpose of an impact assessment, based on the *Guidelines*, is to:

- Identify and evaluate archaeological resources within the project area,
- Identify and assess all impacts on archaeological resources which might result from the project, and
- Recommend viable alternatives for managing unavoidable adverse impacts.

2.0 PROJECT DESCRIPTION

The South Britannia Project (the Project) consists of 17 subject properties on the east shore of Howe Sound. The Project is currently envisioned as a complete residential community, with associated commercial, cultural, light industrial, and recreational developments, as well as transportation corridors (South Britannia 2014a)). The Project extends south from Britannia Beach for approximately 2.7 kilometres (km), and inland for approximately 1.5 km (Figures 1 and 2). There are limited existing structures on these properties; however, they have been affected by industrial activities including aggregate mining and residential settlement.

While a general overview of plans for the South Britannia Project exists, there are as yet no final plans for the Project. Thus the extent of land alterations and disturbance cannot be determined. A construction schedule is also not available; the Project is in the consultation phase (South Britannia 2014b). The subject properties as such are treated as the study area.

3.0 BACKGROUND INFORMATION

An Archaeological Overview Assessment was conducted by AMEC (AMEC 2012) and included as an appendix (Appendix A) details the natural and cultural setting of South Britannia. Summary information on the archaeological, historic, and natural setting of Britannia is presented below.

3.1 Biophysical Setting

Located in the Southern Pacific Ranges Ecoregion, Pacific Ranges Ecoregion of the Coast and Mountains Ecoprovince (Demarchi 2011), the Project terrain is moderately to steeply sloping, rising from Howe Sound to approximately 365 metres above sea level (masl) along its eastern boundary. Thistle Creek and Daisy Creek run through the development into Howe Sound. The area is vegetated primarily with western redcedar, hemlock, Douglas-fir, and red alder in disturbed areas, and is in the Submaritime variant, Very Wet Maritime Subzone of the Coastal Western Hemlock Zone (CWHvm1; Ministry of Forests Research Branch 1994). The Project is located in the Coast Plutonic Complex and its geology is characterized by slate and massive volcanic or Jurassic porphyritic rocks in its upslope sections, while lower elevation geology is typified by recent alluvium and glacial drift, till, and colluvium (Armstrong 1990; James 1929, Journeay and Monger 1994, Mathews 1975).

3.2 Cultural Setting

From at least the time of European contact to the present, the South Britannia Project locality has been the traditional territory of the Squamish Nation (or *skwxwúmesh7úlh* in their own language) and the Tsleil-Waututh Nation, who speak different but related languages in the Central Coast Salish linguistic family. Coast Salish culture in the Central Strait of Georgia region is summarized by Suttles (1990), and was characterized by a semi-sedentary lifestyle and subsistence pursuits typified by fishing, gathering and hunting. Society was stratified, the primary socio-economic unit was a household of extended families, and dances, songs, legends, ancestral names as well as rights to harvesting and ritual sites were inherited.

Central Coast Salish population and settlement were contingent on the seasonal availability of food resources, in particular salmon, sea mammals, land mammals, and birds. Numerous plant resources were used, particularly red and yellow cedar (e.g., Turner 1979). In addition to participating in economic pursuits, individuals pursued spiritual quests to acquire powerful or helpful spirits.

The study area was known by the Squamish people for its abundance of screech owls (*Otus asio*) and was named *Shishaýu7aý*: “lots of screech owls place.” Screech owls were not hunted, as it was believed that some Squamish people who died were transformed into a screech owl (Bouchard and Kennedy 1976a). The area just north of Minaty Bay – Britannia Beach - was known to be abundant in western grebes (*Aechmophorus occidentalis*), which were considered to be good to eat by the Squamish (Bouchard and Kennedy 1976a). Fish were also available in Daisy Creek and offshore (Bouchard and Kennedy 1976b).

3.3 Archaeological Background

Archaeological sites in the Howe Sound region (described in AMEC 2012; Appendix A) consist of middens, artifact scatters, burial places, rock art, fish traps or weirs, wetsites (i.e., waterlogged locations where organic materials that would normally decay are preserved), forest utilization sites and historic sites (i.e., features and artifacts associated with Euro-Canadian or Asian-Canadian settlement and land use). Regional prehistory in the Northwest Coast Culture

Area, which encompasses the west coast of North America from southeastern Alaska to southern Oregon (Ames and Maschner 1999; Matson and Coupland 1995) is divided into five distinct cultural periods that span from 8500 before present (B.P.) to contact (200 B.P.).

Archaeological research in Howe Sound and the Squamish River Valley included early archaeological investigations near Squamish at the turn of the 20th century by Charles Hill-Tout (1978), the identification of a pictograph at Furry Creek by Harlan Smith (1907), and numerous more recent archaeological assessments, particularly for industry including power, forestry, transportation, and residential-commercial (e.g., Arcas Consulting Archeologists 1998, 2000, 2002, 2003; Bussey 1982, 1990; Golder Associates 2004; May and Lucs 1976; Quirolo and Ham 1990; Reimer 2011; Winram 1975). Four archaeological sites and one historic site are located within 5 km of the Project area (Table 2).

Table 2. Archaeological Sites within 5 kilometres of South Britannia Beach

Site	Distance from development	Name	Location	Comment
DjRt-2	725 m SW	Furry Creek Pictograph	East shore of Howe Sound, north of Furry Creek	Human, zoomorphic, and geometric designs
DjRt-11	1.3 km NNE	Historic Site: Britannia Beach Concentrator	Off Hwy 99	Designated National Historic Site in 1987 as an "important 1920s-30s copper mine concentrator"
DJRT-10	2.5 km N	Sts'its'a7in	Granodiorite rock bluff west of Browning Lake in Browning Lake Provincial Park	Red ochre anthropomorphic image
DjRt-5	5 km SW	Defence Island	Above a small cove in centre of island	Shell midden, CMT (aboriginally logged tree), aboriginally logged canoe, bark stripped tree, surface basalt projectile point, flakes
DjRt-7	4.5 km NE	Unknown	Beach, NE of Watts Point	Surface basalt flake

3.4 Historical Background

Britannia Beach Mine

The historic heritage resource, the Britannia Beach National Historic Site (DjRt-11; Table 2) is located immediately north of the Project. Mining activity and decades of prospecting have impacted the Project area. In 1888, copper was discovered in the area by Dr. Alex Forbes and

by 1905 the Britannia Mining and Smelting Company was in operation. Operations eventually consisted of four adjoining mines and associated mills, while people lived in two separate communities – the townsite at Britannia Beach, and farther up the valley at Tunnel Camp and later Mount Sheer (Billwiller 1946; Engineering & Mining Journal 1915; Rickard 1916; Ramsey 1967; Rollwagen 2006). The National Historic Site itself is represented by the Britannia Mines Concentrator. Constructed between 1922 and 1923, the innovative gravity-fed concentrator was pivotal in making the Britannia Mine the largest producer of copper ore in the British Empire between 1925 and 1930 (Canada's Historic Places 2013).

The Britannia Mine used hydroelectric power harnessed by dams up the valley and wooden stave pipes held together with metal bands to transport the water to a powerhouse near the shore (Britannia Mine Museum 2014). Early 20th century maps show the pipeline running from Furry Creek, along the South Britannia Properties (James 1929), crossing Thistle and Daisy Creeks. Museum images show the pipeline being constructed using the assistance of horses (Britannia Mine Museum 2014).

A remediation plan initiated in 2003 to address mine-related pollution in Howe Sound and in soil and groundwater at lower elevations (O'Hara 2007) has since improved the local environment (South Britannia 2014c).

Minaty Bay

Information on the community of Minaty Bay (situated in District Lot 1583; Figure 1) is sparse. Settlement begun, according to Ramsey, "around 1925" (1967). He writes that the isolated community could at first only be reached by boat. Later, a trail connected Minaty Bay to the company town of Britannia Beach to facilitate social activities associated with the mine.

Florida Ann Town, in her book *The Lively Ghost of Howe Sound* (2000), provides some additional information on Minaty Bay, as she lived "outside of Britannia Beach, at Minetta (sic) Bay, right on the water" from the late 1940s to the 1960s (Town 2012:8).

"In the mid-thirties, a group of workers banded together and threatened to walk out if the company could not find living quarters for their families and let them enjoy more normal lives. The men were given their pick of sites around Minaty Bay. They were responsible for clearing the land, and for building their homes. The company co-operated to the extent of providing materials (although their cost was deducted from the men's pay cheques) but did not provide assistance with construction. They also charged a \$1 per month fee for land usage. Presumably, this arrangement would prevent residents from claiming squatter's rights on the land". (Town 2000:79)

Town goes on to add that with the construction of the PGE (Pacific Great Eastern) Railway and then the highway (Highway #99) "Some Beach houses, especially those in the Minaty Bay area, were torn down, others moved" (Town 2000:109). A photograph in Ramsey's *Britannia: The Story of A Mine* (1967:134) shows numerous houses along the waterfront at Minaty Bay in 1966. However, by the early 1990s little remained of the community of Minaty Bay.

4.0 METHODS

4.1 Liaison

Prior to the assessment, representatives of the Squamish and Tsleil-Waututh Nations were contacted by letter, email, and telephone. They were informed about the nature and scope of the Project, and scheduling of the fieldwork. Archaeological permits were applied for from Squamish First Nation and Tsleil-Waututh Nation and received (Tsleil-Waututh Nation Cultural Heritage Inspection Permit 2013-082; Squamish 13-0114). Representatives were invited to participate in the fieldwork, and Louise Williams took part in the survey for Squamish First Nation.

4.2 Field Methods

Field methods were designed to focus on properties assessed in the AOA (2012) as exhibiting moderate to high potential for archaeological resources (Table 3). In-the-field assessment of properties resulted in the re-evaluation of potential for many of these properties based on assessments of slope, sedimentation, and previous disturbance. Testing parameters, site recording methods, significance evaluation, and data analysis methods were outlined in the application for Heritage Inspection Permit #2013-134. However, previous historic development impacts on the subject properties resulted in a downgrading of potential for all properties during the field assessment (refer to Section 5.0 Results).

4.2.1 Field Survey

Field survey was carried out September 10-12, 2013 in accordance with Section 3.5 of the British Columbia Archaeological Impact Assessment Guidelines (Archaeology Branch 1998). The survey focused on lands determined in the AOA (AMEC 2012) and refined in the field to have potential for archaeological resources. These areas included land along the waterfront, as well as forested areas – particularly close to Daisy and Thistle creeks – and where terrain was less steep. Pedestrian survey coverage is shown in Figure 2. Surveyed lands were examined for surface exposures, CMTs, and other archaeological remains. Crew size ranged from two to four people, depending on the area being covered and crew composition for the day. Where landforms allowed and where coverage was appropriate, crew members spread out at 10 m intervals to conduct a visual inspection of the surface and forest cover.

5.0 RESULTS

No archaeological resources or sites were identified during the course of the AIA. In addition, no landforms with archaeological potential were identified or tested, as all lands surveyed were observed to be very steep, rocky with no sedimentation, or previously disturbed. Areas which may have previously had archaeological potential – in particular the Howe Sound shoreline and along Thistle and Daisy Creeks – had been heavily impacted by historic industrial development. The shoreline along Minaty Bay has been completely modified and built up in the past for both industrial (mining and shipping) and residential purposes. Creek margins at higher elevations are rocky and steep, with no sedimentation while those at lower elevations flow through lands substantially altered due to historic activities or flow through channels created from historical alterations.

The remnants of several historic era structures were identified and recorded. These structures – the waterline that previously piped water from Furry Creek to the Britannia Mine as well as several historic building and outbuilding foundations at Minaty Bay – are not protected by the HCA (Table 3). Mine-related historic structures observed during the assessment consist of the former Britannia Mine water pipeline, which was identified in four parcels, a mine bore hole, as well as a large valve structure. The metal remnants of the water pipeline were observed passing through an excavated tunnel, as well as on levelled formations in the bedrock. Locations of historical features is shown on Figure 2.

Identified remains of the Minaty Bay community were also observed in Parcel DL 1583, on the shore of Howe Sound. Four subterranean structures, nine building foundations, a rock retaining wall, a telephone pole, and a portion of the former access road were identified (see Figure 2).

Table 3. AIA Results

Legal Description	PID/PIN	Area (ha)	Survey Results
District Lot 1889 Group 1 New Westminster District	010-025-782	2.6	AOA recommended AIA: Not surveyed; visual inspection of property indicated it to be prohibitively steep (e.g., average 31° slope) for archaeological remains; no water sources; previously logged
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	2.3	AOA recommended no AIA: Survey confirms previously logged; steep terrain (e.g., average 26° slope)
REM District Lot 4009	010-025-634	5.5	AOA recommended AIA: Survey determines property

Legal Description	PID/PIN	Area (ha)	Survey Results
			previously logged; impacted by transmission line; steep terrain (e.g., average slope 28°)
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	4.7	AOA recommended no AIA: Survey confirms property previously cleared and levelled for gravel extraction, steep terrain elsewhere
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	18.7	AOA recommended AIA: Survey determines property previously logged, bisected by road and transmission line; steep terrain (e.g., 34° average)
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	4.2	AOA recommended no AIA: Survey confirms previously developed; modern business and transmission line; Hwy 99; east of highway steep terrain
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	15.3	AOA recommended no AIA: Survey confirms previously levelled for aggregate mining
District Lot 5208, Group 1, New Westminster District	015-825-663	9.8	AOA recommended AIA: Not surveyed; visual inspection determines property completely disturbed by previous shoreline industry and development
District Lot 5210, Group 1, New Westminster District	015-825-680	5.6	AOA recommended AIA: Survey determines entire bench above shoreline is built out and compacted, filled in for previous shoreline and industrial development; pet grave identified; concrete dock

Legal Description	PID/PIN	Area (ha)	Survey Results
			foundation recorded
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	1.3	AOA recommended no AIA: Survey confirms property previously mined for aggregate
District Lot 2617 Group 1 New Westminster District	010-025-677	14.8	AOA recommended AIA: Survey determines previously logged, impacted by transmission line, steep terrain (e.g., 26° average) ; portion of Britannia Mine waterline observed
District Lot 3717	015-896-170	18.2	AOA recommended AIA: Survey determined portions previously logged, including lands adjacent to Thistle Creek Historic waterline observed
District Lot 1583 Group 1 New Westminster District	010-026-151	49.1	AOA recommended AIA: Survey determined portions previously logged and mined for aggregate; some steep sections near shore; banks of Thistle and Daisy creeks impacted; bisected by Hwy 99 and railway; shoreline sections steep or impacted by 20 th century residential development: foundations from several Minaty Bay structures recorded; recent grave, believed to be of pet, identified
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	22.8	AOA recommended AIA: Survey determines property partially cleared for forestry; steep slopes; Daisy Creek vicinity deeply incised; Historic mining shaft identified

Legal Description	PID/PIN	Area (ha)	Survey Results
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	20.9	AOA recommended AIA: Survey identifies evidence of logging; steep terrain in parts
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on Plan LMP17053	010-025-774	20.8	AOA recommended AIA: Survey determines property bisected by Britannia Forest Service Road; previously logged; steep cliffs and rock walls; portions of former Britannia Mine waterline observed in two locations
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	20.9	AOA recommended AIA: Survey determines property bisected by Hwy 99; steep rock; historic and modern debris; remnants of Britannia Mine waterline

Historic mining and residential features and pet memorials identified in properties DL 4005, DL 2933, DL 3717, DL 2617, DL 1583, DL 5210, and DL 4012 are described in detail below.

5.1.1 DL 4005

An earthen and timber-framed historic mining shaft was identified in DL 4005 (Photos 1 and 2; Figure 2). The pit feature associated with the shaft was estimated to measure 10 m x 15 m in diameter at ground level and may have housed works for excavating the shaft. The pit was approximately 6 m deep, but the timber-framed portion of the shaft extended much deeper. An entryway was observed on its southwest side. The structure was flagged with AMEC No-work Zone tape and represents a falling hazard as it is not protected.



Photo 1. Abandoned pit feature in Property DL 4005.



Photo 2. Close-up of mine shaft.

5.1.2 DL 2933

The remnants of an approximately 140-m long section of the Britannia Mine waterline was observed along the southeastern edge and just east of this property (Photo 3; Figure 2). Remaining structures included wooden debris as well as coiled metal coils. Electrical cable was visible in one area.



Photo 3. Remnants of Britannia Mine water line in DL 2933.

5.1.3 DL 3717

The remnants of close to 350 m of discontinuous Britannia Mine waterline pass through this property, crossing both Thistle and Daisy Creeks. Approximately 23 m south from where the line was observed to cross Thistle Creek it passes through approximately 22 m of tunnel, which has been blasted through the bedrock (Photo 4; Figure 2). To the south, the waterline crossing of Daisy Creek was also observed in this section. Here the line has been suspended approximately 30 m above the deeply incised creek. Instead of the wooden pipe and metal coil remnants observed elsewhere, the remaining pipe is metal where it crosses Daisy Creek (Photo 5). Approximately 30 m east of this crossing is a piece of metal equipment, possibly a water control valve, with a concrete base, standing approximately 3 m high, with a base of approximately 1 m x 2 m (Photo 6). The metal plating on the equipment reads, "PEL Q4 12 in valve."



Photo 4. Waterline tunnel blasted through the rock near Thistle Creek in DL 3717.



Photo 5. Waterline crosses deeply incised channel of Daisy Creek in DL 3717.



Photo 6. Water control valve in DL 3717.

5.1.4 DL 2617

The Britannia Mine waterline continues from adjacent and southern Property 3717 north for at least 30 m into Parcel 2617, where it lies atop a small flat bench excavated into the otherwise steep granite (Photo 7; Figure 2).



Photo 7. Waterline on vegetated, cut-away granite in DL 3717.

5.1.5 DL 1583

DL 1583 is located on the shore of Howe Sound, and contains the remains of historic community Minaty Bay (Table 4; Figure 2).

Table 4. Historic Remains Observed in DL 1583

Structure	Estimated dimensions	UTM	Comments
Wood-lined subterranean structure	1.5 m x 1.5 m, ranging from 1-2 m deep	484588, 5495460	Possible root cellar, just south of Daisy Creek
Possible house foundation with retaining wall	10 m x 10 m	484567, 4595425	Sediments with gravels pushed up into rectangular shape above creek gully
Rock wall remnants	Not estimated	484486, 5495428	Some cement in piled formation; piece of engine observed nearby

Structure	Estimated dimensions	UTM	Comments
Possible house foundation	Not estimated	484475, 5495407	Stairs lead up to foundation from retaining wall; bathtub, chimney remnants observed in building remains
Possible house foundation	15 m x 20 m	484591, 5495482	Stone retaining wall and foundation; smaller foundation in front of house, possibly garage
Possible house foundation	10 m x 10 m	484604, 5495486	
Possible house foundation	10 m x 10 m	484658, 5495508	Near Daisy Creek
Old telephone or telephone pole	Not recorded	484642, 5495511	
Possible house foundation	Not recorded	484640, 5495489	Concrete foundation; evidence of indoor plumbing (i.e., water pipe)
Concrete subterranean structure	3 m x 4 m	484615, 5495600	Possible root cellar
Concrete subterranean structure	3 m x 2 m	484653, 5495642	Concrete retaining wall at shore nearby
Possible house foundation	10 m x 10 m	484668, 5495649	Wooden fence remnants remaining
Possible house foundation	8 m x 10 m	484686, 5495652	Evidence of plumbing
Concrete road	Not recorded	484729, 5595686	Lined with rows of fir; likely former access road for Minaty Bay homes
Possible outhouse	1 m x 1 m, 80 cm deep	484558, 5495402	Soft, spongy bottom

Structure	Estimated dimensions	UTM	Comments
Possible house foundation	10 m x 10 m	484588, 5495460	Nearby dense, ivy covered cement and a trail to the shore

Evidence of a grave, believed to be that of a pet, was observed (at 10 U 484720, 5495710) on the northern end of this parcel. The mound measured approximately 0.5 m x 0.5 m, and the wooden cross-stake was marked with the words “RIP Zorro 1994-2011.” (Photo 8; Figure 2)



Photo 8. Grave of pet named “Zorro”.

5.1.6 DL 5210

The recent grave or memorial of what is believed to be a pet was located in this parcel (10 U 484867, 5496201). The built-up stone cairn was accompanied with a laminated piece of paper with a poem and the words, “Bruce Gardner (Nov. 20 2012 – July 5 2012 [sic]) You were more than a pet, you were our best friend. Never forget you baby” (Photo 9; Figure 2).



Photo 9. Grave or memorial to pet named "Bruce Gardner".

The concrete foundation of what is likely a former elevated roadway to the shoreline was also recorded (Photo 10; Figure 2). Consisting of two capped pillars, the concrete structure measures approximately 8 to 10 m high and was likely associated with the former shipping dock for the Britannia Bay mine.



Photo 10. Concrete foundation of former Britannia Mine elevated roadway structure.

5.1.7 DL 4012

Remnants of the Britannia Mine waterline was observed in two locations, approximately 50 m apart, along the steep terrain of this parcel. They consisted of wood debris and metal coils (Photo 11; Figure 2).



Photo 11. Waterline remnants in DL 4012.

6.0 IMPACT ASSESSMENT

No archaeological sites were identified during the AIA and site inventory of the proposed South Britannia Project. Historic resources associated with the former Britannia Mine and South Britannia community were identified, but are not protected by the *HCA*.

7.0 DISCUSSION

No archaeological sites were identified during the field assessment of these properties, and the likelihood undiscovered sites would be encountered during construction-related activities is considered low or nil.

Previous development – aggregate and hard rock mining, forestry, residential, and hydroelectric – has impacted the South Britannia properties. Areas that have not been levelled, subject to aggregate mining or cleared of vegetation exhibit steep terrain, often on bedrock, limiting their potential for archaeological resources. The field assessment did identify the remnants of mining-related activity in several parcels. The remnants are associated with the federally-protected Britannia Mines Concentrator. Remnants of the mine's waterline were observed in four parcels –

District Lots 2933, 4012, 3717, and 2617. Remnants of the line may pass through other parcels – e.g., District Lots 4005, 1879, 1889 or 1981 – but were not observed during the field assessment, as terrain and the scope of the project did not allow for 100% survey coverage. A mine shaft was observed in DL 4005, and a large valve was observed in DL 3717. Waterline remnants in DL 3717 in particular demonstrate the difficult terrain facing those constructing ancillary mine structures and utilities in the early 20th century. Waterline remnants in this parcel include a tunnel blasted through the mountainside, and the suspension of the waterline over Daisy Creek. While they are not protected by the HCA, the mining remnants may have high significance to the local community and to the Britannia Mine Museum.

The remains of the community of Minaty Bay were also observed in DL 1583. These include house and building foundations, rock retaining walls, a road, a telecommunications pole, and several outstructures. Like the mining remnants, these structures are evidence of early 20th century life and industry along the Sea-to-Sky corridor. While associated with the protected historic site of DjRt-11 (the Briannia Mines Concentrator) they are not protected by the HCA. Like the mining remnants identified, the remnants of the community of Minaty Bay may also have high significance to the local community.

8.0 RECOMMENDATIONS

No archaeological sites were identified during the fieldwork for the South Britannia Project, and there are no previously identified archaeological sites in the project area. Several historical resources were identified during the AIA; however, none are protected by the HCA. Due to the Project's location in steep, levelled, or previously cleared terrain, the likelihood as-yet undiscovered archaeological sites are present is considered low. Therefore, it is recommended that:

1. No further archaeological work be required for the South Britannia project, as long as the Project footprint is not redesigned to include lands beyond those covered by the AIA.
2. Taicheng Development Corporation work with local stakeholders to preserve and/or record elements of local mining history which will be potentially impacted by development.

Even the most thorough examination may fail to reveal all archaeological remains that may exist within a study area. Therefore, it is recommended that:

3. In the event that unanticipated suspected subsurface or surface archaeological remains are encountered during land-altering activities associated with the Project development, all ground disturbance in the immediate vicinity be suspended at once and the Archaeology Branch and appropriate First Nations are promptly informed regarding the particulars of the archaeological resources encountered and the extent of the impacts. If suspected culturally modified trees are encountered, clearing activities should also be halted until a qualified archaeologist can be consulted.

9.0 LIMITATIONS AND CLOSURE

Information on archaeological resources and resource potential in the project area presented in this report are based on a time-limited review of relevant documents, a search of relevant databases housing recorded sites-specific data, and a field survey. Efforts were made to verify the accuracy of the data produced or provided by others and extracted from the literature and databases.

This assessment of archaeological potential is based on current understanding of the distribution of archaeological resources (sites and artifacts) in the general project area. AMEC acknowledges that knowledge and understanding of the archaeological record continues to evolve, and that ideas about site locations and distribution may change over time.

The findings and conclusions documented in this report have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care customarily exercised by archaeological professionals currently practising under similar conditions in this region. This study was conducted without prejudice to First Nations' treaty negotiations, Aboriginal rights, or Aboriginal title. Participation by Aboriginal communities in this study does not indicate support of the proposed development by those communities.

10.0 REFERENCES

AMEC

2012 Taicheng Development Corporation South Britannia Project, Britannia Beach, BC: Archaeological Overview Assessment. Report on file, AMEC Environment & Infrastructure, Burnaby, B.C.

Ames, K., and H. Maschner

1999 Peoples of the Northwest Coast: Their Archaeology and Prehistory. Thames & Hudson Ltd., London. Arcas Consulting Archeologists

1998 Squamish Forest District Woodlots: Archaeological Impact Assessments Final Report. (Permit 1997-340). Report on file, Archaeology Branch, Victoria, B.C.

2000 Garibaldi At Squamish, BC. Archaeological Overview Assessment. (Squamish Nation Archaeological Investigation Permit #98-0027). Report on file, Archaeology Branch, Victoria, B.C.

2002 Garibaldi At Squamish Ski Report Archaeological Impact Assessment Preliminary Results. (Heritage Inspection Permit 2000-317). Report on file, Archaeology Branch, Victoria, B.C.

2003 Squamish Forest District Archaeological Assessments. In 2002 Permit Report (Heritage Inspection Permit 2002-028 and Squamish Nation Archaeological Investigation Permit #02-0079). Report prepared for the Ministry of Forests – Squamish Forest District and the Evans Lake Forest Education Society. Report on file, Archaeology Branch, Victoria, B.C.

Archaeology Branch

1998 British Columbia Archaeological Impact Assessment Guidelines [3rd revised edition]. Ministry of Small Business, Tourism and Culture, Archaeology Branch, Victoria, B.C.

Armstrong, J.E.

1990 Vancouver Geology. Cordilleran Section, Geological Survey of Canada, Vancouver, B.C.

Billwiller, P.W.

1946 No. 8 Shaft, Britannia Mines. Western Miner 19:42-54.

Bouchard, R. and D. Kennedy

1976a Knowledge and Usage of Land Mammals, Birds, Insects, Reptiles and Amphibians by the Squamish Indian People of British Columbia. Report on file at the B.C. Indian Language Project, Victoria, B.C.

Bouchard, R. and D. Kennedy

1976b Knowledge and Usage of Fish, Beach Foods, and Marine Mammals by the Squamish Indian People of British Columbia. Report on file at BC Indian Language Project, Victoria, B.C.

Britannia Mine Museum

2014 Online Exhibits of the Museum: Over 100 Years of Micro Hydro, <http://www.britanniaminemuseum.ca/online-exhibits/over-100-years-of-micro-hydro> (Accessed January 30, 2014).

Bussey, J.

1982 Stage II Heritage Resource Impact Assessment B.C. Hydro and Power Authority Kelly - Cheekeye Transmission Line Project. (Heritage Inspection Permit 1982-0006). Report on file, Archaeology Branch, Victoria, B.C.

1990 Heritage Resource Update: Proposed Kelly Lake/Cheekeye 500 kV Transmission Line. (Heritage Inspection Permit 1989-38). Points West Heritage Consulting Ltd. Report on file, Archaeology Branch, Victoria, B.C.

Canada's Historic Places

2013 <http://www.historicplaces.ca/en/rep-reg/place-lieu.aspx?id=7561&pid=0> (accessed Sept. 3, 2013)

DeMarchi, D.A.

2011. The British Columbia Ecoregion Classification. Third Edition. Ecosystem Information Section, Ministry of the Environment, Province of British Columbia, Victoria. Available at: <http://www.env.gov.bc.ca/ecology/ecoregions>, Accessed Sept. 3, 2013.

Engineering & Mining Journal

1915 Fatal Snowslide at Britannia Copper Co.'s Mines – Special Correspondence. The Engineering & Mining Journal, 99(14):628.

Golder Associates

2004 Archaeological Impact Assessment For The Sea-to-Sky Highway Improvement Project Heritage Inspection Permit 2003-111 Squamish Nation Permit 03-001. Report on file, Archaeology Branch, Victoria, B.C.

Hill-Tout, C.

1978 The Salish People: The Contribution of Charles Hill-Tout, Volume III: The Mainland Halkomelem, edited by Ralph Maud. Talonbooks, Vancouver, .BC.

James, H.T.

1929 Britannia Beach Map-area, British Columbia. Geological Survey, Canada Department of Mines, Ottawa, Ontario, Ontario.

Journey, J.M., and J.W.H. Monger

1994 Geology and Crustal Structure of the Southern Coast and Intermontane Belts, Southern Canadian Cordillera, British Columbia [map]. Geological Survey of Canada, Open File. Ottawa, Ontario.

Mathews, W.H.

1975 Garibaldi Geology. Geological Association of Canada, Vancouver, B.C.

Matson, R.G. and G. Coupland

1995 Prehistory of the Northwest Coast. Academic Press, San Diego, California.

May, J. and S. Lucs

1976 South Coast Regional Survey: Vancouver Island and the Lower Fraser Valley. Report on file, Heritage Resource Centre, Ministry of Community, Aboriginal & Women's Services Victoria, B.C.

Ministry of Forests Research Branch

1994 Biogeoclimatic Units of the Vancouver Forest Region: Map Sheet 5 of 6, Southern Vancouver Island – Sunshine Coast, Ministry of Forests Research Branch, Victoria, B.C.

O'Hara, G.

2007 Technical Communication: Water Management Aspects of the Britannia Mine Remediation Project, British Columbia, Canada. Mine Water and the Environment 26: 46-54.

Pojar, J., K. Klinka, and D Demarchi

1991 Coastal Western Hemlock Zone. In Ecosystems of British Columbia, edited by D. Meidinger and J. Pojar, pp 95-112. Ministry of Forests Research Branch, Special Report Series 6, Victoria, B.C.

Quirolo, M.M. and L.C. Ham

1990 Archaeological Resource Overview of the Furry Creek Delta, Howe Sound, British Columbia. Prepared for Michael Geller & Associates/Tanac Development Canada Corp. (Permit #1990-133) Report on file with the Archaeology Branch, Victoria, B.C.

Ramsey, B.

1967 Britannia: Story of a Mine. Second Edition. Trafford Publishing. Victoria, B.C.

Reimer, R. (Yumks)

2011 The Mountains And Rocks Are Forever: Lithics And Landscapes of Skwxwú7mesh Uxwumixw Territory. Unpublished Ph.D. Dissertation, Department of Archaeology, Simon Fraser University, Burnaby, B.C.

Rickard, T.A.

1916 The Britannia Mine and Mill. Mining And Scientific Press 112:693-700.

Rollwagen, K.

2006 "That Touch of Paternalism": Cultivating Community in the Company Town of Britannia Beach, 1920-58. *BC Studies* (51): 39-67

Smith, H.I.

1907 Archaeology of the Gulf of Georgia and Puget Sound. *Publications of the Jesup North Pacific Expedition* 2(6); *Memoirs of the American Museum of Natural History*. 4(6):303-441, New York, New York.

South Britannia

2014a South Britannia Plan, <http://www.southbritannia.com/plan.html> (Accessed January 30, 2014).

2014b South Britannia Process, <http://www.southbritannia.com/process.html> (Accessed January 30, 2014).

2014c South Britannia Environment, <http://www.southbritannia.com/environment.html> (Accessed January 30, 2014).

Suttles, W.

1990 Central Coast Salish. In *Handbook of North American Indians*, Volume 7, Northwest Coast, edited by W. Suttles, pp.453-475. Smithsonian Institution, Washington, D.C.

Town, F.A.

2000 The Lively Ghost of Howe Sound. Bookus Press, Port Coquitlam, B.C.

2010 Before The Road Came. Smashwords. Available at: <http://www.smashwords.com/books/view/15962>; accessed October 5, 2012.

Turner, N.J.

1979 Plants in British Columbia Indian Technology. British Columbia Provincial Museum, Handbook No.38. Victoria, B.C.

Winram, P.

1975 A Report on the Howe Sound Archaeology Survey. Prepared for the Archaeological Sites Advisory Board (Permit #1975-11). Report on file with the Archaeology Branch, Victoria, B.C.

APPENDIX 1

Taicheng Development Corporation South Britannia Project, Britannia Beach, BC: Archaeological Overview Assessment

Taicheng Development Corporation South Britannia Project Britannia Beach, BC

Archaeological Overview Assessment

Submitted to:

Taicheng Development Corporation
West Vancouver, BC

Submitted by:

AMEC Environment & Infrastructure
a division of AMEC Americas Limited
Burnaby, BC

AMEC Project No. VE12405

Revision Log

Version	Date Issued	Description
1.0	31 October 2012	Draft report to Taicheng Development Corporation for review
1.1	1 November 2012	Comments back from Folio Hotel and Resort Architecture; report revised
1.2	9 November 2012	Final report to Taicheng Development Corporations (via Folio Hotel and Resort Architecture)

IMPORTANT NOTICE

This report was prepared exclusively for Taicheng Development Corporation by AMEC Environment & Infrastructure, a wholly owned subsidiary of AMEC Americas Limited. The quality of information, conclusions and estimates contained herein are consistent with the level of effort involved in AMEC services and based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used only by Taicheng Development Corporation, subject to the terms and conditions of its contract with AMEC. Any use of, or reliance on, this report by any third party is at that party's sole risk.

Abbreviations and Acronyms

Abbreviation	Definition
AOA	Archaeological Overview Assessment
AMEC	AMEC Environment & Infrastructure
BC	British Columbia
CMT	Culturally Modified Tree
ha	hectare
km	kilometre
m	metre

Executive Summary

An archaeological overview assessment was carried out by AMEC Environment & Infrastructure for the South Britannia Project, immediately south of Britannia Beach, on the east side of Howe Sound, B.C., for Taicheng Development Corporation.

The assessment concluded that there are no known archaeological sites on the subject properties. However, based on the results of the archaeological overview assessment there are properties within the South Britannia Project that have the potential for archaeological sites. In addition, information on cultural heritage resources (traditional places and land use) is available for several locations along the shoreline of Howe Sound within the development properties and remnants of the historic community of Minaty Bay may be present on the subject properties. Therefore, there is potential for developments within some of the subject properties to affect as yet undiscovered buried archaeological remains. To address these potential effects, it is recommended that:

- Subject properties assessed as having low-to-moderate or moderate-to-high archaeological potential: District Lot 1889, REM District Lot 2009, District Lot 1970 Group 1, District Lot 5208, District Lot 5210, District Lot 2617, District Lot 3717, District Lot 1583, District Lot 4005, District Lot 4008, District Lot 4012, and District Lot 2933; be subject to an Archaeological Impact Assessment (AIA) prior to development of these lots.
- No AIA is recommended for subject properties assessed as having low archaeological potential: East ½ District Lot 1981, Lot A Except: Part Dedicated Road On Plan BCP25632 – District Lot 2001 & 7053, Parcel 1 (Reference Plan 4878) of District Lot 2001, Lot A Except: part Dedicated Road on Plan BCP286651, District Lots 1583, 2001, 7934 Plan 21567, Parcel 1 (Reference Plan 4878) of District Lot 1583, Except Part On Plan 21576.

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1. Introduction

This report describes the results of an archaeological overview assessment (AOA) undertaken in August – November 2012 by AMEC Environment & Infrastructure (AMEC) at the request of Folio Hotel And Resort Architecture on behalf of the proponent, Taicheng Development Corporation, for 16 properties (collectively known as the South Britannia Project) immediately south of Britannia Beach, British Columbia (BC) (Figures 1 & 2; Table 1).

The objective of the assessment was to determine the potential effects of development within the subject properties on cultural heritage resources and determine if follow-up actions are required. Specific impacts from development activities were not assessed, as there are no detailed development plans currently available.

The 16 subject properties cover a total area of approximately 237.5 hectares (ha) south of Britannia Beach along the east shore of Howe Sound and include the abandoned community of Minaty Bay. The South Britannia Project extends from Britannia Beach south along the east shore of Howe Sound for approximately 2.7 kilometres (km) and extends inland for approximately 1.5 km (Figures 2 & 3). Currently no existing developments are situated on the South Britannia Properties though portions of the subject properties have been affected by industrial activities (aggregate mining) and residential settlement.

Table 1. South Britannia Project Properites

Legal Description	PID/PIN	Area (ha)
District Lot 1889 Group 1 New Westminster District	010-025-782	2.6
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	2.3
REM District Lot 4009	010-025-634	5.5
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	4.7
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	18.7
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	4.2
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	15.3

Table 1. South Britannia Project Properites

Legal Description	PID/PIN	Area (ha)
District Lot 5208, Group 1, New Westminster District	015-825-663	9.8
District Lot 5210, Group 1, New Westminster District	015-825-680	5.6
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	1.3
District Lot 2617 Group 1 New Westminster District	010-025-677	14.8
District Lot 3717	015-896-170	18.2
District Lot 1583 Group 1 New Westminster District	010-026-151	49.1
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	22.8
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	20.9
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on Plan LMP17053	010-025-774	20.8
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	20.9

2. Protection of Archaeological Resources in British Columbia

In British Columbia, most archaeological sites are attributable to settlement and resource use by First Nations' people, and if they pre-date AD 1846, are automatically protected from damage, desecration, alteration, or excavation by the *Heritage Conservation Act* (RSBC 1996, Chap. 187). Some sites are protected through designation as "Provincial Heritage Sites" under Section 9 of the *Heritage Conservation Act (HCA)*, or through automatic protection under Section 13 by virtue of particular historic or archaeological values. Sites automatically protected under Section 13 include:

- archaeological sites occupied or used before AD 1846;
- rock art with historical or archaeological value;
- burial places with historical or archaeological value;

- heritage shipwrecks or aircraft wrecks; and
- archaeological sites of unknown age, with a reasonable possibility of having been occupied or used before AD 1846.

Protected sites may be located on public or private land, and may not be altered (changed in any manner) without a permit issued under Sections 12 or 14 of the *HCA*. Additionally, archaeological sites of Aboriginal origin may be subject to interpretations of the Supreme Court of Canada decision in *Delgamuukw* vs. British Columbia (1997), regarding the fiduciary responsibility of provincial governments for protecting cultural heritage.

3. Objectives

To assist with the management of archaeological sites, the Archaeology Branch issued the *British Columbia Archaeological Impact Assessment Guidelines* (Archaeology Branch 1998). These *Guidelines* identify several kinds of archaeological assessments that may be undertaken in response to proposed developments, with the kind of assessment dependent on the stage of development design and the types of archaeological information required. The purpose of an overview assessment, based on the *Guidelines*, is to:

- identify lands that have the potential to contain archaeological resources, within the subject properties;
- identify potential conflicts between archaeological resources and the proposed development; and
- recommend additional studies or other measures to protect archaeological resources, if required.

Archaeological potential is defined as the capability of a landscape (or landform) for having supported the kinds of traditional activities in the past which would have resulted in the formation (and preservation) of archaeological remains. Potential ratings do not predict the probability of sites, but identify lands that should be examined by archaeologists in advance of development projects. Some kinds of traditional activities did not result in the formation of physical remains, and such activities usually cannot be considered in the context of an assessment of archaeological potential.

No heritage inspection permit was required for the assessment of archaeological resources for the South Britannia Project. Additional archaeological studies such as an archaeological impact assessment will require a Heritage Inspection Permit as defined in the *Heritage Conservation Act* (RSBC 1996, Chap. 187).

4. Archaeological Potential Assessment

The assessment of archaeological resource potential was based upon a consideration of the locations of documented archaeological sites, ethnographic and historic information, and topographical and biophysical characteristics that favourably influence the distribution of

archaeological sites. Because archaeological site locations are often correlated with particular micro-environmental attributes, the presence or absence of these variables can be used to identify lands with greater or lesser archaeological potential. The environmental variables considered for this overview study included:

- modern vegetation/forest cover;
- proximity to documented archaeological resources;
- presence of traditional resources (e.g., stone suitable for flaking, economic plants);
- proximity to aquatic features (e.g., streams, wetlands, open water);
- aspect (i.e., wind or solar exposure based on direction of slope);
- presence of fine-textured sediments and soil drainage quality;
- current understanding of traditional resource use and settlement by Aboriginal people;
- environmental settings of documented archaeological sites in the area; and
- integrity of the modern landscape as a reflection of historic land use practices.

5. Methods

The archaeological overview assessment included:

- background research, involving a review of regional historic, ethnographic, and archaeological literature describing research in the Howe Sound - Squamish area generally and Britannia Beach locality specifically;
- A search of the Provincial Heritage Register maintained by the Archaeology Branch of the Ministry of Forests, Lands and Natural Resource Operations, for recorded archaeological and historical sites in the vicinity of the development properties;
- A review of historic aerial photos of the immediate area obtained from the Department of Geography at the University of British Columbia, for information on historic land use and landscape integrity;
- A review of biological, topographical, and hydrological information for the subject properties provided by proponent;
- A brief field inspection of the subject properties, from Highway #99 and along the shoreline, to assess landscape integrity and potential for archaeological sites; this inspection was carried out on October 25, 2012; and
- Preparing this report on the results of the assessment.

The background research involved a review of archaeological reports and other literature in the AMEC library. Sources consulted are provided in Section 10 (References Cited). In addition, the *Archaeological Overview Assessment of the Squamish Forest District* (Millennia Research 1997) was reviewed online via RAAD. The background review sought general information on pre-Contact archaeology, traditional land use practices by First Nations' people in this area, and historic land-use and occupancy of the Britannia Beach locality.

In addition, a brief field reconnaissance was undertaken to take contextual photographs of the subject properties and evaluate the potential for archaeological sites based on the biophysical characteristics of the proposed development area visible from Highway #99. The reconnaissance took place on October 25, 2012, and was conducted by D. Geordie Howe (AMEC). The subject properties were visually inspected from Highway #99 for terrain features, drainage and disturbance factors.

6. Archaeological Overview Background Results

6.1 Study Area and Biophysical Setting

The proposed South Britannia Development Project is located on the east side of Howe Sound in the Southern Pacific Ranges Ecoregion, Pacific Ranges Ecoregion, of the Coast and Mountains Ecoprovince (Demarchi 2011). The topography of the project area is moderately to steeply sloping and rises from Howe Sound to approximately 365 m above sea level along its eastern boundary. Locations within the development properties that are relatively flat are the result of historic land altering activities. Two creeks, Thistle Creek and Daisy Creek, flow west through the development draining into Howe Sound. Another drainage, South Creek, is located immediately south of the south boundary of the development.

No archaeological sites are registered within the Provincial Heritage Register for the subject properties. Lands within the subject properties have not been subject to archaeological study previously and little archaeological work adjacent to the project area has occurred.

6.2 Modern Vegetation

The Project area is situated within the Submaritime variant, Very Wet Maritime Subzone of the Coastal Western Hemlock Zone (CWHvm1) (Ministry of Forests Research Branch 1994; Pojar et al. 1991). This zone is distinguished by the presence of low-lying moist areas interspersed between high elevation, well-drained, dry settings. The CWHvm1 subzone is characteristic of windward montane slopes up to 650 m asl, and has cool summers and mild wet winters with relatively little snow. Zonal sites are typically dominated by western hemlock and true fir (*Abies* spp.) with western redcedar (Green and Klinka 1994), while red alder is dominant on recently-disturbed sites.

Historic mineral exploration and mining, aggregate extraction, railroad and highway development, residential development, and timber harvesting within the South Britannia subject properties have altered natural vegetation patterns at this locality. Historic land altering activities have occurred in the project locality since the early 1900s and has been extensive. Natural regeneration consists mainly of western hemlock, western redcedar, and red alder with an understory comprised of salal, huckleberry, and salmonberry.

6.3 Geology

The Project area is situated in coastal mountainous terrain comprised of rocks attributable to the Coast Plutonic Complex (Roddick et al. 1979). The geology of the northern portion of the development area is typified by the Britannia Formation (slate) or basic, fragmental and massive volcanic or Jurassic porphyritic quartz diorite of the Coast Range Batholithic rocks for the southern portion (James 1929; Journeay and Monger 1994). Lower elevations south from Britannia Beach to Daisy Creek consist of recent alluvium and glacial drift, glacial till, and colluvium (Armstrong 1990; Mathews 1975). Quartz diorite is a coarsely-textured rock that would not have been an attractive lithic raw material for pre-Contact stone-tool makers. Although alluvial sediments are present in the low-elevation, the majority of lands affected by the Project display an upper organic layer comprised of acidic humus which is often present to a depth of 40 cm depth below surface, overlying either gravels or bedrock. The acidic sediments are often poorly drained or moist, and are not ideal for preserving organic archaeological remains (e.g., bone, wood).

6.4 Ethnographic Background

From European contact to the present, the South Britannia Project locality has been the traditional territory of the Squamish Nation (or *skxwúmish7úlh* in their own language) and the Tsleil-Waututh Nation, who speak different, but related languages that make up the Central Coast Salish linguistic family.

Suttles (1990) provides the most recent summary of Coast Salish culture in the Central Strait of Georgia region. Barnett (1955), Hill-Tout (1978), and Suttles (1987) are additional sources that are frequently cited.

Traditional Coast Salish society was characterized by a semi-sedentary lifestyle dependent upon fishing, gathering, and hunting for subsistence. The society was stratified and three classes of people were usually present; a large upper class, a smaller lower class, and a very small class of slaves. The primary socio-economic unit of Coast Salish society was the house group, each consisting of one or more extended families occupying a single plank house. Residence was usually with the man's family ("patrilocal"), while descent was reckoned bilaterally. Each house group owned its house, rights to resource harvesting sites, and ritual property including ancestral names, legends, songs and dances. Rights to these properties were acquired through inheritance and were normally held by the most important members of the household.

Coast Salish villages were usually comprised of one or more houses. Leadership was provided by a "council" of *siyam*, made up of the most respected family heads in the village. The prestige of the *siyam* was based on inherited social position and demonstrated abilities of leadership. Each village was linked through ties of marriage and kinship with other villages to form a social network without distinct boundaries. Marriages arranged between socially equal families in different villages helped to establish a co-operative system for resource procurement, including shared access to specific resource locations and shared labour.

Traditional population and settlement were contingent upon the availability and distribution of seasonally available food resources. These resources would have included anadromous (i.e., sea-run) fish (including coho and chum salmon, steelhead, and minor amounts of coastal cutthroat trout) in the permanent streams emptying into Howe Sound. Herring were taken for their roe, and rockfish, lingcod, and bottom fish such as flatfishes were also of considerable importance to the Coast Salish people. Intertidal marine resources such as clams and mussels were an important part of the diet, and the discarded shells of these creatures are among the principal constituents of coastal archaeological sites today.

Sea mammals were taken by specially-trained hunters, and included harbour porpoises, hair and harbour seals, and sea lions; the Pasley Island group south of Keats Island was especially renowned for sea lion hunting. Land mammals such as deer, elk, and bears were hunted, and mountain goats were a highly-prized specialty of Squamish hunters. Small game and fur-bearing mammals, including beaver, muskrat, otters, and mink, were hunted or trapped from aquatic settings, while other species like marmots were taken in montane, parkland environments. The broad foreshore on the western side of lower Howe Sound would have been important habitat for waterfowl such as ducks and geese.

Numerous plant resources were utilized, including (i) red and yellow cedar trees for timber and bark, and other tree species for firewood and medicinal purposes; (ii) terrestrial plants such as chokecherries, huckleberries, blueberries, and deerberries, were used for food; (iii) aquatic plants such as cranberries and wapato, were also used for food, and cat-tails, for mat-weaving; and (iv) medicinal and edible-root plants in forested and wetland environments. Turner (1975, 1979) provides detailed descriptions of the traditional uses of plants by First Nations' peoples in this region, while Bouchard and Kennedy (1976a, 1976b) provide specific information about utilization of terrestrial and marine food resources by Squamish people.

In addition to economic pursuits, individuals pursued spirit quests throughout their communities' territory, to acquire powerful or helpful spirits. Frequently overlooked by archaeologists, spirit-quest sites leave little trace of their presence, in comparison to resource exploitation sites like shellfish harvesting camps or forest utilization sites.

It is important to note that not all aspects of traditional First Nations' cultures are recorded in the anthropological and ethnohistoric literature. Additional knowledge of traditional culture and lifeways still exists in many contemporary First Nations' communities. Furthermore, Aboriginal societies underwent significant changes as a result of their contact with Europeans, and some cultural aspects reported in the literature may not accurately reflect that culture prior to contact.

6.5 Archaeological Background

An archaeological site is a location containing physical evidence of past human activity in the form of artifacts or cultural features. Artifacts are human-made or modified objects, such as stone and bone tools, ceremonial objects, and fire-altered rocks. Cultural features are

modifications to the landscape or objects which cannot be moved without altering them, such as burials, culturally modified trees (CMTs), rock art, cabins and structures, trails and roads, and the remains of industrial activities.

The age at which artifacts and features become an “archaeological site” is arbitrary, and can be defined according to particular research or management objectives. Those sites that clearly post-date the arrival of Europeans or are documented by written records are called “historic archaeological sites”.

Archaeological sites are numbered according to the Borden Site Designation Scheme (Borden 1952) used throughout Canada. This scheme is based on the maps of the National Topographic System and uses latitude and longitude to indicate a site location within 10'. The four alternating upper and lower case letters (e.g., DjRt) designate a unique 10' latitude by 10' longitude “Borden Unit.” Sites are numbered sequentially within a Borden Unit based (usually) on their date of discovery (i.e., DjRt-2 would be the second site recorded in the DjRt Borden Unit).

General syntheses of Pacific Northwest archaeology in British Columbia include Ames and Mashner (1999), Borden (1970, 1975), Carlson (1983), Fladmark (1982), Matson and Coupland (1995) and Mitchell (1990). Regional archaeological survey reports reviewed for this AOA include Arcas (1995, 1998, 2000, 2002, 2003), Bussey (1982, 1990), May and Lucs (1976), and Winram (1975). Archaeological excavation reports include Arcas (1995) and Reimer (2011). A general archaeological overview for the Squamish Forest District was also reviewed for this study (Millennia Research 1997. Historic sources included Armitage (1997) and Town (2010).

6.5.1 Archaeological Site Types

An archaeological site is defined as a location containing physical evidence of past human activity in the form of artifacts or features. Typical sites in the Project locality and Howe Sound region can include one or more of the following:

- **Middens**, most often situated near marine shorelines, are deposits of mollusc shell, fire-altered rocks, charcoal, and faunal remains (butchered mammal, bird, and fish bones), representing the locations of village sites or resource harvesting camps. Middens in the upper reach of Howe Sound and inland along major rivers have a lower frequency of shellfish remains in a matrix of black anthropogenic loam.
- **Artifact scatters** are comprised of clusters of (usually) stone artifacts, including expedient or formed tools and the waste products of tool manufacture (debitage). Most artifact scatters represent transitory use of the landscape, and are often associated with the exploitation of particular resources.
- **Burial places** are locations where First Nation communities interred their dead, commonly within village middens, but also throughout their territories for individuals who expired away from permanent village sites. In more recent times, the dead were interred above ground at special locations such as bedrock overhangs or earthen mounds.

- **Rock art** sites are locations of non-portable Aboriginal art, either painted (pictographs) or pecked into stone (petroglyphs). Rock art sites are typically found on bedrock outcrops or large boulders, usually along steep shorelines or at locations of strong spiritual significance to First Nations people.
- **Fish traps/weirs** are found on river bars or in creeks and streams supporting runs of sea-run salmonids and other fishes.
- **Wetsites** are found in permanently saturated or waterlogged locations, which allow preservation of organic materials (including wooden artifacts) that would otherwise decay rapidly.
- **Forest utilization sites** consist of one or more culturally modified trees (CMTs), which are trees that have been intentionally altered by First Nations' people. Coastal CMTs are of two basic types: bark-stripped trees and aboriginally-logged trees (Archaeology Branch 2001). The former result from bark collecting, whereas the latter were produced during timber procurement. Aboriginally-logged trees can be divided into different types, including: logged stumps of various kinds, standing test hole trees, plank-stripped trees, plank-stripped logs, and canoe blanks. The majority of CMTs will occur within 500 m of the coastline or a major watercourse, on well-drained, level ground to hillsides, and in old-growth forest stands containing straight-grained cedar trees.
- **Historic Sites:** Post-Contact remains, including artifacts, structures, and features associated with Euro-Canadian or Asian-Canadian settlement and land use.

6.5.2 Overview of Regional Prehistory

The development locality is situated within the Northwest Coast Culture Area, which encompasses the west coast of North America from southeastern Alaska to southern Oregon (Ames and Maschner 1999; Matson and Coupland 1995). Archaeologists have defined a sequence of pre-Contact cultures in this area, based on site investigations in Howe Sound and Burrard Inlet, the Fraser Valley, the east coast of Vancouver Island and southern Gulf Islands, and in Whatcom County and on the San Juan Islands in Washington State. Recent summaries of regional prehistory are Ames and Maschner (1999), Matson and Coupland (1995), Mitchell (1990), and Moss (2011). Researchers have noted continuities in the reliance on marine resources, woodworking technology, ceremonialism, status, and the acquisition of wealth. Based on diagnostic artifact types and technologies, as well as inferred economic, social and other cultural traits, five distinct cultural periods are identified:

- Lithic or Old Cordilleran (ca. 8,500 - 5,000 years Before Present or B.P.);
- Charles (ca. 6,500 - 3,200 B.P.);
- Locarno Beach (ca. 3,200 - 2,400 B.P.);
- Marpole (ca. 2,400 - 1,600 B.P.); and
- Strait of Georgia (ca. 1,600 - 200 B.P.).

6.5.2.1 Archaeological Research near Squamish

Parts of the Howe Sound and the Squamish River valley have been inspected by archaeologists since the early 20th century. The earliest archaeological investigations near Squamish were initiated at the turn of the century by Charles Hill-Tout (1978); later, Harlan Smith (1907) investigated a pictograph at Furry Creek. Since that time, numerous archaeological surveys have been conducted in the area, often in the form of assessments for proposed forestry, road, residential-commercial, and other developments (e.g., Arcas Consulting Archeologists 1998, 2000, 2002, 2003; Golder Associates (2004); May and Lucs 1976; Quirolo and Ham 1990; Reimer 2011; Winram 1975). Of particular note are several studies for BC Hydro transmission lines to the Cheekye substation that examined several route options in the study area (Bussey 1982, 1990). These studies and others have resulted in the identification of approximately 25 archaeological sites in the northern Howe Sound region.

The distribution and frequency of known sites is not necessarily believed to be representative of the archaeological resources in the area as a whole. Archaeological inventories and impact assessment surveys have, by and large, been restricted to development locations, and large landscape units have not been examined systematically.

6.5.2.2 Archaeological Sites near the South Britannia Project

At the time this AOA was undertaken, no archaeological sites had been recorded within the proposed development properties. A search of the Provincial Heritage Register database indicated that seven documented archaeological sites are situated within 8 km of the Project (Figure 1):

- the nearest recorded archaeological site to the subject properties is DjRt-2, a pictograph site, located approximately 2.7 km south at Furry Creek
- the next nearest site is DjRt-10, another pictograph site near Browning Lake approximately 3.4 km north

Additional archaeological sites within 10 km of the development include:

- DjRt-7 (a lithic scatter on the beach) approximately 5.3 km north-northwest
- DjRt-5, a lithic scatter on Defense Islands 6.6 km south-southwest
- DjRt-6, a midden site at Potlatch Creek, located 8.6 km southwest; respectively of the development properties.
- DkRs-6 is situated near the mouth of the Stawamus River on Mamquam Blind Channel, approximately 9.0 km north-northeast of the development. This site is the traditional village of *Stawamus* and has been subject to archaeological investigations for the Squamish Nation (Arcas 1995)

- DkRs-10 is located approximately 9.1 km northeast of the Project within the Olesen Creek drainage, and is a rock shelter/lithic scatter situated in an alpine setting.

The closest archaeological sites north of the Project are situated approximately 3.4 km north-northwest of the Mamquam River (DkRs-9, isolated find) and on the west side of the Squamish River, opposite the mouth of the Mamquam River (DkRs-5, historic cemetery). Additional archaeological sites are present along the banks of the Squamish and Cheakamus River and south along the shore of Howe Sound. The majority of sites located within 8 km of the proposed development are located in one of two environmental settings: 1) low-elevation locations along Howe Sound and the Squamish River; or 2) in the subalpine zone in the local mountains.

One historic site, the Britannia Beach National Historic Site (DjRt-11 – Britannia Mines Concentrator), is situated immediately north of the northern boundary of the subject property and was designated a National Historic Site in 1987.

7. Archaeological Overview Assessment Results

The archaeological overview assessment of the subject properties observed that the terrain within the subject properties is generally well-drained, reaching their highest elevation along the eastern and southern margins, with relatively level or undulating terrain backed by moderate to steeply sloping terrain. Vegetation varies from sparse in relatively open gravel fields to dense re-growth consisting of western hemlock, western redcedar, and some Douglas-fir. Two southeast-northwest trending creeks (Thistle and Daisy) run through the central portion of the subject properties, and based on an historical aerial photo review it appears that they were rechanneled during the operations of the various aggregate pits (Figure 3; Table 2).

Based on the historic airphoto review, extensive deforestation or ground altering activities have occurred within the majority of the properties: However, some properties adjacent to or in proximity to Howe Sound and/or Thistle and Daisy Creeks, with minimum to moderate historic disturbance, are assessed as having low-to-moderate or moderate-to-high archaeological potential (Figures 2 & 3; Table 2).

Given the extent of previous disturbance observed during the historic airphoto review, the possibility of as-yet undiscovered archaeological sites is considered to be low within the remaining lots of the Britannia South properties.

Second or third growth western redcedar is present within the forested portions of the subject properties. Western redcedar was an important source of bark and wood for First Nations people in the past, and cedar bark continues to be collected for ritual and other purposes. Western redcedar exhibiting physical modifications such as scars from bark-stripping, are called CMTs. Based on the forest clearing observed within the subject properties during the review of historic airphotos and the site visit, it is unlikely that CMTs would be present within the subject properties, except for the point of land within District Lot 2925 extending into Howe Sound, which appears to still retain large trees.

Historic aerial photo review: A review of historic aerial photographs, obtained from the Geographic Information Centre at the University of British Columbia, was undertaken to assess the intensity of past land-altering activities within the subject properties. Various land-altering activities have occurred within the South Britannia Project area over the last 106 years including: the development and operations of the Britannia Mine, aggregate extraction operations, construction of the Pacific Great Eastern Railway (subsequently BC Rail and now CN Rail); construction of residential and mining buildings including the community of Minaty Bay; road building, including the Sea To Sky Highway (Highway #99), and intensive logging and vegetation clearing associated with the above activities. For a detailed review of land-altering activities observed during the historic aerial review see *Appendix A*.

First Nation traditional use: The development property lies within the traditional territory of the Squamish Nation and the Tsleil-Waututh Nation. The Squamish Nation has reserves around Howe Sound and in the Squamish River valley and the Tsleil-Waututh Nation reserves are in Burrard Inlet and Indian Arm.

An early source for Squamish land use for the study area is *Conversations With Khahtsahlano 1932 -1954* by Major J.S. Matthews (1955). During those years, Matthews, who was archivist for the City of Vancouver, conducted extensive interviews with Chief Khatsahlano. The beach within the subject properties is referred to as *Huey-qwah-lahun* by Chief Khahtsahlano, and he goes on to add that it was:

“A good, sheltered bay with gravel beach and creek, a mile south of Britannia Beach. A dozen or more small cottages—shacks—ranged in a row along the shore between an extensive grove of alders and the water. The exact location of *Huey-qwah-lahun* (meaning: “A lot of little trout”) is where the creek empties into the sea. Immediately to the south is a small knoll. It is on D.L. 2925.” (1955:427).

Randy Bouchard and Dorothy Kennedy in their *Squamish Indian Band Land Use And Occupancy Study* (1986) prepared for the Squamish Nation state that the general name for Britannia Beach was *Shisháyu7áy* though they go on to say that some Squamish specifically locate this name at the mouth of Daisy Creek (Bouchard and Kennedy 1986:259). One of Bouchard and Kennedy’s major Squamish sources, Louis Miranda, noted that the mouth of Daisy Creek was a good camping spot (1986:259) and he also pointed out that people did not fish in Daisy Creek (1986:259). In addition, Louis Miranda also mentioned that “shacks” used to be near the mouth of the creek (Bouchard and Kennedy 1986:259).

Currently, along the Sea To Sky Highway (Highway #99), roadside kiosks and signs provide the Cultural Journey Sea-To-Sky Highway Route (Squamish Lilwat Cultural Centre). One such sign identifies Britannia Creek as *Shisháyu7áy*.

Archaeological Sites: No archaeological sites have been identified and recorded for the South Britannia Project. However, archaeological sites have been identified in similar environments elsewhere for the Howe Sound – Squamish area.

Historic heritage sites and properties: One historic heritage resource, the Britannia Beach National Historic Site (DjRt-11 – Britannia Mines Concentrator), is situated immediately to the north of the subject property and was designated a National Historic Site in 1988.

Britannia Beach Mine

The original copper claim was discovered in 1888 by Dr. Alex Forbes and by 1905 was in operation as the Britannia Mining and Smelting Company. Eventually the operations consisted of four adjoining mines and associated mills. Two communities formed in association with the mine operations, the town site at Britannia Beach (or the Beach) and further up the valley at Tunnel Camp and later Mount Sheer (Billwiller 1946; Engineering & Mining Journal 1915; Rickard 1916; Ramsey 1967). Various owners operated the mine over its years of operation until it finally closed in 1974. The following year the BC Museum of Mining opened and the mines were declared a National Historic Site in 1988 (Ramsey 1967; Town 2000, 2012).

Minaty Bay

Information on the community of Minaty Bay (situated within District Lot 1583 and shown on Figure 1 (from the National Topographic mapsheet Squamish 93G/11 Edition 2) is extremely sparse. Ramsey mentions that “around 1925 settlement began at Minaty Bay...At first the only way to get to the Bay was by boat...A trail was ultimately put in the Beach to allow the isolated Minaty Bay residents to join in the social activities which went on at the Beach and at the Townsite...In 1944 a road was put in and supplies were brought in by company truck” (Ramsey 1967:127). The Britannia Beach Sheet (Map 199A) accompanying James’ *Britannia Beach Map-area, British Columbia* (1929) dating to 1925 shows no structures or other features at Minaty Bay. A pipeline, providing water from Furry Creek to Britannia Beach, is shown at the eastern boundary of the recent alluvium and glacial drift deposits paralleling the western limit of the Britannia Formation.

Florida Ann Town, in her book *The Lively Ghost of Howe Sound* (2000), provides some additional information on Minaty Bay, as she lived “outside of Britannia Beach, at Minetta (sic) Bay, right on the water” from the late 1940s to the 1960s (Town 2012:8).

“In the mid-thirties, a group of workers banded together and threatened to walk out if the company could not find living quarters for their families and let them enjoy more normal lives. The men were given their pick of sites around Minaty Bay. There were responsible for clearing the land, and for building their homes. The company co-operated to the extent of providing materials (although their cost was deducted from the men’s pay cheques) but did not provide assistance with construction. They also charged a \$1 per month fee for land usage. Presumably, this arrangement would prevent residents from claiming squatter’s rights on the land”. (Town 2000:79)

Town goes on to add that with the construction of the PGE and then the highway (Highway #99) “Some Beach houses, especially those in the Minaty Bay area, were torn down, others moved” (Town 2000:109). A photograph in Ramsey’s *Britannia: The Story of A Mine* (1967:134) shows numerous houses along the waterfront at Minaty Bay in 1966. However, by the early 1990s little remained of the community of Minaty Bay.

Table 2. South Britannia Project Properties AOA Results

Legal Description	PID/PIN	Landscape Integrity - Rationale
District Lot 1889 Group 1 New Westminster District	010-025-782	Moderate historic disturbance except for northern portion; potential for CMTs and habitation sites (rock shelters) in northern portion
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	Moderate to intensive historic disturbance; low potential for archaeological sites
REM District Lot 4009	010-025-634	Moderate to intensive historic disturbance to south half of lot; potential for CMTs and habitation sites (rock shelters) in northern portion
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	Moderate to intensive historic disturbance; low potential for archaeological sites; see Photos 1, 2, & 3
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	Moderate to intensive historic disturbance to south half of lot; potential for CMTs and habitation sites (rock shelters) in northern portion; see Photos 1, 2, 3, & 4
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	Intensive historic disturbance; low potential for archaeological sites
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	Intensive historic disturbance; low potential for archaeological sites
District Lot 5208, Group 1, New Westminster District	015-825-663	Moderate historic disturbance; shoreline property; potential for archaeological sites (intertidal and along shoreline)
District Lot 5210, Group 1, New Westminster District	015-825-680	Moderate historic disturbance; shoreline property; potential for

Table 2. South Britannia Project Properties AOA Results

Legal Description	PID/PIN	Landscape Integrity - Rationale
		archaeological sites (intertidal and along shoreline)
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	Intensive historic disturbance; low potential for archaeological sites; see Photo 4
District Lot 2617 Group 1 New Westminster District	010-025-677	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs, habitation/rock shelters) in undisturbed contexts within northern portion
District Lot 3717	015-896-170	Minor to moderate historic disturbance to lot; potential for archaeological sites (CMTs, habitation/rock shelters); Thistle Creek and Daisy Creek flow through lot
District Lot 1583 Group 1 New Westminster District	010-026-151	Intensive historic disturbance to majority of lot; used as aggregate quarry and Minaty Bay townsite; low to moderate potential for archaeological sites in undisturbed locations and/or forested locations within lot and along shoreline; see Photo 5
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	Minor to moderate historic disturbance to lot; potential for archaeological sites (CMTs and habitation/rock shelters); Daisy Creek flows through portion of lot
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs and habitation/rock shelters) in northeastern portion of lot
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on	010-025-774	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs and

Table 2. South Britannia Project Properties AOA Results

Legal Description	PID/PIN	Landscape Integrity - Rationale
Plan LMP17053		habitation/rock shelters) in undisturbed portions of lot
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	Moderate to intensive historic disturbance to majority of lot; potential for archaeological sites (CMTs and habitation/rock shelters) in undisturbed portions of lot

8. Conclusions and Recommendations

There are no known archaeological sites identified on the subject properties. However, based on the results of the archaeological overview assessment there are properties within the South Britannia Project that have the potential for archaeological sites. In addition, information on cultural heritage resources (traditional places and land use) is available for several locations along the shoreline of Howe Sound within the development properties and remnants of the historic community of Minaty Bay may also be present on the subject properties. Therefore, there is potential for development within some of the subject properties to affect as yet undiscovered buried archaeological remains (Table 3). To address these potential effects, it is recommended that:

- Subject properties assessed as having low-to-moderate or moderate-to-high archaeological potential: District Lot 1889, REM District Lot 4009, District Lot 1970 Group 1, District Lot 5208, District Lot 5210, District Lot 2617, District Lot 3717, District Lot 1583, District Lot 4005, District Lot 4008, District Lot 4012, and District Lot 2933; be subject to an Archaeological Impact Assessment (AIA) prior to development of these lots.
- No AIA is recommended for subject properties assessed as having low archaeological potential: East ½ District Lot 1981, Lot A Except: Part Dedicated Road On Plan BCP25632 – District Lot 2001 & 7053, Parcel 1 (Reference Plan 4878) of District Lot 2001, Lot A Except: part Dedicated Road on Plan BCP286651, District Lots 1583, 2001, 7034 Plan 21567, Parcel 1 (Reference Plan 4878) of District Lot 1583, Except Part On Plan 21576.

Table 3. South Britannia Project Properties AOA Recommendations

Legal Description	PID/PIN	AOA Result (Archaeological Site Potential)	Recommendation
District Lot 1889 Group 1 New Westminster District	010-025-782	Low to moderate potential	AIA
East 1/2 District Lot 1981 Group 1 New Westminster District	010-025-812	Low potential	No further archaeological work
REM District Lot 4009	010-025-634	Low to moderate potential	AIA
Lot A Except: Part Dedicated Road On Plan BCP25632 District Lot 2001 & 7053 Group 1 New Westminster District Plan 20309	006-646-921	Low potential	No further archaeological work
District Lot 1970 Group 1 New Westminster District Except Those Portions Lying Within the Boundaries of District Lots 1583 and 2001	010-025-863	Low to moderate potential	AIA
Parcel 1 (Reference Plan 4878) of District Lot 2001 Group 1 New Westminster District Except Part on Plan 21576	010-025-901	Low potential	No further archaeological work
Lot A Except: Part Dedicated Road on Plan BCP286651, District Lots 1583, 2001 & 7034 Plan 21576	010-077-227	Low potential	No further archaeological work
District Lot 5208, Group 1, New Westminster District	015-825-663	Moderate to high potential	AIA
District Lot 5210, Group 1, New Westminster District	015-825-680	Moderate to high potential	AIA
Parcel 1 (Reference Plan 4878) of District Lot 1583 Group 1 New Westminster District Except Part On Plan 21576	010-025-952	Low potential	No further archaeological work
District Lot 2617 Group 1 New Westminster District	010-025-677	Low to moderate potential	AIA

Table 3. South Britannia Project Properties AOA Recommendations

Legal Description	PID/PIN	AOA Result (Archaeological Site Potential)	Recommendation
District Lot 3717	015-896-170	Low to moderate potential	AIA
District Lot 1583 Group 1 New Westminster District	010-026-151	Moderate to high potential	AIA
District Lot 4005 Group 1 New Westminster District Except Firstly: Portion Dedicated Road on Plan LMP17054, Secondly Part On Plan BCP29234	010-025-740	Low to moderate potential	AIA
District Lot 4008, Group 1 New Westminster District Except: Firstly: Part on Highway Plan 76, Secondly: Part On Plan BCP29235	010-025-766	Low to moderate potential	AIA
District Lot 4012, Group 1 New Westminster District Except Portions Decicated Road on Plan LMP17053	010-025-774	Low to moderate potential	AIA
District Lot 2933 Group 1 New Westminster District Except Firstly: Portion In Highway Plan 76 Secondly: Part On Statutory Right Of Way Plan LMP9997 Thirdly: Portion Dedicated Roan on Plan LMP17053, Fourthly: Part On Plan BCP29233	010-025-715	Low to moderate potential	AIA

9. Limitations and Closure

Information on archaeological resources and resource potential in the subject properties presented in this report are based on a time-limited review of relevant documents, a search of relevant databases housing recorded sites-specific data, an historical aerial photograph review, and a brief field visit on October 25, 2012. Efforts were made to verify the accuracy of the data produced or provided by others and extracted from the literature and databases.

This assessment of archaeological potential is based on current understanding of the distribution of archaeological resources (sites and artifacts) in the general project area. AMEC acknowledges that knowledge and understanding of the archaeological record continues to evolve, and that ideas about site locations and distribution may change over time.

The findings and conclusions documented in this report have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care customarily exercised by archaeological professionals currently practising under similar conditions in this region. This study was conducted without prejudice to First Nations' treaty negotiations, Aboriginal rights, or Aboriginal title. Participation by Aboriginal communities in this study does not indicate support of the proposed development by those communities.

We trust that this report has provided you with the information you require. If you have any questions or comments, please contact Geordie Howe at (604) 295-6182.

**AMEC Environment & Infrastructure
a division of AMEC Americas Limited**

Prepared by:

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10. References Cited

- Ames, K., and H. Maschner
1999 *Peoples of the Northwest Coast: Their Archaeology and Prehistory*. Thames & Hudson Ltd., London.
- Arcas Consulting Archeologists
1995 *Archaeological Investigations in Traditional Squamish Territory 1989-1992. (Permits 1990-32 and 1990-89)*. Report on file, Archaeology Branch, Victoria, BC.
- 1998 *Squamish Forest District Woodlots: Archaeological Impact Assessments Final Report. (Permit 1997-340)*. Report on file, Archaeology Branch, Victoria, BC.
- 2000 *Garibaldi At Squamish Squamish, B.C. Archaeological Overview Assessment. (Squamish Nation Archaeological Investigation Permit #98-0027)*. Report on file, Archaeology Branch, Victoria, BC.
- 2002 *Garibaldi At Squamish Ski Report Archaeological Impact Assessment Preliminary Results. (Heritage Inspection Permit 2000-317)*. Report on file, Archaeology Branch, Victoria, BC.
- 2003 *Squamish Forest District Archaeological Assessments In 2002 Permit Report. (Heritage Inspection Permit 2002-028 and Squamish Nation Archaeological Investigation Permit #02-0079)*. Report prepared for the Ministry of Forests – Squamish Forest District and the Evans Lake Forest Education Society. Report on file, Archaeology Branch, Victoria, BC.
- Archaeology Branch
1998 *British Columbia Archaeological Impact Assessment Guidelines [3rd revised edition]*. Ministry of Small Business, Tourism and Culture, Archaeology Branch, Victoria, B.C.
- 2001 *Culturally Modified Trees of British Columbia: A Handbook for the Identification and Recording of Culturally Modified Trees [version 2.0]*. Archaeology Branch and Resources Inventory Committee, Province of British Columbia. Available on the Internet at <http://www.for.gov.bc.ca/ric>.
- Armitage, D.
1997 *Around the Sound: A History of Howe Sound-Whistler*. Harbour Publishing, Madeira Park, BC.
- Armstrong, J.E.
1990 *Vancouver Geology*. Cordilleran Section, Geological Survey of Canada, Vancouver, BC.
- Backus, H.F.
1969 *Tomboy Pride*. A Woman's Personal Account of Life in Mining Camps of the West Pruett, Boulder, Co.
- Barnett, H.G.
1955 *The Coast Salish of British Columbia*. University of Oregon, Eugene (reprinted 1975 by Greenwood Press Publishers, Westport, Connecticut).
- Billwiller, P.W.
1946 No. 8 Shaft, Britannia Mines. *Western Miner* 19:42-54.

Borden, C.E.

- 1952 A uniform site designation scheme for Canada. *Anthropology in British Columbia* 3: 44-48.
- 1970 Cultural History of the Fraser River-Delta Region: An Outline. In *Archaeology of British Columbia, New Discoveries*, edited by R.L. Carlson. B.C. Studies, Special Issue 6-7:95-112.
- 1975 *Origins and Development of Early Northwest Coast Culture to about 3000 BC*. National Museum of Man Mercury Series, Archaeological Survey of Canada, Paper No. 45. Ottawa, Ontario.

Bouchard, R. And D. Kennedy

- 1986 *Squamish Indian Band land Use And Occupancy Study*. Prepared for the Squamish Nation, on file with the Squamish Nation, North Vancouver, BC.
- 1976a *Knowledge and Usage of Land Mammals, Birds, Insects, Reptiles and Amphibians by the Squamish Indian People of British Columbia*. Report on file at B.C. Indian Language Project, Victoria, BC.
- 1976b *Knowledge and Usage of Fish, Beach Foods, and Marine Mammals by the Squamish Indian People of British Columbia*. Report on file at B.C. Indian Language Project, Victoria, BC.

Bussey, J.

- 1982 *Stage II Heritage Resource Impact Assessment B.C. Hydro and Power Authority Kelly - Cheekeye Transmission Line Project*. (Heritage Inspection Permit 1982-0006). Report on file, Archaeology Branch, Victoria, BC
- 1990 *Heritage Resource Update: Proposed Kelly Lake/Cheekeye 500 kV Transmission Line*. (Heritage Inspection Permit 1989-38). Points West Heritage Consulting Ltd. Report on file, Archaeology Branch, Victoria, BC.

Carlson, R.L.

- 1983 Prehistory of the Northwest Coast. In *Indian Art Traditions of the Northwest Coast*, edited by R.L. Carlson, pp. 13-31. Archaeology Press, Simon Fraser University, Burnaby, BC.

Demarchi, D.A.

- 2011 *The British Columbia Ecoregion Classification. Third Edition*. Ecosystem Information Section, Ministry of the Environment, Province of British Columbia. Victoria. Available at: <http://www.env.gov.bc.ca/ecology/ecoregions/>; accessed October 5, 2012.

Engineering & Mining Journal

- 1915 Fatal Snowslide at Britannia Copper Co.'s Mines – Special Correspondence. *The Engineering & Mining Journal*, 99(14):628.

Fladmark, K.R.

- 1982 An introduction to the prehistory of British Columbia. *Canadian Journal of Archaeology* 6:95-156.

Friesen, D.E.

- 1980 *Heritage Resource Assessment of the Proposed Westcoast Transmission Company Limited Vancouver Island Gas Pipeline Williams Lake to Comox and Squamish Lateral*. (Ministerial Order 1980-0001). Report on file, Archaeology Branch, Victoria, BC.

Golder Associates

2004 *Archaeological Impact Assessment For The Sea-to-Sky Highway Improvement Project Heritage Inspection Permit 2003-111 Squamish Nation Permit 03-001*. Report on file, Archaeology Branch, Victoria, BC.

Green, R.N., and K. Klinka

1994 *A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region*. Ministry of Forests, Land Management Handbook No. 28. Victoria, BC.

Hill-Tout, C.

1978 *The Salish People: The Contribution of Charles Hill-Tout, Volume III: The Mainland Halkomelem*, edited by Ralph Maud. Talonbooks, Vancouver, BC.

James, H.T.

1929 *Britannia Beach Map-area, British Columbia*. Geological Survey, Canada Department of Mines, Ottawa, Ontario, Ontario.

Journeyay, J.M., and J.W.H. Monger

1994 *Geology and Crustal Structure of the Southern Coast and Intermontane Belts, Southern Canadian Cordillera, British Columbia [map]*. Geological Survey of Canada, Open File. Ottawa, Ontario.

Mathews, W.H.

1975 *Garibaldi Geology*. Geological Association of Canada, Vancouver, BC.

Matson, R.G. and G. Coupland

1995 *Prehistory of the Northwest Coast*. Academic Press, San Diego, California.

May, J. and S. Lucs

1976 *South Coast Regional Survey: Vancouver Island and the Lower Fraser Valley*. Report on file, Heritage Resource Centre, Ministry of Community, Aboriginal & Women's Services Victoria, BC.

Millennia Research Ltd.

1997 *Archaeological Overview Assessment of the Squamish Forest District*. Squamish Forest District, Ministry of Forests, Squamish, BC.

Mitchell, D.H.

1990 Prehistory of the Coast of Southern British Columbia and Northern Washington. In *Handbook of North American Indians, Volume 7, Northwest Coast*, edited by W. Suttles, pp.340-358. Smithsonian Institution, Washington, D.C.

Ministry of Forests, Research Branch

1994 *Biogeoclimatic Units of the Vancouver Forest Region: Map Sheet 5 of 6, Southern Vancouver Island -Sunshine Coast*. Ministry of Forests, Research Branch, Victoria, BC.

Moss, M. L.

2011 *Northwest Coast Archaeology as Deep History*. SAA Press. Washington, D.C.

Mullan, M.

2012 *Britannia – The Story of A British Columbia Mine – from Mining Resource to Heritage Resource*. Ministry of Energy, Mines and Natural Gas and Responsible for Housing. Available at: <http://www.empr.gov.bc.ca/MINING/GEOSCIENCE/PUBLICATIONSCATALOGUE/OPENFILES/1992/1992-19/Pages/Britannia.aspx>; accessed October 5, 2012.

Pojar, J., K. Klinka, and D. Demarchi

1991a Coastal Western Hemlock Zone. In *Ecosystems of British Columbia* edited by D. Meidinger and J. Pojar, pp. 95-112. Ministry of Forests, Research Branch, Special Report Series 6, Victoria, BC.

Quirolo, M.M., and L. Ham

1990 *Archaeological Resource Overview of the Furry Creek Delta, Howe Sound, British Columbia*. Report on file, Culture Department Library, Ministry of Small Business, Tourism and Culture, Victoria, BC.

Ramsey, B.

2004 *Britannia: Story of a Mine*. Second Edition. Trafford Publishing. Victoria, BC.

Reimer, R. (Yumks)

2011 *The Mountains And Rocks Are Forever: Lithics And Landscapes of Skwxwú7mesh Uxwumixw Territory*. Unpublished Ph.D. Dissertation, Department of Archaeology, Simon Fraser University, Burnaby, BC.

Richard, T.A.

1916 The Britannia Mine and Mill. *Mining And Scientific Press* 112:693-700.

Roddick, J.A., J.E. Muller and A.V. Okulitch

1979 *Fraser River, British Columbia - Washington, Sheet 92 [map]*. Geological Survey of Canada, Map 1386A. Ottawa, Ontario.

Suttles, W.

1955 Squamish Ethnographic Notes. *Anthropology in British Columbia Memoir Nos. 2 & 3*, University of British Columbia, Vancouver, BC.

1987 *Coast Salish Essays*. Talonbooks, Vancouver & University of Washington Press, Seattle, Washington.

1990 Central Coast Salish. In *Handbook of North American Indians, Volume 7, Northwest Coast*, edited by W. Suttles, pp.453-475. Smithsonian Institution, Washington, D.C.

Smith, H.I.

1907 Archaeology of the Gulf of Georgia and Puget Sound. *Publications of the Jesup North Pacific Expedition* 2(6); *Memoirs of the American Museum of Natural History*. 4(6):303-441, New York, New York.

Squamish Lilwat Cultural Centre

2012 *Cultural Journey Sea-to-Sky Highway Route – Connecting People And Communities Along The Way*. Available at: <http://www.slcc.ca/cultural-journey>; accessed: October 25, 2012.

Town, F.A.

2000 *The Lively Ghost of Howe Sound*. Bookus Press, Port Coquitlam, BC.

2010 *Before The Road Came*. Smashwords. Available at:
<http://www.smashwords.com/books/view/15962>; accessed October 5, 2012.

Turner, N.J.

1975 *Food Plants of British Columbia Indians: Part I – Coastal Peoples*. British Columbia Provincial Museum, Handbook No.34. Victoria, BC.

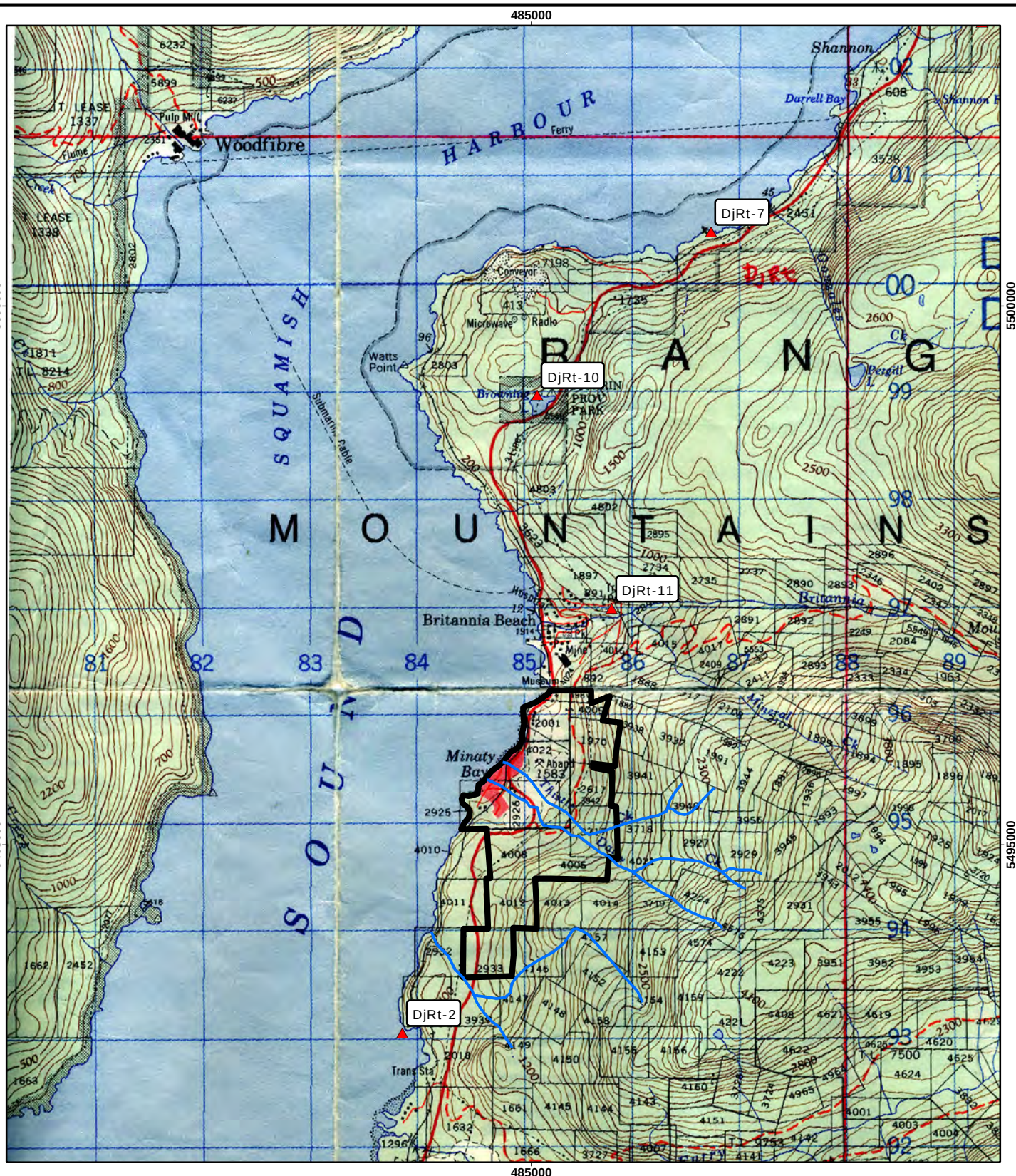
Turner, N.J.

1979 *Plants in British Columbia Indian Technology*. British Columbia Provincial Museum, Handbook No.38. Victoria, BC.

Winram, P.

1975 *A Report on the Howe Sound Archaeology Survey*. [Permit # 1975-011]. Report on file, Archaeology Branch, Victoria BC.

FIGURES

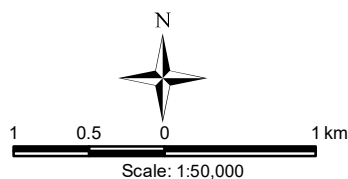


Legend

- South Britannia Subject Properties
- ▲ Archaeological Site
- River

Reference

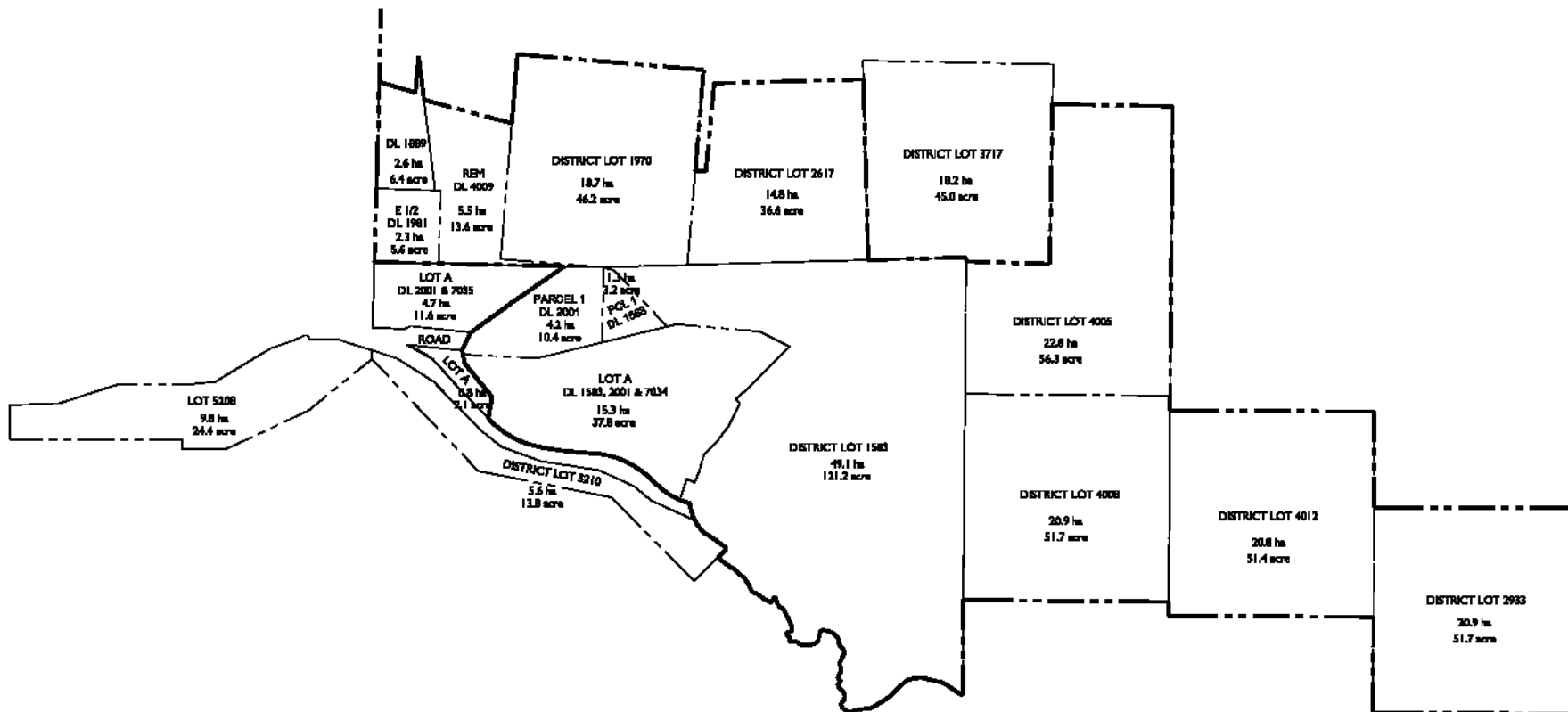
NTS Mapsheet 92G/11



Location of South Britannia Project and nearby Archaeological Sites

CLIENT: Taiching Development Corporation		PROJECT: South Britannia Project AOA
DATE: Nov 08, 2012	ANALYST: AO'S	Figure 1
JOB No: VE12405	QA/QC: GH	
PROJECTION: UTM Zone 10	DATUM: NAD83	





1:15,000



FOLIO Hotel and Resort Architecture SOUTH BRITANNIA MASTERPLAN

Legend

--- South Britannia Subject Properties



Reference

Basemap: from Taiching Development Corporation

South Britannia Project - Development Property Information

CLIENT: Taiching Development Corporation		PROJECT: South Britannia
DATE: Nov 8, 2012	ANALYST: AO'S	Figure 2
JOB No: VE12405	QA/QC: GH	
PROJECTION: UTM Zone 10	DATUM: NAD83	



K:\Drafting\12 Drafting\VE12405\Data\Britannia Fig3.cdr



Legend

 South Britannia Subject Properties



Reference

Basemap: from Taiching Development Corporation

South Britannia Project - Development Property

CLIENT: Taiching Development Corporation		PROJECT: South Britannia
DATE: Nov 7, 2012	ANALYST: AO'S	Figure 3 
JOB No: VE12405	QA/QC: GH	
PROJECTION: UTM Zone 10	DATUM: NAD83	

PHOTOGRAPHS



Photo 2. Panorama view of South Britannia Project. View ESE across District Lot 2001;
Highway #99 on left and right side of photo.



Photo 2 View ESE across District Lot 2001.



Photo 3. View SE across District Lot 2001 and 1583.



Photo 4. View SE across Highway #99 across District Lot 1583 with District Lots 3717 and 4005 along ridgeline.



Photo 5. View SW along shoreline of Howe Sound towards Minaty Bay and District Lot 2925.

APPENDIX A

Historical Aerial Photograph Review

Appendix A. Summary of observations from historic airphoto review of South Britannia Development.				
Date	Flight	Frames	Altitude	Subject Property Observations
1947	BC 398	109	High Oblique	Oblique view east across Howe Sound to Britannia Creek drainage. Hydro transmission line visible inland of Britannia Beach; pipe line (water) from Furry Creek to Britannia Beach Mine and mine site visible. Pacific Great Eastern Railway (subsequently BC Rail, now CN Rail) line not yet constructed. Majority of South Britannia development area covered in vegetation (forest type not identifiable). Road connecting Britannia Beach to Minaty Bay visible; roads from water inland to transmission line visible; evidence of community of Minaty Bay visible; knoll in DL 2925 wooded
	BC 398	110		
1947	BC 398	111	High Oblique	Oblique view east across Howe Sound to Britannia Creek drainage. Hydro transmission line visible inland of Britannia Beach; pipe line (water) from Furry Creek to Britannia Beach Mine and mine site visible. Pacific Great Eastern Railway (subsequently BC Rail, now CN Rail) line not yet constructed. Majority of development covered in vegetation (forest type not identifiable). Road connecting Britannia Beach to Minaty Bay visible; roads from water inland to transmission line visible; evidence of community of Minaty Bay visible; knoll in DL 2925 wooded
	BC 398	112		
1951	Energy, Mines & Resources Canada A 13250	153	Very High	Hydro transmission line visible inland of Britannia Beach; pipe line (water) from Furry Creek to Britannia Beach Mine and mine site visible. Pacific Great Eastern Railway line not yet constructed. Majority of development covered in vegetation (forest type not identifiable). Roads from water inland to transmission line visible; evidence of community of Minaty Bay visible; knoll in DL 2925 wooded
1957	BC 2349	4	Low	Pacific Great Eastern Railway line visible. Majority of development covered in vegetation (forest type not identifiable). Aggregate operations visible in Parcel 1 DL 2001, north side of Lot A DL 1583, 2001 & 7034. Forest cover within south half of Lot A DL 1583, 2001 & 7034 showing clearing in progress. Additional aggregate operation north side of DL 1583, (now west of Highway #99). Highway #99 visible south of Britannia Beach to southern limit of development property. No evidence of logging inland of highway or transmission line. Community of Minaty Bay well established; knoll in DL 2925 wooded
	BC 2349	5		
	BC 2349	6		
	BC 2349	7		
	BC 2349	65		
	BC 2349	66		
	BC 2349	67		
	BC 2349	68		
1969	BC 5342	035	High	Highway #99 constructed. Aggregate operations now very extensive: visible in Parcel 1 DL 2001, all of Lot A DL 1583, 2001 & 7034, PCL 1 DL 1583 and northern

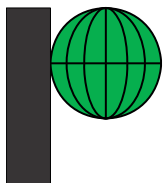
Appendix A. Summary of observations from historic airphoto review of South Britannia Development.				
Date	Flight	Frames	Altitude	Subject Property Observations
	BC 5342	036		portion of DL 1583. Only remnant of forest cover present within DL 1583 north of community of Minaty Bay – remainder is either lands associated with the community of Minaty Bay or aggregate operations. Trees becoming reestablished along Minaty Bay community roads. Rest of development property still covered in forest but forest service roads visible inland (eastern portion of development property); knoll in DL 2925 wooded
	BC 5342	037		
1969	BC 7202	057	Low	Highway #99 constructed. Aggregate operations now very extensive (maximum extent): visible in Parcel 1 DL 2001, all of Lot A DL 1583, 2001 & 7034, PCL 1 DL 1583 and northern portion of DL 1583. Small settling pond visible in Lot A DL 1583, 2001 & 7034 –western portion near Highway #99. Only remnant of forest cover within DL 1583 north of Minaty Bay – remainder is either lands associated with the community of Minaty Bay or aggregate operations. Trees becoming re-established along Minty Bay community roads. Evidence of logging inland within DL 1870, 2617, 3717, 4005, and 4008Rest of development property still covered in forest but forest service roads visible inland (eastern portion of development property); knoll in DL 2925 wooded
	BC 7202	058		
	BC 7202	137		
	BC 7202	138		
	BC 7202	139		
	BC 7202	140		
1974	BC 7558	158	Low	Aggregate operations extensive: visible in Parcel 1 DL 2001, all of Lot A DL 1583, 2001 & 7034, PCL 1 DL 1583 and northern portion of DL 1583. Settling pond has expanded and is now quite large adjacent to Highway #99. Community of Minaty Bay still present. No evidence of new logging visible; knoll in DL 2925 wooded
	BC 7558	159		
1982	BC 82 058	60	High	Trees now covering majority of aggregate pit – operations abandoned. Settling pond no longer present. Streets of Minaty Bay still visible but no buildings present. No evidence of new logging visible – development property becoming reforested; knoll in DL 2925 wooded.
	BC 82 058	61		
	BC 82 058	62		
	BC 82 058	63		
1982	BC 82 060	130	Very High	Trees now covering majority of aggregate pit – operations abandoned. Settling pond no longer present. Streets of Minaty Bay still visible but no buildings present. No evidence of new logging visible – development property becoming reforested; knoll in DL 2925 wooded.
	BC 82 060	131		
	BC 82 060	132		
	BC 82 061	133		
1990	30 BC B90020	25	Very High	A large portion of the aggregate pit has been cleared of vegetation (alder removed). Settling pond no longer present. Southern portion of DL 1583 (south of Highway #99) cleared of vegetation. Forest (alder) covers community of Minaty Bay – roads no longer visible. Various locations within development properties have been cleared of vegetation; knoll in DL 2925 wooded.
	30 BC B90020	26		
	30 BC B90020	27		
	30 BC B90020	40		
	30 BC B90020	41		

Appendix A. Summary of observations from historic airphoto review of South Britannia Development.				
Date	Flight	Frames	Altitude	Subject Property Observations
	30 BC B90020	42		
1994 colour	30 BC C94122	078	Low	The aggregate pit is starting to revegetate. Settling pond no longer present. Southern portion of DL 1583 (south of Highway #99) cleared of vegetation in 1990 is revegetated. Forest (alder) covers community of Minaty Bay – roads no longer visible. Various locations within development properties cleared of vegetation in 1990 regrowing; knoll in DL 2925 wooded.
	30 BC C94122	079		
	30 BC C94122	080		
	30 BC C94122	195		
	30 BC C94122	196		
	30 BC C94122	197		
2004 colour	SRS 6935	79	Very High	The aggregate pit is starting to revegetate though some new clearing appears. Forest (alder) covers community of Minaty Bay – roads no longer visible. Various locations within development properties cleared of vegetation in 1990 regrowing. Most of development property revegetated; knoll in DL 2925 wooded
	SRS 6935	80		
	SRS 6935	81		

9 HYDROGEOLOGY

This section contains two hydrogeologic reports for groundwater supply for the proposed development. These reports confirm that the aquifer underlying the site has sufficient capacity of good quality water to satisfy the needs of the development with a small surplus that might be made available for bolstering supply to North Britannia, if this should ever be required. This section contains the following reports prepared by Piteau Associates Engineering Ltd.

1. Hydrogeologic Assessment for Groundwater Supply, Britannia South, Britannia Beach, BC, Phase 3, File 3122, Piteau Associates Engineering Ltd., March 11, 2014
2. Updated Groundwater Flow Simulations for Britannia South Project, Britannia Beach, BC, File 3122, Piteau Associates Engineering Ltd., March 4, 2016



PITEAU ASSOCIATES
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Our file: 3122

March 11, 2014

Taicheng Development Corporation
710 – 100 Park Royal South
West Vancouver, BC V7T 1A2

Attention: Mr. Daniel Lou

Dear Sirs:

Re: Hydrogeologic Assessment for Groundwater Supply,
Britannia South, Britannia Beach, BC – Phase 3

Piteau Associates Engineering Ltd. (Piteau) has been retained by Taicheng Development Corporation (Taicheng) to assess the groundwater supply potential for the Britannia South Project. This work has been conducted in support of Taicheng's proposal to construct a residential community at this location with commercial and industrial amenities at a former gravel pit and Minaty Bay town site south of Britannia Beach (the "Site"). In accordance with the "South Britannia Beach Master Waterworks Plan" issued by Kerr Wood Leidal Associates Ltd. on March 28, 2013, the "Moderate Buildout Demand" for this project is estimated at 46.6 L/s. This value may ultimately be reduced in accordance more recent updates to the scope of the Britannia South project.

An extended duration aquifer pumping test was conducted at the Site between July 18 and October 28, 2013. The following report describes the results of this test and our analysis of the groundwater supply potential of the Site. Of particular interest is the risk of saltwater intrusion after prolonged pumping during the drier summer months.

This investigation is expected to meet the requirements for permits to construction and operation of a water supply required under the *Water Act*, and to satisfy the requirements of for Certificate of Public Convenience and Necessity. It is also expected to satisfy Squamish Lillooet Regional District's (SLRD) water-supply related concerns for re-zoning.

BACKGROUND

Piteau's investigations at the Site to date have involved the drilling and testing of a test production well (TW1), and monitoring of groundwater levels at surrounding monitoring wells (MW1, MW2). These are described in previous reports dated February and November, 2012.

TW1 was tested at a rate of 34.7 L/s (550 USgpm) for a 22-day period from October 4 to 26, 2012. The purpose of this test was to assess the sustainable yield of the well, and the possibility for saltwater intrusion into the aquifer from Howe Sound. Heavy precipitation in mid-October caused groundwater levels to rise sharply, thereby compromising our ability to measure pumping-



Taicheng Development Corporation

Attention: Mr. Daniel Lou

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induced changes in water levels. A decision was therefore made to terminate this test. The available results indicated no changes in water chemistry at the downgradient monitoring wells, and a sustainable pumping rate at least 26.6 L/s.

2013 FIELD INVESTIGATIONS

To determine whether a higher groundwater extraction rate can be feasible at this Site, and to assess the potential for groundwater at the site to contain pathogens, a second pumping extended aquifer pumping test was completed in 2013. Test production well TW1 (Piteau, 2012b), and a second test production well constructed as part of this current program, were pumped simultaneously for 101 days.

This program of work included the following specific tasks:

- Supervising construction of a second test production well (TW2), located approximately 250m south of TW1;
- Supervising construction of monitoring well MW3 downgradient from TW1;
- Co-ordinating and monitoring a 101-day long extended aquifer pumping test with TW1 and TW2 operating at a maximum combined pumping rate of 41.2 L/s;
- Monitoring groundwater levels and water quality at the pumped wells and downgradient monitoring wells over the testing period; and
- Completing additional water quality analyses in support of an assessment of the potential for the well water to contain pathogens.

The locations of the new test production well TW2, and new monitoring well MW3, are shown on Fig. 1. A detailed description of the program of work is included in the following sections.

Construction of TW2

Well locations were selected with reference to the Master Development Plan so as not to interfere with planned amenities, and were marked in the field by a professional land surveyor (Bunbury Associates Ltd. of Squamish, BC). Construction of access roads to the well sites and preparation of drilling pads was carried out by MBD Construction Services Ltd. of Squamish, BC, working on behalf of Taicheng. This work was supervised by Mr. Rob Bulger and Ms. Brianne Dahle of Piteau.

TW2 was constructed between June 24 and 28, 2013 using a dual-mode air-rotary drilling rig operated by A&H Drilling Ltd. After driving a 254mm (10") diameter surface casing to a depth of 5.5m, drilling continued with 203mm (8") steel casing to a final depth of 36.0m.



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Sediments recovered from the borehole consisted of sand to 28.2m depth, gravelly sand/sandy gravel to 35.1m, and silt to 36.0m. Slot sizes of 2.54mm (0.100") and 3.05mm (0.120") were selected for telescopic well screen based on results of grain size analyses completed on samples of aquifer sediments collected between 30.5 and 35.1m.

A 3m long well screen assembly comprising 203mm (8") nominal diameter telescopic stainless steel well screen with a K-packer and 0.6m riser at the top, and bail bottom at the base, was installed in the borehole. It was exposed to aquifer sediments between 31.7 and 34.7m by pulling back the steel casing, and the screens were developed for eight hours by airlift surging using compressed air from the drill rig compressor.

A surface seal was installed by adding bentonite chips to the annular space between the 254mm (10") and 203mm (8") casings, and then withdrawing the 254mm (10") casing.

The static water level in TW2 on July 16, 2013 was 8.8 metres below ground level (m-bgl). A borehole log for TW2 and the results of grain size analyses performed on the formation materials collected in the vicinity of the well screen are included in Appendix A.

Construction of Monitoring Well MW3

Monitoring well MW3 was installed approximately 100m to the northwest of TW2 to facilitate monitoring groundwater levels and detection of potential inland migration of saltwater during the extended aquifer pumping test.

The dual-mode air-rotary drilling rig was also used to construct MW3 between July 2 and 3, 2013. Sediments encountered during advancement of 150mm (6") diameter casing comprised sand to 21.3m, gravelly sand and sandy gravel to 38.1m, sand to 43.3m, and clay to 44.2 m-bgl. A deep monitoring well screen (MW3-D) was positioned at the bottom of a sandy gravel interval (35.0 to 36.5 m-bgl), and the shallow monitoring well screen (MW3-S) was positioned in the overlying gravelly sand interval (25.9 to 27.4 m-bgl).

Both monitoring wells comprise a 1.5m long section of slotted PVC screen (slot size 0.25mm or 0.1") threaded to a solid PVC riser pipe. Pea gravel was used to backfill the lower portion of the borehole and to provide a competent base for MW3-D. Filter sand was placed around the screens and bentonite pellets were used to seal the borehole above and below. A log for MW3 is provided in Appendix A.

Static water levels measured in MW3-S and MW3-D on July 16, 2013 had equivalent elevations of about 4.64 m-bgl and 4.44 m-bgl, respectively.



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Attention: Mr. Daniel Lou

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Extended Aquifer Pumping Tests

Frontier Pump Installations Inc. (Frontier) of Aldergrove was retained on behalf of Taicheng to supply and install a submersible pump in TW2, along with all necessary equipment needed for the extended aquifer pumping test with TW2 and TW1. The pumps were supplied with power from the BC Hydro electrical lines.

Short-duration, variable-rate and constant-rate tests were first performed with TW2 on July 16 and 18, 2013. During the variable-rate test, TW2 was pumped for 30-minute intervals at 3.5, 9.5, 12.6, and 15.8 L/s, for a total pumping period of 120 minutes. Following some adjustments to the power supply, a 12-hour constant-rate test TW2 was initiated on July 18 at a flow rate of 16.3 L/s. Based on water level drawdown trends measured during the test, it was judged that this pumping rate could be sustained for the duration of a 100-day test.

The extended aquifer pumping test was initiated by Frontier on July 19. Pumping of TW2 at 18.1 L/s commenced at 8:30 AM, and pumping of TW1 at 15.1 L/s began at 9:30 AM (Photos 1, 2). At Taicheng's request, the pumping rates were increased to the maximum rates afforded by the installed pumps on August 2. These pumping rates were 22.0 L/s for TW1 and 19.2 L/s for TW2, respectively, for a combined rate of 41.2 L/s. Pumping of TW2 was interrupted for 48 hours between September 28 and 30 (cause unknown), and for six hours on October 2 to accommodate work conducted on the nearby power lines by BC Hydro. Pumping of TW1 was interrupted for three hours on October 2.

Pumped water was conveyed via lay-flat hose to a location in Thistle Creek approximately 100m downstream from the bridge crossing (Photo 3). Flow rates were measured using dedicated orifice plate flow measurement devices (Photo 4). Flow rates were monitored at least bi-weekly over the duration of the test to check that they remained constant.

Water levels in the pumped wells, upgradient monitoring well MW1, and shallow downgradient monitoring wells MW2-S and MW3-S, were measured continuously using Solinst Levellogger™ pressure transducers. All instrument water level measurements were corrected for variations in atmospheric pressure using data collected by a Solinst Barologger™ installed at an above-ground location.

The extended aquifer pumping test was stopped at 10:30 AM on October 28 after 101 days of pumping.

Water Quality Monitoring

Water quality samples were collected from TW1 and TW2 on five occasions during the extended aquifer pumping test to evaluate water quality and to detect any increase in salinity that could have occurred during the test. These samples were analyzed for basic water quality parameters



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including nutrients, major anions, metals, and bacteria. The sample collected from TW2 on August 2 was also analyzed for polycyclic aromatic hydrocarbons, light and heavy extractable petroleum hydrocarbons, volatile petroleum hydrocarbons, and herbicides, to screen for the potential presence of contaminants associated with current and past land use.

A Hanna model HI 991300 water quality meter was used to measure electrical conductivity, pH, and temperature of groundwater recovered from the monitoring wells at bi-weekly intervals. Water samples collected on September 3 and October 16 were submitted to the project laboratory to verify the field measurements and to obtain corresponding sodium and chloride concentrations.

INVESTIGATION RESULTS

Well Performance and Aquifer Properties

Manual water level and flow measurements collected during the variable- and constant-rate pumping tests with TW2 on July 16 and 18, respectively, are tabulated in Tables B-1 and B-2 of Appendix B.

The upper portion of Fig. 2 includes a semi-logarithmic plot of drawdown measured in TW2 during the variable-rate test. The lower portion includes a plot of pumping rate versus drawdown and specific capacity¹. The specific capacity was observed to decrease with increasing pumping rate, which is a consequence of increased frictional head losses through the well screen. The relatively small decrease in specific capacity between the first and fourth steps indicates a relatively efficient well screen.

Figure 3 presents a semi-logarithmic plot of water level drawdown in TW2 during the constant-rate test, and water level recovery after pumping stopped. Aquifer transmissivity² was estimated from the drawdown trends during the pumping and recovery portions of the tests using the Cooper-Jacob method (1946) and Theis recovery method (1935), respectively. The resultant values were 1.1×10^{-2} and 1.7×10^{-2} m²/s.

Assuming an effective aquifer thickness equal to the screen length (3m) and a representative transmissivity of 1.4×10^{-2} m²/s, a corresponding hydraulic conductivity of 4.6×10^{-3} m/s is estimated. This value is close to the geometric mean of hydraulic conductivity values calculated using the Hazen method (Hazen, 1911) from the grain size distribution curves of formation samples collected adjacent to the well screen (Fig. A-1 of Appendix A) of 4.4×10^{-3} m/s.

¹ Specific capacity is defined as the ratio of pumping rate to water level drawdown.

² Transmissivity (T) is defined as the rate at which water is transmitted through a unit width of aquifer under a unit hydraulic gradient. It is equal to the product of the hydraulic conductivity (K) and aquifer thickness (b).



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Long-Term Water Level Trends and Extended Aquifer Pumping Test

Groundwater level trends measured since the start of Piteau's investigations at the site are shown on Fig. 4. The intervals shaded in yellow indicate the 22-day pumping test in 2012, and the 101-day long extended test in 2013. Daily precipitation amounts measured at the nearest Environment Canada weather monitoring station ("Squamish Airport") are shown as a histogram on the bottom of the graph.

In general, groundwater levels are highest between November and May, then start to drop slowly between May and July. Between July and November, they drop at a faster rate, most likely due to reduced flows in Thistle and Daisy creeks, which lose water to the aquifer. Between July and November, the hydraulic gradient between MW1 and TW2 is roughly halved, meaning that groundwater flow towards Howe Sound is roughly half of what it is at other times of year.

Water level trends measured before and during the extended aquifer pumping test are shown in more detail on Fig. 5. The sensitivity of groundwater levels to precipitation events and changes in creek flows is demonstrated by the 0.8m rise in levels at MW3-S between August 28 and 30, and the 1.4m rise at the same well between September 29 and October 2. Water levels at the other monitoring wells show a similar pattern. This recharge signal effectively masks the drawdown signal caused by pumping TW1 and TW2, thereby rendering data collected between August 28 and October 28 less useful for analysis.

Sustainable Aquifer Yield

The sustainable yield of the aquifer from which TW1 and TW2 draw water was estimated using an approach that mitigates the potential for landward movement of salt water towards the wells during the drier summer months. This inland migration, referred to as "saltwater intrusion" can cause an increase in salinity in the well water and a degradation of water quality.

The sustainable yield were calculated using the drawdowns measured at downgradient monitoring wells MW2-S and MW3-S, and are based on the assumption that saltwater will not reach the pumped wells if groundwater elevations at these wells maintained at or above sea-level.

The maximum allowable drawdown at MW2-S and MW3-S after 100 days of pumping (DD_{100}) during the summer dry period was determined using the equation:

$$DD_{100} = EWL_{\text{initial}} - E_{\text{Sea Level}} - 100 * S$$



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Where:

- $EW_{initial}$ is the initial water level on July 1, 2013 (measured or estimated, Fig. 5)
- $E_{Sea\ Level}$ is the elevation of sea level, approximately -0.07m geodetic
- S is the rate of water level decline under ambient (unpumped) conditions over the summer, calculated from water level trend prior to July 16, 2013 (Fig. 5)

The sustainable yields of wells TW1 and TW2 (Q_{sust}) were determined by prorating the test pumping rate (Q_{test}) by the ratio of the maximum allowable drawdown (DD_{100}) to actual drawdown at the end of the 100-day test (DD_{test}):

$$Q_{sust} = DD_{100} / DD_{test} \times Q_{test}$$

Where:

- DD_{test} is the drawdown measured during the test projected to 100-days (Fig. 6), corrected for the ambient rate of water level decline over the summer
- Q_{test} is the pumping rate of the upgradient production well (TW1 for MW2-S, and TW2 for MW3-S)

These calculations are summarized in the table below:

	Symbol	Units	MW2-S	MW3-S
Initial Water Level	$EW_{initial}$	(mgeod.)	2.4	5.1
Mean Sea Level Elevation	$E_{SeaLevel}$	(mgeod.)	-0.07	-0.07
Rate of Water Level Decline Over Summer	S	(m/day)	0.015	0.011
Allowable Drawdown	DD_{100}	(mgeod.)	1.0	4.0
Projected Drawdown (Corrected) at 100-Days	DD_{test}	(m)	0.8	3.9
Projected Drawdown (Corrected) at 100-Days	DD_{test}	(m)		
Pumping Rate at upgradient well TW1	Q_{test}	(L/s)	22.0	
Pumping Rate at upgradient well TW2	Q_{test}	(L/s)		19.2
Sustainable Yield at Upgradient Well TW1	Q_{sust}	(L/s)	26.7	
Sustainable Yield at Upgradient Well TW2	Q_{sust}	(L/s)		19.9



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Based on the above, it is concluded that TW1 and TW2 can be pumped for 100 days at a combined rate of 46.6 L/s (26.7 and 19.9 L/s, respectively), with little risk of inducing intrusion of saltwater into the aquifer.

Long-term water level trends presented on Fig. 4, indicate that groundwater levels fluctuate within about 1m of their annual maximum elevations until July. Therefore, aquifer recharge in the fall, winter, and spring is sufficient to drive groundwater flow towards Howe Sound and eliminate the risk of saltwater intrusion. It is therefore concluded that the combined pumping rate of 46.6 L/s is sustainable on a year-round basis.

Water chemistry data collected during the extended aquifer pumping test support this conclusion. There was very little indication of saltwater at the downgradient monitoring wells or in the pumped discharge at the 41.2 L/s extraction rate. Figure 7 shows how the physical parameters measured in the well discharge were relatively constant over this period (pH 6-7, conductivity <100 $\mu\text{S}/\text{cm}$).

Chloride concentrations in the pump discharge were also stable throughout the test at about 0.5 mg/L and 4.4 mg/L, respectively (Table I). Near the end of the pumping period, chloride concentrations were 0.6 mg/L at both MW2-S and MW2-D, and 12 mg/L at MW3-S and MW3-D (Table II). These concentrations are well below Health Canada's guideline for Canadian Drinking Water Quality of 250 mg/L (Health Canada, 2012).

Well Capacity

In this case "well capacity" refers to the flow rate can be pumped by a well without drawing the water level too close to the intake of the pump. The well capacities of TW1 and TW2 were calculated to check that TW1 and TW2 can maintain the sustainable yields (Q_{sust}) determined using the above described analysis. The methodology is summarized in Table III, is described in the following points:

- A minimum seasonal static water representative of the water level in early October was assigned to each well;
- The total available drawdown was calculated by subtracting the minimum static water level from the depth to the top of the screened interval;
- Allowable drawdown was calculated by applying a 70% safety factor to available drawdown;
- The drawdown trend during the extended test was extrapolated to 100 days (Fig. 8). This drawdown trend was corrected for the ambient decline in water table, and includes interwell drawdown interferences, since TW1 and TW2 were operated together;
- A projected 100-day specific capacity was calculated by dividing the test pumping rate (Q_{test}) by the projected drawdown;



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- The projected drawdown after 100-days of pumping at the sustainable yield (Q_{sust}) was calculated by dividing Q_{sust} by the projected specific capacity.

The estimated drawdowns in wells TW1 and TW2 after 100-days of pumping at 26.7 and 19.9 L/s (Q_{sust}), are 10.6m and 14.3m, respectively. These drawdowns do not exceed the maximum allowable drawdowns of 21.2m and 15.5m, respectively, and allow for at least 2m of submergence of the pump intake. The sustainable pumping rates are also within the recommended maximum screen capacities (based on length and open area of screen) of 29.3 and 29.2 L/s, respectively.

This analysis confirms that the sustainable well yields determined in the preceding section (26.7 and 19.9 L/s, respectively for TW1 and TW2) are within the physical capacities of wells TW1 and TW2.

Water Quality and GARP Evaluation

Laboratory analytical results for groundwater samples collected from TW1 and TW2 during the extended aquifer pumping test are presented in Table I. In general, the groundwater is of the calcium-carbonate type, slightly acidic, and very low in dissolved minerals. Concentrations of all parameters tested were less than the Guidelines for Canadian Drinking Water Quality (GCDWQ, Health Canada, 2012). Furthermore, there were no detectable concentrations of hydrocarbons or herbicides associated with potential sources of contamination. Laboratory certificates of analysis have been included with Appendix C.

Groundwater at risk of containing pathogens (GARP) is defined as a groundwater supply that is likely to be contaminated by any source of pathogens (anthropogenic or natural), or disease-causing organisms. In accordance with Section 5(2) of the B.C. Drinking Water Protection Regulation, a water supply requires disinfection as it poses a significant threat to public health. Pathogens include various types of bacteria, viruses, and protozoa (e.g., *Giardia* and *Cryptosporidium*), and commonly originate from human and agricultural waste streams, and surface water. Sources of pathogens in surface water include animal excrement and decomposing terrestrial and aquatic organisms.

Groundwater that is under the direct influence of surface water (GWUDI) is groundwater that is hydraulically connected to surface water, and should be considered GARP unless hydrogeological evidence indicates that filtration by the aquifer matrix is sufficient to remove all pathogens.

With reference to the most recent guidance document on the subject (Ministry of Health, 2013), groundwater from TW1 and TW2 is likely to be considered GARP based on the following observations:



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- *Proximity to Thistle Creek:* TW1 and TW2 are both located within 150m of Thistle Creek. Top of bank and channel invert elevations were surveyed at two locations on Thistle Creek in November 2012 (Fig. 1). As the water table fluctuates between 1 and 4m below the creek bottom, seepage from the creek is expected to reach the water table within a relatively short period. The well screens are positioned more than 20m below the water table, it is uncertain whether the time of travel from the creek to the wells is sufficient to meet durations required under the draft guidance to achieve adequate removal of all pathogens (100 days for bacteria and protozoa and 200 days for viruses).
- *Water Chemistry Monitoring Results:* During the first two months of the extended aquifer pumping test TW1 produced water with less than detectable turbidity (< 0.1 NTU, Table II). Following a heavy rainfall event in mid-September, the turbidity rose slightly (0.19 and 0.15 NTU on September 24 and October 16). Also, two counts per 100 mL of total coliform bacteria were detected in the October 16 sample.
- *Microscopic Particulate Analysis (MPA) results:* MPA testing conducted with filtrate samples collected on October 16 indicated moderate counts of algae and plant debris the TW1 discharge. A risk factor of 5 was assigned to this well, indicating a low to moderate likelihood of GWUDI. Concurrent water samples collected from Thistle Creek had 200 counts of total bacteria per 100 mL, and abundant bacteria spores, algae, and surface water organisms. MPA reports are included with Appendix D.

Groundwater from TW2 appears less likely to be GARP than groundwater from TW1, based on the absence of turbidity and bacteria in all TW2 samples collected over the extended aquifer pumping test, and the lower counts of plant debris observed in the MPA (risk factor = 0). TW2 is located further from Thistle Creek than TW1, but is closer to Daisy Creek, which is also interpreted to lose water to the aquifer. As a precautionary measure, water sourced from TW2 should also be considered GARP, and subjected to the same water treatment objectives as TW1.

WELL COMMISSIONING AND OPERATION

Pump Selection and Surface Installations

Use of a variable-speed drive pumps in both wells are recommended as this will facilitate optimization of well operation under various demands. The pump intake should be positioned 0.5m above the top of the well screens.

In accordance with the Ground Water Protection Regulation, both wells should have a minimum of 30 cm casing stickup (above existing or modified ground surface), appropriate drainage away from the well, and completion with a secure well cap plus well identification plate. The owner (Taicheng) is responsible for ensuring that the well cap and well identification plate remain intact.



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It is anticipated that a pitless adapter will be installed in conjunction with installation of permanent submersible pumps. Following installation of pitless adapters, the excavation surrounding the well should be backfilled with a sand bentonite mixture to preserve the surface seal around the well.

Chlorination

Both wells should be chlorinated after the permanent pumps are installed.

Well Operation

Operation of the wells should be controlled to prevent:

- Over-pumping for periods exceeding 24 hours: Special care should be taken to ensure that the start-up surge does not exceed design rates. For example, the pump could be designed to start against closed valves or against a full column of water. A foot valve would keep water in the column.
- Back-washing, unless during development.
- Flushing: If water is allowed to cascade in the well and the well becomes aerated, the well can become iron bacterial slimed within a few months. Thus, the start-up and the shutdown water must not be allowed to enter the well.
- Raw-hiding: If the pump is allowed to start and stop frequently, the well is "raw-hided". This may destabilize aquifer materials, resulting in increased sediment and potentially reduced efficiency. The discharge from the well should be correlated with system demand so that the pump operates for at least one hour after start-up and is idle for at least one hour after shutdown.

Monitoring

The following measures are recommended to monitor aquifer and well performance for the Britannia South project:

- All active groundwater supply wells should be instrumented with pressure transducers to provide a record of water levels and temperature under pumping and non-pumping operating conditions. Flow meters should be used to track the amount of groundwater pumped, and sensors should be included to monitor groundwater salinity. Data from these instruments should be recorded on a frequent and ongoing basis.
- Data loggers should be used to monitor water levels in MW2D and MW3D.
- Groundwater samples from all wells should be analyzed for basic potability on a minimum annual basis.



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All monitoring data should be reviewed by a qualified hydrogeologist on an annual basis. This should start when the wells go into production, and should continue until after the total annual groundwater withdrawal has stabilized and no further increases are anticipated. Thereafter, the recommended review frequency can be relaxed to once every second year.

The efficiency and operational lifespan of the wells will be enhanced by a proactive maintenance program. This program should include downhole imaging, pumping tests, and rehabilitation when well efficiency has dropped by 10-15%.

Comments on Aquifer Protection

Development of an aquifer protection plan may ultimately be required in support of a permit to operate groundwater supply wells at the Site. This generally involves identifying potential groundwater pollution hazards, evaluating risk, and where needed, adopting measures to mitigate risk.

While this is beyond the scope of Piteau's current assignment, the Piteau provides the following comments with respect to aquifer protection at the Site.

The primary risks to the quality of groundwater pumped from TW1 and TW2 that have been considered during this investigation are intrusion of saltwater from Howe Sound and pathogens from surface water. Risks associated with the historic activities at the former Britannia Mine, or gravel extraction at the Site, are judged to be low based on the absence of any known impacts to aquifer water quality.

The aquifer is unconfined and vulnerable to contamination from surface sources. While there are no other industrial or agricultural activities nearby that could lead to groundwater contamination, spillage of hazardous materials such as gasoline and chemicals transported via Highway 99 or CN Rail onto the ground above the aquifer, and/or into Thistle or Daisy creeks, represent perhaps the greatest hazard going forward. Although the duty to clean up after a spill occurring on the highway or railway rests with the owner and/or transporter of the spilled product, it would be prudent to develop spill response and contingency plans to ensure that protection of groundwater resources and drinking water are properly taken into account in the event of a spill in the vicinity of the aquifer.

Future activities at the Site may need to be controlled to reduce the risk of aquifer contamination from commercial operations such storage and dispensing of automotive and marine fuels and dry cleaning.



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CONCLUSIONS AND RECOMMENDATIONS

Piteau has completed the third phase of an investigation of the groundwater supply potential at South Britannia Beach. This has involved the construction of a second test production well and the execution of an extended aquifer pumping test during the summer dry period. The following points summarize the work completed and our ensuing conclusions and recommendations:

1. A second groundwater supply well (TW2), and a nested pair of monitoring wells (MW3-S and MW3-D) were constructed downgradient from TW2 in July 2013. The supply well was completed in a productive sand and gravel aquifer at a total depth of 34.7m.
2. A 101-day long extended aquifer pumping test was conducted with TW1 and TW2 operating together from July 19 to October 28, 2013. Our analysis of groundwater level response to pumping indicates that the wells can sustain flows of 26.7 and 19.9 L/s (total = 46.6 L/s) over the summer drought period and throughout the remainder of the year. At these rates, there is a negligible risk of saltwater intrusion from Howe Sound.
3. Our assessment of available and projected drawdowns at each well confirms that the well capacities are adequate to sustain the above flow rates.
4. Groundwater pumped from TW1 and TW2 meets all objectives in Health Canada's Guidelines for Canadian Drinking Water Quality. Potential contaminants of concern, including extractable hydrocarbons, polycyclic aromatic hydrocarbons, volatile organic compounds, and herbicides, were not detected in the TW2 samples. TW1 was also determined to be un-impacted by contaminants during earlier testing (Piteau, 2012a).
5. Microbiological tests performed on samples collected near the end of the 101-day extended aquifer pumping test indicated that TW1 (and by association, TW2) may be at risk of containing pathogens (GARP) sourced from Thistle and/or Daisy creeks.
6. Recommendations on well commissioning and monitoring included in this report should be implemented.

LIMITATIONS

This investigation has been conducted using a standard of care consistent with that expected of scientific and engineering professionals undertaking similar work under similar conditions in BC. No warranty is expressed or implied.

This letter report is prepared for the sole use of Taicheng Development Corporation and the Squamish Lillooet Regional District. Any use, interpretation, or reliance on this information by any third party, is at the sole risk of that party, and Piteau accepts no liability for such unauthorized use.



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CLOSURE

We trust that this letter report provides the information you require at this time. Please contact the undersigned if you have any questions or comments.

Yours truly,

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REFERENCES

- Cooper, H.H. and Jacob, C.E., 1946. A generalized graphical method for evaluating formation constants and summarizing well field history. In American Geophysical Union Transactions, Vol. 27, p 526-534.
- Hazen, A., 1911. Discussion: Dams on sand foundations. Transactions: American Society of Civil Engineers, v.73, p199.
- Health Canada, 2012. Guidelines for Canadian Drinking Water Quality. Prepared by the Federal-Provincial-Territorial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment. <http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2012-sum_guide-res_recom/index-eng.php> [Accessed December, 2012]
- Ministry of Health, 2013. Guidance Document for Determining Ground Water at Risk of Containing Pathogens (GARP) Including Groundwater Under Direct Influence of Surface Water (GWUDI), Version 2, released July 2013, 51pp.
- Piteau, 2012a. Hydrogeologic Assessment for Groundwater Supply, Phase 2A - South Britannia Beach, B.C. Letter report written for Taicheng Development Corporation. February, 13pp.
- Piteau, 2012b. Hydrogeologic Assessment for Groundwater Supply, Phase 2B Update - South Britannia Beach, B.C. Letter report written for Taicheng Development Corporation. November, 6pp.

TABLES

TABLE I
WATER QUALITY ANALYTIC RESULTS FOR
PRODUCTION WELL GROUNDWATER SAMPLES

Location: Lab/Report ID: Date Sampled: Sample ID:		Guidelines for Canadian Drinking Water Quality ¹		CSR ² Drinking Water (DW) Standards	TW-1							TW-2						
					L1342450-1 2-Aug-13	L1352047-1 22-Aug-13	L1357811-1 03-SEP-13	L1367061-1 10-SEP-13	L1367770-1 24-SEP-13	L1379527-1 16-OCT-13	L1381520-1 22-Oct-13	L1342450-2 2-Aug-13	L1352047-2 22-Aug-13	L1357811-2 03-SEP-13	L1367061-2 10-SEP-13	L1367770-2 24-SEP-13	L1379527-2 16-OCT-13	L1381520-2 22-Oct-13
					TW-1	TW-1	TW-1	TW-1	TW-1	TW-1	TW-1	TW-2	TW-2	TW-2	TW-2	TW-2	TW-2	TW-2
		MAC/IMAC	AO															
Physical Tests																		
Colour, True	CU	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lab Conductivity	uS/cm	-	-	-	43.0	44.8	46.2	49.0	48.7	47.7	-	68.7	61.3	61.0	68.3	59.7	58.1	-
Hardness (as CaCO3)	mg/L	-	-	-	16.8	17.5	17.4	-	17.8	18.6	-	15.8	15.8	15.4	-	15.3	16.7	-
Lab pH ³	pH	-	6.5-8.5	-	6.60	6.96	7.23	6.78	7.39	7.09	-	6.76	6.94	7.23	6.76	7.10	6.88	-
Salinity	psu	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids	mg/L	-	-	-	-	-	-	45	-	-	-	-	-	-	54	-	-	-
Turbidity	NTU	1	5	-	<0.10	<0.10	<0.10	-	0.19	0.15	-	<0.10	<0.10	<0.10	-	<0.10	<0.10	-
Anions																		
Alkalinity, Total (as CaCO3)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromide Br	mg/L	-	-	-	<0.050	-	<0.050	<0.050	-	<0.050	-	<0.050	-	<0.050	<0.050	-	<0.050	-
Chloride Cl	mg/L	-	250	250	0.52	0.52	0.52	0.52	0.52	0.5	-	7.47	4.72	4.45	4.35	4.35	4.18	-
Fluoride F	mg/L	1.5	-	1.5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	-	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	-
Nitrate N	mg/L	10	-	10	0.183	0.180	0.189	0.175	0.202	0.179	-	0.358	0.353	0.337	0.301	0.344	0.328	-
Nitrite N	mg/L	3.2	-	3.2	<0.0010	<0.0010	<0.0010	0.0128	<0.0010	<0.0010	-	<0.0010	<0.0010	<0.0010	0.0164	<0.0010	<0.0010	-
Sulphate SO4	mg/L	-	500	500	5.25	5.03	5.02	4.97	5.07	4.96	-	2.50	2.43	2.41	2.38	2.47	2.40	-
Total Metals																		
Aluminum Al	mg/L	-	0.1	0.2	-	-	<0.010	<0.20	-	-	-	<0.010	-	<0.010	<0.20	-	-	-
Antimony Sb	mg/L	0.006	-	0.006	-	-	<0.00050	<0.20	-	-	-	<0.00050	-	<0.00050	<0.20	-	-	-
Arsenic As	mg/L	0.01	-	0.010	-	-	<0.00010	<0.20	-	-	-	<0.00010	-	<0.00010	<0.20	-	-	-
Barium Ba	mg/L	1	-	1	-	-	<0.020	<0.010	-	-	-	<0.020	-	<0.020	0.013	-	-	-
Beryllium Be	mg/L	-	-	-	-	-	-	<0.0050	-	-	-	-	-	-	<0.0050	-	-	-
Bismuth Bi	mg/L	-	-	-	-	-	-	<0.20	-	-	-	-	-	-	<0.20	-	-	-
Boron B	mg/L	5	-	5	-	-	<0.10	<0.10	-	-	-	<0.10	-	<0.10	<0.10	-	-	-
Cadmium Cd	mg/L	0.005	-	0.005	-	-	<0.00020	<0.010	-	-	-	<0.00020	-	<0.00020	<0.010	-	-	-
Calcium Ca	mg/L	-	-	-	5.30	5.60	5.59	5.87	5.72	5.95	-	5.13	5.18	5.07	6.39	5.07	5.51	-
Chromium Cr	mg/L	0.05	-	0.05	-	-	<0.0020	<0.010	-	-	-	<0.0020	-	<0.0020	<0.010	-	-	-
Cobalt Co	mg/L	-	-	-	-	-	-	<0.010	-	-	-	-	-	-	<0.010	-	-	-
Copper Cu	mg/L	-	1	1	-	-	<0.0010	0.024	-	-	-	<0.0010	-	<0.0010	0.025	-	-	-
Iron Fe	mg/L	-	0.3	0.3	<0.030	<0.030	<0.030	0.058	<0.030	<0.030	-	<0.030	<0.030	<0.030	0.031	<0.030	<0.030	-
Lead Pb	mg/L	0.01	-	0.01	-	-	<0.00050	<0.050	-	-	-	<0.00050	-	<0.00050	<0.050	-	-	-
Lithium Li	mg/L	-	-	-	-	-	-	<0.010	-	-	-	-	-	-	<0.010	-	-	-
Magnesium Mg	mg/L	-	100	100	0.86	0.84	0.83	0.88	0.86	0.92	-	0.74	0.68	0.66	0.70	0.65	0.71	-
Manganese Mn	mg/L	-	0.05	0.05	<0.0050	<0.0050	<0.0020	<0.0050	<0.0050	<0.0020	-	<0.0020	<0.0050	<0.0020	<0.0050	<0.0050	<0.0020	-
Molybdenum Mo	mg/L	-	-	0.25	-	-	-	<0.030	-	-	-	-	-	-	<0.030	-	-	-
Mercury Hg	mg/L	0.001	-	0.001	-	-	<0.00020	-	-	-	-	<0.00020	-	<0.00020	-	-	-	-
Nickel Ni	mg/L	-	-	-	-	-	-	<0.050	-	-	-	-	-	-	<0.050	-	-	-
Phosphorus P	mg/L	-	-	-	-	-	-	<0.30	-	-	-	-	-	-	<0.30	-	-	-
Potassium K	mg/L	-	-	-	<2.0	<2.0	0.57	<2.0	<2.0	0.57	-	1.59	<2.0	1.34	<2.0	<2.0	1.20	-
Selenium Se	mg/L	0.01	-	0.01	-	-	<0.0010	<0.20	-	-	-	<0.0010	-	<0.0010	<0.20	-	-	-
Silicon Si	mg/L	-	-	-	-	-	-	6.2	-	-	-	-	-	-	7.06	-	-	-
Silver Ag	mg/L	-	-	-	-	-	-	<0.010	-	-	-	-	-	-	<0.010	-	-	-
Sodium Na	mg/L	-	200	200	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-	7.2	6.0	5.4	5.4	4.7	5.0	-
Strontium Sr	Bq/L	5	-	-	-	-	-	0.0365	-	-	-	-	-	-	0.1	-	-	-
Thallium Tl	mg/L	-	-	-	-	-	-	<0.20	-	-	-	-	-	-	<0.20	-	-	-
Tin Sn	mg/L	-	-	-	-	-	-	<0.030	-	-	-	-	-	-	<0.030	-	-	-
Titanium Ti	mg/L	-	-	-	-	-	-	<0.010	-	-	-	-	-	-	<0.010	-	-	-
Uranium U	mg/L	0.02	-	0.02	-	-	<0.00010	-	-	-	-	<0.00010	-	<0.00010	-	-	-	-
Vanadium V	mg/L	-	-	-	-	-	-	<0.030	-	-	-	-	-	-	<0.030	-	-	-
Zinc Zn	mg/L	-	5	5	-	-	<0.050	0.0919	-	-	-	<0.050	-	<0.050	0.651	-	-	-
Bacteriological Parameters																		
E. Coli	MPN/100mL	-	-	-	<1	<1	<1	-	<1	<1	<1	<1	<1	<1	-	<1	<1	<1
Coliform Bacteria - Total	MPN/100mL	-	-	-	<1	<1	<1	-	<1	2	<1	<1	<1	<1	-	<1	<1	<1

TABLE I
WATER QUALITY ANALYTIC RESULTS FOR
PRODUCTION WELL GROUNDWATER SAMPLES

Location: Lab/Report ID: Date Sampled: Sample ID:		Guidelines for Canadian Drinking Water Quality ¹		CSR ² Drinking Water (DW) Standards	TW-1							TW-2						
					L1342450-1 2-Aug-13	L1352047-1 22-Aug-13	L1357811-1 03-SEP-13	L1367061-1 10-SEP-13	L1367770-1 24-SEP-13	L1379527-1 16-OCT-13	L1381520-1 22-Oct-13	L1342450-2 2-Aug-13	L1352047-2 22-Aug-13	L1357811-2 03-SEP-13	L1367061-2 10-SEP-13	L1367770-2 24-SEP-13	L1379527-2 16-OCT-13	L1381520-2 22-Oct-13
					TW-1	TW-1	TW-1	TW-1	TW-1	TW-1	TW-1	TW-2	TW-2	TW-2	TW-2	TW-2	TW-2	TW-2
<u>Polycyclic Aromatic Hydrocarbons</u>		MAC/IMAC	AO															
	Acenaphthene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Acenaphthylene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Acridine	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Anthracene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Benzo(a)anthracene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Benzo(a)pyrene	mg/L	0.00001	-	0.00001	-	-	-	-	-	-	<0.000010	-	-	-	-	-	-
	Benzo(b,j)fluoranthene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Benzo(g,h,i)perylene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Benzo(k)fluoranthene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Chrysene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Dibenz(a,h)anthracene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Fluoranthene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Fluorene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Indeno(1,2,3-cd)pyrene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Naphthalene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Phenanthrene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Pyrene	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
	Quinoline	mg/L	-	-	-	-	-	-	-	-	-	<0.000050	-	-	-	-	-	-
<u>Extractable Hydrocarbons</u>																		
	EPH10-19	mg/L			-	-	-	-	-	-	-	<0.25	-	-	-	-	-	-
	EPH19-32	mg/L			-	-	-	-	-	-	-	<0.25	-	-	-	-	-	-
	Light Extractable Petroleum Hydrocarbons (LEPH)	mg/L	-	-	-	-	-	-	-	-	-	<0.25	-	-	-	-	-	-
	Heavy Extractable Petroleum Hydrocarbons (HEPH)	mg/L	-	-	-	-	-	-	-	-	-	<0.25	-	-	-	-	-	-
<u>Volatile Hydrocarbons</u>																		
	Volatile Hydrocarbons VH _w (6-10)	mg/L	15	-	15	-	-	-	-	-	-	<0.10	-	-	-	-	-	-
	VPH (C6-C10)	mg/L	-	-	-	-	-	-	-	-	-	<0.10	-	-	-	-	-	-
<u>Volatile Organic Compounds</u>																		
	Benzene	mg/L	0.005	-	0.005	-	-	-	-	-	-	<0.00050	-	-	-	-	-	-
	Ethylbenzene	mg/L	-	0.0024	0.0024	-	-	-	-	-	-	<0.00050	-	-	-	-	-	-
	Methyl tert-Butyl Ether (MTBE)	mg/L	0.015	-	0.02	-	-	-	-	-	-	<0.00050	-	-	-	-	-	-
	Styrene	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	-	-	-	-	-	-
	Toluene	mg/L	-	0.024	0.024	-	-	-	-	-	-	<0.00050	-	-	-	-	-	-
	Xylenes	mg/L	-	0.3	-	-	-	-	-	-	-	<0.00075	-	-	-	-	-	-
	meta- & para-Xylene	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	-	-	-	-	-	-
	ortho-Xylene	mg/L	-	-	-	-	-	-	-	-	-	<0.00050	-	-	-	-	-	-
<u>Herbicides</u>																		
	Bromoxynil	mg/L	0.005	-	0.005	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Clopyralid	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	2,4-D	mg/L	-	-	0.04	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Dicamba	mg/L	0.12	-	0.120	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	2,4-DB	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	2,4-DP (Dichlorprop)	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Dinoseb	mg/L			0.010	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	MCPA	mg/L	0.1	-	0.10	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	MCPB	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Mecoprop	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Picloram	mg/L	0.19		0.19	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	2,4,5-T	mg/L	-	-	0.02	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	2,4,5-TP	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Triclopyr	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
<u>Pesticides</u>																		
	Ethalfuralin	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Fluazifop-p-butyl	mg/L	-	-	-	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Diclofop-methyl	mg/L	0.009	-	0.009	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Triallate	mg/L	-	-	0.23	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-
	Trifluralin	mg/L	0.045	-	0.045	-	-	-	-	-	-	<0.00010	-	-	-	-	-	-

1. IMAC/MAC - Interim and maximum allowable concentration; AO - Aesthetic objective.
2. From B.C. Contaminated Sites Regulation (CSR). Standard is protective of groundwater used for drinking water (DW).
3. Holding time exceeded for Lab pH.
4. **BOLD TEXT** - denotes parameters exceeding IMAC/MAC or AO. Underlined text denotes parameters exceeding DW CSR.
5. "" - " denotes not measured or no guideline / standard.

H:\Project\3122\Phase 3\Chemistry\TW1_TW2_Analytical Summary.xls]Table1_ProductionWells

TABLE II
SUMMARY OF FIELD AND LAB WATER QUALITY
RESULTS FOR MW2 AND MW3

		<u>Physical Parameters</u>				<u>Saltwater Parameters</u>	
		Conductivity		pH		Chloride Cl	Sodium Na
		Field	Lab	Field	Lab ²		
		(uS/cm)	(uS/cm)	(pH units)	(pH units)	(mg/L)	(mg/L)
Guidelines for Canadian Drinking Water Quality ¹	MAC/IMAC	-	-	-	-	-	-
	AO	-	-	6.5-8.5	6.5-8.5	250	200
Location	Date Sampled						
MW2-S	16-Jul-13	58	-	5.07	-	-	-
	8-Aug-13	83	-	4.54	-	-	-
	12-Aug-13	45	-	5.13	-	-	-
	22-Aug-13	58	-	6.36	-	-	-
	3-Sep-13	69	-	5.27	-	0.56	2.6
	16-Oct-13	52	60.7	6.25	-	0.56	2.6
MW2-D	16-Jul-13	48	-	5.11	-	-	-
	8-Aug-13	47	-	5.05	-	-	-
	12-Aug-13	52	-	5.5	-	-	-
	22-Aug-13	74	-	6.31	-	-	-
	3-Sep-13	59	-	5.56	-	0.6	3.6
	16-Oct-13	64	69.8	6.25	-	0.59	3.3
MW3-S	16-Jul-13	73	-	5.48	-	-	-
	12-Aug-13	110	-	4.72	-	-	-
	22-Aug-13	116	-	5.81	-	-	-
	3-Sep-13	67	-	4.97	-	7.72	8.3
	16-Oct-13	55	75.1	5.75	-	12.1	9.1
MW3-D	16-Jul-13	48	-	5.71	-	-	-
	12-Aug-13	69	-	5.08	-	-	-
	22-Aug-13	99	-	6.81	-	-	-
	3-Sep-13	107	-	5.3	-	9.67	6.1
	16-Oct-13	168	158	6.5	-	11.8	6.6

Notes:

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1. IMAC/MAC - Interim and maximum allowable concentration; AO - Aesthetic objective.
2. Holding time exceeded for Lab pH.
3. "-" denotes not measured or no guideline / standard.
4. **BOLD TEXT** - denotes parameters exceeding IMAC/MAC or AO.

TABLE III
WELL CAPACITY CALCULATIONS FOR WELLS TW1 AND TW2
FROM 100 DAY AQUIFER TESTING RESULTS

	PARAMETER	Unit	TW1		TW2	
			Value	Check	Value	Check
A	Seasonally lowest water level (October 1)	m-bgl	4.5		11.0	
B	Depth to top of screened interval	m-bgl	32.9		31.7	
C	Allowance for tidal variations	m	0.1		0.1	
D	Available drawdown = $B - A - C$	m	28.3		20.6	
E	Drawdown Safety Factor		70%		70%	
F	Interwell drawdown interference accounted for in measured drawdown during 100 day test	m	-		-	
G	Allowable drawdown = $D \times E$	m	19.8		14.4	
H	Test rate used for analysis	L/s	22.0		19.2	
		lgpm	290.4		253.4	
		USgpm	348.7		304.3	
I	Projected drawdown after 100 days of pumping TW1 and TW2 (corrected for seasonal water level decline)	m	8.7		13.8	
J	Projected specific capacity after 100 days of pumping TW1 and TW2 (corrected for seasonal water level decline)	L/s/m	2.5		1.4	
K	Recommended design flow (based on water level response at monitoring wells MW2-S and MW2-D)	L/s	26.7		19.9	
		lgpm	352.4		262.7	
		USgpm	423.2		315.4	
L	Projected drawdown after 100 days continuous pumping at design flow = K / J	m	10.6		14.3	
	Check: % of maximum allowable drawdown used after 100 days at design flow = K / G - <i>should be <100%</i>	%	53%	OK	99%	OK
M	Recommended pump intake level = $B - 1.5m$	m-bgl	31.4		30.2	
N	Recommended depth to low water shutoff = $M - 2.0m$	m-bgl	29.4		28.2	
O	Projected depth to pumping level after 100 days continuous pumping at design flow ($A + L$)	m-bgl	15.1		25.3	
	Check: Minimum pump submergence after 100 days at design flow = $M - O$ <i>should be > 2m</i>	m	16.3	OK	4.9	OK
P	Screen Length	m	3.1		3.0	
Q	Screen Intake Area	m ² /m	0.32		0.32	
R	Maximum Screen Entrance Velocity	m/s	0.03		0.03	
S	Maximum flow based on Screen Entrance Velocity = $P \times Q \times R \times 1000$	L/s	29.3		29.2	
		lgpm	387		386	
		USgpm	465		463	
	Check: Design flow as percent of maximum flow based on screen entrance velocity = K / S - <i>should be < 100 %</i>	m	91%	OK	68%	OK

H:\Project\3122\Phase 3\Pump Test - July 2013\Recommended Yields TW1 TW2.xls]TW1

Notes:

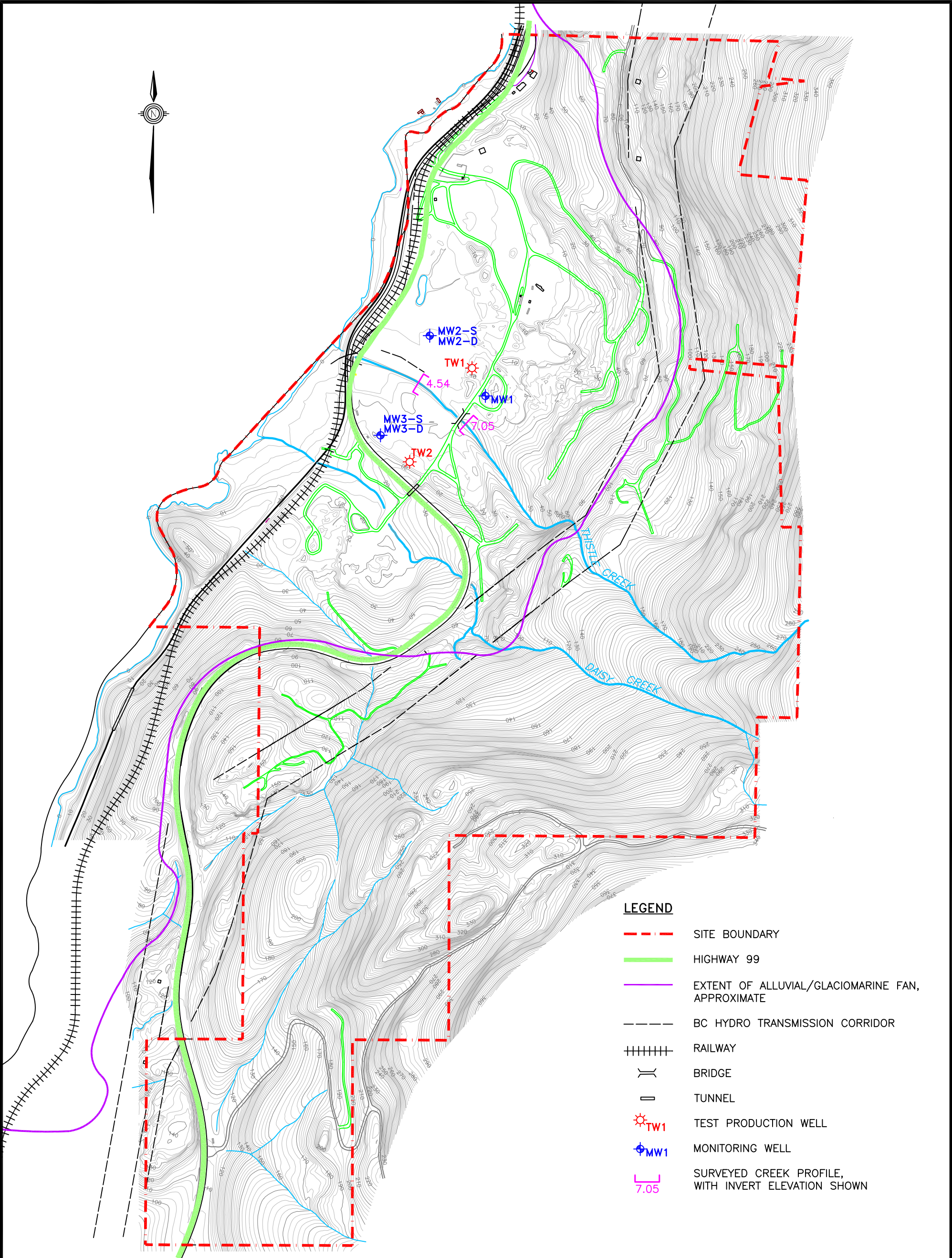
m-bgl = metres below ground level

A: Static water level measured at end of summer drought period in early October

E: For a 70% Factor of Safety, Allowable drawdown = 70% of Available drawdown

F: Interference from simultaneous pumping of TW1 and TW2 accounted for in projected drawdown (I)

FIGURES



- LEGEND**
- SITE BOUNDARY
 - HIGHWAY 99
 - EXTENT OF ALLUVIAL/GLACIOMARINE FAN, APPROXIMATE
 - BC HYDRO TRANSMISSION CORRIDOR
 - ++++ RAILWAY
 - || BRIDGE
 - || TUNNEL
 - ☀ TW1 TEST PRODUCTION WELL
 - ⊕ MW1 MONITORING WELL
 - 7.05 SURVEYED CREEK PROFILE, WITH INVERT ELEVATION SHOWN

NOTE: TOPOGRAPHIC CONTOURS ARE IN METRES ABOVE MEAN SEA LEVEL.

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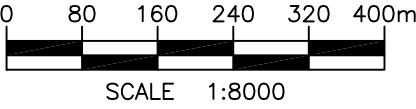
TAICHENG DEVELOPMENT CORPORATION
GROUNDWATER SUPPLY ASSESSMENT
PHASE 3 - BRITANNIA SOUTH PROJECT

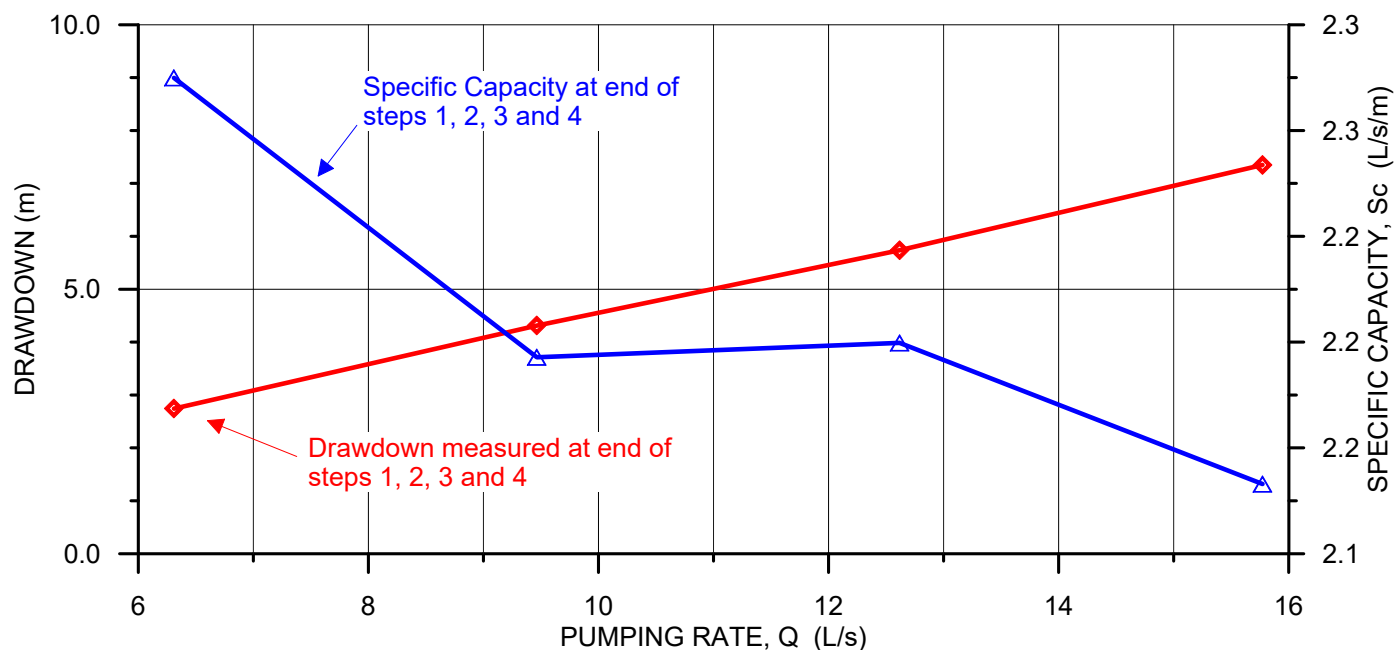
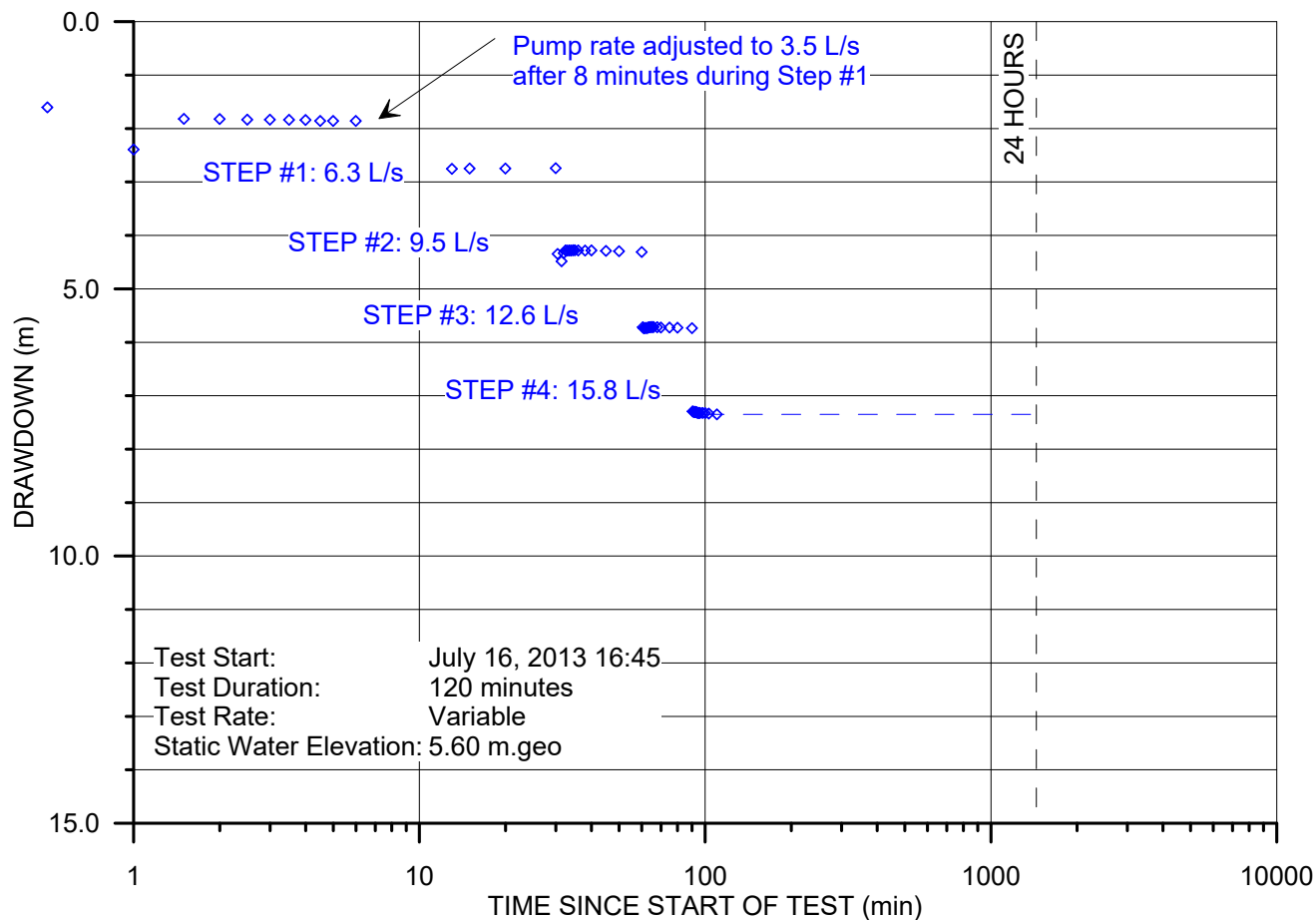


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SITE PLAN

BY:	DATE:
BD/si	JAN 14
APPROVED:	FIG:
DJT	1





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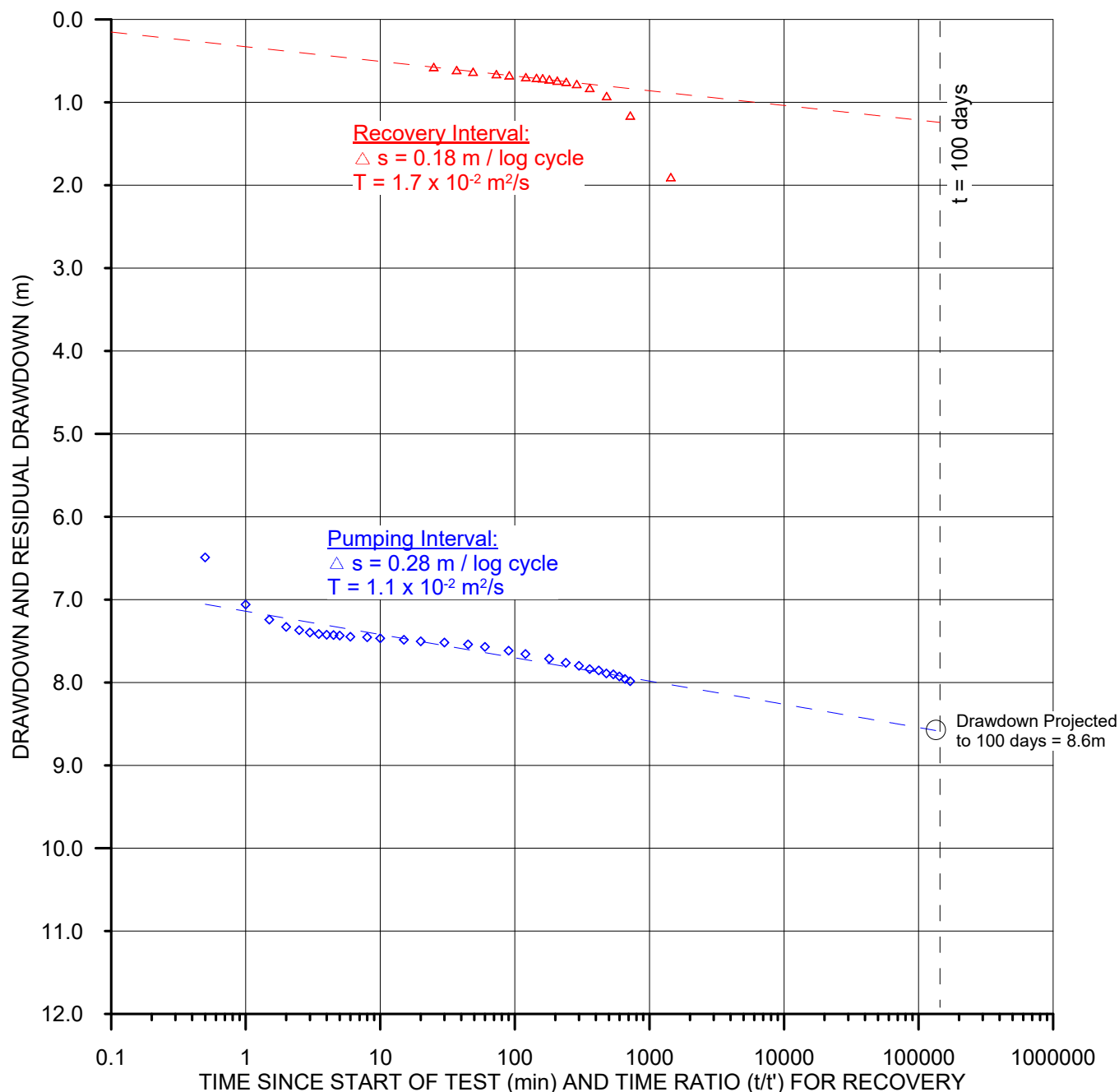
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SEMI-LOG PLOT OF DRAWDOWN IN TW2 DURING VARIABLE
 RATE TEST

BY:	BD	DATE:	JAN 14
APPROVED:	KCT	FIG:	2



Test Start: July 18, 2013 6:20
 Test Duration: 12 hours (720 minutes)
 Test Rate: 16.3 L/s (258 USgpm)
 Static Water Elevation: 5.58 mgeo.

COOPER & JACOB (1946)

$$T = \frac{2.303 \cdot Q \cdot 0.001}{4 \cdot \pi \cdot \Delta s}$$

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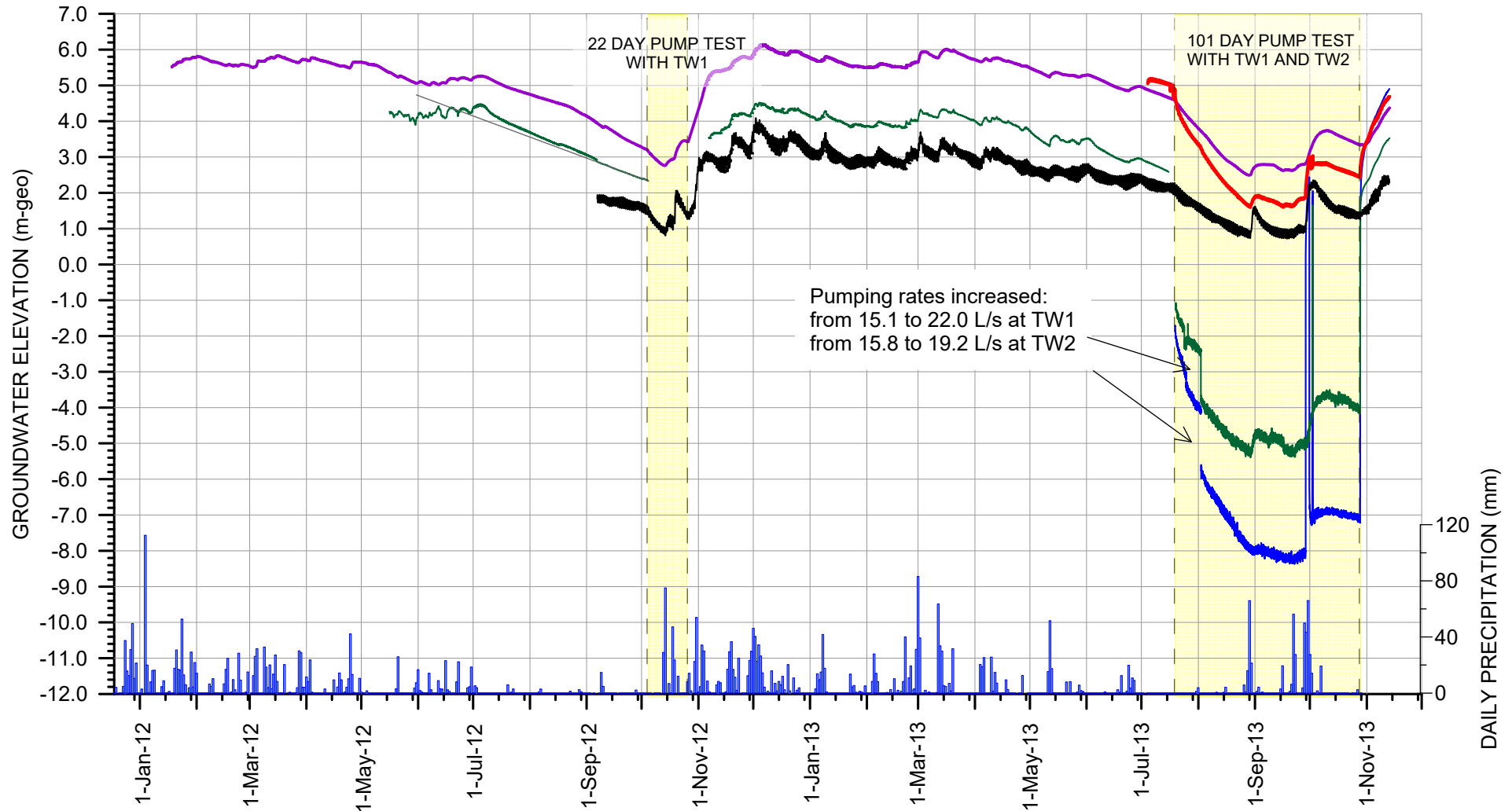
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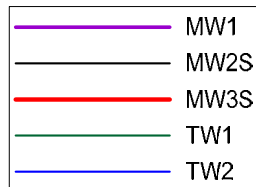
SEMI-LOG PLOT OF DRAWDOWN AND RECOVERY IN TW2 DURING
 12 HR CONSTANT RATE TEST

BY:	DATE:
BD	JAN 14
APPROVED:	FIG:
KCT	3



Note: Precipitation data obtained from Environment Canada's "Squamish Airport" Station

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GROUNDWATER SUPPLY ASSESSMENT
PHASE 3 - BRITANNIA SOUTH PROJECT

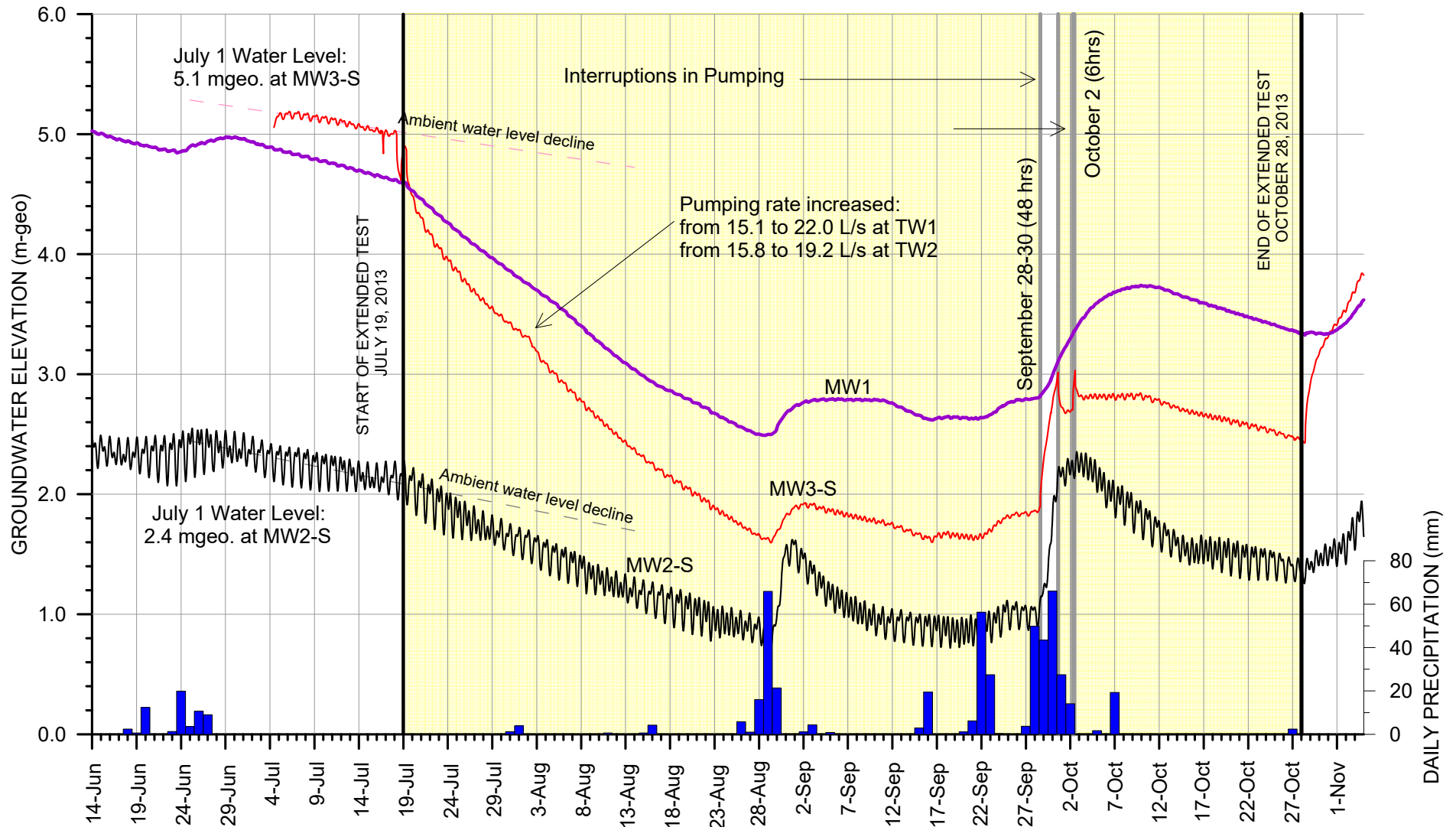


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WATER LEVELS AT TEST WELL AND MONITORING WELLS
PRIOR TO AND DURING EXTENDED TEST WITH TW1 AND TW2

BY:	KCT	DATE:	JAN 14
APPROVED:	DJT	FIG:	4



Note: Precipitation data obtained from Environment Canada's "Squamish Airport" Station

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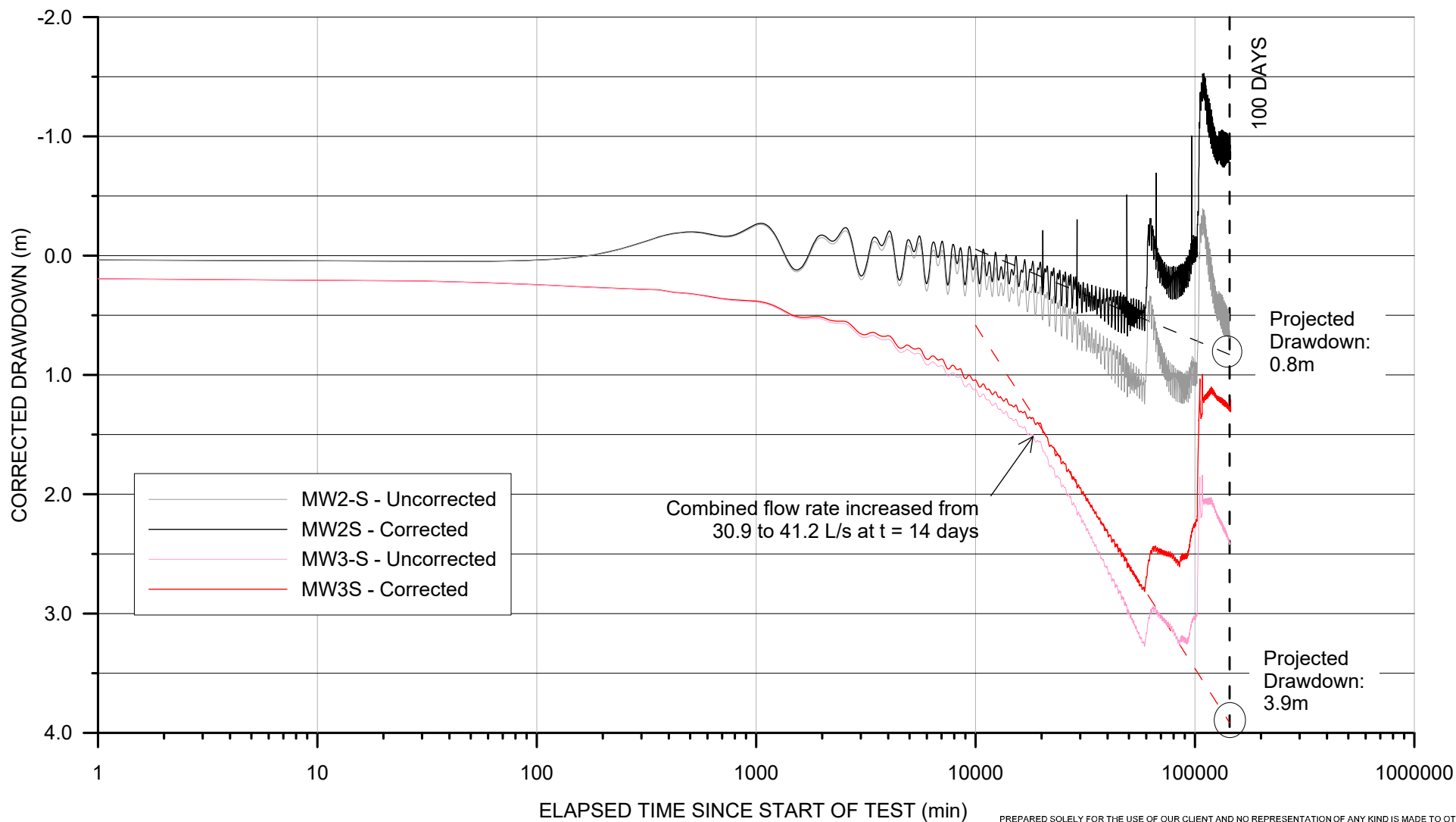
**TAICHENG DEVELOPMENT CORPORATION
GROUNDWATER SUPPLY ASSESSMENT
PHASE 3 - BRITANNIA SOUTH PROJECT**



PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

**WATER LEVELS AT MONITORING WELLS DURING EXTENDED
TEST WITH TW1 AND TW2**

BY:	KCT	DATE:	JAN 14
APPROVED:	DJT	FIG:	5



Test Start: July 19, 2013 8:30am
 Test Duration: 101 Days
 Combined Flow Rate: 30.9 - 41.2 L/s

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TAICHENG DEVELOPMENT CORPORATION
 GROUNDWATER SUPPLY ASSESSMENT
 PHASE 3 - BRITANNIA SOUTH PROJECT

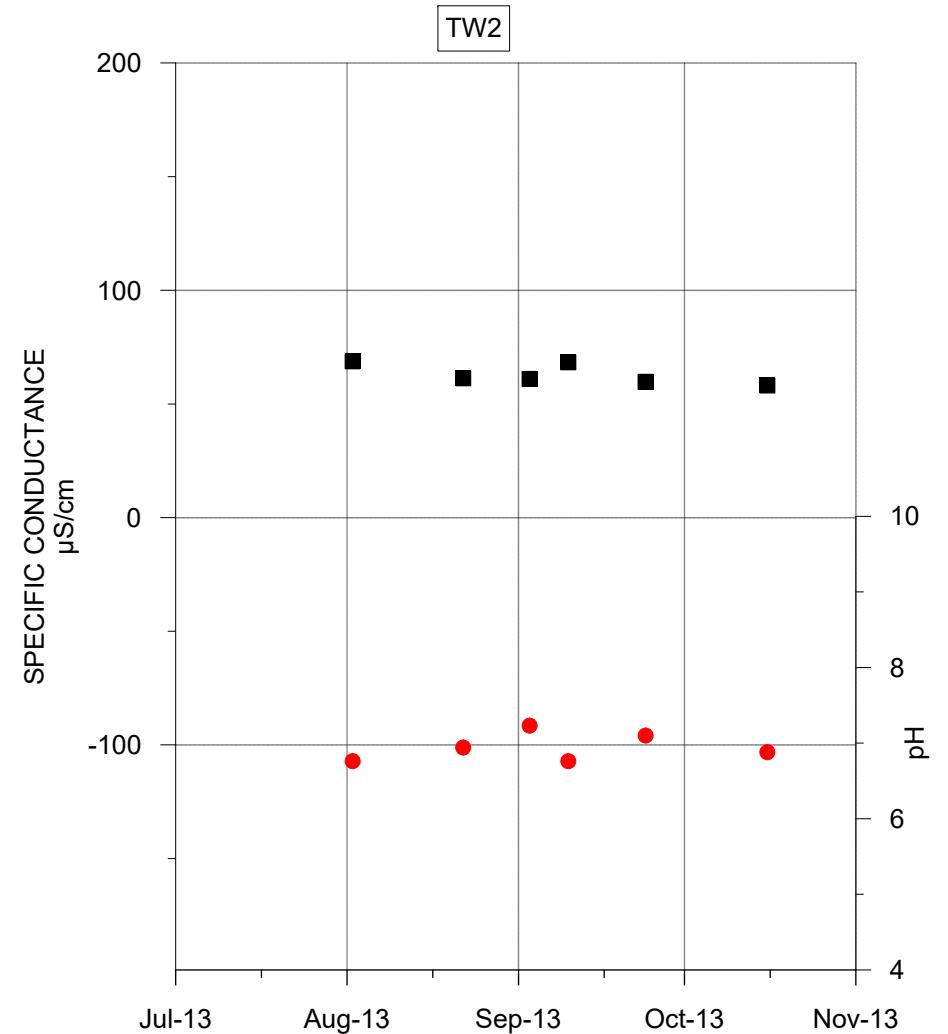
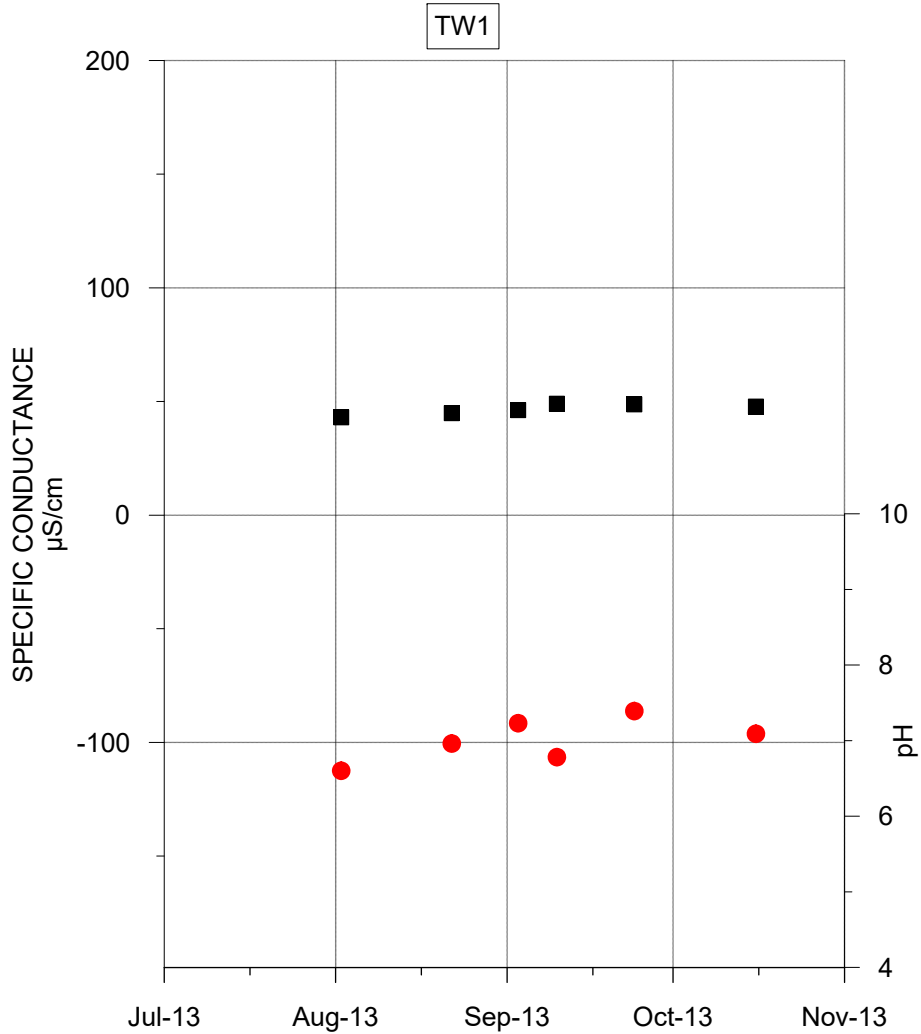


PITEAU ASSOCIATES

GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

**DRAWDOWN AT MONITORING WELLS MW2-S AND MW3-S
 DURING PORTION OF EXTENDED AQUIFER
 PUMPING TEST WITH TW1 AND TW2**

BY:	DATE:
KCT	JAN 14
APPROVED:	FIG:
DJT	6



● ● ● LAB pH
■ ■ ■ LAB CONDUCTIVITY

TAICHENG DEVELOPMENT CORPORATION
GROUNDWATER SUPPLY ASSESSMENT
PHASE 3 - BRITANNIA SOUTH PROJECT

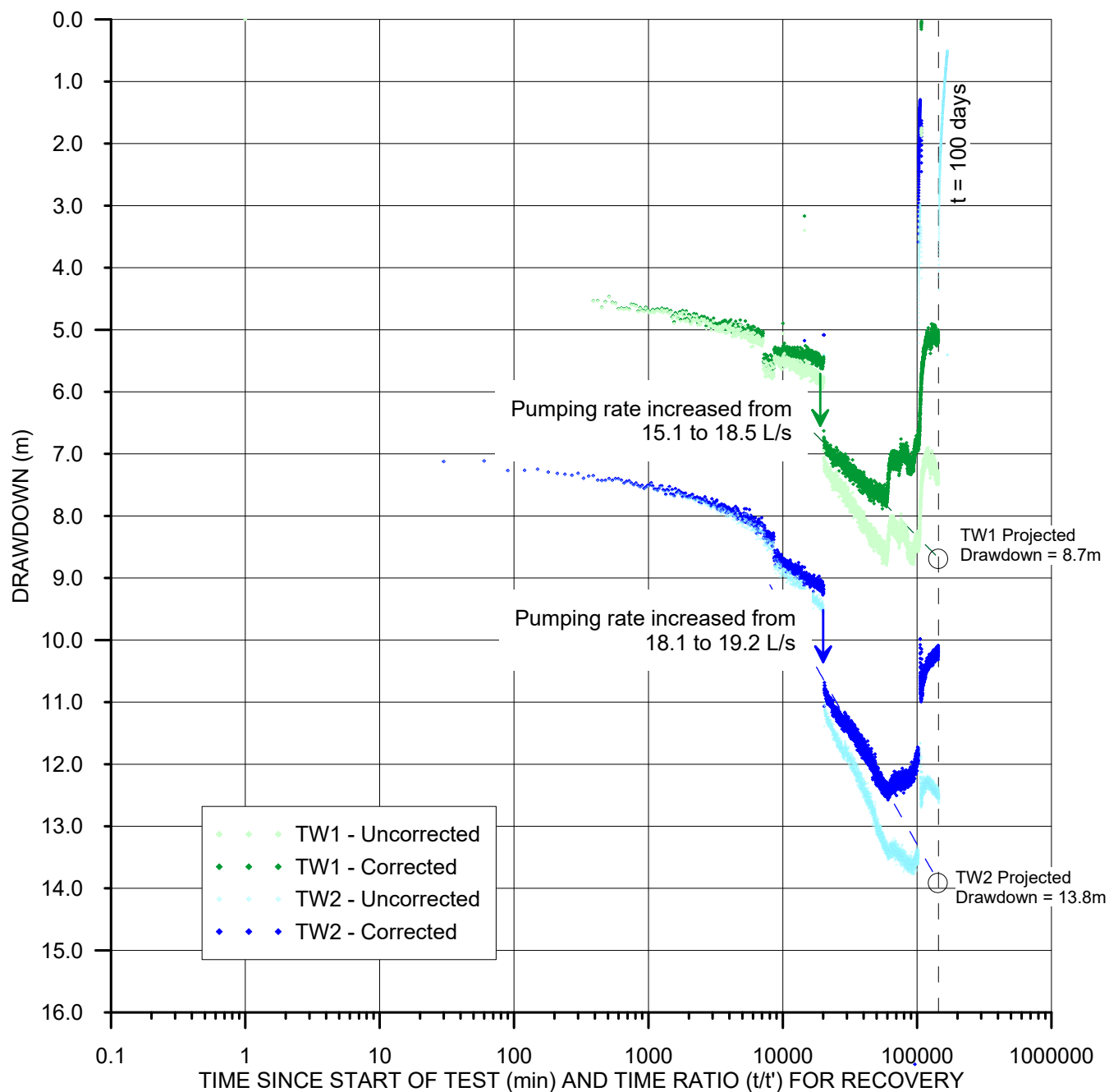
PREPARED SOLELY FOR THE USE OF OUR CLIENT AND NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH PITEAU ASSOCIATES ENGINEERING LTD. HAS NOT ENTERED INTO A CONTRACT.



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GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

CONDUCTIVITY AND PH LEVELS AT TW1 AND TW2 DURING
EXTENDED TESTING AT TW1 AND TW2

BY:	DATE:
KCT	JAN 14
APPROVED:	FIG:
DJT	7



TW1

Test Start: July 19, 2013 9:30am
 Test Duration: 101 days
 Test Rate: 22.0 L/s (293 USgpm)
 Static Water Elevation: 3.40 mgeo.

TW2

July 19, 2013 8:30am
 101 days
 19.2 L/s (304 USgpm)
 5.41 mgeo.

COOPER & JACOB (1946)

$$T = \frac{2.303 * Q * 0.001}{4 * \pi * \Delta s}$$

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TAICHENG DEVELOPMENT CORPORATION
 GROUNDWATER SUPPLY ASSESSMENT
 PHASE 3 - BRITANNIA SOUTH PROJECT



PITEAU ASSOCIATES

GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

SEMI-LOG PLOT OF DRAWDOWN AND RECOVERY IN
 TW1 AND TW2 DURING 100-DAY TEST

BY:	DATE:
BD	JAN 14
APPROVED:	FIG:
KCT	8

PHOTOS



Photo 1.
TW1 well head during pumping test, August 2, 2013.



Photo 2.
TW2 well head during pumping test, August 2, 2013.



Photo 3.

Lay-flat hose carrying discharge from wells TW1 and TW2 along dry creekbed of Thistle Creek, August 2, 2013.



Photo 4.

Orifice plate flow measurement devices at point of well discharge into Thistle Creek, August 2, 2013.

APPENDIX A

GRAIN SIZE ANALYSES AND BOREHOLE LOGS



Client: Taicheng Development Corporation

Drilling Contractor: Field Drilling Contractors Ltd.

Drilling Method: Air Rotary

Drilling Date: December 20, 2011

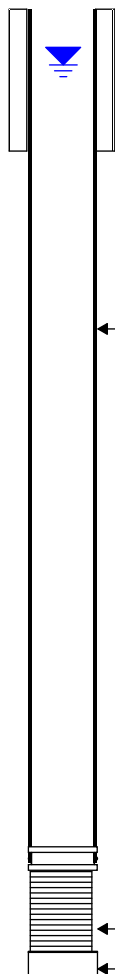
Project: Groundwater Supply Investigations - Phase 2A

Location: Minaty Bay, B.C

Project Number: 3122

Logged By: Jen Mancer

Borehole Diameter: 203mm (8 inch)

Depth Below Ground Surface	Lithologic Description	Depth (m)	Lithology	Remarks	Well Construction
ft m 0 0	Ground Surface	0.0		Surface Completion: 203mm casing stickup to 1.0m and secured with lockable cap. seal. Surface Seal: 305mm surface casing advanced to 5.5m and removed during installation of bentonite seal.	 DTW 2.04mbg Jan 17, 2012 ← 203mm Casing ← Well Screen ← Native Backfill
5	GRAVEL and fine SAND.				
10		4.9			
15 5	Brown fine SAND, some gravel, wet.				
20		18.0			
25					
30					
35 10					
40					
45					
50 15					
55		21.0			
60	Fine to coarse gravelly SAND, water bearing.				
65 20		22.9			
70	Fine to coarse SAND and fine to coarse GRAVEL, subangular to subrounded, water bearing.				
75		25.3			
80 25	Gravelly SAND, water bearing. Iron staining 22.9-25.3m.				
85					
90	Fine to coarse SAND and fine to coarse GRAVEL, water bearing.				
95					
100 30					
105					
110					
115 35					
120		36.9			
125	TILL. End of hole.				
130 40					
135					
140					
145 45					
150					
155					
160					
165 50					
170					
175					

**Drilling Date: September 5-6, 2012**

Borehole Diameter: 150 mm (6 inch)

Depth Below Ground Surface	Lithologic Description	Depth (m)	Lithology	Remarks	Well Construction
ft m					
-5					
0	Ground Surface	0.0		Surface Completion: 150 mm casing stickup to 0.75 m and secured with lockable cap.	
5	Gravelly Sand Light brown, trace silt, moist	1.5			150 mm Casing to 9.1m
10	Sand	3.0			Cuttings
15	Grey brown, moist some gravel	4.6			Bentonite
20	Sand	6.1			25 mm PVC Riser
25	Grey, moist, med to coarse grained. some gravel	7.6			
30	Sand	12.2			25 mm PVC Riser
35	Grey, wet, fine to med grained, trace gravel	13.7			
40	Sand	17.1			
45	Grey, wet, med to coarse grained, some gravel	18.9			
50	Sand	20.1			
55	Grey, wet, fine to medium grained, trace gravel	22.6			
60	Sand	23.8			
65	Grey, wet, med to coarse grained, trace gravel				
70	Sand				
75	Grey, wet, fine to med grained, trace gravel				
80	Sand				
85	Grey, wet, med grained trace gravel				
90	Sand				
95	Grey, wet, coarse grained, trace gravel				
100	Sand				
105	Grey, wet, fine to med grained, trace gravel				Bentonite
110	Sand				Screen
115	Grey, wet, med grained trace gravel				Bentonite
120	Sand				
125	Grey, wet, fine to med grained, trace gravel.				
130		40.8			
135	Sand				
140	Grey wet fine to med grained trace gravel, trace pieces of stiff grey silt.				
145					Bentonite
150					Screen
155					Bentonite
160		49.7			
165	Silt	51.2			
170	Grey brown, moist, very stiff	52.4			
175	Gravel	53.3			
180	Grey, wet				
185	Gravel and Silt				
190	Grey, silt is cementing the gravel				
195	End of Hole				Sluff



Client: Taicheng Development Corporation

Drilling Contractor: A & H Drilling Ltd.

Drilling Method: Air Rotary

Drilling Date: June 24-28, 2013

Project: Groundwater Supply Investigations - Phase 3

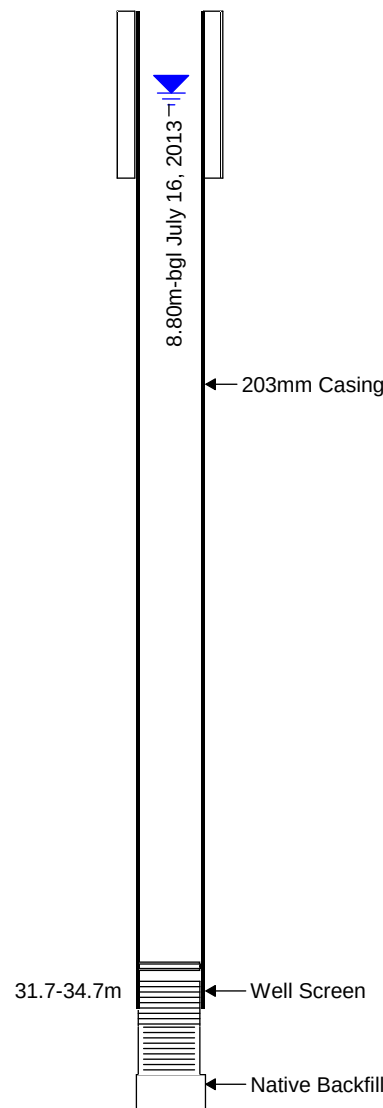
Location: Minaty Bay, B.C

Project Number: 3122

Ground Elevation: 14.4m geo.

Borehole Diameter: 203mm (8 inch)

Depth Below Ground Surface	Lithologic Description	Depth (m)	Lithology	Remarks	Well Construction
0 ft 0 m	Ground Surface	0.0			
5	Sand Grey brown, some gravel			Surface Completion: 203mm casing stickup to 0.83m and secured with lockable cap.	
10		4.9			
15	Sand Grey some gravel, moist becoming wet @ 12 m			Surface Seal: 305mm surface casing advanced to 5.5m and removed during installation of bentonite seal.	
20					
25					
30					
35					
40					
45					
50					
55					
60		18.3			
65	Gravelly Sand Grey, wet	19.8			
70	Sand Grey, wet, some gravel				
75					
80					
85		25.9		203mm casing drilled to 35.9m and pulled back to 31.4m to expose screen.	
90	Sand Grey, wet, fine grained	27.4			
95	Sand Grey, wet, some gravel	28.2		Telescopic Stainless Steel Well Screen Assembly Installed from 30.7-34.7m Solid Riser and K-Packer: 30.7-31.7m Screen Interval: Slot size 2.54mm: 31.7-33.2m Slot size 3.05mm: 33.2-34.7m	
100	Gravelly Sand Grey, wet	32.0			
105					
110	Sandy Gravel Grey, wet				
115		35.1			
120	Silt Grey, moist, stiff	36.0			
125	End of Hole				
130					
135					
140					
145					
150					





Client: Taicheng Development Corporation

Drilling Contractor: A & H Drilling Ltd.

Drilling Method: Air Rotary

Drilling Date: July 2-3, 2013

Project: Groundwater Supply Investigations - Phase 3

Location: Minaty Bay, B.C

Project Number: 3122

Ground Elevation: 9.6m geo.

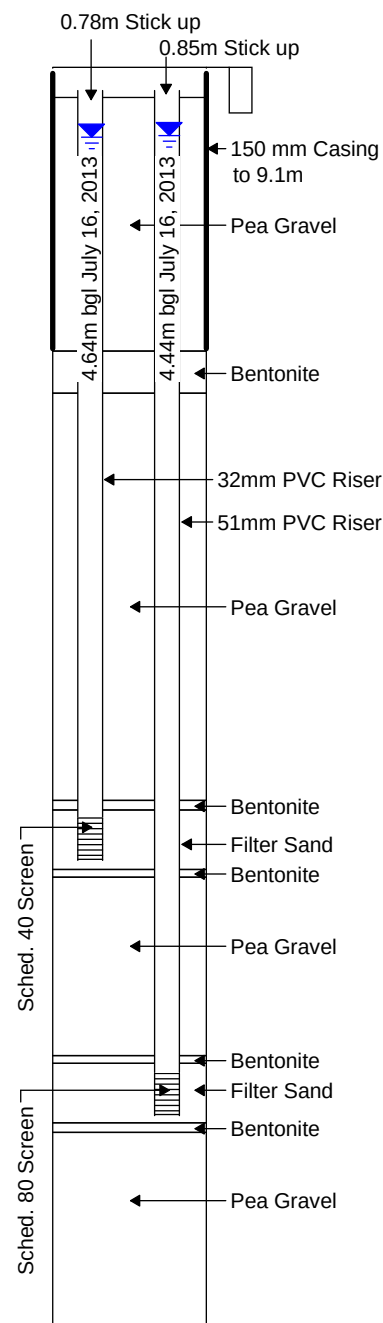
Borehole Diameter: 150 mm (6 inch)

Depth Below Ground Surface	Lithologic Description	Depth (m)	Lithology	Remarks	Well Construction
ft m					
-10					
-5					
0	Ground Surface				
5	Sand Brown, some gravel fill	3.0			
10					
15	Sand Grey, moist, some gravel				
20					
25					
30					
35					
40					
45		13.7			
50	Sand Grey, wet, trace gravel.				
55					
60					
65					
70		21.3			
75	Gravelly Sand Grey, wet				
80					
85					
90					
95					
100		30.5			
105	Sandy Gravel Grey, wet, subangular to angular, fine grained gravel with fine to coarse grained sand, trace fines.				
110					
115					
120					
125		38.1			
130	Sand Grey, wet, fine to medium grained, some fines.				
135					
140		43.3			
145	Clay/Silt Light grey, wet, trace sand.	44.2			
150					
155	End of Hole				

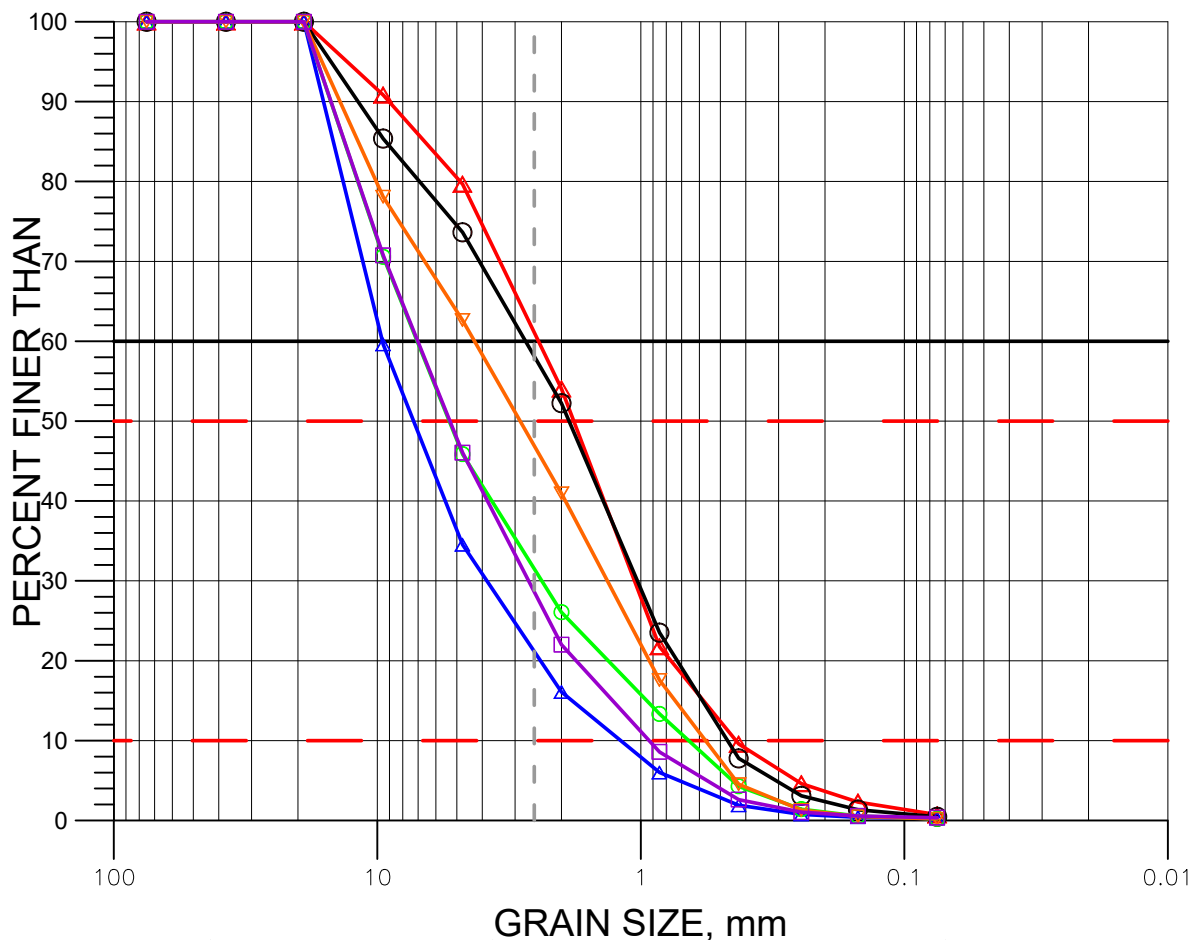
Surface Completion: 150 mm casing stickup to 0.97 m and secured with lockable cap.

MW-3S:
32mm SCH 40 PVC
Screen: 25.9-27.4 m
Filter Sand: 25.6-27.7m

MW-3D:
51mm SCH 80 PVC
Screen: 35.0-36.5m
Filter Sand: 34.7-36.8m



UNIFIED SOIL CLASSIFICATION SYSTEM 1992



USCS		Coarse	Fine	Coarse	Medium	Fine	
COBBLE SIZE	GRAVEL SIZE		SAND SIZE			SILT or CLAY SIZE	

Hydraulic Conductivity Estimation (Hazen, 1911)

$$K \text{ [m/s]} = D_{10}^2 \times 0.01$$

LEGEND

▲-▲-▲	30.5-31.1m (100-102')
○-○-○	31.1-32.0m (102-105')
△-△-△	32.0-32.6m (105-107')
◇-◇-◇	32.6-33.5m (107-110')
▽-▽-▽	33.5-34.1m (110-112')
□-□-□	35.0-35.7m (115-117')
- - -	100 SLOT

Sample Depth	D10 (mm)	K (m/s)
30.5-31.1m	0.43	1.8E-03
31.1-32.0m	0.47	2.2E-03
32.0-32.6m	1.20	1.4E-02
32.6-33.5m	0.67	4.5E-03
33.5-34.1m	0.56	3.1E-03
35.0-35.7m	0.92	8.5E-03
Geometric Mean		4.4E-03

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TAICHENG DEVELOPMENT CORPORATION
HDRYOGEOLOGIC ASSESSMENT FOR
PHASE 3 - BRITANNIA SOUTH PROJECT



PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

GRAIN SIZE DISTRIBUTION AT WELL TW2

BY:	BD	DATE:	JAN 14
APPROVED:	KCT	FIG:	A-1

APPENDIX B

MANUAL WATER LEVEL DATA RECORDED DURING PUMPING TESTS WITH TW2

TABLE B-1
SUMMARY OF MANUAL DATA DURING VARIABLE-RATE PUMPING TEST WITH TW2

Date	Time	Elapsed Time (min)	Depth to water TW2 (ft-btoc)	Depth to water TW2 (m-btoc)	Drawdown TW2 (m)	Pumping Rate TW1		Comments
						(USgpm)	(L/s)	
16-Jul-13	16:45:00	0	31.59			100.0	6.30	Static Water Level
16-Jul-13	16:45:30	0.5	36.86					Step 1 (6.30 L/s)
16-Jul-13	16:46:00	1	37.41					
16-Jul-13	16:46:30	1.5	37.6					
16-Jul-13	16:47:00	2	37.57					
16-Jul-13	16:47:30	2.5	37.61					
16-Jul-13	16:48:00	3	37.61					
16-Jul-13	16:48:30	3.5	37.62					
16-Jul-13	16:49:00	4	37.63					
16-Jul-13	16:49:30	4.5	37.69					
16-Jul-13	16:50:00	5	37.69					
16-Jul-13	16:51:00	6	37.69					2" at orifice
16-Jul-13	16:53:00	8						Valve up, Valve up, Valve down, Valve down, Valve down
16-Jul-13	16:58:00	13	40.63					6 1/2" at orifice
16-Jul-13	17:00:00	15	40.61					
16-Jul-13	17:05:00	20	40.61					
16-Jul-13	17:15:00	30	40.59					Valve up
16-Jul-13	17:15:30	30.5	45.85			150.0	9.45	Step 2: Valve Up (9.45L/s)
16-Jul-13	17:16:00	31						
16-Jul-13	17:16:30	31.5	46.30					16 1/2", Valve down
16-Jul-13	17:17:00	32	45.80					
16-Jul-13	17:17:30	32.5	45.64					
16-Jul-13	17:18:00	33	45.65					14 1/2" at orifice
16-Jul-13	17:18:30	33.5	45.64					
16-Jul-13	17:19:00	34	45.65					
16-Jul-13	17:19:30	34.5	45.63					
16-Jul-13	17:20:00	35	45.63					
16-Jul-13	17:21:00	36	45.64					
16-Jul-13	17:23:00	38	45.65					
16-Jul-13	17:25:00	40	45.64					
16-Jul-13	17:30:00	45	45.67					
16-Jul-13	17:35:00	50	45.69					
16-Jul-13	17:45:00	60	45.74					Valve up
16-Jul-13	17:45:30	60.5	50.35			200.0	12.6	Step 3: Valve up (12.6 L/s) 25 1/2" at orifice
16-Jul-13	17:46:00	61	50.42					
16-Jul-13	17:46:30	61.5	50.40					
16-Jul-13	17:47:00	62	50.40					
16-Jul-13	17:47:30	62.5	50.40					
16-Jul-13	17:48:00	63	50.39					
16-Jul-13	17:48:30	63.5	50.35					
16-Jul-13	17:49:00	64	50.35					
16-Jul-13	17:49:30	64.5	50.34					
16-Jul-13	17:50:00	65	50.34					
16-Jul-13	17:51:00	66	50.34					
16-Jul-13	17:53:00	68	50.35					
16-Jul-13	17:55:00	70	50.37					
16-Jul-13	18:00:00	75	50.38					
16-Jul-13	18:05:00	80	50.38					
16-Jul-13	18:15:00	90	50.41					40" at orifice, valve up
16-Jul-13	18:15:30	90.5	55.5			250.0	15.8	Step 4: Valve up (15.8 L/s)
16-Jul-13	18:16:00	91	55.55					
16-Jul-13	18:16:30	91.5	55.56					
16-Jul-13	18:17:00	92	55.56					
16-Jul-13	18:17:30	92.5	55.55					
16-Jul-13	18:18:00	93	55.57					
16-Jul-13	18:18:30	93.5	55.59					
16-Jul-13	18:19:00	94	55.61					
16-Jul-13	18:19:30	94.5	55.62					
16-Jul-13	18:20:00	95	55.62					
16-Jul-13	18:21:00	96	55.62					
16-Jul-13	18:23:00	98	55.62					
16-Jul-13	18:25:00	100	55.63					
16-Jul-13	18:30:00	105	55.66					
16-Jul-13	18:35:00	110	55.70					
16-Jul-13	18:45:00	120	55.65					Pump Off

H:\Project\3122\Phase 3\Pump Test - July 2013\Frontier Manual Step Test Data_TW2.xls|Table B-1

TABLE B-1
SUMMARY OF MANUAL DATA DURING VARIABLE-RATE PUMPING TEST WITH TW2

16-Jul-13	18:45:30	120.5	52.00			0.0	0	Recovery
16-Jul-13	18:46:00	121	41.85					
16-Jul-13	18:46:30	121.5	41.05					
16-Jul-13	18:47:00	122	41.06					
16-Jul-13	18:47:30	122.5	41.08					
16-Jul-13	18:48:00	123	41.10					
16-Jul-13	18:48:30	123.5	41.10					
16-Jul-13	18:49:00	124	41.10					
16-Jul-13	18:49:30	124.5	41.11					
16-Jul-13	18:50:00	125	41.11					
16-Jul-13	18:51:00	126	41.12					
16-Jul-13	18:53:00	128	41.12					Pump kicks out

H:\Project\3122\Phase 3\Pump Test - July 2013\[Frontier Manual Step Test Data_TW2.xls]Table B-1

TABLE B-2
SUMMARY OF MANUAL DATA DURING CONSTANT RATE TEST WITH TW2

Date	Time	Elapsed Time (min)	Depth to water TW2 (ft-btloc)	Depth to water TW2 (m-btloc)	Drawdown TW2 (m)	Pumping Rate TW2		Comments
						(USgpm)	(L/s)	
18-Jul-13	6:20:00	0	31.65	9.65				
18-Jul-13	6:20:30	0.5	52.95	16.14				
18-Jul-13	6:21:00	1	54.81	16.71				
18-Jul-13	6:21:30	1.5	55.4	16.89				
18-Jul-13	6:22:00	2	55.70	16.98				
18-Jul-13	6:22:30	2.5	55.83	17.02				
18-Jul-13	6:23:00	3	55.92	17.04				
18-Jul-13	6:23:30	3.5	55.98	17.06				
18-Jul-13	6:24:00	4	56.01	17.07				
18-Jul-13	6:24:30	4.5	56.02	17.07				
18-Jul-13	6:25:00	5	56.04	17.08				
18-Jul-13	6:26:00	6	56.09	17.10				
18-Jul-13	6:28:00	8	56.11	17.10				
18-Jul-13	6:30:00	10	56.15	17.11				
18-Jul-13	6:35:00	15	56.21	17.13				
18-Jul-13	6:40:00	20	56.27	17.15				
18-Jul-13	6:50:00	30	56.32	17.17				
18-Jul-13	7:15:00	45	56.39	17.19				
18-Jul-13	7:20:00	60	56.49	17.22				
18-Jul-13	7:50:00	90	56.64	17.26				
18-Jul-13	8:20:00	120	56.77	17.30		258.00	16.3	42 1/3" at 4" pipe with 3" orifice
18-Jul-13	9:20:00	180	56.96	17.36				
18-Jul-13	10:20:00	240	57.12	17.41				
18-Jul-13	11:20:00	300	57.24	17.45				
18-Jul-13	12:20:00	360	57.37	17.49				
18-Jul-13	13:20:00	420	57.42	17.50				
18-Jul-13	14:20:00	480	57.54	17.54				
18-Jul-13	15:20:00	540	57.58	17.55				
18-Jul-13	16:20:00	600	57.66	17.57				
18-Jul-13	17:20:00	660	57.76	17.61				
18-Jul-13	18:20:00	720	57.85	17.63				
18-Jul-13	18:20:30	720.5	37.89	11.55		0.00	0.0	Recovery
18-Jul-13	18:21:00	721	35.45	10.81				
18-Jul-13	18:21:30	721.5	34.68	10.57				
18-Jul-13	18:22:00	722	34.36	10.47				
18-Jul-13	18:22:30	722.5	34.20	10.42				
18-Jul-13	18:23:00	723	34.12	10.40				
18-Jul-13	18:23:30	723.5	34.07	10.38				
18-Jul-13	18:24:00	724	34.02	10.37				
18-Jul-13	18:24:30	724.5	33.98	10.36				
18-Jul-13	18:25:00	725	33.96	10.35				
18-Jul-13	18:26:00	726	33.93	10.34				
18-Jul-13	18:28:00	728	33.86	10.32				
18-Jul-13	18:30:00	730	33.81	10.31				
18-Jul-13	18:35:00	735	33.72	10.28				
18-Jul-13	18:40:00	740	33.65	10.26				
18-Jul-13	18:50:00	750	33.53	10.22				

H:\Project\3122\Phase 3\Pump Test - July 2013\Frontier Manual Constant Rate Data_TW2.xls]TableB-2

APPENDIX C

LABORATORY ANALYTICAL REPORTS



PITEAU ASSOC. ENGINEERING LTD.

ATTN: Kathy Tixier

215 - 260 West Esplanade

North Vancouver BC V7M 3G7

Date Received: 02-AUG-13

Report Date: 09-AUG-13 13:47 (MT)

Version: FINAL

Client Phone: 604-986-8551

Certificate of Analysis

Lab Work Order #: L1342450

Project P.O. #: NOT SUBMITTED

Job Reference: 3122

C of C Numbers:

Legal Site Desc:

Brent Mack
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ADDRESS: 8081 Lougheed Hwy, Suite 100, Burnaby, BC V5A 1W9 Canada | Phone: +1 604 253 4188 | Fax: +1 604 253 6700

ALS CANADA LTD Part of the ALS Group A Campbell Brothers Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID				
		Description				
		Sampled Date				
		Sampled Time				
		Client ID				
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (uS/cm)	43.0	68.7			
	Hardness (as CaCO3) (mg/L)	16.8	15.8			
	pH (pH)	6.60	6.76			
	Turbidity (NTU)	<0.10	<0.10			
Anions and Nutrients	Bromide (Br) (mg/L)	<0.050	<0.050			
	Chloride (Cl) (mg/L)	0.52	7.47			
	Fluoride (F) (mg/L)	<0.020	<0.020			
	Nitrate (as N) (mg/L)	0.183	0.358			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Sulfate (SO4) (mg/L)	5.25	2.50			
Bacteriological Tests	E. coli (MPN/100mL)	<1	<1			
	Coliform Bacteria - Total (MPN/100mL)	<1	<1			
Total Metals	Aluminum (Al)-Total (mg/L)		<0.010			
	Antimony (Sb)-Total (mg/L)		<0.00050			
	Arsenic (As)-Total (mg/L)		<0.00010			
	Barium (Ba)-Total (mg/L)		<0.020			
	Boron (B)-Total (mg/L)		<0.10			
	Cadmium (Cd)-Total (mg/L)		<0.00020			
	Calcium (Ca)-Total (mg/L)	5.30	5.13			
	Chromium (Cr)-Total (mg/L)		<0.0020			
	Copper (Cu)-Total (mg/L)		<0.0010			
	Iron (Fe)-Total (mg/L)	<0.030	<0.030			
	Lead (Pb)-Total (mg/L)		<0.00050			
	Magnesium (Mg)-Total (mg/L)	0.86	0.74			
	Manganese (Mn)-Total (mg/L)	<0.0050	<0.0020			
	Mercury (Hg)-Total (mg/L)		<0.00020			
	Potassium (K)-Total (mg/L)	<2.0	1.59			
	Selenium (Se)-Total (mg/L)		<0.0010			
	Sodium (Na)-Total (mg/L)	<2.0	7.2			
	Uranium (U)-Total (mg/L)		<0.00010			
	Zinc (Zn)-Total (mg/L)		<0.050			
Volatile Organic Compounds	Benzene (mg/L)		<0.00050			
	Ethylbenzene (mg/L)		<0.00050			
	Methyl t-butyl ether (MTBE) (mg/L)		<0.00050			
	Styrene (mg/L)		<0.00050			
	Toluene (mg/L)		<0.00050			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1342450-1 water TW-1	L1342450-2 water TW-2			
Grouping	Analyte					
WATER						
Volatile Organic Compounds	ortho-Xylene (mg/L)		<0.00050			
	meta- & para-Xylene (mg/L)		<0.00050			
	Xylenes (mg/L)		<0.00075			
	Surrogate: 4-Bromofluorobenzene (SS) (%)		98.4			
	Surrogate: 1,4-Difluorobenzene (SS) (%)		99.7			
Hydrocarbons	EPH10-19 (mg/L)		<0.25			
	EPH19-32 (mg/L)		<0.25			
	LEPH (mg/L)		<0.25			
	HEPH (mg/L)		<0.25			
	Volatile Hydrocarbons (VH6-10) (mg/L)		<0.10			
	VPH (C6-C10) (mg/L)		<0.10			
	Surrogate: 3,4-Dichlorotoluene (SS) (%)		95.0			
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/L)		<0.000050			
	Acenaphthylene (mg/L)		<0.000050			
	Acridine (mg/L)		<0.000050			
	Anthracene (mg/L)		<0.000050			
	Benz(a)anthracene (mg/L)		<0.000050			
	Benzo(a)pyrene (mg/L)		<0.000010			
	Benzo(b)fluoranthene (mg/L)		<0.000050			
	Benzo(g,h,i)perylene (mg/L)		<0.000050			
	Benzo(k)fluoranthene (mg/L)		<0.000050			
	Chrysene (mg/L)		<0.000050			
	Dibenz(a,h)anthracene (mg/L)		<0.000050			
	Fluoranthene (mg/L)		<0.000050			
	Fluorene (mg/L)		<0.000050			
	Indeno(1,2,3-c,d)pyrene (mg/L)		<0.000050			
	Naphthalene (mg/L)		<0.000050			
	Phenanthrene (mg/L)		<0.000050			
	Pyrene (mg/L)		<0.000050			
	Quinoline (mg/L)		<0.000050			
	Surrogate: Acenaphthene d10 (%)		85.4			
	Surrogate: Acridine d9 (%)		90.7			
	Surrogate: Chrysene d12 (%)		85.9			
	Surrogate: Naphthalene d8 (%)		84.2			
	Surrogate: Phenanthrene d10 (%)		85.1			
Herbicides	Bromoxynil (mg/L)		<0.00010			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1342450-1 water TW-1	L1342450-2 water TW-2			
Grouping	Analyte					
WATER						
Herbicides	Clopyralid (mg/L)		<0.00010			
	2,4-D (mg/L)		<0.00010			
	Dicamba (mg/L)		<0.00010			
	2,4-DB (mg/L)		<0.00010			
	2,4-DP (Dichlorprop) (mg/L)		<0.00010			
	Dinoseb (mg/L)		<0.00010			
	MCPA (mg/L)		<0.00010			
	MCPB (mg/L)		<0.00010			
	Mecoprop (mg/L)		<0.00010			
	Picloram (mg/L)		<0.00010			
	2,4,5-T (mg/L)		<0.00010			
	2,4,5-TP (mg/L)		<0.00010			
	Triclopyr (mg/L)		<0.00010			
	Surrogate: 2,4-Dichlorophenylacetic Acid (%)		107.1			
Pesticides	Ethalfuralin (mg/L)		<0.00010			
	Fluazifop-p-butyl (mg/L)		<0.00010			
	Diclofop-methyl (mg/L)		<0.00010			
	Triallate (mg/L)		<0.00010			
	Trifluralin (mg/L)		<0.00010			
	Surrogate: D14-Terphenyl (%)		124.5			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Bromide (Br)	DLM	L1342450-1, -2
Duplicate	Chloride (Cl)	DLM	L1342450-1, -2
Duplicate	Nitrite (as N)	DLM	L1342450-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2
This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.			
ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.			
ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.			
ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength
This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Apparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.			
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
ECOLI-COLI-HLTH-VA	Water	E.coli by Colilert	APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the positive responses to a probability table.			
EPH-SF-FID-VA	Water	EPH in Water by Tumbler and GCFID	BC MOE EPH GCFID
Analysis is in accordance with BC MOE Lab Manual method "Extractable Petroleum Hydrocarbons in Water by GC/FID", v2.1, July 1999. Whole water samples are extracted with DCM prior to gas chromatography with flame ionization detection (GC-FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).			
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B
Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.			
HERBSCR-WT	Water	Herbicides in water	SW846 8270
HG-TOT-CVAFS-VA	Water	Total Mercury in Water by CVAFS	EPA 245.7
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption			

Reference Information

spectrophotometry (EPA Method 245.7).

LEPH/HEPH-CALC-VA	Water	LEPHs and HEPHs	BC MOE LABORATORY MANUAL (2005)
Light and Heavy Extractable Petroleum Hydrocarbons in water. These results are determined according to the British Columbia Ministry of Environment, Lands, and Parks Analytical Method for Contaminated Sites "Calculation of Light and Heavy Extractable Petroleum Hydrocarbons in Solids or Water". According to this method, LEPH and HEPH are calculated by subtracting selected Polycyclic Aromatic Hydrocarbon results from Extractable Petroleum Hydrocarbon results. To calculate LEPH, the individual results for Acenaphthene, Acridine, Anthracene, Fluorene, Naphthalene and Phenanthrene are subtracted from EPH(C10-19). To calculate HEPH, the individual results for Benz(a)anthracene, Benzo(a)pyrene, Fluoranthene, and Pyrene are subtracted from EPH(C19-32). Analysis of Extractable Petroleum Hydrocarbons adheres to all prescribed elements of the BCMELP method "Extractable Petroleum Hydrocarbons in Water by GC/FID" (Version 2.1, July 20, 1999).			
MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).			
MET-TOT-LOW-MS-VA	Water	Total Metals in Water by ICPMS(Low)	EPA SW-846 3005A/6020A
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).			
MISCS-VR-WT	Water	Miscellaneous Pesticides	SW846 8270
PAH-SF-MS-VA	Water	PAH in Water by GCMS	EPA 3510, 8270
The entire water sample is extracted with dichloromethane, prior to analysis by gas chromatography with mass spectrometric detection (GC/MS). Because the two isomers cannot be readily chromatographically separated, benzo(j)fluoranthene is reported as part of the benzo(b)fluoranthene parameter.			
PAH-SURR-MS-VA	Water	PAH Surrogates for Waters	EPA 3510, 8270
Analysed as per the corresponding PAH test method. Known quantities of surrogate compounds are added prior to analysis to each sample to demonstrate analytical accuracy.			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
TCOLI-COLI-HLTH-VA	Water	Total coliform by Colilert	APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is quantified by a statistical estimation of bacteria density (most probable number).			
TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC
This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.			
TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"
This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.			
TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity
This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.			
VH-HSFID-VA	Water	VH in Water by Headspace GC/FID	B.C. MIN. OF ENV. LAB. MAN. (2009)
The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transferred into a gas chromatograph. Compounds eluting between n-hexane and n-decane are measured and summed together using flame-ionization detection.			
VH-SURR-FID-VA	Water	VH Surrogates for Waters	B.C. MIN. OF ENV. LAB. MAN. (2009)
VOC7-HSMS-VA	Water	BTEX/MTBE/Styrene by Headspace GCMS	EPA8260B, 5021
The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transferred into a gas chromatograph. Target compound concentrations are measured using mass spectrometry detection.			

Reference Information

VOC7/VOC-SURR-MS-VA	Water	VOC7 and/or VOC Surrogates for Waters	EPA8260B, 5021
VPH-CALC-VA	Water	VPH is VH minus select aromatics	BC MOE LABORATORY MANUAL (2005)

These results are determined according to the British Columbia Ministry of Environment Analytical Method for Contaminated Sites "Calculation of Volatile Petroleum Hydrocarbons in Solids or Water". The concentrations of specific Monocyclic Aromatic Hydrocarbons (Benzene, Toluene, Ethylbenzene, Xylenes and, in solids, Styrene) are subtracted from the collective concentration of Volatile Hydrocarbons (VH) that elute between n-hexane (nC6) and n-decane (nC10).

XYLENES-CALC-VA	Water	Sum of Xylene Isomer Concentrations	CALCULATION
Calculation of Total Xylenes			

Total Xylenes is the sum of the concentrations of the ortho, meta, and para Xylene isomers. Results below detection limit (DL) are treated as zero. The DL for Total Xylenes is set to a value no less than the square root of the sum of the squares of the DLs of the individual Xylenes.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

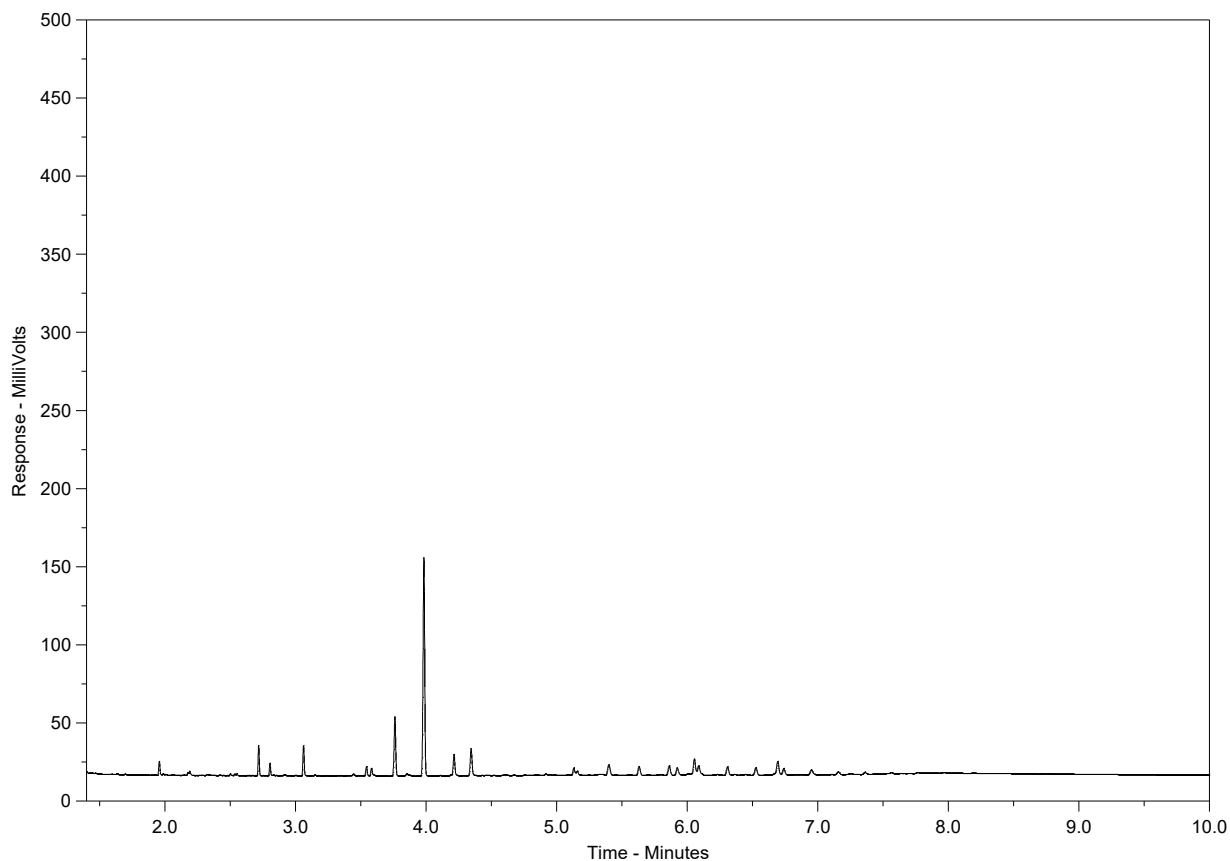
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Hydrocarbon Distribution Report



ALS Sample ID: L1342450-2
Client Sample ID: TW-2



nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline → ← Diesel / Jet Fuels → ← Motor Oils / Lube Oils / Grease →		

The EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample. For further interpretation, a current library of reference products is available on www.alsglobal.com or upon request.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples by as much as 0.5 minutes.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the response scale at the left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Report To			Report Format / Distribution			Service Requested (Rush for routine analysis subject to availability)														
Company: Piteau Associates			☒ Standard ☐ Other			☐ Regular (Standard Turnaround Times - Business Days)														
Contact: Kathy Tixier			☒ PDF ☒ Excel ☒ Digital ☐ Fax			☒ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT														
Address: 215 - 260 West Esplanade			Email 1: ktixier@niteau.com			☐ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT														
V7M 3G7			Email 2:			☐ Same Day or Weekend Emergency - Contact ALS to Confirm TAT														
Phone: 604-986-8551 Fax: 604-985-7286			Email 3:			Analysis Request Please indicate below Filtered, Preserved or both (F, P, F/P)														
Invoice To Same as Report? ☒ Yes ☐ No Hardcopy of Invoice with Report? ☒ Yes ☐ No			Client / Project Information Job #: 3122 PO / AFE: LSD: Quote #:																	
Company: Contact: Address: Phone:			ALS Contact: B.Mack Sampler: S.Dueck			pH conductivity turbidity anions (Br, SO4, F, Cl, NO3, NO2) basic metals (Ca, Fe, Mg, Mn, K, Na) (Drinking Water Guideline), total E. Coli & Total Coliform full metals (all) (Drinking Water Guideline), total BTEX + VPH LEPH/HEPH w/ PAH Herbicide Screen Number of Containers														
 L1342450-COFC																				
Sample # _____ (Description will appear on the report)			Date (dd-mm-yy) Time (hh:mm) Sample Type																	
TW-1							x	x	x	x	x	x							1	
TW-2							x	x	x	x		x	x	x	x	x			1	
RUSH Priority processing																			1	
																				1
																				1
																				1
																				1
																				1
																	1			
																	1			
																	1			
Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details																				
Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab. Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.																				
SHIPMENT RELEASE (client use)						SHIPMENT RECEPTION (lab use only)						SHIPMENT VERIFICATION (lab use only)								
Released by:	Date (dd-mm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations:										
J. Robert Bulger	Aug 2/13	3:00	Elise	Aug 02	15:46	8.5 °C														



PITEAU ASSOC. ENGINEERING LTD.

ATTN: Kathy Tixier

215 - 260 West Esplanade

North Vancouver BC V7M 3G7

Date Received: 22-AUG-13

Report Date: 03-SEP-13 16:16 (MT)

Version: FINAL

Client Phone: 604-986-8551

Certificate of Analysis

Lab Work Order #: L1352047

Project P.O. #: NOT SUBMITTED

Job Reference: 3122

C of C Numbers: 10-299835

Legal Site Desc:

Brent Mack
Account Manager

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ALS CANADA LTD Part of the ALS Group A Campbell Brothers Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	Description			
		Sampled Date	Sampled Time			
		Client ID				
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (uS/cm)	44.8	61.3			
	Hardness (as CaCO3) (mg/L)	17.5	15.8			
	pH (pH)	6.96	6.94			
	Turbidity (NTU)	<0.10	<0.10			
Anions and Nutrients	Chloride (Cl) (mg/L)	0.52	4.72			
	Fluoride (F) (mg/L)	<0.020	<0.020			
	Nitrate (as N) (mg/L)	0.180	0.353			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Sulfate (SO4) (mg/L)	5.03	2.43			
Bacteriological Tests	E. coli (MPN/100mL)	<1	<1			
	Coliform Bacteria - Total (MPN/100mL)	<1	<1			
Total Metals	Calcium (Ca)-Total (mg/L)	5.60	5.18			
	Iron (Fe)-Total (mg/L)	<0.030	<0.030			
	Magnesium (Mg)-Total (mg/L)	0.84	0.68			
	Manganese (Mn)-Total (mg/L)	<0.0050	<0.0050			
	Potassium (K)-Total (mg/L)	<2.0	<2.0			
	Sodium (Na)-Total (mg/L)	<2.0	6.0			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Nitrite (as N)	DLM	L1352047-1, -2
Duplicate	Nitrate (as N)	DLM	L1352047-1, -2
Duplicate	Chloride (Cl)	DLM	L1352047-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.			
ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.			
ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
ECOLI-COLI-HLTH-VA	Water	E.coli by Colilert	APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the positive responses to a probability table.			
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B
Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.			
MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
TCOLI-COLI-HLTH-VA	Water	Total coliform by Colilert	APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is quantified by a statistical estimation of bacteria density (most probable number).			
TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

Reference Information

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-299835

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

[illegible]

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PITEAU ASSOC. ENGINEERING LTD.

ATTN: Kathy Tixier

215 - 260 West Esplanade

North Vancouver BC V7M 3G7

Date Received: 04-SEP-13

Report Date: 09-SEP-13 16:32 (MT)

Version: FINAL

Client Phone: 604-986-8551

Certificate of Analysis

Lab Work Order #: L1357811

Project P.O. #: NOT SUBMITTED

Job Reference: 3122

C of C Numbers:

Legal Site Desc:

Brent Mack
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1357811-1 Water 03-SEP-13 TW-1	L1357811-2 Water 03-SEP-13 TW-2			
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (uS/cm)	46.2	61.0			
	Hardness (as CaCO3) (mg/L)	17.4	15.4			
	pH (pH)	7.23	7.23			
	Turbidity (NTU)	<0.10	<0.10			
Anions and Nutrients	Bromide (Br) (mg/L)	<0.050	<0.050			
	Chloride (Cl) (mg/L)	0.52	4.45			
	Fluoride (F) (mg/L)	<0.020	<0.020			
	Nitrate (as N) (mg/L)	0.189	0.337			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Sulfate (SO4) (mg/L)	5.02	2.41			
Bacteriological Tests	E. coli (MPN/100mL)	<1	<1			
	Coliform Bacteria - Total (MPN/100mL)	<1	<1			
Total Metals	Aluminum (Al)-Total (mg/L)	<0.010	<0.010			
	Antimony (Sb)-Total (mg/L)	<0.00050	<0.00050			
	Arsenic (As)-Total (mg/L)	<0.00010	<0.00010			
	Barium (Ba)-Total (mg/L)	<0.020	<0.020			
	Boron (B)-Total (mg/L)	<0.10	<0.10			
	Cadmium (Cd)-Total (mg/L)	<0.00020	<0.00020			
	Calcium (Ca)-Total (mg/L)	5.59	5.07			
	Chromium (Cr)-Total (mg/L)	<0.0020	<0.0020			
	Copper (Cu)-Total (mg/L)	<0.0010	<0.0010			
	Iron (Fe)-Total (mg/L)	<0.030	<0.030			
	Lead (Pb)-Total (mg/L)	<0.00050	<0.00050			
	Magnesium (Mg)-Total (mg/L)	0.83	0.66			
	Manganese (Mn)-Total (mg/L)	<0.0020	<0.0020			
	Mercury (Hg)-Total (mg/L)	<0.00020	<0.00020			
	Potassium (K)-Total (mg/L)	0.57	1.34			
	Selenium (Se)-Total (mg/L)	<0.0010	<0.0010			
	Sodium (Na)-Total (mg/L)	<2.0	5.4			
	Uranium (U)-Total (mg/L)	<0.00010	<0.00010			
	Zinc (Zn)-Total (mg/L)	<0.050	<0.050			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.			
ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.			
ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
ECOLI-COLI-BCDW-VA	Water	E.coli by Colilert	APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the positive responses to a probability table.			
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B
Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.			
HG-TOT-CVAFS-VA	Water	Total Mercury in Water by CVAFS	EPA 245.7
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).			
MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).			
MET-TOT-LOW-MS-VA	Water	Total Metals in Water by ICPMS(Low)	EPA SW-846 3005A/6020A
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
TCOLI-COLI-BCDW-VA	Water	Total coliform by Colilert	APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is			

Reference Information

incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is quantified by a statistical estimation of bacteria density (most probable number).

TURBIDITY-VA Water Turbidity by Meter APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
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VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA
----	---

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.



L1357811-COFC

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Page 1 of 1

Re		Report Format / Distribution				Service Requested (Rush for routine analysis subject to availability)											
Company: Piteau Associates		☒ Standard ☐ Other				☒ Regular (Standard Turnaround Times - Business Days)											
Contact: Kathy Tixier		☒ PDF ☒ Excel ☒ Digital ☐ Fax				☐ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT											
Address: 215 - 260 West Esplanade		Email 1: ktixier@piteau.com				☐ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT											
V7M 3G7		Email 2:				☐ Same Day or Weekend Emergency - Contact ALS to Confirm TAT											
Phone: 604-986-8551 Fax: 604-985-7286		Email 3:				Analysis Request											
Invoice To Same as Report ? ☒ Yes ☐ No		Client / Project Information				Please indicate below Filtered, Preserved or both (F, P, F/P)											
Hardcopy of Invoice with Report? ☒ Yes ☐ No		Job #: 3122															
Company:		PO / AFE:															
Contact:		LSD:															
Address:		Quote #:															
Phone: Fax:		ALS Contact: B.Mack															
Lab Work Order # (lab use only)		Sampler: Rob Bulger															
L1357811																	
Sample #	Sample Identification (This description will appear on the report)	Date (dd-mm-yy)	Time (hh:mm)	Sample Type	pH	conductivity	turbidity	anions (Br, SO4, F, Cl, NO3, NO2)	basic metals (Ca, Fe, Mg, Mn, K, Na) (Drinking Water Guideline), total	E. Coli & Total Coliform	full metals (all) (Drinking Water Guideline), total	BTEX + VPH	LEPH/HEPH w/ PAH	Herbicide Screen	Number of Containers		
	TW-1	03/09/13		water	x	x	x	x	x	x							
	TW-2	11		11	x	x	x	x	x	x							
Short Holding Time <i>Rush Processing</i>																	
Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details																	
Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.																	
By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.																	
Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.																	
SHIPMENT RELEASE (client use)				SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)									
Released by:	Date (dd-mm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations:							
J. Robert Bulger	Sept 4/13		Christ	Sept 4 2013	1335	11.2 °C											



PITEAU ASSOC. ENGINEERING LTD.

ATTN: Kathy Tixier

215 - 260 West Esplanade

North Vancouver BC V7M 3G7

Date Received: 23-SEP-13

Report Date: 25-SEP-13 17:10 (MT)

Version: FINAL

Client Phone: 604-986-8551

Certificate of Analysis

Lab Work Order #: L1367061

Project P.O. #: NOT SUBMITTED

Job Reference: 3122

C of C Numbers:

Legal Site Desc:

Brent Mack
Account Manager

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ALS CANADA LTD Part of the ALS Group A Campbell Brothers Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1367061-1 water 10-SEP-13 TW-1	L1367061-2 water 10-SEP-13 TW-2			
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (uS/cm)	49.0	68.3			
	pH (pH)	6.78	6.76			
	Total Dissolved Solids (mg/L)	45	54			
Anions and Nutrients	Bromide (Br) (mg/L)	<0.050	<0.050			
	Chloride (Cl) (mg/L)	0.52	4.35			
	Fluoride (F) (mg/L)	<0.020	<0.020			
	Nitrate (as N) (mg/L)	0.175	0.301			
	Nitrite (as N) (mg/L)	0.0128	0.0164			
	Sulfate (SO4) (mg/L)	4.97	2.38			
Total Metals	Aluminum (Al)-Total (mg/L)	<0.20	<0.20			
	Antimony (Sb)-Total (mg/L)	<0.20	<0.20			
	Arsenic (As)-Total (mg/L)	<0.20	<0.20			
	Barium (Ba)-Total (mg/L)	<0.010	0.013			
	Beryllium (Be)-Total (mg/L)	<0.0050	<0.0050			
	Bismuth (Bi)-Total (mg/L)	<0.20	<0.20			
	Boron (B)-Total (mg/L)	<0.10	<0.10			
	Cadmium (Cd)-Total (mg/L)	<0.010	<0.010			
	Calcium (Ca)-Total (mg/L)	5.87	6.39			
	Chromium (Cr)-Total (mg/L)	<0.010	<0.010			
	Cobalt (Co)-Total (mg/L)	<0.010	<0.010			
	Copper (Cu)-Total (mg/L)	0.024	0.025			
	Iron (Fe)-Total (mg/L)	0.058	0.031			
	Lead (Pb)-Total (mg/L)	<0.050	<0.050			
	Lithium (Li)-Total (mg/L)	<0.010	<0.010			
	Magnesium (Mg)-Total (mg/L)	0.88	0.70			
	Manganese (Mn)-Total (mg/L)	<0.0050	<0.0050			
	Molybdenum (Mo)-Total (mg/L)	<0.030	<0.030			
	Nickel (Ni)-Total (mg/L)	<0.050	<0.050			
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30			
	Potassium (K)-Total (mg/L)	<2.0	<2.0			
	Selenium (Se)-Total (mg/L)	<0.20	<0.20			
	Silicon (Si)-Total (mg/L)	6.20	7.06			
	Silver (Ag)-Total (mg/L)	<0.010	<0.010			
	Sodium (Na)-Total (mg/L)	<2.0	5.4			
	Strontium (Sr)-Total (mg/L)	0.0365	0.0537			
	Thallium (Tl)-Total (mg/L)	<0.20	<0.20			
	Tin (Sn)-Total (mg/L)	<0.030	<0.030			

		Sample ID Description Sampled Date Sampled Time Client ID	L1367061-1 water 10-SEP-13 TW-1	L1367061-2 water 10-SEP-13 TW-2			
Grouping	Analyte						
WATER							
Total Metals	Titanium (Ti)-Total (mg/L)	<0.010	<0.010				
	Vanadium (V)-Total (mg/L)	<0.030	<0.030				
	Zinc (Zn)-Total (mg/L)	0.0919	0.651				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.			
ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.			
ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC
This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lw - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.



Chain of Custody / Analytical Request Form
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Page 1 of 1

GENF 18.01 Front



PITEAU ASSOC. ENGINEERING LTD.

ATTN: Kathy Tixier

215 - 260 West Esplanade

North Vancouver BC V7M 3G7

Date Received: 24-SEP-13

Report Date: 02-OCT-13 14:01 (MT)

Version: FINAL

Client Phone: 604-986-8551

Certificate of Analysis

Lab Work Order #: L1367770

Project P.O. #: NOT SUBMITTED

Job Reference: 3122

C of C Numbers:

Legal Site Desc:

Brent Mack
Account Manager

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ADDRESS: 8081 Lougheed Hwy, Suite 100, Burnaby, BC V5A 1W9 Canada | Phone: +1 604 253 4188 | Fax: +1 604 253 6700

ALS CANADA LTD Part of the ALS Group A Campbell Brothers Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1367770-1 water 24-SEP-13 TW-1	L1367770-2 water 24-SEP-13 TW-2			
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (uS/cm)	48.7	59.7			
	Hardness (as CaCO3) (mg/L)	17.8	15.3			
	pH (pH)	7.39	7.10			
	Turbidity (NTU)	0.19	<0.10			
Anions and Nutrients	Chloride (Cl) (mg/L)	0.52	4.35			
	Fluoride (F) (mg/L)	<0.020	<0.020			
	Nitrate (as N) (mg/L)	0.202	0.344			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Sulfate (SO4) (mg/L)	5.07	2.47			
Bacteriological Tests	E. coli (MPN/100mL)	<1	<1			
	Coliform Bacteria - Total (MPN/100mL)	<1	<1			
Total Metals	Calcium (Ca)-Total (mg/L)	5.72	5.07			
	Iron (Fe)-Total (mg/L)	<0.030	<0.030			
	Magnesium (Mg)-Total (mg/L)	0.86	0.65			
	Manganese (Mn)-Total (mg/L)	<0.0050	<0.0050			
	Potassium (K)-Total (mg/L)	<2.0	<2.0			
	Sodium (Na)-Total (mg/L)	<2.0	4.7			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.			
ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.			
ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
ECOLI-COLI-HLTH-VA	Water	E.coli by Colilert	APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the positive responses to a probability table.			
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B
Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.			
MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
TCOLI-COLI-HLTH-VA	Water	Total coliform by Colilert	APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is quantified by a statistical estimation of bacteria density (most probable number).			
TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"
This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.			
TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity
This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Reference Information

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Report To			Report Format / Distribution			Service Requested (Rush for routine analysis subject to availability)																								
Company: Piteau Associates			☒ Standard ☐ Other			☒ Regular (Standard Turnaround Times - Business Days)																								
Contact: Kathy Tixier			☒ PDF ☒ Excel ☒ Digital ☐ Fax			☐ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT																								
Address: 215 - 260 West Esplanade			Email 1: ktixier@piteau.com			☐ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT																								
V7M 3G7			Email 2:			☐ Same Day or Weekend Emergency - Contact ALS to Confirm TAT																								
Phone: 604-986-8551 Fax: 604-985-7286			Email 3:			Analysis Request																								
Invoice To Same as Report? ☒ Yes ☐ No			Client / Project Information			Please indicate below Filtered, Preserved or both (F, P, F/P)																								
Hardcopy of Invoice with Report? ☒ Yes ☐ No			Job #: 3122																											
Company:			PO / AFE:																											
Contact:			LSD:																											
Address:			Quote #:																											
Phone:																														
 Lab W/ (lab) L1367770-COFC			 ALS Contact: B.Mack		Sampler: B. Dahle																									
Sample #			Date (dd-mmm-yy)		Time (hh:mm)		Sample Type		pH		conductivity		turbidity		anions (Br, SO4, F, Cl, NO3, NO2)		basic metals (Ca, Fe, Mg, Mn, K, Na) (Drinking Water Guideline), total		E.Coli & Total Coliform		full metals (all) (Drinking Water Guideline), total		BTEX + VPH		LEPH/HEPH w/ PAH		Herbicide Screen		Number of Containers	
TW-1			24-09-2013						x		x		x		x		x		x											
TW-2			24-09-2013						x		x		x		x		x		x											



PITEAU ASSOC. ENGINEERING LTD.

ATTN: Kathy Tixier

215 - 260 West Esplanade

North Vancouver BC V7M 3G7

Date Received: 17-OCT-13

Report Date: 28-OCT-13 18:09 (MT)

Version: FINAL

Client Phone: 604-986-8551

Certificate of Analysis

Lab Work Order #: L1379527

Project P.O. #: NOT SUBMITTED

Job Reference: 3122

C of C Numbers:

Legal Site Desc:

Brent Mack
Account Manager

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ALS CANADA LTD Part of the ALS Group A Campbell Brothers Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1379527-1 Water 16-OCT-13 TW-1	L1379527-2 Water 16-OCT-13 TW-2	L1379527-3 Water 16-OCT-13 MW2-S	L1379527-4 Water 16-OCT-13 MW2-D	L1379527-5 Water 16-OCT-13 MW3-S
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (uS/cm)	47.7	58.1	60.7	69.8	75.1
	Hardness (as CaCO3) (mg/L)	18.6	16.7			
	pH (pH)	7.09	6.88			
	Turbidity (NTU)	0.15	<0.10			
Anions and Nutrients	Bromide (Br) (mg/L)	<0.050	<0.050			
	Chloride (Cl) (mg/L)	0.50	4.18	0.56	0.59	12.1
	Fluoride (F) (mg/L)	<0.020	<0.020			
	Nitrate (as N) (mg/L)	0.179	0.328			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Sulfate (SO4) (mg/L)	4.96	2.40			
Bacteriological Tests	E. coli (MPN/100mL)	<1	<1			
	Coliform Bacteria - Total (MPN/100mL)	2	<1			
Total Metals	Calcium (Ca)-Total (mg/L)	5.95	5.51			
	Iron (Fe)-Total (mg/L)	<0.030	<0.030			
	Magnesium (Mg)-Total (mg/L)	0.92	0.71			
	Manganese (Mn)-Total (mg/L)	<0.0020	<0.0020			
	Potassium (K)-Total (mg/L)	0.57	1.20			
	Sodium (Na)-Total (mg/L)	<2.0	5.0	2.6	3.3	9.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1379527-6 Water 16-OCT-13 MW3-D	L1379527-7 Water 03-SEP-13 MW2-S	L1379527-8 Water 03-SEP-13 MW2-D	L1379527-9 Water 03-SEP-13 MW3-S	L1379527-10 Water 03-SEP-13 MW3-D
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (uS/cm)	158				
	Hardness (as CaCO3) (mg/L)					
	pH (pH)					
	Turbidity (NTU)					
Anions and Nutrients	Bromide (Br) (mg/L)	11.8	0.56	0.60	7.72	9.67
	Chloride (Cl) (mg/L)					
	Fluoride (F) (mg/L)					
	Nitrate (as N) (mg/L)					
	Nitrite (as N) (mg/L)					
	Sulfate (SO4) (mg/L)					
Bacteriological Tests	E. coli (MPN/100mL)					
	Coliform Bacteria - Total (MPN/100mL)					
Total Metals	Calcium (Ca)-Total (mg/L)	6.6	2.6	3.6	8.3	6.1
	Iron (Fe)-Total (mg/L)					
	Magnesium (Mg)-Total (mg/L)					
	Manganese (Mn)-Total (mg/L)					
	Potassium (K)-Total (mg/L)					
	Sodium (Na)-Total (mg/L)					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Nitrate (as N)	MS-B	L1379527-1, -2
Matrix Spike	Sulfate (SO ₄)	MS-B	L1379527-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.			
ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0
This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.			
ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.
This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".			
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
ECOLI-COLI-HLTH-VA	Water	E.coli by Colilert	APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the positive responses to a probability table.			
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B
Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO ₃ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.			
HG-TOT-CVAFS-VA	Water	Total Mercury in Water by CVAFS	EPA 245.7
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).			
MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).			
MET-TOT-LOW-MS-VA	Water	Total Metals in Water by ICPMS(Low)	EPA SW-846 3005A/6020A
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			

Reference Information

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

TCOLI-COLI-HLTH-VA Water Total coliform by Colilert APHA METHOD 9223
This analysis is carried out using procedures adapted from APHA Method 9223 "Enzyme Substrate Coliform Test". E. coli and Total Coliform are determined simultaneously. The sample is mixed with a mixture hydrolyzable substrates and then sealed in a multi-well packet. The packet is incubated for 18 or 24 hours and then the number of wells exhibiting a positive response are counted. The final result is quantified by a statistical estimation of bacteria density (most probable number).

TURBIDITY-VA Water Turbidity by Meter APHA 2130 "Turbidity"
This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity
This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

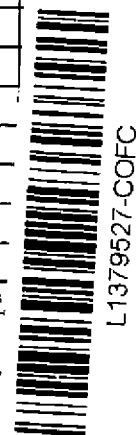
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Report To				Report Format / Distribution				Service Requested (Rush for routine analysis subject to availability)																																											
Company: Pileau Associates				☒ Standard ☐ Other				☒ Regular (Standard Turnaround Times - Business Days)																																											
Contact: Kathy Tixier				☒ PDF ☒ Excel ☒ Digital ☐ Fax				☐ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT																																											
Address: 215 - 260 West Esplanade V7M 3G7				Email 1: ktixier@pileau.com				☐ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT																																											
Phone: 604-986-8551 Fax: 604-985-7286				Email 2:				☐ Same Day or Weekend Emergency - Contact ALS to Confirm TAT																																											
Email 3:																																																			
Invoice To Same as Report ? ☒ Yes ☐ No				Client / Project Information				Analysis Request																																											
Hardcopy of Invoice with Report? ☒ Yes ☐ No				Job #: 3122				Please indicate below Filtered, Preserved or both (F, P, F/P)																																											
Company:				PO / AFE:				<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">pH</td> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">conductivity</td> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">turbidity</td> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">anions (Br, SO4, F, Cl, NO3, NO2)</td> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">basic metals (Ca, Fe, Mg, Mn, K, Na)</td> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">(Drinking Water Guideline), total</td> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">E. Coli & Total Coliform</td> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">chloride</td> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">sodium</td> <td colspan="10" rowspan="4"></td> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">Number of Containers</td> </tr> <tr></tr> <tr></tr> <tr></tr> </table>												pH	conductivity	turbidity	anions (Br, SO4, F, Cl, NO3, NO2)	basic metals (Ca, Fe, Mg, Mn, K, Na)	(Drinking Water Guideline), total	E. Coli & Total Coliform	chloride	sodium											Number of Containers												
pH	conductivity	turbidity	anions (Br, SO4, F, Cl, NO3, NO2)	basic metals (Ca, Fe, Mg, Mn, K, Na)	(Drinking Water Guideline), total	E. Coli & Total Coliform	chloride																																	sodium											Number of Containers
Contact:				LSD:																																															
Address:				Quote #:																																															
Phone:				Fax:																																															
Lab Work Order # (lab use only) L1379527				ALS Contact: B. Mack Sampler: B. Dahle																																															
Sample #		Sample Identification (This description will appear on the report)		Date (dd-mm-yy)		Time (hh:mm)		Sample Type																																											
TW-1				16-Oct-13				water																																											
TW-2				16-Oct-13				water																																											
MW2-S				16-Oct-13				water																																											
MW2-D				16-Oct-13				water																																											
MW3-S				16-Oct-13				water																																											
MW3-D				16-Oct-13				water																																											
MW2-S				03-Sep-13				water																																											
MW2-D				03-Sep-13				water																																											
MW3-S				03-Sep-13				water																																											
MW3-D				03-Sep-13				water																																											
Short Holding Time <i>Rush Processing</i>																																																			
Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details																																																			
Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab. Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.																																																			
SHIPMENT RELEASE (client use)						SHIPMENT RECEPTION (lab use only)						SHIPMENT VERIFICATION (lab use only)																																							
Released by:		Date (dd-mm-yy)		Time (hh-mm)		Received by:		Date:		Time:		Temperature:		Verified by:		Date:		Time:		Observations: Yes / No ? If Yes add SIF																															
J. Robert B...		Oct 17/13				PR		17 OCT		13:10		13.9 °C																																							



L1379527-COFC

15:10

APPENDIX D

MICROSCOPIC PARTICULATE ANALYSIS REPORTS



MICROSCOPIC PARTICULATE ANALYSIS REPORT SHEET (GUDI)

CLIENT: Kathy Tixier
Piteau Associates
215 - 260 West Esplanade
North Vancouver, BC
V7M 3G7
TELEPHONE: (604) 986-8551
FAX: (604) 985-7286

Date of Sample: 16-Oct-13
Sample Location: Tw1
Type: Raw
Volume Filtered (L): 107 **Method?:**
Temperature (°C): 9 **MPA-1623**
pH: 5.99
Conductivity:

The methodology used to generate this report conforms to the USEPA Consensus Method for the Microscopic Particulate Analysis or to the MPA-1623 modification. Based on the validation data, the method is fit for its intended use. Hyperion Research Ltd. is accredited for this analysis by CALA under ISO/IEC 17025:2005.

Sample Processing Information			Process Date: 21-Oct-2013		Final Pellet Vol. (μL): 10.0	
Date Received 21-Oct-13	Time Received 1100	Customer # 149	Temp. on Arrival (°C) 11.5	Lab ID 53310	Density Medium	Sediment (mL) 0.10
Total Wash (mL) 1200	Concentrated (mL) 1200	G/C Volume (μL) 100	MPA Volume (μL) 100	Suspension Vol. (μL) 100	Equiv. Vol. (L) 107	

GIARDIA and CRYPTOSPORIDIUM RESULTS

Giardia cysts/100 L: 0.00

Cryptosporidium oocysts/100 L: 0.00

PARTICULATE ANALYSIS RESULTS

Primary Particulates	Total Count	#/380 L (100 US gal.)	Relative Risk Factor
Diatoms:	0	0.00	NS
Other Algae:	1	3.54	R
Insect/larvae:	0	0.00	NS
Rotifers:	0	0.00	NS
Plant Debris:	10	35.39	M
Relative Risk Factors: EH - extremely heavy M - moderate H - heavy R - Rare NS - not significant			

Secondary Particulates	Total Count	#/380 L (100 US gal.)
Pollen	0	0.0
Nematodes	0	0.0
Crustacea	0	0
Amoebae	0	0
Ciliates/flagellates	0	0
Other	0	0
Large Debris	none	
Fine Debris	iron,silica,clay	
Minerals		

CONCLUSION: Based on this sample, the risk of surface water contamination is judged to be Low and the risk factor is 5

Additional Data: Bacteria Spores. Algae and surface water organisms abundant in Thistle Cr. water sampled with well water. REVISED REPORT

Analyst:

Peter M. Wallis, Ph.D.

From the EPA Consensus Method:

Risk of Surface Water Contamination

20+ - high risk
10 to 19 - moderate risk
0 to 9 - low risk

Recovery efficiencies for particles are known to be low by the Consensus method. Minimum recovery was measured to be 6.5 +/-1.2% for *Giardia* cysts, 0.5 +/-0.2% for *Cryptosporidium* oocysts and 4.2 +/-2.3% for *Euglena* (algae). Recovery using the MPA-1623 Method is 47.4 +/- 4.3% for *Giardia*, 63.8 +/- 5.9% for *Cryptosporidium* and 19.5 +/- 5.6% for *Euglena*.



Hyperion Research Ltd.

1008 Allowance Ave. SE,
Medicine Hat, AB T1A 3G8
Tel: (403) 529-0847 Toll Free: (888) 529-0847
Fax: (403) 529-0852 Email: hyperion@telusplanet.net
Principal Scientist: Peter M. Wallis, Ph.D.



MICROSCOPIC PARTICULATE ANALYSIS REPORT SHEET (GUDI)

CLIENT: Kathy Tixier
Piteau Associates
215 - 260 West Esplanade
North Vancouver, BC
V7M 3G7

TELEPHONE: (604) 986-8551

FAX: (604) 985-7286

Date of Sample: 16-Oct-13

Sample Location: Tw2

Type: Raw

Volume Filtered (L): 100

Method?:

Temperature (°C): 8.9 **MPA-1623**

pH: 6.16

Conductivity:

The methodology used to generate this report conforms to the USEPA Consensus Method for the Microscopic Particulate Analysis. Based on the validation data, the method is fit for its intended use. Hyperion Research Ltd. is accredited for this analysis by CALA under the ISO/IEC 17025:2005 standard.

Sample Processing Information

Final Pellet Vol. (µL): 10.0

Date Received	Time Received	Customer #	Temp. on Arrival (°C)	Lab ID	Density Medium	Sediment (mL)
21-Oct-13	1100	149	12.5	53111		0.10
Total Wash (mL)	Concentrated (mL)	G/C Volume (µL)	MPA Volume (µL)	Suspension Vol. (µL)	Equiv. Vol. (L)	
1200	1200	100	100	100	200	

GIARDIA and CRYPTOSPORIDIUM RESULTS

Giardia cysts/100 L: 0.00

Cryptosporidium oocysts/100 L: 0.00

PARTICULATE ANALYSIS RESULTS

Primary Particulates	Total Count	#/380 L (100 US gal.)	Relative Risk Factor
Diatoms:	0	0.00	NS
Other Algae:	0	0.00	NS
Insect/larvae:	0	0.00	NS
Rotifers:	0	0.00	NS
Plant Debris:	1	3.80	R
Relative Risk Factors: EH - extremely heavy M - moderate H - heavy R - Rare NS - not significant			

Secondary Particulates	Total Count	#/380 L (100 US gal.)
Pollen	1	3.8
Nematodes	0	0.0
Crustacea	0	0
Amoebae	0	0
Ciliates/flagellates	0	0
Other	0	0
Large Debris	none	
Fine Debris	iron,silica,clay	
Minerals		

CONCLUSION: Based on this sample, the risk of surface water contamination is judged to be Low and the risk factor is 0

Additional Data: No Surface Water

Analyst:

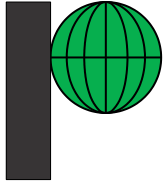
Peter M. Wallis, Ph.D.

From the EPA Consensus Method:

Risk of Surface Water Contamination

20+	- high risk
10 to 19	- moderate risk
0 to 9	- low risk

Recovery efficiencies for particles are known to be low by this method but are compensated for by filtering a large volume of water. Minimum recovery was measured to be 6.5 +/-1.2% for *Giardia* cysts, 0.5 +/-0.2% for *Cryptosporidium* oocysts and 4.2 +/-2.3% for *Euglena* (algae). Despite the low recovery, the method reliably detected as few as 1 cell/L of groundwater in validation trials with no false positives.



PITEAU ASSOCIATES
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HYDROGEOLOGICAL CONSULTANTS

SUITE 300 - 788 COPPING STREET
NORTH VANCOUVER, B.C.
CANADA - V7M 3G6
TEL: (604) 986-8551 / FAX: (604) 985-7286
www.piteau.com

Our file: 3122

March 4, 2016

Taicheng Development Corporation
710 – 100 Park Royal South
West Vancouver, BC V7T 1A2

Attention: Mr. Daniel Lou

Dear Sirs:

Re: Updated Groundwater Flow Simulations for Britannia South Project,
Britannia Beach, BC

In 2014, Piteau Associates Engineering Ltd. (Piteau) completed an investigation of groundwater supply potential for the Britannia South project that involved construction of two production water wells and an extended aquifer pumping test during the summer dry period. The production water wells were identified as TW1 and TW2 (Fig. 1). These wells draw from a localized aquifer situated between the base of the steep mountain slope to the east and Howe Sound to the west. The aquifer dimensions are approximately 850m parallel to the shore and 320m wide (perpendicular to shore).

Thistle and Daisy creeks drain from the steep mountain slopes and flow across the aquifer before discharging into the ocean, and infiltration from both creeks is the primary source of recharge to the aquifer. Flows in the creeks are highly variable, and dry season flows are small and provide minimal recharge to the aquifer. As lowering aquifer water levels below sea level for prolonged intervals may lead to salt water intrusion and aquifer contamination, it is important to avoid over pumping the aquifer. This is especially important during the drier summer and fall months, when freshwater recharge is lowest.

Based on the results of an extended aquifer pumping test conducted with the wells between July and October 2013, Piteau (2014¹) concluded that TW1 and TW2 can sustain a combined flow of about 47 L/s of good quality groundwater with low risk of causing saltwater intrusion from Howe Sound during the summer and fall. As this quantity met the projected water supply needs of the project at the time, it was considered sufficient.

Subsequent to Piteau's 2014 report, additional commercial opportunities on the Britannia South lands were identified. Their scale would be, in part, based on water availability. Piteau provided a proposal on March 27, 2015 to provide services to quantify the potential maximum amount of groundwater that can be drawn from the aquifer, assuming extra wells were drilled. The proposed work plan included:

¹ Piteau, 2014. Hydrogeologic Assessment for Groundwater Supply, Phase 3 - South Britannia Beach, B.C. Letter report written for Taicheng Development Corporation, March 11.



Taicheng Development Corporation

Attention: Mr. Daniel Lou

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1. Analysis of existing information and groundwater flow simulations
2. Construction of additional wells and conducting aquifer pumping tests
3. Continuous water level monitoring
4. Water quality analyses
5. Data analyses and further groundwater flow simulations to predict safe aquifer yield
6. Reporting

Authorization to proceed with Task 1, described above, was received from Taicheng on June 1, 2015. The work has involved back analysis of existing aquifer pumping test data, and use of a numerical groundwater flow model to predict aquifer performance. The work is described in this letter-report.

MODEL CONCEPTUALIZATION AND RECALIBRATION

Model Conceptualization

The grid from a groundwater flow model previously developed by Piteau (2013²) was refined to accommodate the high gradient induced by the pumping test in the area around pumping wells TW1 and TW2, and now consists of 95 rows and 67 columns with cell dimensions ranging from 6.9 to 28.1m. The model was subdivided into four layers on the basis of the geology interpreted from the logs of the existing wells and monitoring wells. All the wells are screened in Layer 3, which corresponds to sand and gravel deposits.

Initial values of hydraulic conductivity, specific storage, and specific yield, were assigned to all cells in the model. The property zones were based on the geology interpreted from the logs of the test wells and monitoring wells, and the results of the 2013 aquifer pumping test. Minor adjustments were made to the original material property zone during model recalibration; and two new zones that represent silty to fine sand lenses were introduced based on the available geo-stratigraphic logs and the need to recalibrate the model to match the observed head at the different monitoring targets.

Constant-head boundary conditions were applied to cells along the west edge of the model which corresponds to the interface at Howe Sound. A series of injection wells were added along the east side of the model to simulate recharge from bedrock, and injection wells were positioned along Thistle and Daisy creeks to simulate infiltration of surface water along the upper 25 to 50m of the creeks. No flow boundary conditions were applied to all remaining borders of the model domain. The model grid, property zones, and relevant sections cut through the model domain are presented on Figs. 2A and 2B.

² Piteau, 2013. Hydrogeologic Assessment for Groundwater Supply – South Britannia Beach, B.C. – Numerical Groundwater Flow Model. Letter report written for Taicheng Development Corporation, March 5.



Taicheng Development Corporation

Attention: Mr. Daniel Lou

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Precipitation infiltration was applied to the upper most active cells of the model as direct recharge into the aquifer.

Model Recalibration and Sensitivity Analysis

The model was first calibrated in steady-state mode to simulate the flow regime condition that existed in the aquifer during the summer dry season prior to the beginning of the 2013 pumping test. The simulated flow regime was later used as the initial condition for transient-state calibration, and model input parameters were adjusted to achieve a relatively close agreement between actual and predicted water levels.

Results for steady-state calibration, and observed versus simulated hydrographs for the transient-state calibration, and sensitivity analyses results, are included on Fig. 3. Predicted groundwater head contours for the steady state and the lowest water level occurring on September 18, 2013 for the transient state and sensitivity analyses are included on Fig. 4.

A normalized residual mean square (RMS) error³ of 5.8% was achieved for the steady-state calibration (Fig.3). This was considered satisfactory, as normalized RMS error of 10% is generally considered a reasonable calibration target. Predicted water level trends closely match actual water levels in monitoring wells MW1, MW2 and MW3 (Fig. 3). Based on these results, the degree of calibration can be considered as satisfactory.

MODEL PREDICTION AND SENSITIVITY ANALYSIS

Under natural conditions fresh groundwater in the aquifer flows eastward toward Howe Sound. For the purposes of this evaluation, risk of sea water intrusion is considered to exist when aquifer water levels next to the shoreline are below sea level and the direction of flow is reversed.

The calibrated model was used to run predictive simulations to assess the optimum safe aquifer yield that could be withdrawn from various well configurations. In each case, this was achieved by trial and error adjustment of flows rates during repeated simulations to determine the value that results in the onset of flow reversal along the shoreline after 100 days of pumping ending in the fall.

During each simulation there was no direct precipitation recharge, and seepage rates from Thistle and Daisy creeks were held at rates determined for the calibration.

The results of the following four simulations are shown on Fig. 5:

- Case 1: This simulation included the two existing wells (TW1 and TW2) operating at their previously determined long-term safe yields of 19.9 and 26.6 L/s, respectively (Piteau, 2014).

³ Residual mean square or RMS represents the sample standard deviation of the differences between predicted values and observed values. Normalized RMS error divides the RMS by the difference between the maximum observed value and the minimum observed value and is expressed in percentage.



Taicheng Development Corporation

Attention: Mr. Daniel Lou

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The results indicate that after 100 days of operation the predicted water levels at MW2 and MW3 were 0.31 and 1.30m above mean sea level, respectively, and that groundwater flow remains westward towards Howe Sound.

- Case 2: This simulation included pumping from TW1 and TW2 (as in Case 1 above), but the pumping rates were increased to determine the rates at which flow reversal would occur. The result indicates pumping rates of 31.3 L/s and 29.2 L/s, respectively, for TW1 and TW2, for a combined rate of 60.4 L/s.
- Case 3: This simulation included TW1 and TW2, along with two additional pumping wells positioned approximately 70m to either side of TW2. The results indicate the onset of flow reversal at the shoreline occurred at combined pumping rate of 72.0 L/s.
- Case 4: This simulation included the same wells as Case 3 along with an additional well on the south side of Daisy Creek to further spread out the drawdown. The maximum cumulative pumping rate for this case was 68.6 L/s.

Additional simulations were performed to assess the sensitivity of the Case 3 results to variations in the volume of water infiltrating from Thistle and Daisy creeks. The results of the simulations are shown on Fig.6. It was found that a 10% decrease in infiltration resulted in a reversal in flow direction near the shoreline would occur about 53 days after the start of the simulation. Groundwater flow remained westward towards Howe Sound with a 10% increase in infiltration.

CONCLUSIONS AND RECOMMENDATIONS

At 60.4 L/s, the sustainable flow predicted for Case 2 is 29% greater than the sustainable flow determined directly from the aquifer pumping test results in 2014 (47 L/s). As the difference may relate to the uncertainties inherent to the model, the higher value is unproven. The value is useful; however, as a basis for comparison of alternatives.

The apparent safe yield for Case 3 (72 L/s), which included two additional wells in the vicinity of TW2, is approximately 19% greater than the result for Case 2. Applying an increase of this magnitude to the actual proven safe yield (47 L/s) suggests that an increase in safe yield to 56 L/s may be feasible.

The results for Case 4, which includes two additional wells in the vicinity of TW2, and an additional well on the south side of Daisy Creek, suggests a slightly smaller increase (13%) in safe yield to 53 L/s.

The analyses demonstrate that the sustainable safe aquifer yield is sensitive to flow rates in Thistle and Daisy creeks. Given the potential for reduced summer flows during drought or years with reduced snowpack, an adaptive approach could be utilized to optimize groundwater withdrawals while preventing over pumping possibly leading to salt water intrusion. This could be achieved by forecasting summer creek flows based on snowpack, and frequent monitoring of



Taicheng Development Corporation

Attention: Mr. Daniel Lou

- 5 - March 4, 2016

water levels and total dissolved solids in monitoring wells along the western edge of the site. Allowable pumping rates could be determined on a year-by-year basis on the basis of forecasted flows, and experience with long-term aquifer performance.

In support of this approach, Piteau recommends initiation of ongoing flow monitoring in Thistle and Daisy creeks, and continuous water level monitoring in MW2 and MW3.

LIMITATIONS

This investigation has been conducted using a standard of care consistent with that expected of scientific and engineering professionals undertaking similar work under similar conditions in BC. No warranty is expressed or implied.

This letter report is prepared for the sole use of Taicheng Development Corporation. Any use, interpretation, or reliance on this information by any third party, is at the sole risk of that party, and Piteau accepts no liability for such unauthorized use.

CLOSURE

We trust that this letter report provides the information you require at this time. Please contact the undersigned if you have any questions or comments.

Yours truly,

PITEAU ASSOCIATES ENGINEERING LTD.

ORIGINAL SIGNED

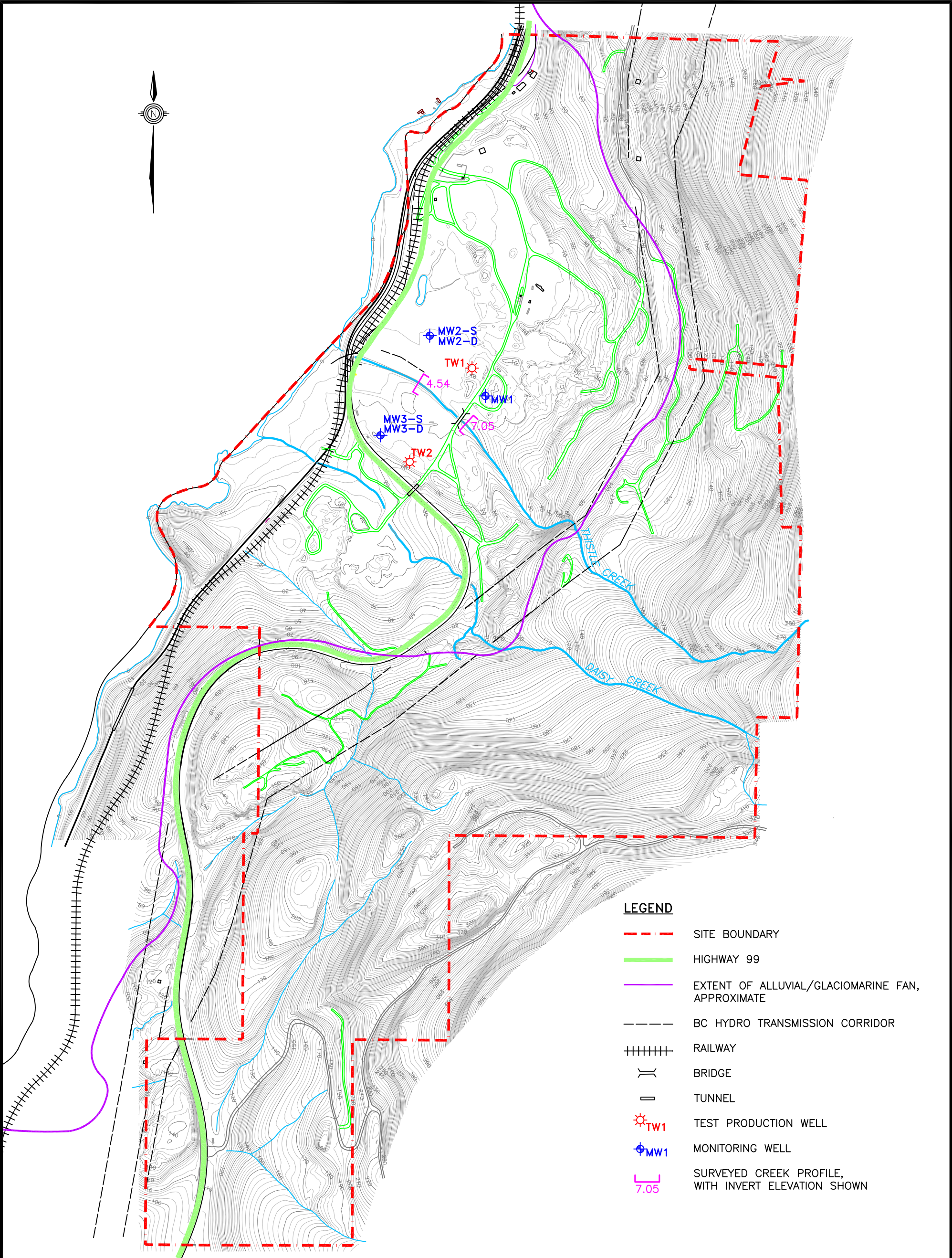
D. Raoul Gnansounou, P.Geo.
Senior Hydrogeologist

ORIGINAL SIGNED

David J. Tiplady, P.Eng.
Principal Hydrogeologist
Vice President – Groundwater

DRG/DJT/slc
Att.

FIGURES



- LEGEND**
- SITE BOUNDARY
 - HIGHWAY 99
 - EXTENT OF ALLUVIAL/GLACIOMARINE FAN, APPROXIMATE
 - BC HYDRO TRANSMISSION CORRIDOR
 - ++++ RAILWAY
 - || BRIDGE
 - TUNNEL
 - ☀ TW1 TEST PRODUCTION WELL
 - ⊕ MW1 MONITORING WELL
 - 7.05 SURVEYED CREEK PROFILE, WITH INVERT ELEVATION SHOWN

NOTE: TOPOGRAPHIC CONTOURS ARE IN METRES ABOVE MEAN SEA LEVEL.

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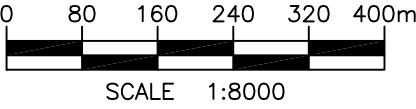
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GROUNDWATER SUPPLY ASSESSMENT
PHASE 3 - BRITANNIA SOUTH PROJECT

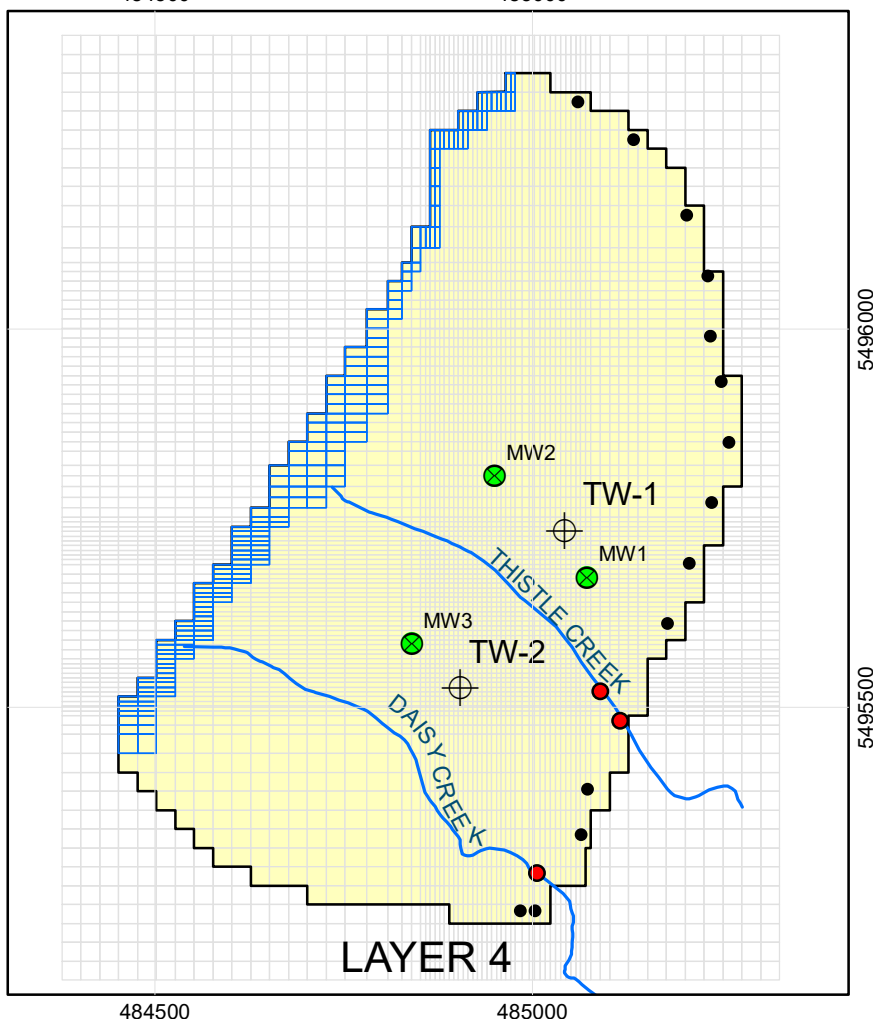
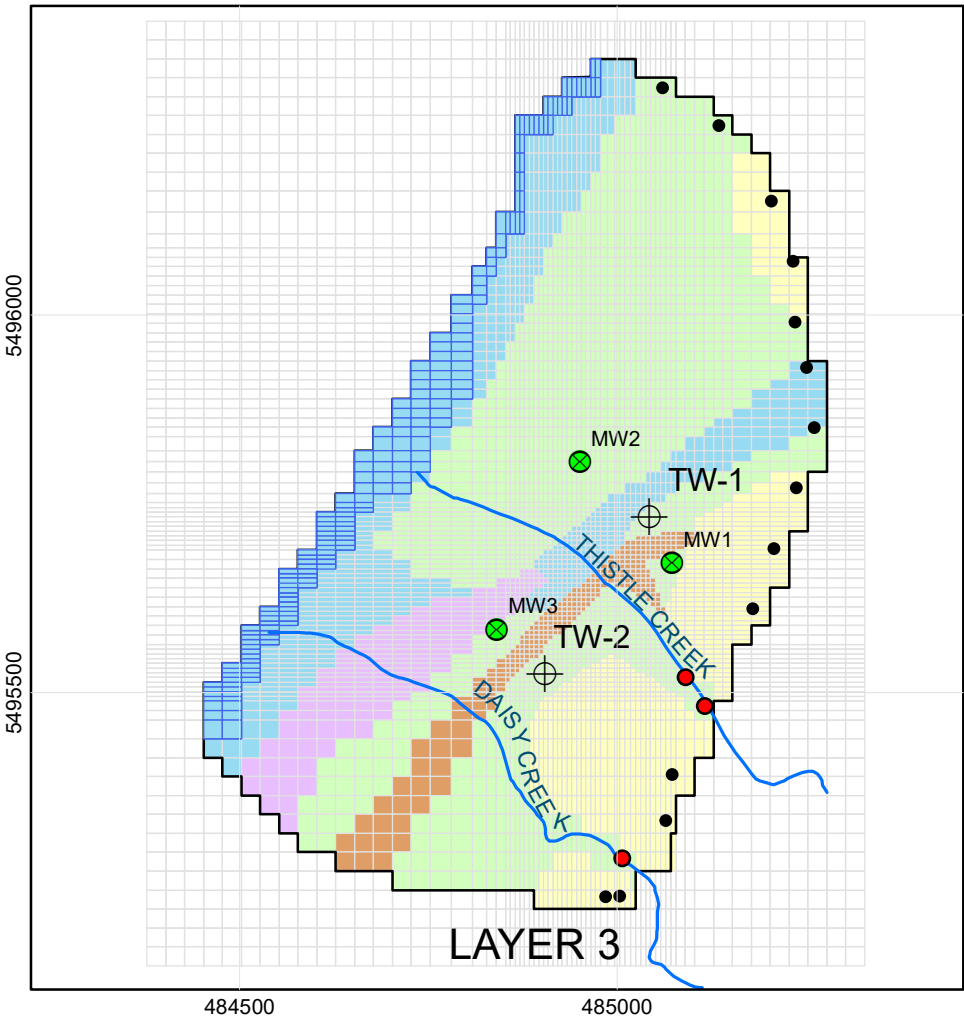
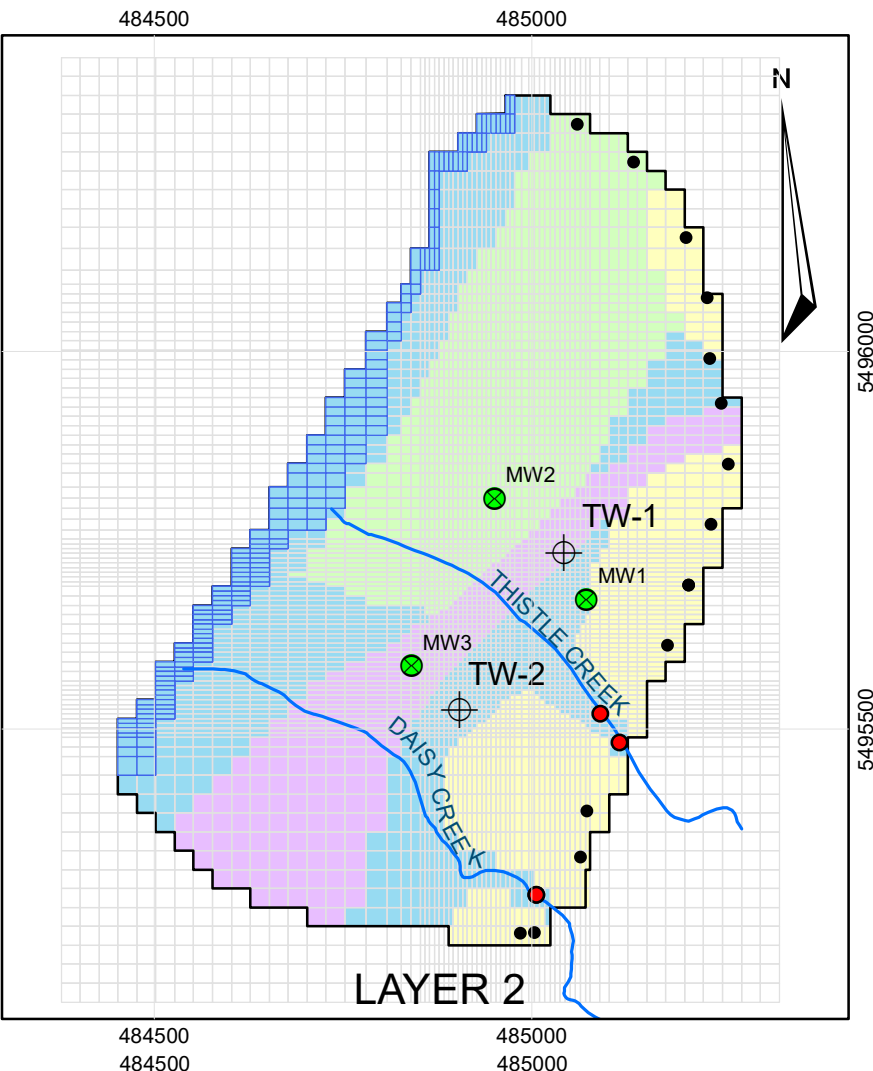
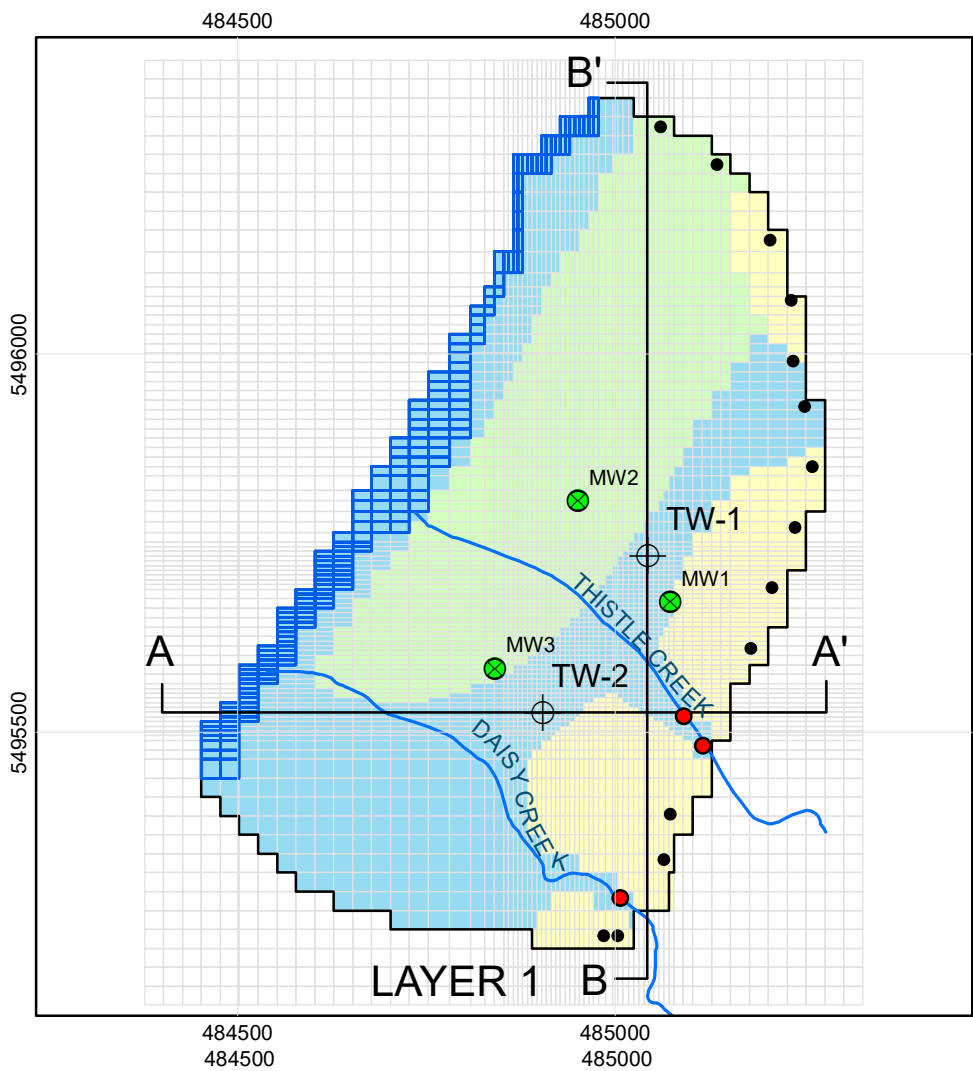


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SITE PLAN

BY:	DATE:
BD/si	JUN 15
APPROVED:	FIG:
DJT	1



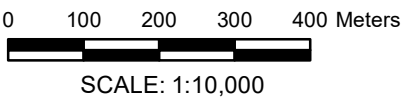


LEGEND

- Injection Well Representing Seepage From Creek
- Injection Well Representing Groundwater Inflow From Bedrock
- ⊗ Monitoring Well
- ⊕ Production Well
- Creek
- ▨ Constant Head Representing Howe Sound Sea

Property Zone

- ▨ Silty - Fine Sand Lenses
- ▨ Fine Sand
- ▨ Sand and Gravel
- ▨ Bedrock
- ▨ Medium to Fine Sand



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SOUTH BRITANNIA PROJECT

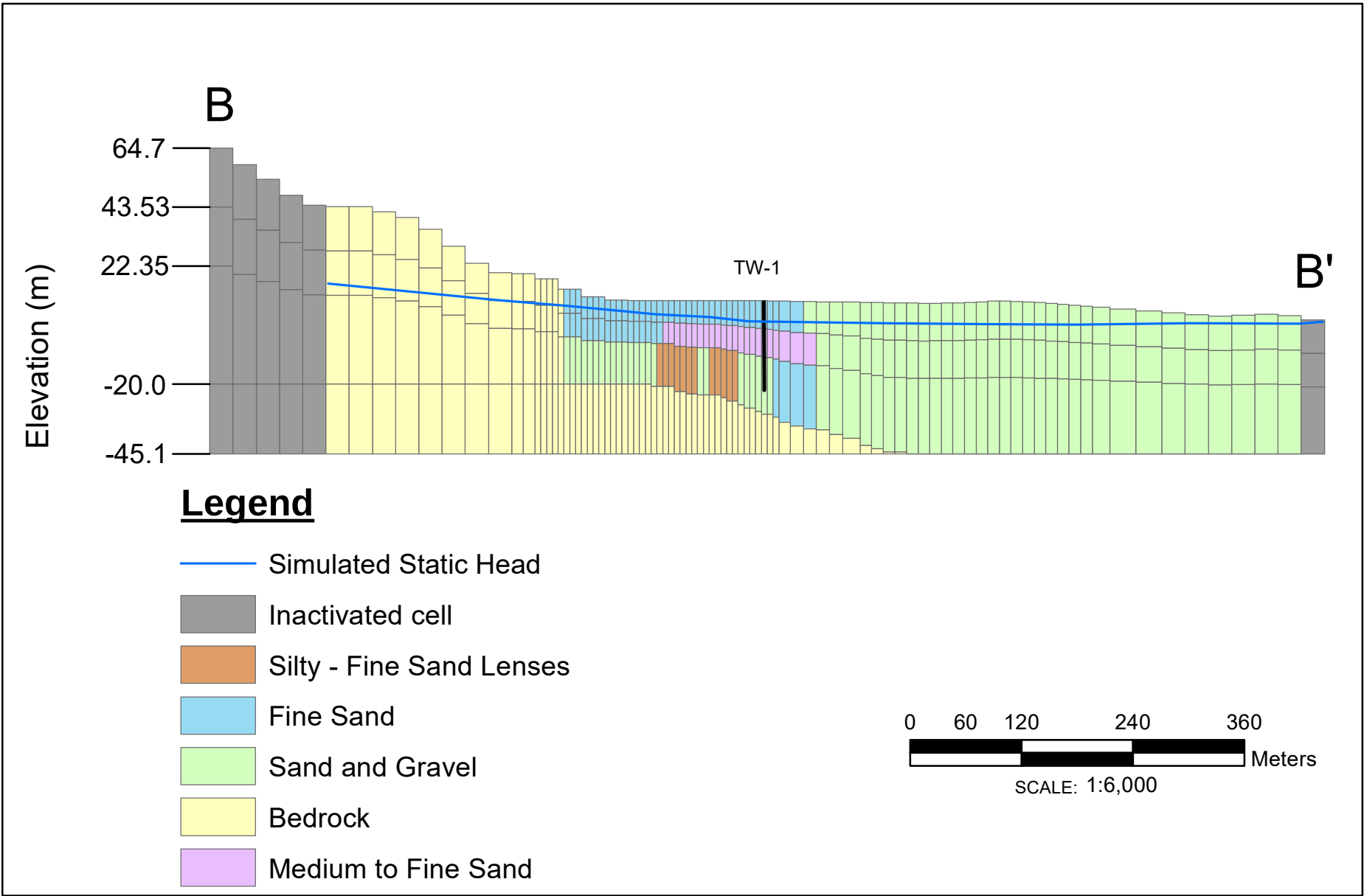
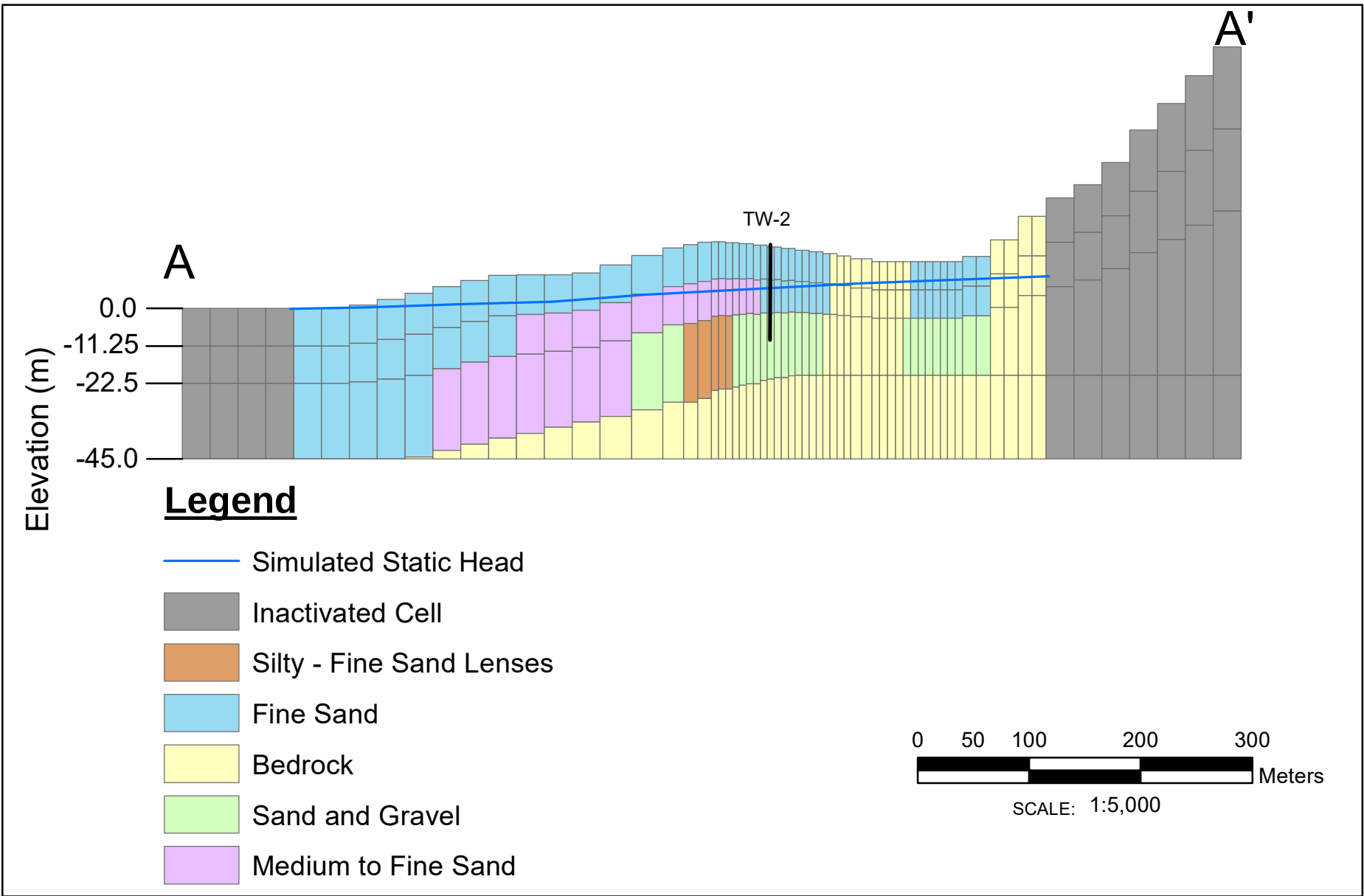
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**MODEL GRID AND PROPERTY ZONES
FOR RECALIBRATED MODEL**

BY:	DRG	DATE:	FEB 16
APPROVED:	DJT	FIG:	2A



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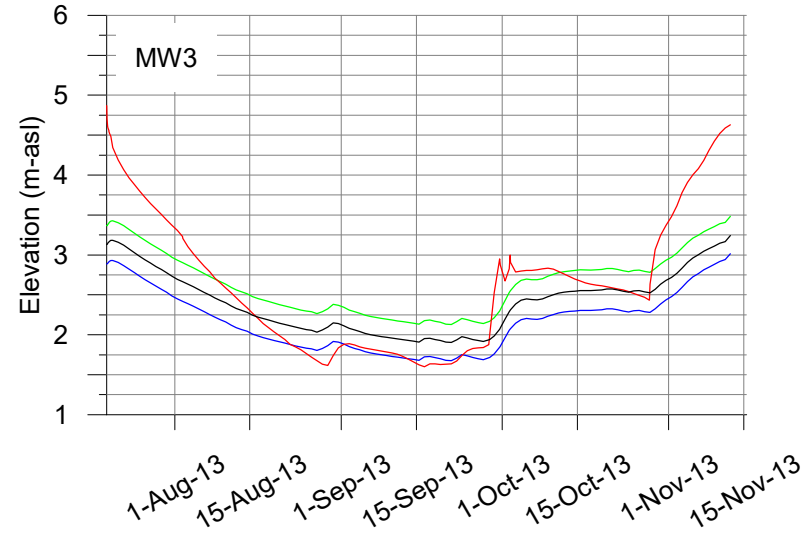
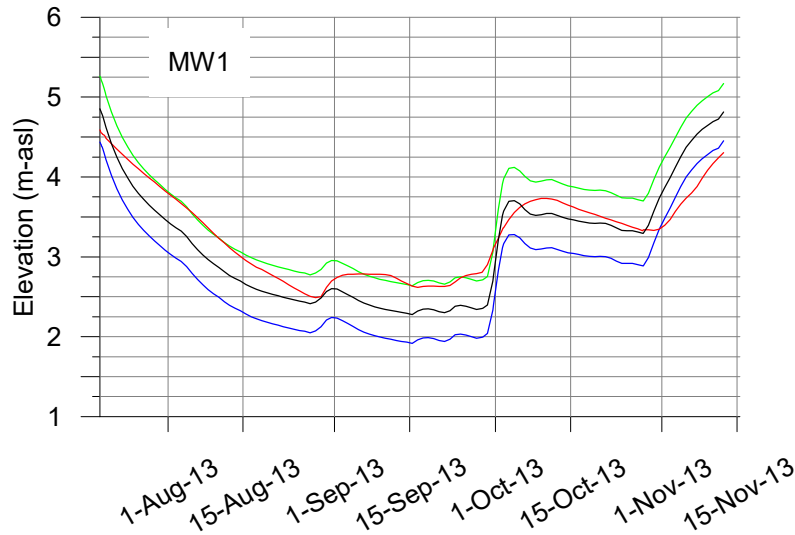
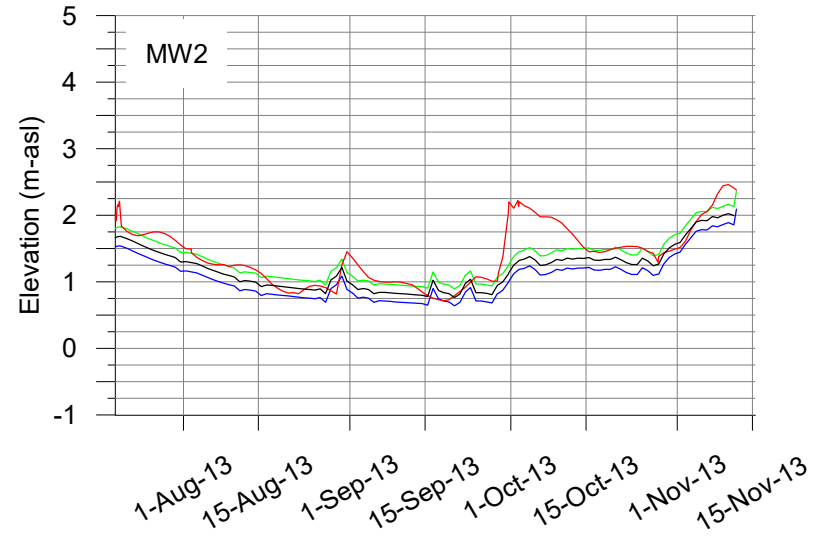
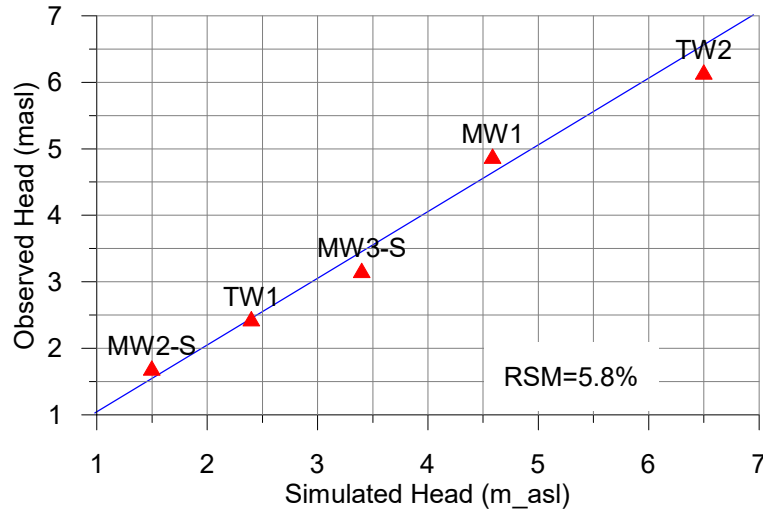
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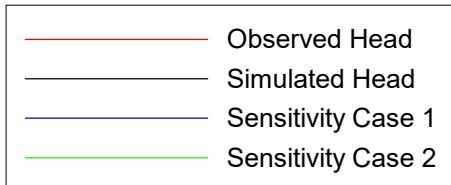
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**SECTION AA' AND BB' SHOWING
PROPERTY ZONES FOR RECALBRATED MODEL**

BY:	DRG	DATE:	FEB 16
APPROVED:	DJT	FIG:	2B



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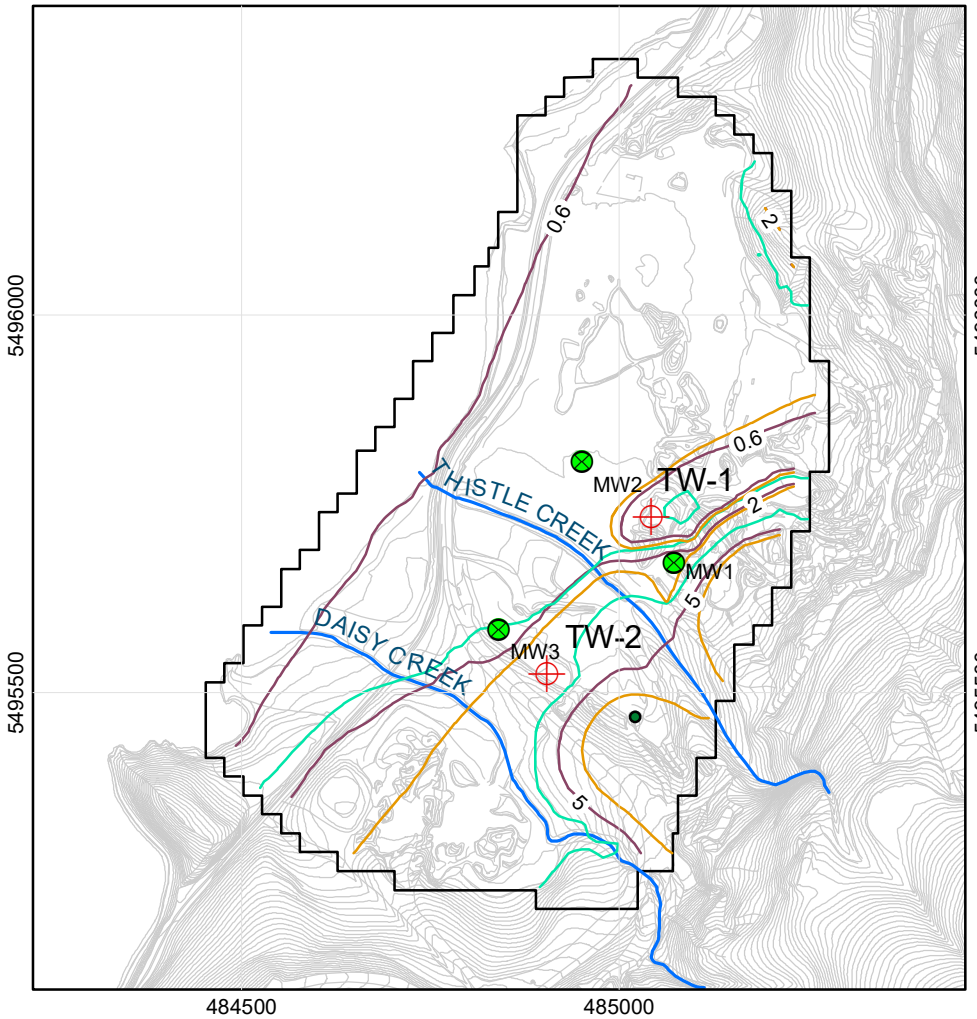
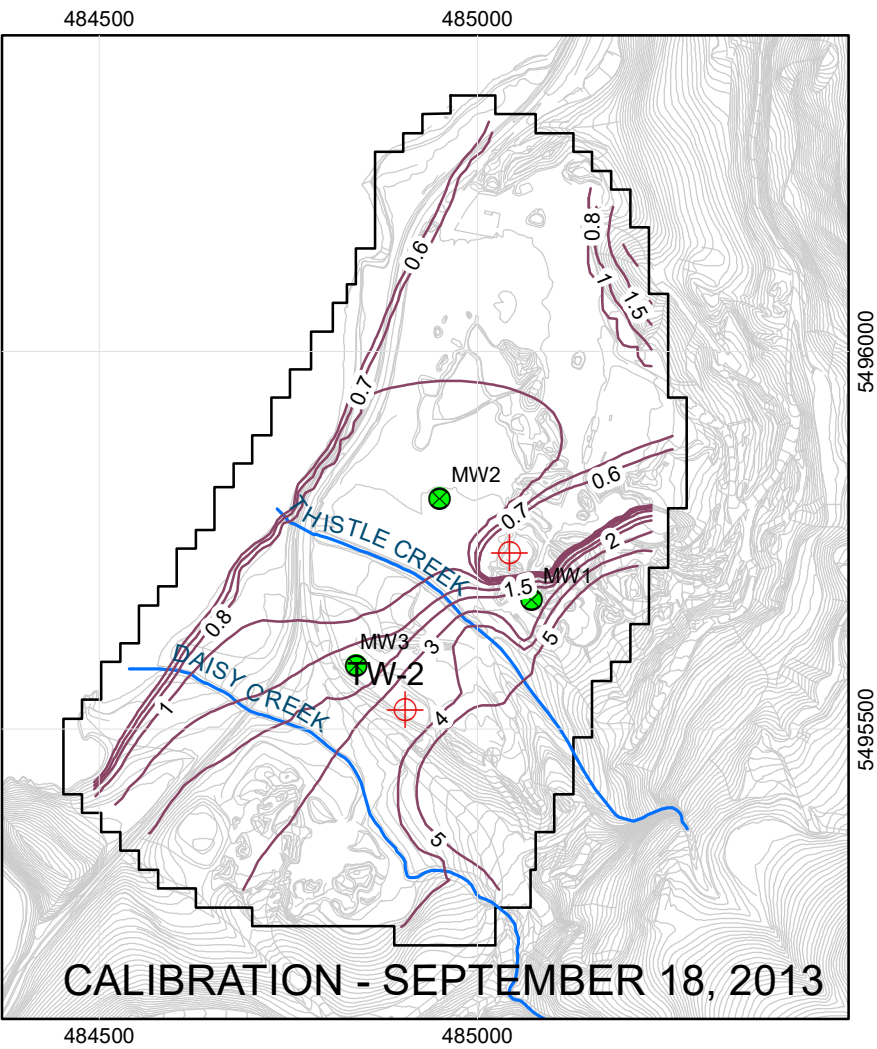
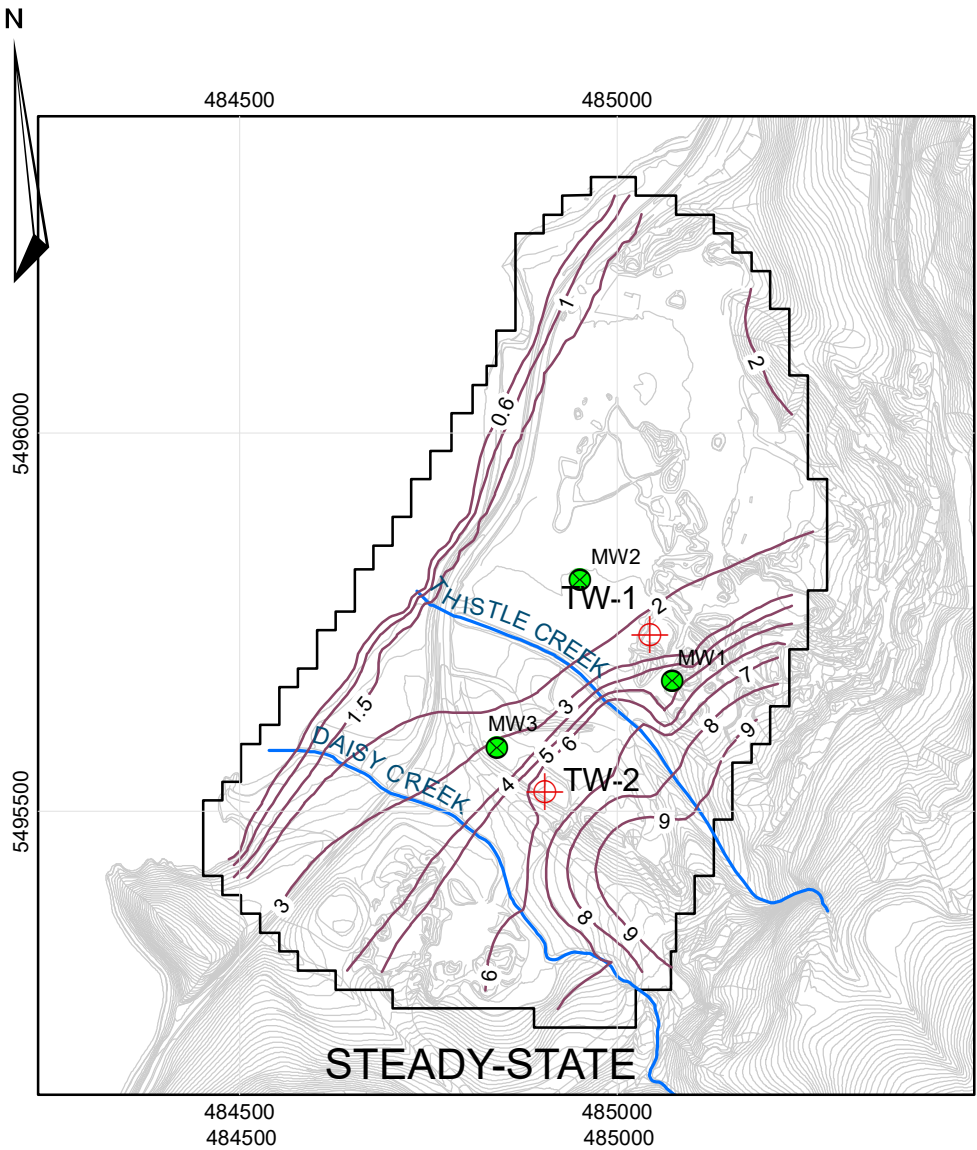
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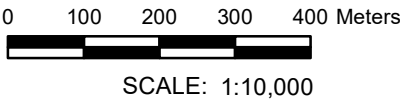
GROUNDWATER FLOW NUMERICAL MODEL
CALIBRATION PLOT RESULT AND OBSERVED VS. SIMULATED
HYDROGRAPHS FOR MONITORING WELLS MW1, MW2 AND MW3

BY:	DRG	DATE:	FEB 16
APPROVED:	DJT	FIG:	3



Legend

- Monitoring Well
- Production Well
- Creek
- Groundwater Equipotential (m)
- Sensitivity Analysis Case 1
- Sensitivity Analysis Case 2
- Outline Of Model Domain



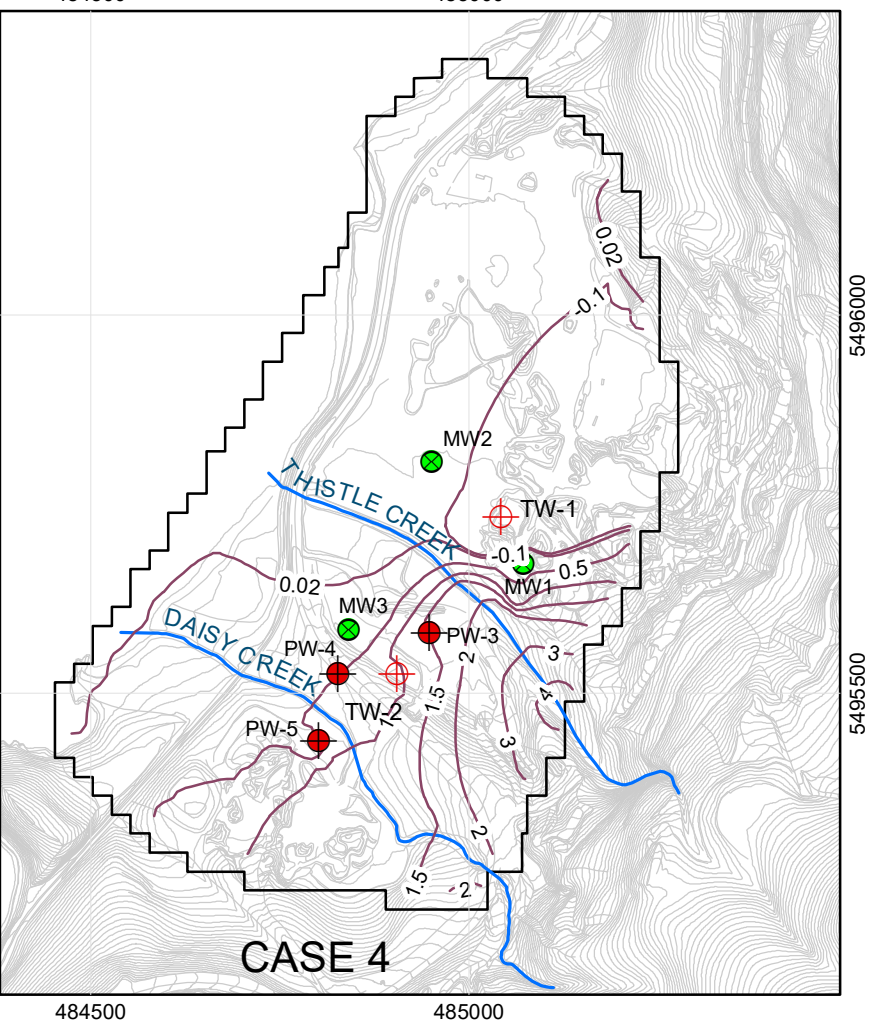
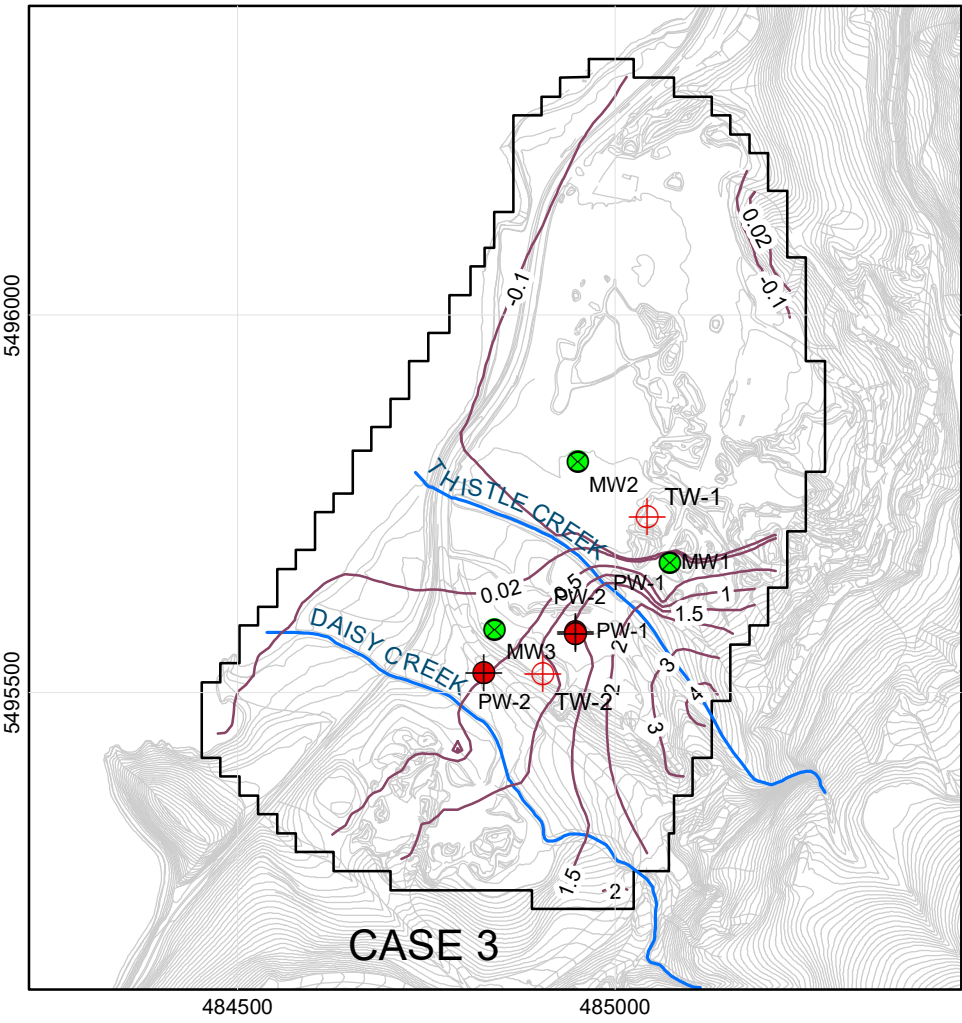
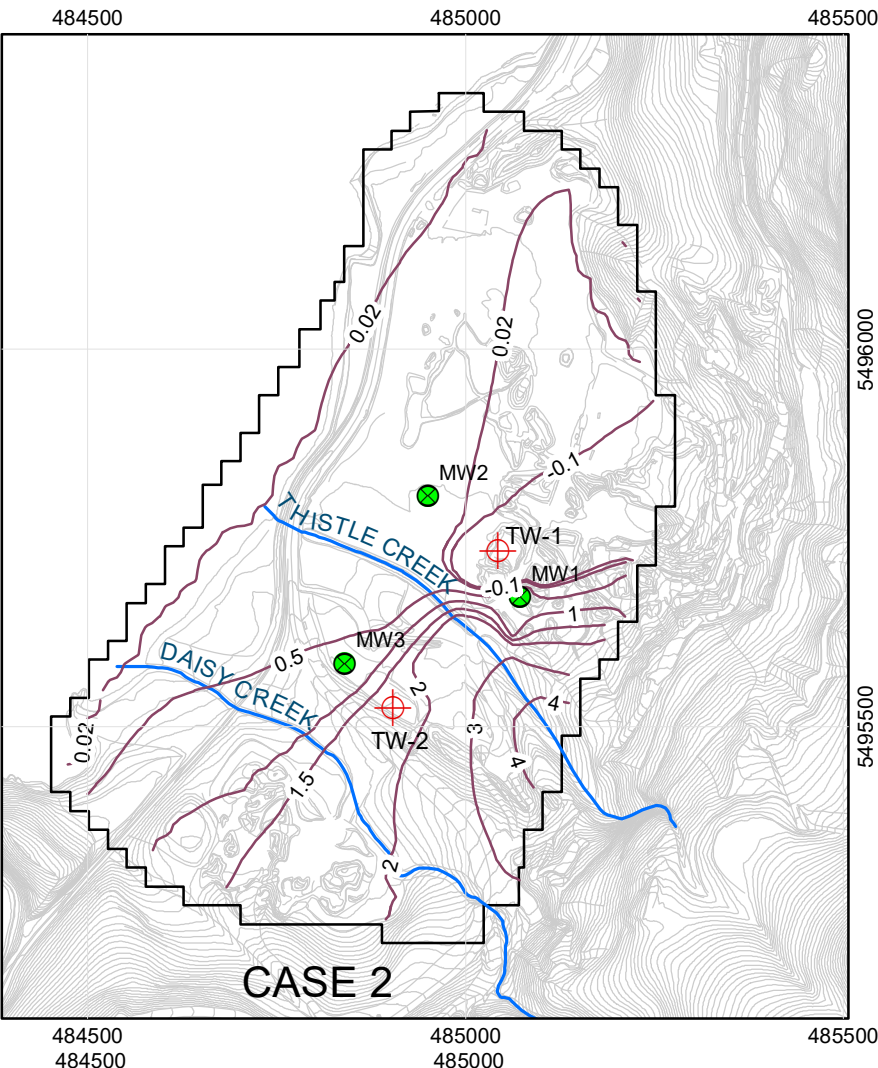
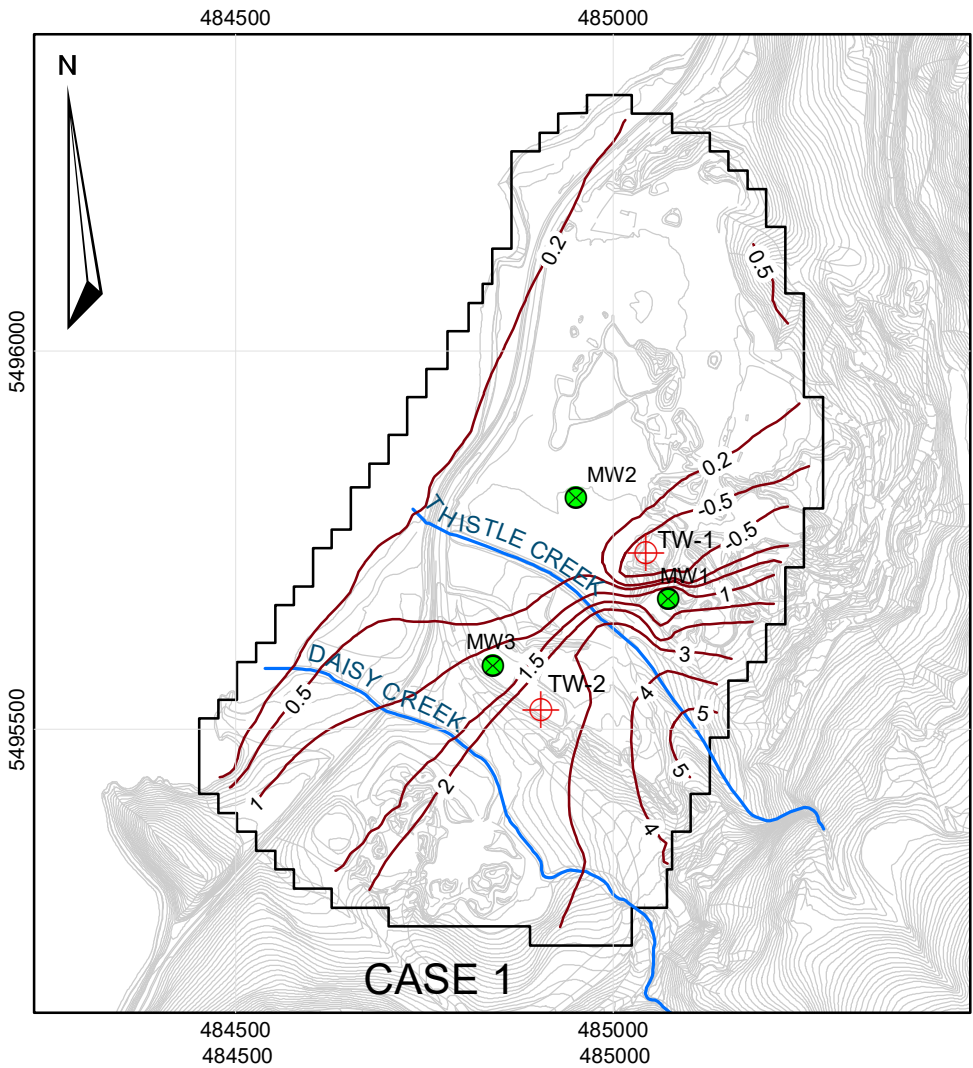
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GROUNDWATER SUPPLY ASSESSMENT
SOUTH BRITANNIA PROJECT

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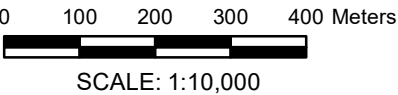
EQUIPOTENTIALS OF AQUIFER HEAD FOR
CALIBRATION AND SENSITIVITY ANALYSES

BY:	DRG	DATE:	FEB 16
APPROVED:	DJT	FIG:	4



Legend

-  Monitoring Well
-  Existing Well
-  Additional Test Well Assumed For Simulation Purposes
-  Groundwater Equipotential (m)
-  Creek



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GROUNDWATER SUPPLY ASSESSMENT
SOUTH BRITANNIA PROJECT

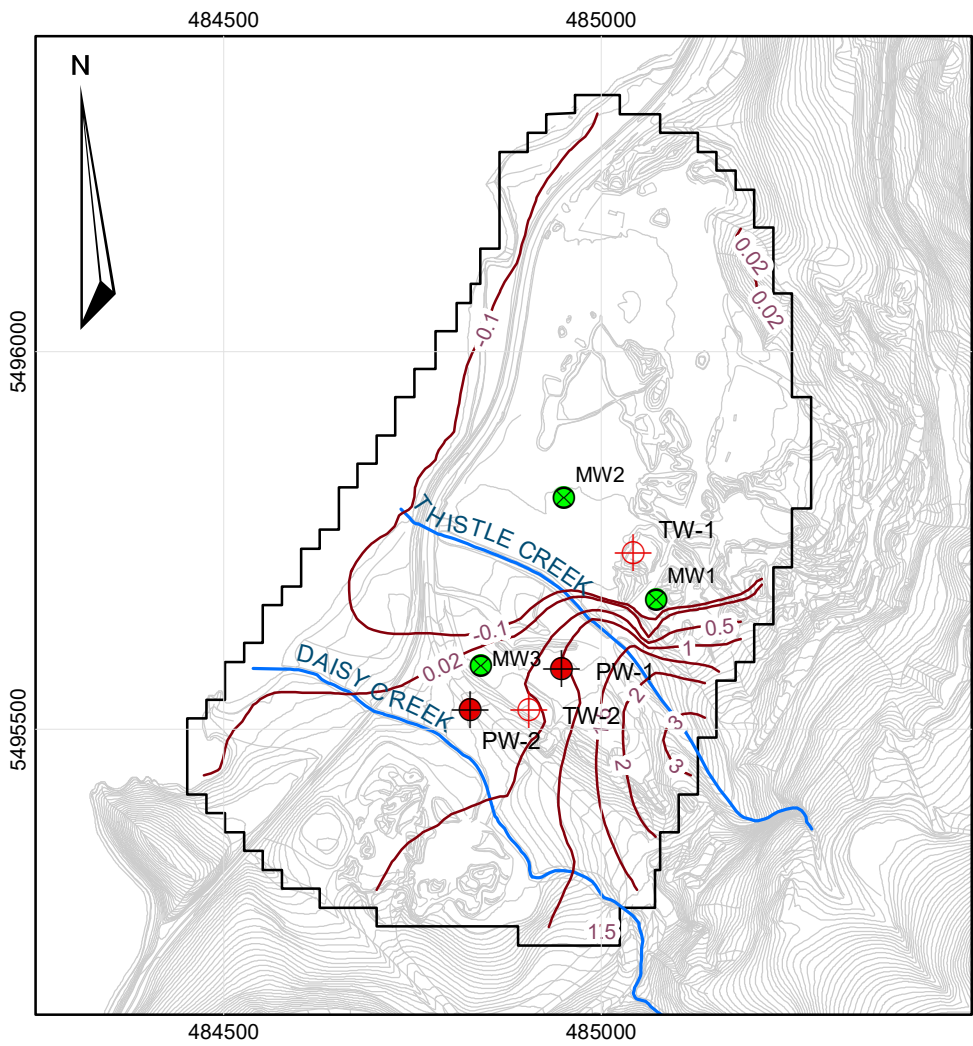
NUMERICAL GROUNDWATER FLOW MODEL
MODEL PREDICTIONS

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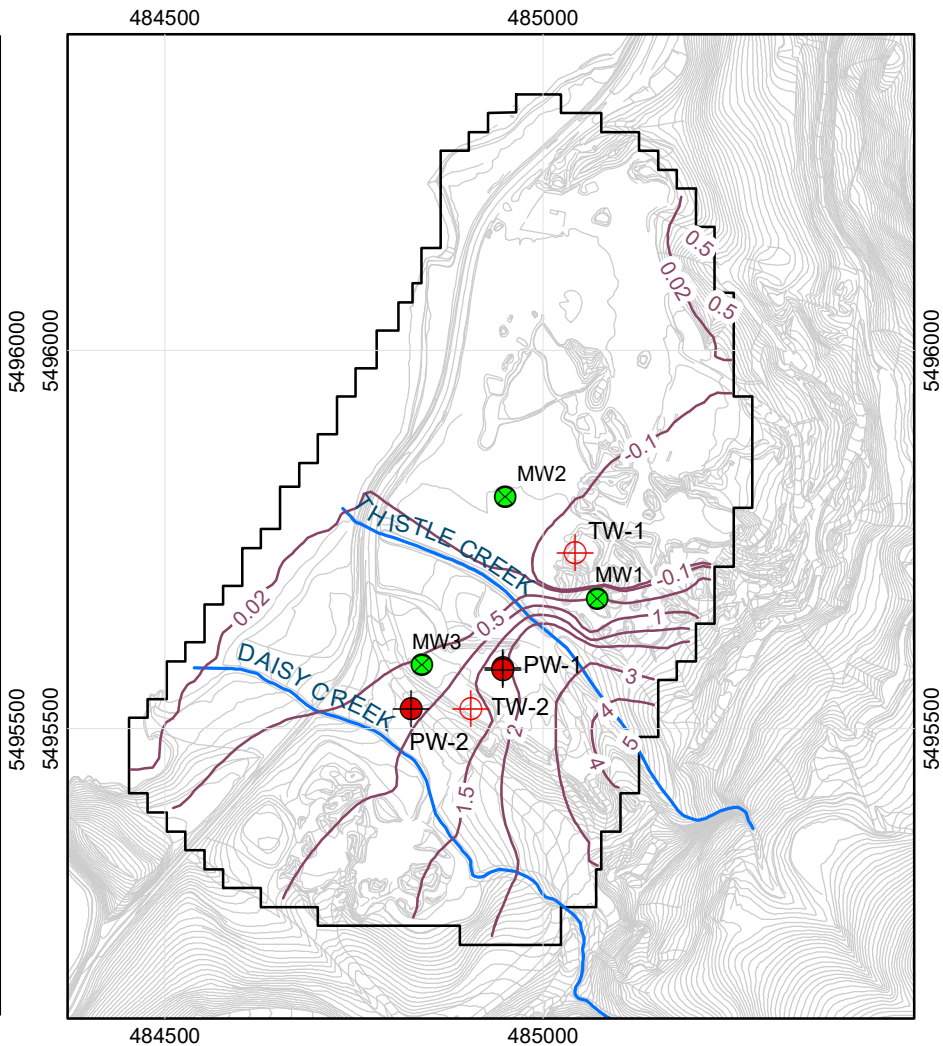


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BY:	DRG	DATE:	FEB 16
APPROVED:	DJT	FIG:	5



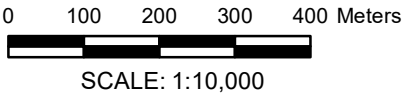
SENSITIVITY ANALYSIS
CREEK INFILTRATION - 10%



SENSITIVITY ANALYSIS
CREEK INFILTRATION + 10%

LEGEND

- Monitoring Well
- Existing Well
- Additional Test Well Assumed For Simulation Purposes
- Groundwater equipotential (m)
- Creek



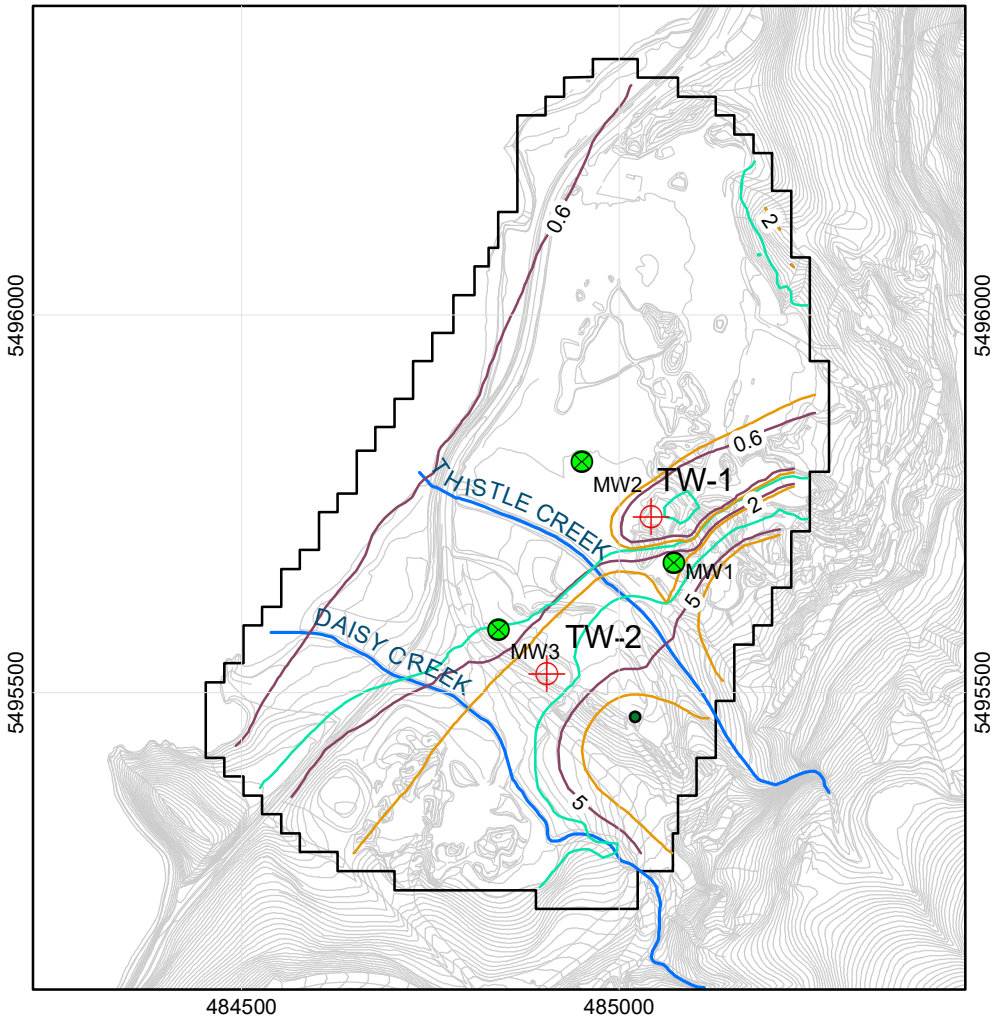
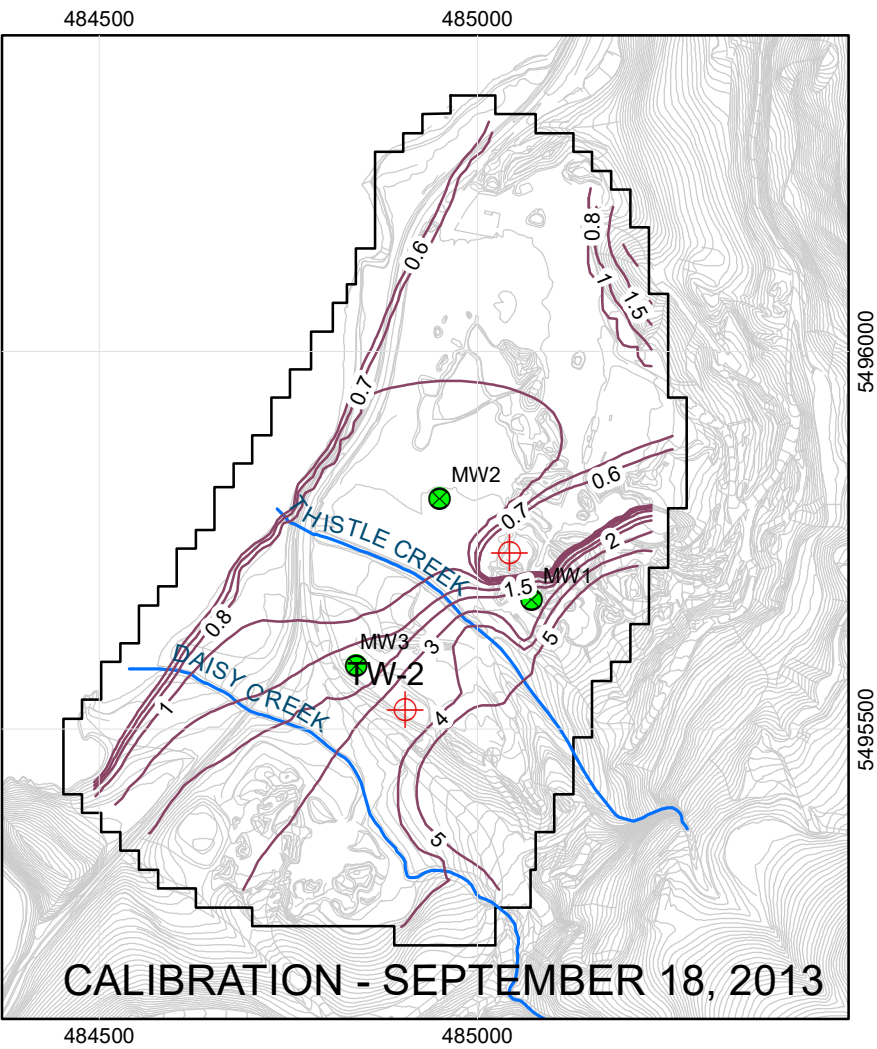
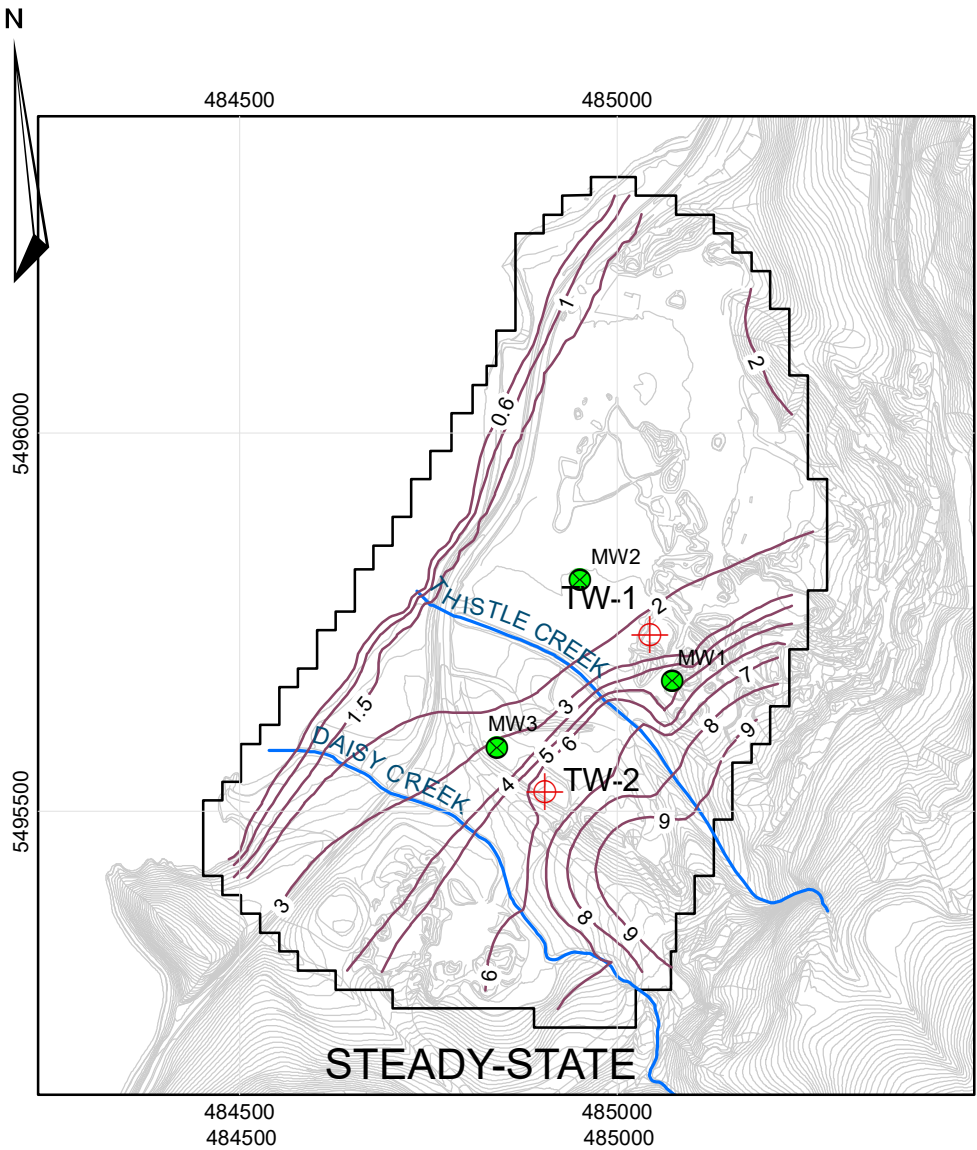
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GROUNDWATER SUPPLY ASSESSMENT
SOUTH BRITANNIA PROJECT

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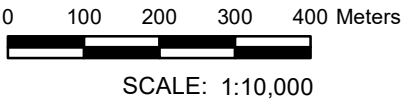
NUMERICAL GROUNDWATER FLOW MODEL
SENSITIVITY ANALYSIS FOR PREDICTION CASE 3

BY:	DRG	DATE:	FEB 16
APPROVED:	DJT	FIG:	6



Legend

- Monitoring Well
- Production Well
- Creek
- Groundwater Equipotential (m)
- Sensitivity Analysis Case 1
- Sensitivity Analysis Case 2
- Outline Of Model Domain



CALIBRATION SHOWING SENSITIVITY ANALYSIS CASE1 AND CASE 2 (CONTOURS EL.0,6, 1 AND 5M ONLY IN SEPTEMBER 18, 2013)

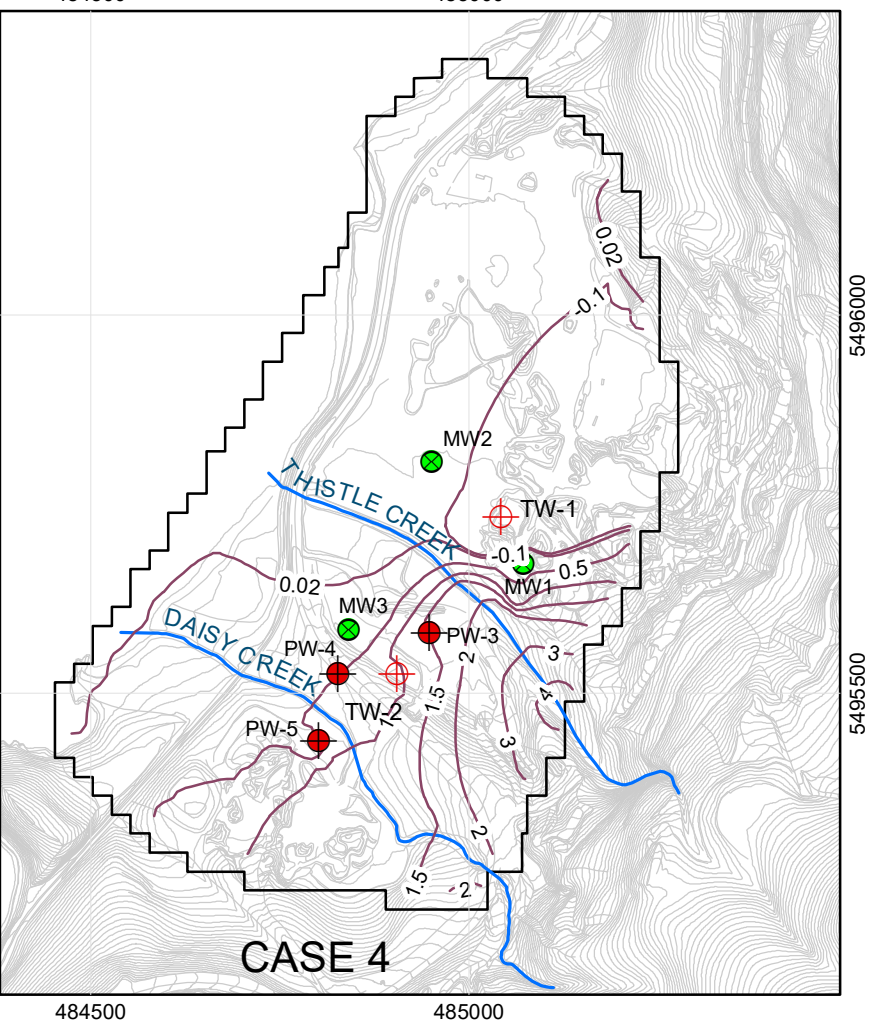
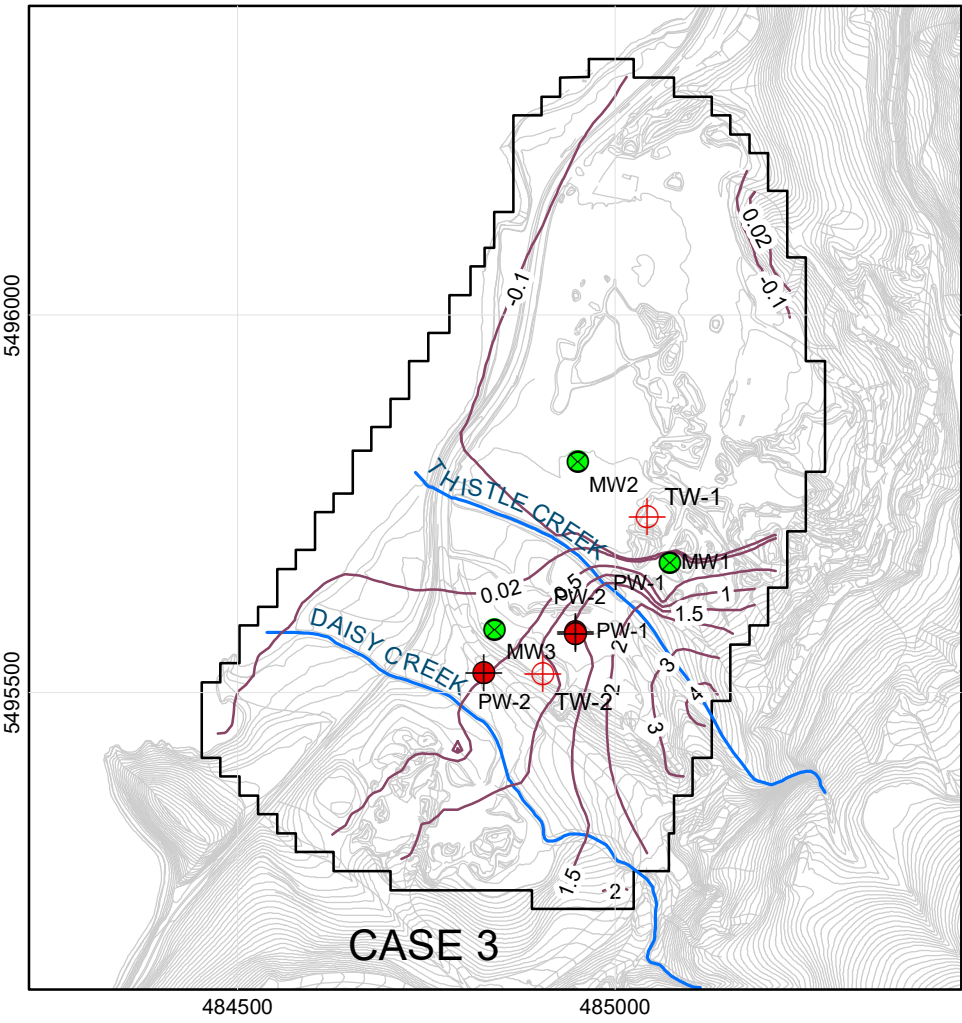
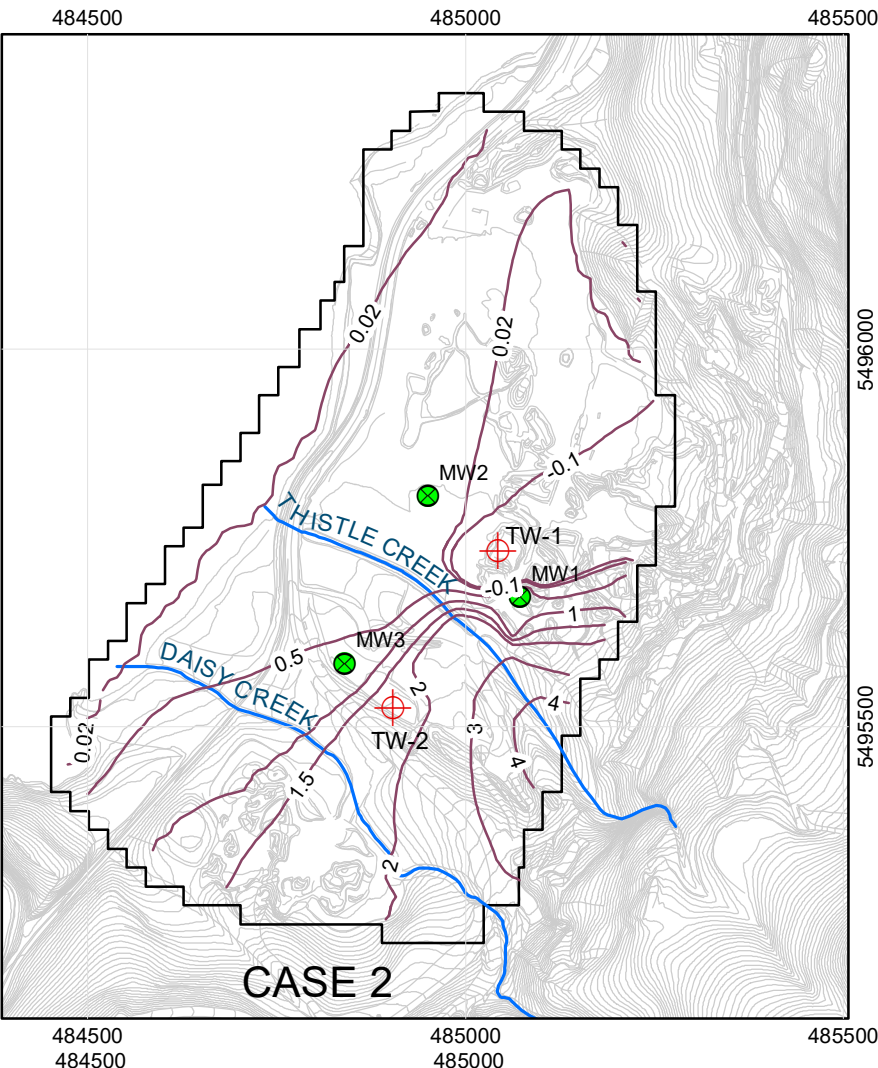
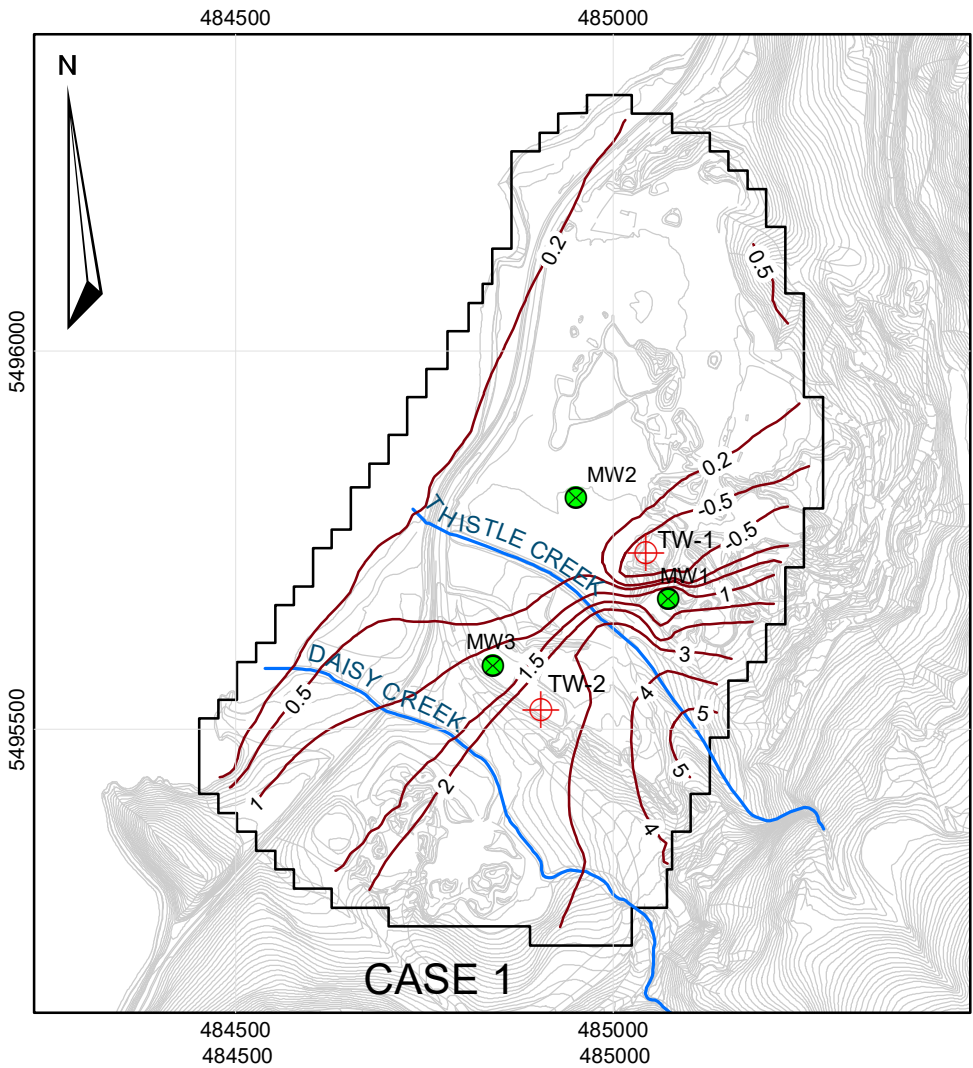
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SOUTH BRITANNIA PROJECT

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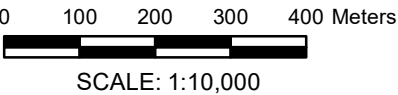
EQUIPOTENTIALS OF AQUIFER HEAD FOR
CALIBRATION AND SENSITIVITY ANALYSES

BY:	DRG	DATE:	FEB 16
APPROVED:	DJT	FIG:	4



Legend

- Monitoring Well
- Existing Well
- Additional Test Well Assumed For Simulation Purposes
- Groundwater Equipotential (m)
- Creek



TAICHENG DEVELOPMENT CORPORATION
GROUNDWATER SUPPLY ASSESSMENT
SOUTH BRITANNIA PROJECT

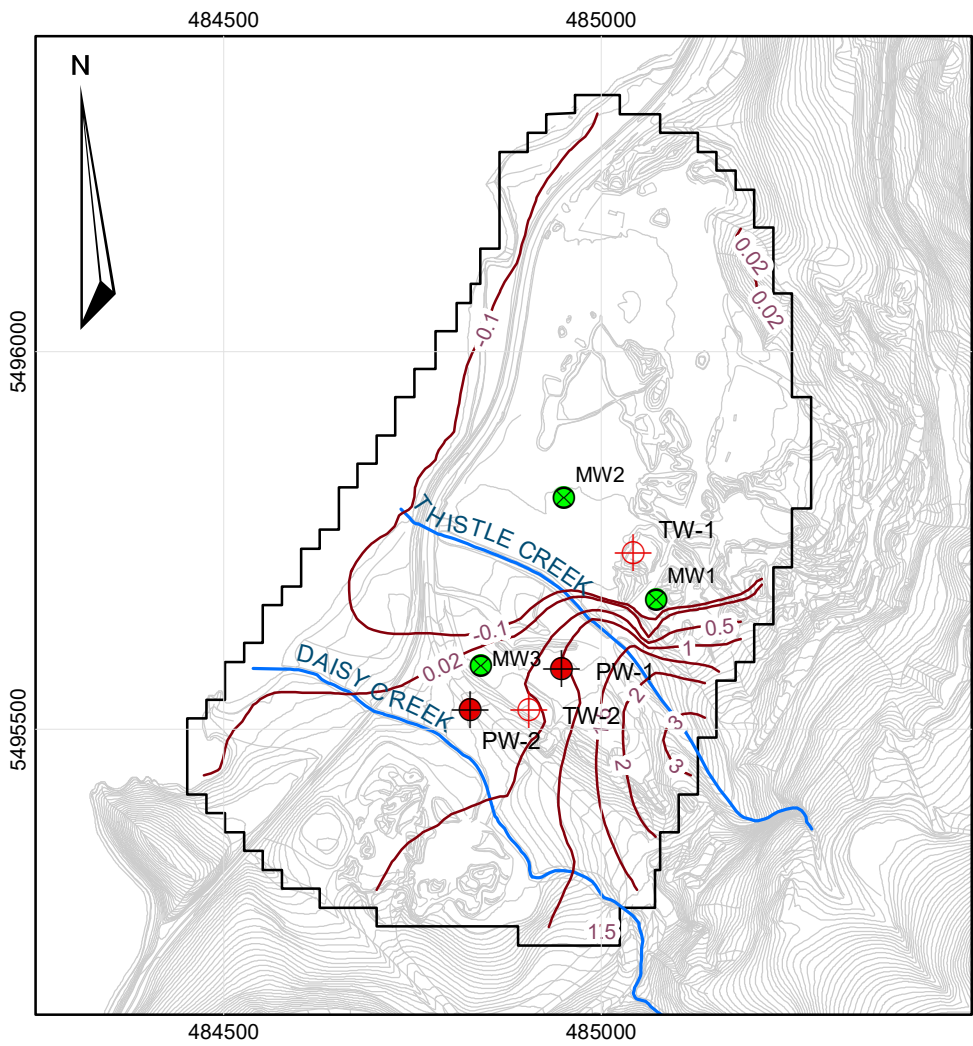
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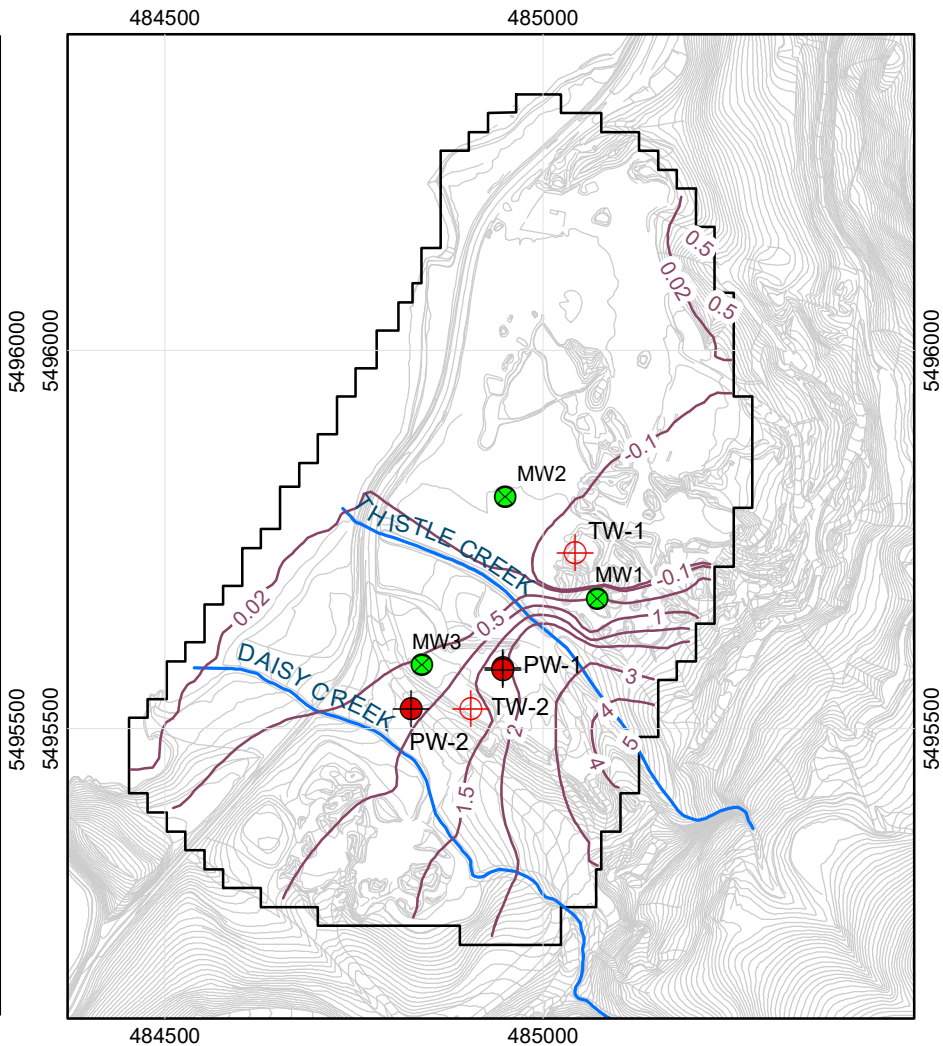
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**NUMERICAL GROUNDWATER FLOW MODEL
MODEL PREDICTIONS**

BY:	DRG	DATE:	FEB 16
APPROVED:	DJT	FIG:	5



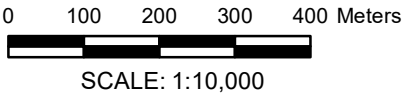
SENSITIVITY ANALYSIS
CREEK INFILTRATION - 10%



SENSITIVITY ANALYSIS
CREEK INFILTRATION + 10%

LEGEND

- Monitoring Well
- Existing Well
- Additional Test Well Assumed For Simulation Purposes
- Groundwater equipotential (m)
- Creek



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GROUNDWATER SUPPLY ASSESSMENT
SOUTH BRITANNIA PROJECT

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GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

NUMERICAL GROUNDWATER FLOW MODEL
SENSITIVITY ANALYSIS FOR PREDICTION CASE 3

BY:	DRG	DATE:	FEB 16
APPROVED:	DJT	FIG:	6

From: [David J. Tiplady](#)
To: paul@turje.ca
Cc: "Office"
Subject: RE: BRITANNIA hydrogeology
Date: February 26, 2020 11:43:53 AM
Attachments: [image002.png](#)

Paul,

The projected well yields are based on the drawdown trends between the start of the pumping interval on July 19, 2014 and the recharge event on August 28, 2014 (Figure 8). As there was virtually no precipitation during this interval, the estimated safe yields account for dry conditions that may be anticipated with future climate change. Accordingly, I don't think any further analysis is warranted.

Regards,

DAVID J. TIPLADY, P.ENG.

Principal Hydrogeologist, Vice President - Groundwater

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10 TRANSPORTATION

This study contains an updated transportation impact assessment completed by Bunt & Associates Engineering Ltd. The major issue addressed is the interface between the proposed development and Highway 99. The report proposes phased development of intersections at the main entrance and into Minaty Bay. The report also comments on existing problems with the highway intersection into North Britannia, provides potential solutions but notes that the problems are historic and therefore not the responsibility of Taicheng to remedy.

The development plan accommodates a highway bypass around North and South Britannia by setting aside a highway corridor between the proposed community and the BC Hydro transmission line Right of Way. This corridor defines the eastern boundary of the proposed development area and is located in lands shown as remaining undeveloped.

Bunt will be retained by Tiger Bay to continue consultations with the Ministry of Transportation and Infrastructure with the goal of securing the appropriate permits for the on-site roads and the intersections with the Highway.



South Britannia Master Plan Transportation Impact Analysis **Draft Update 4**

Prepared for

Tiger Bay Development Corporation

Date

June 26, 2019

Project No.

04-17-0272

June 21, 2019
04-17-0272

Long Cheng
Tiger Bay Development Corporation
Suite 710, 100 Park Royal South
West Vancouver, V7T 1A2
V7T 1A2

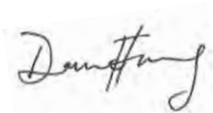
Dear Long:

**Re: South Britannia Master Plan
Draft Transportation Impact Assessment Update**

Please find attached the transportation impact assessment for the South Britannia Master Plan. This report includes updated information, per progression of site information, and is an update to the previously submitted transportation impact assessments.

I trust this report addresses Tiger Bay's, Squamish Lillooet Regional District's, and Ministry of Transportation and Infrastructure's requirements. Should you have any questions / comments, please do not hesitate to contact the undersigned.

Yours truly,
Bunt & Associates



Daniel Fung, P.Eng.
Associate



Stuart Thornley, EIT
Transportation Analyst

Cc: Tony Petricevic; Paul Turje; Michael von Hausen

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Date: 2019-06-26
Project No. 04-17-0272
Status: Draft

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1. INTRODUCTION

1.1 Study Purpose

Bunt & Associates (Bunt) has been engaged by the Tiger Bay Development Corporation (Tiger Bay), previously Taicheng, to prepare an updated Transportation Assessment Report for the proposed Britannia Beach Master Plan Development in Britannia Beach, BC. This report provides a summary of the proposed access strategy, traffic operations impact results and design recommendations to support the Britannia Beach development. The scope of the assessment includes:

- Collection & review of available relevant information along the Highway 99 corridor;
- Collection & review of traffic counts in the defined study area;
- An assessment of existing traffic demand and operational conditions as well as existing provision for alternative modes of travel;
- An assessment of future background traffic demand and operational conditions, without the site development traffic;
- Estimation of future site traffic volumes during key periods and operational conditions of adjacent intersections;
- Development of a phased access strategy to connect to Highway 99;
- Determination of improvements, if any, required to support the additional traffic generated by the proposed development; and,
- A review of the site plan including vehicle access and circulation, high level parking review, and provision for potential alternative modes of travel.

This is an update to a previously submitted proposal with Tiger Bay as a response to updates to the site land-use mix / site plan. Bunt was also involved with the previous South Britannia Beach proposal presented back in October 2012, November 2014, and April 2016.

1.2 Site Location

The South Britannia site is located approximately 12km south of the District of Squamish municipality and 50km north of the Vancouver Region along Highway 99. It is situated just south of the Historic Britannia Beach town site near the Britannia Mine Museum. The site location is highlighted in **Exhibit 1.1**.

The South Britannia development site comprises approximately 186 acres of land adjacent to Howe Sound. This unique setting and development opportunity has the potential to create a great neighbourhood that complements all other communities along this section of the Sea to Sky corridor for the Squamish-Lillooet Regional District (SLRD).

Highway 99 (Sea to Sky Highway) provides access to the site and is the only link between Vancouver, Squamish, and Whistler and all of the communities in between. Recent upgrades to the Sea to Sky Highway were completed for the 2010 Winter Olympics and have increased safety and accessibility both to the site and between the various communities along the Sea to Sky corridor.

Highway 99 has a posted speed limit of 60km/h in the vicinity of the site and up to 80km/h south of the site and north of Britannia Beach. There is a traffic signal located just north of the site at the intersection of Highway 99 / Copper Drive, which functions as the main access to North Britannia and the Britannia Mine Museum.

1.3 Study Area

The proposed study area for the operational analysis consists of approximately 2.5 km of Highway 99, extending up to the Copper Drive intersection to the north and the edge of the proposed development to the south. **Exhibit 1.2** identifies the traffic study area.

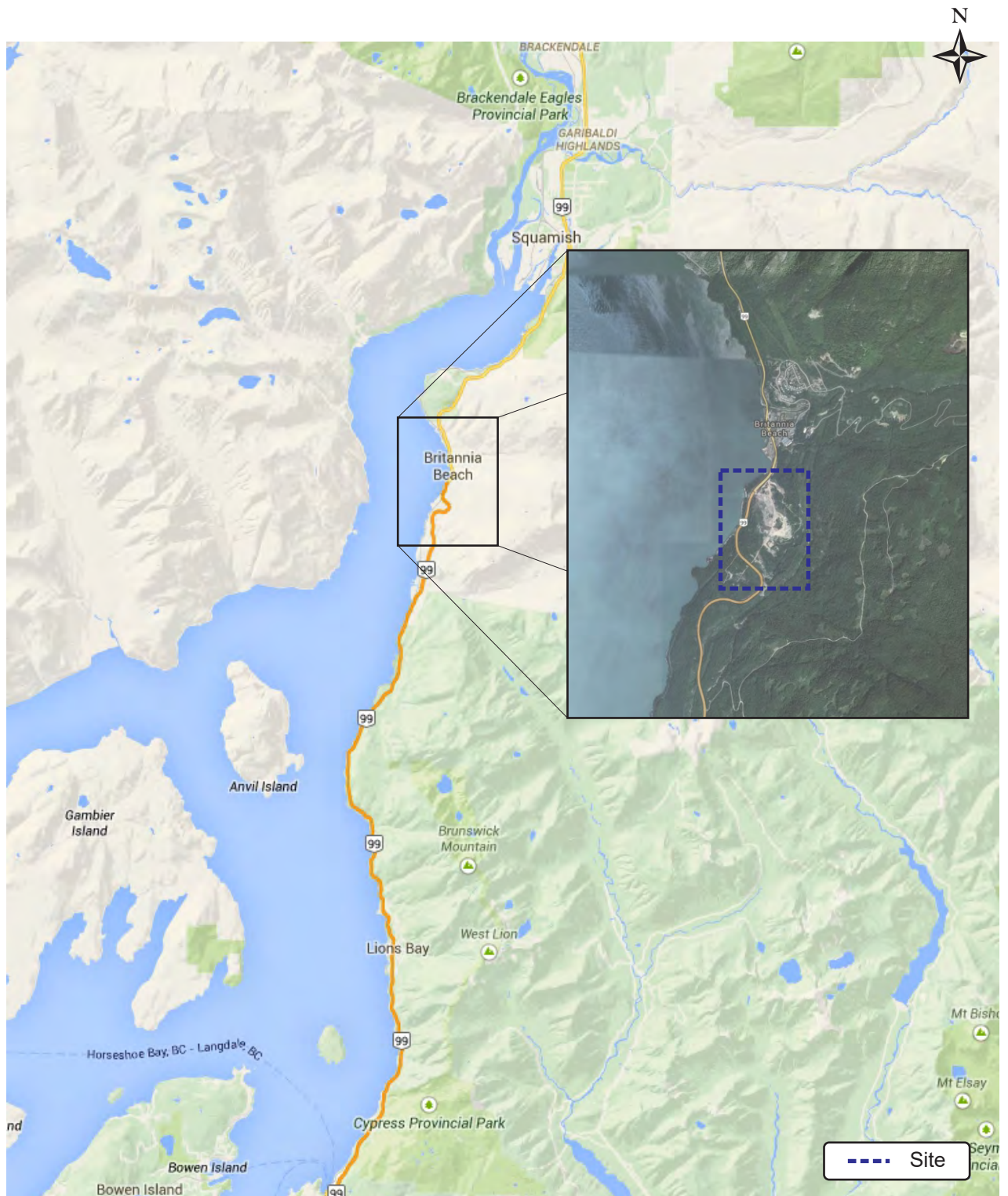


Exhibit 1.1 Site Location

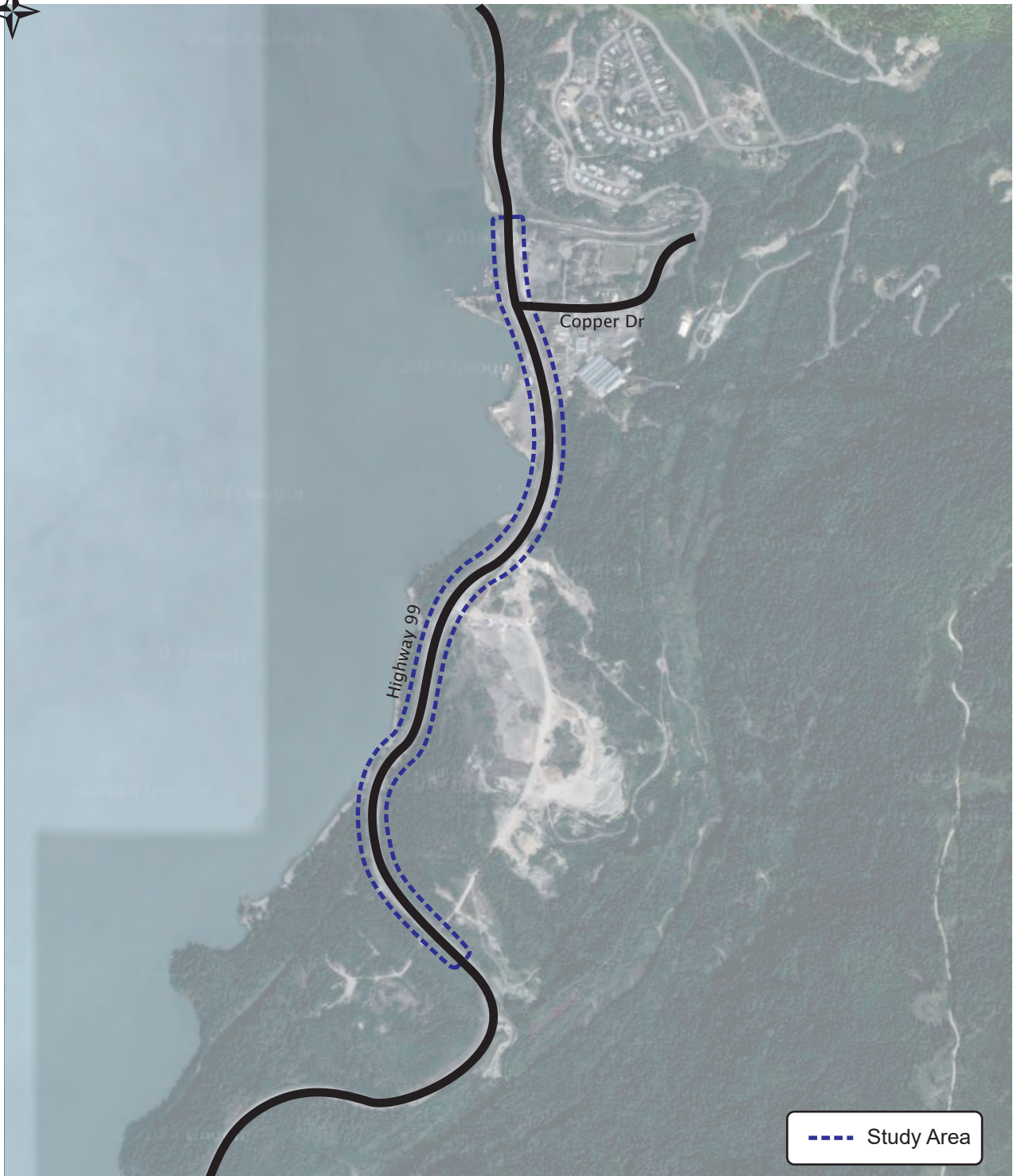


Exhibit 1.2 Study Area

1.4 Development Description

The proposal calls for the development of mixed residential/commercial uses, a wave pool, and a hotel. South Britannia Development would be completed over 4 phases that range in planning horizons between 1-5 years. For analysis purposes, Phase 1 is anticipated to be completed by 2025, Phase 2 is anticipated to be completed by 2028, Phase 3 is anticipated to be completed by 2032, and Phase 4 (build-out) is anticipated to be completed by 2037. The development statistics for each of the phases are detailed in Section 2 below while the for the full build-out, the development is anticipate to house 1,050 residential units, approximately 7,500 square feet of eatery spaces, approximately 31,000 square feet commercial and office space, 190-hotel rooms/glamping space, supporting municipal use (11,000 square feet) and recreational amenity development (including surf park/wave pool – 269,000 square feet, parks area, and etc.).

The South Britannia Development site has been identified by the SLRD Electoral D as part of the Britannia Beach “Planned Community” (i.e. Town Centre) in their Official Community Plan (OCP) referred to as Britannia South. The OCP currently allows for the development of up to 1,000 residential units (with a total of up to 2,000 residential units for the Britannia Beach community overall), up to 16,000 square feet of community-oriented commercial development, as well as other amenities including parks and open spaces, schools, and tourist accommodation (hotel) amongst other uses.

2. PROPOSED DEVELOPMENT

The proposed South Britannia Development site is envisioned as a complete Master Planned Development. It aims to be an integrated community along with the existing North Britannia site that will provide the essential services and amenities for its residents. It also proposes to be a community which will adhere to and promote environmentally sound development practices that reduce impact on natural ecosystems and fits within the context.

South Britannia Development will comprise up to 1,050 residential units and approximately 31,000 square feet of commercial and office space, 7,500 square feet of eatery, and 150 hotel rooms with 40 glamping spaces, 11,000 square feet of municipal office, and other recreational uses (wave pool / surf park / skate park / etc.) throughout the development. Community amenities will include several parks and plazas.

2.1 Phasing and Timing

The South Britannia Development is planned to be developed in a series of phases over the next 25 years. A specific year has been included for each of the phases for the purpose of analysis only. **Table 2.1** summarizes the proposed development phasing and timing, as well as the anticipated number of units / square footage for each land use for South Britannia Development throughout the course and for full build-out conditions.

Table 2.1: Proposed Development Phasing, Timing, and Breakdown

Land Use	Phase 1 2022-2025	Phase 2: 2026-2030	Phase 3: 2031-2035	Phase 4: 2036-2045	Total
Residential (units)		202	259	589	1,050
Commercial and office (sf)		27,000	4,000		31,000
Recreational	Wave garden/Surf Park (269,000 square feet) Skate park (2.4 acres)	Park Use – 0.3 acres of environmental sensitive / natural / park space	Park Use – 11 acres of environmental sensitive / natural / park space	Park Use – 0.3 acres of environmental sensitive / natural / park space	Wave garden/Surf Park (269,000 square feet) Skate park (2.4 acres) Park Use – 11.6 acres of environmental sensitive / natural / park space
Eatery (sf)	4,300		3,200		7,500
Accommodation (hotel rooms and glamping space)	20	70	70	30	190
Municipal (sf)				11,000	11,000

For the purpose of analysis, we have assumed that the Phase 1 build-out would be by 2025, the Phase 2 build-out would be by 2032, and the Phase 3 build-out would be by 2037. This is within the range of time as noted above and also with the planning horizons for the previous version of study for this site.

With respect to the above table, the phasing and timing will be subject to adjustment as the project progresses.

Also, aside from the phases above, an additional scenario will be evaluated for 2047, which represents full build out + 10 years.

The proposed development is shown in **Exhibit 2.1**. Detailed development statistics, broken down by phase and land use types, are provided in **Appendix A**.

2.2 Traffic Data and Time Periods

The Sea to Sky corridor is monitored by the MOTI permanent count stations located along the highway. The northbound and southbound traffic data are available for annual, monthly, daily and hourly conditions. Two stations were evaluated to understand the existing traffic patterns along the highway and develop projections for future traffic volumes. The permanent count stations selected were P-15-5 north of Horseshoe Bay and P-15-3 Cheekeye north of Squamish. In addition, Bunt performed traffic counts at the Copper Drive / Highway 99 intersection during the AM, PM, and Sunday peak periods. **Appendix B** includes the traffic volumes collected for the Highway 99 / Copper Road intersection.

Key observations relating to existing highway traffic conditions are as follows:

- The two highest traffic volume periods for the Sea to Sky highway tend to be Friday late afternoon into early evening period for northbound traffic, and Sunday afternoon for southbound traffic;
- Although the summer daily traffic volumes tend to be greater than winter volumes, the peak hourly volumes during the winter tend to be higher than the summer period peak hourly volumes; and

The highest peak hour traffic conditions typically fall during the New Year season (January 1st – 2nd), spring break and summer holidays (July – August). The traffic analysis was prepared based on a normal peak condition rather than extraordinary time periods in a year.

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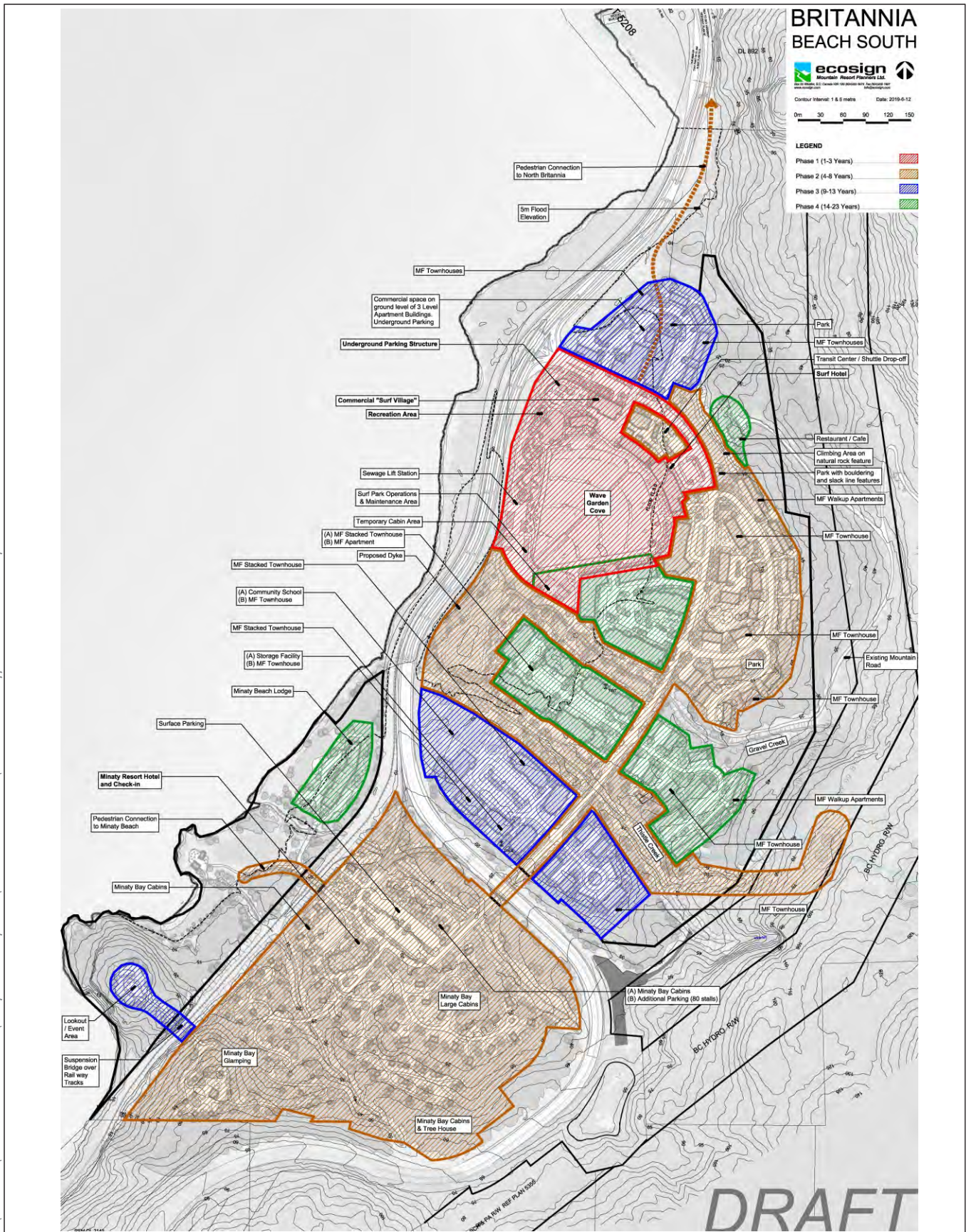


Exhibit 2.1 Site Plan

04.17.0272

Britannia Master Plan
June 2019



3. AREA CONDITIONS

3.1 Study Area

The study area for this analysis includes the south edge of the proposed site (approximately 1.5km south of the existing Britannia Beach access) up to the Highway 99 / Copper Drive intersection.

3.1.1 Roadway System

Highway 99

Also known as the Sea to Sky Highway, Highway 99 is the major north-south corridor connecting the US Border to the Howe Sound Area through Greater Vancouver, Britannia, Squamish, Whistler and Pemberton. It runs north up to Cache Creek and connects to Highway 97.

The recently upgraded Highway 99, a legacy of the 2010 Olympics, is a lifeline for all communities along the Sea to Sky Corridor. At Britannia Beach, Highway 99 provides for the safe and efficient movement of longer distance highway traffic while also supporting good access to development.

The existing highway consists of a combination of one and two lanes per direction. Posted speeds range from 60km to 100km, with lower speed limits designated in urban areas such as Squamish and near signalized intersections.

In time, a bypass route for Highway 99 may be built along the hillside above the community. The new section of highway would provide for the higher speed movement of longer distance traffic along the Sea to Sky Corridor. The old highway route through the lower lands at Britannia Beach would become an urban collector route for the community with slower moving vehicle traffic mixed together with pedestrians and cyclists and a more urban streetscape treatment.

Copper Drive

Copper Drive is the main access road providing Highway connections to the existing North Britannia community and Mine Museum. It is a 2 lane road that connects to Highway 99 as a T-intersection with traffic signal control. Right turn channelized lanes are in place for the northbound and westbound approaches.

3.2 Existing Traffic Volumes and Conditions

To document the existing traffic characteristics within the study area and estimate future traffic generation for the site, a series of traffic surveys were conducted by Bunt & Associates on Friday, April 12th, 2019 (from 7:00-9:00 AM, and 3:00-6:00 PM), and Sunday, April 14th, 2019 (from 11:00AM to 4:00PM). **Table 3.1** below summarizes the peak traffic volumes for each peak period.

Table 3.1: Existing Highway 99 Volumes at Copper Drive

DIRECTION	EXISTING (VEHICLES PER HOUR)		
	Weekday AM	Weekday PM	Sunday
Northbound	500	1,200	600
Southbound	600	750	1,200

Exhibit 3.1 shows traffic volumes for the typical Friday Weekday AM and PM and Sunday PM peak traffic periods.

Note the above count is the most recent count from Bunt and forms the basis for this analysis. Further detail on assumptions regarding background traffic is provided in Section 5.1.1.

Also, Highway 99 traffic volumes are largely relevant to the amount of people traveling from Vancouver to Squamish, Whistler and beyond. As such, the time of year can have a noteworthy impact on volumes. Although the summer daily traffic volumes tend to be greater than winter volumes, the peak hourly volumes during the winter tend to be higher than the summer period peak hourly volumes. Aside from the summer and winter peaks (which are normally extraordinary peaks for the year), the typical seasonal variations were found not to be significant. As such, our April count used as basis for analysis is assumed acceptable.

3.2.1 Capacity Analysis

Traffic operations at the intersections within the study area were evaluated using the Synchro 9 traffic analysis software package, developed by Trafficware. This operational analysis includes the calculation of volume-to-capacity (v/c) ratios, and a predicted “delay based” Level of Service (LOS) indicator for each traffic movement at the key intersections.

At signalized intersections, the v/c ratio is used as a measurement of traffic congestion for individual traffic lanes and/or lane groups and for the intersection as a whole. Volume/capacity values up to 0.85 are generally considered appropriate for an intersection, and up to 0.90 for individual lanes or lane groups. A v/c ratio of 1.0 or greater indicates that the traffic operation is over-capacity. The traffic LOS indicator also ranges from LOS A condition with minimal or no delay through to the LOS F conditions with extensive delay.

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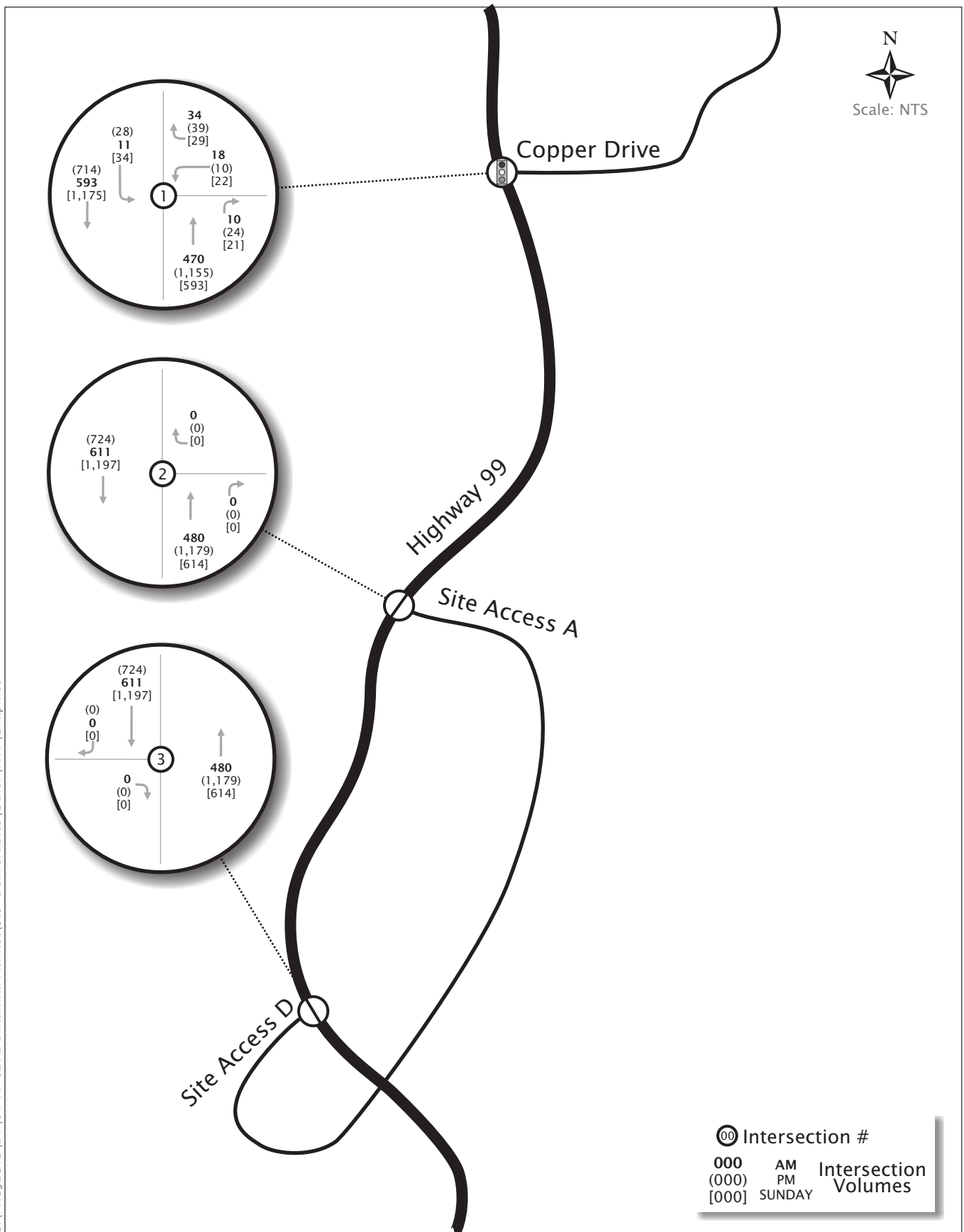


Exhibit 3.1 Existing Peak Hour Traffic Volumes

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For unsignalized intersections, the LOS indicator is based on the estimated average control delay per vehicle for each critical movement. A control delay of less than 10 seconds indicates sufficient capacity and good traffic conditions, i.e. LOS A traffic operation. A calculated control delay value greater than 50 seconds is assigned as LOS F performance measure. SimTraffic, a microsimulation software, is used to determine the control delay and queuing of the intersection as we have found through past experience that SimTraffic is better at determining intersection operations at unsignalized and congested conditions / locations.

Of note, the 2019 traffic counts were conducted and were used for the 2019 existing conditions scenario analysis. The future conditions, to be discussed in later sections, were calculated with a standard growth rate throughout the analysis horizon to account growth in the area.

3.2.2 Existing Conditions Analysis

The 2019 data analysis is presented in **Table 3.2**. Detailed Synchro reports are provided in **Appendix C**.

Of side note, at the time of our traffic count survey, the World Ski & Snowboard Festival, hosted in Whistler, took place. As a result, we would expect our traffic count data to be conservative as it would encompass higher volumes than would be expected during typical conditions.

Table 3.2: Existing Vehicle Traffic Operations

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	<i>Overall</i>	A	0.51		A	0.83		A	0.82	
	WBL	C	0.16	6	D	0.13	6	C	0.26	10
	WBR	C	0.02	6	D	0.03	9	C	0.02	8
	NBT	A	0.45	55	B	0.87	276	A	0.46	60
	NBR	A	0.01	2	A	0.02	2	A	0.01	2
	SBL	A	0.02	1	B	0.17	2	A	0.06	2
	SBT	A	0.49	42	A	0.50	53	A	0.79	157
Highway 99 & Site Access A (Unsignalized)	<i>Overall</i>									
	WBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT		0.31	0		0.75	0		0.39	0
	SBT		0.20	0		0.23	0		0.38	0
Highway 99 & Site Access D (Unsignalized)	<i>Overall</i>									
	EBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT		0.31	0		0.75	0		0.39	0
	SBT/R		0.20	0		0.23	0		0.38	0

- The signal at Copper Drive and Highway 99 was optimized to a 90-second cycle length.

- Overall intersection operations are acceptable during the Weekday AM and PM, and Sunday peak hours, each having Level of Service (LOS) 'A'. The overall volume-to-capacity (v/c) ratios do not exceed 0.83, and northbound vehicle queues do not exceed 276 m (approximately 40 vehicles). The southbound through lane also exhibits long queues of 157 m (22 m).
- For this existing conditions case, either an additional northbound or southbound lane could be worthwhile.
- For the purpose of analysis, we would suggest such improvements be added by Phase 1 (2025).

3.3 Transit Service

Currently, public transit services along the Highway 99 corridor are limited. TransLink (officially known as South Coast British Columbia Transportation Authority) is the corporation responsible for the regional transportation network in Greater Vancouver. They provide transit services that extend north up to the community of Lions Bay (Routes 259 and 262) approximately 20km south of Britannia Beach. BC Transit, the transit authority responsible for transportation services outside of the Greater Vancouver area provides public transit services in Squamish, Whistler and Pemberton. No regional transit connections are presently provided between Lions Bay and Squamish / Whistler.

Private coach bus companies offer transportation services along the corridor. Pacific Coach Lines (PCL), Squamish Shuttle (Squamish Connector), and Whistler Shuttle, provide connections from the Vancouver International Airport through Downtown Vancouver to Squamish and Whistler. Some of these services do stop on request at specific locations along the Highway 99 corridor, including the existing Britannia Beach access and North Britannia (at Copper Drive).

4. PROPOSED ACCESS STRATEGY

4.1 Access and Egress to the Site

For the four phases of development, it is anticipated there will be two access egress configurations. Specifically:

Phase 1

One access is being proposed for this phase where Access A is anticipated to be a full movement unsignalized intersection.

Phases 2-4

Two accesses are being proposed. **Exhibit 4.1** identifies the locations of the proposed site accesses to/from the highway which are described below:

- Access A - Proposed at-grade right-in, right-out access to the highway which will serve northbound (from highway) ingress traffic and northbound (from highway) egress traffic for the site; and
- Access D - Proposed at-grade right-in, right-out access to which will serve the southbound (from highway) ingress and southbound (from highway) egress traffic for the site.

These proposed intersections will work together with the existing Copper Drive signalized intersection to provide access to the Britannia Beach community.

Table 4.1 summarizes the phased site access scenarios (for Phases 2 to 4). The methodology and results of this analysis are included in a later section.

Table 4.1: Access Scenarios

ACCESS	PHASE 2	PHASE 3	PHASE 4
Access A	Right in / right out (with inbound deceleration lane and outbound yield control)		
Access D	Right in / right out (with inbound deceleration lane and outbound acceleration lane)		
Others	Pedestrian and Bike connection to North Britannia, and Transit Centre		Upgraded vehicular connection (existing culvert)

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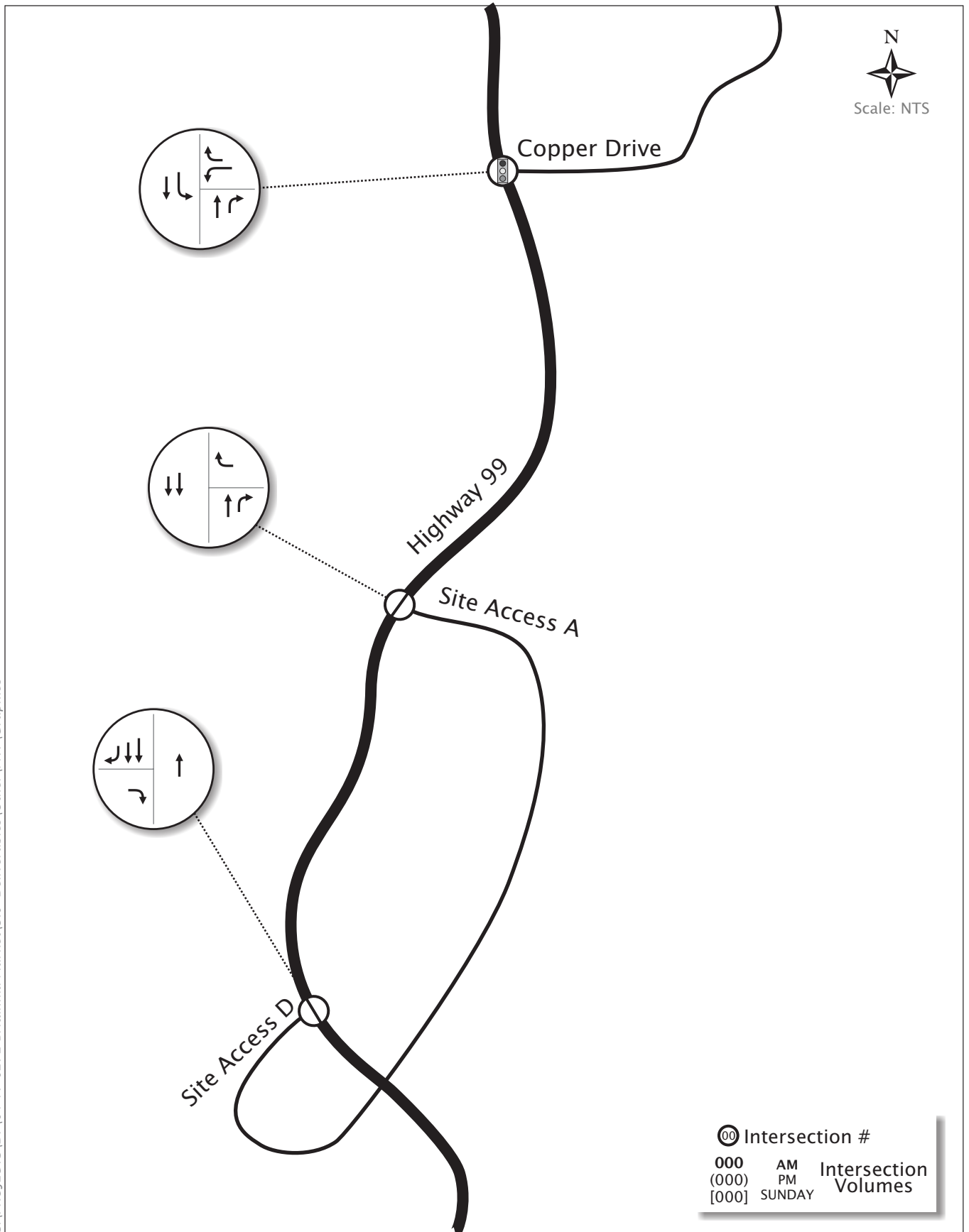


Exhibit 4.1 Access Configuration

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4.2 Consideration for Future Bypass

4.2.1 Interchange for a Future Highway 99 Bypass Route

The MOTI have advised that the Highway 99 Bypass will most likely extend from the point where Daisy Creek crosses the Highway to a point north of Britannia Creek along a schematic route illustrated on **Exhibit 4.2** below. Bypass rights of way have been established through North Britannia but none have been identified through South Britannia. New grade separated interchange will be required at both ends of the Bypass in order to connect the Bypass with the existing highway, and to provide access to the community. The replaced old highway will revert to a local road. An implementation schedule for the Bypass has not been established.

With the construction of the Highway Bypass, the Highway 99 operations would improve within the study area by providing additional roadway capacity in the vicinity.

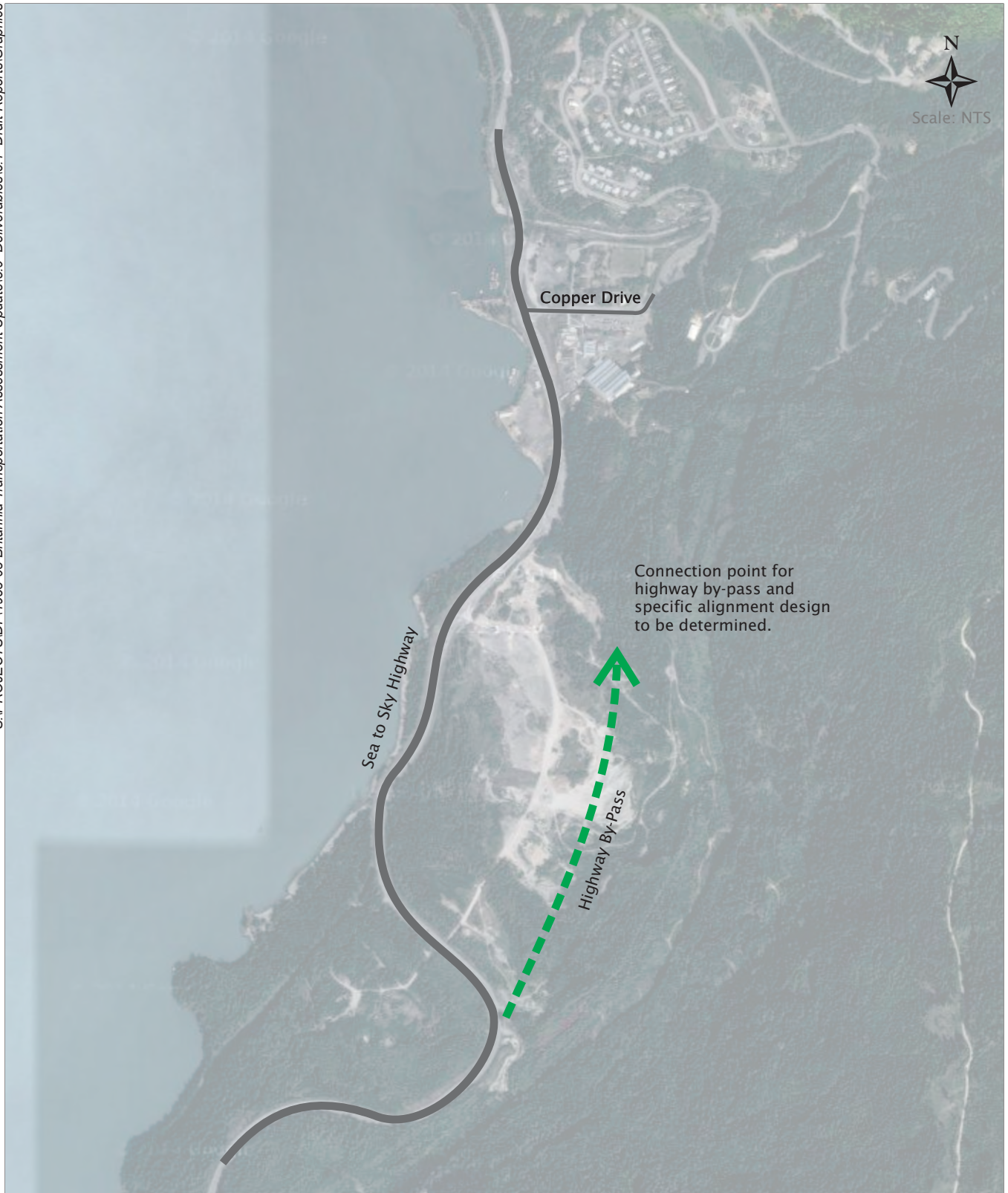


Exhibit 4.2 Potential Future Highway By-Pass

5. PROJECTED FUTURE TRAFFIC

This section discusses the background traffic volumes, projected site trip generation and trip distribution for the proposed development.

5.1 Future Traffic Volumes

5.1.1 Background Traffic

The background traffic volume is calculated using a growth rate of 2.3% per year (compounded) for Highway 99 imposed on the April 2019 traffic volumes noted above with no highway traffic capacity constraints. This is an increase from the previous reports where we had previously used 1.8% per annum and is a result of the latest information gathered.

As noted above, Phase 1 is estimated to be completed in 2025 at the latest, Phase 2 in 2028, Phase 3 in 2032, and Phase 4 in 2037. The analysis also included a scenario for full build-out plus 10 years (2047).

Table 5.1 shows the estimated background highway traffic volumes at years 2025, 2032, 2037, and 2047. Note the weekday peaks below are of the Friday AM and PM peak hours.

Table 5.1: Projected 2025 to 2047 Highway 99 Volumes

	PHASE 1 - 2025			PHASE 2 - 2028			PHASE 3 - 2032			PHASE 4 - 2037			BUILD-OUT + 10 YEARS - 2047		
	AM	PM	SUN	AM	PM	SUN	AM	PM	SUN	AM	PM	SUN	AM	PM	SUN
NB	550	1,350	700	650	1,600	850	650	1,600	850	750	1,800	950	950	2,250	1,150
SB	700	850	1,400	800	1,000	1,600	800	1,000	1,650	900	1,100	1,800	1,150	1,400	2,300

5.2 Trip Generation

The traffic generated by the new development is estimated using trip rates calculated from traffic surveys collected by Bunt for similar developments and from the ITE Trip Generation Manual (10th Edition). The estimates coincide with the scenarios illustrated in Table 5.1. **Table 5.2** below summarizes the trip rates used. Note, further trip generation breakdown is provided in Appendix A.

Table 5.2: Trip Generation Rates

LAND USE	SOURCE	AM			PM			SUNDAY		
		IN	OUT	TOT	IN	OUT	TOT	IN	OUT	TOT
Residential	ITE-Multi-family housing low rise (220)	0.11	0.35	0.46	0.35	0.21	0.56	0.28	0.17	0.45
	ITE-Multi-family housing mid rise (221)	0.09	0.27	0.36	0.27	0.17	0.44	0.21	0.14	0.35
	AVERAGE	0.10	0.31	0.41	0.31	0.19	0.50	0.25	0.15	0.40
Commercial	ITE – Specialty Retail (826)	0.42	0.26	0.68	1.19	1.52	2.71	0.95	1.22	2.17
Recreational	ITE – Public Park (411) – environmental sensitive areas	0.01	0.01	0.02	0.06	0.05	0.11	0.12	0.19	0.31
	ITE – Public Park (411) Maximum Rate	2.66	1.85	4.50	1.93	1.58	3.50	1.95	3.05	5.00
	Surf Park, skate park, and etc.	Varies								
Office	ITE – Government Office Building (730)	2.51	0.84	3.34	0.43	1.28	1.71	0.34	1.03	1.37
Hotel	ITE - Hotel (310)	0.28	0.19	0.47	0.31	0.29	0.60	0.26	0.30	0.56
Restaurant	ITE Quality Restaurant (931)	0.46	0.27	0.73	5.23	2.57	7.80	4.91	2.89	7.80
	ITE Fast Casual Restaurant (930)	1.39	0.68	2.07	7.77	6.36	14.13	18.71	15.31	34.02
	Average	0.92	0.48	1.40	6.50	4.47	10.97	11.81	9.10	20.91

In the instance where the above rate shows an average, the average rates were used for analysis.

5.2.1 General Land Use Types

Residential Trip Rates – Multi-Family Dwellings

In general, for the single family detached homes housing in the vicinity, the ITE Trip Generation Handbook suggests a rate of 0.75 and 1.01 trips per unit for the AM and PM peak hour conditions, respectively. The observed trip generation rates for the Furry Creek and Lions Bay communities averaged in considerably lower at 0.41 and 0.43 trips per unit for the AM and PM peak hour respectively.

For communities like this located on recreational travel corridors near to but outside of major cities, we surmise that the lower trip generation rates can be attributed to several factors. A number of the homes in these communities tend to be vacation homes (mainly weekend and seasonal use) and not generate the same vehicle trip patterns as traditional residential neighbourhoods. Moreover, a higher percentage of homes in these communities are occupied by retired or semi-retired households, again having travel patterns quite different than those of traditional residential neighbourhoods.

In addition, trips generated by these more distant communities tend to be linked, i.e. residents combine trips (e.g. work and shopping) on account of the travel distances involved rather than making separate trips for these different trip purposes.

As a conservative measure for our analysis for the South Britannia development, we have assumed an average between the ITE residential trip rates and the more local values obtained from our observations at Lions Bay and Furry Creek. These averaged rates calculate to 0.58 vehicle trips per unit in the weekday morning peak and 0.72 trips per unit during the weekday afternoon peak hour.

The Sunday afternoon peak generation rates were calculated as 80% of the weekday afternoon peak, based on residential day of week trip rate information provided in the ITE Trip Generation Handbook.

For the multi-family component, the ITE Trip Generation Manual suggests a trip generation rate that calculates to approximately two thirds (2/3) of the single family use. Following this approach, Bunt calculated the trip generation rate for multi-family homes to be 0.39 trips per hour for the AM and 0.48 trips per hour during the PM peak period. Note, secondary suites are assumed to have multi-family residential trip rates.

Commercial, Institutional and Hotel Trip Rates

The South Britannia Master Plan also contemplates the development of commercial, municipal / institutional and hotel uses. Table 5.2 above summarizes the trip generation rates assumed, which are generally based on the trip rates recommended in the ITE Trip Generation Handbook. Note, to be conservative, we have assumed Glamping spaces to generate trips similarly to a hotel use.

Recreation Uses

There are numerous uses associated with recreation uses such as surf parks, park land, skate park and etc. With these uses, the breakdown of trips are detailed in Appendix A of the report as these uses have varying trip rates and some of the trip rates were determined based on a first principle basis.

5.2.2 Internal Capture and General Reductions

Due to the nature of the design of the site, it is expected there would be internal capture amongst the different uses. With this in mind, the National Cooperative Highway Research Program (NCHRP) Internal Trip Capture Estimation for Mixed Used Developments was utilized. The details of the application of the methodology are highlighted in Appendix A of this report.

In addition to internal capture of the site, our Client has indicated that approximately 15% of the multifamily units will be used as residences for on-site staff. With that in mind, we anticipate most of their peak hour trips to be internal and that we had reduced the multi-family trips by 10%.

Tables 5.3 to 5.6 present the generated vehicle volumes for Phases 1 through 3 as well as their cumulative trips. Detailed trip statistics, broken down by phase and land use type, are provided in **Appendix A**.

Table 5.3: Trip Generation Volumes – Phase 1 (Includes reductions and NCHRP internal capture)

LAND USE	AM			PM			SUNDAY		
	IN	OUT	TOTAL	IN	OUT	TOTAL	IN	OUT	TOTAL
Residential	0	0	0	0	0	0	0	0	0
Commercial / Office	0	0	0	0	0	0	0	0	0
Hotel	6	4	10	4	4	8	3	3	6
Municipal Institutional	0	0	0	0	0	0	0	0	0
Restaurant / Eatery	4	2	6	24	15	39	44	32	76
Recreational (mixed types)	32	32	64	30	31	61	46	48	94
TOTAL	42	38	80	58	50	108	93	83	176

Table 5.4: Trip Generation Volumes – Phase 1 + 2 (Includes reductions and NCHRP internal capture)

LAND USE	AM			PM			SUNDAY		
	IN	OUT	TOTAL	IN	OUT	TOTAL	IN	OUT	TOTAL
Residential	18	53	71	39	26	65	27	18	45
Commercial / Office	9	6	15	18	18	36	8	11	19
Hotel	23	16	39	23	23	46	18	23	41
Municipal / Institutional	0	0	0	0	0	0	0	0	0
Restaurant / Eatery	3	2	5	13	5	18	29	13	42
Recreational (mixed types)	32	32	64	28	27	55	44	45	89
TOTAL	68	139	207	139	96	236	111	77	188

Table 5.5: Trip Generation Volumes – Phase 1 + Phase 2 + Phase 3 (Includes reductions and NCHRP internal capture)

LAND USE	AM			PM			SUNDAY		
	IN	OUT	TOTAL	IN	OUT	TOTAL	IN	OUT	TOTAL
Residential	39	118	157	103	65	168	73	43	116
Commercial / Office	9	7	16	18	17	35	9	13	22
Hotel	42	28	70	39	41	80	31	41	72
Municipal / Institutional	0	0	0	0	0	0	0	0	0
Restaurant / Eatery	4	3	7	23	8	31	55	28	83
Recreational (mixed types)	45	41	86	40	37	77	55	61	116
TOTAL	139	197	336	223	168	391	223	186	409

Table 5.6: Trip Generation Volumes – Phase 1 + Phase 2 + Phase 3 + Phase 4 (Includes reductions and NCHRP internal capture)

LAND USE	AM			PM			SUNDAY		
	IN	OUT	TOTAL	IN	OUT	TOTAL	IN	OUT	TOTAL
Residential	88	274	362	259	156	415	197	117	314
Commercial / Office	7	6	13	16	16	32	8	13	21
Hotel	50	33	83	45	50	95	36	50	86
Municipal / Institutional	23	5	28	1	10	11	1	8	9
Restaurant / Eatery	3	2	5	23	8	31	55	28	83
Recreational (mixed types)	44	40	84	38	33	71	53	55	108
TOTAL	215	360	575	382	273	655	350	271	621

5.2.3 Future Traffic

Future traffic volumes were calculated by adding the net trip volumes to the background volumes previously calculated for 2025, 2032, 2037, and 2047. The assignment of the estimated site traffic onto the road network is generally based on the observed turning movements at the study intersections and directional highway volumes. The capacity analysis and operation results will be described in the next section. The resulting future background and total traffic volume summaries for the traffic study area are summarized in **Exhibits 5.1** and **5.2** for the Year 2025, **Exhibits 5.3** and **5.4** for the Year 2032, **Exhibits 5.5** and **5.6** for the Year 2037, and **Exhibits 5.7** and **5.8** for the 2047 Horizon Year.

5.2.4 Development Traffic – Trip Distribution

The estimated traffic generated by the proposed site was distributed based on existing highway traffic patterns and observations at other communities along the Sea to Sky corridor, as well as per discussions with SLRD staff. **Table 5.7** summarizes the northbound and southbound split distributions along the highway.

Table 5.7: Traffic Distribution – Highway Splits

TIME PERIOD	HIGHWAY TRAFFIC	
	NORTHBOUND	SOUTHBOUND
Weekday AM	50%	50%
Weekday PM	50%	50%
Sunday	55%	45%

5.2.5 Development Traffic – Sensitivity Analysis

To ensure that the traffic analysis is robust, sensitivity analyses was completed for the 2047 planning horizon. Specifically:

Directional distribution - Weekday AM and PM peak hour assumed a northbound distribution of 70% and a southbound distribution of 30% as well as a northbound distribution of 30% and a southbound distribution of 70%. The total traffic volumes for this scenario can be found in **Exhibits 5.9** and **5.10**.

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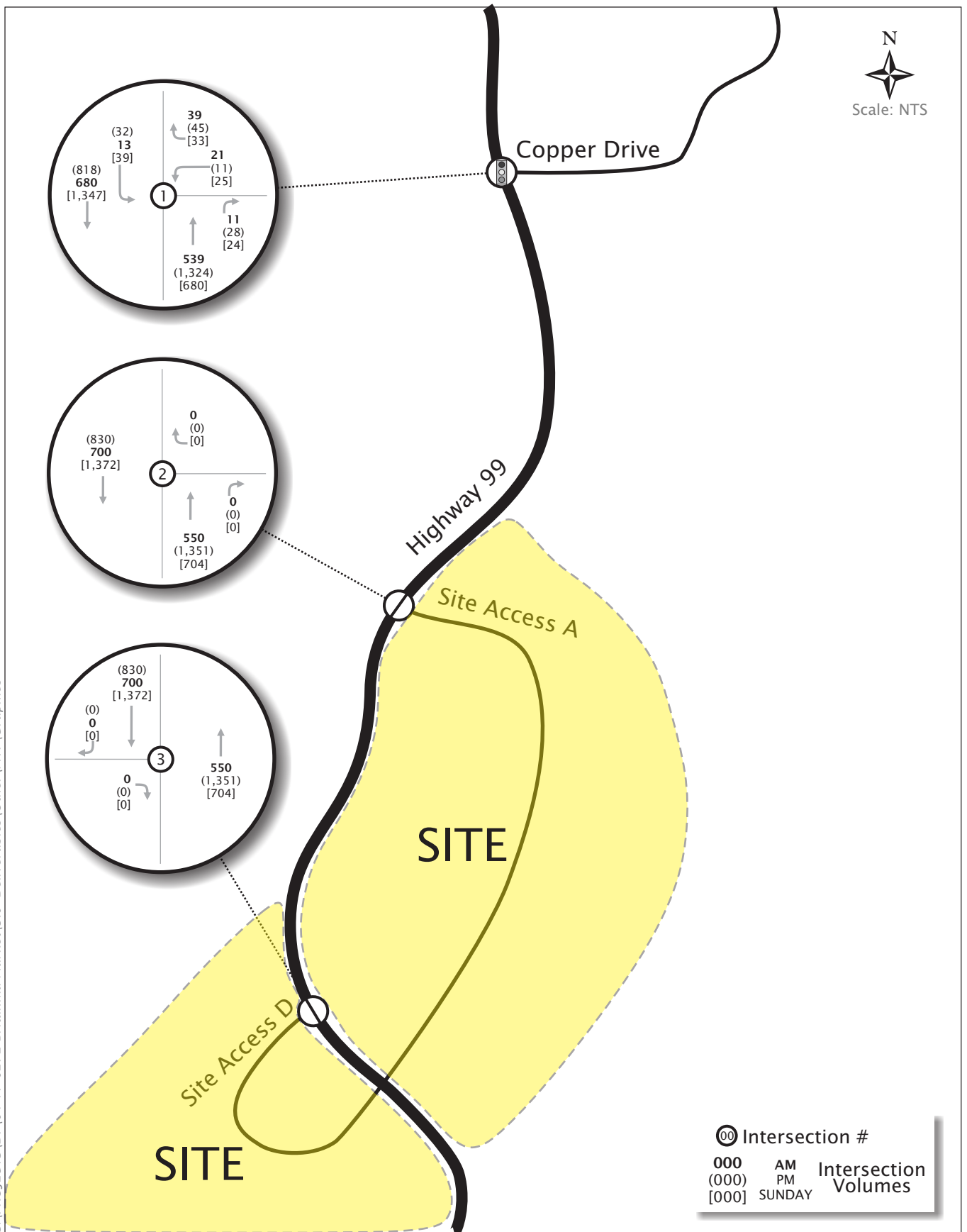


Exhibit 5.1 Phase 1 Background Peak Hour Traffic Forecasts

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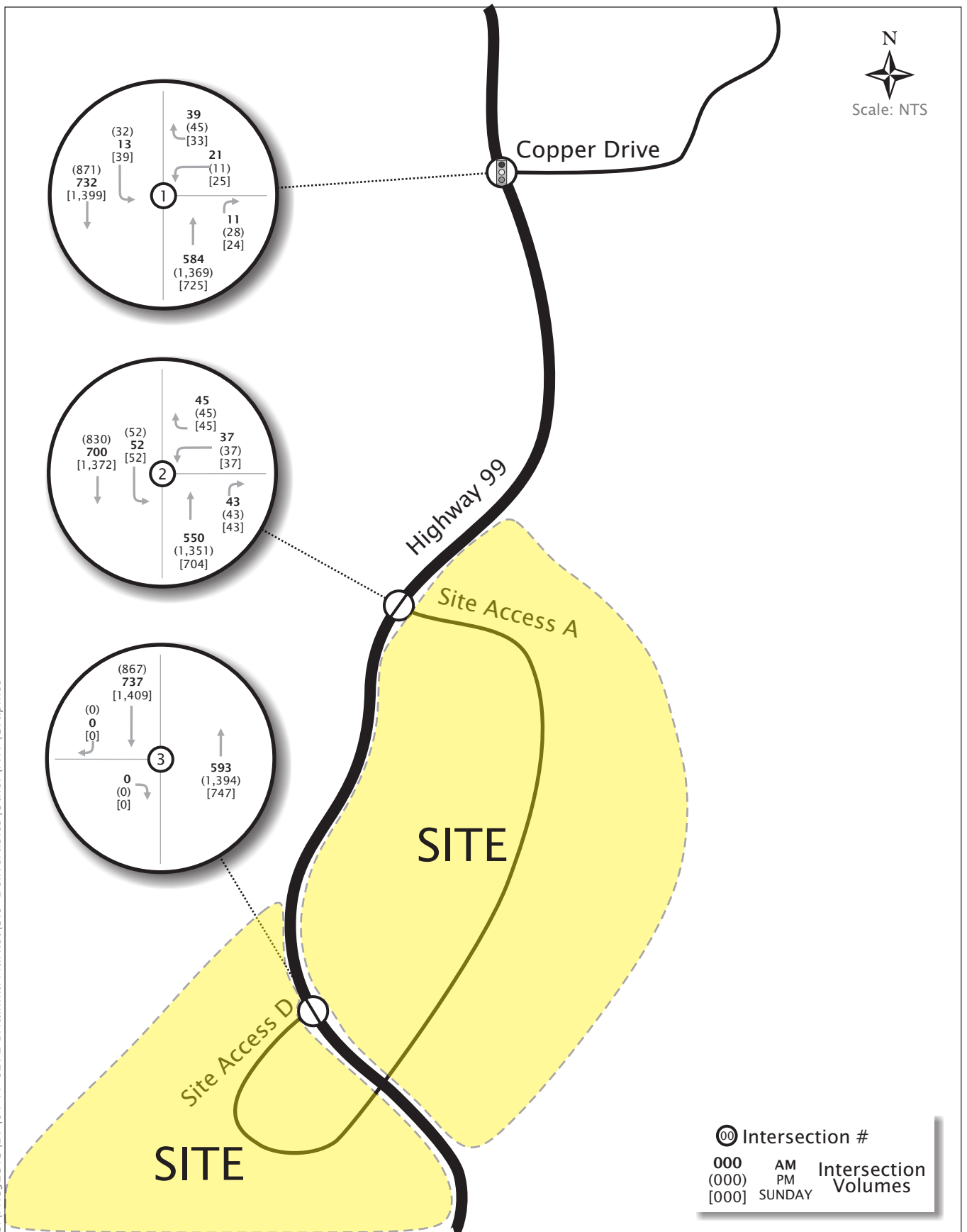


Exhibit 5.2 Phase 1 Total Peak Hour Traffic Forecasts

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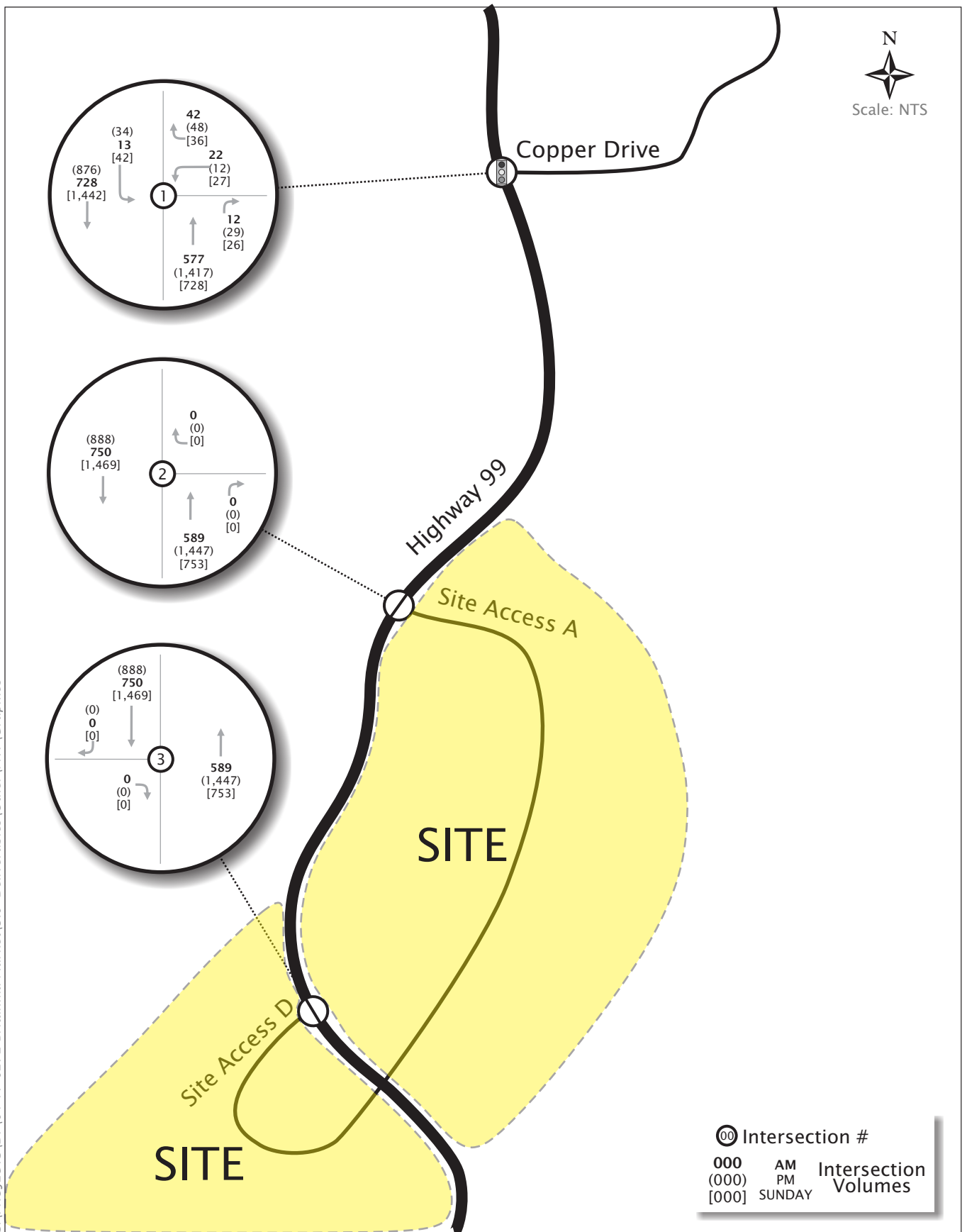


Exhibit 5.3 Phase 2 Background Peak Hour Traffic Forecasts

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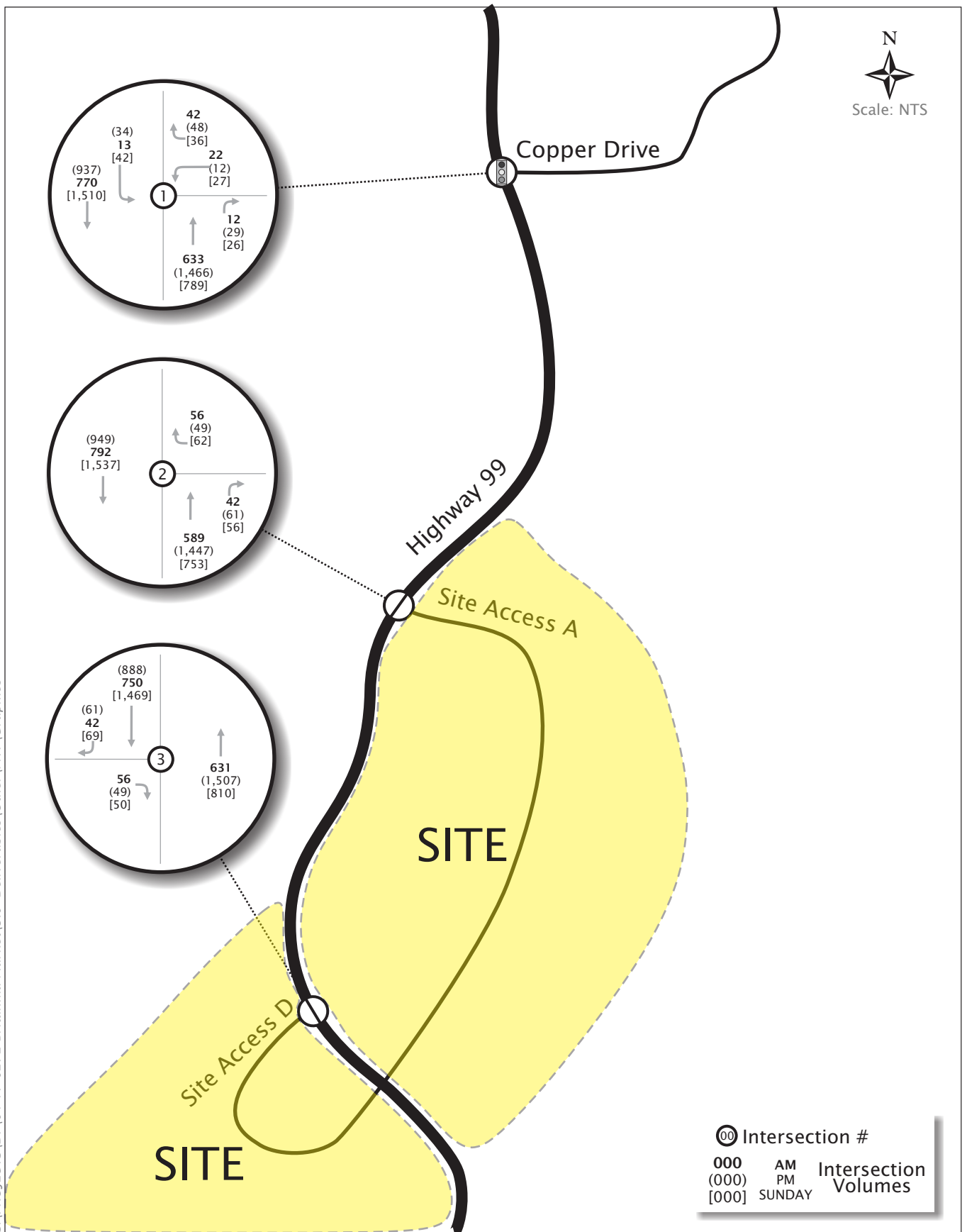


Exhibit 5.4 Phase 2 Total Peak Hour Traffic Forecasts

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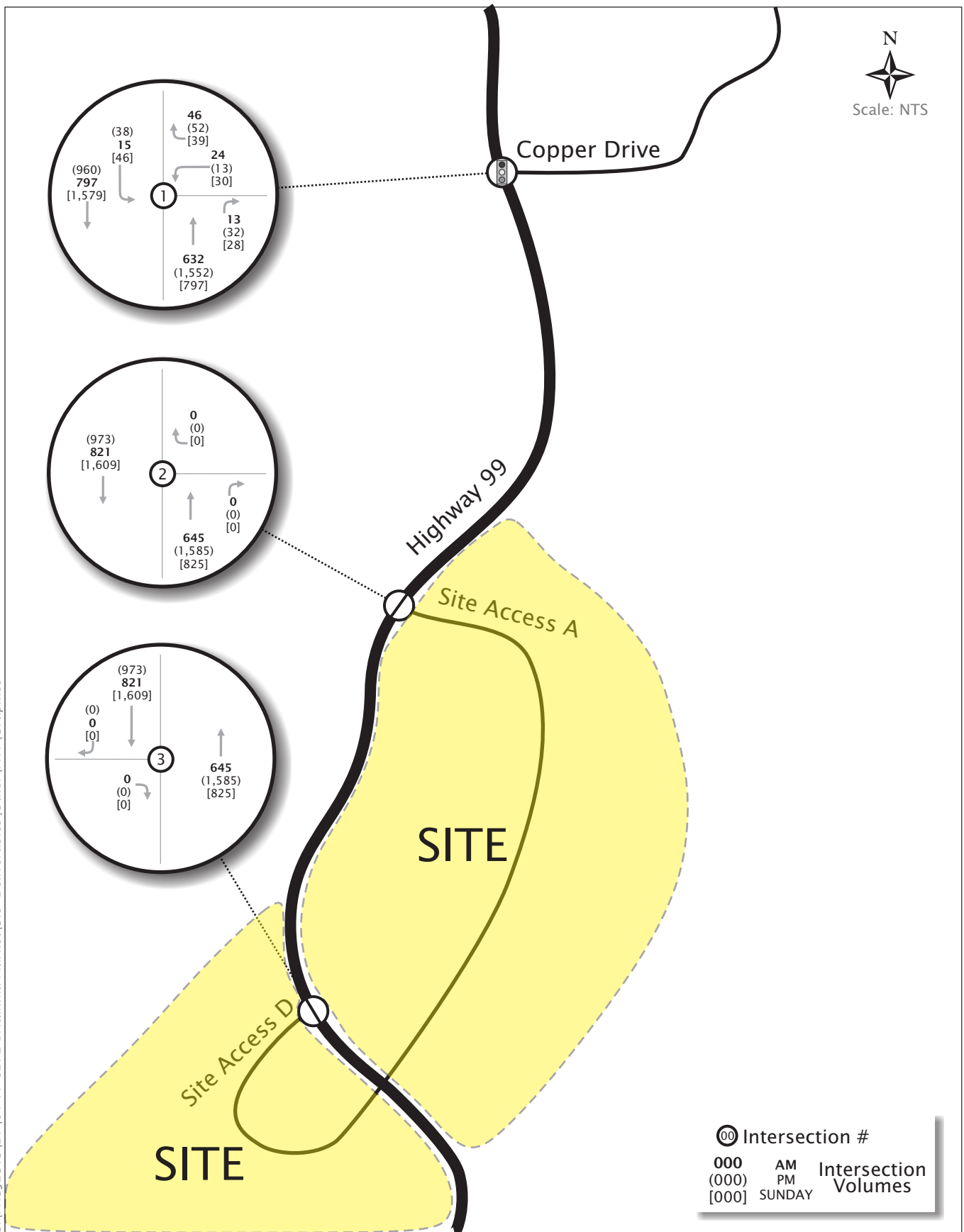


Exhibit 5.5 Phase 3 Background Peak Hour Traffic Forecasts

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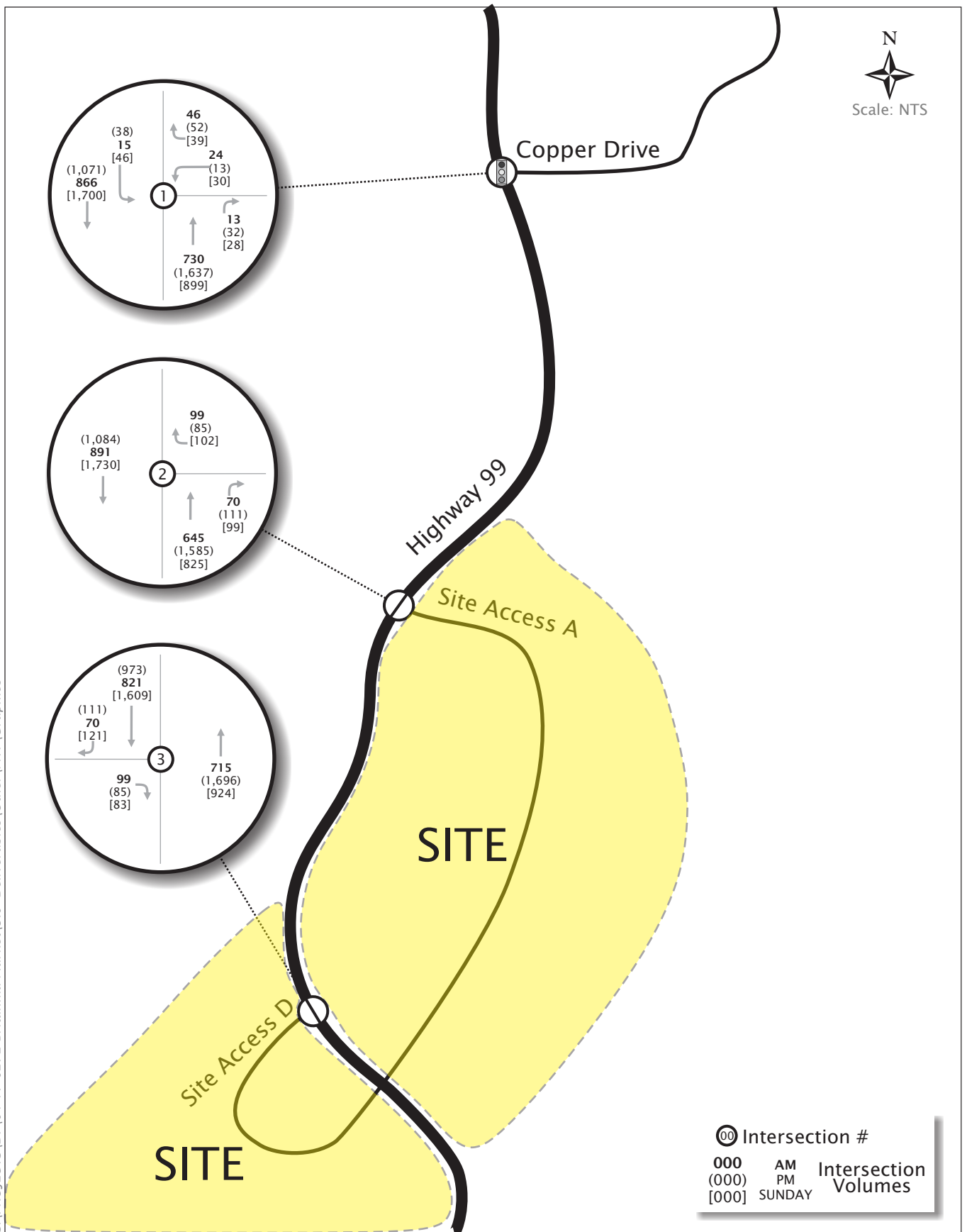


Exhibit 5.6 Phase 3 Total Peak Hour Traffic Forecasts

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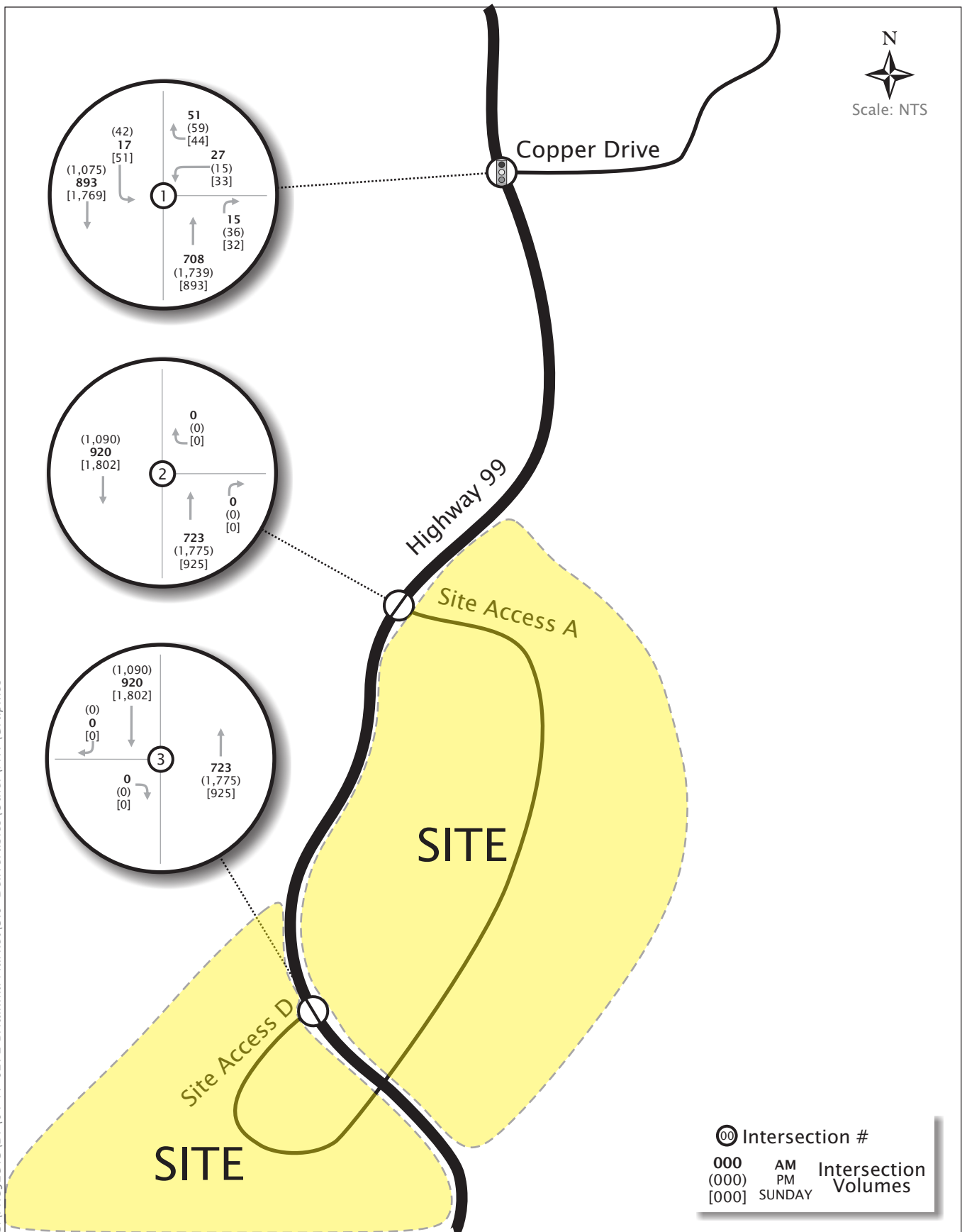


Exhibit 5.7 Phase 4 Background Peak Hour Traffic Forecasts

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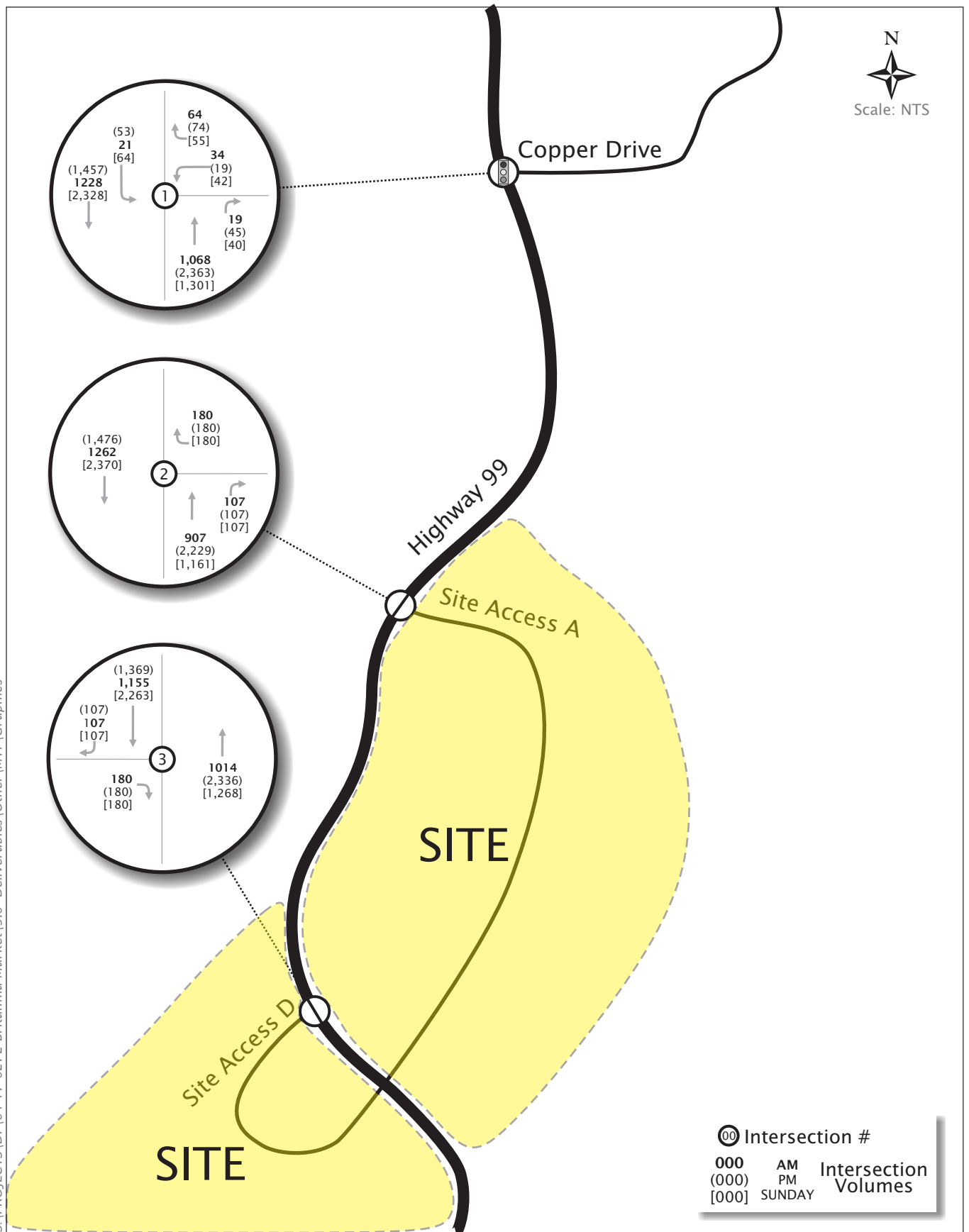


Exhibit 5.8 Phase 4 Total Peak Hour Traffic Forecasts

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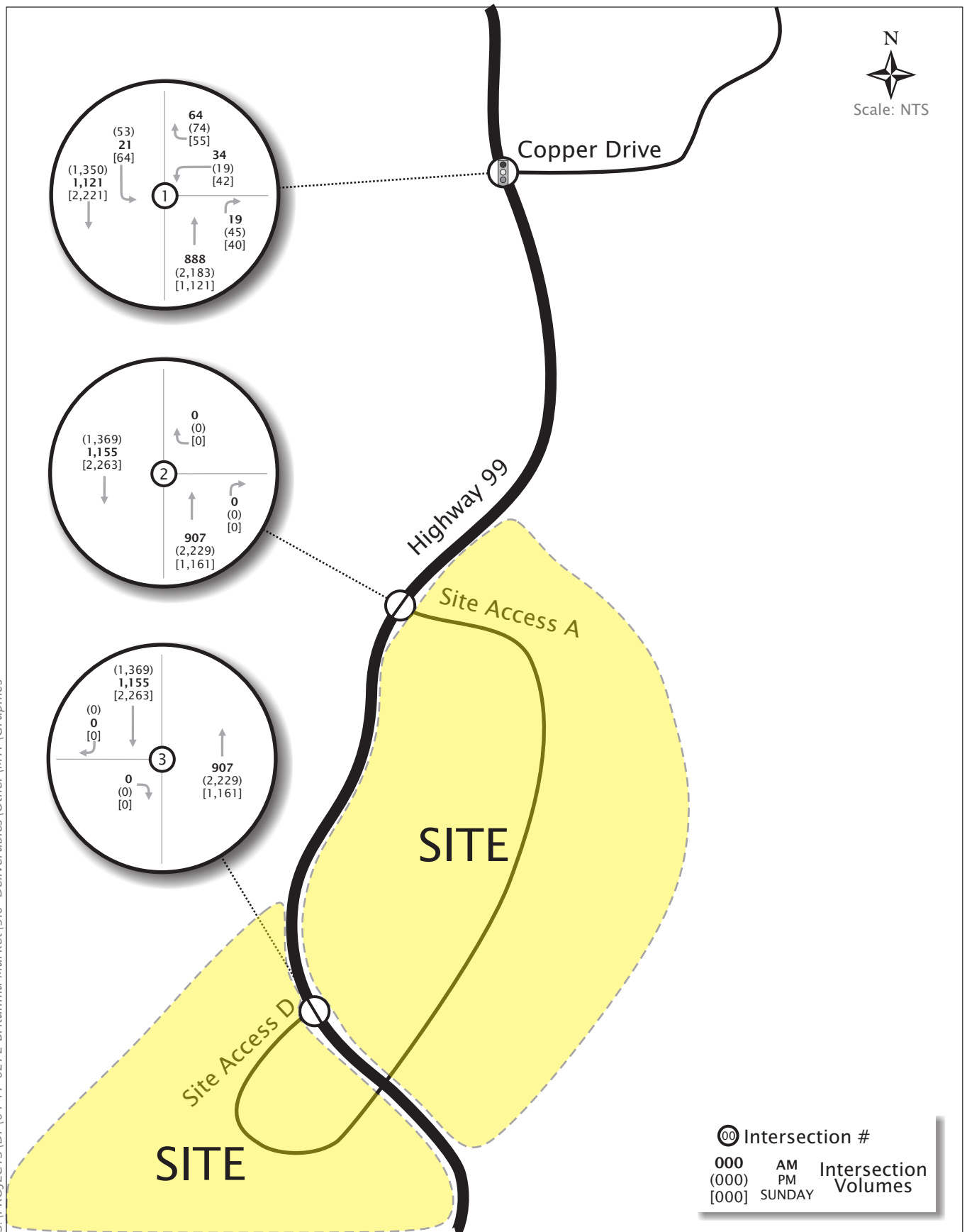


Exhibit 5.9 Full Buildout + 10 Background Peak Hour Traffic Forecasts

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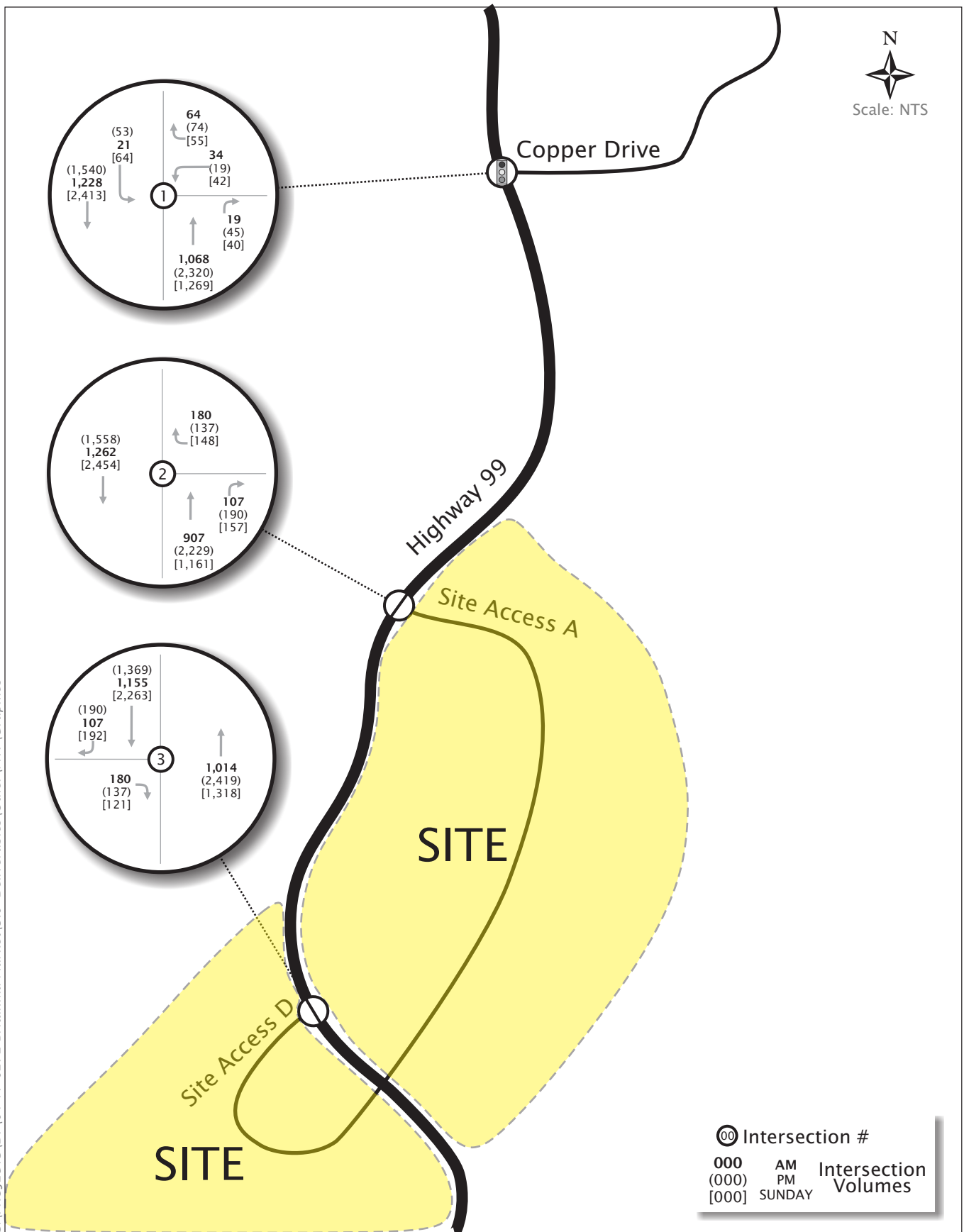


Exhibit 5.10 Full Buildout + 10 Total Peak Hour Traffic Forecasts

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6. TRAFFIC ANALYSIS

The following sections describe the projected traffic conditions along Highway 99 and the traffic operation results for the study intersections for the future Background (without development) and Total (with development) traffic conditions.

The key objectives of this traffic analysis are to assess peak period traffic operations on the highway system, and identify potential road improvement measures, where necessary, to adequately accommodate the anticipated increase in background traffic growth and site traffic.

Future Background and Total traffic operations were tested using the Synchro/SimTraffic traffic model. Note the Synchro traffic model uses the Highway Capacity Manual (HCM) calculation methodologies in determining delays, Level of Service (LOS), and queues while the SimTraffic model determines the above measures of effectiveness based on micro-simulation modelling. Both have benefits and are further discussed within the analysis sections below. For all future year analysis, the signal timing optimization feature of Synchro was used, assuming signal cycle lengths could not exceed 90 seconds.

The following sections summarize the operational results for the background and future 2025, 2028, 2032, 2037 and 2047 evaluation scenarios. Note, the future laning configuration outlined as improvements in this report are provided following the exhibits cited below.

6.1 2025 Traffic Conditions Analysis

6.1.1 Background 2025 Traffic Conditions

- As suggested in the existing traffic operations analysis, Highway 99 and Copper Drive requires an additional northbound and southbound lane to alleviate the traffic queues during the peak periods for the Friday PM and Sunday peak hour.
- Based on current site geometry and geotechnical constraints, the second northbound / southbound lane may be limited to a length of just 55 m south of Copper Drive and extending north of Copper Drive to the Britannia Creek Bridge. This localized lane would alleviate some of the northbound traffic congestion. Note, the dual laning of the northbound/southbound direction for the bridge will eventually be required, unless the Highway 99 bypass is constructed above the community.

Table 6.1 summarizes the operation results for the Background 2025 traffic condition with an additional northbound and southbound lane as noted above.

Table 6.1: Phase 1 Background Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	Overall	A	0.34		A	0.56		A	0.56	
	WBL	B	0.16	6	C	0.12	6	C	0.21	8
	WBR	B	0.03	6	C	0.03	9	C	0.02	6
	NBT	A	0.30	27	A	0.59	72	A	0.33	32
	NBR	A	0.01	2	A	0.02	2	A	0.02	3
	SBL	A	0.03	1	A	0.15	2	A	0.08	3
	SBT	A	0.32	18	A	0.33	22	A	0.53	43
Highway 99 & Site Access A (Unsignalized)	Overall									
	WBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT/R		0.35	0		0.86	0		0.45	0
	SBT		0.22	0		0.27	0		0.44	0
Highway 99 & Site Access D (Unsignalized)	Overall									
	EBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT		0.35	0		0.86	0		0.45	0
	SBT/R		0.22	0		0.27	0		0.44	0

Key findings and insights for the Phase 1 Background traffic analysis:

- Without improvements to the existing conditions at the Copper / Highway 99 intersection, queues were found to be in excess of 300 m in both northbound and southbound directions. As such, our analysis (and the following findings) assumed a second southbound lane and northbound lane at Copper Drive / Highway 99 was implemented as mitigation measures.
- During the AM peak hour, Highway 99 & Copper Drive is expected to operate with acceptable capacity and delay thresholds.
- During the PM peak hour, the overall V/C ratio was found to be acceptable at 0.56. The estimated queuing northbound on Highway 99 during the weekday PM peak and southbound during the weekend peak was estimated at 72m and 43m, respectively. Site (model) observations show that even though queues are expected during the weekend peak period, vehicles are able to clear the intersection within one or two signal cycles, as the northbound and southbound directions are operating with substantial green interval time for most of the signal cycle length.
- During the PM peak, the northbound through movement is expected to approach capacity with a V/C ratio of 0.86 found on Highway 99 at both Access A and Access D.

6.1.2 Total 2025 Traffic Conditions – Phase 1

The Year 2025 Total traffic condition incorporates the proposed Phase 1 future site traffic volumes. Note, for the Phase 1 scenario, it is assumed Access A will be a full movement unsignalized intersection while

Access D will not have been constructed at that point. Also, as per the Background 2025 condition, it is assumed that at the Copper Drive intersection, there will be dual northbound and southbound lanes.

Table 6.2 summarizes the operational results for the total 2025 traffic conditions. Based on our analysis, site traffic entering / exiting the proposed development would require a second northbound lane at Access A to facilitate acceptable traffic operations.

Table 6.2: Phase 1 Total Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	<i>Overall</i>	A	0.35		A	0.57		A	0.57	
	WBL	B	0.16	6	C	0.12	6	C	0.22	8
	WBR	B	0.03	6	C	0.03	9	C	0.02	6
	NBT	A	0.30	27	A	0.60	74	A	0.34	34
	NBR	A	0.01	2	A	0.02	2	A	0.02	3
	SBL	A	0.03	1	A	0.15	2	A	0.08	3
	SBT	A	0.32	19	A	0.34	23	A	0.55	45
Highway 99 & Site Access A (Unsignalized)	<i>Overall</i>									
	WBL	C	0.09	2	F	0.51	14	F	0.46	15
	WBR	B	0.03	1	C	0.07	2	B	0.08	2
	NBT/R		0.18	0		0.43	0		0.23	0
	SBT	A	0.02	1	B	0.07	2	A	0.07	2
Highway 99 & Site Access D (Unsignalized)	<i>Overall</i>									
	EBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT		0.36	0		0.88	0		0.48	0
	SBT/R		0.23	0		0.27	0		0.45	0

Key findings and insights for Phase 1 Total traffic analysis:

- Highway 99 & Copper Drive operates acceptably during the AM, PM and Sunday peak hours, again, as a result of the additional northbound and southbound lanes being implemented as mitigation measures.
- The estimated 95th percentile queues were significantly improved as a result of the second northbound and southbound lanes. The northbound through queue was reduced from 350m to 74m, and the southbound through queue was reduced from 314m to 45m.
- According to SimTraffic results, the northbound through queue (at Copper Drive) is expected to reach 100m and a delay per vehicle of 14 seconds, which translates to an acceptable LOS 'B' during the PM peak hour. During the Sunday afternoon peak hour, the southbound through experiences a queue of 25m and delays of only 2 seconds, which translates to an LOS 'A'.
- Access A is anticipated to operate acceptably, except for the westbound left movement (exiting the site) during the Friday PM and Sunday peak hours. According to HCM results, the westbound

left is anticipated to experience long delays (LOS F) but operate within capacity (Friday PM: V/C = 0.51; Sunday: V/C = 0.46).

- To further investigate the westbound left movement, SimTraffic analysis was conducted to supplement the traffic results, as it better accounts for gaps in traffic and vehicle platooning behaviour. SimTraffic results indicated the westbound left movement would experience an average delay per vehicle of 33 seconds, which translates to an acceptable LOS D, during the Friday PM peak hour. Estimated queues were found to be acceptable at 17m. Note, the Phase 1 traffic will require an additional northbound through lane at Highway 99 & Access A.
- The Highway 99 & Access D northbound through movement was found to approach capacity (v/c = 0.88), likely caused by the limitation of inputting high volumes through a single lane in conjunction with background growth.

6.2 2028 Traffic Conditions Analysis

6.2.1 Background 2028 Traffic Conditions

The 2028 Background traffic volumes were increased from the 2025 Background conditions based on background growth. With the noted improvements, the following are the traffic operation results.

Table 6.3: Phase 2 Background Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	Overall	A	0.35		A	0.59		A	0.59	
	WBL	B	0.17	6	C	0.14	7	C	0.22	9
	WBR	B	0.03	6	C	0.03	10	C	0.02	7
	NBT	A	0.31	29	A	0.62	80	A	0.35	31
	NBR	A	0.01	2	A	0.02	2	A	0.02	3
	SBL	A	0.03	1	A	0.17	2	A	0.09	3
	SBT	A	0.33	20	A	0.34	24	A	0.57	48
Highway 99 & Site Access A (Unsignalized)	Overall									
	WBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT/R		0.38	0		0.93	0		0.48	0
	SBT		0.24	0		0.28	0		0.47	0
Highway 99 & Site Access D (Unsignalized)	Overall									
	EBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT		0.38	0		0.93	0		0.48	0
	SBT/R		0.24	0		0.28	0		0.47	0

Key findings and insights for Phase 2 Background traffic analysis:

- With the extra northbound/southbound lane (mitigation measure from the Phase 1 Background), Highway 99 & Copper Drive operates acceptably during the peak hours.
- The northbound through movement on Highway 99 at both Access A and Access D was found to approach capacity ($V/C = 0.93$), which is likely caused by the limitation of inputting high volumes through a single lane in conjunction with background growth. Widening for this section was not assumed a mitigation measure due to potential land cuts on either side of the highway.
- The Phase 2 conditions operations at Copper Drive would fail without the noted mitigation measures.

6.2.2 Total 2028 Traffic Conditions – Phase 2

The Year 2028 Total traffic condition incorporates the proposed Phase 2 future site traffic volumes. Note, for this phase, both Access A and Access D are constructed. They are both right-in, right-out accesses.

Table 6.4 summarizes the operational results for the Total 2028 traffic conditions.

Table 6.4: Phase 2 Total Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	<i>Overall</i>	A	0.37		A	0.60		A	0.61	
	WBL	B	0.17	6	C	0.14	7	C	0.24	9
	WBR	B	0.03	6	C	0.03	10	C	0.02	7
	NBT	A	0.34	32	A	0.64	85	A	0.37	34
	NBR	A	0.01	2	A	0.02	2	A	0.02	2
	SBL	A	0.03	1	A	0.18	2	A	0.10	3
	SBT	A	0.35	21	A	0.37	26	A	0.58	52
Highway 99 & Site Access A (Unsignalized)	<i>Overall</i>									
	WBR	B	0.09	2	C	0.16	4	B	0.11	3
	NBT/R		0.19	0		0.46	0		0.24	0
	SBT		0.25	0		0.30	0		0.49	0
Highway 99 & Site Access D (Unsignalized)	<i>Overall</i>									
	EBR	B	0.10	3	B	0.10	3	C	0.16	4
	NBT		0.40	0		0.96	0		0.52	0
	SBT/R		0.03	0		0.04	0		0.04	0

Key findings and insights for the Phase 2 Total traffic analysis:

- Highway 99 & Copper Drive was found to operate acceptably during the peak hours.
- Without previously mentioned mitigations applied, the intersection would operate beyond acceptable thresholds for capacity and delay.

- HCM calculations report Sunday peak southbound queues of 52m. Based on SimTraffic, the southbound queue was found to be 26m with an average traffic delay of only 2 seconds per vehicle, translating to very acceptable LOS 'A' traffic operation.
- The northbound through movement on Highway 99 at Access D was found to approach capacity ($V/C = 0.96$), which is likely caused by the limitation of inputting high volumes through a single lane in conjunction with background growth.

6.3 2032 Traffic Conditions Analysis

6.3.1 Background 2032 Traffic Conditions

The 2032 Background traffic volumes were increased from the 2028 Background conditions based on background growth. With the noted improvements, the following are the operations analysis results.

Table 6.5: Phase 3 Background Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	Overall	A	0.38		A	0.63		A	0.63	
	WBL	B	0.19	7	C	0.15	7	C	0.26	11
	WBR	B	0.03	7	C	0.04	10	C	0.03	8
	NBT	A	0.34	32	A	0.67	100	A	0.36	35
	NBR	A	0.01	2	A	0.02	3	A	0.02	3
	SBL	A	0.04	2	A	0.21	3	A	0.10	3
	SBT	A	0.36	22	A	0.37	27	A	0.60	58
Highway 99 & Site Access A (Unsignalized)	Overall									
	WBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT/R		0.41	0		1.01	0		0.53	0
	SBT		0.26	0		0.31	0		0.51	0
Highway 99 & Site Access D (Unsignalized)	Overall									
	EBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT		0.41	0		1.01	0		0.53	0
	SBT/R		0.26	0		0.31	0		0.51	0

Key findings and insights for the Phase 3 Background traffic analysis:

- Highway 99 & Copper Drive operates acceptably during the Friday AM and PM peak hours.
- The Highway 99 & Access D northbound through movement exceeded theoretical capacity ($v/c = 1.01$), likely caused by the limitation of inputting high volumes through a single lane in conjunction with background growth.

- The above finding would be caused by the limitation of inputting high volumes through a single lane. This, in combination with the background growth, would likely cause the northbound movement to reach capacity. Widening for this section was not assumed a mitigation measure due to potential land cuts on either side of the highway (between Access A and Access D).

6.3.2 Total 2032 Traffic Conditions – Phase 3

The Year 2032 total traffic condition incorporates the proposed Phase 3 future site traffic volumes. **Table 6.6** summarizes the operational results for the Total 2032 traffic conditions.

Table 6.6: Phase 3 Total Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	<i>Overall</i>	A	0.41		A	0.65		A	0.66	
	WBL	C	0.20	7	C	0.12	7	C	0.28	12
	WBR	B	0.03	7	C	0.04	10	C	0.03	8
	NBT	A	0.38	37	A	0.70	105	A	0.39	40
	NBR	A	0.01	2	A	0.02	2	A	0.02	2
	SBL	A	0.04	2	A	0.25	3	A	0.11	3
	SBT	A	0.38	25	A	0.42	32	A	0.63	66
Highway 99 & Site Access A (Unsignalized)	<i>Overall</i>									
	WBR	B	0.17	5	C	0.31	10	B	0.20	6
	NBT/R		0.21	0		0.51	0		0.26	0
	SBT		0.28	0		0.35	0		0.55	0
Highway 99 & Site Access D (Unsignalized)	<i>Overall</i>									
	EBR	B	0.19	5	B	0.19	5	C	0.31	10
	NBT		0.46	0		1.08	0		0.59	0
	SBT/R		0.26	0		0.31	0		0.51	0

Key findings and insights about the Phase 3 Total traffic analysis include:

- Highway 99 & Copper Drive was found to operate acceptably for all peak hours.
- Based on SimTraffic, the southbound queue on Highway 99 approach to the Copper Drive intersection is estimated to be 30 m with average traffic delay of only 2 seconds per vehicle, translating to very acceptable LOS 'A' traffic operation.
- The Highway 99 & Access D northbound through movement exceeded theoretical capacity (v/c = 1.08), likely caused by the limitation of inputting high volumes through a single lane in conjunction with background growth.

6.4 2037 Traffic Conditions Analysis

6.4.1 Background 2037 Traffic Conditions

The traffic operations for the Year 2037 background traffic scenario are presented below.

Table 6.7: Phase 4 Background Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	Overall	A	0.42		A	0.69		A	0.67	
	WBL	C	0.21	8	C	0.13	8	C	0.24	13
	WBR	B	0.04	7	C	0.04	11	C	0.03	9
	NBT	A	0.37	36	A	0.74	121	A	0.39	39
	NBR	A	0.01	2	A	0.02	3	A	0.02	3
	SBL	A	0.04	2	A	0.30	3	A	0.13	3
	SBT	A	0.39	26	A	0.42	33	A	0.66	72
Highway 99 & Site Access A (Unsignalized)	Overall									
	WBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT/R		0.46	0		1.13	0		0.59	0
	SBT		0.29	0		0.35	0		0.58	0
Highway 99 & Site Access D (Unsignalized)	Overall									
	EBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT		0.46	0		1.13	0		0.59	0
	SBT/R		0.29	0		0.35	0		0.58	0

Key findings and insights for the Phase 4 Background traffic analysis:

- Highway 99 & Copper Drive – this intersection was still found to operate within acceptable thresholds (LOS 'A') assuming aforementioned mitigations are implemented. The southbound through queues during the Sunday peak hour were found to be 72m (based on Synchro), while SimTraffic indicated queues to be 36m.
- The Highway 99 & Access D northbound through movement exceeded theoretical capacity ($v/c = 1.13$), likely caused by the limitation of inputting high volumes through a single lane in conjunction with background growth.

6.4.2 Total 2037 Traffic Conditions – Phase 4

Phase 3 is anticipated to be completed by the Year 2037 and is the final phase of the South Britannia Beach development. The traffic operations for the Year 2037 Total traffic scenario are presented below.

Table 6.8: Phase 4 Total Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	Overall	A	0.46		A	0.74		A	0.72	
	WBL	C	0.23	9	C	0.14	8	C	0.27	13
	WBR	C	0.04	8	C	0.04	11	C	0.03	9
	NBT	A	0.44	47	A	0.79	146	A	0.44	49
	NBR	A	0.01	2	A	0.02	3	A	0.02	3
	SBL	A	0.05	2	B	0.31	3	A	0.15	3
	SBT	A	0.43	30	A	0.49	42	A	0.71	91
Highway 99 & Site Access A (Unsignalized)	Overall									
	WBR	B	0.33	11	E	0.60	27	C	0.33	11
	NBT/R		0.23	0		0.57	0		0.30	0
	SBT		0.33	0		0.41	0		0.64	0
Highway 99 & Site Access D (Unsignalized)	Overall									
	EBR	C	0.38	14	C	0.34	11	E	0.56	24
	NBT		0.53	0		1.26	0		0.69	0
	SBT/R		0.29	0		0.35	0		0.58	0

Key findings and insights about the Phase 4 Total traffic analysis include:

- Highway 99 & Copper Drive was found to operate acceptably for all peak hours.
- The southbound through queues during the Sunday peak hour were found to be 91m (based on Synchro), while SimTraffic indicated queues to be 40m.
- The northbound through queues during the PM peak hour were found to be 146m (based on Synchro) while SimTraffic reported a northbound queue of 40m during the Friday PM peak.
- At Highway 99 & Access A, the overall intersection is operating within capacity during the PM peak, however, the westbound right movement experiences moderately long delays (LOS E) but operates within capacity (V/C = 0.60).
- The Highway 99 & Access D northbound through movement exceeded theoretical capacity (v/c = 1.26), likely caused by the limitation of inputting high volumes through a single lane in conjunction with background growth.
- At Highway 99 and Access D, the overall intersection is operating within capacity during the Sunday peak, however, the eastbound right movement experiences moderately long delays (LOS E) but operates within capacity (V/C = 0.56).

6.5 2047 Traffic Conditions Analysis (Build-out +10 Year Horizon)

6.5.1 Background 2047 Traffic Conditions

This scenario represents much longer term traffic conditions 10 years after the full completion of the Britannia site development. The laning and traffic operations used for Background 2047 scenario are the same as the ones assumed for the Background 2037 scenario. The results of the traffic operational analysis are summarized in **Table 6.9**.

Table 6.9: Full Buildout + 10 Background Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	Overall	A	0.51		B	0.84		A	0.81	
	WBL	C	0.21	10	D	0.18	10	D	0.34	16
	WBR	C	0.04	9	D	0.07	12	C	0.04	10
	NBT	A	0.46	48	B	0.91	248	A	0.47	58
	NBR	A	0.01	3	A	0.03	4	A	0.03	3
	SBL	A	0.07	2	C	0.38	5	A	0.19	4
	SBT	A	0.50	37	A	0.51	49	A	0.80	135
Highway 99 & Site Access A (Unsignalized)	Overall									
	WBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT/R		0.58	0		1.43	0		0.74	0
	SBT		0.37	0		0.44	0		0.72	0
Highway 99 & Site Access D (Unsignalized)	Overall									
	EBR	A	0.00	0	A	0.00	0	A	0.00	0
	NBT		0.58	0		1.43	0		0.74	0
	SBT/R		0.37	0		0.44	0		0.72	0

Key findings and insights for the Opening Day + 10 (2047) Background traffic analysis:

- As would be expected, the results follow the operations reported for Background 2037 with longer delays and queues due to the increased background growth on the Highway 99 corridor. During the PM peak hour, the northbound through movement at Highway 99 & Copper Drive experiences queue lengths of 248m, acceptable delays (LOS 'B') and approaching capacity (V/C = 0.91).
- For the Sunday peak hour, the southbound through movement at the Highway 99 & Copper Drive intersection is estimated to experience vehicle queues of 135 m, a v/c ratio of 0.80 and LOS 'A' traffic operation. The intersection operates acceptably with the previously mentioned mitigation measures implemented.

- The Highway 99 & Access D northbound through movement exceeded theoretical capacity ($v/c = 1.43$), likely caused by the limitation of inputting high volumes through a single lane in conjunction with background growth.

6.5.2 Total 2047 Traffic Conditions – Build-out + 10 Years

For the Build-out + 10 year horizon, the traffic laning configuration and intersection operations will further deteriorate from the Year 2037 Total traffic condition reported earlier with increased queues and delays for all approaches due to the increase in background traffic on the highway. The estimated traffic operation results are presented in **Table 6.10**.

Table 6.10: Full Buildout + 10 Total Vehicle Traffic Operations – Mitigated

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	Overall	A	0.54		B	0.90		A	0.86	
	WBL	C	0.22	11	D	0.18	9	D	0.34	16
	WBR	C	0.05	9	D	0.08	13	D	0.04	10
	NBT	A	0.52	56	C	0.96	276	A	0.53	71
	NBR	A	0.01	2	A	0.03	4	A	0.03	3
	SBL	A	0.09	2	C	0.38	5	A	0.22	4
	SBT	A	0.53	43	A	0.59	63	A	0.86	180
Highway 99 & Site Access A (Unsignalized)	Overall									
	WBR	C	0.38	13	F	0.88	49	C	0.40	14
	NBT/R		0.29	0		0.71	0		0.37	0
	SBT		0.40	0		0.50	0		0.79	0
Highway 99 & Site Access D (Unsignalized)	Overall									
	EBR	C	0.46	18	C	0.43	16	F	0.82	42
	NBT		0.65	0		1.55	0		0.84	0
	SBT/R		0.37	0		0.44	0		0.72	0

Key findings and insights for the Opening Day + 10 (2047) Total traffic analysis:

- During the PM peak hour, the northbound Highway 99 through traffic movement at the intersection of Highway 99 and Copper Drive is expected to experience queues of 276 m, an overall v/c ratio of 0.90 and LOS 'B' traffic operation. SimTraffic results indicate a northbound queue of 160m during the PM peak hour.
- During the Sunday peak hour, the southbound through lane is experiencing queues of 180 m, an overall v/c ratio of 0.86 and LOS 'A'. SimTraffic results indicate a southbound queue of 270m during the PM peak hour.

- This is understandable with the amount time elapsed for the planning horizon and when traffic is grown at a 2.3% growth (compounded) rate unrestricted. Note that the deterioration of traffic is mainly a result of the background growth.
- As for the Highway 99 / Access A intersection during the PM peak hour, the intersection would experience challenges for the westbound right movement having LOS F and V/C of 0.88, which is beyond acceptable thresholds.
- At Highway 99 and Access D, the overall intersection is operating within capacity during the Sunday peak, however, the eastbound right movement experiences long delays (LOS F) but operates within capacity (V/C = 0.82).

6.5.3 Total 2047 Traffic Conditions – Build-out + 10 Years – Sensitivity Analyses

Tables 6.11 and 6.12 showcase the operations for the 2047 sensitivity analysis cases. In comparison to the 2047 Total scenario (Table 6.10), the changes in operations are minor. The change in directional distribution (northbound 70% and southbound 30% and vice versa) analyses do not materially affect the operations of the study area.

Table 6.11: Total 2047 Conditions Sensitivity Analysis (30% NB / 70% SB)

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	Overall	A	0.54		B	0.90		A	0.84	
	WBL	C	0.21	11	D	0.18	9	D	0.34	16
	WBR	C	0.04	9	D	0.08	13	D	0.04	10
	NBT	A	0.50	56	C	0.96	276	A	0.50	65
	NBR	A	0.01	2	A	0.03	4	A	0.03	3
	SBL	A	0.08	2	C	0.38	5	A	0.20	4
	SBT	A	0.53	41	A	0.59	63	A	0.83	157
Highway 99 & Site Access A (Unsignalized)	Overall									
	WBR	B	0.23	7	F	0.88	49	C	0.22	6
	NBT/R		0.29	0		0.71	0		0.37	0
	SBT		0.39	0		0.50	0		0.76	0
Highway 99 & Site Access D (Unsignalized)	Overall									
	EBR	D	0.65	34	C	0.43	16	F	1.28	94
	NBT		0.68	0		1.55	0		0.90	0
	SBT/R		0.37	0		0.44	0		0.72	0

Table 6.12: Total 2047 Conditions Sensitivity Analysis (70% NB / 30% SB)

INTERSECTION/ TRAFFIC CONTROL	MOVEMENT	AM			PM			SUNDAY		
		LOS	V/C	Q (M)	LOS	V/C	Q (M)	LOS	V/C	Q (M)
Highway 99 & Copper Drive (Signalized)	Overall	A	0.55		B	0.92		A	0.88	
	WBL	C	0.22	11	D	0.18	9	D	0.34	16
	WBR	C	0.05	9	D	0.08	13	D	0.04	10
	NBT	A	0.52	56	C	0.99	287	A	0.54	74
	NBR	A	0.01	2	A	0.03	4	A	0.03	3
	SBL	A	0.09	2	C	0.38	5	A	0.23	4
	SBT	A	0.54	44	A	0.62	70	A	0.88	214
Highway 99 & Site Access A (Unsignalized)	Overall									
	WBR	C	0.38	13	F	1.24	91	C	0.51	21
	NBT/R		0.29	0		0.71	0		0.37	0
	SBT		0.40	0		0.53	0		0.80	0
Highway 99 & Site Access D (Unsignalized)	Overall									
	EBR	C	0.46	18	C	0.26	8	E	0.54	21
	NBT		0.65	0		1.50	0		0.81	0
	SBT/R		0.37	0		0.44	0		0.72	0

With the above operations findings, it does not materially deviate from the Total 2047 non-sensitivity analysis results. This further showcases the operations issues in the nearby area as a result of high background growth.

6.6 Summary of Road Improvements Required

Based on the operations results determined for each development phase, the **Table 6.13** on the following page provides a summary of the road improvements required to accommodate the anticipated future background and total traffic conditions to Year 2047. A diagrammatic review of the laning requirements are provided as **Exhibit 6.1 – 6.3**. Note, in the context of the development, it is assumed that the likely responsibility of only the improvements for Accesses A and D will be the developer since these are the main interfaces of the development to the Highway network.

In general, it must be noted that the Highway corridor itself is anticipated to exceed capacity by the 2032 horizon (background conditions). This is resultant of a conservative growth rate anticipated, which may or may not be fully realized. It is suggested that the highway corridor be observed on a continuous basis to ensure there is effective operational efficiency to better determine the need for improvements along the highway.

Table 6.13: Summary of Suggested Improvements

SCENARIO	COPPER DRIVE & HWY 99	ACCESS A	ACCESS D
Existing	N/A	N/A	N/A
Background 2025	Addition of second northbound lane (55m length due to site constraints) and second southbound lane	N/A	N/A
Background 2028	-	N/A	N/A
Background 2032	-	N/A	N/A
Background 2037	-	N/A	N/A
Background 2047	-	N/A	N/A
Total 2025 (Phase 1)	-	Full Movement Access plus additional northbound lane	N/A
Total 2028 (Phase 2)	-	Right In / Out Access (maintain additional northbound lane)	Right In / Out Access
Total 2032 (Phase 3)	-	-	-
Total 2037 (Phase 4)	-	-	-
Total 2047 (Full Build out + 10 years)	-	-	-

Note, solutions for access on the Highway presented above assume acceleration and deceleration lanes for turning movements.

Should the Highway Bypass be provided within or before any of the above phases, the above suggested improvements will not be required.

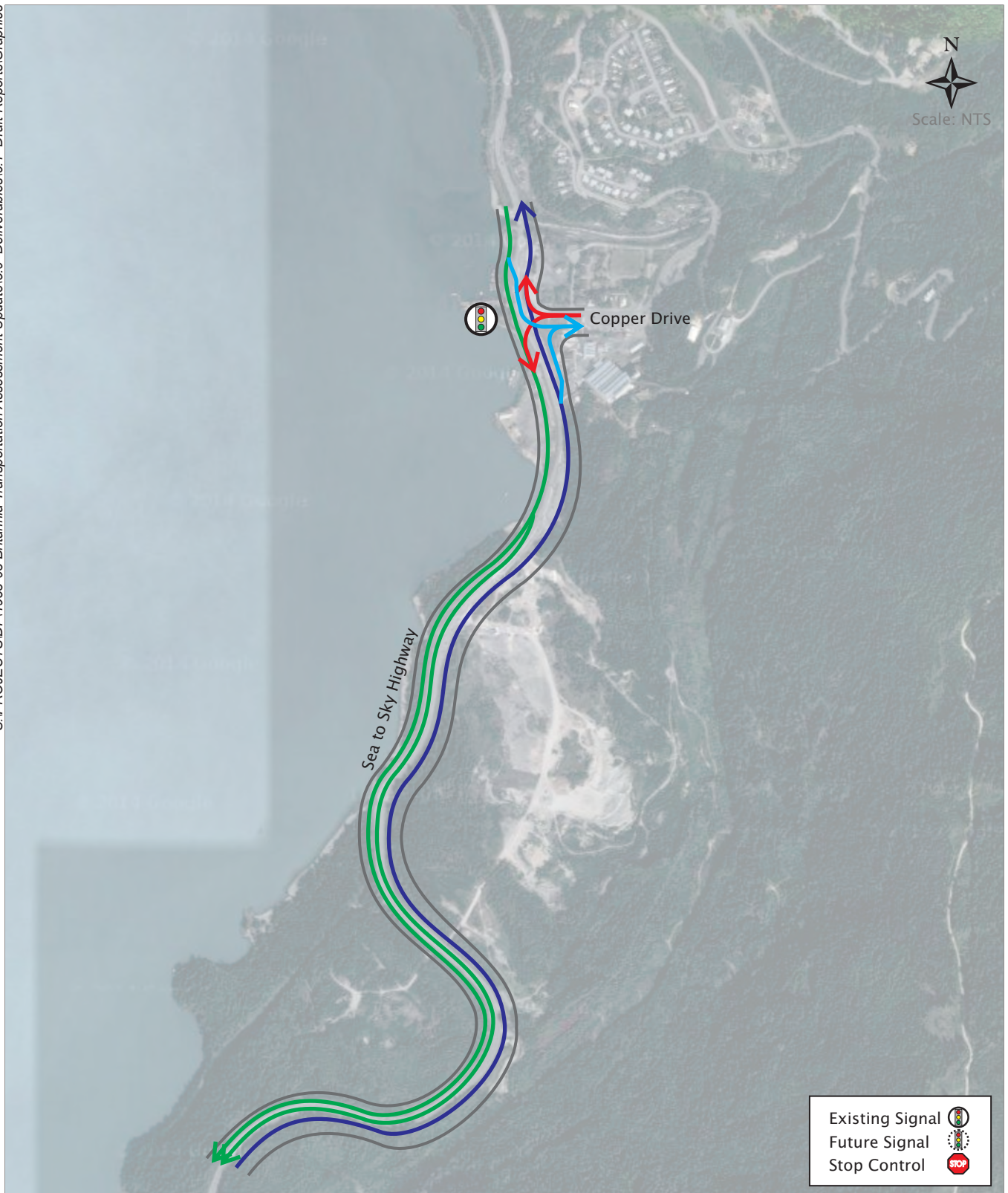


Exhibit 6.1 Existing Laning

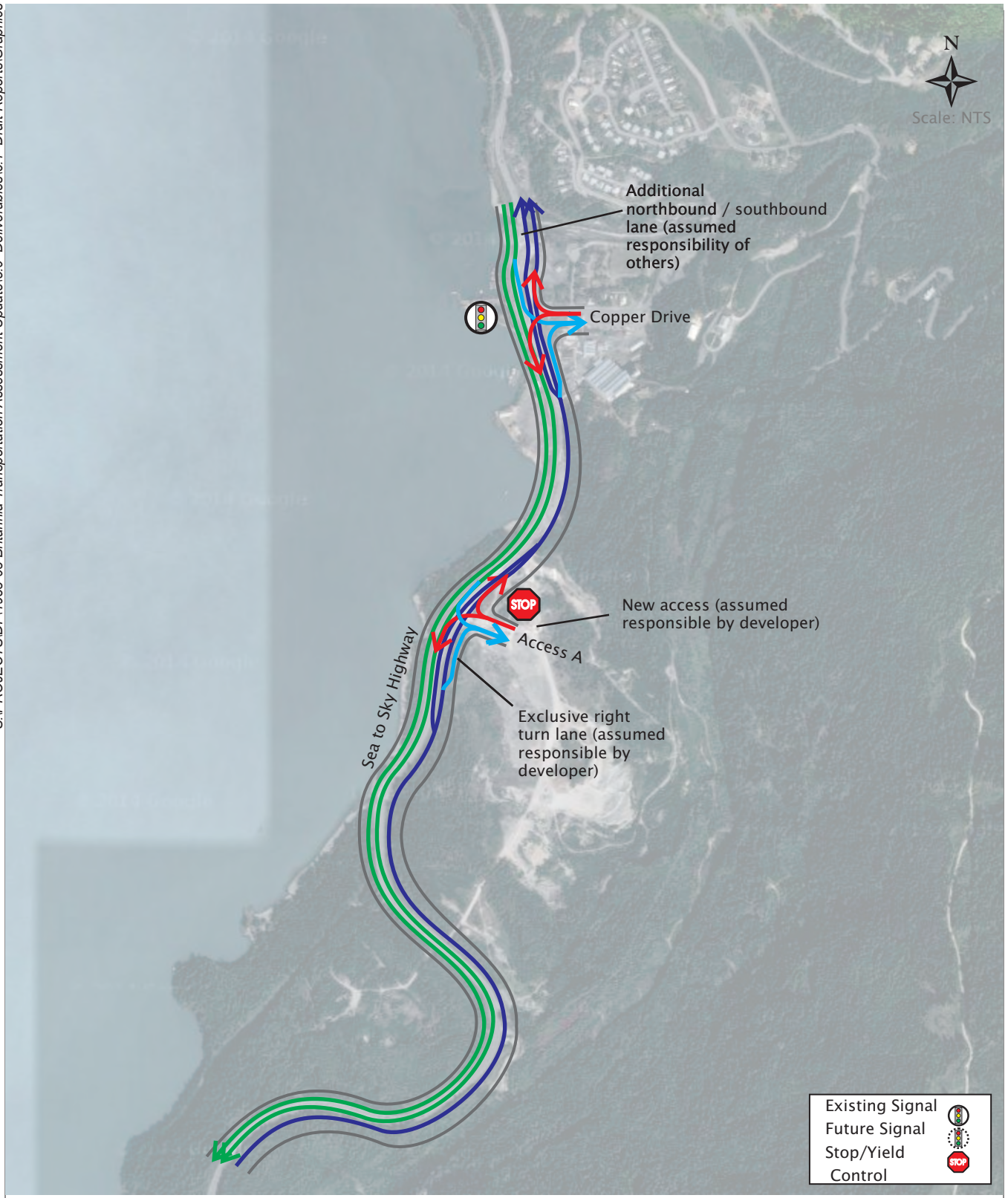


Exhibit 6.2 2025 Laning Background and Total Condition

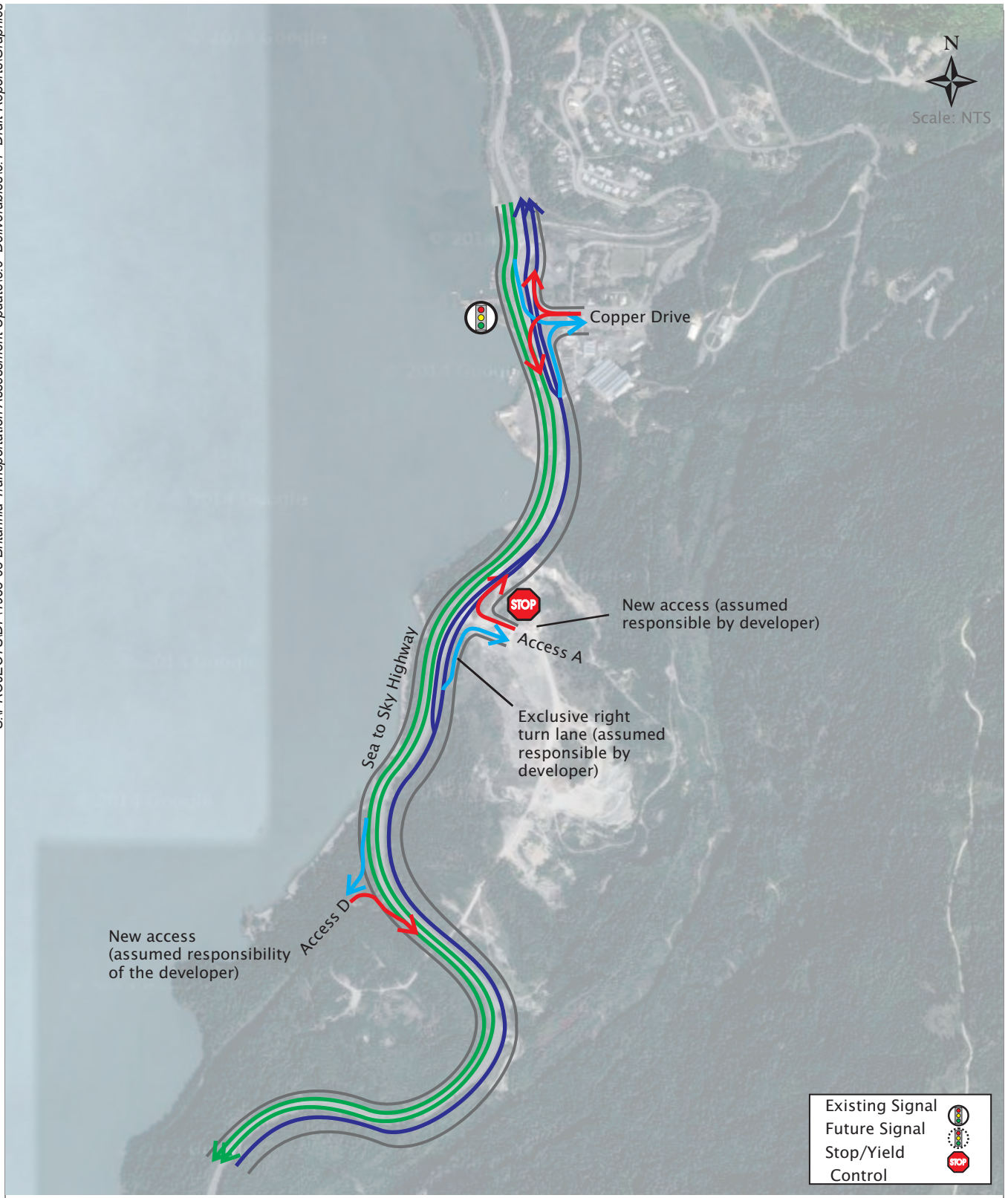


Exhibit 6.3 2028 Laning Background and Total Condition

7. SITE PLAN REVIEW

7.1 Site Circulation and Connectivity

7.1.1 Site Circulation

For Phase 1 of development, Access A connects to the spine of the development and acts as the access and egress for all directions.

For Phase 2 and beyond, the access connections are as shown in Exhibit 2.1. The Main Street is the main thoroughfare / spine between the different phases of development access. Main Street is connected to Access A on the north end and Access D on the south end. As noted earlier, both Access A and D will be right-in, right-out access where Access A services northbound traffic and D services southbound traffic.

7.1.2 Connectivity between the Different Phases

As the Highway bisects the site, a tunnel with a single lane of travel will be provided as connection between different areas of the development areas. This connection is expected to be completed at the Opening Day of Phase 2 since the unsignalized full movement Access A will no longer be adequate for the land use proposed. As the tunnel will be utilized by alternating traffic flows, signalization will need to be provided. A possible efficient way of signaling for the tunnel would be to have signal rest in green in one primary direction (usually the more busy direction for that specific period of the day) and a green light be provided for the alternate direction (while a red light is provided for the primary direction) as and when a vehicle is detected for the alternate direction.

In each direction of movement, it is expected that several hundred vehicles could utilize the signalized tunnel based on an alternating signal. From a high level perspective and reviewing the anticipated trips generated, the tunnel could see 300 to 400 trips during the peak hours in each direction of movement. It is anticipated the tunnel should operate acceptably with this level of traffic.

Aside from vehicular travel, it is also envisaged that pedestrians and bikes will be able to use this tunnel as connection between the different phases of development. As such, adequate lighting and width is necessary in ensuring a safe and efficient environment for all modes.

7.2 Parking Requirements

At this stage of the Master Plan planning process, a detailed parking allocation and analysis has not been undertaken. Bunt has however conducted a review of the existing SLRD Zoning Bylaw parking supply requirements to identify the District's existing regulatory parking supply requirements for the proposed South Britannia Development.

7.2.1 Off-Street Parking Bylaw

The Squamish-Lillooet Regional District Zoning Bylaw No.1350-2016 (August 2016) specifies off-street parking rates for different land uses. **Table 7.1** summarizes the rates and corresponding spaces required for the proposed development.

Table 7.1: Parking Bylaw Requirements

LAND USE	SIZE	ZONING BY-LAW REQUIREMENTS	
		Rate	Spaces
Multi-family Residential (apartments)	1,050 units	1.25 spaces per dwelling unit, plus 1 visitor space per 5 units	1,523
Commercial and office	31,000 sf	3 per 100 m2 gross floor area (assuming the worst case of commercial uses)	87
Restaurant (Eatery)	7,500 sf	6 per 100 m2 of grossfloor area	42
Hotel	190 Rooms (or equivalent)	1 per guest room or 1 per sleeping unit or 1 per campsite	190
Municipal	11,000 sf	1 space for every 50 m2 of Gross Floor Area (assuming similar to an office space)	20
Surf Park, pump traffic, surf park		Rough estimate based on worst case scenario of the number of trips entering / exiting the site during a two hour peak period	200
TOTAL	-	-	2,062

Based on the Bylaw, an approximate total of 2,100 off-street parking spaces will be required for the development in its entirety.

7.3 Bicycle and Pedestrian Facilities

In order to support and encourage alternative transportation modes, the development plan focuses on the provision of efficient bicycle and pedestrian facilities to ensure proper connectivity throughout the site. The plan considers the following:

- Two-way bicycle and pedestrian path connecting South and North Britannia;
- Pedestrian on-street and off-street trail network providing efficient connections throughout the site; and,

- Urban design approach to provide a functioning and inviting streetscape that creates “people places” especially in the commercial core and other high density areas.

7.4 Transit and Car Sharing

Transit, Ride-Sharing, and Car Sharing programs are fundamental to the success of this community. The following are programs being progressed.

7.4.1 Transit

At the on-set of development, it is anticipated that transit will be served mainly by private entities until ridership increases to a point where BC Transit will see provision of services as viable in this community.

We have discussed with the managers of Squamish Connector (<http://www.squamishconnector.com/>) about the South Britannia Master Plan. The Squamish Connector is a private service that currently operates between Squamish and Vancouver. They have indicated that they are interested in providing a shuttle service for the development when it is completed. The details of service will need to be discussed further.

In addition to the above, the developer is also looking into the potential for on-demand transit services. Prior to BC Transit having buses servicing the nearby area, on-demand transit would aid fill the gap in the meanwhile.

From a transit circulation planning standpoint, it is envisaged that a “transit loop” will be provided on site. With the current access to the site, northbound transit traffic would enter the site via Access A and exit via Access A while buses southbound would enter Access D and exit Access D (thereby travelling through the tunnel).

7.4.2 Ride Share

There are various ride share programs available from Squamish such as poparide.com, ridesharing.com, carpoolworld.com, and etc.

It is envisaged that ride-sharing stalls can be provided in the near vicinity to the commercial area immediately accessed from Access A on Main Street near the bus loop location. At the on-set of the project, it is envisaged 2 to 3 ride share stalls can be provided as a pilot. Based on actual on-going observations of demands for the ride share stalls every year, the number of ride share stalls can be adjusted upwards or downwards to meet community needs.

7.4.3 Car Share Programs

We have had discussions with the MODO Car Share Program staff about the South Britannia development. At this particular time, they could not commit to providing vehicles at the South Britannia site. However, they are open to providing their technologies should the owner / strata provide the vehicles and maintenance thereof. That is, MODO would make available their booking technologies (such as their

website) as well as their telephone coordinators (for booking purposes) for monthly fee. The owner / strata would have to buy and maintain vehicles as well as react to any maintenance calls for the drivers (such as flat tires and mechanical failures among others).

8. CONCLUSION

- Tiger Bay Development Corporation is proposing the development of the South Britannia Beach community located on the Highway 99 corridor, south of the existing historic mine museum in Britannia Beach, BC.
- The Master Plan comprises the development of 1,050 residential units 31,000 square ft of commercial floor area , 7,500 square feet of eatery, 150 room hotel rooms with 40 glamping spaces, 11,000 square feet of municipal office (along with other recreation uses such as a surf park, skate park, parks, and etc.).
- The site is anticipated to be developed over a series of 4 development phases. As a rough estimate, the Phase 1 opening day is anticipated to be 2025, the Phase 2 opening day is anticipated to be 2028, the Phase 3 opening day is anticipated to be 2032, and the Phase 4 opening day is anticipated to be 2037. However, these numbers are rough estimate and for the purpose of the transportation study only.
- The proposed Master Plan is expected to be developed over the next 5-25 years. All horizon years were analyzed as part of the traffic assessment to understand the potential impacts along the highway. An additional 2047 longer term horizon year was included in the analysis to account for the full build-out plus 10 years horizon.
- In order to account for growth along the Highway 99 corridor, a 2.3% per year growth rate was applied to all horizon years.
- The traffic analysis evaluation scenarios included the typical Friday AM, Friday PM and Sunday afternoon peak hours which generally represent the peak hour traffic volume conditions along the Highway 99, Sea to Sky corridor.
- Access A is assumed to be the only access for Phase 1. During that time, this access will house full movements and will be unsignalized.
- Access A and D will be unsignalized and will only house right-in, right-out movements including and beyond Phase 2 development.
- Based on traffic operations results, the improvements required to support the additional traffic expected along the corridor are as follows:
 - By 2025 it is required to consider a second northbound lane with a second southbound lane at the intersection of Copper Drive to alleviate northbound and southbound delays / queues during the Friday afternoon and Sunday peak hour conditions. Such improvement is limited by the existing sheer rock on the east and rail tracks on the west side that creates a “pinch point” along this stretch of the highway;

- Proposed Access A will require, at a minimum, a northbound right turn deceleration lane for access to the site while an additional northbound lane (making two northbound lanes total) at the access will be required by 2025 Total Scenario (Phase 1);
 - For the 2025 Total Phase 1 Scenario, a full movement unsignalized Access A is adequate to serve the site.
 - Proposed Access D requires proper acceleration and deceleration lanes for the right in/out configuration according to design standards as it is located right at a curvature and uphill roadway condition by 2028 Total Phase 2 conditions;
 - The improvements to the long term condition of the highway and the accesses indicate beyond capacity conditions, it is assumed that in the actual case peak spreading will have occurred to accommodate to the capacities of the highway;
 - The Highway corridor itself is anticipated to exceed capacity by the 2032 horizon (background conditions) and is mainly resultant of conservative growth – continuous highway corridor observations are suggested to more accurately determine the improvement needs from a timeline perspective.
 - Note, MOTI is anticipating a Highway Bypass that would alleviate and detour traffic volumes away from the existing Highway 99 in the vicinity of the study area that would likely render the above traffic improvement unnecessary;
 - Noting the above, improvements to the Highway should only be implemented based on observed demand as-and-when necessary; and
 - In the context of the development, it is assumed that the developer is likely responsible for improvements of Access A and D only.
- In order to support and encourage sustainable transportation modes, the site plan includes the provision of a pedestrian and bicycle path to North Britannia, and pedestrian trail systems and greenways throughout the community;
 - Based on the SLRD Zoning Bylaw, the proposed site will require 2,100 parking stalls for the proposed development site at full build-out; and,
 - Transit, car sharing and ride sharing programs are currently being solidified based on on-going discussion with multiple organizations.

APPENDIX A

Detailed Development Statistics and Trip Generation

Phase 4 Trip Generation Organized by Parcel Number

Parcel # (2019/02/11) NEW	Land Use	Type	Quantity	Variable	Source	AM			PM			Sunday			Notes
						In	Out	Total	In	Out	Total	In	Out	Total	
1	I	Institutional	10.8	1000 ft² GFA	ITE #730	27	9	36	5	14	18	4	11	15	Assumed two thirds land area for building approximation
2	MF1	Townhouses	10.0	Units	ITE 220 and 221 AVG	1	3	4	3	2	5	2	2	4	
3	MF3	Apartment and commercial	75.0	Units	ITE 220 and 221 AVG	7	23	31	23	14	38	19	11	30	
			21.5	1000 ft² GFA	ITE #826	9	6	15	26	33	58	20	26	47	
5	MF1	Mixed Use Townhouses	20.0	Units	ITE 220 and 221 AVG	2	6	8	6	4	10	5	3	8	
7	C	Restaurant	3.2	1000 ft² GFA	Average of ITE #931 and ITE #930	3	2	5	21	14	35	38	29	68	Average of quality and casual restaurant to be conservative with uncertainty
9	MF3	WALK UP APARTMENTS	42.0	Units	ITE 220 and 221 AVG	4	13	17	13	8	21	10	6	17	
10	MF1	Townhouse	32.0	Units	ITE 220 and 221 AVG	3	10	13	10	6	16	8	5	13	
11	MF1	Townhouse	14.0	units	ITE 220 and 221 AVG	1	4	6	4	3	7	3	2	6	
12	MF1	Townhouse	12.0	units	ITE 220 and 221 AVG	1	4	5	4	2	6	3	2	5	
13	RC	RECREATIONAL, pump track	2.4	Acres	ITE #411	13	9	22	9	8	17	9	15	24	Assumed similar to a park use but will have a higher number of users. To be conservative assumed twice of the maximum rates per the park usage rates
14		Brewery	4.3	1000 ft² GFA	Average of ITE #931 and ITE #930	4	2	6	28	19	47	50	39	89	
		Commercial	5.4	1000 ft² GFA	ITE #826	2	1	4	6	8	15	5	7	12	Assumed commercial for trip generation
		Retail/office building	4.3	1000 ft² GFA	ITE #826	2	1	3	5	7	12	4	5	9	Assume reduced to 2000 square feet to minimize commercial space to cut down trip gen
15	TH	Transit Hub	80.0	SM footprint area	N/A										
16	TC1	Surf Hotel	50.0	Rooms	ITE #310	14	10	24	15	15	30	13	15	28	
17	UT	SEWAGE LIFT STATION	167.0	SM footprint area	N/A										
18	RC	SURF PARK/ LAGOON	269.1	1000 ft² GFA	ASSUMPTION	33	33	67	33	33	67	51	51	103	Assumed Trip Numbers and size is 2.5 hectares as indicated in email
19	MF3	6 STORIES APARTMENT	401.0	Units	ITE 220 and 221 AVG	40	124	164	125	76	201	100	61	160	
22	MF1	TOWN HOUSE	12.0	Units	ITE 220 and 221 AVG	1	4	5	4	2	6	3	2	5	
23	MF3	WALK UP APARTMENTS	24.0	Units	ITE 220 and 221 AVG	2	7	10	7	5	12	6	4	10	
24	MF1	TOWN HOUSE	24.0	Units	ITE 220 and 221 AVG	2	7	10	7	5	12	6	4	10	
26	UT	Utilities	N/A	N/A	N/A			0			0			0	
28	MF3	APARTMENT	230.0	Units	ITE 220 and 221 AVG	23	71	94	71	44	115	57	35	92	
30	MF2	STACKED TOWNHOUSE	48.0	Units	ITE 220 and 221 AVG	5	15	20	15	9	24	12	7	19	
31	MF2	STACKED TOWNHOUSE	13.0	Units	ITE 220 and 221 AVG	1	4	5	4	2	7	3	2	5	
32	MF2	STACKED TOWNHOUSE	36.0	Units	ITE 220 and 221 AVG	4	11	15	11	7	18	9	5	14	
33	MF2	STACKED TOWNHOUSE	27.0	Units	ITE 220 and 221 AVG	3	8	11	8	5	14	7	4	11	
34	MF1	TOWNHOUSE	30.0	Units	ITE 220 and 221 AVG	3	9	12	9	6	15	7	5	12	
37	TC2	CABINS	20.0	rooms	ITE #310	6	4	9	6	6	12	5	6	11	
40	TC2	CABINS or parking	0.0	Rooms	ITE #310	0	0	0	0	0	0	0	0	0	Parking for Option B, cabins for option A
41	PK	SURFACE PARKING	140.0	stalls	N/A			0			0			0	
43	UT	Utilities	0.2	Acre	N/A			0			0			0	
45	TC2	CABINS	0.0	Rooms	ITE #310	0	0	0	0	0	0	0	0	0	
46	TC1	MINATY RESORT HOTEL	40.0	Rooms	ITE #310	11	8	19	12	12	24	10	12	22	
47	TC2	CABINS	10.0	Rooms	ITE #310	3	2	5	3	3	6	3	3	6	Assumed rooms Reduced to 10 for smaller trip gen
50	TC2	GLAMPING	20.0	Rooms	ITE #310	6	4	9	6	6	12	5	6	11	
51	TC2	GLAMPING	20.0	Rooms	ITE #310	6	4	9	6	6	12	5	6	11	
53	TC1	MINATY BEACH LODGE	30.0	Rooms	ITE #310	8	6	14	9	9	18	8	9	17	
	P	Park	11.6	Acre	ITE #411	0	0	0	1	1	1	1	2	4	
Estimated Total						251	426	677	518	391	909	494	402	896	

Base Trip Generation Rates

Land Use	AM			PM			Sunday			Source
	IN	OUT	TOTAL	IN	OUT	TOTAL	In	Out	Total	
Multi-residential	0.10	0.31	0.41	0.31	0.19	0.50	0.25	0.15	0.40	ITE 220 and 221 AVG
Commercial	0.42	0.26	0.68	1.19	1.52	2.71	0.95	1.22	2.17	ITE #826
Restaurant	0.92	0.48	1.40	6.50	4.47	10.97	11.81	9.10	20.91	Average of ITE #931 and ITE #930
Hotel	0.28	0.19	0.47	0.31	0.29	0.60	0.26	0.30	0.56	ITE #310

Land Use	AM			PM			Sunday			Source
	IN	OUT	TOTAL	IN	OUT	TOTAL	In	Out	Total	
Public park (411)	0.01	0.01	0.02	0.06	0.05	0.11	0.12	0.19	0.31	ITE #411
Public park (411) Maximum Rate	2.66	1.85	4.50	1.93	1.58	3.50	1.95	3.05	5.00	ITE #411
Government Office Building (730)	2.51	0.84	3.34	0.43	1.28	1.71	0.34	1.03	1.37	ITE #730

2019-02-11 Map Gross Trip Generation Calculation Sorted by Land Use

Land Use	Quantity	Variable	FRIDAY AM			FRIDAY PM			SUNDAY			Notes
			In	Out	Total	In	Out	Total	In	Out	Total	
Residential	1050	units	105	326	431	326	199	525	261	159	420	Similar to previous study
Commercial	31.216	1000 sqft GFA	13	8	21	37	47	85	30	38	68	
Hotel	190	rooms	53	37	89	58	56	114	49	57	106	More than previous study (new calculations included glamping, cabins, and hotels)
Tourism Restaurant/ café	7.491744	1000 sqft GFA	7	4	10	49	33	82	88	68	157	
Municipal	10.785528	1000 sqft GFA	27	9	36	5	14	18	4	11	15	
Recreational		mixed	47	43	89	44	42	85	62	69	131	Was not included in previous study
TOTAL			251	426	677	518	391	909	494	402	896	Based on Base Trip Generation Rates

Reductions to Gross Trip Generation Calculations

Land Use	Quantity	Variable	FRIDAY AM			FRIDAY PM			SUNDAY			Notes
			In	Out	Total	In	Out	Total	In	Out	Total	
Residential	1050	units	105	326	431	326	199	525	261	159	420	Assumed 10% Deduction For Local Employees that would not generate vehicle trips
	-10%		-10	-33	-43	-33	-20	-53	-26	-16	-42	
Commercial	31.216	1000 sqft GFA	13	8	21	37	47	85	30	38	68	
Hotel	190	rooms	53	37	89	58	56	114	49	57	106	
Tourism Restaurant/ café	7.491744	1000 sqft GFA	7	4	10	49	33	82	88	68	157	
Municipal	10.785528	1000 sqft GFA	27	9	36	5	14	18	4	11	15	
Recreational		mixed	47	43	89	44	42	85	62	69	131	
New Total with Deductions			240	393	634	486	371	857	468	386	854	
New Total with Internal Capture Deductions			215	360	575	382	273	655	350	271	621	Sunday values are from the Sunday-PM internal capture spreadsheet tool
April 2016 TIA Trip Gen Calculations Total			175	369	544	420	305	719	336	244	575	

Increase in trips From April 2016 TIA			40	-9	31	-38	-32	-64	14	27	46
Percent Increase			23%	-3%	6%	-9%	-11%	-9%	4%	11%	8%

Trip Generation Breakdown with Internal Capture Applied

Land Use	Quantity	Variable	FRIDAY AM			FRIDAY PM			SUNDAY		
			In	Out	Total	In	Out	Total	In	Out	Total
Residential	1050	units	88	274	362	259	156	415	197	117	314
Commercial/office	31.216	1000 sqft GFA	7	6	13	16	16	32	8	13	21
Hotel	190	rooms	50	33	83	45	50	95	36	50	86
Tourism Restaurant/ café/ brew pub	7.491744	1000 sqft GFA	3	2	5	23	8	31	55	28	83
Municipal	10.785528	1000 sqft GFA	23	5	28	1	10	11	1	8	9
Recreational		mixed	44	40	84	38	33	71	53	55	108
TOTAL			215	360	575	382	273	655	350	271	621

6/14/2019

04-17-0272

Britannia MTP - Trip Gen Summary (Internal Capture included)

ST

	land use	variable	units	Fri AM			Fri PM			Sun		
				IN	OUT	TOT	IN	OUT	TOT	IN	OUT	TOT
Phase 1 2025	residential		0 units	0	0	0	0	0	0	0	0	0
	commercial/office		0 1000 sf GFA	0	0	0	0	0	0	0	0	0
	hotel		20 rooms	6	4	10	4	4	8	3	3	6
	restaurant/brewpub		4.306 1000 sf GFA	4	2	6	24	15	39	44	32	76
	municipal		0 1000 sf GFA	0	0	0	0	0	0	0	0	0
	recreational		varies mixed	32	32	64	30	31	61	46	48	94
				42	38	80	58	50	108	93	83	176
Phase 2 2028	residential		202 units	18	53	71	39	26	65	27	18	45
	commercial/office		26.91 1000 sf GFA	9	6	15	18	18	36	8	11	19
	hotel		90 rooms	23	16	39	23	23	46	18	23	41
	restaurant/brewpub		4.306 1000 sf GFA	3	2	5	13	5	18	29	13	42
	municipal		0 1000 sf GFA	0	0	0	0	0	0	0	0	0
	recreational		varies mixed	32	32	64	28	27	55	44	45	89
				85	109	194	121	99	220	126	110	236
Phase 3 2032	residential		461 units	39	118	157	103	65	168	73	43	116
	commercial/office		31.216 1000 sf GFA	9	7	16	18	17	35	9	13	22
	hotel		160 rooms	42	28	70	39	41	80	31	41	72
	restaurant/brewpub		7.492 1000 sf GFA	4	3	7	23	8	31	55	28	83
	municipal		0 1000 sf GFA	0	0	0	0	0	0	0	0	0
	recreational		varies mixed	45	41	86	40	37	77	55	61	116
				139	197	336	223	168	391	223	186	409
Phase 4 2037	residential		1050 units	88	274	362	259	156	415	197	117	314
	commercial/office		31.216 1000 sf GFA	7	6	13	16	16	32	8	13	21
	hotel		190 rooms	50	33	83	45	50	95	36	50	86
	restaurant/brewpub		7.492 1000 sf GFA	3	2	5	23	8	31	55	28	83
	municipal		10.785 1000 sf GFA	23	5	28	1	10	11	1	8	9
	recreational		varies mixed	44	40	84	38	33	71	53	55	108
				215	360	575	382	273	655	350	271	621

APPENDIX B

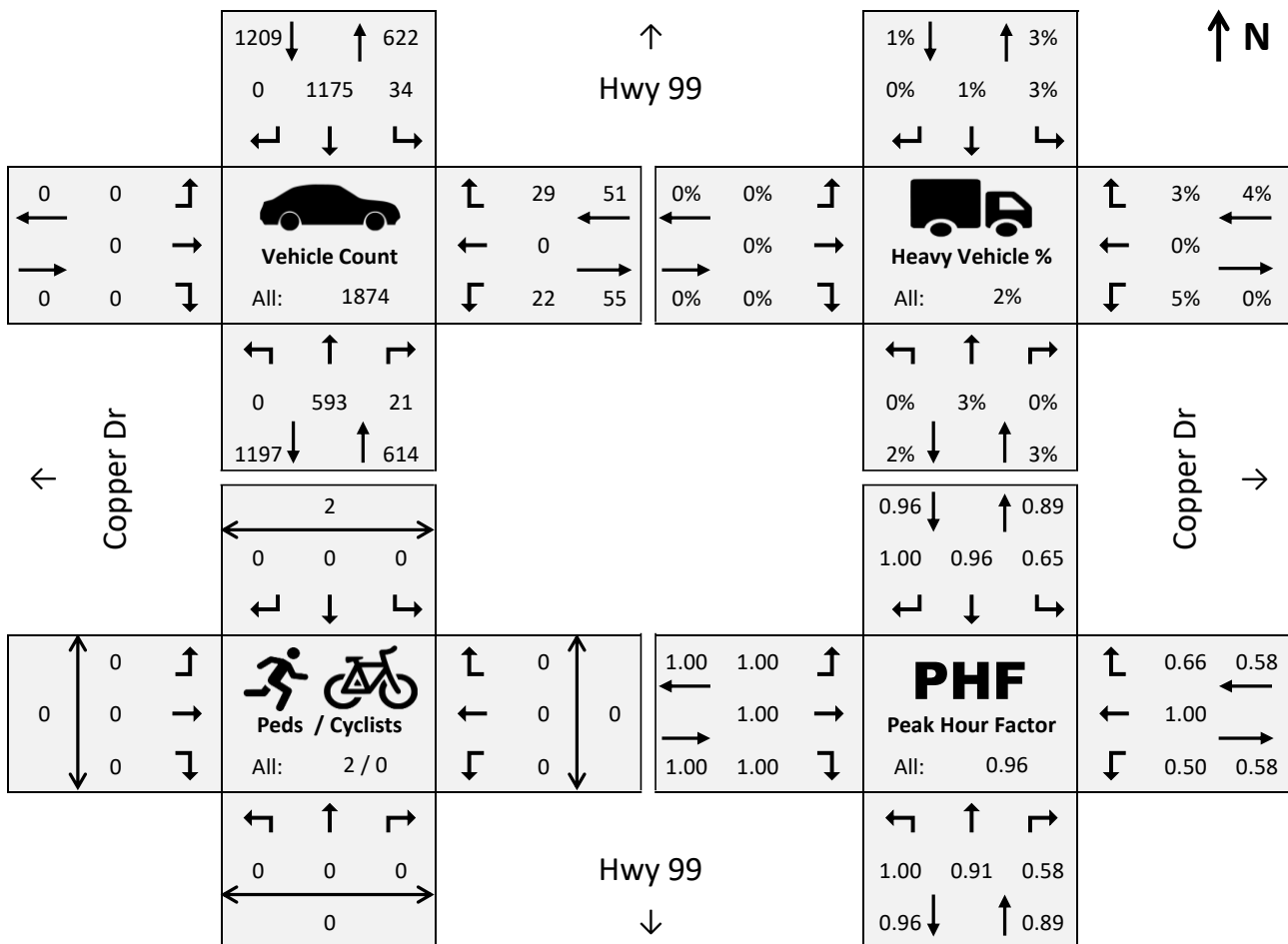
Highway 99 / Copper Road Collected Traffic Volumes

Hwy 99 @ Copper Dr – Squamish, BC

Project#: 04-17-0272 **Weather:** Sunny **Analysis Period:** 15:00 - 16:00
Date: Apr 14, 2019 (Sun) **Road Cond:** Dry **Intersection Peak:** 15:00 - 16:00
Notes:



TIME INTERVAL	AUTOMOBILE COUNT												PEDESTRIANS			
	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR	N	S	E	W
12:00 - 12:15	0	134	2	9	252	0	0	0	0	3	0	10	4	0	0	0
12:15 - 12:30	0	118	4	7	222	0	0	0	0	7	0	3	0	0	0	0
12:30 - 12:45	0	125	7	6	261	0	0	0	0	6	0	5	2	0	0	0
12:45 - 13:00	0	90	7	8	258	0	0	0	0	4	0	9	4	0	0	0
13:00 - 13:15	0	82	4	5	277	0	0	0	0	3	0	12	0	0	0	0
13:15 - 13:30	0	106	6	14	259	0	0	0	0	8	0	8	0	0	0	0
13:30 - 13:45	0	122	2	7	233	0	0	0	0	6	0	12	0	0	0	0
13:45 - 14:00	0	121	4	11	228	0	0	0	0	9	0	7	0	0	0	0
14:00 - 14:15	0	143	5	9	242	0	0	0	0	3	0	2	0	0	0	0
14:15 - 14:30	0	182	3	9	262	0	0	0	0	4	0	5	0	0	0	0
14:30 - 14:45	0	154	7	10	255	0	0	0	0	5	0	6	1	0	0	0
14:45 - 15:00	0	135	8	5	253	0	0	0	0	5	0	10	2	0	0	0
15:00 - 15:15	0	147	7	13	284	0	0	0	0	2	0	5	0	0	0	0
15:15 - 15:30	0	163	9	8	284	0	0	0	0	11	0	11	0	0	0	0
15:30 - 15:45	0	124	2	4	302	0	0	0	0	2	0	7	0	0	0	0
15:45 - 16:00	0	159	3	9	305	0	0	0	0	7	0	6	2	0	0	0

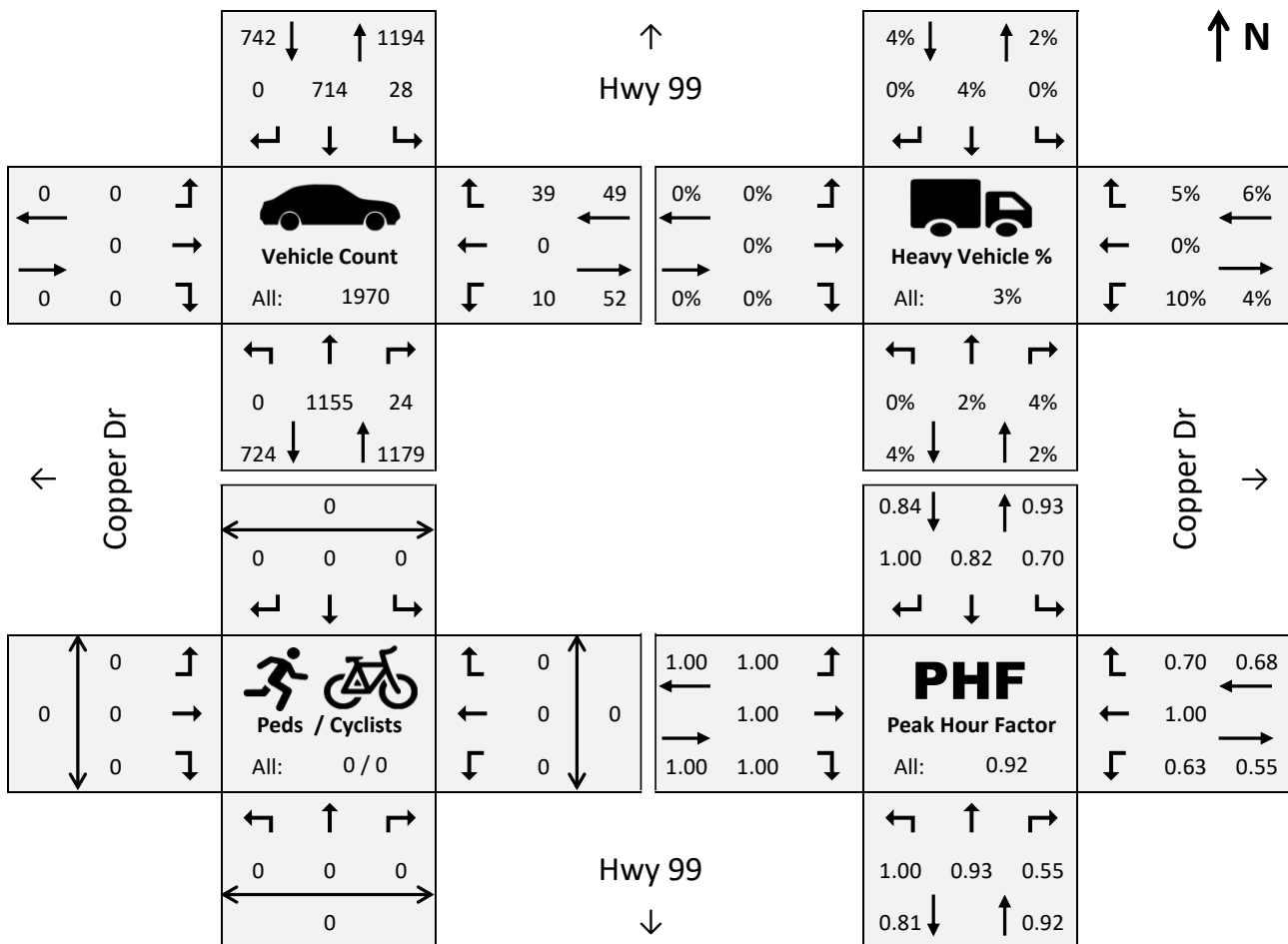


Hwy 99 @ Copper Dr – Squamish, BC

Project#: 04-17-0272 **Weather:** Sunny **Analysis Period:** 16:15 - 17:15
Date: Apr 12, 2019 (Fri) **Road Cond:** Dry **Intersection Peak:** 16:15 - 17:15
Notes:



TIME INTERVAL	AUTOMOBILE COUNT												PEDESTRIANS			
	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR	N	S	E	W
15:00 - 15:15	0	162	7	4	158	0	0	0	0	2	0	6	0	0	0	0
15:15 - 15:30	0	198	11	8	175	0	0	0	0	7	0	7	1	0	1	0
15:30 - 15:45	0	211	4	8	171	0	0	0	0	1	0	6	0	0	0	0
15:45 - 16:00	0	255	8	9	160	0	0	0	0	3	0	6	0	0	0	0
16:00 - 16:15	0	263	3	12	165	0	0	0	0	6	0	10	0	0	0	0
16:15 - 16:30	0	274	11	10	173	0	0	0	0	3	0	11	0	0	0	0
16:30 - 16:45	0	289	5	2	219	0	0	0	0	4	0	14	0	0	0	0
16:45 - 17:00	0	312	7	10	155	0	0	0	0	2	0	8	0	0	0	0
17:00 - 17:15	0	280	1	6	167	0	0	0	0	1	0	6	0	0	0	0
17:15 - 17:30	0	287	5	14	165	0	0	0	0	3	0	3	0	0	1	0
17:30 - 17:45	0	281	6	10	146	0	0	0	0	2	0	7	1	0	0	0
17:45 - 18:00	0	285	9	5	149	0	0	0	0	3	0	15	1	0	1	0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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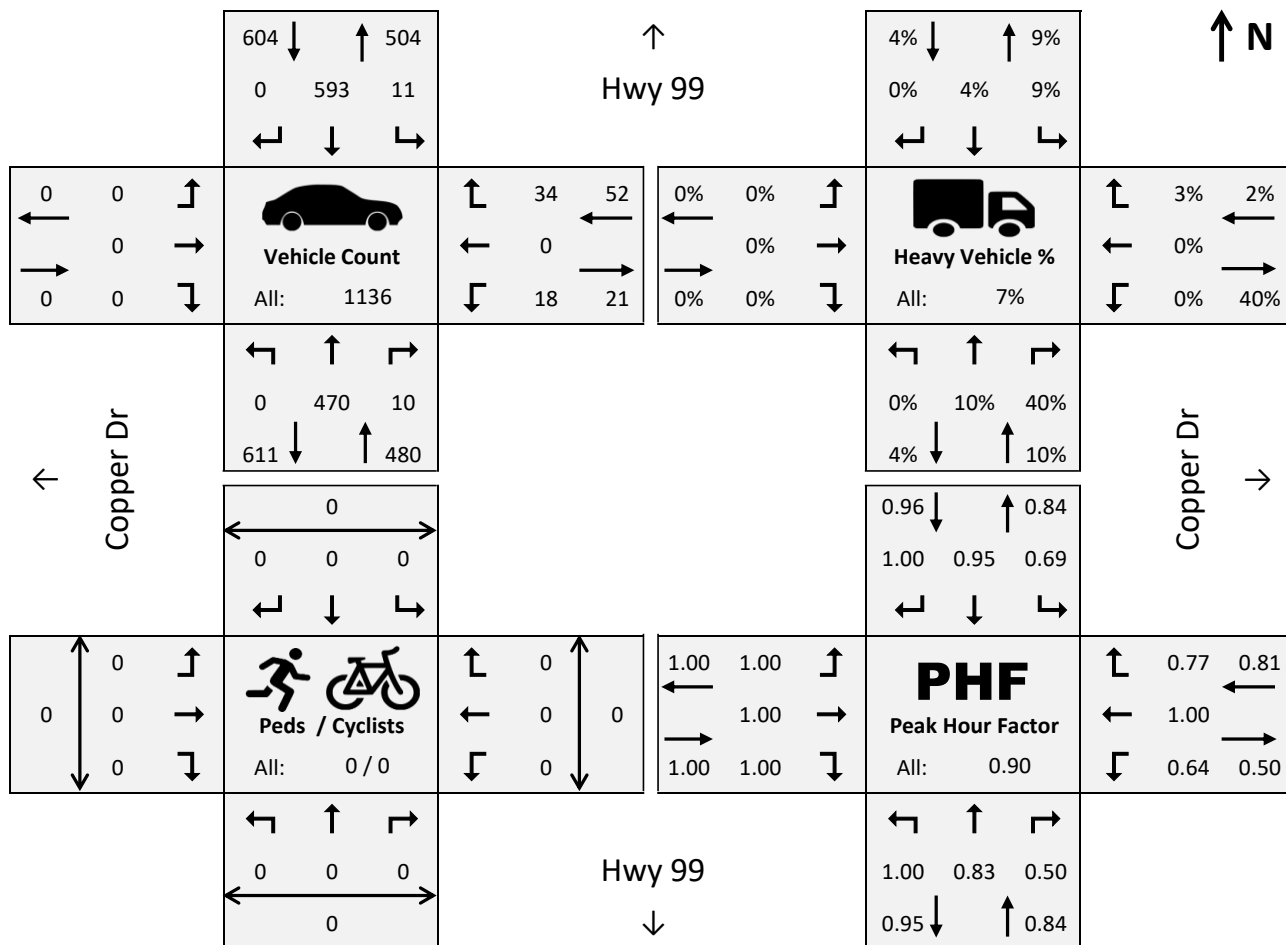


Hwy 99 @ Copper Dr – Squamish, BC

Project#: 04-17-0272 **Weather:** Sunny **Analysis Period:** 7:00 - 8:00
Date: Apr 12, 2019 (Fri) **Road Cond:** Dry **Intersection Peak:** 7:00 - 8:00
Notes:



TIME INTERVAL	AUTOMOBILE COUNT												PEDESTRIANS			
	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR	N	S	E	W
7:00 - 7:15	0	94	2	1	156	0	0	0	0	4	0	6	0	0	0	0
7:15 - 7:30	0	125	1	3	135	0	0	0	0	3	0	8	0	0	0	0
7:30 - 7:45	0	141	2	4	151	0	0	0	0	7	0	9	0	0	0	0
7:45 - 8:00	0	110	5	3	151	0	0	0	0	4	0	11	0	0	0	0
8:00 - 8:15	0	101	2	3	89	0	0	0	0	2	0	4	0	0	0	0
8:15 - 8:30	0	94	1	6	118	0	0	0	0	6	0	10	0	0	0	0
8:30 - 8:45	0	97	2	3	123	0	0	0	0	3	0	16	0	0	0	0
8:45 - 9:00	0	136	2	8	142	0	0	0	0	6	0	11	0	0	0	0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



APPENDIX C

Synchro Results

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	3.0	1.6	1.1
Total Del/Veh (s)	17.9	1.4	5.7	5.3	5.4	3.1	4.1

2: Hwy 99 & Access A Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.8	1.3	1.1

3: Hwy 99 & Access D Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.6	1.2	1.0

Total Network Performance

Denied Del/Veh (s)			1.2
Total Del/Veh (s)			20.8

Queuing and Blocking Report

Existing Sunday

05/14/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	SB	SB
Directions Served	L	T	L	T
Maximum Queue (m)	11.0	33.4	12.3	43.8
Average Queue (m)	4.7	11.8	4.4	15.1
95th Queue (m)	13.1	34.1	12.6	43.4
Link Distance (m)	193.6	496.4		156.9
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (m)			75.0	
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 0

Queues
1: Hwy 99 & Copper Dr

Existing Sunday
05/14/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	23	30	618	22	35	1224
v/c Ratio	0.13	0.16	0.41	0.02	0.05	0.74
Control Delay	36.5	15.8	5.5	2.0	1.8	8.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	36.5	15.8	5.5	2.0	1.8	8.0
Queue Length 50th (m)	3.5	0.0	36.6	0.0	0.7	77.9
Queue Length 95th (m)	10.2	7.6	60.2	1.9	2.3	157.0
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	453	436	1523	1338	638	1663
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.07	0.41	0.02	0.05	0.74
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Existing Sunday
05/14/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	22	29	593	21	34	1175
Future Volume (vph)	22	29	593	21	34	1175
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	1865	1633	1772	1902
Flt Permitted	0.95	1.00	1.00	1.00	0.36	1.00
Satd. Flow (perm)	1738	1585	1865	1633	672	1902
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	23	30	618	22	35	1224
RTOR Reduction (vph)	0	28	0	6	0	0
Lane Group Flow (vph)	23	2	618	16	35	1224
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.6	3.6	52.2	52.2	58.1	58.1
Effective Green, g (s)	3.6	3.6	52.2	52.2	58.1	58.1
Actuated g/C Ratio	0.05	0.05	0.73	0.73	0.81	0.81
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	87	79	1357	1188	573	1541
v/s Ratio Prot	c0.01		0.33		0.00	c0.64
v/s Ratio Perm		0.00		0.01	0.05	
v/c Ratio	0.26	0.02	0.46	0.01	0.06	0.79
Uniform Delay, d1	32.8	32.4	4.0	2.7	1.9	3.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.6	0.1	0.2	0.0	0.0	2.9
Delay (s)	34.4	32.5	4.2	2.7	2.0	6.5
Level of Service	C	C	A	A	A	A
Approach Delay (s)	33.3		4.2			6.4
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			6.4		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.82			
Actuated Cycle Length (s)			71.7		Sum of lost time (s)	14.0
Intersection Capacity Utilization			73.5%		ICU Level of Service	D
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Existing Sunday
05/14/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	614	0	0	1197
Future Volume (Veh/h)	0	0	614	0	0	1197
Sign Control	Stop		Free			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	0	667	0	0	1301
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	1318	667			667	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1318	667			667	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	149	401			919	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	667	0	650	650	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.39	0.00	0.38	0.38	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			36.4%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Existing Sunday
05/14/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	614	1197	0
Future Volume (Veh/h)	0	0	0	614	1197	0
Sign Control	Stop			Free	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	0	0	667	1301	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	1968	650	1301			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1968	650	1301			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	55	411	528			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	667	650	650	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.39	0.38	0.38	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		36.4%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	3.1	0.8	0.4
Total Del/Veh (s)	13.4	1.6	8.5	7.8	7.6	0.9	5.5

2: Hwy 99 & Access A Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	1.0	1.1	1.0

3: Hwy 99 & Access D Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.8	1.0	0.8

Total Network Performance

Denied Del/Veh (s)	1.6
Total Del/Veh (s)	25.3

Queuing and Blocking Report

Existing Fri PM

05/14/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	NB	SB	SB
Directions Served	L	T	R	L	T
Maximum Queue (m)	7.3	49.3	6.6	13.9	15.3
Average Queue (m)	2.4	21.8	0.9	4.6	3.6
95th Queue (m)	8.8	55.5	13.9	14.6	17.5
Link Distance (m)	193.6	496.4			156.9
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (m)			65.0	75.0	
Storage Blk Time (%)		0	0		
Queuing Penalty (veh)		0	0		

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 0

Queues
1: Hwy 99 & Copper Dr

Existing Fri PM
05/14/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	11	42	1255	26	30	776
v/c Ratio	0.08	0.26	0.81	0.02	0.14	0.48
Control Delay	37.1	16.1	14.6	2.1	2.9	3.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	37.1	16.1	14.6	2.1	2.9	3.3
Queue Length 50th (m)	2.0	0.0	143.2	0.3	0.6	28.3
Queue Length 95th (m)	6.2	9.0	#275.5	2.3	2.0	52.6
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	348	345	1559	1329	215	1631
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.12	0.81	0.02	0.14	0.48

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Existing Fri PM
05/14/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	10	39	1155	24	28	714
Future Volume (vph)	10	39	1155	24	28	714
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	1883	1601	1789	1847
Flt Permitted	0.95	1.00	1.00	1.00	0.08	1.00
Satd. Flow (perm)	1789	1601	1883	1601	156	1847
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	42	1255	26	30	776
RTOR Reduction (vph)	0	40	0	5	0	0
Lane Group Flow (vph)	11	2	1255	21	30	776
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	4.0	4.0	66.4	66.4	72.7	72.7
Effective Green, g (s)	4.0	4.0	66.4	66.4	72.7	72.7
Actuated g/C Ratio	0.05	0.05	0.77	0.77	0.84	0.84
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	82	73	1442	1226	174	1548
v/s Ratio Prot	c0.01		c0.67		0.00	c0.42
v/s Ratio Perm		0.00		0.01	0.14	
v/c Ratio	0.13	0.03	0.87	0.02	0.17	0.50
Uniform Delay, d1	39.7	39.5	7.1	2.4	14.1	2.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.1	6.0	0.0	0.5	0.3
Delay (s)	40.4	39.6	13.1	2.4	14.6	2.2
Level of Service	D	D	B	A	B	A
Approach Delay (s)	39.8		12.9			2.7
Approach LOS	D		B			A
Intersection Summary						
HCM 2000 Control Delay			9.7		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.83			
Actuated Cycle Length (s)			86.7		Sum of lost time (s)	14.0
Intersection Capacity Utilization			72.5%		ICU Level of Service	C
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Existing Fri PM
05/14/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						 
Traffic Volume (veh/h)	0	0	1179	0	0	724
Future Volume (Veh/h)	0	0	1179	0	0	724
Sign Control	Stop		Free			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	0	1282	0	0	787
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	1676	1282			1282	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1676	1282			1282	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	86	156			537	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	1282	0	394	394	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.75	0.00	0.23	0.23	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			65.4%		ICU Level of Service	C
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Existing Fri PM
05/14/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1179	724	0
Future Volume (Veh/h)	0	0	0	1179	724	0
Sign Control	Stop			Free	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	0	0	1282	787	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	2069	394	787			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2069	394	787			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	47	606	828			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1282	394	394	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.75	0.23	0.23	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		65.4%		ICU Level of Service		C
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.1	3.7	0.5	0.3
Total Del/Veh (s)	7.0	1.4	4.8	5.4	6.6	1.2	2.9

2: Hwy 99 & Access A Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.7	1.0	0.9

3: Hwy 99 & Access D Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.5	0.9	0.7

Total Network Performance

Denied Del/Veh (s)	0.5
Total Del/Veh (s)	16.3

Queuing and Blocking Report

Existing Fri AM

05/14/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	SB	SB
Directions Served	L	T	L	T
Maximum Queue (m)	9.7	31.0	8.4	25.9
Average Queue (m)	4.2	8.5	1.9	6.4
95th Queue (m)	11.8	29.6	7.5	23.6
Link Distance (m)	193.6	496.4		156.9
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (m)			75.0	
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 0

Queues
1: Hwy 99 & Copper Dr

Existing Fri AM
05/14/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	20	38	522	11	12	659
v/c Ratio	0.07	0.14	0.36	0.01	0.02	0.44
Control Delay	20.1	9.7	6.0	3.5	2.5	4.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	20.1	9.7	6.0	3.5	2.5	4.5
Queue Length 50th (m)	1.5	0.0	15.3	0.0	0.2	21.5
Queue Length 95th (m)	6.4	6.3	55.4	1.8	1.2	41.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	847	756	1877	1596	707	1883
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.05	0.28	0.01	0.02	0.35
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Existing Fri AM
05/14/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	18	34	470	10	11	593
Future Volume (vph)	18	34	470	10	11	593
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	1883	1601	1789	1883
Flt Permitted	0.95	1.00	1.00	1.00	0.38	1.00
Satd. Flow (perm)	1825	1585	1883	1601	713	1883
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	20	38	522	11	12	659
RTOR Reduction (vph)	0	35	0	4	0	0
Lane Group Flow (vph)	20	3	522	7	12	659
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.3	3.3	28.9	28.9	33.8	33.8
Effective Green, g (s)	3.3	3.3	28.9	28.9	33.8	33.8
Actuated g/C Ratio	0.07	0.07	0.61	0.61	0.72	0.72
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	127	111	1155	982	532	1351
v/s Ratio Prot	c0.01		0.28		0.00	c0.35
v/s Ratio Perm		0.00		0.00	0.02	
v/c Ratio	0.16	0.02	0.45	0.01	0.02	0.49
Uniform Delay, d1	20.6	20.4	4.9	3.5	2.3	2.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.3	0.0	0.0	0.3
Delay (s)	21.2	20.5	5.1	3.5	2.4	3.2
Level of Service	C	C	A	A	A	A
Approach Delay (s)	20.7		5.1			3.2
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.8		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.51			
Actuated Cycle Length (s)			47.1		Sum of lost time (s)	14.0
Intersection Capacity Utilization			42.9%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Existing Fri AM
05/14/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	480	0	0	611
Future Volume (Veh/h)	0	0	480	0	0	611
Sign Control	Stop		Free			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	0	522	0	0	664
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	522			522	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	854	522			522	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	298	499			1041	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	522	0	332	332	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.31	0.00	0.20	0.20	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			28.6%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Existing Fri AM
05/14/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	480	611	0
Future Volume (Veh/h)	0	0	0	480	611	0
Sign Control	Stop			Free	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	0	0	522	664	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	1186	332	664			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1186	332	664			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	181	664	921			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	522	332	332	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.31	0.20	0.20	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		28.6%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Total Del/Veh (s)	11.3	1.4	5.4	1.7	4.0	1.2	2.7

2: Hwy 99 & Access A Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.2	0.0	0.0	0.0	0.0	0.0
Total Del/Veh (s)	13.0	1.9	0.5	1.7	5.3	1.6	1.6

3: Hwy 99 & Access D Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.6	1.3	1.1

Total Network Performance

Denied Del/Veh (s)	0.4
Total Del/Veh (s)	18.4

Queuing and Blocking Report

Phase 1 Total Sunday MIT

06/21/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	NB	SB	SB	SB
Directions Served	L	T	T	L	T	T
Maximum Queue (m)	12.7	40.8	7.7	7.8	23.5	19.8
Average Queue (m)	6.0	15.8	1.5	4.2	9.9	6.2
95th Queue (m)	14.8	43.7	16.1	11.7	28.9	22.4
Link Distance (m)	189.9	496.3	496.3		77.9	77.9
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (m)				75.0		
Storage Blk Time (%)			0			
Queuing Penalty (veh)			0			

Intersection: 2: Hwy 99 & Access A

Movement	WB	SB
Directions Served	L	L
Maximum Queue (m)	13.6	7.8
Average Queue (m)	7.8	4.5
95th Queue (m)	16.5	12.1
Link Distance (m)		
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (m)	75.0	75.0
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 0

Queues
1: Hwy 99 & Copper Dr

Phase 1 Total Sunday MIT
06/20/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	26	34	755	25	41	1457
v/c Ratio	0.11	0.14	0.29	0.02	0.07	0.50
Control Delay	22.2	10.5	5.8	3.5	2.6	4.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	22.2	10.5	5.8	3.5	2.6	4.0
Queue Length 50th (m)	2.6	0.0	11.0	0.0	0.8	28.1
Queue Length 95th (m)	8.0	6.2	34.0	2.7	2.8	45.4
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	691	651	3397	1566	620	3614
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.05	0.22	0.02	0.07	0.40
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Total Sunday MIT
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	25	33	725	24	39	1399
Future Volume (vph)	25	33	725	24	39	1399
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.32	1.00
Satd. Flow (perm)	1738	1585	3544	1633	595	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	26	34	755	25	41	1457
RTOR Reduction (vph)	0	32	0	9	0	0
Lane Group Flow (vph)	26	2	755	16	41	1457
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.6	3.6	32.3	32.3	38.4	38.4
Effective Green, g (s)	3.6	3.6	32.3	32.3	38.4	38.4
Actuated g/C Ratio	0.07	0.07	0.62	0.62	0.74	0.74
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	120	109	2201	1014	486	2668
v/s Ratio Prot	c0.01		0.21		0.00	c0.40
v/s Ratio Perm		0.00		0.01	0.06	
v/c Ratio	0.22	0.02	0.34	0.02	0.08	0.55
Uniform Delay, d1	22.9	22.6	4.7	3.8	2.0	3.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.9	0.1	0.1	0.0	0.1	0.2
Delay (s)	23.8	22.6	4.8	3.8	2.1	3.2
Level of Service	C	C	A	A	A	A
Approach Delay (s)	23.1		4.8			3.2
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.2		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.57			
Actuated Cycle Length (s)			52.0		Sum of lost time (s)	14.0
Intersection Capacity Utilization			50.3%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Total Sunday MIT
06/20/2019

								
Movement	WBL	WBR	NBT	NBR	SBL	SBT		
Lane Configurations								
Traffic Volume (veh/h)	37	45	704	43	52	1372		
Future Volume (Veh/h)	37	45	704	43	52	1372		
Sign Control	Stop		Free			Free		
Grade	0%		0%			0%		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92		
Hourly flow rate (vph)	40	49	765	47	57	1491		
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	1624	382			765			
vC1, stage 1 conf vol								
vC2, stage 2 conf vol								
vCu, unblocked vol	1624	382			765			
tC, single (s)	6.8	6.9			4.1			
tC, 2 stage (s)								
tF (s)	3.5	3.3			2.2			
p0 queue free %	54	92			93			
cM capacity (veh/h)	87	616			844			
Direction, Lane #	WB 1	WB 2	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	40	49	382	382	47	57	746	746
Volume Left	40	0	0	0	0	57	0	0
Volume Right	0	49	0	0	47	0	0	0
cSH	87	616	1700	1700	1700	844	1700	1700
Volume to Capacity	0.46	0.08	0.23	0.23	0.03	0.07	0.44	0.44
Queue Length 95th (m)	14.6	2.0	0.0	0.0	0.0	1.6	0.0	0.0
Control Delay (s)	77.7	11.4	0.0	0.0	0.0	9.6	0.0	0.0
Lane LOS	F	B				A		
Approach Delay (s)	41.2		0.0			0.4		
Approach LOS	E							
Intersection Summary								
Average Delay			1.7					
Intersection Capacity Utilization			47.9%		ICU Level of Service		A	
Analysis Period (min)			15					

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 1 Total Sunday MIT
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	747	1409	0
Future Volume (Veh/h)	0	0	0	747	1409	0
Sign Control	Stop			Free	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	0	0	812	1532	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	2344	766	1532			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2344	766	1532			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	30	345	430			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	812	766	766	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.48	0.45	0.45	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			42.6%	ICU Level of Service		A
Analysis Period (min)			15			

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.2	0.1	0.0	0.0	8.4	10.0	6.4
Total Del/Veh (s)	24.0	1.3	5.7	5.2	10.0	10.2	8.8

2: Hwy 99 & Access A Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	0.2	0.0	0.0
Total Del/Veh (s)	18.9	1.7	1.0	1.6	5.9	1.4	1.7

3: Hwy 99 & Access D Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.6	1.3	1.1

Total Network Performance

Denied Del/Veh (s)		6.2
Total Del/Veh (s)		26.9

Queuing and Blocking Report
Phase 1 Total Sunday adjusted

06/20/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	SB	SB
Directions Served	L	T	L	T
Maximum Queue (m)	13.6	35.7	18.4	107.1
Average Queue (m)	6.4	15.8	6.1	46.5
95th Queue (m)	15.3	39.1	22.5	134.7
Link Distance (m)	193.6	496.4		156.9
Upstream Blk Time (%)				2
Queuing Penalty (veh)				0
Storage Bay Dist (m)			75.0	
Storage Blk Time (%)				2
Queuing Penalty (veh)				1

Intersection: 2: Hwy 99 & Access A

Movement	WB	SB
Directions Served	L	L
Maximum Queue (m)	16.2	14.9
Average Queue (m)	8.4	5.8
95th Queue (m)	16.6	15.1
Link Distance (m)		
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (m)	75.0	75.0
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 1

Queues
1: Hwy 99 & Copper Dr

Phase 1 Total Sunday adjusted
06/20/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	26	34	755	25	41	1457
v/c Ratio	0.22	0.24	0.47	0.02	0.07	0.85
Control Delay	46.3	19.4	4.8	1.3	1.3	11.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	46.3	19.4	4.8	1.3	1.3	11.2
Queue Length 50th (m)	5.0	0.0	45.7	0.0	0.7	119.5
Queue Length 95th (m)	12.4	9.0	67.8	1.6	1.8	#318.5
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	117	139	1591	1396	576	1719
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.22	0.24	0.47	0.02	0.07	0.85

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Total Sunday adjusted
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	25	33	725	24	39	1399
Future Volume (vph)	25	33	725	24	39	1399
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	1865	1633	1772	1902
Flt Permitted	0.95	1.00	1.00	1.00	0.31	1.00
Satd. Flow (perm)	1738	1585	1865	1633	579	1902
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	26	34	755	25	41	1457
RTOR Reduction (vph)	0	33	0	6	0	0
Lane Group Flow (vph)	26	1	755	19	41	1457
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	2.5	2.5	64.5	64.5	70.5	70.5
Effective Green, g (s)	2.5	2.5	64.5	64.5	70.5	70.5
Actuated g/C Ratio	0.03	0.03	0.78	0.78	0.85	0.85
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	52	47	1449	1269	520	1615
v/s Ratio Prot	c0.01		0.40		0.00	c0.77
v/s Ratio Perm		0.00		0.01	0.06	
v/c Ratio	0.50	0.02	0.52	0.02	0.08	0.90
Uniform Delay, d1	39.6	39.1	3.5	2.1	1.9	4.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	7.4	0.2	0.3	0.0	0.1	7.4
Delay (s)	47.0	39.3	3.8	2.1	2.0	11.4
Level of Service	D	D	A	A	A	B
Approach Delay (s)	42.6		3.7			11.2
Approach LOS	D		A			B
Intersection Summary						
HCM 2000 Control Delay			9.5		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.94			
Actuated Cycle Length (s)			83.0		Sum of lost time (s)	14.0
Intersection Capacity Utilization			85.3%		ICU Level of Service	E
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Total Sunday adjusted
06/20/2019

							
Movement	WBL	WBR	NBT	NBR	SBL	SBT	
Lane Configurations							
Traffic Volume (veh/h)	37	45	704	43	52	1372	
Future Volume (Veh/h)	37	45	704	43	52	1372	
Sign Control	Stop		Free			Free	
Grade	0%		0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	
Hourly flow rate (vph)	40	49	765	47	57	1491	
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	1624	765			765		
vC1, stage 1 conf vol							
vC2, stage 2 conf vol							
vCu, unblocked vol	1624	765			765		
tC, single (s)	6.8	6.9			4.1		
tC, 2 stage (s)							
tF (s)	3.5	3.3			2.2		
p0 queue free %	54	86			93		
cM capacity (veh/h)	87	346			844		
Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	40	49	765	47	57	746	746
Volume Left	40	0	0	0	57	0	0
Volume Right	0	49	0	47	0	0	0
cSH	87	346	1700	1700	844	1700	1700
Volume to Capacity	0.46	0.14	0.45	0.03	0.07	0.44	0.44
Queue Length 95th (m)	14.6	3.7	0.0	0.0	1.6	0.0	0.0
Control Delay (s)	77.7	17.1	0.0	0.0	9.6	0.0	0.0
Lane LOS	F	C			A		
Approach Delay (s)	44.3		0.0		0.4		
Approach LOS	E						
Intersection Summary							
Average Delay			1.8				
Intersection Capacity Utilization			53.2%		ICU Level of Service		A
Analysis Period (min)			15				

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 1 Total Sunday adjusted
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	747	1409	0
Future Volume (Veh/h)	0	0	0	747	1409	0
Sign Control	Stop			Free	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	0	0	812	1532	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	2344	766	1532			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2344	766	1532			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	30	345	430			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	812	766	766	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.48	0.45	0.45	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		42.6%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Total Del/Veh (s)	20.3	1.5	14.7	4.4	9.7	0.5	8.9

Total Network Performance

Denied Del/Veh (s)	0.1
Total Del/Veh (s)	166.8

Queues
1: Hwy 99 & Copper Dr

Phase 1 Total Friday PM MIT
06/20/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	12	49	1464	30	35	922
v/c Ratio	0.06	0.21	0.52	0.02	0.11	0.31
Control Delay	29.7	12.7	6.4	2.0	2.6	2.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	29.7	12.7	6.4	2.0	2.6	2.4
Queue Length 50th (m)	1.4	0.0	49.3	0.0	0.7	13.7
Queue Length 95th (m)	6.2	9.0	74.0	2.4	2.3	23.3
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	565	539	3162	1418	318	3344
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.09	0.46	0.02	0.11	0.28
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Total Friday PM MIT

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	11	45	1347	28	32	848
Future Volume (vph)	11	45	1347	28	32	848
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.13	1.00
Satd. Flow (perm)	1789	1601	3579	1601	238	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	49	1464	30	35	922
RTOR Reduction (vph)	0	46	0	10	0	0
Lane Group Flow (vph)	12	3	1464	20	35	922
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.3	3.3	41.1	41.1	47.0	47.0
Effective Green, g (s)	3.3	3.3	41.1	41.1	47.0	47.0
Actuated g/C Ratio	0.05	0.05	0.68	0.68	0.78	0.78
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	97	87	2439	1091	234	2735
v/s Ratio Prot	c0.01		c0.41		0.00	c0.26
v/s Ratio Perm		0.00		0.01	0.11	
v/c Ratio	0.12	0.03	0.60	0.02	0.15	0.34
Uniform Delay, d1	27.1	27.0	5.2	3.1	3.1	2.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.4	0.0	0.3	0.1
Delay (s)	27.7	27.1	5.6	3.1	3.4	2.1
Level of Service	C	C	A	A	A	A
Approach Delay (s)	27.2		5.5			2.1
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.8		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.57			
Actuated Cycle Length (s)			60.3		Sum of lost time (s)	14.0
Intersection Capacity Utilization			48.9%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Total Friday PM MIT
06/20/2019

								
Movement	WBL	WBR	NBT	NBR	SBL	SBT		
Lane Configurations								
Traffic Volume (veh/h)	23	23	1351	30	30	830		
Future Volume (Veh/h)	23	23	1351	30	30	830		
Sign Control	Stop		Free			Free		
Grade	0%		0%			0%		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92		
Hourly flow rate (vph)	25	25	1468	33	33	902		
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	1985	734			1468			
vC1, stage 1 conf vol								
vC2, stage 2 conf vol								
vCu, unblocked vol	1985	734			1468			
tC, single (s)	6.8	6.9			4.1			
tC, 2 stage (s)								
tF (s)	3.5	3.3			2.2			
p0 queue free %	49	93			93			
cM capacity (veh/h)	49	363			456			
Direction, Lane #	WB 1	WB 2	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	25	25	734	734	33	33	451	451
Volume Left	25	0	0	0	0	33	0	0
Volume Right	0	25	0	0	33	0	0	0
cSH	49	363	1700	1700	1700	456	1700	1700
Volume to Capacity	0.51	0.07	0.43	0.43	0.02	0.07	0.27	0.27
Queue Length 95th (m)	14.4	1.7	0.0	0.0	0.0	1.8	0.0	0.0
Control Delay (s)	136.5	15.7	0.0	0.0	0.0	13.5	0.0	0.0
Lane LOS	F	C				B		
Approach Delay (s)	76.1		0.0			0.5		
Approach LOS	F							
Intersection Summary								
Average Delay	1.7							
Intersection Capacity Utilization	47.3%				ICU Level of Service			
Analysis Period (min)	15							
	A							

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 1 Total Friday PM MIT
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1381	853	0
Future Volume (Veh/h)	0	0	0	1381	853	0
Sign Control	Stop			Free	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	0	0	1501	927	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	2428	464	927			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2428	464	927			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	27	545	733			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1501	464	464	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.88	0.27	0.27	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		76.0%		ICU Level of Service		D
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	2.9	0.8	0.3
Total Del/Veh (s)	28.1	1.9	13.9	12.1	21.6	1.1	9.1

2: Hwy 99 & Access A Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	0.1	0.0	0.0
Total Del/Veh (s)	54.6	1.6	1.3	1.7	23.6	1.2	2.0

3: Hwy 99 & Access D Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.8	1.0	0.9

Total Network Performance

Denied Del/Veh (s)		2.7
Total Del/Veh (s)		31.3

Queuing and Blocking Report
Phase 1 Total Fri PM adjusted

06/20/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	NB	SB	SB
Directions Served	L	T	R	L	T
Maximum Queue (m)	9.4	89.1	6.7	12.8	17.3
Average Queue (m)	2.7	33.3	1.0	5.9	4.5
95th Queue (m)	9.9	85.2	14.2	14.7	20.0
Link Distance (m)	193.6	496.4			156.9
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (m)			65.0	75.0	
Storage Blk Time (%)		2	0		
Queuing Penalty (veh)		1	0		

Intersection: 2: Hwy 99 & Access A

Movement	WB	SB
Directions Served	L	L
Maximum Queue (m)	13.8	17.3
Average Queue (m)	5.4	6.9
95th Queue (m)	15.4	17.4
Link Distance (m)		
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (m)	75.0	75.0
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 1

Queues
1: Hwy 99 & Copper Dr

Phase 1 Total Fri PM adjusted

06/20/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	12	49	1464	30	35	922
v/c Ratio	0.21	0.49	0.90	0.02	0.22	0.54
Control Delay	52.0	30.8	18.1	1.0	4.0	2.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	52.0	30.8	18.1	1.0	4.0	2.7
Queue Length 50th (m)	2.4	0.0	209.1	0.0	0.5	27.4
Queue Length 95th (m)	7.5	#12.8	#346.7	1.6	1.2	41.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	58	99	1631	1391	157	1694
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.21	0.49	0.90	0.02	0.22	0.54

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Total Fri PM adjusted
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	11	45	1347	28	32	848
Future Volume (vph)	11	45	1347	28	32	848
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	1883	1601	1789	1847
Flt Permitted	0.95	1.00	1.00	1.00	0.05	1.00
Satd. Flow (perm)	1789	1601	1883	1601	92	1847
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	49	1464	30	35	922
RTOR Reduction (vph)	0	48	0	6	0	0
Lane Group Flow (vph)	12	1	1464	24	35	922
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	1.8	1.8	77.9	77.9	84.2	84.2
Effective Green, g (s)	1.8	1.8	77.9	77.9	84.2	84.2
Actuated g/C Ratio	0.02	0.02	0.81	0.81	0.88	0.88
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	33	30	1527	1299	121	1619
v/s Ratio Prot	c0.01		c0.78		0.01	c0.50
v/s Ratio Perm		0.00		0.02	0.25	
v/c Ratio	0.36	0.03	0.96	0.02	0.29	0.57
Uniform Delay, d1	46.5	46.2	7.7	1.7	32.9	1.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	6.7	0.4	14.3	0.0	1.3	0.5
Delay (s)	53.2	46.7	21.9	1.7	34.2	1.9
Level of Service	D	D	C	A	C	A
Approach Delay (s)	48.0		21.5			3.1
Approach LOS	D		C			A
Intersection Summary						
HCM 2000 Control Delay			15.2		HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio			0.94			
Actuated Cycle Length (s)			96.0		Sum of lost time (s)	14.0
Intersection Capacity Utilization			82.6%		ICU Level of Service	E
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Total Fri PM adjusted
06/20/2019

							
Movement	WBL	WBR	NBT	NBR	SBL	SBT	
Lane Configurations							
Traffic Volume (veh/h)	23	23	1351	30	30	830	
Future Volume (Veh/h)	23	23	1351	30	30	830	
Sign Control	Stop		Free		Free		
Grade	0%		0%		0%		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	
Hourly flow rate (vph)	25	25	1468	33	33	902	
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	1985	1468	1468				
vC1, stage 1 conf vol							
vC2, stage 2 conf vol							
vCu, unblocked vol	1985	1468	1468				
tC, single (s)	6.8	6.9	4.1				
tC, 2 stage (s)							
tF (s)	3.5	3.3	2.2				
p0 queue free %	49	79	93				
cM capacity (veh/h)	49	117	456				
Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	25	25	1468	33	33	451	451
Volume Left	25	0	0	0	33	0	0
Volume Right	0	25	0	33	0	0	0
cSH	49	117	1700	1700	456	1700	1700
Volume to Capacity	0.51	0.21	0.86	0.02	0.07	0.27	0.27
Queue Length 95th (m)	14.4	5.8	0.0	0.0	1.8	0.0	0.0
Control Delay (s)	136.5	44.0	0.0	0.0	13.5	0.0	0.0
Lane LOS	F	E	B				
Approach Delay (s)	90.3		0.0		0.5		
Approach LOS	F						
Intersection Summary							
Average Delay			2.0				
Intersection Capacity Utilization			81.1%	ICU Level of Service		D	
Analysis Period (min)			15				

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 1 Total Fri PM adjusted
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1381	853	0
Future Volume (Veh/h)	0	0	0	1381	853	0
Sign Control	Stop			Free	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	0	0	1501	927	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	2428	464	927			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2428	464	927			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	27	545	733			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1501	464	464	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.88	0.27	0.27	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		76.0%		ICU Level of Service		D
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 1 Total Friday AM MIT
06/20/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	23	43	619	12	14	778
v/c Ratio	0.08	0.14	0.24	0.01	0.02	0.29
Control Delay	16.6	8.1	5.1	4.2	2.9	3.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	16.6	8.1	5.1	4.2	2.9	3.4
Queue Length 50th (m)	1.6	0.0	8.3	0.0	0.3	11.1
Queue Length 95th (m)	5.9	5.8	27.4	2.0	1.4	18.8
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	1072	949	3579	1601	742	3510
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.05	0.17	0.01	0.02	0.22
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Total Friday AM MIT

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			
Traffic Volume (vph)	21	39	557	11	13	700
Future Volume (vph)	21	39	557	11	13	700
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.36	1.00
Satd. Flow (perm)	1825	1585	3579	1601	676	3510
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	23	43	619	12	14	778
RTOR Reduction (vph)	0	40	0	5	0	0
Lane Group Flow (vph)	23	3	619	7	14	778
Heavy Vehicles (%)	0%	3%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.3	3.3	24.5	24.5	29.5	29.5
Effective Green, g (s)	3.3	3.3	24.5	24.5	29.5	29.5
Actuated g/C Ratio	0.08	0.08	0.57	0.57	0.69	0.69
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	140	122	2048	916	491	2419
v/s Ratio Prot	c0.01		0.17		0.00	c0.22
v/s Ratio Perm		0.00		0.00	0.02	
v/c Ratio	0.16	0.03	0.30	0.01	0.03	0.32
Uniform Delay, d1	18.5	18.3	4.7	3.9	2.3	2.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.1	0.0	0.0	0.1
Delay (s)	19.0	18.4	4.8	3.9	2.3	2.7
Level of Service	B	B	A	A	A	A
Approach Delay (s)	18.6		4.8			2.7
Approach LOS	B		A			A
Intersection Summary						
HCM 2000 Control Delay			4.3		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.35			
Actuated Cycle Length (s)			42.8		Sum of lost time (s)	14.0
Intersection Capacity Utilization			31.0%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Total Friday AM MIT
06/20/2019

								
Movement	WBL	WBR	NBT	NBR	SBL	SBT		
Lane Configurations								
Traffic Volume (veh/h)	19	19	550	20	20	700		
Future Volume (Veh/h)	19	19	550	20	20	700		
Sign Control	Stop		Free			Free		
Grade	0%		0%			0%		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92		
Hourly flow rate (vph)	21	21	598	22	22	761		
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	1022	299			598			
vC1, stage 1 conf vol								
vC2, stage 2 conf vol								
vCu, unblocked vol	1022	299			598			
tC, single (s)	6.8	6.9			4.1			
tC, 2 stage (s)								
tF (s)	3.5	3.3			2.2			
p0 queue free %	91	97			98			
cM capacity (veh/h)	227	697			975			
Direction, Lane #	WB 1	WB 2	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	21	21	299	299	22	22	380	380
Volume Left	21	0	0	0	0	22	0	0
Volume Right	0	21	0	0	22	0	0	0
cSH	227	697	1700	1700	1700	975	1700	1700
Volume to Capacity	0.09	0.03	0.18	0.18	0.01	0.02	0.22	0.22
Queue Length 95th (m)	2.3	0.7	0.0	0.0	0.0	0.5	0.0	0.0
Control Delay (s)	22.5	10.3	0.0	0.0	0.0	8.8	0.0	0.0
Lane LOS	C	B				A		
Approach Delay (s)	16.4		0.0			0.2		
Approach LOS	C							
Intersection Summary								
Average Delay			0.6					
Intersection Capacity Utilization			29.3%		ICU Level of Service		A	
Analysis Period (min)			15					

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 1 Total Friday AM MIT
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	570	719	0
Future Volume (Veh/h)	0	0	0	570	719	0
Sign Control	Stop			Free	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	0	0	620	782	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	1402	391	782			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1402	391	782			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	131	608	832			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	620	391	391	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.36	0.23	0.23	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		33.3%		ICU Level of Service		A
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 1 Total Fri AM
06/20/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	23	43	619	12	14	778
v/c Ratio	0.09	0.16	0.42	0.01	0.02	0.51
Control Delay	21.8	10.0	5.8	2.9	2.5	5.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.8	10.0	5.8	2.9	2.5	5.0
Queue Length 50th (m)	2.0	0.0	19.9	0.0	0.3	28.7
Queue Length 95th (m)	7.2	6.9	64.1	1.7	1.3	55.4
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	708	641	1882	1600	591	1883
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.07	0.33	0.01	0.02	0.41
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Total Fri AM
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	21	39	557	11	13	700
Future Volume (vph)	21	39	557	11	13	700
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	1883	1601	1789	1883
Flt Permitted	0.95	1.00	1.00	1.00	0.33	1.00
Satd. Flow (perm)	1825	1585	1883	1601	620	1883
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	23	43	619	12	14	778
RTOR Reduction (vph)	0	40	0	4	0	0
Lane Group Flow (vph)	23	3	619	8	14	778
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.4	3.4	31.9	31.9	36.5	36.5
Effective Green, g (s)	3.4	3.4	31.9	31.9	36.5	36.5
Actuated g/C Ratio	0.07	0.07	0.64	0.64	0.73	0.73
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	124	107	1203	1023	467	1377
v/s Ratio Prot	c0.01		0.33		0.00	c0.41
v/s Ratio Perm		0.00		0.00	0.02	
v/c Ratio	0.19	0.03	0.51	0.01	0.03	0.56
Uniform Delay, d1	21.9	21.7	4.8	3.3	2.5	3.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.1	0.4	0.0	0.0	0.5
Delay (s)	22.7	21.8	5.2	3.3	2.6	3.6
Level of Service	C	C	A	A	A	A
Approach Delay (s)	22.1		5.2			3.6
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			5.1		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.59			
Actuated Cycle Length (s)			49.9		Sum of lost time (s)	14.0
Intersection Capacity Utilization			48.5%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Total Fri AM
06/20/2019

							
Movement	WBL	WBR	NBT	NBR	SBL	SBT	
Lane Configurations							
Traffic Volume (veh/h)	19	19	550	20	20	700	
Future Volume (Veh/h)	19	19	550	20	20	700	
Sign Control	Stop		Free			Free	
Grade	0%		0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	
Hourly flow rate (vph)	21	21	598	22	22	761	
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	1022	598			598		
vC1, stage 1 conf vol							
vC2, stage 2 conf vol							
vCu, unblocked vol	1022	598			598		
tC, single (s)	6.8	6.9			4.1		
tC, 2 stage (s)							
tF (s)	3.5	3.3			2.2		
p0 queue free %	91	95			98		
cM capacity (veh/h)	227	445			975		
Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	21	21	598	22	22	380	380
Volume Left	21	0	0	0	22	0	0
Volume Right	0	21	0	22	0	0	0
cSH	227	445	1700	1700	975	1700	1700
Volume to Capacity	0.09	0.05	0.35	0.01	0.02	0.22	0.22
Queue Length 95th (m)	2.3	1.1	0.0	0.0	0.5	0.0	0.0
Control Delay (s)	22.5	13.5	0.0	0.0	8.8	0.0	0.0
Lane LOS	C	B			A		
Approach Delay (s)	18.0		0.0		0.2		
Approach LOS	C						
Intersection Summary							
Average Delay			0.7				
Intersection Capacity Utilization			38.9%		ICU Level of Service		A
Analysis Period (min)			15				

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 1 Total Fri AM
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	570	719	0
Future Volume (Veh/h)	0	0	0	570	719	0
Sign Control	Stop			Free	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	0	0	620	782	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	1402	391	782			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1402	391	782			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	131	608	832			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	620	391	391	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.36	0.23	0.23	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		33.3%		ICU Level of Service		A
Analysis Period (min)		15				

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	26	34	708	25	41	1403
v/c Ratio	0.10	0.13	0.27	0.02	0.06	0.48
Control Delay	21.2	10.0	6.0	3.7	2.7	4.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.2	10.0	6.0	3.7	2.7	4.0
Queue Length 50th (m)	2.5	0.0	10.1	0.0	0.8	26.2
Queue Length 95th (m)	7.8	6.1	31.6	2.8	2.8	42.6
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	718	674	3444	1588	641	3614
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.05	0.21	0.02	0.06	0.39
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Background Sunday MIT

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	25	33	680	24	39	1347
Future Volume (vph)	25	33	680	24	39	1347
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.34	1.00
Satd. Flow (perm)	1738	1585	3544	1633	627	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	26	34	708	25	41	1403
RTOR Reduction (vph)	0	32	0	10	0	0
Lane Group Flow (vph)	26	2	708	15	41	1403
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.6	3.6	30.6	30.6	36.8	36.8
Effective Green, g (s)	3.6	3.6	30.6	30.6	36.8	36.8
Actuated g/C Ratio	0.07	0.07	0.61	0.61	0.73	0.73
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	124	113	2151	991	507	2638
v/s Ratio Prot	c0.01		0.20		0.00	c0.39
v/s Ratio Perm		0.00		0.01	0.06	
v/c Ratio	0.21	0.02	0.33	0.02	0.08	0.53
Uniform Delay, d1	22.1	21.8	4.9	3.9	2.1	3.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.8	0.1	0.1	0.0	0.1	0.2
Delay (s)	22.9	21.8	5.0	3.9	2.1	3.2
Level of Service	C	C	A	A	A	A
Approach Delay (s)	22.3		4.9			3.2
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.3		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.56			
Actuated Cycle Length (s)			50.4		Sum of lost time (s)	14.0
Intersection Capacity Utilization			48.9%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Background Sunday MIT
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	704	0	0	1372
Future Volume (Veh/h)	0	0	704	0	0	1372
Sign Control	Stop		Free			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	0	765	0	0	1491
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	1510	765			765	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1510	765			765	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	111	346			844	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	765	0	746	746	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.45	0.00	0.44	0.44	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			41.3%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 1 Background Sunday MIT
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	704	1372	0
Future Volume (Veh/h)	0	0	0	704	1372	0
Sign Control	Stop			Free	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	0	0	765	1491	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	2256	746	1491			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2256	746	1491			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	35	356	446			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	765	746	746	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.45	0.44	0.44	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		41.3%		ICU Level of Service		A
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 1 Background Sunday
06/20/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	26	34	708	25	41	1403
v/c Ratio	0.19	0.22	0.46	0.02	0.07	0.84
Control Delay	38.8	15.9	5.9	1.8	1.8	12.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	38.8	15.9	5.9	1.8	1.8	12.7
Queue Length 50th (m)	4.4	0.0	45.4	0.0	0.9	122.8
Queue Length 95th (m)	10.9	7.9	74.9	2.1	2.6	#295.6
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	327	326	1530	1344	582	1667
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.08	0.10	0.46	0.02	0.07	0.84

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Background Sunday
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	25	33	680	24	39	1347
Future Volume (vph)	25	33	680	24	39	1347
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	1865	1633	1772	1902
Flt Permitted	0.95	1.00	1.00	1.00	0.33	1.00
Satd. Flow (perm)	1738	1585	1865	1633	609	1902
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	26	34	708	25	41	1403
RTOR Reduction (vph)	0	32	0	6	0	0
Lane Group Flow (vph)	26	2	708	19	41	1403
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	4.5	4.5	67.7	67.7	74.1	74.1
Effective Green, g (s)	4.5	4.5	67.7	67.7	74.1	74.1
Actuated g/C Ratio	0.05	0.05	0.76	0.76	0.84	0.84
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	88	80	1425	1247	540	1590
v/s Ratio Prot	c0.01		0.38		0.00	c0.74
v/s Ratio Perm		0.00		0.01	0.06	
v/c Ratio	0.30	0.02	0.50	0.02	0.08	0.88
Uniform Delay, d1	40.5	40.0	4.0	2.5	2.2	4.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.9	0.1	0.3	0.0	0.1	6.1
Delay (s)	42.4	40.1	4.2	2.5	2.2	10.7
Level of Service	D	D	A	A	A	B
Approach Delay (s)	41.1		4.2			10.4
Approach LOS	D		A			B
Intersection Summary						
HCM 2000 Control Delay			9.2		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.89			
Actuated Cycle Length (s)			88.6		Sum of lost time (s)	14.0
Intersection Capacity Utilization			82.6%		ICU Level of Service	E
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Background Sunday
06/20/2019

							
Movement	WBL	WBR	NBT	NBR	SBL	SBT	
Lane Configurations							
Traffic Volume (veh/h)	0	0	704	0	0	1372	
Future Volume (Veh/h)	0	0	704	0	0	1372	
Sign Control	Stop		Free			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	0	765	0	0	1491	
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	1510	765			765		
vC1, stage 1 conf vol							
vC2, stage 2 conf vol							
vCu, unblocked vol	1510	765			765		
tC, single (s)	6.8	6.9			4.1		
tC, 2 stage (s)							
tF (s)	3.5	3.3			2.2		
p0 queue free %	100	100			100		
cM capacity (veh/h)	111	346			844		
Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	0	0	765	0	0	746	746
Volume Left	0	0	0	0	0	0	0
Volume Right	0	0	0	0	0	0	0
cSH	1700	1700	1700	1700	1700	1700	1700
Volume to Capacity	0.00	0.00	0.45	0.00	0.00	0.44	0.44
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lane LOS	A	A					
Approach Delay (s)	0.0		0.0		0.0		
Approach LOS	A						
Intersection Summary							
Average Delay			0.0				
Intersection Capacity Utilization			41.3%		ICU Level of Service		A
Analysis Period (min)			15				

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 1 Background Sunday
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	704	1372	0
Future Volume (Veh/h)	0	0	0	704	1372	0
Sign Control	Stop			Free	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	0	0	765	1491	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	2256	746	1491			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2256	746	1491			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	35	356	446			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	765	746	746	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.45	0.44	0.44	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		41.3%		ICU Level of Service		A
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 1 Background Friday PM MIT
06/19/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	12	49	1439	30	35	889
v/c Ratio	0.06	0.21	0.51	0.02	0.11	0.30
Control Delay	29.1	12.4	6.3	2.1	2.6	2.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	29.1	12.4	6.3	2.1	2.6	2.4
Queue Length 50th (m)	1.4	0.0	47.8	0.0	0.7	13.1
Queue Length 95th (m)	6.1	8.9	72.0	2.4	2.3	22.2
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	570	543	3186	1429	324	3371
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.09	0.45	0.02	0.11	0.26
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Background Friday PM MIT

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	11	45	1324	28	32	818
Future Volume (vph)	11	45	1324	28	32	818
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.13	1.00
Satd. Flow (perm)	1789	1601	3579	1601	246	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	49	1439	30	35	889
RTOR Reduction (vph)	0	46	0	10	0	0
Lane Group Flow (vph)	12	3	1439	20	35	889
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.3	3.3	40.4	40.4	46.3	46.3
Effective Green, g (s)	3.3	3.3	40.4	40.4	46.3	46.3
Actuated g/C Ratio	0.06	0.06	0.68	0.68	0.78	0.78
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	99	88	2426	1085	240	2726
v/s Ratio Prot	c0.01		c0.40		0.00	c0.25
v/s Ratio Perm		0.00		0.01	0.11	
v/c Ratio	0.12	0.03	0.59	0.02	0.15	0.33
Uniform Delay, d1	26.8	26.6	5.2	3.1	3.1	2.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.4	0.0	0.3	0.1
Delay (s)	27.3	26.8	5.6	3.1	3.4	2.1
Level of Service	C	C	A	A	A	A
Approach Delay (s)	26.9		5.5			2.1
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.8		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.56			
Actuated Cycle Length (s)			59.6		Sum of lost time (s)	14.0
Intersection Capacity Utilization			48.3%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis 2: Hwy 99 & Access A

Phase 1 Background Friday PM MIT
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	1351	0	0	830
Future Volume (Veh/h)	0	0	1351	0	0	830
Sign Control	Stop		Free			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	0	1468	0	0	902
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	1919	1468			1468	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1919	1468			1468	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	59	117			456	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	1468	0	451	451	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.86	0.00	0.27	0.27	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			74.4%	ICU Level of Service		D
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 1 Background Friday PM MIT
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1351	830	0
Future Volume (Veh/h)	0	0	0	1351	830	0
Sign Control	Stop			Free	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	0	0	1468	902	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	2370	451	902			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2370	451	902			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	29	556	749			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1468	451	451	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.86	0.27	0.27	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		74.4%		ICU Level of Service		D
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 1 Background Fri PM

06/20/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	12	49	1439	30	35	889
v/c Ratio	0.09	0.29	0.93	0.02	0.20	0.55
Control Delay	36.6	15.6	24.5	2.3	4.1	4.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	36.6	15.6	24.5	2.3	4.1	4.1
Queue Length 50th (m)	2.0	0.0	~275.4	0.4	0.7	36.3
Queue Length 95th (m)	6.6	9.6	#339.9	2.7	2.3	70.2
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	351	354	1551	1323	176	1626
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.14	0.93	0.02	0.20	0.55

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.

Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Background Fri PM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	11	45	1324	28	32	818
Future Volume (vph)	11	45	1324	28	32	818
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	1883	1601	1789	1847
Flt Permitted	0.95	1.00	1.00	1.00	0.06	1.00
Satd. Flow (perm)	1789	1601	1883	1601	109	1847
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	49	1439	30	35	889
RTOR Reduction (vph)	0	47	0	5	0	0
Lane Group Flow (vph)	12	2	1439	25	35	889
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	4.0	4.0	65.2	65.2	71.5	71.5
Effective Green, g (s)	4.0	4.0	65.2	65.2	71.5	71.5
Actuated g/C Ratio	0.05	0.05	0.76	0.76	0.84	0.84
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	83	74	1435	1220	136	1544
v/s Ratio Prot	c0.01		c0.76		0.01	c0.48
v/s Ratio Perm		0.00		0.02	0.21	
v/c Ratio	0.14	0.03	1.00	0.02	0.26	0.58
Uniform Delay, d1	39.1	38.9	10.1	2.4	26.5	2.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.8	0.2	24.4	0.0	1.0	0.5
Delay (s)	39.9	39.1	34.6	2.5	27.5	2.7
Level of Service	D	D	C	A	C	A
Approach Delay (s)	39.2		33.9			3.7
Approach LOS	D		C			A
Intersection Summary						
HCM 2000 Control Delay			22.7		HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio			0.95			
Actuated Cycle Length (s)			85.5		Sum of lost time (s)	14.0
Intersection Capacity Utilization			81.4%		ICU Level of Service	D
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Background Fri PM

06/20/2019

							
Movement	WBL	WBR	NBT	NBR	SBL	SBT	
Lane Configurations							
Traffic Volume (veh/h)	0	0	1351	0	0	830	
Future Volume (Veh/h)	0	0	1351	0	0	830	
Sign Control	Stop		Free			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	0	1468	0	0	902	
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	1919	1468			1468		
vC1, stage 1 conf vol							
vC2, stage 2 conf vol							
vCu, unblocked vol	1919	1468			1468		
tC, single (s)	6.8	6.9			4.1		
tC, 2 stage (s)							
tF (s)	3.5	3.3			2.2		
p0 queue free %	100	100			100		
cM capacity (veh/h)	59	117			456		
Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	0	0	1468	0	0	451	451
Volume Left	0	0	0	0	0	0	0
Volume Right	0	0	0	0	0	0	0
cSH	1700	1700	1700	1700	1700	1700	1700
Volume to Capacity	0.00	0.00	0.86	0.00	0.00	0.27	0.27
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lane LOS	A	A					
Approach Delay (s)	0.0		0.0		0.0		
Approach LOS	A						
Intersection Summary							
Average Delay			0.0				
Intersection Capacity Utilization			74.4%		ICU Level of Service		D
Analysis Period (min)			15				

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 1 Background Fri PM

06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1351	830	0
Future Volume (Veh/h)	0	0	0	1351	830	0
Sign Control	Stop			Free	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	0	0	1468	902	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	2370	451	902			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2370	451	902			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	29	556	749			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1468	451	451	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.86	0.27	0.27	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		74.4%		ICU Level of Service		D
Analysis Period (min)		15				

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	23	43	599	12	14	756
v/c Ratio	0.07	0.14	0.23	0.01	0.02	0.28
Control Delay	16.0	7.8	5.2	4.4	3.0	3.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	16.0	7.8	5.2	4.4	3.0	3.4
Queue Length 50th (m)	1.6	0.0	8.0	0.0	0.3	10.7
Queue Length 95th (m)	5.7	5.7	26.7	2.1	1.4	18.4
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	1137	1004	3579	1601	747	3510
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.04	0.17	0.01	0.02	0.22
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Background Friday AM MIT

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	21	39	539	11	13	680
Future Volume (vph)	21	39	539	11	13	680
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.36	1.00
Satd. Flow (perm)	1825	1585	3579	1601	687	3510
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	23	43	599	12	14	756
RTOR Reduction (vph)	0	40	0	5	0	0
Lane Group Flow (vph)	23	3	599	7	14	756
Heavy Vehicles (%)	0%	3%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.4	3.4	23.9	23.9	28.9	28.9
Effective Green, g (s)	3.4	3.4	23.9	23.9	28.9	28.9
Actuated g/C Ratio	0.08	0.08	0.57	0.57	0.68	0.68
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	146	127	2022	904	495	2398
v/s Ratio Prot	c0.01		0.17		0.00	c0.22
v/s Ratio Perm		0.00		0.00	0.02	
v/c Ratio	0.16	0.03	0.30	0.01	0.03	0.32
Uniform Delay, d1	18.1	17.9	4.8	4.0	2.3	2.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.1	0.1	0.0	0.0	0.1
Delay (s)	18.6	18.0	4.9	4.0	2.4	2.8
Level of Service	B	B	A	A	A	A
Approach Delay (s)	18.2		4.9			2.8
Approach LOS	B		A			A
Intersection Summary						
HCM 2000 Control Delay			4.4		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.34			
Actuated Cycle Length (s)			42.3		Sum of lost time (s)	14.0
Intersection Capacity Utilization			30.5%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis 2: Hwy 99 & Access A

Phase 1 Background Friday AM MIT
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	550	0	0	700
Future Volume (Veh/h)	0	0	550	0	0	700
Sign Control	Stop		Free			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	0	598	0	0	761
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	978	598			598	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	978	598			598	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	248	445			975	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	598	0	380	380	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.35	0.00	0.22	0.22	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			32.3%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 1 Background Friday AM MIT

06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	550	700	0
Future Volume (Veh/h)	0	0	0	550	700	0
Sign Control	Stop			Free	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	0	0	598	761	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	1359	380	761			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1359	380	761			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	140	617	847			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	598	380	380	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.35	0.22	0.22	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		32.3%		ICU Level of Service		A
Analysis Period (min)		15				

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	23	43	599	12	14	756
v/c Ratio	0.08	0.16	0.41	0.01	0.02	0.50
Control Delay	20.9	9.7	5.8	3.0	2.5	5.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	20.9	9.7	5.8	3.0	2.5	5.0
Queue Length 50th (m)	1.9	0.0	18.8	0.0	0.3	27.1
Queue Length 95th (m)	7.0	6.7	61.6	1.7	1.3	52.9
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	766	690	1883	1601	601	1883
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.06	0.32	0.01	0.02	0.40
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 1 Background Fri AM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	21	39	539	11	13	680
Future Volume (vph)	21	39	539	11	13	680
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	1883	1601	1789	1883
Flt Permitted	0.95	1.00	1.00	1.00	0.34	1.00
Satd. Flow (perm)	1825	1585	1883	1601	636	1883
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	23	43	599	12	14	756
RTOR Reduction (vph)	0	40	0	4	0	0
Lane Group Flow (vph)	23	3	599	8	14	756
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.4	3.4	30.8	30.8	35.4	35.4
Effective Green, g (s)	3.4	3.4	30.8	30.8	35.4	35.4
Actuated g/C Ratio	0.07	0.07	0.63	0.63	0.73	0.73
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	127	110	1188	1010	475	1365
v/s Ratio Prot	c0.01		0.32		0.00	c0.40
v/s Ratio Perm		0.00		0.00	0.02	
v/c Ratio	0.18	0.03	0.50	0.01	0.03	0.55
Uniform Delay, d1	21.4	21.2	4.9	3.3	2.5	3.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.1	0.3	0.0	0.0	0.5
Delay (s)	22.1	21.3	5.2	3.3	2.5	3.6
Level of Service	C	C	A	A	A	A
Approach Delay (s)	21.5		5.2			3.5
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			5.1		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.58			
Actuated Cycle Length (s)			48.8		Sum of lost time (s)	14.0
Intersection Capacity Utilization			47.5%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 1 Background Fri AM

06/20/2019

							
Movement	WBL	WBR	NBT	NBR	SBL	SBT	
Lane Configurations							
Traffic Volume (veh/h)	0	0	550	0	0	700	
Future Volume (Veh/h)	0	0	550	0	0	700	
Sign Control	Stop		Free			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	0	598	0	0	761	
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	978	598			598		
vC1, stage 1 conf vol							
vC2, stage 2 conf vol							
vCu, unblocked vol	978	598			598		
tC, single (s)	6.8	6.9			4.1		
tC, 2 stage (s)							
tF (s)	3.5	3.3			2.2		
p0 queue free %	100	100			100		
cM capacity (veh/h)	248	445			975		
Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	0	0	598	0	0	380	380
Volume Left	0	0	0	0	0	0	0
Volume Right	0	0	0	0	0	0	0
cSH	1700	1700	1700	1700	1700	1700	1700
Volume to Capacity	0.00	0.00	0.35	0.00	0.00	0.22	0.22
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lane LOS	A	A					
Approach Delay (s)	0.0		0.0		0.0		
Approach LOS	A						
Intersection Summary							
Average Delay			0.0				
Intersection Capacity Utilization			32.3%		ICU Level of Service		A
Analysis Period (min)			15				

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 1 Background Fri AM

06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	550	700	0
Future Volume (Veh/h)	0	0	0	550	700	0
Sign Control	Stop			Free	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	0	0	598	761	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	1359	380	761			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1359	380	761			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	140	617	847			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	598	380	380	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.35	0.22	0.22	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		32.3%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	10.7	10.0	6.3
Total Del/Veh (s)	17.9	1.4	6.1	4.9	11.2	8.4	7.6

2: Hwy 99 & Access A Performance by movement

Movement	WBR	NBT	NBR	SBT	All
Denied Del/Veh (s)	0.1	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.0	1.2	1.8	1.3	1.3

3: Hwy 99 & Access D Performance by movement

Movement	EBR	NBT	SBT	SBR	All
Denied Del/Veh (s)	0.1	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.0	0.7	1.5	2.9	1.3

Total Network Performance

Denied Del/Veh (s)	6.1
Total Del/Veh (s)	26.4

Queuing and Blocking Report
Phase 2 Total Sunday

06/20/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	B18	SB	SB
Directions Served	L	T	T	L	T
Maximum Queue (m)	11.2	43.3	38.9	11.7	88.6
Average Queue (m)	4.7	17.1	5.6	5.3	28.1
95th Queue (m)	13.3	41.2	81.7	14.0	93.0
Link Distance (m)	193.6	496.4	384.2		156.9
Upstream Blk Time (%)			0		1
Queuing Penalty (veh)			0		0
Storage Bay Dist (m)				75.0	
Storage Blk Time (%)					1
Queuing Penalty (veh)					0

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Queuing and Blocking Report

Phase 2 Total Sunday

06/20/2019

Intersection: 12: Bend

Movement	SE
Directions Served	T
Maximum Queue (m)	1.7
Average Queue (m)	0.2
95th Queue (m)	3.5
Link Distance (m)	75.8
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (m)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Network Summary

Network wide Queuing Penalty: 1

Queues
1: Hwy 99 & Copper Dr

Phase 2 Total Sunday
06/20/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	28	38	822	27	44	1573
v/c Ratio	0.36	0.36	0.53	0.02	0.08	0.94
Control Delay	56.7	23.8	5.2	1.1	1.3	19.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	56.7	23.8	5.2	1.1	1.3	19.1
Queue Length 50th (m)	5.3	0.0	49.7	0.0	0.7	154.6
Queue Length 95th (m)	13.2	9.5	74.2	1.6	1.6	#357.5
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	77	106	1550	1361	524	1679
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.36	0.36	0.53	0.02	0.08	0.94

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 2 Total Sunday
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	27	36	789	26	42	1510
Future Volume (vph)	27	36	789	26	42	1510
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	1865	1633	1772	1902
Flt Permitted	0.95	1.00	1.00	1.00	0.29	1.00
Satd. Flow (perm)	1738	1585	1865	1633	534	1902
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	28	38	822	27	44	1573
RTOR Reduction (vph)	0	37	0	6	0	0
Lane Group Flow (vph)	28	1	822	21	44	1573
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.1	3.1	74.7	74.7	81.1	81.1
Effective Green, g (s)	3.1	3.1	74.7	74.7	81.1	81.1
Actuated g/C Ratio	0.03	0.03	0.79	0.79	0.86	0.86
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	57	52	1478	1294	491	1637
v/s Ratio Prot	c0.02		0.44		0.00	c0.83
v/s Ratio Perm		0.00		0.01	0.07	
v/c Ratio	0.49	0.02	0.56	0.02	0.09	0.96
Uniform Delay, d1	44.8	44.1	3.6	2.0	2.3	5.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	6.5	0.2	0.5	0.0	0.1	14.1
Delay (s)	51.3	44.3	4.1	2.1	2.4	19.3
Level of Service	D	D	A	A	A	B
Approach Delay (s)	47.3		4.0			18.9
Approach LOS	D		A			B
Intersection Summary						
HCM 2000 Control Delay			14.6		HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio			0.99			
Actuated Cycle Length (s)			94.2		Sum of lost time (s)	14.0
Intersection Capacity Utilization			91.1%		ICU Level of Service	F
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 2 Total Sunday
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	62	753	56	0	1537
Future Volume (Veh/h)	0	62	753	56	0	1537
Sign Control	Stop		Free			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	67	818	61	0	1671
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	1654	818			818	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1654	818			818	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	79			100	
cM capacity (veh/h)	89	319			806	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	67	818	61	836	836	
Volume Left	0	0	0	0	0	
Volume Right	67	0	61	0	0	
cSH	319	1700	1700	1700	1700	
Volume to Capacity	0.21	0.48	0.04	0.49	0.49	
Queue Length 95th (m)	5.9	0.0	0.0	0.0	0.0	
Control Delay (s)	19.3	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	19.3	0.0		0.0		
Approach LOS	C					
Intersection Summary						
Average Delay			0.5			
Intersection Capacity Utilization			50.1%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 2 Total Sunday
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	50	0	810	1469	69
Future Volume (Veh/h)	0	50	0	810	1469	69
Sign Control	Stop			Free	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	54	0	880	1597	75
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	2477	798	1597			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2477	798	1597			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	84	100			
cM capacity (veh/h)	25	329	406			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	54	880	798	798	75	
Volume Left	0	0	0	0	0	
Volume Right	54	0	0	0	75	
cSH	329	1700	1700	1700	1700	
Volume to Capacity	0.16	0.52	0.47	0.47	0.04	
Queue Length 95th (m)	4.4	0.0	0.0	0.0	0.0	
Control Delay (s)	18.1	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	18.1	0.0	0.0			
Approach LOS	C					
Intersection Summary						
Average Delay		0.4				
Intersection Capacity Utilization		50.6%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	2.1	0.3	0.2
Total Del/Veh (s)	15.8	1.4	3.9	3.1	4.6	1.5	2.5

2: Hwy 99 & Access A Performance by movement

Movement	WBR	NBT	NBR	SBT	All
Denied Del/Veh (s)	0.2	0.0	0.0	0.0	0.0
Total Del/Veh (s)	1.8	0.6	1.8	1.9	1.5

3: Hwy 99 & Access D Performance by movement

Movement	EBR	NBT	SBT	SBR	All
Denied Del/Veh (s)	0.1	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.1	0.7	1.6	3.0	1.3

Total Network Performance

Denied Del/Veh (s)			0.5	
Total Del/Veh (s)			19.8	

Queuing and Blocking Report

Phase 2 Total Sunday

06/21/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	NB	SB	SB	SB
Directions Served	L	T	T	L	T	T
Maximum Queue (m)	11.0	23.4	28.0	13.1	27.2	22.8
Average Queue (m)	4.8	9.0	11.6	5.7	10.9	7.3
95th Queue (m)	12.9	24.2	28.6	15.1	30.5	22.9
Link Distance (m)	189.9	496.3	496.3		156.9	156.9
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (m)				75.0		
Storage Blk Time (%)						
Queuing Penalty (veh)						

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 0

Queues
1: Hwy 99 & Copper Dr

Phase 2 Total Sunday
06/20/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	28	38	822	27	44	1573
v/c Ratio	0.12	0.15	0.31	0.02	0.08	0.53
Control Delay	24.3	11.2	5.7	2.7	2.6	4.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	24.3	11.2	5.7	2.7	2.6	4.2
Queue Length 50th (m)	2.6	0.0	21.8	0.0	0.9	32.4
Queue Length 95th (m)	9.3	7.1	34.0	2.4	2.9	52.2
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	623	593	3439	1586	535	3601
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.06	0.24	0.02	0.08	0.44
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 2 Total Sunday
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	27	36	789	26	42	1510
Future Volume (vph)	27	36	789	26	42	1510
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.29	1.00
Satd. Flow (perm)	1738	1585	3544	1633	549	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	28	38	822	27	44	1573
RTOR Reduction (vph)	0	35	0	10	0	0
Lane Group Flow (vph)	28	3	822	17	44	1573
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.7	3.7	34.0	34.0	40.1	40.1
Effective Green, g (s)	3.7	3.7	34.0	34.0	40.1	40.1
Actuated g/C Ratio	0.07	0.07	0.63	0.63	0.75	0.75
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	119	109	2239	1032	456	2693
v/s Ratio Prot	c0.02		0.23		0.00	c0.44
v/s Ratio Perm		0.00		0.01	0.07	
v/c Ratio	0.24	0.02	0.37	0.02	0.10	0.58
Uniform Delay, d1	23.7	23.4	4.7	3.7	2.1	3.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.0	0.1	0.1	0.0	0.1	0.3
Delay (s)	24.7	23.5	4.8	3.7	2.2	3.4
Level of Service	C	C	A	A	A	A
Approach Delay (s)	24.0		4.8			3.4
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.4		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.61			
Actuated Cycle Length (s)			53.8		Sum of lost time (s)	14.0
Intersection Capacity Utilization			53.4%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 2 Total Sunday
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	62	753	56	0	1537
Future Volume (Veh/h)	0	62	753	56	0	1537
Sign Control	Stop		Free			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	67	818	61	0	1671
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	1654	409			818	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1654	409			818	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	89			100	
cM capacity (veh/h)	89	592			806	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	67	409	409	61	836	836
Volume Left	0	0	0	0	0	0
Volume Right	67	0	0	61	0	0
cSH	592	1700	1700	1700	1700	1700
Volume to Capacity	0.11	0.24	0.24	0.04	0.49	0.49
Queue Length 95th (m)	2.9	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	11.9	0.0	0.0	0.0	0.0	0.0
Lane LOS	B					
Approach Delay (s)	11.9	0.0			0.0	
Approach LOS	B					
Intersection Summary						
Average Delay			0.3			
Intersection Capacity Utilization			45.8%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 2 Total Sunday
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	50	0	810	1469	69
Future Volume (Veh/h)	0	50	0	810	1469	69
Sign Control	Stop			Free	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	54	0	880	1597	75
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	2477	798	1597			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2477	798	1597			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	84	100			
cM capacity (veh/h)	25	329	406			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	54	880	798	798	75	
Volume Left	0	0	0	0	0	
Volume Right	54	0	0	0	75	
cSH	329	1700	1700	1700	1700	
Volume to Capacity	0.16	0.52	0.47	0.47	0.04	
Queue Length 95th (m)	4.4	0.0	0.0	0.0	0.0	
Control Delay (s)	18.1	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	18.1	0.0	0.0			
Approach LOS	C					
Intersection Summary						
Average Delay		0.4				
Intersection Capacity Utilization		50.6%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	2.8	1.0	0.4
Total Del/Veh (s)	34.2	2.1	25.8	23.0	22.4	1.3	16.4

2: Hwy 99 & Access A Performance by movement

Movement	WBR	NBT	NBR	SBT	All
Denied Del/Veh (s)	0.1	0.0	0.0	0.0	0.0
Total Del/Veh (s)	6.0	2.0	1.9	1.1	1.7

3: Hwy 99 & Access D Performance by movement

Movement	EBR	NBT	SBT	SBR	All
Denied Del/Veh (s)	0.1	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.1	0.8	1.0	2.4	1.0

Total Network Performance

Denied Del/Veh (s)	6.4
Total Del/Veh (s)	39.4

Queuing and Blocking Report

Phase 2 Total Fri PM

06/20/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	WB	NB	NB	SB	SB
Directions Served	L	R	T	R	L	T
Maximum Queue (m)	9.4	3.2	149.2	27.0	14.2	21.4
Average Queue (m)	3.0	0.5	63.9	3.8	7.7	5.1
95th Queue (m)	10.0	6.7	167.4	29.7	16.7	20.8
Link Distance (m)	193.6	193.6	496.4			156.9
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (m)				65.0	75.0	
Storage Blk Time (%)			5	0		
Queuing Penalty (veh)			1	1		

Intersection: 2: Hwy 99 & Access A

Movement	WB
Directions Served	R
Maximum Queue (m)	11.5
Average Queue (m)	0.4
95th Queue (m)	6.5
Link Distance (m)	755.0
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (m)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 3

Queues
1: Hwy 99 & Copper Dr

Phase 2 Total Fri PM
06/20/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	13	52	1593	32	37	1018
v/c Ratio	0.34	0.62	1.00	0.02	0.24	0.61
Control Delay	68.8	44.2	34.4	0.9	4.3	3.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	68.8	44.2	34.4	0.9	4.3	3.4
Queue Length 50th (m)	2.6	0.0	~340.9	0.0	0.4	29.1
Queue Length 95th (m)	#9.5	#16.4	#390.5	1.5	1.0	45.0
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	38	84	1595	1361	155	1659
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.34	0.62	1.00	0.02	0.24	0.61

Intersection Summary

- ~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
- # 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 2 Total Fri PM
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	12	48	1466	29	34	937
Future Volume (vph)	12	48	1466	29	34	937
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	1883	1601	1789	1847
Flt Permitted	0.95	1.00	1.00	1.00	0.05	1.00
Satd. Flow (perm)	1789	1601	1883	1601	91	1847
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	13	52	1593	32	37	1018
RTOR Reduction (vph)	0	51	0	6	0	0
Lane Group Flow (vph)	13	1	1593	26	37	1018
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	1.6	1.6	78.4	78.4	84.8	84.8
Effective Green, g (s)	1.6	1.6	78.4	78.4	84.8	84.8
Actuated g/C Ratio	0.02	0.02	0.81	0.81	0.88	0.88
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	29	26	1531	1302	122	1624
v/s Ratio Prot	c0.01		c0.85		0.01	c0.55
v/s Ratio Perm		0.00		0.02	0.26	
v/c Ratio	0.45	0.03	1.04	0.02	0.30	0.63
Uniform Delay, d1	47.0	46.6	9.0	1.7	33.2	1.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	10.6	0.5	34.3	0.0	1.4	0.8
Delay (s)	57.6	47.2	43.3	1.7	34.6	2.3
Level of Service	E	D	D	A	C	A
Approach Delay (s)	49.2		42.5			3.5
Approach LOS	D		D			A
Intersection Summary						
HCM 2000 Control Delay			27.6		HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio			1.03			
Actuated Cycle Length (s)			96.4		Sum of lost time (s)	14.0
Intersection Capacity Utilization			88.8%		ICU Level of Service	E
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 2 Total Fri PM
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	49	1447	61	0	949
Future Volume (Veh/h)	0	49	1447	61	0	949
Sign Control	Stop		Free			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	53	1573	66	0	1032
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	2089	786			1573	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2089	786			1573	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	84			100	
cM capacity (veh/h)	45	335			415	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	53	786	786	66	516	516
Volume Left	0	0	0	0	0	0
Volume Right	53	0	0	66	0	0
cSH	335	1700	1700	1700	1700	1700
Volume to Capacity	0.16	0.46	0.46	0.04	0.30	0.30
Queue Length 95th (m)	4.2	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	17.8	0.0	0.0	0.0	0.0	0.0
Lane LOS	C					
Approach Delay (s)	17.8	0.0			0.0	
Approach LOS	C					
Intersection Summary						
Average Delay			0.3			
Intersection Capacity Utilization			50.0%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 2 Total Fri PM
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	49	0	1507	888	61
Future Volume (Veh/h)	0	49	0	1507	888	61
Sign Control	Stop			Free	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	53	0	1638	965	66
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	2603	482	965			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2603	482	965			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	90	100			
cM capacity (veh/h)	20	530	709			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	53	1638	482	482	66	
Volume Left	0	0	0	0	0	
Volume Right	53	0	0	0	66	
cSH	530	1700	1700	1700	1700	
Volume to Capacity	0.10	0.96	0.28	0.28	0.04	
Queue Length 95th (m)	2.5	0.0	0.0	0.0	0.0	
Control Delay (s)	12.5	0.0	0.0	0.0	0.0	
Lane LOS	B					
Approach Delay (s)	12.5	0.0	0.0			
Approach LOS	B					
Intersection Summary						
Average Delay			0.2			
Intersection Capacity Utilization			82.6%	ICU Level of Service		E
Analysis Period (min)			15			

Queues
1: Hwy 99 & Copper Dr

Phase 2 Total Fri PM
06/20/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	13	52	1593	32	37	1018
v/c Ratio	0.06	0.23	0.56	0.02	0.13	0.34
Control Delay	32.7	13.5	6.4	1.8	2.7	2.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.7	13.5	6.4	1.8	2.7	2.3
Queue Length 50th (m)	1.7	0.0	57.6	0.0	0.7	16.0
Queue Length 95th (m)	6.9	9.7	84.6	2.4	2.4	26.1
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	530	511	3041	1365	285	3208
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.10	0.52	0.02	0.13	0.32
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 2 Total Fri PM
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	12	48	1466	29	34	937
Future Volume (vph)	12	48	1466	29	34	937
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.11	1.00
Satd. Flow (perm)	1789	1601	3579	1601	201	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	13	52	1593	32	37	1018
RTOR Reduction (vph)	0	49	0	10	0	0
Lane Group Flow (vph)	13	3	1593	22	37	1018
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.4	3.4	45.1	45.1	51.0	51.0
Effective Green, g (s)	3.4	3.4	45.1	45.1	51.0	51.0
Actuated g/C Ratio	0.05	0.05	0.70	0.70	0.79	0.79
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	94	84	2506	1121	206	2779
v/s Ratio Prot	c0.01		c0.45		0.01	c0.29
v/s Ratio Perm		0.00		0.01	0.14	
v/c Ratio	0.14	0.03	0.64	0.02	0.18	0.37
Uniform Delay, d1	29.1	28.9	5.2	2.9	3.6	2.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.2	0.5	0.0	0.4	0.1
Delay (s)	29.8	29.1	5.7	2.9	4.1	2.0
Level of Service	C	C	A	A	A	A
Approach Delay (s)	29.2		5.7			2.1
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.9		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.60			
Actuated Cycle Length (s)			64.4		Sum of lost time (s)	14.0
Intersection Capacity Utilization			52.2%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 2 Total Fri PM
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	49	1447	61	0	949
Future Volume (Veh/h)	0	49	1447	61	0	949
Sign Control	Stop		Free			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	53	1573	66	0	1032
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	2089	786			1573	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2089	786			1573	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	84			100	
cM capacity (veh/h)	45	335			415	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	53	786	786	66	516	516
Volume Left	0	0	0	0	0	0
Volume Right	53	0	0	66	0	0
cSH	335	1700	1700	1700	1700	1700
Volume to Capacity	0.16	0.46	0.46	0.04	0.30	0.30
Queue Length 95th (m)	4.2	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	17.8	0.0	0.0	0.0	0.0	0.0
Lane LOS	C					
Approach Delay (s)	17.8	0.0			0.0	
Approach LOS	C					
Intersection Summary						
Average Delay			0.3			
Intersection Capacity Utilization			50.0%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 2 Total Fri PM
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations					 	
Traffic Volume (veh/h)	0	49	0	1507	888	61
Future Volume (Veh/h)	0	49	0	1507	888	61
Sign Control	Stop			Free	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	53	0	1638	965	66
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	2603	482	965			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2603	482	965			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	90	100			
cM capacity (veh/h)	20	530	709			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	53	1638	482	482	66	
Volume Left	0	0	0	0	0	
Volume Right	53	0	0	0	66	
cSH	530	1700	1700	1700	1700	
Volume to Capacity	0.10	0.96	0.28	0.28	0.04	
Queue Length 95th (m)	2.5	0.0	0.0	0.0	0.0	
Control Delay (s)	12.5	0.0	0.0	0.0	0.0	
Lane LOS	B					
Approach Delay (s)	12.5	0.0	0.0			
Approach LOS	B					
Intersection Summary						
Average Delay		0.2				
Intersection Capacity Utilization		82.6%		ICU Level of Service	E	
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 2 Total Fri AM
06/20/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	24	47	703	13	14	856
v/c Ratio	0.08	0.16	0.27	0.01	0.02	0.31
Control Delay	17.0	8.1	5.1	4.0	2.9	3.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	17.0	8.1	5.1	4.0	2.9	3.4
Queue Length 50th (m)	1.7	0.0	9.8	0.0	0.3	12.6
Queue Length 95th (m)	6.3	6.3	31.7	2.1	1.4	21.2
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	1052	933	3579	1601	713	3579
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.05	0.20	0.01	0.02	0.24
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 2 Total Fri AM
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	22	42	633	12	13	770
Future Volume (vph)	22	42	633	12	13	770
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3579
Flt Permitted	0.95	1.00	1.00	1.00	0.33	1.00
Satd. Flow (perm)	1825	1585	3579	1601	625	3579
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	24	47	703	13	14	856
RTOR Reduction (vph)	0	43	0	5	0	0
Lane Group Flow (vph)	24	4	703	8	14	856
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.4	3.4	25.2	25.2	30.2	30.2
Effective Green, g (s)	3.4	3.4	25.2	25.2	30.2	30.2
Actuated g/C Ratio	0.08	0.08	0.58	0.58	0.69	0.69
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	142	123	2068	925	459	2479
v/s Ratio Prot	c0.01		0.20		0.00	c0.24
v/s Ratio Perm		0.00		0.00	0.02	
v/c Ratio	0.17	0.03	0.34	0.01	0.03	0.35
Uniform Delay, d1	18.8	18.6	4.8	3.9	2.3	2.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.1	0.0	0.0	0.1
Delay (s)	19.3	18.7	4.9	3.9	2.3	2.8
Level of Service	B	B	A	A	A	A
Approach Delay (s)	18.9		4.9			2.8
Approach LOS	B		A			A
Intersection Summary						
HCM 2000 Control Delay			4.4		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.37			
Actuated Cycle Length (s)			43.6		Sum of lost time (s)	14.0
Intersection Capacity Utilization			33.0%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 2 Total Fri AM
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	56	589	42	0	792
Future Volume (Veh/h)	0	56	589	42	0	792
Sign Control	Stop		Free			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	61	640	46	0	861
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	1070	320			640	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1070	320			640	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	91			100	
cM capacity (veh/h)	216	676			940	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	61	320	320	46	430	430
Volume Left	0	0	0	0	0	0
Volume Right	61	0	0	46	0	0
cSH	676	1700	1700	1700	1700	1700
Volume to Capacity	0.09	0.19	0.19	0.03	0.25	0.25
Queue Length 95th (m)	2.3	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	10.9	0.0	0.0	0.0	0.0	0.0
Lane LOS	B					
Approach Delay (s)	10.9	0.0			0.0	
Approach LOS	B					
Intersection Summary						
Average Delay			0.4			
Intersection Capacity Utilization			26.4%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 2 Total Fri AM
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	56	0	631	750	42
Future Volume (Veh/h)	0	56	0	631	750	42
Sign Control	Stop			Free	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	61	0	686	815	46
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	1501	408	815			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1501	408	815			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	90	100			
cM capacity (veh/h)	113	593	808			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	61	686	408	408	46	
Volume Left	0	0	0	0	0	
Volume Right	61	0	0	0	46	
cSH	593	1700	1700	1700	1700	
Volume to Capacity	0.10	0.40	0.24	0.24	0.03	
Queue Length 95th (m)	2.6	0.0	0.0	0.0	0.0	
Control Delay (s)	11.8	0.0	0.0	0.0	0.0	
Lane LOS	B					
Approach Delay (s)	11.8	0.0	0.0			
Approach LOS	B					
Intersection Summary						
Average Delay		0.4				
Intersection Capacity Utilization		36.5%		ICU Level of Service		A
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 2 Background Sunday
06/19/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	28	38	758	27	44	1502
v/c Ratio	0.11	0.15	0.30	0.02	0.08	0.51
Control Delay	22.6	10.5	5.9	2.9	2.7	4.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	22.6	10.5	5.9	2.9	2.7	4.2
Queue Length 50th (m)	2.5	0.0	19.7	0.0	0.9	29.7
Queue Length 95th (m)	8.8	6.8	31.1	2.5	2.9	48.0
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	654	620	3544	1633	564	3614
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.06	0.21	0.02	0.08	0.42
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 2 Background Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	27	36	728	26	42	1442
Future Volume (vph)	27	36	728	26	42	1442
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.32	1.00
Satd. Flow (perm)	1738	1585	3544	1633	590	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	28	38	758	27	44	1502
RTOR Reduction (vph)	0	35	0	10	0	0
Lane Group Flow (vph)	28	3	758	17	44	1502
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.7	3.7	31.5	31.5	37.6	37.6
Effective Green, g (s)	3.7	3.7	31.5	31.5	37.6	37.6
Actuated g/C Ratio	0.07	0.07	0.61	0.61	0.73	0.73
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	125	114	2176	1002	480	2648
v/s Ratio Prot	c0.02		0.21		0.00	c0.42
v/s Ratio Perm		0.00		0.01	0.06	
v/c Ratio	0.22	0.02	0.35	0.02	0.09	0.57
Uniform Delay, d1	22.4	22.1	4.9	3.9	2.1	3.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.9	0.1	0.1	0.0	0.1	0.3
Delay (s)	23.4	22.2	5.0	3.9	2.2	3.4
Level of Service	C	C	A	A	A	A
Approach Delay (s)	22.7		4.9			3.4
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.4		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.59			
Actuated Cycle Length (s)			51.3		Sum of lost time (s)	14.0
Intersection Capacity Utilization			51.5%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 2 Background Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	753	0	0	1469
Future Volume (Veh/h)	0	0	753	0	0	1469
Sign Control	Stop		Free			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	0	818	0	0	1597
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	1616	818			818	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1616	818			818	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	94	319			806	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	818	0	798	798	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.48	0.00	0.47	0.47	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			43.9%	ICU Level of Service		A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 2 Background Sunday
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	753	1469	0
Future Volume (Veh/h)	0	0	0	753	1469	0
Sign Control	Stop			Free	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	0	0	818	1597	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	2415	798	1597			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2415	798	1597			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	27	329	406			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	818	798	798	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.48	0.47	0.47	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		43.9%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	2.9	0.9	0.4
Total Del/Veh (s)	38.5	2.0	17.1	13.4	18.9	1.6	11.3

2: Hwy 99 & Access A Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	1.0	1.2	1.1

3: Hwy 99 & Access D Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.8	1.1	0.9

Total Network Performance

Denied Del/Veh (s)	2.7
Total Del/Veh (s)	32.6

Queuing and Blocking Report
Phase 2 Background Fri PM

06/20/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	NB	SB	SB
Directions Served	L	T	R	L	T
Maximum Queue (m)	12.3	102.0	6.8	17.5	27.7
Average Queue (m)	4.7	42.6	1.0	7.3	7.1
95th Queue (m)	13.8	94.6	14.2	17.5	24.8
Link Distance (m)	193.6	496.4			156.9
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (m)			65.0	75.0	
Storage Blk Time (%)		3	0		
Queuing Penalty (veh)		1	0		

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 1

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	13	52	1540	32	37	952
v/c Ratio	0.23	0.51	0.98	0.02	0.24	0.58
Control Delay	53.0	31.2	29.5	1.0	4.4	3.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	53.0	31.2	29.5	1.0	4.4	3.3
Queue Length 50th (m)	2.5	0.0	~323.2	0.0	0.5	29.2
Queue Length 95th (m)	8.1	#13.2	#374.7	1.6	1.2	44.9
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	57	101	1579	1347	154	1643
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.23	0.51	0.98	0.02	0.24	0.58

Intersection Summary

- ~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
- # 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 2 Background Fri PM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	12	48	1417	29	34	876
Future Volume (vph)	12	48	1417	29	34	876
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	1883	1601	1789	1847
Flt Permitted	0.95	1.00	1.00	1.00	0.05	1.00
Satd. Flow (perm)	1789	1601	1883	1601	93	1847
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	13	52	1540	32	37	952
RTOR Reduction (vph)	0	51	0	6	0	0
Lane Group Flow (vph)	13	1	1540	26	37	952
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	2.4	2.4	77.4	77.4	83.8	83.8
Effective Green, g (s)	2.4	2.4	77.4	77.4	83.8	83.8
Actuated g/C Ratio	0.02	0.02	0.80	0.80	0.87	0.87
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	44	39	1515	1288	123	1608
v/s Ratio Prot	c0.01		c0.82		0.01	c0.52
v/s Ratio Perm		0.00		0.02	0.26	
v/c Ratio	0.30	0.03	1.02	0.02	0.30	0.59
Uniform Delay, d1	46.1	45.8	9.4	1.9	32.6	1.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	3.7	0.3	27.3	0.0	1.4	0.6
Delay (s)	49.8	46.1	36.7	1.9	34.0	2.2
Level of Service	D	D	D	A	C	A
Approach Delay (s)	46.9		36.0			3.4
Approach LOS	D		D			A
Intersection Summary						
HCM 2000 Control Delay			24.0		HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio			0.99			
Actuated Cycle Length (s)			96.2		Sum of lost time (s)	14.0
Intersection Capacity Utilization			86.2%		ICU Level of Service	E
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis 2: Hwy 99 & Access A

Phase 2 Background Fri PM
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	1447	0	0	888
Future Volume (Veh/h)	0	0	1447	0	0	888
Sign Control	Stop		Free			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	0	1573	0	0	965
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	2056	1573			1573	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2056	1573			1573	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	48	99			415	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	1573	0	482	482	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.93	0.00	0.28	0.28	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			79.5%	ICU Level of Service		D
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 2 Background Fri PM

06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1447	888	0
Future Volume (Veh/h)	0	0	0	1447	888	0
Sign Control	Stop			Free	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	0	0	1573	965	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	2538	482	965			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2538	482	965			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	22	530	709			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1573	482	482	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.93	0.28	0.28	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		79.5%		ICU Level of Service		D
Analysis Period (min)		15				

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	13	52	1540	32	37	952
v/c Ratio	0.06	0.23	0.54	0.03	0.12	0.32
Control Delay	31.7	13.2	6.4	1.9	2.6	2.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	31.7	13.2	6.4	1.9	2.6	2.3
Queue Length 50th (m)	1.6	0.0	54.1	0.0	0.7	14.5
Queue Length 95th (m)	7.0	9.7	79.6	2.4	2.4	23.9
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	542	522	3088	1386	298	3261
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.10	0.50	0.02	0.12	0.29
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 2 Background Fri PM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	12	48	1417	29	34	876
Future Volume (vph)	12	48	1417	29	34	876
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.11	1.00
Satd. Flow (perm)	1789	1601	3579	1601	216	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	13	52	1540	32	37	952
RTOR Reduction (vph)	0	49	0	10	0	0
Lane Group Flow (vph)	13	3	1540	22	37	952
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.4	3.4	43.5	43.5	49.4	49.4
Effective Green, g (s)	3.4	3.4	43.5	43.5	49.4	49.4
Actuated g/C Ratio	0.05	0.05	0.69	0.69	0.79	0.79
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	96	86	2479	1108	217	2761
v/s Ratio Prot	c0.01		c0.43		0.01	c0.27
v/s Ratio Perm		0.00		0.01	0.13	
v/c Ratio	0.14	0.03	0.62	0.02	0.17	0.34
Uniform Delay, d1	28.3	28.1	5.2	3.0	3.4	2.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.2	0.5	0.0	0.4	0.1
Delay (s)	28.9	28.3	5.7	3.0	3.8	2.0
Level of Service	C	C	A	A	A	A
Approach Delay (s)	28.4		5.6			2.1
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.9		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.59			
Actuated Cycle Length (s)			62.8		Sum of lost time (s)	14.0
Intersection Capacity Utilization			50.8%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 2 Background Fri PM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	1447	0	0	888
Future Volume (Veh/h)	0	0	1447	0	0	888
Sign Control	Stop		Free			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	0	1573	0	0	965
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	2056	1573			1573	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2056	1573			1573	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	48	99			415	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	1573	0	482	482	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.93	0.00	0.28	0.28	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			79.5%	ICU Level of Service		D
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 2 Background Fri PM

06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1447	888	0
Future Volume (Veh/h)	0	0	0	1447	888	0
Sign Control	Stop			Free	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	0	0	1573	965	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	2538	482	965			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2538	482	965			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	22	530	709			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1573	482	482	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.93	0.28	0.28	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		79.5%		ICU Level of Service		D
Analysis Period (min)		15				

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	24	47	641	13	14	809
v/c Ratio	0.08	0.15	0.25	0.01	0.02	0.29
Control Delay	16.6	8.0	5.1	4.1	3.0	3.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	16.6	8.0	5.1	4.1	3.0	3.4
Queue Length 50th (m)	1.7	0.0	8.6	0.0	0.3	11.6
Queue Length 95th (m)	6.1	6.1	28.7	2.1	1.4	19.9
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	1061	942	3579	1601	732	3579
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.05	0.18	0.01	0.02	0.23
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 2 Background Fri AM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	22	42	577	12	13	728
Future Volume (vph)	22	42	577	12	13	728
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3579
Flt Permitted	0.95	1.00	1.00	1.00	0.35	1.00
Satd. Flow (perm)	1825	1585	3579	1601	662	3579
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	24	47	641	13	14	809
RTOR Reduction (vph)	0	43	0	6	0	0
Lane Group Flow (vph)	24	4	641	7	14	809
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.4	3.4	24.7	24.7	29.7	29.7
Effective Green, g (s)	3.4	3.4	24.7	24.7	29.7	29.7
Actuated g/C Ratio	0.08	0.08	0.57	0.57	0.69	0.69
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	143	125	2051	917	482	2466
v/s Ratio Prot	c0.01		0.18		0.00	c0.23
v/s Ratio Perm		0.00		0.00	0.02	
v/c Ratio	0.17	0.03	0.31	0.01	0.03	0.33
Uniform Delay, d1	18.5	18.3	4.8	3.9	2.3	2.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.1	0.0	0.0	0.1
Delay (s)	19.1	18.4	4.9	3.9	2.3	2.8
Level of Service	B	B	A	A	A	A
Approach Delay (s)	18.6		4.9			2.8
Approach LOS	B		A			A
Intersection Summary						
HCM 2000 Control Delay			4.4		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.35			
Actuated Cycle Length (s)			43.1		Sum of lost time (s)	14.0
Intersection Capacity Utilization			31.8%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 2 Background Fri AM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						 
Traffic Volume (veh/h)	0	0	589	0	0	750
Future Volume (Veh/h)	0	0	589	0	0	750
Sign Control	Stop		Free			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	0	640	0	0	815
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	1048	640			640	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1048	640			640	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	223	418			940	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	640	0	408	408	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.38	0.00	0.24	0.24	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			34.3%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 2 Background Fri AM
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	589	750	0
Future Volume (Veh/h)	0	0	0	589	750	0
Sign Control	Stop			Free	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	0	0	640	815	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	1455	408	815			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1455	408	815			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	121	593	808			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	640	408	408	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.38	0.24	0.24	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		34.3%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	2.1	0.4	0.3
Total Del/Veh (s)	18.3	1.6	4.4	4.0	5.1	2.2	3.2

2: Hwy 99 & Access A Performance by movement

Movement	WBR	NBT	NBR	SBT	All
Denied Del/Veh (s)	0.1	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.0	0.7	2.0	2.3	1.8

3: Hwy 99 & Access D Performance by movement

Movement	EBR	NBT	SBT	SBR	All
Denied Del/Veh (s)	0.1	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.3	0.7	1.9	3.4	1.5

Total Network Performance

Denied Del/Veh (s)			0.6	
Total Del/Veh (s)			21.6	

Queuing and Blocking Report

Phase 3 Total Sunday

06/21/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	NB	SB	SB	SB
Directions Served	L	T	T	L	T	T
Maximum Queue (m)	10.5	31.4	29.4	11.0	27.1	26.3
Average Queue (m)	6.3	11.6	13.3	5.8	14.9	9.9
95th Queue (m)	13.1	30.8	30.6	13.4	33.9	27.1
Link Distance (m)	189.9	496.3	496.3		156.9	156.9
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (m)				75.0		
Storage Blk Time (%)						
Queuing Penalty (veh)						

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 0

Queues
1: Hwy 99 & Copper Dr

Phase 3 Total Sunday
06/19/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	31	41	936	29	48	1771
v/c Ratio	0.14	0.18	0.34	0.02	0.10	0.58
Control Delay	29.4	12.8	5.3	2.1	2.5	4.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	29.4	12.8	5.3	2.1	2.5	4.3
Queue Length 50th (m)	3.3	0.0	26.4	0.0	1.0	41.4
Queue Length 95th (m)	11.7	8.4	39.6	2.3	3.1	65.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	522	504	3211	1482	491	3489
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.08	0.29	0.02	0.10	0.51
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 3 Total Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	30	39	899	28	46	1700
Future Volume (vph)	30	39	899	28	46	1700
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.26	1.00
Satd. Flow (perm)	1738	1585	3544	1633	487	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	31	41	936	29	48	1771
RTOR Reduction (vph)	0	38	0	10	0	0
Lane Group Flow (vph)	31	3	936	19	48	1771
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.9	3.9	40.9	40.9	47.0	47.0
Effective Green, g (s)	3.9	3.9	40.9	40.9	47.0	47.0
Actuated g/C Ratio	0.06	0.06	0.67	0.67	0.77	0.77
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	111	101	2380	1096	420	2789
v/s Ratio Prot	c0.02		0.26		0.00	c0.49
v/s Ratio Perm		0.00		0.01	0.08	
v/c Ratio	0.28	0.03	0.39	0.02	0.11	0.63
Uniform Delay, d1	27.2	26.7	4.5	3.3	2.0	3.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.4	0.1	0.1	0.0	0.1	0.5
Delay (s)	28.5	26.8	4.6	3.3	2.1	3.6
Level of Service	C	C	A	A	A	A
Approach Delay (s)	27.6		4.5			3.6
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.5		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.66			
Actuated Cycle Length (s)			60.9		Sum of lost time (s)	14.0
Intersection Capacity Utilization			58.7%		ICU Level of Service	B
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 3 Total Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	102	825	99	0	1730
Future Volume (Veh/h)	0	102	825	99	0	1730
Sign Control	Stop		Free			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	111	897	108	0	1880
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	1837	448			897	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1837	448			897	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	80			100	
cM capacity (veh/h)	67	558			753	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	111	448	448	108	940	940
Volume Left	0	0	0	0	0	0
Volume Right	111	0	0	108	0	0
cSH	558	1700	1700	1700	1700	1700
Volume to Capacity	0.20	0.26	0.26	0.06	0.55	0.55
Queue Length 95th (m)	5.6	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	13.1	0.0	0.0	0.0	0.0	0.0
Lane LOS	B					
Approach Delay (s)	13.1	0.0			0.0	
Approach LOS	B					
Intersection Summary						
Average Delay			0.5			
Intersection Capacity Utilization			51.2%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 3 Total Sunday
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	83	0	924	1609	121
Future Volume (Veh/h)	0	83	0	924	1609	121
Sign Control	Stop			Free	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	90	0	1004	1749	132
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	2753	874	1749			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2753	874	1749			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	69	100			
cM capacity (veh/h)	16	293	355			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	90	1004	874	874	132	
Volume Left	0	0	0	0	0	
Volume Right	90	0	0	0	132	
cSH	293	1700	1700	1700	1700	
Volume to Capacity	0.31	0.59	0.51	0.51	0.08	
Queue Length 95th (m)	9.6	0.0	0.0	0.0	0.0	
Control Delay (s)	22.7	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	22.7	0.0	0.0			
Approach LOS	C					
Intersection Summary						
Average Delay		0.7				
Intersection Capacity Utilization		56.3%		ICU Level of Service		B
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 3 Total Fri PM
06/19/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	14	57	1779	35	41	1164
v/c Ratio	0.08	0.27	0.65	0.03	0.18	0.40
Control Delay	35.0	14.0	7.8	1.7	3.5	2.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	35.0	14.0	7.8	1.7	3.5	2.9
Queue Length 50th (m)	2.0	0.0	71.2	0.0	0.8	19.5
Queue Length 95th (m)	7.4	10.2	105.4	2.4	2.6	31.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	449	444	2841	1278	224	3075
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.13	0.63	0.03	0.18	0.38
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 3 Total Fri PM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	13	52	1637	32	38	1071
Future Volume (vph)	13	52	1637	32	38	1071
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.08	1.00
Satd. Flow (perm)	1789	1601	3579	1601	149	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	14	57	1779	35	41	1164
RTOR Reduction (vph)	0	53	0	10	0	0
Lane Group Flow (vph)	14	4	1779	25	41	1164
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	4.8	4.8	51.0	51.0	57.0	57.0
Effective Green, g (s)	4.8	4.8	51.0	51.0	57.0	57.0
Actuated g/C Ratio	0.07	0.07	0.71	0.71	0.79	0.79
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	119	107	2542	1137	163	2786
v/s Ratio Prot	c0.01		c0.50		0.01	c0.33
v/s Ratio Perm		0.00		0.02	0.19	
v/c Ratio	0.12	0.04	0.70	0.02	0.25	0.42
Uniform Delay, d1	31.5	31.3	6.0	3.1	5.4	2.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.4	0.1	0.9	0.0	0.8	0.1
Delay (s)	32.0	31.5	6.9	3.1	6.3	2.4
Level of Service	C	C	A	A	A	A
Approach Delay (s)	31.6		6.8			2.5
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			5.7		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.65			
Actuated Cycle Length (s)			71.8		Sum of lost time (s)	14.0
Intersection Capacity Utilization			56.9%		ICU Level of Service	B
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 3 Total Fri PM
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	85	1585	111	0	1084
Future Volume (Veh/h)	0	85	1585	111	0	1084
Sign Control	Stop		Free			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	92	1723	121	0	1178
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	2312	862			1723	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2312	862			1723	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	69			100	
cM capacity (veh/h)	32	299			363	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	92	862	862	121	589	589
Volume Left	0	0	0	0	0	0
Volume Right	92	0	0	121	0	0
cSH	299	1700	1700	1700	1700	1700
Volume to Capacity	0.31	0.51	0.51	0.07	0.35	0.35
Queue Length 95th (m)	9.7	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	22.3	0.0	0.0	0.0	0.0	0.0
Lane LOS	C					
Approach Delay (s)	22.3	0.0			0.0	
Approach LOS	C					
Intersection Summary						
Average Delay			0.7			
Intersection Capacity Utilization			55.7%		ICU Level of Service	B
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 3 Total Fri PM
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	85	0	1696	973	111
Future Volume (Veh/h)	0	85	0	1696	973	111
Sign Control	Stop			Free	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	92	0	1843	1058	121
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	2901	529	1058			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2901	529	1058			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	81	100			
cM capacity (veh/h)	12	494	654			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	92	1843	529	529	121	
Volume Left	0	0	0	0	0	
Volume Right	92	0	0	0	121	
cSH	494	1700	1700	1700	1700	
Volume to Capacity	0.19	1.08	0.31	0.31	0.07	
Queue Length 95th (m)	5.1	0.0	0.0	0.0	0.0	
Control Delay (s)	13.9	0.0	0.0	0.0	0.0	
Lane LOS	B					
Approach Delay (s)	13.9	0.0	0.0			
Approach LOS	B					
Intersection Summary						
Average Delay			0.4			
Intersection Capacity Utilization			92.6%	ICU Level of Service		F
Analysis Period (min)			15			

Queues
1: Hwy 99 & Copper Dr

Phase 3 Total Fri AM
06/19/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	27	51	811	14	17	962
v/c Ratio	0.09	0.17	0.30	0.01	0.03	0.34
Control Delay	18.3	8.5	5.1	3.8	2.9	3.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	18.3	8.5	5.1	3.8	2.9	3.5
Queue Length 50th (m)	2.0	0.0	11.9	0.0	0.3	14.9
Queue Length 95th (m)	7.2	6.8	37.1	2.1	1.6	24.6
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	939	840	3572	1598	634	3579
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.06	0.23	0.01	0.03	0.27
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 3 Total Fri AM
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	24	46	730	13	15	866
Future Volume (vph)	24	46	730	13	15	866
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3579
Flt Permitted	0.95	1.00	1.00	1.00	0.29	1.00
Satd. Flow (perm)	1825	1585	3579	1601	553	3579
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	27	51	811	14	17	962
RTOR Reduction (vph)	0	47	0	6	0	0
Lane Group Flow (vph)	27	4	811	8	17	962
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.5	3.5	27.5	27.5	32.5	32.5
Effective Green, g (s)	3.5	3.5	27.5	27.5	32.5	32.5
Actuated g/C Ratio	0.08	0.08	0.60	0.60	0.71	0.71
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	138	120	2139	957	417	2528
v/s Ratio Prot	c0.01		0.23		0.00	c0.27
v/s Ratio Perm		0.00		0.01	0.03	
v/c Ratio	0.20	0.03	0.38	0.01	0.04	0.38
Uniform Delay, d1	19.9	19.7	4.8	3.7	2.3	2.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.1	0.1	0.0	0.0	0.1
Delay (s)	20.6	19.8	4.9	3.7	2.3	2.8
Level of Service	C	B	A	A	A	A
Approach Delay (s)	20.1		4.9			2.8
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.4		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.41			
Actuated Cycle Length (s)			46.0		Sum of lost time (s)	14.0
Intersection Capacity Utilization			35.6%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 3 Total Fri AM
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	99	645	70	0	891
Future Volume (Veh/h)	0	99	645	70	0	891
Sign Control	Stop		Free			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	108	701	76	0	968
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	1185	350			701	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1185	350			701	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	83			100	
cM capacity (veh/h)	182	646			892	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	108	350	350	76	484	484
Volume Left	0	0	0	0	0	0
Volume Right	108	0	0	76	0	0
cSH	646	1700	1700	1700	1700	1700
Volume to Capacity	0.17	0.21	0.21	0.04	0.28	0.28
Queue Length 95th (m)	4.5	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	11.7	0.0	0.0	0.0	0.0	0.0
Lane LOS	B					
Approach Delay (s)	11.7	0.0			0.0	
Approach LOS	B					
Intersection Summary						
Average Delay			0.7			
Intersection Capacity Utilization			30.6%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 3 Total Fri AM
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	99	0	715	821	70
Future Volume (Veh/h)	0	99	0	715	821	70
Sign Control	Stop			Free	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	108	0	777	892	76
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	1669	446	892			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1669	446	892			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	81	100			
cM capacity (veh/h)	87	560	756			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	108	777	446	446	76	
Volume Left	0	0	0	0	0	
Volume Right	108	0	0	0	76	
cSH	560	1700	1700	1700	1700	
Volume to Capacity	0.19	0.46	0.26	0.26	0.04	
Queue Length 95th (m)	5.4	0.0	0.0	0.0	0.0	
Control Delay (s)	13.0	0.0	0.0	0.0	0.0	
Lane LOS	B					
Approach Delay (s)	13.0	0.0	0.0			
Approach LOS	B					
Intersection Summary						
Average Delay			0.8			
Intersection Capacity Utilization			41.0%	ICU Level of Service		A
Analysis Period (min)			15			

Queues
1: Hwy 99 & Copper Dr

Phase 3 Background Sunday
06/20/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	31	41	830	29	48	1645
v/c Ratio	0.14	0.17	0.31	0.02	0.09	0.55
Control Delay	26.0	11.6	5.6	2.5	2.6	4.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	26.0	11.6	5.6	2.5	2.6	4.3
Queue Length 50th (m)	3.0	0.0	22.4	0.0	1.0	35.5
Queue Length 95th (m)	10.5	7.7	34.6	2.5	3.1	57.5
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	562	541	3395	1565	534	3562
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.08	0.24	0.02	0.09	0.46
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 3 Background Sunday
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	30	39	797	28	46	1579
Future Volume (vph)	30	39	797	28	46	1579
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.29	1.00
Satd. Flow (perm)	1738	1585	3544	1633	548	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	31	41	830	29	48	1645
RTOR Reduction (vph)	0	38	0	10	0	0
Lane Group Flow (vph)	31	3	830	19	48	1645
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.8	3.8	36.2	36.2	42.3	42.3
Effective Green, g (s)	3.8	3.8	36.2	36.2	42.3	42.3
Actuated g/C Ratio	0.07	0.07	0.65	0.65	0.75	0.75
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	117	107	2286	1053	459	2724
v/s Ratio Prot	c0.02		0.23		0.00	c0.46
v/s Ratio Perm		0.00		0.01	0.07	
v/c Ratio	0.26	0.03	0.36	0.02	0.10	0.60
Uniform Delay, d1	24.8	24.4	4.6	3.6	2.0	3.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	0.1	0.1	0.0	0.1	0.4
Delay (s)	26.0	24.5	4.7	3.6	2.1	3.5
Level of Service	C	C	A	A	A	A
Approach Delay (s)	25.2		4.7			3.5
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.5		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.63			
Actuated Cycle Length (s)			56.1		Sum of lost time (s)	14.0
Intersection Capacity Utilization			55.3%		ICU Level of Service	B
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 3 Background Sunday
06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	825	0	0	1609
Future Volume (Veh/h)	0	0	825	0	0	1609
Sign Control	Stop		Free			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	0	897	0	0	1749
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	1772	897			897	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1772	897			897	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	74	283			753	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	897	0	874	874	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.53	0.00	0.51	0.51	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			47.8%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 3 Background Sunday
06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	825	1609	0
Future Volume (Veh/h)	0	0	0	825	1609	0
Sign Control	Stop			Free	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	0	0	897	1749	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	2646	874	1749			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2646	874	1749			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	19	293	355			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	897	874	874	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.53	0.51	0.51	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			47.8%	ICU Level of Service		A
Analysis Period (min)			15			

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	14	57	1687	35	41	1043
v/c Ratio	0.07	0.26	0.59	0.03	0.14	0.34
Control Delay	34.1	13.7	7.1	1.8	2.8	2.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	34.1	13.7	7.1	1.8	2.8	2.3
Queue Length 50th (m)	1.9	0.0	67.7	0.0	0.8	16.7
Queue Length 95th (m)	7.4	10.2	99.5	2.6	2.6	27.4
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	487	478	2938	1320	284	3123
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.12	0.57	0.03	0.14	0.33
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 3 Background Fri PM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	13	52	1552	32	38	960
Future Volume (vph)	13	52	1552	32	38	960
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.09	1.00
Satd. Flow (perm)	1789	1601	3579	1601	175	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	14	57	1687	35	41	1043
RTOR Reduction (vph)	0	54	0	10	0	0
Lane Group Flow (vph)	14	3	1687	25	41	1043
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.5	3.5	48.6	48.6	55.1	55.1
Effective Green, g (s)	3.5	3.5	48.6	48.6	55.1	55.1
Actuated g/C Ratio	0.05	0.05	0.71	0.71	0.80	0.80
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	91	81	2535	1134	199	2819
v/s Ratio Prot	c0.01		c0.47		0.01	c0.30
v/s Ratio Perm		0.00		0.02	0.16	
v/c Ratio	0.15	0.04	0.67	0.02	0.21	0.37
Uniform Delay, d1	31.1	30.9	5.5	3.0	4.3	1.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.8	0.2	0.7	0.0	0.5	0.1
Delay (s)	31.9	31.1	6.2	3.0	4.8	2.0
Level of Service	C	C	A	A	A	A
Approach Delay (s)	31.3		6.1			2.1
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			5.2		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.63			
Actuated Cycle Length (s)			68.6		Sum of lost time (s)	14.0
Intersection Capacity Utilization			54.6%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 3 Background Fri PM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	1585	0	0	973
Future Volume (Veh/h)	0	0	1585	0	0	973
Sign Control	Stop		Free			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	0	1723	0	0	1058
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	2252	1723			1723	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2252	1723			1723	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	35	78			363	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	1723	0	529	529	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	1.01	0.00	0.31	0.31	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			86.8%	ICU Level of Service		E
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 3 Background Fri PM

06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1585	973	0
Future Volume (Veh/h)	0	0	0	1585	973	0
Sign Control	Stop			Free	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	0	0	1723	1058	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	2781	529	1058			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2781	529	1058			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	15	494	654			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1723	529	529	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	1.01	0.31	0.31	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		86.8%		ICU Level of Service	E	
Analysis Period (min)		15				

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	27	51	702	14	17	886
v/c Ratio	0.09	0.17	0.27	0.01	0.03	0.32
Control Delay	17.0	7.9	5.2	4.0	3.0	3.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	17.0	7.9	5.2	4.0	3.0	3.5
Queue Length 50th (m)	2.0	0.0	9.9	0.0	0.3	13.4
Queue Length 95th (m)	6.8	6.5	31.7	2.2	1.6	22.3
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	1027	914	3579	1601	709	3579
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.06	0.20	0.01	0.02	0.25
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 3 Background Fri AM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	24	46	632	13	15	797
Future Volume (vph)	24	46	632	13	15	797
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3579
Flt Permitted	0.95	1.00	1.00	1.00	0.33	1.00
Satd. Flow (perm)	1825	1585	3579	1601	627	3579
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	27	51	702	14	17	886
RTOR Reduction (vph)	0	47	0	6	0	0
Lane Group Flow (vph)	27	4	702	8	17	886
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.5	3.5	25.7	25.7	30.7	30.7
Effective Green, g (s)	3.5	3.5	25.7	25.7	30.7	30.7
Actuated g/C Ratio	0.08	0.08	0.58	0.58	0.69	0.69
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	144	125	2081	930	461	2485
v/s Ratio Prot	c0.01		0.20		0.00	c0.25
v/s Ratio Perm		0.00		0.01	0.02	
v/c Ratio	0.19	0.03	0.34	0.01	0.04	0.36
Uniform Delay, d1	19.0	18.8	4.8	3.9	2.3	2.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.1	0.0	0.0	0.1
Delay (s)	19.7	18.9	4.9	3.9	2.3	2.8
Level of Service	B	B	A	A	A	A
Approach Delay (s)	19.2		4.9			2.8
Approach LOS	B		A			A
Intersection Summary						
HCM 2000 Control Delay			4.4		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.38			
Actuated Cycle Length (s)			44.2		Sum of lost time (s)	14.0
Intersection Capacity Utilization			33.7%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 3 Background Fri AM

06/20/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	645	0	0	821
Future Volume (Veh/h)	0	0	645	0	0	821
Sign Control	Stop		Free			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	0	701	0	0	892
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	1147	701			701	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1147	701			701	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	192	381			892	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	701	0	446	446	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.41	0.00	0.26	0.26	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			37.3%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 3 Background Fri AM

06/20/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	645	821	0
Future Volume (Veh/h)	0	0	0	645	821	0
Sign Control	Stop			Free	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	0	0	701	892	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	1593	446	892			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1593	446	892			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	98	560	756			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	701	446	446	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.41	0.26	0.26	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		37.3%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.2	0.1	0.0	0.0	2.0	0.5	0.4
Total Del/Veh (s)	23.6	1.5	4.4	5.0	7.3	2.9	3.7

2: Hwy 99 & Access A Performance by movement

Movement	WBR	NBT	NBR	SBT	All
Denied Del/Veh (s)	0.2	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.7	0.8	2.2	2.8	2.2

3: Hwy 99 & Access D Performance by movement

Movement	EBR	NBT	SBT	SBR	All
Denied Del/Veh (s)	0.2	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.4	0.7	2.1	3.9	1.8

Total Network Performance

Denied Del/Veh (s)	0.9
Total Del/Veh (s)	23.2

Queuing and Blocking Report
Phase 4 Total Sunday

06/21/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	NB	SB	SB	SB
Directions Served	L	T	T	L	T	T
Maximum Queue (m)	15.3	25.7	30.2	13.6	40.4	33.1
Average Queue (m)	6.6	10.6	14.8	7.3	18.1	13.1
95th Queue (m)	15.0	26.2	30.9	16.4	44.2	36.5
Link Distance (m)	189.9	496.3	496.3		156.9	156.9
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (m)				75.0		
Storage Blk Time (%)						
Queuing Penalty (veh)						

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Queuing and Blocking Report
Phase 4 Total Sunday

06/21/2019

Intersection: 12: Bend

Movement	SE
Directions Served	T
Maximum Queue (m)	1.7
Average Queue (m)	0.2
95th Queue (m)	3.5
Link Distance (m)	75.8
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (m)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Network Summary

Network wide Queuing Penalty: 0

Queues
1: Hwy 99 & Copper Dr

Phase 4 Total Sunday
06/19/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	34	46	1093	33	53	2046
v/c Ratio	0.19	0.23	0.41	0.03	0.13	0.69
Control Delay	36.0	14.1	5.4	1.7	2.6	5.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	36.0	14.1	5.4	1.7	2.6	5.7
Queue Length 50th (m)	4.5	0.0	33.5	0.0	1.2	58.5
Queue Length 95th (m)	13.1	9.1	48.8	2.5	3.3	90.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	409	408	2762	1280	411	3094
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.08	0.11	0.40	0.03	0.13	0.66
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 4 Total Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	33	44	1049	32	51	1964
Future Volume (vph)	33	44	1049	32	51	1964
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.22	1.00
Satd. Flow (perm)	1738	1585	3544	1633	408	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	34	46	1093	33	53	2046
RTOR Reduction (vph)	0	43	0	10	0	0
Lane Group Flow (vph)	34	3	1093	23	53	2046
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.5	5.5	52.8	52.8	59.0	59.0
Effective Green, g (s)	5.5	5.5	52.8	52.8	59.0	59.0
Actuated g/C Ratio	0.07	0.07	0.71	0.71	0.79	0.79
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	128	117	2511	1157	363	2862
v/s Ratio Prot	c0.02		0.31		0.00	c0.57
v/s Ratio Perm		0.00		0.01	0.11	
v/c Ratio	0.27	0.03	0.44	0.02	0.15	0.71
Uniform Delay, d1	32.6	32.0	4.6	3.2	2.3	3.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.1	0.1	0.1	0.0	0.2	0.9
Delay (s)	33.7	32.1	4.7	3.2	2.5	4.6
Level of Service	C	C	A	A	A	A
Approach Delay (s)	32.8		4.6			4.5
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			5.3	HCM 2000 Level of Service		A
HCM 2000 Volume to Capacity ratio			0.72			
Actuated Cycle Length (s)			74.5	Sum of lost time (s)		14.0
Intersection Capacity Utilization			66.0%	ICU Level of Service		C
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 4 Total Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	156	925	159	0	1997
Future Volume (Veh/h)	0	156	925	159	0	1997
Sign Control	Stop		Free			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	170	1005	173	0	2171
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	2090	502			1005	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2090	502			1005	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	67			100	
cM capacity (veh/h)	45	514			685	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	170	502	502	173	1086	1086
Volume Left	0	0	0	0	0	0
Volume Right	170	0	0	173	0	0
cSH	514	1700	1700	1700	1700	1700
Volume to Capacity	0.33	0.30	0.30	0.10	0.64	0.64
Queue Length 95th (m)	10.9	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	15.4	0.0	0.0	0.0	0.0	0.0
Lane LOS	C					
Approach Delay (s)	15.4	0.0			0.0	
Approach LOS	C					
Intersection Summary						
Average Delay			0.7			
Intersection Capacity Utilization			58.5%		ICU Level of Service	B
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 4 Total Sunday
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	128	0	1084	1802	195
Future Volume (Veh/h)	0	128	0	1084	1802	195
Sign Control	Stop			Free	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	139	0	1178	1959	212
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	3137	980	1959			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3137	980	1959			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	44	100			
cM capacity (veh/h)	8	249	294			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	139	1178	980	980	212	
Volume Left	0	0	0	0	0	
Volume Right	139	0	0	0	212	
cSH	249	1700	1700	1700	1700	
Volume to Capacity	0.56	0.69	0.58	0.58	0.12	
Queue Length 95th (m)	23.5	0.0	0.0	0.0	0.0	
Control Delay (s)	36.2	0.0	0.0	0.0	0.0	
Lane LOS	E					
Approach Delay (s)	36.2	0.0	0.0			
Approach LOS	E					
Intersection Summary						
Average Delay		1.4				
Intersection Capacity Utilization		64.4%		ICU Level of Service		C
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.1	0.0	0.0	2.4	0.3	0.1
Total Del/Veh (s)	16.4	1.6	5.4	5.0	7.8	1.4	3.7

2: Hwy 99 & Access A Performance by movement

Movement	WBR	NBT	NBR	SBT	All
Denied Del/Veh (s)	0.2	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.4	1.0	2.0	1.6	1.4

3: Hwy 99 & Access D Performance by movement

Movement	EBR	NBT	SBT	SBR	All
Denied Del/Veh (s)	0.2	0.0	0.0	0.0	0.0
Total Del/Veh (s)	2.6	0.8	1.2	2.9	1.2

Total Network Performance

Denied Del/Veh (s)	73.0
Total Del/Veh (s)	24.5

Queuing and Blocking Report

Phase 4 Total Fri PM

06/21/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	NB	SB	SB	SB
Directions Served	L	T	T	L	T	T
Maximum Queue (m)	10.3	35.5	39.5	10.3	31.7	21.0
Average Queue (m)	4.6	16.6	22.0	6.3	10.2	5.4
95th Queue (m)	12.1	37.8	42.7	13.1	30.7	19.7
Link Distance (m)	189.9	496.3	496.3		156.9	156.9
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (m)				75.0		
Storage Blk Time (%)						
Queuing Penalty (veh)						

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 0

Queues
1: Hwy 99 & Copper Dr

Phase 4 Total Fri PM
06/19/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	16	64	2045	39	46	1382
v/c Ratio	0.10	0.32	0.74	0.03	0.23	0.47
Control Delay	35.9	14.3	9.4	1.7	4.5	3.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	35.9	14.3	9.4	1.7	4.5	3.2
Queue Length 50th (m)	2.5	0.0	96.6	0.1	0.9	25.8
Queue Length 95th (m)	7.8	10.8	145.9	2.7	2.9	42.2
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	401	409	2780	1252	196	2952
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.16	0.74	0.03	0.23	0.47
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 4 Total Fri PM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	15	59	1881	36	42	1271
Future Volume (vph)	15	59	1881	36	42	1271
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.07	1.00
Satd. Flow (perm)	1789	1601	3579	1601	125	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	16	64	2045	39	46	1382
RTOR Reduction (vph)	0	60	0	10	0	0
Lane Group Flow (vph)	16	4	2045	29	46	1382
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.0	5.0	56.5	56.5	62.7	62.7
Effective Green, g (s)	5.0	5.0	56.5	56.5	62.7	62.7
Actuated g/C Ratio	0.06	0.06	0.73	0.73	0.81	0.81
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	115	103	2602	1164	147	2832
v/s Ratio Prot	c0.01		c0.57		0.01	c0.39
v/s Ratio Perm		0.00		0.02	0.24	
v/c Ratio	0.14	0.04	0.79	0.02	0.31	0.49
Uniform Delay, d1	34.3	34.1	6.7	2.9	8.8	2.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.2	1.6	0.0	1.2	0.1
Delay (s)	34.9	34.3	8.4	3.0	10.0	2.5
Level of Service	C	C	A	A	B	A
Approach Delay (s)	34.4		8.3			2.8
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			6.7		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.74			
Actuated Cycle Length (s)			77.7		Sum of lost time (s)	14.0
Intersection Capacity Utilization			64.0%		ICU Level of Service	B
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 4 Total Fri PM
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	142	1775	196	0	1286
Future Volume (Veh/h)	0	142	1775	196	0	1286
Sign Control	Stop		Free			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	154	1929	213	0	1398
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	2628	964			1929	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2628	964			1929	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	40			100	
cM capacity (veh/h)	19	255			302	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	154	964	964	213	699	699
Volume Left	0	0	0	0	0	0
Volume Right	154	0	0	213	0	0
cSH	255	1700	1700	1700	1700	1700
Volume to Capacity	0.60	0.57	0.57	0.13	0.41	0.41
Queue Length 95th (m)	27.1	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	38.5	0.0	0.0	0.0	0.0	0.0
Lane LOS	E					
Approach Delay (s)	38.5	0.0			0.0	
Approach LOS	E					
Intersection Summary						
Average Delay			1.6			
Intersection Capacity Utilization			64.5%		ICU Level of Service	C
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 4 Total Fri PM
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	142	0	1971	1090	196
Future Volume (Veh/h)	0	142	0	1971	1090	196
Sign Control	Stop			Free	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	154	0	2142	1185	213
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	3327	592	1185			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3327	592	1185			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	66	100			
cM capacity (veh/h)	6	449	585			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	154	2142	592	592	213	
Volume Left	0	0	0	0	0	
Volume Right	154	0	0	0	213	
cSH	449	1700	1700	1700	1700	
Volume to Capacity	0.34	1.26	0.35	0.35	0.13	
Queue Length 95th (m)	11.4	0.0	0.0	0.0	0.0	
Control Delay (s)	17.1	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	17.1	0.0	0.0			
Approach LOS	C					
Intersection Summary						
Average Delay		0.7				
Intersection Capacity Utilization		107.1%		ICU Level of Service		G
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 4 Total Fri AM
06/19/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	30	57	989	17	19	1116
v/c Ratio	0.11	0.20	0.36	0.01	0.04	0.39
Control Delay	20.7	9.2	5.1	3.2	2.8	3.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	20.7	9.2	5.1	3.2	2.8	3.5
Queue Length 50th (m)	2.4	0.0	15.6	0.0	0.4	18.5
Queue Length 95th (m)	8.6	7.9	47.4	2.2	1.6	30.2
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	829	751	3517	1574	531	3579
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.08	0.28	0.01	0.04	0.31
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 4 Total Fri AM
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	27	51	890	15	17	1004
Future Volume (vph)	27	51	890	15	17	1004
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3579
Flt Permitted	0.95	1.00	1.00	1.00	0.24	1.00
Satd. Flow (perm)	1825	1585	3579	1601	444	3579
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	30	57	989	17	19	1116
RTOR Reduction (vph)	0	53	0	6	0	0
Lane Group Flow (vph)	30	4	989	11	19	1116
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.6	3.6	30.9	30.9	35.8	35.8
Effective Green, g (s)	3.6	3.6	30.9	30.9	35.8	35.8
Actuated g/C Ratio	0.07	0.07	0.63	0.63	0.72	0.72
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	132	115	2238	1001	346	2593
v/s Ratio Prot	c0.02		0.28		0.00	c0.31
v/s Ratio Perm		0.00		0.01	0.04	
v/c Ratio	0.23	0.04	0.44	0.01	0.05	0.43
Uniform Delay, d1	21.6	21.3	4.8	3.5	2.3	2.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.9	0.1	0.1	0.0	0.1	0.1
Delay (s)	22.5	21.4	4.9	3.5	2.4	2.8
Level of Service	C	C	A	A	A	A
Approach Delay (s)	21.8		4.9			2.8
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			4.5		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.46			
Actuated Cycle Length (s)			49.4		Sum of lost time (s)	14.0
Intersection Capacity Utilization			39.4%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 4 Total Fri AM
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	182	723	111	0	1031
Future Volume (Veh/h)	0	182	723	111	0	1031
Sign Control	Stop		Free			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	198	786	121	0	1121
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	1346	393			786	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1346	393			786	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	67			100	
cM capacity (veh/h)	142	606			829	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	198	393	393	121	560	560
Volume Left	0	0	0	0	0	0
Volume Right	198	0	0	121	0	0
cSH	606	1700	1700	1700	1700	1700
Volume to Capacity	0.33	0.23	0.23	0.07	0.33	0.33
Queue Length 95th (m)	10.8	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	13.8	0.0	0.0	0.0	0.0	0.0
Lane LOS	B					
Approach Delay (s)	13.8	0.0			0.0	
Approach LOS	B					
Intersection Summary						
Average Delay			1.2			
Intersection Capacity Utilization			37.9%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 4 Total Fri AM
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	182	0	834	920	111
Future Volume (Veh/h)	0	182	0	834	920	111
Sign Control	Stop			Free	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	198	0	907	1000	121
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	1907	500	1000			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1907	500	1000			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	62	100			
cM capacity (veh/h)	60	516	688			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	198	907	500	500	121	
Volume Left	0	0	0	0	0	
Volume Right	198	0	0	0	121	
cSH	516	1700	1700	1700	1700	
Volume to Capacity	0.38	0.53	0.29	0.29	0.07	
Queue Length 95th (m)	13.6	0.0	0.0	0.0	0.0	
Control Delay (s)	16.2	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	16.2	0.0	0.0			
Approach LOS	C					
Intersection Summary						
Average Delay		1.4				
Intersection Capacity Utilization		47.2%		ICU Level of Service		A
Analysis Period (min)		15				

1: Hwy 99 & Copper Dr Performance by movement

Movement	WBL	WBR	NBT	NBR	SBL	SBT	All
Denied Del/Veh (s)	0.1	0.2	0.0	0.0	2.2	0.4	0.3
Total Del/Veh (s)	21.4	1.6	4.2	3.3	6.2	2.9	3.6

2: Hwy 99 & Access A Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.9	2.5	2.0

3: Hwy 99 & Access D Performance by movement

Movement	NBT	SBT	All
Denied Del/Veh (s)	0.0	0.0	0.0
Total Del/Veh (s)	0.7	1.6	1.3

Total Network Performance

Denied Del/Veh (s)			0.6
Total Del/Veh (s)			24.2

Queuing and Blocking Report

Phase 4 Background Sunday

06/21/2019

Intersection: 1: Hwy 99 & Copper Dr

Movement	WB	NB	NB	SB	SB	SB
Directions Served	L	T	T	L	T	T
Maximum Queue (m)	17.6	28.1	28.2	13.5	39.9	30.6
Average Queue (m)	9.0	13.7	13.5	5.9	18.5	13.1
95th Queue (m)	18.5	30.7	30.7	15.0	41.7	31.2
Link Distance (m)	189.9	496.3	496.3		156.9	156.9
Upstream Blk Time (%)						
Queuing Penalty (veh)						
Storage Bay Dist (m)				75.0		
Storage Blk Time (%)						
Queuing Penalty (veh)						

Intersection: 2: Hwy 99 & Access A

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Intersection: 3: Hwy 99 & Access D

Movement
Directions Served
Maximum Queue (m)
Average Queue (m)
95th Queue (m)
Link Distance (m)
Upstream Blk Time (%)
Queuing Penalty (veh)
Storage Bay Dist (m)
Storage Blk Time (%)
Queuing Penalty (veh)

Network Summary

Network wide Queuing Penalty: 0

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	34	46	930	33	53	1843
v/c Ratio	0.18	0.21	0.36	0.03	0.11	0.64
Control Delay	32.3	13.2	5.5	1.9	2.5	5.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.3	13.2	5.5	1.9	2.5	5.2
Queue Length 50th (m)	3.7	0.0	26.4	0.0	1.1	45.3
Queue Length 95th (m)	13.1	9.1	39.2	2.5	3.3	71.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	458	451	2997	1386	473	3382
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.07	0.10	0.31	0.02	0.11	0.54
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 4 Background Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	33	44	893	32	51	1769
Future Volume (vph)	33	44	893	32	51	1769
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.26	1.00
Satd. Flow (perm)	1738	1585	3544	1633	491	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	34	46	930	33	53	1843
RTOR Reduction (vph)	0	42	0	11	0	0
Lane Group Flow (vph)	34	4	930	22	53	1843
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.4	5.4	45.4	45.4	51.6	51.6
Effective Green, g (s)	5.4	5.4	45.4	45.4	51.6	51.6
Actuated g/C Ratio	0.08	0.08	0.68	0.68	0.77	0.77
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	140	127	2401	1106	420	2783
v/s Ratio Prot	c0.02		0.26		0.00	c0.51
v/s Ratio Perm		0.00		0.01	0.09	
v/c Ratio	0.24	0.03	0.39	0.02	0.13	0.66
Uniform Delay, d1	28.9	28.4	4.7	3.5	2.2	3.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.9	0.1	0.1	0.0	0.1	0.6
Delay (s)	29.8	28.5	4.8	3.5	2.4	4.2
Level of Service	C	C	A	A	A	A
Approach Delay (s)	29.0		4.8			4.2
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			5.0		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.67			
Actuated Cycle Length (s)			67.0		Sum of lost time (s)	14.0
Intersection Capacity Utilization			60.6%		ICU Level of Service	B
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 4 Background Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	925	0	0	1802
Future Volume (Veh/h)	0	0	925	0	0	1802
Sign Control	Stop		Free			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	0	1005	0	0	1959
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	1984	1005			1005	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1984	1005			1005	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	53	240			685	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	1005	0	980	980	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.59	0.00	0.58	0.58	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			53.1%	ICU Level of Service		A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 4 Background Sunday
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	925	1802	0
Future Volume (Veh/h)	0	0	0	925	1802	0
Sign Control	Stop			Free	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	0	0	1005	1959	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	2964	980	1959			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2964	980	1959			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	11	249	294			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1005	980	980	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.59	0.58	0.58	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			53.1%	ICU Level of Service		A
Analysis Period (min)			15			

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	16	64	1890	39	46	1168
v/c Ratio	0.09	0.30	0.69	0.03	0.22	0.40
Control Delay	35.5	14.0	8.4	1.6	4.2	2.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	35.5	14.0	8.4	1.6	4.2	2.9
Queue Length 50th (m)	2.4	0.0	81.1	0.0	0.9	19.9
Queue Length 95th (m)	7.8	10.8	121.3	2.6	2.9	32.5
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	430	433	2797	1259	207	3031
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.15	0.68	0.03	0.22	0.39
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 4 Background Fri PM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	15	59	1739	36	42	1075
Future Volume (vph)	15	59	1739	36	42	1075
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.07	1.00
Satd. Flow (perm)	1789	1601	3579	1601	132	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	16	64	1890	39	46	1168
RTOR Reduction (vph)	0	60	0	11	0	0
Lane Group Flow (vph)	16	4	1890	28	46	1168
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.0	5.0	53.1	53.1	59.2	59.2
Effective Green, g (s)	5.0	5.0	53.1	53.1	59.2	59.2
Actuated g/C Ratio	0.07	0.07	0.72	0.72	0.80	0.80
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	120	107	2561	1145	152	2800
v/s Ratio Prot	c0.01		c0.53		0.01	c0.33
v/s Ratio Perm		0.00		0.02	0.23	
v/c Ratio	0.13	0.04	0.74	0.02	0.30	0.42
Uniform Delay, d1	32.6	32.4	6.4	3.1	6.8	2.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.2	1.1	0.0	1.1	0.1
Delay (s)	33.1	32.5	7.5	3.1	7.9	2.4
Level of Service	C	C	A	A	A	A
Approach Delay (s)	32.6		7.4			2.6
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			6.2		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.69			
Actuated Cycle Length (s)			74.2		Sum of lost time (s)	14.0
Intersection Capacity Utilization			60.1%		ICU Level of Service	B
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 4 Background Fri PM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	1775	0	0	1090
Future Volume (Veh/h)	0	0	1775	0	0	1090
Sign Control	Stop		Free			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	0	1929	0	0	1185
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	2522	1929			1929	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2522	1929			1929	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	23	56			302	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	1929	0	592	592	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	1.13	0.00	0.35	0.35	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			96.8%	ICU Level of Service		F
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

Phase 4 Background Fri PM

06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1775	1090	0
Future Volume (Veh/h)	0	0	0	1775	1090	0
Sign Control	Stop			Free	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	0	0	1929	1185	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	3114	592	1185			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3114	592	1185			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	9	449	585			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1929	592	592	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	1.13	0.35	0.35	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		96.8%		ICU Level of Service		F
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

Phase 4 Background Fri AM
06/19/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	30	57	787	17	19	992
v/c Ratio	0.10	0.19	0.30	0.01	0.03	0.36
Control Delay	18.0	8.2	5.2	3.7	2.9	3.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	18.0	8.2	5.2	3.7	2.9	3.6
Queue Length 50th (m)	2.2	0.0	11.5	0.0	0.4	15.6
Queue Length 95th (m)	7.7	7.2	36.2	2.4	1.7	25.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	936	840	3573	1598	641	3579
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.07	0.22	0.01	0.03	0.28
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

Phase 4 Background Fri AM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	27	51	708	15	17	893
Future Volume (vph)	27	51	708	15	17	893
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3579
Flt Permitted	0.95	1.00	1.00	1.00	0.30	1.00
Satd. Flow (perm)	1825	1585	3579	1601	569	3579
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	30	57	787	17	19	992
RTOR Reduction (vph)	0	53	0	7	0	0
Lane Group Flow (vph)	30	4	787	10	19	992
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	3.6	3.6	27.3	27.3	32.3	32.3
Effective Green, g (s)	3.6	3.6	27.3	27.3	32.3	32.3
Actuated g/C Ratio	0.08	0.08	0.59	0.59	0.70	0.70
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	143	124	2128	952	426	2518
v/s Ratio Prot	c0.02		0.22		0.00	c0.28
v/s Ratio Perm		0.00		0.01	0.03	
v/c Ratio	0.21	0.04	0.37	0.01	0.04	0.39
Uniform Delay, d1	19.8	19.5	4.8	3.8	2.3	2.8
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.1	0.1	0.0	0.0	0.1
Delay (s)	20.6	19.7	4.9	3.8	2.3	2.9
Level of Service	C	B	A	A	A	A
Approach Delay (s)	20.0		4.9			2.9
Approach LOS	B		A			A
Intersection Summary						
HCM 2000 Control Delay			4.5		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.42			
Actuated Cycle Length (s)			45.9		Sum of lost time (s)	14.0
Intersection Capacity Utilization			36.4%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

Phase 4 Background Fri AM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	723	0	0	920
Future Volume (Veh/h)	0	0	723	0	0	920
Sign Control	Stop		Free			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	0	786	0	0	1000
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	1286	786			786	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1286	786			786	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	156	335			829	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	786	0	500	500	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.46	0.23	0.29	0.29	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			41.4%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

Phase 4 Background Fri AM

06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	723	920	0
Future Volume (Veh/h)	0	0	0	723	920	0
Sign Control	Stop			Free	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	0	0	786	1000	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	1786	500	1000			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1786	500	1000			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	73	516	688			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	786	500	500	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.46	0.29	0.29	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		41.4%		ICU Level of Service		A
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

(2047) Total Sunday
06/19/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	44	57	1330	42	67	2517
v/c Ratio	0.28	0.29	0.50	0.03	0.20	0.84
Control Delay	39.4	14.0	7.0	1.8	3.3	9.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	39.4	14.0	7.0	1.8	3.3	9.9
Queue Length 50th (m)	6.5	0.0	48.4	0.0	1.5	105.3
Queue Length 95th (m)	15.9	10.0	70.5	3.0	4.2	179.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	338	354	2638	1226	336	2996
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.13	0.16	0.50	0.03	0.20	0.84
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

(2047) Total Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	42	55	1277	40	64	2416
Future Volume (vph)	42	55	1277	40	64	2416
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.16	1.00
Satd. Flow (perm)	1738	1585	3544	1633	298	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	44	57	1330	42	67	2517
RTOR Reduction (vph)	0	53	0	12	0	0
Lane Group Flow (vph)	44	4	1330	30	67	2517
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	6.4	6.4	60.5	60.5	68.4	68.4
Effective Green, g (s)	6.4	6.4	60.5	60.5	68.4	68.4
Actuated g/C Ratio	0.08	0.08	0.71	0.71	0.81	0.81
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	131	119	2528	1165	308	2915
v/s Ratio Prot	c0.03		0.38		0.01	c0.70
v/s Ratio Perm		0.00		0.02	0.17	
v/c Ratio	0.34	0.04	0.53	0.03	0.22	0.86
Uniform Delay, d1	37.2	36.3	5.6	3.5	3.1	5.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.5	0.1	0.2	0.0	0.4	2.9
Delay (s)	38.7	36.5	5.8	3.6	3.5	8.1
Level of Service	D	D	A	A	A	A
Approach Delay (s)	37.4		5.7			8.0
Approach LOS	D		A			A
Intersection Summary						
HCM 2000 Control Delay			8.0		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.86			
Actuated Cycle Length (s)			84.8		Sum of lost time (s)	14.0
Intersection Capacity Utilization			78.5%		ICU Level of Service	D
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

(2047) Total Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	156	1161	159	0	2457
Future Volume (Veh/h)	0	156	1161	159	0	2457
Sign Control	Stop		Free			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	170	1262	173	0	2671
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	2598	631			1262	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2598	631			1262	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	60			100	
cM capacity (veh/h)	20	424			547	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	170	631	631	173	1336	1336
Volume Left	0	0	0	0	0	0
Volume Right	170	0	0	173	0	0
cSH	424	1700	1700	1700	1700	1700
Volume to Capacity	0.40	0.37	0.37	0.10	0.79	0.79
Queue Length 95th (m)	14.4	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	19.1	0.0	0.0	0.0	0.0	0.0
Lane LOS	C					
Approach Delay (s)	19.1	0.0			0.0	
Approach LOS	C					
Intersection Summary						
Average Delay			0.8			
Intersection Capacity Utilization			71.3%		ICU Level of Service	C
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

(2047) Total Sunday
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	128	0	1320	2263	195
Future Volume (Veh/h)	0	128	0	1320	2263	195
Sign Control	Stop			Free	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	139	0	1435	2460	212
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	3895	1230	2460			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3895	1230	2460			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	18	100			
cM capacity (veh/h)	2	169	186			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	139	1435	1230	1230	212	
Volume Left	0	0	0	0	0	
Volume Right	139	0	0	0	212	
cSH	169	1700	1700	1700	1700	
Volume to Capacity	0.82	0.84	0.72	0.72	0.12	
Queue Length 95th (m)	42.3	0.0	0.0	0.0	0.0	
Control Delay (s)	83.3	0.0	0.0	0.0	0.0	
Lane LOS	F					
Approach Delay (s)	83.3	0.0	0.0			
Approach LOS	F					
Intersection Summary						
Average Delay		2.7				
Intersection Capacity Utilization		77.1%		ICU Level of Service		D
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

(2047) Total Fri PM
06/19/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	21	80	2527	49	58	1680
v/c Ratio	0.14	0.40	0.93	0.04	0.33	0.57
Control Delay	36.6	15.9	19.9	2.1	7.9	4.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	36.6	15.9	19.9	2.1	7.9	4.0
Queue Length 50th (m)	3.1	0.6	~180.1	0.5	1.2	37.2
Queue Length 95th (m)	9.4	12.6	#276.2	3.6	5.4	63.1
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	345	370	2725	1227	175	2938
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.22	0.93	0.04	0.33	0.57

Intersection Summary

- ~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
- # 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

(2047) Total Fri PM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	19	74	2325	45	53	1546
Future Volume (vph)	19	74	2325	45	53	1546
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.06	1.00
Satd. Flow (perm)	1789	1601	3579	1601	114	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	21	80	2527	49	58	1680
RTOR Reduction (vph)	0	71	0	10	0	0
Lane Group Flow (vph)	21	9	2527	39	58	1680
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.7	5.7	62.3	62.3	69.4	69.4
Effective Green, g (s)	5.7	5.7	62.3	62.3	69.4	69.4
Actuated g/C Ratio	0.07	0.07	0.73	0.73	0.82	0.82
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	119	107	2620	1172	153	2862
v/s Ratio Prot	c0.01		c0.71		0.01	c0.48
v/s Ratio Perm		0.01		0.02	0.29	
v/c Ratio	0.18	0.08	0.96	0.03	0.38	0.59
Uniform Delay, d1	37.5	37.3	10.4	3.1	25.0	2.8
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.3	10.5	0.0	1.6	0.3
Delay (s)	38.2	37.6	20.9	3.1	26.6	3.1
Level of Service	D	D	C	A	C	A
Approach Delay (s)	37.7		20.6			3.9
Approach LOS	D		C			A
Intersection Summary						
HCM 2000 Control Delay			14.4		HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio			0.90			
Actuated Cycle Length (s)			85.1		Sum of lost time (s)	14.0
Intersection Capacity Utilization			77.2%		ICU Level of Service	D
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

(2047) Total Fri PM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	142	2229	196	0	1565
Future Volume (Veh/h)	0	142	2229	196	0	1565
Sign Control	Stop		Free			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	154	2423	213	0	1701
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	3274	1212			2423	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3274	1212			2423	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	12			100	
cM capacity (veh/h)	7	174			193	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	154	1212	1212	213	850	850
Volume Left	0	0	0	0	0	0
Volume Right	154	0	0	213	0	0
cSH	174	1700	1700	1700	1700	1700
Volume to Capacity	0.88	0.71	0.71	0.13	0.50	0.50
Queue Length 95th (m)	48.9	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	93.9	0.0	0.0	0.0	0.0	0.0
Lane LOS	F					
Approach Delay (s)	93.9	0.0			0.0	
Approach LOS	F					
Intersection Summary						
Average Delay			3.2			
Intersection Capacity Utilization			77.1%		ICU Level of Service	D
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

(2047) Total Fri PM
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	142	0	2425	1369	196
Future Volume (Veh/h)	0	142	0	2425	1369	196
Sign Control	Stop			Free	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	154	0	2636	1488	213
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	4124	744	1488			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	4124	744	1488			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	57	100			
cM capacity (veh/h)	2	357	448			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	154	2636	744	744	213	
Volume Left	0	0	0	0	0	
Volume Right	154	0	0	0	213	
cSH	357	1700	1700	1700	1700	
Volume to Capacity	0.43	1.55	0.44	0.44	0.13	
Queue Length 95th (m)	16.0	0.0	0.0	0.0	0.0	
Control Delay (s)	22.5	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	22.5	0.0	0.0			
Approach LOS	C					
Intersection Summary						
Average Delay		0.8				
Intersection Capacity Utilization		131.0%		ICU Level of Service		H
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

(2047) Total Fri AM
06/19/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	38	71	1187	21	23	1364
v/c Ratio	0.15	0.25	0.46	0.02	0.06	0.51
Control Delay	23.1	9.6	5.6	2.5	2.9	4.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	23.1	9.6	5.6	2.5	2.9	4.8
Queue Length 50th (m)	3.2	0.0	20.8	0.0	0.5	26.1
Queue Length 95th (m)	11.2	9.4	56.1	2.2	1.9	42.6
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	686	641	3480	1557	369	3571
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.11	0.34	0.01	0.06	0.38
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

(2047) Total Fri AM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	34	64	1068	19	21	1228
Future Volume (vph)	34	64	1068	19	21	1228
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3579
Flt Permitted	0.95	1.00	1.00	1.00	0.18	1.00
Satd. Flow (perm)	1825	1585	3579	1601	337	3579
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	38	71	1187	21	23	1364
RTOR Reduction (vph)	0	64	0	8	0	0
Lane Group Flow (vph)	38	7	1187	13	23	1364
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.2	5.2	34.5	34.5	39.1	39.1
Effective Green, g (s)	5.2	5.2	34.5	34.5	39.1	39.1
Actuated g/C Ratio	0.10	0.10	0.64	0.64	0.72	0.72
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	174	151	2273	1017	258	2577
v/s Ratio Prot	c0.02		0.33		0.00	c0.38
v/s Ratio Perm		0.00		0.01	0.06	
v/c Ratio	0.22	0.05	0.52	0.01	0.09	0.53
Uniform Delay, d1	22.7	22.3	5.4	3.6	3.0	3.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.2	0.0	0.2	0.2
Delay (s)	23.3	22.4	5.6	3.6	3.2	3.6
Level of Service	C	C	A	A	A	A
Approach Delay (s)	22.7		5.6			3.6
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			5.3		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.54			
Actuated Cycle Length (s)			54.3		Sum of lost time (s)	14.0
Intersection Capacity Utilization			45.6%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

(2047) Total Fri AM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	180	907	107	0	1262
Future Volume (Veh/h)	0	180	907	107	0	1262
Sign Control	Stop		Free			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	196	986	116	0	1372
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	1672	493			986	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1672	493			986	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	62			100	
cM capacity (veh/h)	87	522			696	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	196	493	493	116	686	686
Volume Left	0	0	0	0	0	0
Volume Right	196	0	0	116	0	0
cSH	522	1700	1700	1700	1700	1700
Volume to Capacity	0.38	0.29	0.29	0.07	0.40	0.40
Queue Length 95th (m)	13.2	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	16.0	0.0	0.0	0.0	0.0	0.0
Lane LOS	C					
Approach Delay (s)	16.0	0.0			0.0	
Approach LOS	C					
Intersection Summary						
Average Delay			1.2			
Intersection Capacity Utilization			42.9%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

(2047) Total Fri AM

06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	180	0	1014	1155	107
Future Volume (Veh/h)	0	180	0	1014	1155	107
Sign Control	Stop			Free	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	196	0	1102	1255	116
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	2357	628	1255			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2357	628	1255			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	54	100			
cM capacity (veh/h)	30	426	550			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	196	1102	628	628	116	
Volume Left	0	0	0	0	0	
Volume Right	196	0	0	0	116	
cSH	426	1700	1700	1700	1700	
Volume to Capacity	0.46	0.65	0.37	0.37	0.07	
Queue Length 95th (m)	18.0	0.0	0.0	0.0	0.0	
Control Delay (s)	20.4	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	20.4	0.0	0.0			
Approach LOS	C					
Intersection Summary						
Average Delay		1.5				
Intersection Capacity Utilization		56.7%		ICU Level of Service		B
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

(2047) Background Sunday
06/19/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	44	57	1168	42	67	2314
v/c Ratio	0.26	0.28	0.44	0.03	0.17	0.77
Control Delay	38.7	13.7	6.5	1.8	2.9	7.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	38.7	13.7	6.5	1.8	2.9	7.5
Queue Length 50th (m)	6.5	0.0	39.5	0.0	1.5	81.6
Queue Length 95th (m)	15.9	10.0	57.9	3.0	4.2	134.9
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	365	378	2630	1222	394	2991
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.12	0.15	0.44	0.03	0.17	0.77
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

(2047) Background Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	42	55	1121	40	64	2221
Future Volume (vph)	42	55	1121	40	64	2221
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.20	1.00
Satd. Flow (perm)	1738	1585	3544	1633	368	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	44	57	1168	42	67	2314
RTOR Reduction (vph)	0	53	0	12	0	0
Lane Group Flow (vph)	44	4	1168	30	67	2314
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	6.1	6.1	56.8	56.8	64.5	64.5
Effective Green, g (s)	6.1	6.1	56.8	56.8	64.5	64.5
Actuated g/C Ratio	0.08	0.08	0.70	0.70	0.80	0.80
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	131	119	2497	1150	358	2892
v/s Ratio Prot	c0.03		0.33		0.01	c0.64
v/s Ratio Perm		0.00		0.02	0.14	
v/c Ratio	0.34	0.04	0.47	0.03	0.19	0.80
Uniform Delay, d1	35.3	34.5	5.2	3.6	2.6	4.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.5	0.1	0.1	0.0	0.3	1.7
Delay (s)	36.8	34.7	5.4	3.6	2.9	6.1
Level of Service	D	C	A	A	A	A
Approach Delay (s)	35.6		5.3			6.0
Approach LOS	D		A			A
Intersection Summary						
HCM 2000 Control Delay			6.6		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.81			
Actuated Cycle Length (s)			80.6		Sum of lost time (s)	14.0
Intersection Capacity Utilization			73.1%		ICU Level of Service	D
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

(2047) Background Sunday
06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	1161	0	0	2263
Future Volume (Veh/h)	0	0	1161	0	0	2263
Sign Control	Stop		Free			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	0	1262	0	0	2460
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	2492	1262			1262	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2492	1262			1262	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	24	161			547	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	1262	0	1230	1230	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.74	0.00	0.72	0.72	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			65.9%	ICU Level of Service		C
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

3: Hwy 99 & Access D

(2047) Background Sunday
06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	1161	2263	0
Future Volume (Veh/h)	0	0	0	1161	2263	0
Sign Control	Stop			Free	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	0	0	1262	2460	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	3722	1230	2460			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3722	1230	2460			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	3	169	186			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	1262	1230	1230	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.74	0.72	0.72	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		65.9%		ICU Level of Service		C
Analysis Period (min)		15				

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	21	80	2373	49	58	1467
v/c Ratio	0.14	0.39	0.87	0.04	0.33	0.50
Control Delay	36.7	15.3	15.5	2.0	7.9	3.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	36.7	15.3	15.5	2.0	7.9	3.4
Queue Length 50th (m)	3.1	0.3	144.3	0.4	1.2	29.1
Queue Length 95th (m)	9.5	12.3	#248.4	3.5	5.4	48.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	345	372	2726	1229	175	2939
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.22	0.87	0.04	0.33	0.50

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

(2047) Background Fri PM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	19	74	2183	45	53	1350
Future Volume (vph)	19	74	2183	45	53	1350
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.06	1.00
Satd. Flow (perm)	1789	1601	3579	1601	114	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	21	80	2373	49	58	1467
RTOR Reduction (vph)	0	73	0	11	0	0
Lane Group Flow (vph)	21	7	2373	38	58	1467
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.7	5.7	62.3	62.3	69.4	69.4
Effective Green, g (s)	5.7	5.7	62.3	62.3	69.4	69.4
Actuated g/C Ratio	0.07	0.07	0.73	0.73	0.82	0.82
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	119	107	2620	1172	153	2862
v/s Ratio Prot	c0.01		c0.66		0.01	c0.42
v/s Ratio Perm		0.00		0.02	0.29	
v/c Ratio	0.18	0.07	0.91	0.03	0.38	0.51
Uniform Delay, d1	37.5	37.2	9.1	3.1	18.6	2.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.3	5.0	0.0	1.6	0.2
Delay (s)	38.2	37.5	14.0	3.1	20.2	2.6
Level of Service	D	D	B	A	C	A
Approach Delay (s)	37.6		13.8			3.3
Approach LOS	D		B			A
Intersection Summary						
HCM 2000 Control Delay			10.4		HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio			0.84			
Actuated Cycle Length (s)			85.1		Sum of lost time (s)	14.0
Intersection Capacity Utilization			73.3%		ICU Level of Service	D
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

(2047) Background Fri PM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						 
Traffic Volume (veh/h)	0	0	2229	0	0	1369
Future Volume (Veh/h)	0	0	2229	0	0	1369
Sign Control	Stop		Free			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	0	2423	0	0	1488
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	3167	2423			2423	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3167	2423			2423	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	8	25			193	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	2423	0	744	744	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	1.43	0.00	0.44	0.44	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			120.6%		ICU Level of Service	H
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

(2047) Background Fri PM

06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	2229	1369	0
Future Volume (Veh/h)	0	0	0	2229	1369	0
Sign Control	Stop			Free	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	0	0	2423	1488	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	3911	744	1488			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3911	744	1488			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	2	357	448			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	2423	744	744	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	1.43	0.44	0.44	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay		0.0				
Intersection Capacity Utilization		120.6%		ICU Level of Service		H
Analysis Period (min)		15				

Queues
1: Hwy 99 & Copper Dr

(2047) Background Fri AM
06/19/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	38	71	987	21	23	1246
v/c Ratio	0.14	0.24	0.40	0.02	0.05	0.48
Control Delay	20.8	8.8	5.9	3.1	2.9	4.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	20.8	8.8	5.9	3.1	2.9	4.7
Queue Length 50th (m)	3.0	0.0	15.9	0.0	0.5	22.3
Queue Length 95th (m)	10.2	8.8	48.2	2.5	1.9	36.8
Internal Link Dist (m)	177.0		485.0			136.4
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	773	712	3508	1570	493	3579
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.10	0.28	0.01	0.05	0.35
Intersection Summary						

HCM Signalized Intersection Capacity Analysis

1: Hwy 99 & Copper Dr

(2047) Background Fri AM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	34	64	888	19	21	1121
Future Volume (vph)	34	64	888	19	21	1121
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3579
Flt Permitted	0.95	1.00	1.00	1.00	0.23	1.00
Satd. Flow (perm)	1825	1585	3579	1601	434	3579
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	38	71	987	21	23	1246
RTOR Reduction (vph)	0	64	0	8	0	0
Lane Group Flow (vph)	38	7	987	13	23	1246
Heavy Vehicles (%)	0%	3%	2%	2%	2%	2%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.2	5.2	30.9	30.9	35.9	35.9
Effective Green, g (s)	5.2	5.2	30.9	30.9	35.9	35.9
Actuated g/C Ratio	0.10	0.10	0.60	0.60	0.70	0.70
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	185	161	2164	968	331	2514
v/s Ratio Prot	c0.02		0.28		0.00	c0.35
v/s Ratio Perm		0.00		0.01	0.05	
v/c Ratio	0.21	0.04	0.46	0.01	0.07	0.50
Uniform Delay, d1	21.1	20.7	5.5	4.0	2.8	3.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.2	0.0	0.1	0.2
Delay (s)	21.6	20.8	5.7	4.0	2.9	3.6
Level of Service	C	C	A	A	A	A
Approach Delay (s)	21.1		5.6			3.6
Approach LOS	C		A			A
Intersection Summary						
HCM 2000 Control Delay			5.3		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.51			
Actuated Cycle Length (s)			51.1		Sum of lost time (s)	14.0
Intersection Capacity Utilization			42.7%		ICU Level of Service	A
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis

2: Hwy 99 & Access A

(2047) Background Fri AM

06/19/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	0	907	0	0	1155
Future Volume (Veh/h)	0	0	907	0	0	1155
Sign Control	Stop		Free			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	0	986	0	0	1255
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	1614	986			986	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1614	986			986	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			100	
cM capacity (veh/h)	95	247			696	
Direction, Lane #	WB 1	NB 1	NB 2	SB 1	SB 2	
Volume Total	0	986	0	628	628	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.58	0.29	0.37	0.37	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			51.1%	ICU Level of Service		A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 3: Hwy 99 & Access D

(2047) Background Fri AM

06/19/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	0	0	0	907	1155	0
Future Volume (Veh/h)	0	0	0	907	1155	0
Sign Control	Stop			Free	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	0	0	986	1255	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	2241	628	1255			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2241	628	1255			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	36	426	550			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	0	986	628	628	0	
Volume Left	0	0	0	0	0	
Volume Right	0	0	0	0	0	
cSH	1700	1700	1700	1700	1700	
Volume to Capacity	0.00	0.58	0.37	0.37	0.00	
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	
Lane LOS	A					
Approach Delay (s)	0.0	0.0	0.0			
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			51.1%	ICU Level of Service		A
Analysis Period (min)			15			

Queues
1: Hwy 99 & Copper Dr

Opening Day + 10 (2047) Total Sunday - Mitigated - 70/30

05/22/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	44	57	1375	42	67	2572
v/c Ratio	0.28	0.29	0.52	0.03	0.21	0.86
Control Delay	39.6	14.2	7.2	1.8	3.5	10.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	39.6	14.2	7.2	1.8	3.5	10.7
Queue Length 50th (m)	6.5	0.0	50.9	0.0	1.5	113.8
Queue Length 95th (m)	15.9	10.0	74.4	3.0	4.2	#213.8
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	328	345	2638	1226	321	2996
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.13	0.17	0.52	0.03	0.21	0.86

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis Day + 10 (2047) Total Sunday - Mitigated - 70/30

1: Hwy 99 & Copper Dr

05/22/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	42	55	1320	40	64	2469
Future Volume (vph)	42	55	1320	40	64	2469
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.15	1.00
Satd. Flow (perm)	1738	1585	3544	1633	281	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	44	57	1375	42	67	2572
RTOR Reduction (vph)	0	53	0	12	0	0
Lane Group Flow (vph)	44	4	1375	30	67	2572
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	6.5	6.5	62.3	62.3	70.3	70.3
Effective Green, g (s)	6.5	6.5	62.3	62.3	70.3	70.3
Actuated g/C Ratio	0.07	0.07	0.72	0.72	0.81	0.81
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	130	118	2543	1172	296	2927
v/s Ratio Prot	c0.03		0.39		0.01	c0.71
v/s Ratio Perm		0.00		0.02	0.17	
v/c Ratio	0.34	0.04	0.54	0.03	0.23	0.88
Uniform Delay, d1	38.1	37.2	5.7	3.5	3.3	5.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.6	0.1	0.2	0.0	0.4	3.3
Delay (s)	39.7	37.4	5.9	3.5	3.7	8.8
Level of Service	D	D	A	A	A	A
Approach Delay (s)	38.4		5.8			8.6
Approach LOS	D		A			A
Intersection Summary						
HCM 2000 Control Delay			8.4		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.88			
Actuated Cycle Length (s)			86.8		Sum of lost time (s)	14.0
Intersection Capacity Utilization			79.9%		ICU Level of Service	D
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis + 10 (2047) Total Sunday - Mitigated - 70/30 2: Hwy 99 & Access A

05/22/2019



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations		↗	↕↕	↗		↕↕
Traffic Volume (veh/h)	0	199	1161	106	0	2510
Future Volume (Veh/h)	0	199	1161	106	0	2510
Sign Control	Stop		Free			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	216	1262	115	0	2728
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	2626	631			1262	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2626	631			1262	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	49			100	
cM capacity (veh/h)	19	424			547	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	216	631	631	115	1364	1364
Volume Left	0	0	0	0	0	0
Volume Right	216	0	0	115	0	0
cSH	424	1700	1700	1700	1700	1700
Volume to Capacity	0.51	0.37	0.37	0.07	0.80	0.80
Queue Length 95th (m)	21.4	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	22.0	0.0	0.0	0.0	0.0	0.0
Lane LOS	C					
Approach Delay (s)	22.0	0.0			0.0	
Approach LOS	C					
Intersection Summary						
Average Delay		1.1				
Intersection Capacity Utilization		72.7%		ICU Level of Service		C
Analysis Period (min)		15				

HCM Unsignalized Intersection Capacity Analysis + 10 (2047) Total Sunday - Mitigated - 70/30 3: Hwy 99 & Access D

05/22/2019



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations		↗		↑	↑↑	↗
Traffic Volume (veh/h)	0	85	0	1267	2263	248
Future Volume (Veh/h)	0	85	0	1267	2263	248
Sign Control	Stop			Free	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	92	0	1377	2460	270
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	3837	1230	2460			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3837	1230	2460			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	46	100			
cM capacity (veh/h)	3	169	186			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	92	1377	1230	1230	270	
Volume Left	0	0	0	0	0	
Volume Right	92	0	0	0	270	
cSH	169	1700	1700	1700	1700	
Volume to Capacity	0.54	0.81	0.72	0.72	0.16	
Queue Length 95th (m)	21.1	0.0	0.0	0.0	0.0	
Control Delay (s)	49.0	0.0	0.0	0.0	0.0	
Lane LOS	E					
Approach Delay (s)	49.0	0.0	0.0			
Approach LOS	E					
Intersection Summary						
Average Delay			1.1			
Intersection Capacity Utilization			74.5%	ICU Level of Service		D
Analysis Period (min)			15			

Queues
1: Hwy 99 & Copper Dr

Opening Day + 10 (2047) Total Sunday - Mitigated - 30/70

05/22/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	44	57	1256	42	67	2424
v/c Ratio	0.27	0.28	0.48	0.03	0.19	0.81
Control Delay	39.1	13.9	6.8	1.8	3.1	8.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	39.1	13.9	6.8	1.8	3.1	8.6
Queue Length 50th (m)	6.5	0.0	44.0	0.0	1.5	93.5
Queue Length 95th (m)	15.9	10.0	64.6	3.0	4.2	157.0
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	350	365	2638	1226	361	2996
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.13	0.16	0.48	0.03	0.19	0.81
Intersection Summary						

HCM Signalized Intersection Capacity Analysis 1: Hwy 99 & Copper Dr

05/22/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	42	55	1206	40	64	2327
Future Volume (vph)	42	55	1206	40	64	2327
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1738	1585	3544	1633	1772	3614
Flt Permitted	0.95	1.00	1.00	1.00	0.18	1.00
Satd. Flow (perm)	1738	1585	3544	1633	329	3614
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	44	57	1256	42	67	2424
RTOR Reduction (vph)	0	53	0	12	0	0
Lane Group Flow (vph)	44	4	1256	30	67	2424
Heavy Vehicles (%)	5%	3%	3%	0%	3%	1%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	6.2	6.2	58.8	58.8	66.6	66.6
Effective Green, g (s)	6.2	6.2	58.8	58.8	66.6	66.6
Actuated g/C Ratio	0.07	0.07	0.71	0.71	0.80	0.80
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	130	118	2516	1159	330	2906
v/s Ratio Prot	c0.03		0.35		0.01	c0.67
v/s Ratio Perm		0.00		0.02	0.15	
v/c Ratio	0.34	0.04	0.50	0.03	0.20	0.83
Uniform Delay, d1	36.4	35.5	5.4	3.5	2.9	4.8
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.6	0.1	0.2	0.0	0.3	2.2
Delay (s)	37.9	35.7	5.5	3.6	3.2	7.0
Level of Service	D	D	A	A	A	A
Approach Delay (s)	36.6		5.5			6.9
Approach LOS	D		A			A
Intersection Summary						
HCM 2000 Control Delay			7.2		HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio			0.84			
Actuated Cycle Length (s)			82.8		Sum of lost time (s)	14.0
Intersection Capacity Utilization			76.0%		ICU Level of Service	D
Analysis Period (min)			15			
c Critical Lane Group						

HCM Unsignalized Intersection Capacity Analysis + 10 (2047) Total Sunday - Mitigated - 30/70 2: Hwy 99 & Access A

05/22/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 			 
Traffic Volume (veh/h)	0	85	1161	248	0	2369
Future Volume (Veh/h)	0	85	1161	248	0	2369
Sign Control	Stop		Free			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	92	1262	270	0	2575
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	2550	631			1262	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2550	631			1262	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	78			100	
cM capacity (veh/h)	22	424			547	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	92	631	631	270	1288	1288
Volume Left	0	0	0	0	0	0
Volume Right	92	0	0	270	0	0
cSH	424	1700	1700	1700	1700	1700
Volume to Capacity	0.22	0.37	0.37	0.16	0.76	0.76
Queue Length 95th (m)	6.2	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	15.8	0.0	0.0	0.0	0.0	0.0
Lane LOS	C					
Approach Delay (s)	15.8	0.0			0.0	
Approach LOS	C					
Intersection Summary						
Average Delay			0.3			
Intersection Capacity Utilization			68.8%		ICU Level of Service	C
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis + 10 (2047) Total Sunday - Mitigated - 30/70 3: Hwy 99 & Access D

05/22/2019

						
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations					 	
Traffic Volume (veh/h)	0	199	0	1408	2263	106
Future Volume (Veh/h)	0	199	0	1408	2263	106
Sign Control	Stop			Free	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	216	0	1530	2460	115
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	3990	1230	2460			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3990	1230	2460			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	0	100			
cM capacity (veh/h)	2	169	186			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	216	1530	1230	1230	115	
Volume Left	0	0	0	0	0	
Volume Right	216	0	0	0	115	
cSH	169	1700	1700	1700	1700	
Volume to Capacity	1.28	0.90	0.72	0.72	0.07	
Queue Length 95th (m)	94.1	0.0	0.0	0.0	0.0	
Control Delay (s)	215.1	0.0	0.0	0.0	0.0	
Lane LOS	F					
Approach Delay (s)	215.1	0.0	0.0			
Approach LOS	F					
Intersection Summary						
Average Delay			10.8			
Intersection Capacity Utilization			81.5%	ICU Level of Service		D
Analysis Period (min)			15			

Queues
1: Hwy 99 & Copper Dr

Opening Day + 10 (2047) Total Friday PM - Mitigated - 70/30

05/22/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	21	80	2589	49	58	1765
v/c Ratio	0.14	0.40	0.95	0.04	0.33	0.60
Control Delay	36.6	15.9	22.7	2.2	7.9	4.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	36.6	15.9	22.7	2.2	7.9	4.3
Queue Length 50th (m)	3.1	0.6	~230.6	0.5	1.2	41.1
Queue Length 95th (m)	9.4	12.6	#287.2	3.7	5.4	69.5
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	345	370	2725	1227	175	2938
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.22	0.95	0.04	0.33	0.60

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.

Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis - 10 (2047) Total Friday PM - Mitigated - 70/30
 1: Hwy 99 & Copper Dr

05/22/2019



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	19	74	2382	45	53	1624
Future Volume (vph)	19	74	2382	45	53	1624
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.06	1.00
Satd. Flow (perm)	1789	1601	3579	1601	114	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	21	80	2589	49	58	1765
RTOR Reduction (vph)	0	71	0	10	0	0
Lane Group Flow (vph)	21	9	2589	39	58	1765
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.7	5.7	62.3	62.3	69.4	69.4
Effective Green, g (s)	5.7	5.7	62.3	62.3	69.4	69.4
Actuated g/C Ratio	0.07	0.07	0.73	0.73	0.82	0.82
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	119	107	2620	1172	153	2862
v/s Ratio Prot	c0.01		c0.72		0.01	c0.50
v/s Ratio Perm		0.01		0.02	0.29	
v/c Ratio	0.18	0.08	0.99	0.03	0.38	0.62
Uniform Delay, d1	37.5	37.3	11.0	3.1	25.0	2.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.3	14.7	0.0	1.6	0.4
Delay (s)	38.2	37.6	25.8	3.1	26.6	3.3
Level of Service	D	D	C	A	C	A
Approach Delay (s)	37.7		25.4			4.1
Approach LOS	D		C			A

Intersection Summary

HCM 2000 Control Delay	17.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	85.1	Sum of lost time (s)	14.0
Intersection Capacity Utilization	78.8%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis 10 (2047) Total Friday PM - Mitigated - 70/30 2: Hwy 99 & Access A

05/22/2019



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations		↗	↕	↗		↕
Traffic Volume (veh/h)	0	199	2229	118	0	1643
Future Volume (Veh/h)	0	199	2229	118	0	1643
Sign Control	Stop		Free			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	216	2423	128	0	1786
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	3316	1212			2423	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3316	1212			2423	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	0			100	
cM capacity (veh/h)	6	174			193	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	216	1212	1212	128	893	893
Volume Left	0	0	0	0	0	0
Volume Right	216	0	0	128	0	0
cSH	174	1700	1700	1700	1700	1700
Volume to Capacity	1.24	0.71	0.71	0.08	0.53	0.53
Queue Length 95th (m)	91.1	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	199.8	0.0	0.0	0.0	0.0	0.0
Lane LOS	F					
Approach Delay (s)	199.8	0.0			0.0	
Approach LOS	F					
Intersection Summary						
Average Delay		9.5				
Intersection Capacity Utilization		80.6%		ICU Level of Service		D
Analysis Period (min)		15				

HCM Unsignalized Intersection Capacity Analysis 10 (2047) Total Friday PM - Mitigated - 70/30 3: Hwy 99 & Access D

05/22/2019



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations		↗		↑	↑↑	↗
Traffic Volume (veh/h)	0	85	0	2346	1369	274
Future Volume (Veh/h)	0	85	0	2346	1369	274
Sign Control	Stop			Free	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	92	0	2550	1488	298
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	4038	744	1488			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	4038	744	1488			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	74	100			
cM capacity (veh/h)	2	357	448			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	92	2550	744	744	298	
Volume Left	0	0	0	0	0	
Volume Right	92	0	0	0	298	
cSH	357	1700	1700	1700	1700	
Volume to Capacity	0.26	1.50	0.44	0.44	0.18	
Queue Length 95th (m)	7.7	0.0	0.0	0.0	0.0	
Control Delay (s)	18.5	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	18.5	0.0	0.0			
Approach LOS	C					
Intersection Summary						
Average Delay			0.4			
Intersection Capacity Utilization			126.8%	ICU Level of Service		H
Analysis Period (min)			15			

Queues
1: Hwy 99 & Copper Dr

Opening Day + 10 (2047) Total Friday PM - Mitigated - 30/70

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Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	21	80	2465	49	58	1595
v/c Ratio	0.14	0.39	0.90	0.04	0.33	0.54
Control Delay	36.6	15.6	17.8	2.0	7.9	3.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	36.6	15.6	17.8	2.0	7.9	3.7
Queue Length 50th (m)	3.1	0.5	162.2	0.4	1.2	33.9
Queue Length 95th (m)	9.4	12.4	#265.3	3.6	5.4	57.0
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	345	371	2726	1228	175	2938
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.22	0.90	0.04	0.33	0.54

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis + 10 (2047) Total Friday PM - Mitigated - 30/70 1: Hwy 99 & Copper Dr

05/22/2019



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	19	74	2268	45	53	1467
Future Volume (vph)	19	74	2268	45	53	1467
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.06	1.00
Satd. Flow (perm)	1789	1601	3579	1601	114	3510
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	21	80	2465	49	58	1595
RTOR Reduction (vph)	0	72	0	10	0	0
Lane Group Flow (vph)	21	8	2465	39	58	1595
Heavy Vehicles (%)	2%	2%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.7	5.7	62.3	62.3	69.4	69.4
Effective Green, g (s)	5.7	5.7	62.3	62.3	69.4	69.4
Actuated g/C Ratio	0.07	0.07	0.73	0.73	0.82	0.82
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	119	107	2620	1172	153	2862
v/s Ratio Prot	c0.01		c0.69		0.01	c0.45
v/s Ratio Perm		0.01		0.02	0.29	
v/c Ratio	0.18	0.08	0.94	0.03	0.38	0.56
Uniform Delay, d1	37.5	37.2	9.8	3.1	22.5	2.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.3	7.7	0.0	1.6	0.2
Delay (s)	38.2	37.5	17.5	3.1	24.1	2.9
Level of Service	D	D	B	A	C	A
Approach Delay (s)	37.7		17.2			3.6
Approach LOS	D		B			A

Intersection Summary

HCM 2000 Control Delay	12.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	85.1	Sum of lost time (s)	14.0
Intersection Capacity Utilization	75.6%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis 10 (2047) Total Friday PM - Mitigated - 30/70 2: Hwy 99 & Access A

05/22/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	85	2229	274	0	1486
Future Volume (Veh/h)	0	85	2229	274	0	1486
Sign Control	Stop		Free			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	92	2423	298	0	1615
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	3230	1212			2423	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3230	1212			2423	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	47			100	
cM capacity (veh/h)	7	174			193	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	92	1212	1212	298	808	808
Volume Left	0	0	0	0	0	0
Volume Right	92	0	0	298	0	0
cSH	174	1700	1700	1700	1700	1700
Volume to Capacity	0.53	0.71	0.71	0.18	0.47	0.47
Queue Length 95th (m)	20.3	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	46.7	0.0	0.0	0.0	0.0	0.0
Lane LOS	E					
Approach Delay (s)	46.7	0.0			0.0	
Approach LOS	E					
Intersection Summary						
Average Delay			1.0			
Intersection Capacity Utilization			73.5%		ICU Level of Service	D
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 10 (2047) Total Friday PM - Mitigated - 30/70 3: Hwy 99 & Access D

05/22/2019



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations		↗		↖	↖↗	↗
Traffic Volume (veh/h)	0	199	0	2503	1369	118
Future Volume (Veh/h)	0	199	0	2503	1369	118
Sign Control	Stop			Free	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	216	0	2721	1488	128
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	4209	744	1488			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	4209	744	1488			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	40	100			
cM capacity (veh/h)	1	357	448			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	216	2721	744	744	128	
Volume Left	0	0	0	0	0	
Volume Right	216	0	0	0	128	
cSH	357	1700	1700	1700	1700	
Volume to Capacity	0.60	1.60	0.44	0.44	0.08	
Queue Length 95th (m)	28.7	0.0	0.0	0.0	0.0	
Control Delay (s)	29.4	0.0	0.0	0.0	0.0	
Lane LOS	D					
Approach Delay (s)	29.4	0.0	0.0			
Approach LOS	D					
Intersection Summary						
Average Delay			1.4			
Intersection Capacity Utilization			135.1%	ICU Level of Service		H
Analysis Period (min)			15			

Queues
1: Hwy 99 & Copper Dr

Opening Day + 10 (2047) Total Friday AM - Mitigated - 70/30

05/22/2019

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	38	71	1271	21	23	1419
v/c Ratio	0.16	0.26	0.49	0.02	0.07	0.53
Control Delay	24.6	10.1	5.7	2.4	2.9	4.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	24.6	10.1	5.7	2.4	2.9	4.8
Queue Length 50th (m)	3.4	0.0	23.3	0.0	0.5	28.1
Queue Length 95th (m)	11.8	9.8	61.9	2.2	1.9	46.4
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	622	588	3457	1547	345	3475
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.12	0.37	0.01	0.07	0.41
Intersection Summary						

HCM Signalized Intersection Capacity Analysis + 10 (2047) Total Friday AM - Mitigated - 70/30 1: Hwy 99 & Copper Dr

05/22/2019



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	34	64	1144	19	21	1277
Future Volume (vph)	34	64	1144	19	21	1277
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.16	1.00
Satd. Flow (perm)	1825	1585	3579	1601	302	3510
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	38	71	1271	21	23	1419
RTOR Reduction (vph)	0	64	0	7	0	0
Lane Group Flow (vph)	38	7	1271	14	23	1419
Heavy Vehicles (%)	0%	3%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.3	5.3	36.6	36.6	41.2	41.2
Effective Green, g (s)	5.3	5.3	36.6	36.6	41.2	41.2
Actuated g/C Ratio	0.09	0.09	0.65	0.65	0.73	0.73
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	171	148	2318	1037	236	2559
v/s Ratio Prot	c0.02		0.36		0.00	c0.40
v/s Ratio Perm		0.00		0.01	0.07	
v/c Ratio	0.22	0.05	0.55	0.01	0.10	0.55
Uniform Delay, d1	23.7	23.3	5.4	3.5	3.2	3.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.1	0.3	0.0	0.2	0.3
Delay (s)	24.4	23.4	5.7	3.5	3.4	3.7
Level of Service	C	C	A	A	A	A
Approach Delay (s)	23.7		5.7			3.7
Approach LOS	C		A			A

Intersection Summary

HCM 2000 Control Delay	5.4	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	56.5	Sum of lost time (s)	14.0
Intersection Capacity Utilization	47.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis 10 (2047) Total Friday AM - Mitigated - 70/30

2: Hwy 99 & Access A

05/22/2019



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations		↗	↕↕	↗		↕↕
Traffic Volume (veh/h)	0	255	907	67	0	1311
Future Volume (Veh/h)	0	255	907	67	0	1311
Sign Control	Stop		Free			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	277	986	73	0	1425
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	1698	493			986	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1698	493			986	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	47			100	
cM capacity (veh/h)	83	522			696	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	277	493	493	73	712	712
Volume Left	0	0	0	0	0	0
Volume Right	277	0	0	73	0	0
cSH	522	1700	1700	1700	1700	1700
Volume to Capacity	0.53	0.29	0.29	0.04	0.42	0.42
Queue Length 95th (m)	23.4	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	19.4	0.0	0.0	0.0	0.0	0.0
Lane LOS	C					
Approach Delay (s)	19.4	0.0			0.0	
Approach LOS	C					
Intersection Summary						
Average Delay		2.0				
Intersection Capacity Utilization		47.5%		ICU Level of Service		A
Analysis Period (min)		15				

HCM Unsignalized Intersection Capacity Analysis 10 (2047) Total Friday AM - Mitigated - 70/30 3: Hwy 99 & Access D

05/22/2019



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations		↗		↑	↑↑	↗
Traffic Volume (veh/h)	0	109	0	974	1155	156
Future Volume (Veh/h)	0	109	0	974	1155	156
Sign Control	Stop			Free	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	118	0	1059	1255	170
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	2314	628	1255			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2314	628	1255			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	72	100			
cM capacity (veh/h)	32	426	550			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	118	1059	628	628	170	
Volume Left	0	0	0	0	0	
Volume Right	118	0	0	0	170	
cSH	426	1700	1700	1700	1700	
Volume to Capacity	0.28	0.62	0.37	0.37	0.10	
Queue Length 95th (m)	8.5	0.0	0.0	0.0	0.0	
Control Delay (s)	16.7	0.0	0.0	0.0	0.0	
Lane LOS	C					
Approach Delay (s)	16.7	0.0	0.0			
Approach LOS	C					
Intersection Summary						
Average Delay			0.8			
Intersection Capacity Utilization			54.6%	ICU Level of Service		A
Analysis Period (min)			15			

Queues
1: Hwy 99 & Copper Dr

Opening Day + 10 (2047) Total Friday AM - Mitigated - 30/70

05/22/2019

						
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	38	71	1109	21	23	1320
v/c Ratio	0.15	0.25	0.44	0.02	0.05	0.51
Control Delay	22.6	9.4	5.9	2.9	2.9	4.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	22.6	9.4	5.9	2.9	2.9	4.8
Queue Length 50th (m)	3.2	0.0	19.0	0.0	0.5	25.0
Queue Length 95th (m)	11.0	9.3	56.1	2.4	1.9	41.3
Internal Link Dist (m)	177.0		485.0			62.6
Turn Bay Length (m)				65.0	75.0	
Base Capacity (vph)	696	648	3464	1550	452	3510
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.11	0.32	0.01	0.05	0.38
Intersection Summary						

HCM Signalized Intersection Capacity Analysis - 10 (2047) Total Friday AM - Mitigated - 30/70 1: Hwy 99 & Copper Dr

05/22/2019



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	34	64	998	19	21	1188
Future Volume (vph)	34	64	998	19	21	1188
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Lane Util. Factor	1.00	1.00	0.95	1.00	1.00	0.95
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1825	1585	3579	1601	1789	3510
Flt Permitted	0.95	1.00	1.00	1.00	0.20	1.00
Satd. Flow (perm)	1825	1585	3579	1601	371	3510
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	38	71	1109	21	23	1320
RTOR Reduction (vph)	0	64	0	8	0	0
Lane Group Flow (vph)	38	7	1109	13	23	1320
Heavy Vehicles (%)	0%	3%	2%	2%	2%	4%
Turn Type	Prot	Perm	NA	Perm	pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8		2	6	
Actuated Green, G (s)	5.3	5.3	33.4	33.4	38.4	38.4
Effective Green, g (s)	5.3	5.3	33.4	33.4	38.4	38.4
Actuated g/C Ratio	0.10	0.10	0.62	0.62	0.72	0.72
Clearance Time (s)	5.0	5.0	5.0	5.0	4.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	180	156	2226	995	291	2509
v/s Ratio Prot	c0.02		0.31		0.00	c0.38
v/s Ratio Perm		0.00		0.01	0.05	
v/c Ratio	0.21	0.04	0.50	0.01	0.08	0.53
Uniform Delay, d1	22.3	21.9	5.6	3.9	3.0	3.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	0.2	0.0	0.1	0.2
Delay (s)	22.9	22.0	5.7	3.9	3.1	3.7
Level of Service	C	C	A	A	A	A
Approach Delay (s)	22.3		5.7			3.7
Approach LOS	C		A			A

Intersection Summary

HCM 2000 Control Delay	5.4	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	53.7	Sum of lost time (s)	14.0
Intersection Capacity Utilization	44.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis 10 (2047) Total Friday AM - Mitigated - 30/70 2: Hwy 99 & Access A

05/22/2019

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (veh/h)	0	109	907	156	0	1222
Future Volume (Veh/h)	0	109	907	156	0	1222
Sign Control	Stop		Free			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	118	986	170	0	1328
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	1650	493			986	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1650	493			986	
tC, single (s)	6.8	6.9			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	77			100	
cM capacity (veh/h)	90	522			696	
Direction, Lane #	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	118	493	493	170	664	664
Volume Left	0	0	0	0	0	0
Volume Right	118	0	0	170	0	0
cSH	522	1700	1700	1700	1700	1700
Volume to Capacity	0.23	0.29	0.29	0.10	0.39	0.39
Queue Length 95th (m)	6.6	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	13.9	0.0	0.0	0.0	0.0	0.0
Lane LOS	B					
Approach Delay (s)	13.9	0.0			0.0	
Approach LOS	B					
Intersection Summary						
Average Delay			0.6			
Intersection Capacity Utilization			38.5%		ICU Level of Service	A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis 10 (2047) Total Friday AM - Mitigated - 30/70 3: Hwy 99 & Access D

05/22/2019



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations		↗		↑	↑↑	↗
Traffic Volume (veh/h)	0	255	0	1063	1155	67
Future Volume (Veh/h)	0	255	0	1063	1155	67
Sign Control	Stop			Free	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	277	0	1155	1255	73
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	2410	628	1255			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2410	628	1255			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	35	100			
cM capacity (veh/h)	27	426	550			
Direction, Lane #	EB 1	NB 1	SB 1	SB 2	SB 3	
Volume Total	277	1155	628	628	73	
Volume Left	0	0	0	0	0	
Volume Right	277	0	0	0	73	
cSH	426	1700	1700	1700	1700	
Volume to Capacity	0.65	0.68	0.37	0.37	0.04	
Queue Length 95th (m)	34.1	0.0	0.0	0.0	0.0	
Control Delay (s)	27.8	0.0	0.0	0.0	0.0	
Lane LOS	D					
Approach Delay (s)	27.8	0.0	0.0			
Approach LOS	D					
Intersection Summary						
Average Delay			2.8			
Intersection Capacity Utilization			59.3%	ICU Level of Service		B
Analysis Period (min)			15			

11 LIFE SAFETY PROTECTION PLAN

This section contains the Life Safety and Protection Plan prepared by FireWise Consulting in January 2013. The plan references the development proposal advanced by the previous planning team, that included buildings greater than 4 stories in height and a population much greater than currently proposed. It is noted that the current development plan limits building height to 6 stories, therefore the recommendations related to types of equipment will be modified. In addition, the plan advances recommendations that are not yet accepted by Taicheng/Tiger Bay but are considered to be discussion points at present. The plan also addresses issues that affect both North and South Britannia, specifically, fire safety recommendations for the Mine Museum, that are clearly not the responsibility of the developer. The developer remains committed to the installation of centrally monitored alarm and individual building fire suppression systems, as well as the adoption of Fire Smart principles for protection against wildfires.

The following is the concluding recommendation of the report: “Based on recommendations outlined later in this Report, the development proposed for the South Britannia site, will neither increase the fire risk nor the immediate demands on the SLRD to provide a significantly different fire service from the one currently in place”.

The Life Safety Protection Plan will be updated during the next phase of development planning to reflect the actual scope of the current plan, and to provide a more focused and easily understood set of recommendations.

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Helping the Fire Community Succeed



Taicheng Development Corporation South Britannia Life Safety Protection Plan

January 23, 2013



Prepared by: Dave Ferguson
Glen Sanders
Monty Armstrong

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1.0 RELIANCE AND LIMITATION

We have relied on the general accuracy of the information provided to us by the client and other stakeholders. The conclusions we have arrived at in this report depend upon the accuracy and completeness of the data that was provided at the time this report was written. Any discrepancies or inaccuracies in the information within this report should be brought to the authors' attention immediately so the report can be amended accordingly.

2.0 BACKGROUND

In August 2011, the Taicheng Development Corporation (the "Developer") purchased a 200 hectares property in South Britannia Beach (the "Property") previously called the Makin Lands. The vision of the Developer is to create a self-sustaining community of residential, tourist, educational and cultural facilities combined with some retail and light industrial businesses. The Property has a waterfront component and currently straddles both the upgraded Sea-to-Sky Corridor, Highway 99, and the railroad tracks which are operated primarily by CN Rail.

The Property lies within the boundaries of the Squamish-Lillooet Regional District (the "SLRD"). The SLRD provides regional government to approximately 35,000 residents and is comprised of four member municipalities - Squamish, Whistler, Pemberton and Lillooet; and four Electoral Areas. The Property lies within Electoral Area D of the SLRD.

The Developer, through the master planner for the project, Folio Hotel and Resort Architecture, have engaged the services of FireWise Consulting Ltd. ("FWC") to provide a report outlining considerations with respect to the provision of fire protection for the Property as it evolves through its' ten-phase development schedule.

FireWise Consulting Ltd is a team of fire safety professionals with a passion for due diligence and safety within the fire service. The passion comes from years of experience – the management team knows what can happen to front line personnel when adherence to training procedures and protocols is not complemented with comprehensive corporate due diligence by both the Authority Having Jurisdiction (AHJ) for a fire department and the fire department officers.

With over 85 years of combined experience, the management team FWC has a wealth of real world experience to draw upon. After leaving leadership positions within the fire service, they recognized their complementary skill sets and leveraged the synergies they offered to form a consulting firm like no other. FWC provides to clients informed, effective solutions to meet regulatory compliance challenges.

3.0 PROJECT SCOPE

The scope of the project is as follows:

- Conduct a community risk assessment.
- Analyze existing fire department response capability by conducting an Inspection and Audit using the Office of the Fire Commissioner checklist.
- Review water supply requirements for firefighting.
- Review Fire Department access to the development.
- Review Travel distance of existing emergency services to the development including police, fire, ambulance, Wildfire Management Branch, BC Hydro and other agencies.
- Review current apparatus and equipment capacity and anticipated needs.
- Review human resources available to the fire department.
- Recommend fire department staffing, fire hall location and equipment when development milestones are achieved.

The Report will be positioned as a Life Safety Protection Plan for the Development

4.0 EXECUTIVE SUMMARY

This report makes specific recommendations regarding the implications of the proposed South Britannia development on the existing Britannia Beach Volunteer Fire Department (“BBVFD”). It also addresses the many fire protection and life safety issues which will result from a significant growth in the community of Britannia Beach.

The report contains observations, suggestions, and recommendations on a variety of key aspects of fire prevention with the focus being on how the Developer, Taicheng Development Corp., can play a significant role in reducing the immediate demands on the fire department while providing leadership in the community on how fire protection service levels can be enhanced with minimal financial impact on the Squamish-Lillooet Regional District and the taxpayers of the Howe Sound East Fire Protection Service (“HSEFPS”) area.

The BBVFD has existed for over 100 years but it has only been since 2007, that the SLRD has assumed responsibility for the administration of the BBVFD. The creation of a fire department is purely a local government decision which is supported by the community. The support of the BBVFD by the community is clearly demonstrated through the establishment of the Howe Sound East Fire Protection Association.

One of the primary objectives of this report is to forecast how the development of the site will impact the BBVFD operational requirements over the next 10 to 15 years. The report will recommend steps that the Developer can take to lessen the burden on the existing fire department while cooperating with the SLRD to increase the capabilities of the BBVFD and the competencies of the volunteer firefighters to meet the demands of more structures and population to protect. The report identifies actions the Developer may take to complement the SLRD Bylaws presently in place and to meet the demands of provincial codes, standards and regulations that guide the project through the various phases. Additionally the report has identified components of the fire service which may not be the responsibility of the Developer. These observations and suggestions are made with respect to how improvements could be made to enhance the overall level of the fire service in the Howe Sound East area of the SLRD.

In being proactive, the Developer has requisitioned this report to offer unbiased independent third party advice on the future needs of the BBVFD and the community it provides fire and rescue services to. This report provides detailed information on the needs of BBVFD with respect to the current fire hall and makes other recommendations on how the service can be improved thereby complementing the Regional Growth Strategy, the Official Community Plan, the vision of the Developer and the specific needs that the South Britannia project will bring to the HSEFPS area.

In the opinion of FWC, the South Britannia Master Waterworks Plan, developed by Kerr Wood Leidal, Consulting Engineers, at the request of the Developer, addresses all of the key requirements of the project with respect to firefighting water supplies.

FWC believes that a comprehensive Fire Safety Plan, developed and maintained during the construction period will provide an opportunity for the Developer to show the importance of access to the site for not only the fire department but for all emergency services.

The Developer has indicated to FWC, a willingness to be proactive in adopting fire prevention techniques in all aspects of the development. Examples of this are the installation of a built-in fire suppression system in both residential and commercial properties and the commitment to an upgraded infrastructure with respect to roads and water supplies. The use of fire-resistant materials, the application of FireSmart principles and the adoption of spatial separation strategies are examples of ways that the Developer will reduce the demands on the fire service, save lives and protect property.

The Developer has seized the opportunity to provide a higher standard of fire protection with fire education, inspection and early detection, which will minimize the taxpayer impact. FWC is confident that this report offers a practical approach to fire protection that is not typical because it is not suggesting that expensive new equipment and paid personnel are required by the fire department. It is believed that the suggestions and recommendations will, if they are followed, increase community equity in the BBVFD in a sustainable fashion so the re-defined service area will achieve better fire protection, that can grow with the community in a manageable fashion.

Over the next 10 years it is anticipated that the SLRD will give consideration to transitioning to a slightly different fire service delivery model. This model may include a full-time chief supported by a membership of volunteer firefighters who are fully competent and trained to respond to a more diverse type of fire rescue incidents. This new service delivery model may include responses to marine incidents, calls to 4 storey plus buildings, motor vehicle accidents, and could complement the BC Ambulance Service in a first medical response capacity from within the community.

Fire protection services are expensive to establish and expensive to maintain. The view taken in this report is to provide a balanced approach to the increased demands on the existing fire protection service and how the development which is proposed for the site in South Britannia would impact it. With the Developer committed to reducing the likelihood of a significant fire occurring by ensuring there will be a more than adequate water supply and by offering to play a role in the upgrading of the fire department's facilities when demands dictate the benefits to the community and the SLRD as a whole are significant. This approach acknowledges the responsibilities and accountabilities of the SLRD with respect to meeting a Duty of Care and a corresponding Standard of Care for the community fire service they are delivering.

The report is intended to provide information to the Developer and other stakeholders with regard to fire safety protection that will assist in the decision-making process. It also contains suggestions on how this significant undertaking will be mutually beneficial

for all residents of the Squamish-Lillooet Regional District, especially those who choose to live and work within the new community proposed for South Britannia.

5.0 SUMMARY OF RECOMMENDATIONS

9.01 Recommendation:

*While the suggested changes are directed at the SLRD, it is recommended that the Developer encourage the SLRD to make these changes, referencing the **Fire Services Act** and the BC Fire Code, in the best interests of public safety throughout the SLRD.*

10.01 Recommendation:

It is recommended that the Developer adopt the South Britannia Master Waterworks Plan developed by Kerr Wood Leidal, Consulting Engineers as it meets, and in some instances may exceed, the requirements of the SLRD as laid out in Bylaw No. 741.

10.02 Recommendation:

It is recommended that the Developer offer to the SLRD that they (Taicheng Development Corporation) will be responsible for the maintenance and testing of the water system until it is appropriate that ownership of the water system should be taken over by local government.

10.03 Recommendation:

It is recommended that the Developer commit to the SLRD to ensure that techniques which will conserve the water supply will be undertaken wherever possible to reflect the best interests of the SLRD as a whole but not at the expense of putting the Project at risk from a reduction of firefighting water resources.

11.01 Recommendation:

It is recommended that, particularly during the construction phases, special attention be paid to the presence of adequate site security and that an after-hours fire watch is in place. These items are seen as key components of the Fire Safety Plan.

11.02 Recommendation:

It is recommended that access for all emergency vehicles is considered during the construction phases and that RCMP, BCAS, Ministry of Forests Wildfire Management Branch, BC Hydro, Fortis and Evacuation-related personnel be included as part of that consideration.

12.01 Recommendation:

That the Developer offer assistance to the SLRD in developing a strategic plan designed to progressively upgrade the BBVFD to meet the incremental demands of the 10 phase development of the site. Recognize an integral part of the plan would be the creation of a formal training program to prepare BBVFD firefighters to respond to fires in new and different environments.

12.02 Recommendation:

That the Developer offer to work with the SLRD to establish and maintain a program of fire and life safety education for all residents of the Britannia Beach community both during the construction phases and after completion of the Project.

12.03 Recommendation:

That the Developer commit to install fire protection systems in all residential dwellings including fire detection and alarm systems plus fire suppression systems. Encourage the SLRD to expand Bylaw No. 879-2003 to include the South Britannia site, citing such action combined with an appropriate SLRD policy would be prudent with respect to the SLRD meeting stringent fire response times for the BBVFD.

12.04 Recommendation:

That the Developer commit to the use of fire-resistant construction materials and techniques and FireSmart principles to address issues of spatial separation between buildings, embers transplanted by wildfire and to reduce the threat of fire spread.

12.05 Recommendation:

That the Developer engage stakeholders in the development of the construction site fire safety plan, particularly the SLRD and the BBVFD.

13.01 Recommendation:

Because of the age of the second engine, it is recommended that consideration be given to adding at least one additional Type 1 engine to service the community as it grows and as new risks are analyzed with respect to required pumping capacity. Consideration of this purchase should occur during Phase 1 of the Project.

13.02 Recommendation:

It is recommended that consideration be given to the new apparatus being an aerial device that can service the new structures planned for the community. It should have a 6000 L/min (1250 IGPM) fire pump with at least a 24 meter (75 feet) ladder with a master stream capability. This type of apparatus is commonly known as a Quint and can serve as a frontline engine with an aerial ladder.

While the purchase of equipment is the responsibility of the SLRD, it is recommended that the Developer advise the SLRD of the potential need and offer to partner with the SLRD when the appropriate time arrives to ensure the demands on the taxpayers is minimal.

13.03 Recommendation:

It is recommended that the Developer reach out to the SLRD to offer this significant investment of land for a public safety building, on behalf of the SLRD, to improve the delivery of emergency response in the Britannia Beach community.

14.01 Recommendation:

It is recommended that a formal Mutual Aid and/or Automatic Aid agreement be established between the SLRD and the District of Squamish.

14.02 Recommendation:

It is recommended that a similar arrangement, as outlined in Recommendation 14.01, be formalized with Lions Bay to assist during significant events.

14.03 Recommendation:

It is recommended that the Developer request the SLRD to consider the establishment of formal Automatic Aid and/or Mutual Aid agreements with the District of Squamish and the Village of Lions Bay as a contingency in the event that additional firefighting resources are required to assist the BBVFD in the unlikely occurrence of an extraordinary fire event.

16.01 Recommendation:

It is recommended that a new fire hall is not a priority today. Having stated that, it is recommended that the concept of a new fire hall, or the development of a public safety building within the South Britannia development, should be re-visited on a regular basis.

6.0 DISCLAIMER

This report is being submitted for your review and consideration. FireWise Consulting Ltd. makes no representation or warranty to the Recipient with respect to the information and shall not be liable for any errors or omissions in the information or the use thereof.

7.0 METHODOLOGY

Preliminary conversations were held with Mr. Ron Lea, a Partner with the master planner, Folio Hotel and Resort Architecture.

The result of these conversations was the development of a FireWise Service Agreement, which was accepted by the Developer, Taicheng Development Corporation, December 12, 2012.

A site visit to the Property was conducted on December 13th and 14th, 2012.

Also on December 13th, a meeting was held in Pemberton at the SLRD's offices with Mr. Peter DeJong, Director of Administrative Services for the SLRD. Mr. DeJong's responsibilities include oversight of protection services for the SLRD including the Britannia Beach Volunteer Fire Department. Mr. Ryan Wainwright, the SLRD's Emergency Program Manager attended the meeting at Mr. DeJong's request. Information was exchanged and Mr. DeJong agreed to provide background information on behalf of the SLRD and also authorized FWC to contact the BBVFD's Fire Chief.

On December 14th, a meeting was held with Fire Chief Steve Virgint of the Britannia Beach Volunteer Fire Department at the fire hall in Britannia Beach. Chief Virgint invited Captain David Rittberg of the BBVFD to attend the meeting. Information regarding the current structure and capabilities of the BBVFD was provided by Chief Virgint and Captain Rittberg.

Follow-up e-mails with Mr. DeJong and other members of the SLRD's staff provided additional background information which has been used to develop the content of this report.

Other research on relevant legislation, codes, standards and best practices was also undertaken to ensure that concepts and suggestions contained in this report reflected the most up-to-date options deemed worthy of consideration in managing issues related to fire and life safety protection for the Development.

A telephone conversation was held with Mr. Ken Ferraby of Kerr Wood Leidal ("KWL") who shared the Master Waterworks Plan for the Development that KWL prepared, with FWC.

A draft report was prepared for review by Mr. Lea to comment on and then the final report was prepared for presentation to the Developer.

8.0 COMMUNITY RISK ASSESSMENT

The purpose of a community risk assessment, in the context of this report, is to identify hazards, vulnerabilities and risks and to consider the likelihood of those issues creating emergency situations and the impact of such situations on the people, property, environment and the community as a whole, if they should occur.

The SLRD has an Emergency Program Manager who has responsibility to complete an operational plan to reflect the Britannia Beach area's safety and preparedness for emergencies resulting from such hazards. The SLRD has a Get Emergency Ready guide which addresses catastrophic events such as earthquakes, tsunamis, floods, winds and winter storms. It is the opinion of FWC that the SLRD's Emergency Program has addressed potential hazards which may occur within the Britannia Beach community.

FWC has conducted a high-level community risk assessment for Britannia Beach.

According to the latest census data obtained from Statistics Canada the fire protection area covered by the Britannia Beach Volunteer Fire Department has a total of 247 private dwellings. This total reflects dwellings in both Britannia Beach and Furry Creek. The exact number of public occupancies in the area is undetermined but the community of Britannia Beach is dominated by the property which houses the Britannia Mine Museum. The area population is approximately 500.

The site of the Museum was first developed between 1900 and 1904 as the Britannia Mining and Smelting Company. The Museum was opened in 1975 and designated as a National Historic Site in 1988.

The Britannia Mine Museum has 15 historic buildings in its care. The oldest building dates from around 1905, while the youngest dates from 1951.

The Mill, also known as Mill 3 or the Concentrator, is the building that most visitors to the Museum come to see. In September 2005, a rehabilitation project was enabled which has rendered the buildings on the property as structurally sound. The property is considered a low risk from a fire perspective.



Concerns of pollution from many years of mine and mill operation have been addressed and a history of slides, floods and fires in the area has not been repeated during the past ninety years.

The issue that appears to present the highest risk to the community would appear to emanate from the increased volume of traffic and tourists that visit the Museum and the corresponding management of the increase of up to 1,000 additional people in the community on any given day. It is anticipated that an evacuation plan for the Museum is in place but whether it has been tested is unknown. A challenge would be the management of both the visitors once they have left the Museum and their vehicles in the Museum parking lot.

There are limited other public buildings in the Britannia Beach community. There are no schools but there is a post office and a few retail outlets, primarily focused at the tourist trade.

Highway 99, also known as the Sea-to-Sky Corridor, runs the length of the fire protection district and was recently upgraded, work being completed in 2009.

CN Rail operates regular freight trains along the tracks which also run the length of the fire protection district. In the summer there are scheduled passenger trains running along the same tracks carrying tourists between North Vancouver and Whistler. The exact number of daily train movements and the manifests of the freight trains are unknown but it is assumed that hazardous materials are transported by CN Rail in the area. There are no scheduled stops in the area for trains and while there have been instances of derailments and fuel spills within the SLRD, no records were found of such incidents occurring in the Britannia Beach area. An emergency response plan involving a railroad incident should be developed by the fire department complete with operating guidelines written for this possibility. A supplemental report entitled the Britannia Beach Volunteer Fire Department Inspection and Audit is part of the scope of this project. This recommendation will be passed along to the BBVFD as part of that report.

There are currently no permanent industrial structures in Britannia Beach.

Information regarding the water system serving the current community was provided and is assessed to be adequate for current firefighting demands.

The current fire protection district has some vulnerability to seasonal wildfires which are usually small in nature. There was an exception to this rule in 2012 when a piece of privately owned property in the southern part of the fire protection district required a lengthy response to extinguish, due to challenging terrain and the requirement of the local fire department to attend in order to access the assistance of provincial forest service resources.

The records from Statistics Canada indicate that growth in Britannia Beach has been modest, approximately 10%, over the past five years.



The Regional Growth Strategy (“RGS”) of the SLRD highlights their desire to promote a more complete community - providing for a mix of land uses in the development of the Britannia Beach area and to enhance the potential for more integrated, complete communities.

The RGS also supports the creation (and management) of an inter-connected network of regional green spaces / corridors to serve as recreation and wildlife corridors, growth boundaries and wildfire interface areas.

The RGS acknowledges the larger scale development that is planned on a comprehensive basis within the defined boundaries of Britannia Beach. The RGS objective for this, and other like areas, is to encourage compact, clustered residential and local commercial, mixed use developments with distinct edges and full community water and sewer services.

The goals in the RGS indicate that the community risk, with respect to issues impacting fire services, have been assessed and that the risk factor can best be described currently as medium to low risk.

The Vision document for the South Britannia project appears to recognize and comply with the ideals of the SLRD’s RGS.

The Britannia Beach Volunteer Fire Department currently provides basic fire protection service to the community. The capacity and capability of the fire department to handle the demands of a significantly larger community is addressed later in this report.

Pre-hospital care is the responsibility of the Provincial Government and is delivered through the British Columbia Ambulance Service (BCAS). Pre-hospital care service to the Property is delivered by BCAS from BCAS Station 222 in Squamish. The BCAS station is approximately 14 kms from the Property. One ambulance is staffed on a full-time basis during the day. Two other ambulances are available on a call-out basis. A similar resource is available from BCAS Station 233 in Lions Bay, which is approximately 21 kms to the south. The expansion of BCAS service into Britannia Beach will be contingent upon call volume. It is anticipated that the first step they will take is to station an ambulance with “on-call” paramedics in the community. It is difficult to predict during which phase such a service would be introduced.

Policing for Britannia Beach is also provided from Squamish. The RCMP has a detachment located in that community. The travel distance is also approximately 14 kms. Policing on Highway 99 is provided by the RCMP’s Lower Mainland District Traffic

Services. As indicated with the BCAS above, the RCMP will monitor the responses they make into the Britannia Beach area and will introduce a presence in the community when certain levels are reached. Their past practice has been to initially open a community police station that will be staffed on an ``as and when`` basis. If however the community was to incorporate and especially when the population reaches 5,000, policing will become a municipal responsibility. The new municipal council would determine how police services would be provided.

CN Police are responsible for the security and safety of the railroad.

Based on recommendations outlined later in this Report, the development proposed for the South Britannia site, will neither increase the fire risk nor the immediate demands on the SLRD to provide a significantly different fire service from the one currently in place.

9.0 SQUAMISH-LILLOOET REGIONAL DISTRICT

Fire protection services for the Development site are provided by the SLRD. This section of the report will identify the various bylaws, policies and relationships in place which impact Britannia Beach and more specifically the fire protection of the Property owned by the Developer.

Bylaw No. 1032-2006

In 2007, the SLRD passed Bylaw No. 1032-2006 which established the HSEFPS. The boundaries of the Service Area are a portion of the SLRD's Electoral Area D and include the communities of Britannia Beach and Furry Creek. This bylaw was the "establishment bylaw" for the fire department which operates as the BBVFD.

Bylaw No. 1034-2006

The same year, 2007, the SLRD passed Bylaw No. 1034-2006 which authorized the SLRD to borrow funds to purchase a fire truck and other equipment for the HSEFPS area.

Bylaw No. 1110, 2008

On October 27, 2008, the SLRD adopted Bylaw No. 1110, 2008 which regulates the fire protection services throughout the Squamish-Lillooet Regional District. This bylaw indicates how the SLRD would manage the provision of fire protection in the Howe Sound East Fire Protection Service Area. This bylaw states that each Regional Fire Department is authorized and directed to:

- (a) protect human lives, including those of its' own members;
- (b) protect property, including taking all proper measures to prevent, control and extinguish fires;

but is limited to the parameters of the Bylaw and shall respond only to the extent and level to which its members have been trained.

Observations regarding this Bylaw, which the SLRD are encouraged to consider would be:

- a. The addition of a reference to the **Fire Services Act** such as
“The **Fire Services Act** and all amendments thereto are deemed to be in full force and effect within the Squamish-Lillooet Regional District, in conjunction with this bylaw.”
- b. There is no authority given to the Fire Chiefs to be appointed as LAFCs and to enforce the **Fire Services Act**. The following wording is offered as suggested additional language in this bylaw in this regard:
“The Fire Chief shall take responsibility for all fire protection matters including the enforcement of the **Fire Services Act** and Regulations in addition to the British Columbia Fire Code there under and shall assume the responsibilities of the Local Assistant to the Fire Commissioner.”
- c. In Section 3 it is suggested the British Columbia Fire Code and all amendments to it be included with the reference to the National Fire Code of Canada

9.01 Recommendation;

While the suggested changes are directed at the SLRD, it is recommended that the Developer encourage the SLRD to make these changes, referencing the Fire Services Act and the BC Fire Code, in the best interests of public safety throughout the SLRD.

Bylaw No. 1145-2009

Bylaw No. 1145-2009 was adopted on November 23, 2009 which amended Bylaw No. 1032-2006 by introducing the following Section:

“The maximum amount that may be requisitioned annually under Section 816(l) (a) for the Local Service shall be \$245,500.00 or \$0.9526/\$1000 of the net taxable values of land and improvements, whichever is greater”.

The purpose was to allow the SLRD to increase the maximum annual requisition limitation by 25%.

In addition to the bylaws in effect relative to the provision of fire protection services in the Britannia Beach area, research of other SLRD bylaws uncovered the following references to the provision of fire services:

Bylaw No. 540, 1994

Bylaw No. 540, 1994, the Electoral Area D Zoning Bylaw, using the consolidated copy dated October 4, 2012 states the following in Section 10.1.7 (2) (g) (ii):

- (g) at the time of issuance of any building permit authorizing the construction of one or more dwellings in the CD1 zone such that the number of such dwellings in the CD1 zone will exceed 700:
- ii) the payment to the Squamish-Lillooet Regional District of \$250,000 to be placed in a reserve fund established for the provision of fire protection services to Electoral Area D of the Squamish-Lillooet Regional District; and of the Squamish-Lillooet Regional District;

Bylaw No.741, 2002

Bylaw No.741, 2002, the Electoral Area D Subdivision and Development Servicing (Planned Communities) Bylaw, using the consolidated copy dated February 2011, lays out a number of the key elements of the water supply requirements including specifics of Capacity (3.1.4.1), Fire Flow Demands (3.1.4.5), Hydrants (3.1.5.12), Fire Lines (3.1.5.17), Reservoir Capacity (3.1.6.2) and Pump Stations (3.1.7)

Bylaw No. 879-2003

One other bylaw adopted by the SLRD which does not impact the Development today but which indicates forward thinking by the SLRD in areas with limited or a delayed fire response is Bylaw No. 879-2003 dated December 17, 2003. This bylaw required the installation of sprinklers in the Furry Creek community for every building for a residential occupancy. The sprinklers are to be installed in accordance with UL 1626 (1994) and NFPA 13D-1999.

Howe Sound East Fire Protection Association ("HSEFPA")

The HSEFPA, which serves three communities, Britannia Beach, Furry Creek, and Porteau Cove, was formed in 2007. The HSEFPA represents the taxpayers of the HSEFPS area. The purpose of the society is to support and assist the fire service in the HSEFPS area.

The society allows community members, who may not be volunteer firefighters, to participate in the fire protection service for the area, to lobby SLRD regarding fire service, to raise funds to support community fire service activities and programs, to participate in fire prevention education and programs; and to inform and provide oversight to the community regarding fire service issues.

SLRD Key Issues

From meetings, and the exchange emails, with SLRD staff, together with research conducted independently, a number of issues have been identified as being of importance to the SLRD with respect to the provision of fire protection service.

Residential Sprinklers

The acknowledgement that residential sprinklers are an effective way of reducing fire deaths and containing fires to the area of origin has been identified through the introduction of a Bylaw to this effect.

FireSmart

The recognition that many of the residences within the SLRD are built, or are being built, within the Wildland Urban Interface has motivated the SLRD to promote the concept that preparing for the threat of wildfire is a shared responsibility. Wildland Urban Interface is a popular term used to describe an area where structures and forested areas meet. Those areas become more exposed to the danger of wildfire. The SLRD has used the FireSmart program to help residents understand the potential of wildfire affecting their home and their community. How the Developer can adopt FireSmart principles is discussed under Section 11 of the report.

Fire Underwriters Survey

The references to the Fire Underwriters Survey ("FUS") in their bylaws indicates that meeting the standards outlined in the Water Supply for Public Fire Protection booklet are important to the SLRD. The FUS feeds information into a Public Fire Protection Classification system which is designed to provide a standardized measure of the ability of the protective facilities of a community to prevent and control the major fires that may be expected to occur.

Fire Protection Services

It is evident from a review of the SLRD's Regional Growth Strategy and the Official Community Plan for Electoral Area D that the provision of effective and efficient fire protection services is of importance to the SLRD.

The SLRD is interested in adopting best practices which will allow the Developer to introduce leading edge technology. A number of suggestions/recommendations will be presented within the report for consideration by the Developer, concepts which will demonstrate the desire of the Developer to be an active partner with the SLRD to create a fire safe community.

The SLRD provides an annual budget for the provision of fire protection services in the HSEFPS area. The budget for the current year is \$168,000.00 and is projected to remain at the same level in 2013. The mil rate in 2011 was set at \$.5427. It was reduced to \$.4348 in 2012 and is projected to be the same rate for 2013. The change from 2011 to 2012 is attributed to the increase in development in the Furry Creek community.

South Britannia Project



It is apparent that the SLRD is earnestly looking at the implications of the Development on services and other SLRD responsibilities. A dedicated planning consultant has been retained to deal with the project. A comprehensive information report was presented to the SLRD in November 2012 providing an update

on the development and highlighting some aspects of the Project which the SLRD will have to address as the Developer has submitted a preliminary application to amend the Official Community Plan and for re-zoning consideration on a portion of the overall project site.

This report addresses these SLRD key issues and makes recommendations in subsequent sections of the report to outline how the Developer has taken steps to ensure the Project clearly supports these key issues. The report will highlight the benefit to the community, and the SLRD, of the Developer's actions.

10.0 WATER SUPPLY REQUIREMENTS

Water supply is one of a number of important components of an overall fire protection system. In any assessment of a water supply system, the major emphasis is placed upon its ability to deliver adequate water to control major fires on a reliable basis via sufficient and suitable hydrants.

From research and reviews conducted, the requirements of the SLRD as laid out in their Bylaw 741 together with the South Britannia Master Waterworks Plan developed by Kerr Wood Leidal, Consulting Engineers, indicates that the provision for an adequate water supply for firefighting purposes has been addressed.

The reference in Bylaw 741 to the Fire Underwriters Survey's document, "Water Supply for Public Water Supply – A guide to Recommended Practice" confirms that appropriate standards are in place with respect to the fire flows, hydrants and fire lines.

A review of the Kerr Wood Leidal plan, from an experienced fire service perspective, indicates it to be a complete and accurate plan, designed to meet the needs of the SLRD Bylaw. While this review was conducted by individuals who do not have the qualifications that Kerr Wood Leidal staff possesses, the level of detail in the plan, the credentials of the authors of the plan, FWC is accepting of the approach recommended within this plan.

10.01 Recommendation

It is recommended that the Developer adopt the South Britannia Master Waterworks Plan developed by Kerr Wood Leidal, Consulting Engineers as it meets, and in some instances may exceed, the requirements of the SLRD as laid out in Bylaw No. 741.

The following comments, suggestions and recommendations are offered as issues that fire service professionals identify as key considerations in the water supply conversation.

The NFPA Fire Protection Handbook, 20th edition, Section 15, Chapter 2, refers to the American Water Works Association and the Insurance Services Office (ISO) Method for calculating needed fire flows (NFF). These would be done in consideration for each building in question, taking into account design, construction materials, exposures, and use of the building. This level of detail has not been done for the scope of this report.

The calculation of specific fire flows for individual buildings is completed in accordance with the size of each building. It is assumed from the Kerr Wood Leidal plan that the Developer will install infrastructure at the start of the Project which will have the capacity to handle the demands of each phase of the development through to completion. To assist in the understanding of fire flow calculations, two work-sheets have been attached to the report as appendices. NFPA 13: Standard for the Installation of Sprinkler Systems is the standard required by the SLRD. It is anticipated that Kerr Wood Leidal, or a similarly qualified professional engineer, will assist with the calculations for the Developer.



FWC would encourage the Developer to work with the SLRD and BBVFD to develop a program to regularly flush and flow test the water system to confirm the availability of water flows at initial acceptance, and over the life time of the system. Responsibility for carrying out such tests lies with the owner of the water system. It is recommended that the Developer establish a record for such testing on a minimum of a bi-annual basis.

10.02 Recommendation:

It is recommended that the Developer offer to the SLRD that they (Taicheng Development Corporation) will be responsible for the maintenance and testing of the water system until it is appropriate that ownership of the water system should be taken over by local government.

10.03 Recommendation:

It is recommended that the Developer commit to the SLRD to ensure that techniques which will conserve the water supply will be undertaken wherever possible to reflect the best interests of the SLRD as a whole but not at the expense of putting the Project at risk from a reduction of firefighting water resources.

11.0 FIRE DEPARTMENT ACCESS

Access to the Property must be in accordance with the BC Building and Fire Code, and any other requirements specified by the SLRD. The provincial Ministry of Transportation and Infrastructure (``MOTI``) will also be involved in the approval process on road widths, grades, dead ends, etc. A useful resource in assessing the needs of the MOTI is their Planning and Designing Access to Developments Manual. A recognized standard that provides helpful guidance on what a developer should be prepared to consider is NFPA 1141: Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas. Chapter 5 of that standard is dedicated to Means of Access.

During the construction phases of this project, identifying and maintaining proper fire department access is crucial to the ongoing protection of the site. A detailed Construction Fire Safety Plan should be developed and adjusted for all phases of construction.

During the construction phase, fire department access to the entire site must be maintained in accordance with the BC Fire Code.

It is noted that the documents provided, for consideration in preparing this report, are only conceptual drawings and adequate fire department access is implied, but cannot be verified.



11.01 Recommendation:

It is recommended that, particularly during the construction phases, special attention be paid to the presence of adequate site security and that an after-hours fire watch is in place. These items are seen as key components of the Fire Safety Plan.

It is also noted that as the phases of the development on the shore-line side of the railroad are undertaken, appropriate railway crossings are established for emergency vehicles and such crossings are developed with the approval of CN Rail, the authority having jurisdiction with respect to this matter.

11.02 Recommendation:

It is recommended that access for all emergency vehicles is considered during the construction phases and that RCMP, BCAS, Ministry of Forests Wildfire Management Branch, BC Hydro, Fortis and Evacuation-related personnel be included as part of that consideration.

12.0 FIRE DEPARTMENT RESPONSE CAPABILITY

As previously stated, the residents of Howe Sound East have chosen to have fire protection for their communities. Responsibility for the provision and oversight of fire service in the HSEFPS area now rests with the SLRD. The SLRD is now obliged to meet the Duty of Care and a corresponding Standard of Care in the administration and operation of the fire service. This service is currently provided by the BBVFD.

While the BBVFD has been in existence since the early 1900's, it operated for most of those years as part of the mine community. When the mine closed, the BBVFD continued to exist but without local government overview and with minimal funding. As documented elsewhere in this report, the SLRD assumed responsibility for the BBVFD in 2007. A funding formula was created which assessed property owners in the service area. Since the SLRD assumed responsibility for the BBVFD, two significant developments have occurred.



First, a new engine was purchased. Built by Hub Fire Engines, on a 2008 Freightliner chassis, Engine 1 has a pump capacity of 1050 gpm and carries 750 gallons of water.

Secondly the SLRD built a new fire station for the BBVFD. The new premises which includes three bays, a training room and recreational facilities for the volunteer firefighters was officially opened in July 2010. Located on Copper Road in Britannia Beach the fire hall has good access to Highway 99.



Information provided to FWC by the BBVFD indicates there are 24 volunteer firefighters under the direction of Fire Chief Steve Virgint. Chief Virgint has spent over 35 years in the fire service having served the District of Squamish as a career firefighter for most of those years and retiring as Deputy Chief of Squamish Fire Rescue in 2009.

The BBVFD responds to fires of all types but the members are not trained or equipped to provide auto rescue or marine rescue. BBVFD currently does not provide pre-hospital care through a first medical response program. The volunteers meet weekly for training purposes. The training program is coordinated by Chief Virgint and includes visits to the Squamish Fire Training ground.

The BBVFD has two other pieces of apparatus, an engine on a 1981 Mack chassis, which has a pump capacity of 1250 gpm and carries 700 gallons, and a utility vehicle which is used primarily for bush fires. They are also equipped with self-contained breathing apparatus and have been furnished with personal protective clothing that is compliant with provincial safety standards.



In summary, the BBVFD has the core elements required to respond to the demands of the service area as it is today.



An audit of the BBVFD is being conducted in coordination with this Report. Early information received in this regard suggests a number of policies and operating guidelines have not been established for the department. Recommendations to address this situation will be outlined in the report compiled as a result of the audit.

While it is accepted that the ability of the current BBVFD to undertake the provision of fire protection services to the completed South Britannia Beach development would be a challenge, it is felt that a strategic plan could be developed by the SLRD to ensure that a satisfactory level of service is provided throughout the construction period and that such a plan would guide the upgrade of the BBVFD to meet the demands that the proposed phases of development will present. The creation of such a plan could be positively influenced through decisions made by the Developer during the construction phases of the Project. Suggestions and recommendations are outlined later in this section of the report.

The internal Information Report created by the SLRD and dated November 26, 2012 regarding the Development made the following observation:

“The development will ultimately accommodate up to about 8,000 people. This number of people and the associated services required by them will go beyond the current capability of the SLRD to manage. This includes the provision of fire services.

For example, over 40% of the proposed development is potentially within a 4+ storey configuration, requiring skilled firefighting resources. Currently the closest fire department is the volunteer Britannia Beach fire department, which has limited resources and no capacity to fight mid or high rise building fires. The applicant is proposing to complete a Fire Response Protection Plan.”

It is intended that this report by FWC will present appropriate suggestions and recommendations to allay concerns about the ability of the SLRD to deliver the required level of fire protection service to meet the demands of the Development.



To minimize the demands on the BBVFD during both the construction phase and the initial occupancy phases, it is considered prudent that an approach which is focused on fire prevention rather than fire suppression be pursued. The mitigation of fire risk as opposed to the concept of an expanded fire service is deemed preferable. Fire departments are expensive to establish and expensive to maintain.

A pro-active approach aimed at fire education and prevention, in conjunction with built in fire protection systems would lessen the immediate and long term impact on the taxpayers of the SLRD who are obligated to pay for fire protection. This would allow for a systematic growth of the fire service rather than incurring significant debt through the addition of assets; and increased operating budgets that the taxpayers of the specified service area would be responsible for in perpetuity. The Developer has committed that all buildings in the new development will have built in fire protection systems which will include fire detection and alarm systems plus fire suppression systems which would exceed current SLRD requirements. This “up front” investment in fire safety by the Developer translates into a long term lower financial burden to the taxpayer by reducing the need for more equipment and staff in a smaller fire department.

It is accepted that the current structure of the BBVFD will make it difficult for their response time to meet current standards. It is therefore strongly recommended that the SLRD implement a bylaw similar to Bylaw No. 879-2003 which required residences in other parts of the Regional District to have residential sprinklers installed. An accompanying SLRD policy indicating that this requirement is viewed by the local government as offsetting the need to meet stringent response times will reduce any potential liability resulting from a delayed response.

To further support the notion of focusing on fire prevention, the design of all buildings within the Property should be reflective of the options available to mitigate the incidence of serious loss from fire. In addition to having all buildings fully sprinklered, it is recommended that construction techniques such as cladding and soffit protection, fire-resistant roofing materials and the use of other construction materials be used to reduce the chance of significant fire spread.

Examples of this, in single family dwellings, would be the use of fire-resistant materials in the interior of attached garages, the addition of fire-resistant material under flammable siding and a restriction in the size and number of windows and vented soffits facing nearby homes. For multi-family dwellings, such as apartment buildings it is recommended that sprinklers be added in concealed spaces and on balconies.



It is also suggested that consideration be given to the installation of deluge systems to provide roof protection.

By exceeding current code requirements, the Developer has clearly demonstrated a commitment to work with the SLRD on the delivery of fire protection service in the area. An outcome of this action would be to lessen the perceived major changes that would be expected of the volunteer fire department.

During the construction phase a solid fire safety plan, in accordance with the requirements of the BC Building and Fire Codes will significantly reduce the risk of fire. An appropriate work site fire safety plan will ensure that:

- Fire hazards will be controlled.
- Emergency responders will be notified of a fire emergency.
- Access by fire apparatus to all areas of the development will be established and kept clear at all times.
- Emergency responders will not be delayed in carrying out their duties.
- Firefighting operations will be managed effectively, without unnecessary delays.
- Designated supervisory staff will be appointed and organized to respond to fire emergencies.
- Instructions including schematic diagrams describing the type, location and operation of building fire emergency systems are established.
- Water supplies for firefighting commensurate with the risk will be in place and operational.
- Building facilities, systems, equipment and devices will be properly inspected and maintained as an ongoing and perpetual program.

The fire safety plan not only reflects the unique characteristics of building, operation and construction techniques (including the construction trades), but also considers the available firefighting infrastructure. The fire safety plan must be prepared by the Developer and it is strongly recommended that it be done in cooperation with the BBVFD Fire Chief and other applicable regulatory authorities. There are a number of

excellent reference guides available to ensure that the fire safety plan clearly reduces the likelihood of a fire by meeting all applicable codes, standards and regulations. A bulletin issued by the Office of the Fire Commissioner is attached as an appendix to this report and provides guidance on the minimum requirements of Construction Site Fire Safety Plan.

To enhance and support fire prevention it is suggested that all structures have state-of-the-art security-type smoke alarm systems installed. The new codes in force in British Columbia have been developed to raise the bar in this regard.

The concerns of the SLRD that the location of the Property may be at risk from the threat of wildfire can be addressed by the application of FireSmart principles. As stated previously, the choice of construction materials makes a substantial difference when it comes to increasing a structure's chance of surviving a wildfire. Additionally, it is suggested that consideration be given to using fire-rated material when constructing siding and roofing. Also, tempered glass is more fire resistant than single pane and consideration should be given to upgrading windows to increase the chance of structures surviving a wildfire. Careful control over the outdoor burning of debris and the clearing of debris and needles from roofs are key issues in avoiding both the starting a wildfire and having structures impacted by a wildfire. An outdoor burning ban bylaw for the summer months should be considered by the SLRD as a fire prevention strategy.

The Developer may wish to discuss provisions for structure protection with the SLRD to ensure this key concern of the SLRD is adequately addressed.

Additional information about the Fire Smart program is outlined in a couple of manuals. FireSmart: Protecting Your Community from Wildfire and FireSmart Home Owners' Manual. Both are available to review online through the FireSmart Canada website. <https://www.firesmartcanada.ca/resources-library/c/manuals>

Another key consideration is to explore systems that would ensure that needles and leaves are cleaned from roofs and gutters regularly. Embers from an approaching wildfire will often hit the roof first, causing a fire to spread to the rest of the structure.

One additional step that the Developer should consider is to implement a regular system of inspections of all public buildings on the Property. It is the building owners' responsibility to maintain a fire safe property that is compliant with the applicable codes and standards. It is recommended that the Developer approach the SLRD to determine a frequency of inspection that is mutually agreeable and that the Developer identifies an independent qualified contractor to carry out the inspections. It is also recommended that the fire safety inspections include a requirement to meet with the BBVFD Fire Chief to report concerns and to perhaps assist the BBVFD with pre-plans of the various public buildings to aid in the training of the firefighters in advance of emergency calls to those buildings.

Lastly it is recommended that all residents and occupants of structures on the Property have access to fire and life safety public education material. The delivery of this key information could be accomplished by the Developer reaching out to the HSEFPA to determine an approach that would both introduce and sustain a meaningful and relevant program. Use of the Office of the Fire Commissioner's "Getting to Know Fire" program would provide material suitable for all age groups. It is also suggested that the SLRD's Emergency Program Manager be included in the delivery of any fire and life safety program.

In summary, the Developer is committed to reducing the demands that would be made on the BBVFD especially in the early phases of development. The initiative shown by the Developer to create a "fire safe community" throughout the build out time, will allow the SLRD to grow the capabilities of the BBVFD in a manner commensurate with the types of structures being introduced to the community. A larger fire station, more apparatus and paid firefighting staff are not seen as requirements until multi-story structures have been built. Preparing firefighters with a formal training program to address new risks, such as the multi-storey buildings and the proposed marina, will become a priority. Based on information provided, the introduction of additional apparatus should be a consideration during Phase 2 with the other considerations for Phase 4.



Other new risks BBVFD should plan to get equipped and trained for are responses to motor vehicle accidents. Increased population density will result in and increase in these types of incidents. FWC believes good planning supported by sound policy and operational guidelines will see this being accomplished in a manner that will put neither firefighters nor the community at unnecessary risk.

Provision of pre-hospital care may also be a consideration for BBVFD. During the construction phases in the new development, contractors will be required to have their own first aid responders and Emergency Transport Vehicle. As the area develops however, the residents of East Howe Sound may wish to have the BBVFD complement the BCAS by offering a first medical response since the nearest ambulances are located at Squamish and at Lions Bay. A major accident on the Sea-to-Sky highway would deplete BCAS resources and if another medical emergency were to occur in Britannia Beach, medical aid for the patient would be delayed. A properly trained and equipped first medical response crew from the BBVFD would be able to respond in timely fashion thereby reducing pain and suffering.

As part of the summary of this Section, the following recommendations are made with respect to actions the Developer can take to mitigate the event of a serious fire and consequently assist the SLRD transition the provision of fire services to an expanded and more diverse community:

12.01 Recommendation:

That the Developer offer assistance to the SLRD in developing a strategic plan designed to progressively upgrade the BBVFD to meet the incremental demands of the 10 phase development of the site. Recognize an integral part of the plan would be the creation of a formal training program to prepare BBVFD firefighters to respond to fires in new and different environments.

12.02 Recommendation:

That the Developer offer to work with the SLRD to establish and maintain a program of fire and life safety education for all residents of the Britannia Beach community both during the construction phases and after completion of the Project.

12.03 Recommendation:

That the Developer commit to install fire protection systems in all residential dwellings including fire detection and alarm systems plus fire suppression systems. Encourage the SLRD to expand Bylaw No. 879-2003 to include the South Britannia site, citing such action combined with an appropriate SLRD policy would be prudent with respect to the SLRD meeting stringent fire response times for the BBVFD.

12.04 Recommendation:

That the Developer commit to the use of fire-resistant construction materials and techniques and FireSmart principles to address issues of spatial separation between buildings, embers transplanted by wildfire and to reduce the threat of fire spread.

12.05 Recommendation:

That the Developer engage stakeholders in the development of the construction site fire safety plan, particularly the SLRD and the BBVFD.

13.0 CURRENT APPARATUS AND EQUIPMENT

The Britannia Beach Volunteer Fire Department currently has two pumpers.

Engine 1 is a 2008 Type 1 fire engine with a 1050 IGPM/min fire pump and a 750 Imperial Gallon water tank.

The second Engine had just been delivered to the department as a back-up to Engine 1 at the time of this report. It is an older model unit, built on a 1981 chassis, which was acquired from another department in the Metro Vancouver region. Details of pump and water tank capacity have been requested but are anticipated to be similar to Engine 1.

13.01 Recommendation:

Because of the age of the second engine, it is recommended that consideration be given to adding at least one additional Type 1 engine to service the community as it grows and as new risks are analyzed with respect to required pumping capacity. Consideration of this purchase should occur during Phase 1 of the Project.

13.02 Recommendation:

It is recommended that consideration be given to the new apparatus being an aerial device that can service the new structures planned for the community. It should have a 6000 L/min (1250 IGPM) fire pump with at least a 24 meter (75 feet) ladder with a master stream capability. This type of apparatus is commonly known as a Quint and can serve as a frontline engine with an aerial ladder.

While, the purchase of equipment is the responsibility of the SLRD, it is recommended that the Developer advise the SLRD of the potential need and offer to partner with the SLRD when the appropriate time arrives to ensure the demand on the taxpayers is minimal.



A quintuple combination pumper or quint is a fire service apparatus that serves the dual purpose of an engine and a ladder truck. The name quint is derived from the Latin prefix quinque, meaning five, and refers to the five functions that a quint provides: pump, water tank, fire hose, aerial device, and ground ladders.

BBVFD also has a Utility vehicle which is used to transport personnel and access areas where a traditional engine may not be able travel, such as in the event of a bush fire.

All apparatus appears to be well laid out with innovative features that have been added to make them operationally efficient for the community as it is today. They also appear to be well maintained and tested annually in accordance with industry standards. The equipment and the fire hall are kept very clean and tidy.

It is noted in the Project material that a parcel of land in the site plan has been set aside for the construction of a fire station. It is agreed that the demands of the enlarged community will require a re-assessment of the current fire hall both from a size and location perspective. This re-assessment should occur during the early phases of development, as the community risk profile changes and the need for additional emergency services in the community is projected and supported by the taxpayers of the HSEFP area.

Having noted that, it is respectfully submitted, the Developer encourage the SLRD to consider constructing a public safety building rather than a dedicated fire service structure. The inclusion of a BC Ambulance Service facility and an RCMP community police station in a public safety building concept, would both enhance the level of safety provided to the community and may provide some revenue to the community on a long term lease arrangement with those other agencies. It would also be a significant gesture of true partnership with the SLRD as they have expressed concern regarding capacity to address increased demands in this area. If space was available, reaching out to the Search and Rescue community with an offer of premises for them would be viewed as a major contribution to those emergency responders who are woefully under-funded for the outstanding and demanding service that they provide.

13.03 Recommendation:

It is recommended that the Developer reach out to the SLRD to offer this significant investment of land for a public safety building, on behalf of the SLRD, to improve the delivery of emergency response in the Britannia Beach community.

This land for a public safety building should be appropriate in size and location for a larger multi-agency building. More detail on location is found in section 16 of this report.

14.0 TRAVEL DISTANCES FOR FIRST RESPONDERS

Response distance has historically been a determining factor rather than response time, due to the large number of unmanned fire halls. FUS has accepted travel distance as a determining factor for grade classifications. In reality, overall response time is a better measure for a responding fire department. Overall response time is an important consideration when a fire is in its incipient phase and small in size. In a volunteer model like BBVFD uses, response by the volunteer firefighters to the fire hall must be factored into the equation. The time it takes the volunteer firefighters to respond from home or work to the fire hall when a call for service has been received by the 911 dispatch centre and the appropriate fire department has been alerted, will add several minutes to the overall response time.



Through the commitment the Developer has made to have all occupancies sprinklered, along with early detection and alerting systems, the overall effectiveness of BBVFD to working fires in the new development will be enhanced thereby offsetting the time difference of a volunteer fire department response.

A report provided to FWC by the SLRD indicates that all members of the BBVFD live within the fire protection district and within 8 km of the fire station.

When the report was compiled, 75% of the volunteers were employed within the fire protection district or within 8 km of the fire station. This is a significant statistic as quite often rural fire departments in British Columbia have an issue with day-time responses as a result of many of their volunteer firefighters working outside of the fire protection district.

Emergency incident dispatching for the SLRD including BBVFD is contracted out to E-Comm 9-1-1, an emergency communications centre for southwest British Columbia, which is located in Vancouver B.C.. For the purposes of this report it is assumed that the E-Comm 9-1-1 meets an emergency call management and dispatch standard such as NFPA 1221 and that the standard of service is acceptable to the SLRD.

Another standard to be considered, with respect to the response of the BBVFD, is NFPA 1720: Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations and Special Operations to the Public by Volunteer Fire Departments.

An excerpt from NFPA 1720 is as follows:

Purpose:

- Specify the minimum criteria addressing the effectiveness and efficiency of the volunteer emergency response delivery in protecting the citizens in the jurisdiction
- This standard does not restrict any jurisdiction from exceeding these minimum requirements
- Authority having jurisdiction (AHJ) shall determine if this standard is applicable to their fire department

It is our suggestion that the SLRD administration and elected officials in consultation with the BBVFD Fire Chief should review this standard to determine if all or part of this standard may apply to emergency calls in the Howe Sound East Fire Protection service area.

It has been previously stated in this report that other first responders such as RCMP, BCAS and the Initial Attack crews of the Ministry of Forests Wildfire Management Branch are located in Squamish and would have a 10 minute response time to the Britannia Beach community in the event of an incident.

A resource that has not been discussed previously in the report is the issue of mutual aid with neighbouring fire-rescue departments. To the north, the HSEFPS area shares a border with the District of Squamish. The Squamish Fire Rescue service is comprised of both career and paid-on-call volunteer firefighters. FWC have been advised that the Squamish Fire Rescue service has responded into Britannia Beach at the request of the BBVFD in the past.

14.01 Recommendation:

It is recommended that a formal Mutual Aid and/or Automatic Aid agreement be established between the SLRD and the District of Squamish.

An Automatic Aid arrangement would be established by the SLRD to have the District of Squamish provide resources automatically when pre-determined occupancies experience a fire incident. These occupancies would usually include those identified as being of significant and complex risk but could be as simple as any confirmed structure fire. This type of agreement arranges for additional fire suppression equipment and personnel to be automatically dispatched without delay.

To the south, the border is shared with the Village of Lions Bay.

14.02 Recommendation:

It is recommended that a similar arrangement, as outlined in Recommendation 14.01, be formalized with Lions Bay to assist during significant events.

Normally such arrangements are reciprocal but for a volunteer department with modest resources, such as the BBVFD, the capacity to assist another community is limited. They need to ensure that the release of equipment and personnel to assist a neighbor does not put their jurisdiction at risk.

The commitment the Developer has made to incorporate fire protection systems including fire sprinklers in all occupancies in addition to fire resistive materials and design elements will mean fewer fires that will be smaller in size thereby reducing the need for multiple engine companies to respond. This reduced response will also mean that a mutual aid response from a neighbouring community would be very infrequent.

14.03 Recommendation:

It is recommended that the Developer request the SLRD to consider the establishment of formal Automatic Aid and/or Mutual Aid agreements with the District of Squamish and the Village of Lions Bay as a contingency in the event that additional firefighting resources are required to assist the BBVFD in the unlikely occurrence of an extraordinary fire event.

15.0 FIRE DEPARTMENT HUMAN RESOURCES

Fire departments are generally formed to create the ability and capacity to respond to, and mitigate, emergencies. As communities grow there is usually a corresponding increase in fire risk. At some point demands and/or expectations increase and communities must decide the model with which they wish to deliver the service. There is a wide spectrum of models from having no fire protection whatsoever to having an entirely full-time career staff. Most places are

somewhere in between. As they grow, they may transition from a strictly 'volunteer' service to a 'paid-on-call' service. Next steps may see a further change to a composite model with limited full-time staff augmented by paid-on-call members. At some point the fire risk situation may justify having more, or indeed exclusively, full-time career staff. Any decision regarding the desired fire service delivery model is entirely one for elected officials to make. There is no legislation requiring any community, incorporated or not, to have a fire department.

BBVFD is a volunteer service under the leadership of a Chief, a Deputy Chief, three Officers and a number of firefighters. The current complement is 24 in total although this number is subject to fluctuation.

The current BBVFD chief receives some compensation from the SLRD to coordinate and lead the delivery of a training program to the fire department members.



The firefighters meet once a week for a two hour training session. The training is not conducted to a specific standard but information obtained from the SLRD suggests that the training is consistent with the recommended provincial standard established by the Fire Commissioner.

By way of background and understanding of the volunteer fire service the following information is provided to give the Developer some insight into why people are willing to offer their time on a voluntary basis to ensure their community has a fire service.

A study done in 2007 by Caitlin Myers, Jeffery Carpenter of Middlebury College, Vermont and the Institute for the Study of Labor, IZA of Bonn, Germany determined by the evidence they gathered that people will volunteer as firefighters for three main reasons. They are, Altruism, Reputation and Incentives, in that order. Our experience would bear this out as well. In the application of Psychometrics we have found that the main reason people want to be involved in any emergency service discipline is to simply help people. The Myers, Carpenter, IZA study concluded that "volunteer labor supply is determined more by tastes for pro-social activities than by income and costs. In addition, government spending appears to at least partially crowd out volunteering, suggesting that volunteers care both about the level of provision of their product as well as about the act of giving itself". In other words firefighters put a significant amount of importance on the quality of service they provide.

The reputation firefighters enjoy in society is another reason that a person would want to be a firefighter. Firefighting will provide opportunities for a person to realize the "idealized persona bias" or through the training and operational responses they will start to become the person they would like to be.

Incentives are not always monetary and are not usually a reason that a person will volunteer. Incentives in a volunteer fire department can be training opportunities where personal growth and job satisfaction are sought. Recognition is also a strong incentive where years of service, special awards and other personal goals are attained with respect to their individual effort.



Most volunteer fire departments rely on their officers and members to do more than emergency responses and training. They expect members to be involved in new truck committees, equipment purchases, maintenance, truck checks, membership interviews, fire hall janitorial duties, and other team building or social events for example. If too much is demanded of the members beyond the critical training they burn out and tend to move on.

As the community grows, particularly as is laid out by the Developer of the Property in South Britannia, the transition to a composite fire department should be considered to build capacity. Incident probability modeling could be utilized to provide information on when and where a fire is most likely to occur which will be a useful tool in determining staff levels and deployment. This does not necessarily mean fully staffed fire halls 24/7. Many fire departments have transitioned from volunteer to paid-on-call to a paid daytime crew of 3 or 4 firefighters and a Fire Chief Officer who is available during peak times. This transition could occur over the 10 stage phase-in period of the Property, if further study by the SLRD determines that is warranted.

A sample Fire Chief Profile is attached as an Appendix for reference. A Job Profile may be more appropriate, as a job description can be too prescriptive and in reality a Fire Chief of a paid on call or volunteer fire department will often be required to perform duties or functions beyond a prescriptive job description.

After careful study of the proposed development and with the planned phases of construction by the Developer, it is suggested that the BBVFD will be able to grow accordingly to match the risk. It does not suggest that profound changes will be required immediately to the structure of BBVFD.



A fire department does not “gear up” for the largest possible incident but neither should it ignore it. A balance between what may occur and the most commonly occurring incident must be found along with the financial capacity of the taxpayers and willingness to pay for the service.

With the Developer working in concert with the SLRD and BBVFD, as the development milestones are achieved, the fire service will be able to plan well in advance for additional resources. During the construction phases it is possible that many of the construction workers would want to live close by where they work. This demographic is often where a typical volunteer firefighter is drawn from. In the safety first reality of today that companies conduct business in, it will be in their best interest to have trained workers with firefighting skills on the worksite.

Innovative programs to recruit volunteer firefighters can be implemented to augment the BBVFD ranks especially during the construction phases. Subsidized accommodation for volunteer firefighters would be one method to attract members. A robust training program as mentioned earlier where the members learn new skills and are challenged to grow personally will result in the retention of members. Incentives to help volunteer firefighters who may wish to pursue a full-time firefighter career by offering certified training to the NFPA 1001 Standard is another way to recruit and retain members.

At final build out the proposed new development is estimated to have a population of approximately 10,000 people including Furry Creek and Britannia Beach. With a population of this size there will be pressure to incorporate the area. If incorporation becomes a reality, the fire department will have mandated responsibilities. Even in incorporated areas there is no mandated requirement to have a fire department. There is however a mandate to have regular system of inspections for all the public occupancies. As suggested elsewhere in this report, the SLRD or new municipality can be innovative in how this achieved. It does not necessarily mean that paid fire department staff conducts fire code inspections.

As the community starts to grow, a full time Fire Chief should be employed to plan and coordinate the operations of the BBVFD to ensure the department is equipped and trained to match the risk. The job profile of a fire chief is 95% organization and administration and 5% operational. It takes a tremendous amount of work to get a fire department organized before they do respond to any emergencies. One milestone that could be considered for when to hire a full time fire chief is when the area population hits 3000 people and is trending up.

A fire department does not exist for what it does. It exists for what it may have to do.

16.0 RECOMMENDED FIRE DEPARTMENT STAFFING LOCATION AND EQUIPMENT

Many of the traditional aspects of this section have been recorded elsewhere in this report.

This section will capture the key elements of the recommended course of action required to develop the resources of the fire service in the HSEFPS area to meet the projected increased demands brought on by the development of the South Britannia Beach site.

On the issue of the staffing, the current roster of 24 firefighters, all of whom live within the service area and a significant number work in the area also should be increased to a minimum of 32 firefighters as the population of the community grows. It is more important that the existing fire department focuses on the training of their current firefighters to strengthen their competencies prior to the demands made on the department increasing as the previously mentioned new response demands are considered. Responses to pre-hospital care, vehicle extrication and marine rescue incidents combined with the firefighting techniques required to

deal with fires in 4+ storey buildings should be considered sooner than later by the BBVFD and the SLRD.

Due to pending renovations of the BC Mining Museum lands, the BBVFD was required to find a new home in 2010. In the RFP for the new fire hall the SLRD stated that the building design should take into consideration that the fire hall may need to be moved in the future. Such a move may take place within one to five years, or not at all. The outcome was that the new BBVFD fire hall was built in 2010. The building is steel/wood construction building on a slab. There is little office space in the fire hall and the meeting/training room is modest. The apparatus bays are adequate to house the three trucks.



The fire hall is on an adequate lot for the size of the building and there is sufficient parking for the firefighters. The parking lot is also used to do some training.

It is located on Copper Drive which is a primary road in Britannia Beach which meets Highway 99 through a controlled intersection.

The fire hall is both well built and maintained. Its location is close to the Mining Museum but is over 20km travel distance to the southern boundary of the fire protection district. 8 kilometers, within the fire protection area is the maximum travel distances recommended by Fire Underwriters Survey (FUS). The travel distance to Furry Creek is approximately 9 kilometers. When the Britannia Beach fire hall was built it was stated that while it would serve the communities of Britannia Beach, Furry Creek and the future Porteau Cove development, it would be the first in a series of community fire halls to be constructed as the population grows and the three communities evolve.

The BBVFD has done a good job of making use of available space in the apparatus bays for setting up or storing essential equipment required for maintenance. The cubicles for the firefighters' personal protective equipment are adequate for the current number of personnel and for the apparatus that the fire department has.

The main floor meeting room serves as an adequate training room. The social room for the volunteer firefighters is on the second floor.

There is laundry equipment for cleaning dirty or contaminated turn out gear. Gear that is contaminated from the smoke of a fire, hazardous materials, body fluids or from other sources should be kept out and away from personal areas of the fire hall to avoid cross contamination of personal clothes or the common staff and social areas of the fire hall. The BBVFD has done an acceptable job of addressing this issue.

At this time, it is FWC's opinion that the current fire hall meets the needs of the community and the fire department today but as the Project develops, a re-assessment will be required by the SLRD to ensure they are able to continue to deliver the service demanded by the expanded

community. The property on which the current fire hall is built does have space for expansion to accommodate additional apparatus and training facilities.

16.01 Recommendation:

It is recommended that a new fire hall is not a priority today. Having stated that, it is recommended that the concept of a new fire hall, or the development of a public safety building within the South Britannia development, should be re-visited on a regular basis.



The functional worth of a fire station is established in the planning stages. In these days of high construction costs the expenditure of public funds must be carefully considered to avoid serious and costly mistakes.

The area to be protected is a determining factor in planning the location, type and size of the station whether it is residential, urban, suburban, rural, mercantile or industrial, congested, high hazard, open, zoned, or unrestricted.

The proximity of schools, community facilities or other places of public assembly; also the geographical and topographical relationship to the current fire station; and the existence of traffic obstructions such as rail road tracks and high volume highways must all be taken into account.

Other fundamental considerations include the number and types of apparatus to be quartered and whether or not a chief officer or officers will be headquartered there as well.

Fire stations should not be located on heavily travelled roads or one-way streets. The street should be of good width, perhaps a secondary arterial which could provide a clear fire lane across the protection area. There should be a minimum of traffic congestion in the area.

The site should be level, never on a hill side. When possible, one or more rear doors could provide for a drive through capability for the apparatus.

The problem of locating a fire station, or public safety building, has probably caused more debate than anything else affecting the fire service. Fire Chiefs who encounter the opposition of taxpayers, real estate and other groups in selecting a fire station site in a residential area should be able to prove that locating a modern fire station in any residential area does not decrease property values, but rather tends to increase them because emergency services are close at hand.

The apparatus floor area is the heart of every fire station. The location, size, shape, layout and provision for easy and quick access from all areas are one of the factors that establish good functional design.

In determining the size and layout of the station, the planning committee must consider both the immediate and the future needs of the firefighters occupying the station.

Apparatus room doors should be at least 3.6 m (12 ft.) wide and 4.3 m (14 ft.) high, and when possible each piece of apparatus should have direct access to the street. Single truck stations should be at least 7.5 m (25 ft.) wide whereas multi truck stations require a minimum width of 6 m (20 ft.) per truck.

Depth is dependent upon the number of pieces of apparatus to be housed. Ample space must be provided at the front, sides and rear of apparatus to permit routine maintenance, access to tools and equipment, ease of response and repacking of hose.

Apparatus room floors should be of concrete slab construction with care taken to avoid a slick finish. The floor should be pitched for adequate drainage, but not so steeply that the apparatus will roll toward the doors when the brakes are off.

Suggested ceiling height for the room is 5 m (16 ft.). Overhead, counterbalanced, electrically operated doors with controls either at the alarm room or apparatus room are recommended, however, provision should be made for manual operation in case of power failure.

Other equipment in the apparatus room should include a battery charger, water taps, cleanup tools and maintenance equipment, work bench with hand tools, air compressor and vice.

Electric or gas fired hose drying equipment is now available which can effectively replace the hose tower of days gone by. Several of the advantages of this modern equipment include reduced construction costs and energy efficiency. Fire hose washing machines along with dryers and storage racks properly belong in the apparatus area unless a special hose-servicing room is provided. The mobile type of hose rack, equipped with locking casters and a rotating table for reloading apparatus, is very popular and offers several advantages over the old type racks which were made of pipe and wood.

The Alarm Room/Office is the nerve center of the station, where supervision is maintained over all communications. The old time watch desk, formerly located on the apparatus floor, has given way to a separate room where all alarm communications and controls are centered.

Tack boards, bulletins, radio consoles, chargers, telephones and all other related equipment should be arranged in a compact orderly manner and conveniently located.

A minimum of two showers, two water closets, two urinals and two wash basins should be provided for male personnel and the appropriate equivalent for female personnel.



The electrical system should have plenty of service outlets for cooking, air conditioning, radio, television, battery chargers, electric portable tools, projection and sound equipment, and breathing air compressor, to name a few. Fluorescent lighting fixtures are recommended in all areas, with the possible exceptions of closets, storage rooms, and basements. Exterior flood lights are advisable for drives and parking areas. Ample windows, providing plenty of daylight, ease the demand on lighting circuits.

It is preferable to have a clean, sound proof room dedicated to a self-contained breathing apparatus air filling station incorporated into the design. The compressor and cascade air bank should be located for easy access. All breathing air must comply with WorkSafe BC Regulation 8.37, Respirable Air Quality.

A well-equipped lecture and reading room with good chairs, convenient tables, television, and media players should be provided. Also a library with training manuals, fire related books and subscriptions to leading Fire Trade periodicals is an asset. An internet connection is also essential for accessing information and training materials.

While the requirements considered above are common to both volunteer and paid departments, there are some differences in station design. The volunteer station may be used for other functions and will be equipped with a kitchen and large meeting room. The meeting room could be divided into smaller rooms as required by means of folding partitions.

A separate entrance to these facilities will help alleviate traffic through the fire station. The fire protection needs of jurisdictions are always changing and a fire station which is adequate today may require extensive expansion or modification in just a few years. It is necessary for local fire stations to be designed and constructed to accommodate anticipated changes to their staff, equipment and services. Only when they have been designed for flexibility and adaptability to change can these essential facilities expand and adjust to meet new demands with the cost effective alterations.

In areas of the province where power outages are frequent, standby generators are also installed at fire stations so the fire department can still function in a safe manner especially during an emergency situation.

There are many fire stations located within each region of the province. Fire departments that are contemplating a new station should look at existing fire stations. Other fire departments will be more than willing to discuss the pros and cons of their own fire halls.

As stated previously, the BBVFD currently has two engines.

One is a front line engine built by Hub Fire Engines, on a 2008 Freightliner chassis, has a pump capacity of 1050 IGPM and carries 750 gallons of water.



The other is an older model engine, built on a 1981 Mack chassis. It has a pump capacity of 1050 IGPM and carries 700 gallons of water.

The second engine is over 30 years of age and is not recognized by FUS as a suitable fire engine regardless of its condition.

BBVFD also has a utility vehicle which is used primarily for bush fires. The department is also equipped with self-contained breathing apparatus and the firefighters have been furnished with personal protective clothing that is compliant with provincial safety standards.

As noted in section 13 of this report it is recommended that consideration be given as part of a strategic plan to complement the 10 stage development of the Property, that a replacement for the older model engine should be planned.

It is further recommended that this new apparatus should be an aerial device that can service the expanded and enhanced BBVFD area.

It should have a minimum 1250 IGPM fire pump with at least a 24 meter (75 feet) ladder with a master stream capability. As stated in Section 13 of the report, a Quint would be a suitable consideration.

The Quint is a versatile apparatus. If properly designed, a Quint will be able to access any property a full size Type I engine will. The ladder can be used for many other things than just an elevated stream or for rescuing occupants from upper floor windows. For example, roof operations are much safer if for no other reason than the illumination that lights on the end of the elevated ladder can provide to light up the scene at night.

An elevated stream can also be an effective tactic for exposure protection or when used to hit a bush fire hard from above sweeping the fire back into the already burned area or from the flanks. Aerial ladders are useful devices in some situations such as an over the bank patient rescue because of their reach and lifting functions. The multiple functions of an aerial ladder in tactical operations are only limited by the intuition of the incident commander and fire crews.

Within the fire service community there is much debate about fire apparatus. There are standards such as NFPA 1901, ULC S215 or ISO that apply to mandatory features and equipment. In reality there are very few identical fire engines. When it comes time to decide on which type is best, the Fire Chief or a truck committee would usually make the final recommendation to the SLRD.

If the community has an adequate firefighting water supply, as is projected, and with properly spaced fire hydrants, the amount of water an aerial ladder truck carries in its tank is not as much of a concern, whereas the ability to access a building with close enough proximity to be effective at a working fire is more important. An extra 1000 litres of water on board makes little difference if the aerial device can't be situated close enough to the fire, due to the size of the truck.

Points to be considered are that single axle aerial ladder trucks are much shorter in length than a larger tandem axle truck. Aluminum aerial ladders are lighter in weight and "Huck" bolted aluminum ladders employ aircraft technology making ladder maintenance and repair less expensive. Mid-mount aerial ladders are typically lower in height which translates into better handling characteristics. Mid-mount ladders typically are not as heavy due to less weight required in the torque box and the engine can be serviced without having to raise the ladder.

The needs of the community along with access, clearance and weight issues all have to be factored into the purchase of a major piece of equipment such as an aerial ladder device. There are a number of examples in the province of the use of a Quint as a frontline fire apparatus. Kelowna Fire Department is such an example where Quints have been deployed from two of their fire halls with great success.

The cost of a 75' aerial ladder truck will depend on the equipment ordered with the unit but they typically cost between \$600,000.00 and \$800,000.00. Additional information on a 75' mid-mount aerial ladder truck has been included as an Appendix.

17.0 GLOSSARY

AHJ	Authority Having Jurisdiction
BBVFD	Britannia Beach Volunteer Fire Department
BCAS	British Columbia Ambulance Service
Developer	Taicheng Development Corporation
DPG	Dwelling Protection Grade
EMBC	Emergency Management BC
FSA	Fire Services Act
FUS	Fire Underwriters Survey
FSAC	Fire Safety Advisory Council
FWC	FireWise Consulting Ltd.
HSEFPS	Howe Sound East Fire Protection Service
HSEFPA	Howe Sound East Fire Protection Association
IGPM	Imperial Gallons per minute
ISO	Insurance Services Office
LAFC	Local Assistant to the Fire Commissioner
MOTI	Ministry of Transportation and Infrastructure
NFF	Needed Fire Flows
NPFA	National Fire Protection Association
OCP	Official Community Plan
OFC	Office of the Fire Commissioner
OG	Operational Guideline
OH&S	Occupational Health and Safety
Project	South Britannia Beach Project
PSI	Pounds per square inch
RGS	Regional Growth Strategy
SAR	Search and Rescue
SLRD	Squamish-Lillooet Regional District
ULC	Underwriters Laboratory Canada
WMB	Wildfire Management Branch – Ministry of Forests

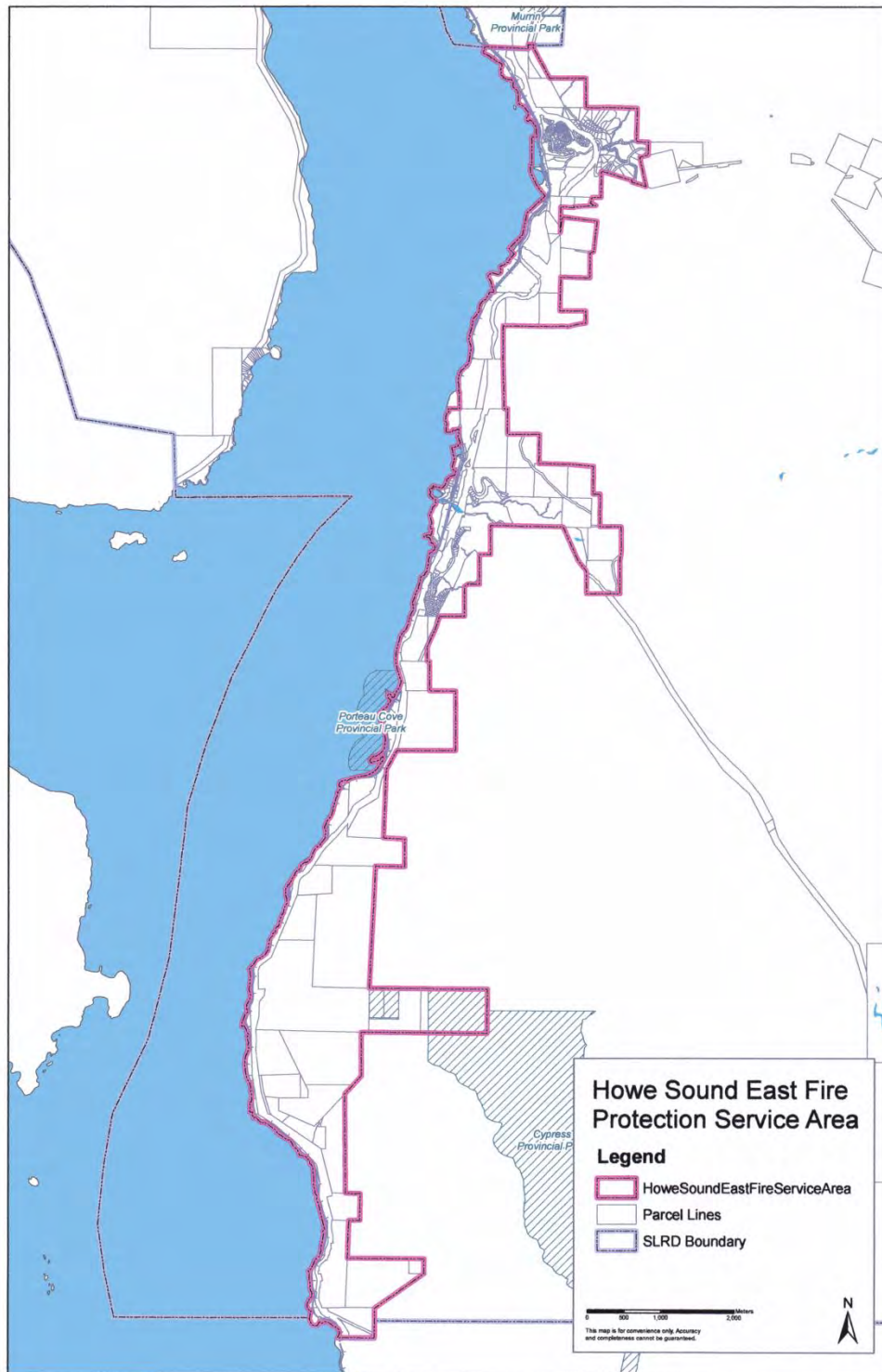
18.0 References

- Electoral Area D Zoning Bylaw No. 540, 1994 Consolidated Copy - October 4, 2012
- Electoral Area D Subdivision and Development Serving (Planned Communities) Bylaw No. 741, 2002 Consolidated Copy – February 2011
- Squamish-Lillooet Regional District Bylaw No. 879-2003 (A By-law to require installation of sprinklers in the Furry Creek community)
- Squamish-Lillooet Regional District Bylaw No. 1032-2006 (A By-law to establish Howe Sound East Fire Protection Service)
- Squamish-Lillooet Regional District Bylaw No. 1034-2006 (A Borrowing By-law for Howe Sound East Fire Service)
- Squamish-Lillooet Regional District Bylaw No. 1110-2008 (A bylaw to regulate fire protection services throughout the Squamish-Lillooet Regional District)
- OCP Bylaw 495 Schedule B Howe Sound East Sub-Area 3 Plan
- Alberta codes and standards (High-Intensity Residential Fires)
- British Columbia Building Code
- British Columbia Fire Code

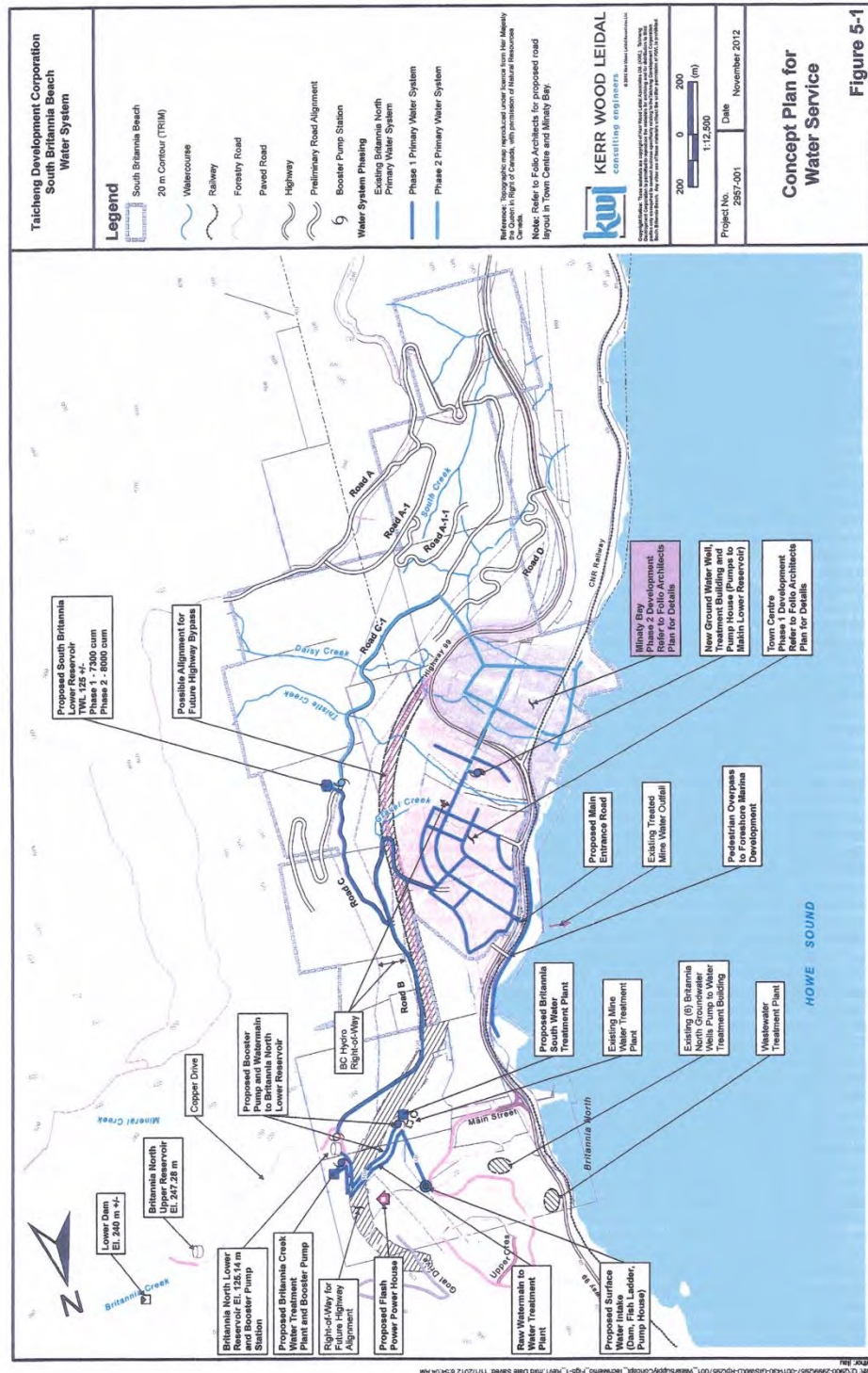
19.0 Appendices

- A. Howe Sound East Fire Protection Service area map
- B. South Britannia Development Site Plan map
- C. South Britannia Development Phasing Information
- D. Britannia Beach and Furry Creek Fire Hydrant locations (Current)
- E. Fire Safety Planning for Construction and Demolition Sites (<http://embc.gov.bc.ca/ofc/services/bulletins/pdf/firesafeplan.pdf>)
- F. Information on a 75' mid-mount aerial ladder truck
- G. Sample Fire Chief Profile
- H. Fire Flow Calculations Sheet (Courtesy of the City of Fort St. John)
- I. Basic Fire Flow Formula (Courtesy of Palm Beach County Fire Rescue)

South Britannia Beach Appendix "A"



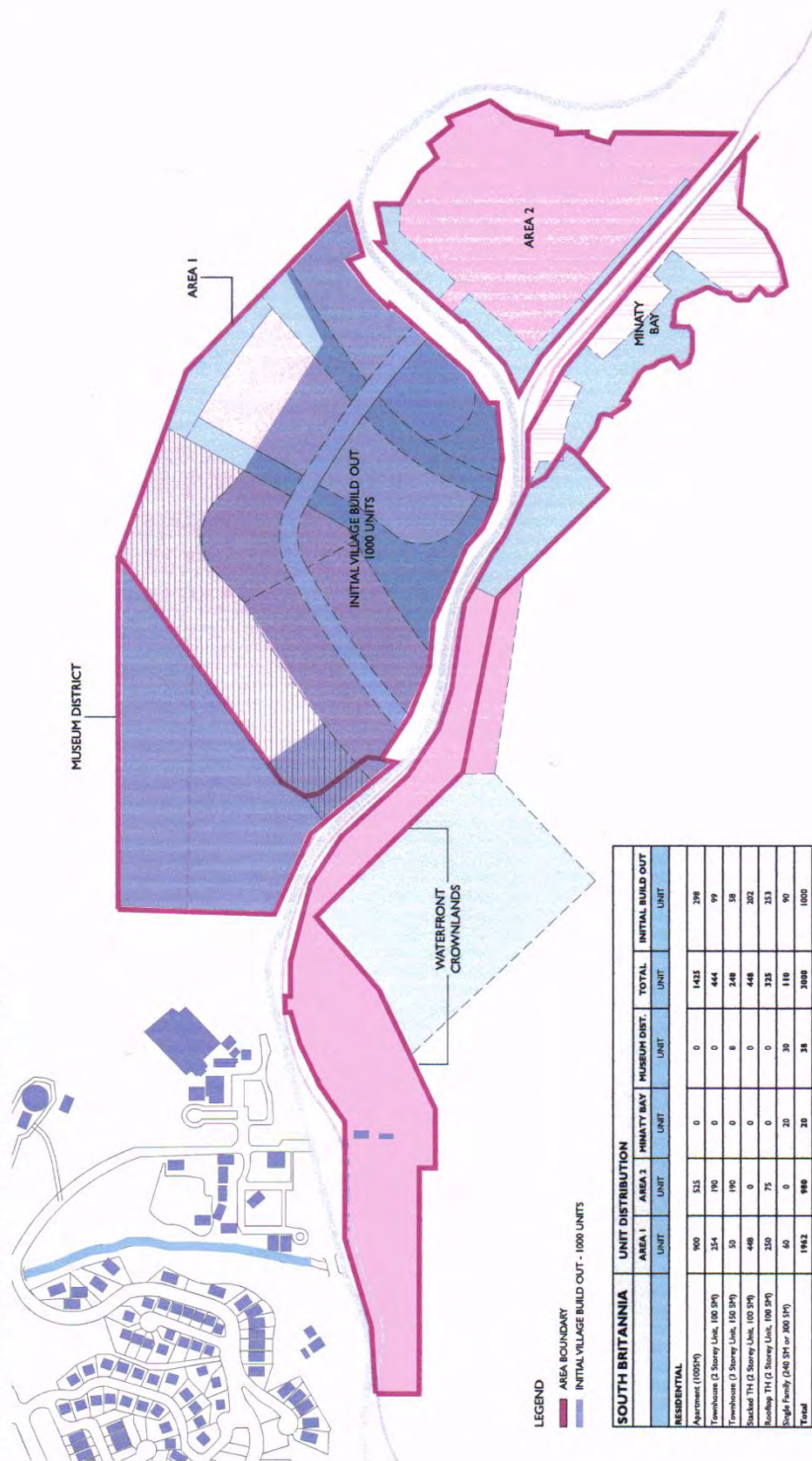
www.firewiseconsulting.com



South Britannia Beach Appendix "C"

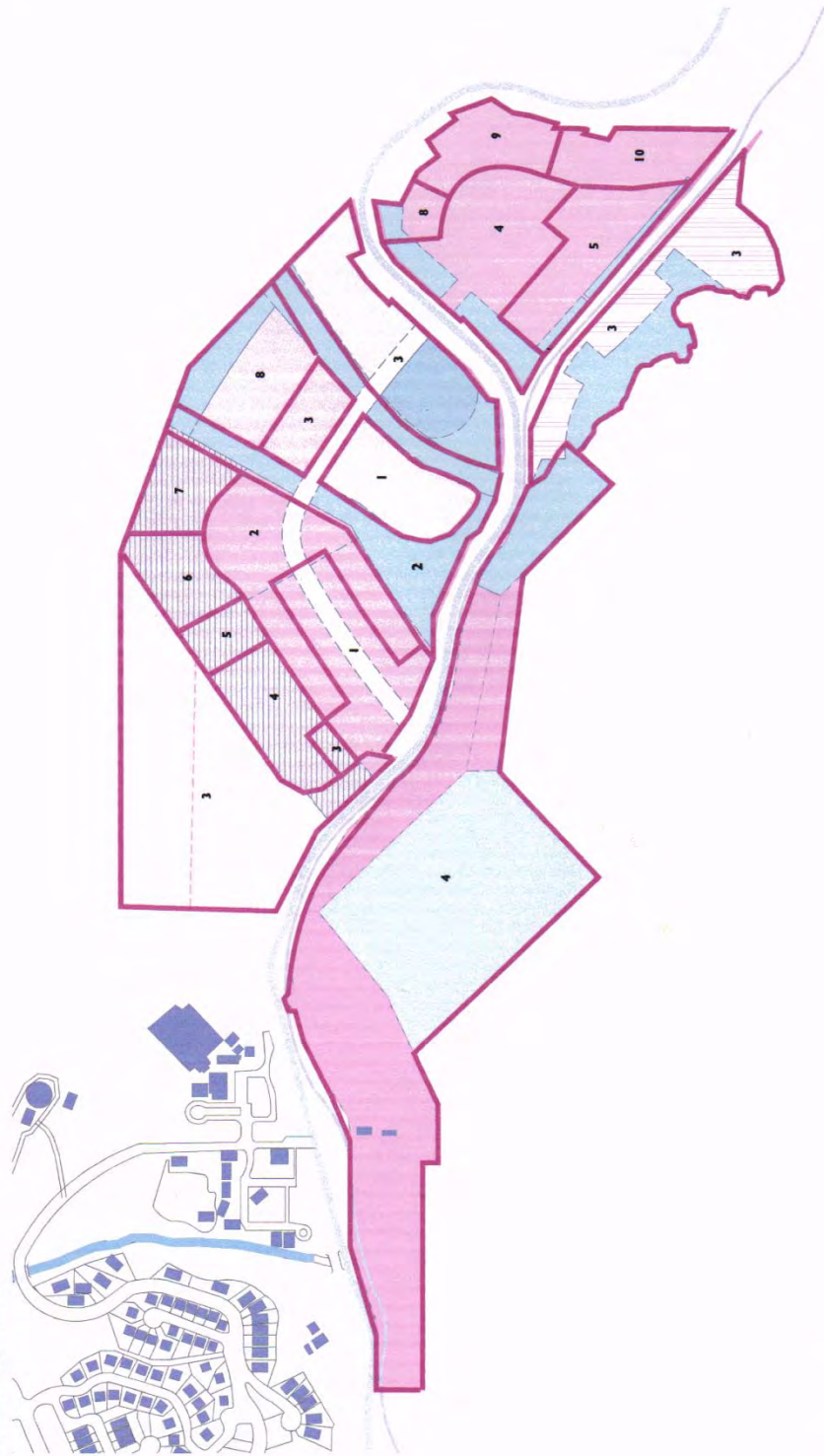


PHASING PLAN-DEVELOPMENT DISTRICTS & INITIAL VILLAGE BUILD OUT



SOUTH BRITANNIA

PHASING PLAN - 10 PHASES



10 PHASE DEVELOPMENT AREAS & SCHEDULE

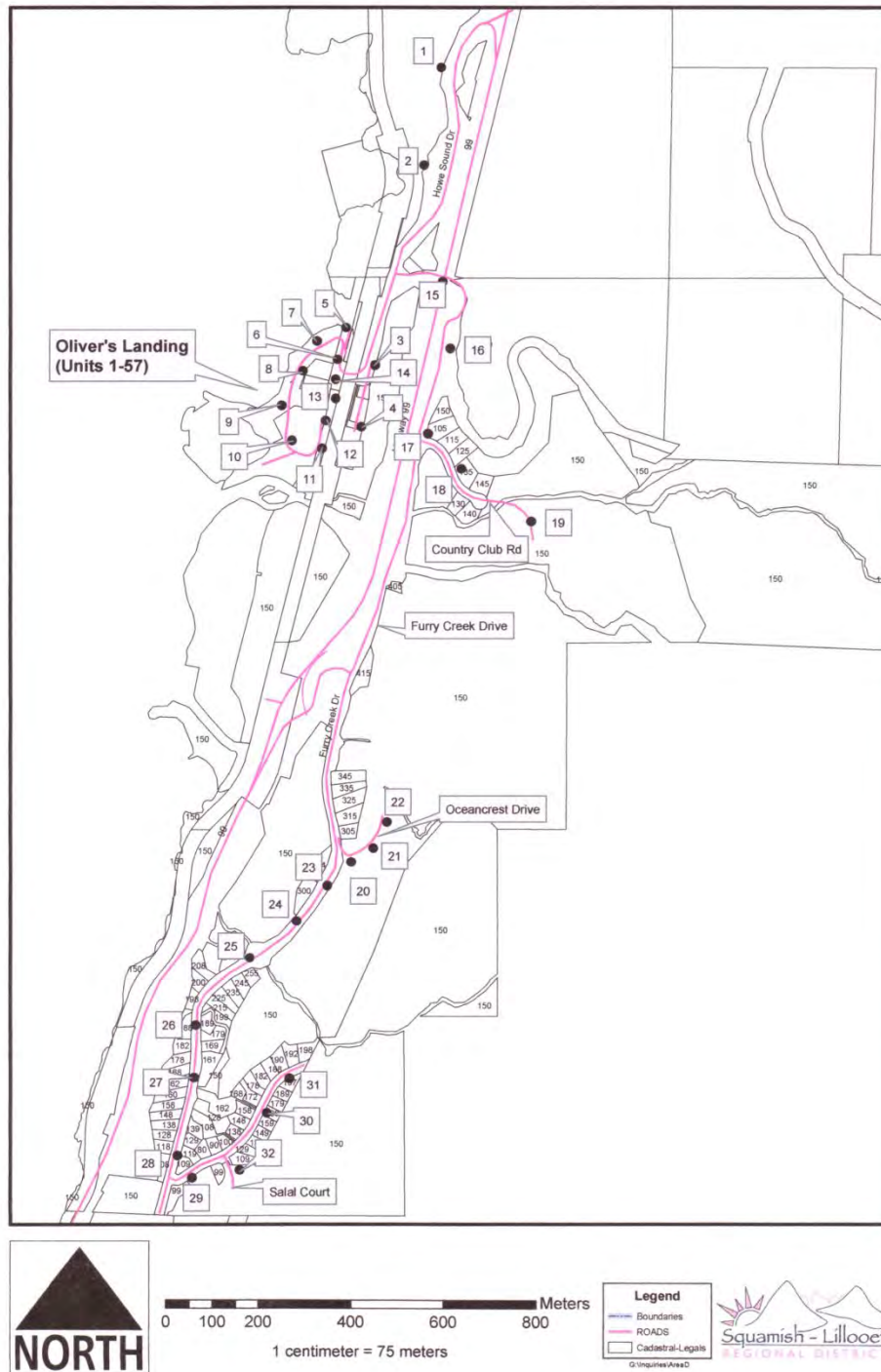
SOUTH BRITANNIA		10 PHASE DEVELOPMENT SCHEDULE																				TOTAL	
PHASE		1		2		3		4		5		6		7		8		9		10		TOTAL	
		UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)		
RESIDENTIAL																							
	Apartment (105SP)	164	16400	138	13800	0	0	860	8600	100	10000	196	19600	196	19600	0	0	237	23700	202	20200	1423	142300
	Townhouse (2 Storey Unit, 100 SP)	15	1500	30	3000	22	2200	88	8800	20	2000	40	4000	40	4000	74	7400	56	5600	64	6400	443	44300
	Townhouse (3 Storey Unit, 150 SP)	32	4800	0	0	26	3900	17	2550	126	18900	0	0	0	0	0	0	13	1950	34	5100	248	37200
	Stacked TH (2 Storey Unit, 100 SP)	36	3600	0	0	166	16600	0	0	34	3400	64	6400	64	6400	84	8400	0	0	0	0	448	44800
	Rowlock TH (2 Storey Unit, 100 SP)	83	8300	122	13200	18	1800	25	9500	0	0	0	0	0	0	0	0	0	0	0	0	238	23800
	Single Family (240 SP or 300 SP)	30	7200	0	0	60	16200	0	0	20	6000	0	0	0	0	0	0	0	0	0	0	110	29400
COMMERCIAL																							
	Retail	0	9000	0	5350	0	0	0	2200	0	0	0	0	0	0	0	0	0	0	0	0	1720	17200
	Office	0	1000	0	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1800	18000
	Hotel	0	0	0	2320	0	0	0	6000	0	3300	0	0	0	0	0	0	0	0	0	0	11620	116200
INSTITUTIONAL																							
	School	0	0	0	0	0	0	2400	0	0	0	0	0	0	0	0	0	0	0	0	0	2400	24000
	Amenity Facilities	0	0	0	6400	0	4320	0	10140	0	0	0	0	0	0	0	0	0	0	0	0	21010	210100
	Display Centre	0	1400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1400	14000
	LIGHT INDUSTRIAL	0	0	0	0	0	0	0	2600	0	0	0	0	0	0	0	0	0	0	0	0	2600	26000
	TOTAL	300	47200	300	44870	300	48100	300	57780	300	43600	300	30000	300	30000	300	30000	300	30650	300	31700	3000	389000

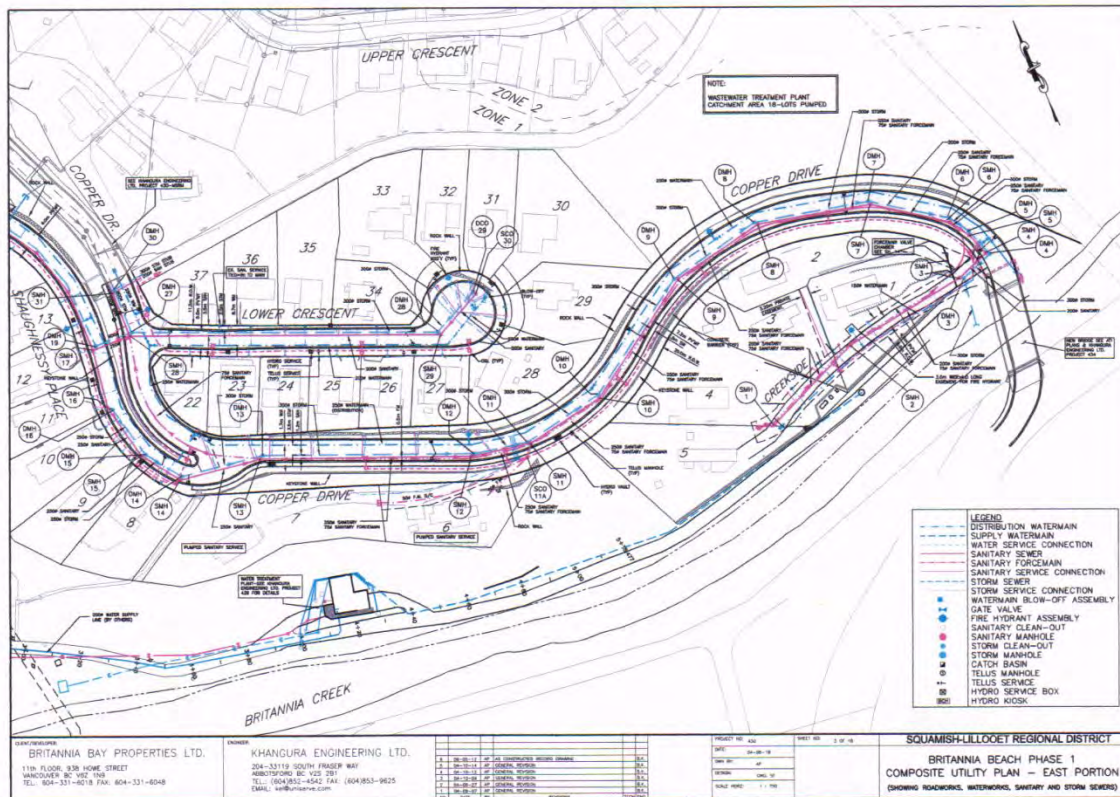
PROPOSED BUILDING TYPES & AREAS

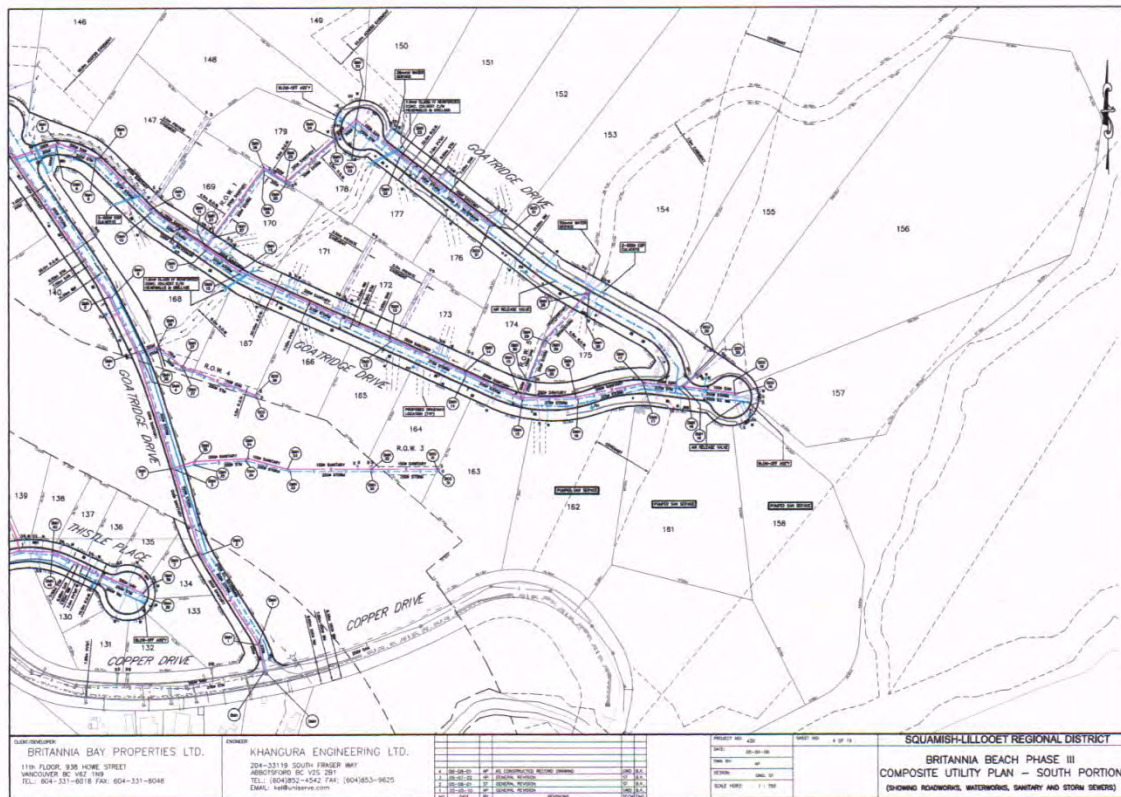
SOUTH BRITANNIA	PROPOSED BUILDING AREAS										TOTAL		INITIAL BUILD OUT	
	AREA 1		AREA 2		MINATY BAY		MUSEUM DIST.		WATERFRONT					
	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)	UNIT	AREA (SQ)
RESIDENTIAL														
Apartments (100SQ)	900	90,000	535	53,500	0	0	0	0	0	0	0	1435	143,500	240
Townhouses (2 Storey Unit, 100 SQ)	254	25,400	190	19,000	0	0	0	0	0	0	0	444	44,400	99
Townhouses (3 Storey Unit, 150 SQ)	30	7,500	190	28,500	0	0	8	1,200	0	0	0	248	37,200	58
Stacked TH (2 Storey Unit, 100 SQ)	448	44,800	0	0	0	0	0	0	0	0	0	448	44,800	202
Rowing TH (2 Storey Unit, 100 SQ)	250	25,000	75	7,500	0	0	0	0	0	0	0	325	32,500	253
Single Family (240 SQ or 300 SQ)	40	14,400	0	0	20	6,000	30	9,000	0	0	0	110	29,400	99
COMMERCIAL														
Retail	0	14350	0	0	0	0	0	200	0	2920	0	17,470	0	14350
Office	0	1800	0	0	0	0	0	0	0	0	0	1800	0	1800
Hotel	0	2330	0	0	0	3300	0	0	0	6000	0	11,630	0	2330
INSTITUTIONAL														
School	0	2400	0	0	0	0	0	0	0	0	0	2400	0	2400
Arts/Community Facilities	0	9400	0	5380	0	0	0	1200	0	5130	0	21,910	0	9400
Display Centre	0	1400	0	0	0	0	0	0	0	0	0	1400	0	1400
LIGHT INDUSTRIAL														
	0	2600	0	0	0	0	0	0	0	0	0	2600	0	0
TOTAL	1942	241770	980	112780	20	9300	38	11600	0	14050	3000	389100	1000	148970

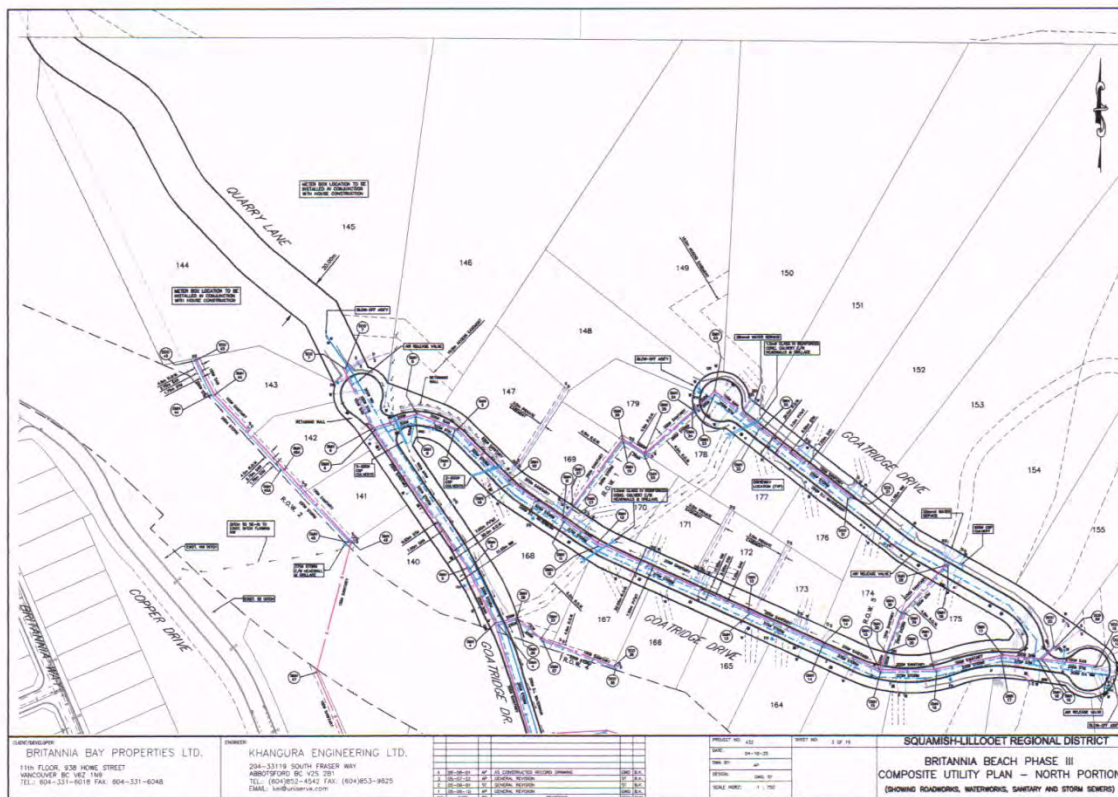
South Britannia Beach Appendix "D"

Furry Creek Fire Hydrants









South Britannia Beach Appendix “E”



INFORMATION BULLETIN

For Immediate Release
release number
April 17, 2009

Ministry of Public Safety and
Solicitor General
Office of the Fire Commissioner

Fire Safety Planning for Construction and Demolition Sites

The purpose of this Information Bulletin is to provide the construction and demolition industry with an easy to follow checklist to assist them in meeting the fire safety requirements of British Columbia's Building and Fire Codes. The goal is to prevent fires in and around construction/demolition sites and reduce the fire risk to life and property.

This bulletin only covers provincial building and fire code requirements. Specifically:

- British Columbia Building Code 2006, Division B, Section 8.1 makes reference to the British Columbia Fire Code (BCFC) 2006, Division B, Section 5.6 which applies to buildings, parts of buildings, and associated areas undergoing construction or demolition operations, including renovations.
- BCFC, Division B, Section 5.6.1.2 (1) states: “**Prior to the commencement of construction/demolition operations, a fire safety plan shall be prepared for the site.**”

The owner or owner's authorized agent is responsible for carrying out the provisions of the BCFC, which includes establishing a work site fire safety plan to ensure that:

- Fire hazards will be controlled.
- Emergency responders will be notified of a fire emergency.
- Emergency responders will not be delayed in carrying out their duties.
- Firefighting operations will be managed effectively, without unnecessary delays.
- Designated supervisory staff will be appointed and organized to respond to fire emergencies.
- Instructions including schematic diagrams describing the type, location and operation of building fire emergency systems will be established.
- Building facilities, systems, equipment and devices will be properly inspected and maintained.

The fire safety plan not only reflects the unique characteristics of building, operation and construction techniques (including the construction/demolition trades), but also considers the available firefighting infrastructure. For this reason, the fire safety plan must be prepared by the owner or owner's authorized agent in cooperation with the local fire department and other applicable regulatory authorities.

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Fire Safety Planning for Construction and Demolition Sites

Prior to commencing any work at a site, it's important for the owner or authorized agent of the owner to:

- ensure they are also in compliance with the laws, regulations and requirements of the BCBC, the BCFC, local government and other regulatory authorities; and
- contact the local fire department and other regulatory authorities such as the [British Columbia Safety Authority](#) and [WorkSafeBC](#).

Fire safety planning and risk management assessments of the site done prior to, during and after building construction/demolition is completed, are essential to prepare for and manage fire hazards. Planning and assessment will identify and lead to methods and processes that will minimize or contain potential fire hazards. All site safety activities should be coordinated through the planning and assessment process.

BCFC provisions are included in the fire safety plan and are applied depending on the project's scope and conditions of the site, e.g. the size and type of the building and its proximity to adjacent buildings.

At a minimum, a fire safety plan should include the following information:

1. Emergency procedures and information needed to plan for an emergency:

- ☐ Who is the designate and backup person responsible to sound the fire alarm (horn)?
- ☐ Who is the designate and backup person responsible to notify the fire department (9-1-1)?
- ☐ Is instruction given to site personnel on the procedure to follow when an alarm is sounded?
- ☐ Are exit routes clearly visible within the site and on all floors?
- ☐ Is the muster point (or meeting place) known by all site personnel?
- ☐ Is there a list of on-site personnel, and is it updated and current? (Can everybody on-site be accounted for?)
- ☐ Are there assigned personnel to meet the fire department upon arrival and give information, such as the location of the fire or injury?
- ☐ Are there persons assigned as site fire wardens (ensuring various trades are represented)?
- ☐ Are there personnel directed and trained to confine or control the fire?

2. Training of site personnel on evacuation procedures:

- ☐ Is site orientation provided?
- ☐ Are regular site fire safety meetings a part of regular safety meetings?
- ☐ Are simulated fire drills conducted when applicable and warranted?

3. Assigned site personnel must be responsible to install and maintain fire safety duties such as:

- ☐ Controlling combustibles on the site and around the buildings.
- ☐ General site housekeeping.
- ☐ Removing excess pallets, garbage/waste material and other combustibles on a regular basis.
- ☐ Maintaining separation of combustibles from open flame devices.

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Fire Safety Planning for Construction and Demolition Sites

- ☐ Maintaining clear unobstructed access route(s) for fire department apparatus and to fire hydrants.
- ☐ Designating and maintaining at least one exit from every floor.
- ☐ Separating access routes from materials stored on-site, combustibles, etc.
- ☐ Parking of vehicles or delivery trucks should not obstruct fire department access to the site, and
- ☐ adjacent buildings (off-site parking and storage may be considered).

4. Firefighting Services – Hydrant, Siamese Connection, Sprinkler, Access Route:

- ☐ Are they installed, tested and activated at the start of construction?
- ☐ Are firefighter access route(s) to the building provided?
- ☐ Are firefighting services (standpipes, hydrants) maintained and accessible?
- ☐ Do drawings provided to the fire department show the location of firefighting systems as they become operational?
- ☐ Is the site address sign visible and legible to emergency crews from the street? (if they must be provided according to bylaw)

5. Fire Extinguishers:

- ☐ Is there sufficient quantity and type on-site? Such as:
 - 2-A:10-B:C on movable equipment?
 - 4-A:40-B:C in all other locations?
- ☐ Is the servicing up-to-date (within the last year)?
- ☐ Are they provided at or near fuel operated equipment?
- ☐ Are they mounted with proper signage at exit locations within the required travel distance?
- ☐ Are they adjacent to any hot works operations (e.g. cutting torch, welding, torching, etc)?

6. Hot Works Operations:

- ☐ Is the area clear of flammable and combustible materials?
- ☐ Is a fire watch assigned during a hot works operation and for 60 minutes after its completion?
- ☐ Is there a final inspection of the hot works area 4 hours after completion?
- ☐ Are the hot works in the proximity of combustible or flammable materials?
- ☐ Have provisions been made for protection of such materials by non-combustible materials, thermal barrier or other means?
- ☐ Is the work being performed by trained or certified personnel?
- ☐ Is a fire extinguisher present at all times? Such as:
 - 2-A:10-B:C on movable equipment?
 - 4-A:40-B:C in all other locations?
- ☐ Is proper ventilation provided as required?
- ☐ Are the hot tar pots on-site complete with fire extinguishers, trained personnel, and located away from combustible materials?

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7. Flammable and Combustible Storage:

- ☐ Are flammable and combustible liquids properly stored, handled and used in and around the building?
- ☐ Are non-petroleum based compressed gases properly stored, handled and used in and around the building?
- ☐ Is the storage area separated from combustible material by 3 metres?
- ☐ Is the storage area locked and vented?
- ☐ Is the storage area protected from vehicular/ industrial motorized traffic?
- ☐ Do containers and/or storage areas have proper signage/placards in place?
- ☐ Is there a current or updated list of dangerous goods on-site such as material safety data sheets (MSDS), as per the [Workplace Hazardous Materials Information System \(WHMIS\)](#)?
- ☐ Are portable extinguishers provided in close proximity to storage and work areas such as:
 - 2-A:10-B:C on movable equipment?
 - 4-A:40-B:C in all other locations?
- ☐ Is the storage area away from egress and access routes to the site?

8. Electrical Installations and Petroleum Gases:

- ☐ Do the electrical installations, storage and use of petroleum gases comply with the requirements of the Safety Standards Act and pursuant regulation? (contact the [British Columbia Safety Authority 1-866-566-7233](#))

9. Security:

- ☐ What type of on-site security is provided: e.g. locked gate, monitored alarm and/or CCTV, 24 hour or nightly walk around?
- ☐ Do security personnel have knowledge of and understand their role in the site's fire safety plan?
- ☐ Can the fire department effectively communicate with the security personnel during an emergency?
- ☐ Do security personnel have access (keys) to locked areas?

10. Contact Personnel:

- ☐ Is there a list of names and telephone numbers of persons to be contacted during and after normal operating hours or in the event of an emergency?
- ☐ Are the contact personnel able to respond in a timely fashion?
- ☐ What is their estimated response time?

11. Building Diagrams:

- ☐ Are diagrams available on-site? These diagrams should indicate:
 - Plans of each floor area;
 - Muster point(s);
 - Location of nearest hydrant(s);
 - Location of fire protection equipment;
 - Exit paths; and,
 - Service rooms.

Information Bulletin:
Fire Safety Planning for Construction and Demolition Sites

The fire safety plan must be reviewed and updated as construction/demolition progresses and then periodically afterwards to provide the greatest value. The plan that is developed for a building construction site should evolve into the plan that will be used to maintain and protect the building and its occupants after completion. It's very important that all supervisory staff remain familiar with the plan throughout the process so they are familiar with how it pertains to their responsibilities.

It may be beneficial to owners to obtain the services of a consultant who specializes in fire safety planning. This consultant would oversee the fire safety plan's development and implementation. This is especially useful to owners who have neither the time nor the expertise to develop their own plan as well as when a fire department isn't available to them.

Contact: Stephen Watt
Codes and Standards Coordinator
1-888-988-9488

Page 5 of 5

The contents of this Information Bulletin are not intended to be provided as legal advice and should not be relied upon as legal advice.

SUTPHEN SL75 MID-MOUNT AERIAL LADDER

AMERICA'S HIGHEST RATED AERIAL LADDER THE NEW SUTPHEN 75' MID-MOUNT



When you need high performance from your fire apparatus, you need Sutphen.

There's nothing like a Sutphen, and there's no other aerial ladder that can match our new 75' Mid-mount Aerial Ladder.



While flowing up to 1,500 gallons per minute of water, this aerial is rated at a **750-pound tip load**, and when dry, the aerial offers an astonishing **1,000-pound rating**, by far **the highest** in the industry. Additionally, set up time is just 20 seconds using one central control, the fastest in the industry.



The new 75' Aerial Ladder is built on Sutphen's custom designed single axle chassis, and features our signature mid-mount technology that provides better maneuverability and ease of handling due to a low center of gravity. Sutphen construction features the highest quality 6005-T5 aluminum and just like Sutphen's other aerial products, includes aircraft style Huck Bolts that provide superior strength and performance – unlike commonly used welds that easily break. It is this combination of strength and mid-mount technology that gives the new 75' ladder a 3:1 structural safety factor.



Other features of the new ladder include an electric radio controlled monitor and nozzle that can be operated at the tip of the third or the fourth section of the ladder. The aerial is also equipped with a full capacity bolt-on egress tip.



ALL OUT - SINCE 1890.



Elkhart Brass
Fire Fighting Equipment

FEATURING THE NEW
ELKHART BRASS
SCORPION RF MONITOR

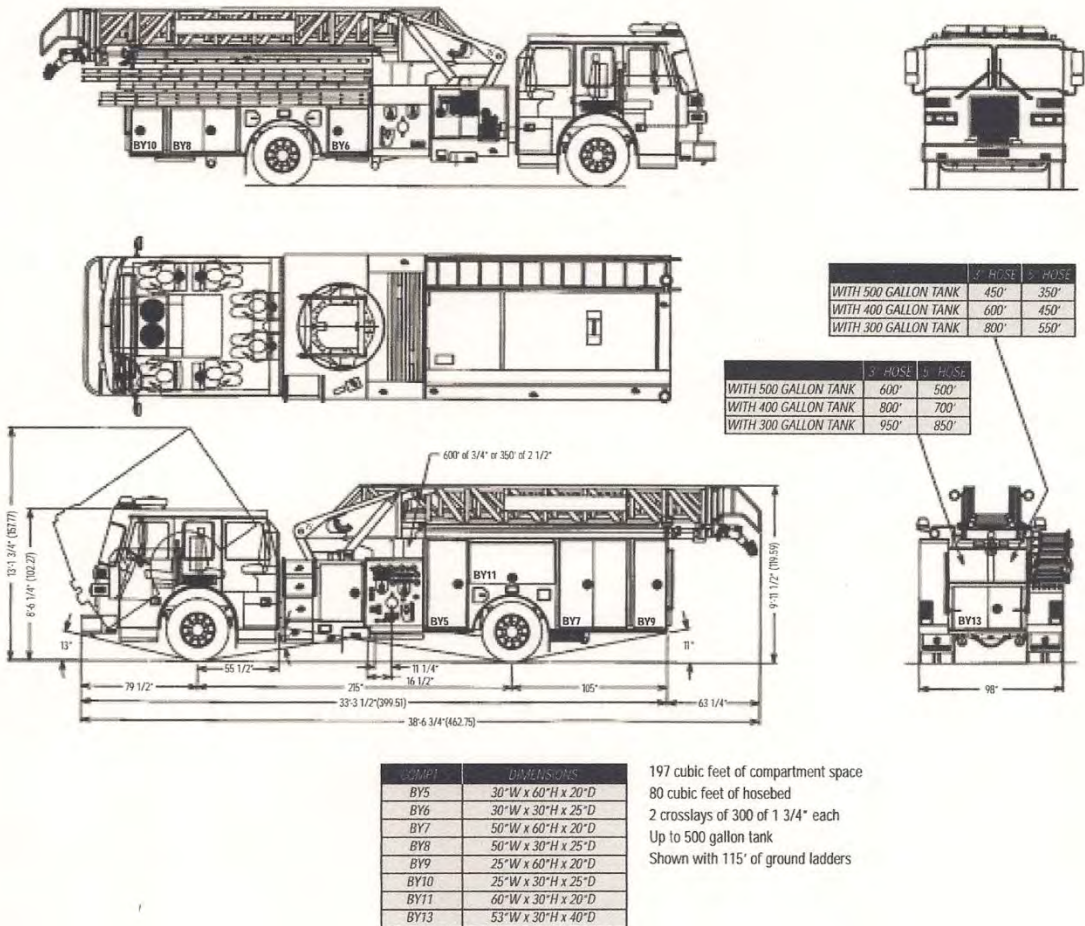
ADDITIONAL FEATURES:

- Full tilt, 6- to 10-man "Safety Cabs."
- Cab can be tilted inside most stations.
- Caterpillar, Detroit, or Cummins engines.
- Booster tank capacities up to 500 gallons.
- Hose capacity for up to 1000' of 5" LDH.
- Extra air cylinder compartments and optional roll-up doors available.
- Fully adjustable shelves fit individual needs.
- Mid-mount aerial improves driver visibility.
- 75-foot, four section ladder for better maneuverability in tight spots.
- 2-1.75" crosslays standard.



1,000-POUND TIP LOAD
750-POUND TIP LOAD FLOWING WATER

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CONTACT YOUR LOCAL DEALER FOR MORE INFORMATION, TODAY.

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SEE SUTPHEN ONLINE AT WWW.SUTPHEN.COM

South Britannia Beach Appendix “G”

Job Profile Volunteer Fire Chief

Purpose of the Job:

Reporting to the (CAO or), the Fire Chief will direct, manage and supervise the fire suppression, fire prevention, fire inspection and rescue activities of the Department as authorized by the Fire Department Establishment and Control Bylaw. The Fire Chief will also administer applicable regulations under local bylaws, building and fire codes and the *Fire Services Act*.

Duties and Responsibilities:

- a. Plan, direct and supervise through subordinate officers the activities of the Volunteer Fire Department as specified in the Fire Department Establishment and Control Bylaw.
- b. Establish and implement Operational Guidelines based on the model provided by the FVRD, the Office of the Fire Commissioner and WorkSafe BC Regulations.
- c. Develop and implement training programs in accordance with accepted standards to improve the understanding and skill of all volunteer fire fighters in fire fighting, rescue procedures and direct coaching of such procedures.
- d. Ensure adequate records are kept of all required maintenance and training.
- e. Prepare and submit an annual budget and long-range plan and make expenditures within approved limits.
- f. Develop and revise a long-range capital plan to keep pace with development.
- g. Advise planning, engineering and other departments on development implications for firefighting as part of the development approval process.
- h. Ensure that all FVRD policies and processes are adhered to.
- i. Maintain an effective working relationship with all FVRD departments and carry out such additional duties and exercises as the FVRD Administrator may direct.
- j. Ensure that inquiries and complaints regarding Fire Department activities or responsibilities are handled promptly, efficiently, effectively and with courtesy.
- k. Liaise with representatives of neighboring Fire Departments to ensure adequate mutual aid agreements are made for mitigating major emergency incidents.
- l. Participate in the Regional and District Emergency Planning process.
- m. Participate in Fire Chiefs' Associations at the provincial or regional level.

Organizational Relationship:

The Fire Chief reports to (CAO or) in the FVRD Administration.

Recommended Qualifications:

Education/Training:

Secondary School graduate.

Completed or participating in a training program based on *IFSTA Essentials of Fire Firefighting*.

Enrolled in or completed a recognized Officer Training Program.

Recommended Experience:

A minimum of five (5) years with a fire department.
Progressive responsibility level within the fire service.
Previous experience as a fire department officer.
Previous management experience is an asset.

Occupational Certification:

Valid BC Class 5 Driver's License for the Province of British Columbia, Class 3 with air endorsement preferred.
Certified First Aid Level I with CPR and First Responder Level III or equivalent.

Knowledge:

Provincial acts, codes, regulations and standards relating to the delivery of fire services.
FVRD bylaws.
VFD Operational Guidelines, policies and procedures.
BC Firefighter Standard.
WorkSafe BC Regulations.
Knowledge and training in British Columbia Emergency Response Management System (BCERMS) minimum Incident Command System (ICS) 200.
Knowledge of the community and Fire Protection Area.

Skills & Abilities:

Ability to be an effective leader.
Ability to delegate, supervise and mentor.
Ability to organize.
Ability to effectively administer the operations of a volunteer fire department.
Ability to effectively communicate verbally and in writing and maintain positive public relations for the fire department and the District.
Ability to supervise and participate in the preparation of all necessary reports, records and correspondence.
Willingness and commitment to participate in training programs and workshops.

I have read and understand this job description.

Employee signature

Date

This job description is the minimum requirement of this job's assigned duties, tasks and responsibilities.

District Official Signature (title)

Date

South Britannia Beach Appendix "H"

City of Fort St. John

Fire Flow Calculations Sheet

Address:

(Calculations based on "Guide for Determination of Fireflow" prepared by Fire Underwriter's Survey)

1. Type(s) of Construction: _____
Co-efficient (c) based on type of construction: _____
Ground Floor Area: _____ ft² Number of Stories: _____
Total Floor Areas: _____ ft²
Fire Flow from Formula ($F = 14.8 C \sqrt{A}$): _____ IGPM (a)

2. Type of Occupancy: _____ Hazard: Low _____ High _____ Other _____
Hazard Allowance: Add or Subtract: _____ % x (a) = _____ IGPM
Sub Total: _____ IGMP (b)

3. Automatic Sprinklers: Yes _____ No _____
Sprinkler Allowance: Subtract: _____ % x (b) = _____ IGMP (c)
Sub Total: _____ IGMP (d)

4. Exposures: Distance / Hazard
1. Front _____ Add _____ %
2. Left _____ Add _____ %
3. Rear _____ Add _____ %
4. Right _____ Add _____ %
Exposure Allowance: Add _____ (e) % x (b) = _____ IGMP (f)

- TOTAL FIRE FLOW REQUIRED:** _____ **IGMP (g)**
REQUIRED PRESSURE: _____ **P.S.I.**

Sprinkler System Information

- (a) If building has automatic sprinklers:
Distance from sprinkler fire connections at building to nearest available fire hydrant on an unobstructed route: _____ m.

Will sprinkler system be wet or dry: Wet _____ Dry _____
If wet, will system contain anti-freeze or any other chemical additive? Yes _____ No _____

Backflow protection (describe) _____

- (b) If building has no automatic sprinklers:
Distance from main building entrance to nearest available fire hydrant on an unobstructed route _____ m.

Calculations by: _____ Date: _____

P. Eng. Signature: _____ Professional Seal: _____



BASIC FIRE FLOW FORMULA

Indication: Company Officers need to ensure sufficient water is available to contain and extinguish the fire. The Needed Fire Flow Formula is a helpful tool to determine total fire flow necessary. The Company Officer needs to determine the flow required and communicate the need to the Driver Operator. The Driver Operator can then ensure that an adequate and reliable water source is identified to supply the necessary fire flow.

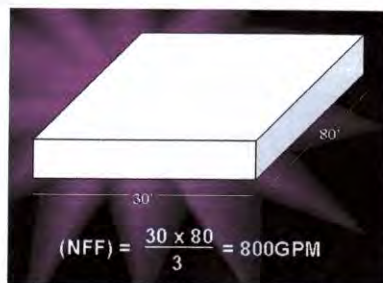
Limitations: Variables that effect fire flow include: fire load, concealed spaces, building construction, and configuration.

Basic Formula:

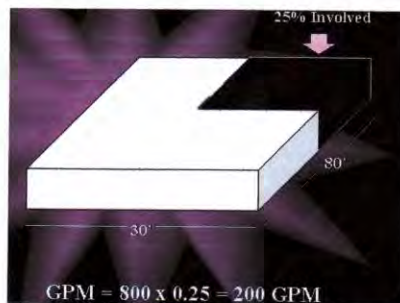
Needed Fire Flow (NFF) = $\frac{\text{Length} \times \text{Width}}{3}$ X Percentage of fire involvement

Example:

1. To calculate the total fire flow for an entire building involved in fire:

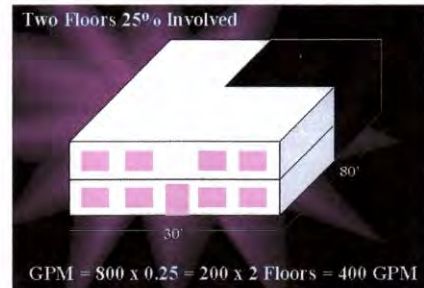


2. To calculate the needed fire flow for a portion of the building involved in fire. In this example 25% of the entire structure is involved in fire:





For additional floors, multiply the percent involved times the number of floors involved.



Exposures

Exposures are classified as internal (additional floors above the fire) or external (buildings adjacent to the involved structure).

1. For internal exposures (additional floors), a constant factor of 25% is added for each exposure (to a maximum of 5 floors) to Needed Fire Flow. Therefore the Exposure Formula is:

$$\frac{\text{Length} \times \text{Width}}{3} + 25\% \text{ for each floor above the fire (maximum of 5 floors)}$$



This example shows the exposure of 2 additional floors above the fire (add 25% for each floor) to the NFF

2. For External Exposures (building adjacent to the involved structure), a constant factor of 25% is added for each side that has an exposure. Therefore the Exposure Formula is:



$$\frac{\text{Length} \times \text{Width}}{3} + 25\% \text{ for each side with an exposure}$$

This example shows exposures on the B and C side of the structure (add 25% for each side with an exposure) to the NFF

12 **SERVICING**

This section contains a servicing report Engineering Servicing for South Britannia Beach prepared by Ker Wood Leidal (KWL) Engineering Ltd in November 2014. This report supersedes the earlier servicing reports prepared in support of the previous development concept. This report is less detailed than the previously prepared servicing reports as its primary intent is to establish feasibility, rather than to provide details that will be presented in later phases of the project. It is noted that this report was prepared to reflect an earlier, less well articulated, development concept than the one currently being proposed. Nevertheless, the concepts provide useful background to the Turje report.



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Engineering Servicing for

South Britannia Beach

Final Report – Revision 1

November 27, 2014

KWL Project No. 2957.006-300

Prepared for:



Taicheng Development Corporation



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Appendix

Appendix: SLRD Standard Road Details



Executive Summary

In preparation for rezoning, development plans for the Britannia South lands were assessed for civil site servicing. Servicing includes roads, water, sewer, drainage, flood protection, and other utilities. The development plans were developed by a planning team led by MVH under the direction of the owner, Taicheng Development Corporation. In general, the plans were developed to conform to the land uses, servicing and maximum 850 to 1,000 units established in the Squamish-Lillooet Regional District's (SLRD) Official Community Plan (OCP).

Site access strategies have been developed by the project transportation consultants. The lands are currently accessed from a connection to Highway 99. This current configuration is expected to serve the early phases of development. Later phases will require a right in, right out connection to the southbound lanes of Highway 99 in the Minaty Bay area. Upgrades to the primary highway connection, such as a two-lane roundabout, may be desirable or required during the last phase of development. In addition, a right of way allowance has been identified for a future high-level highway just below the BC Hydro right of way. The development plans do not intrude upon this right of way allowance.

The internal road network includes a single collector road that links the current highway connection to the future right in, right out connection. This collector road will run through the existing single-lane tunnel under the highway that will be signalized when traffic warrants it. The remaining roads are local access roads and lanes. Proposed 22 m collector, 20 m local, and 6 m lane rights of way are ample to support SLRD and Ministry of Transportation and Infrastructure (MoTI) road standards, although more pedestrian friendly and environmentally sustainable designs may be pursued subject to SLRD and MoTI acceptance. The last phase includes a higher elevation road that would connect to North Britannia. A lower bicycle and pedestrian connection to North Britannia will be constructed in the first phase. The existing rail crossing at Minaty Bay is proposed to be shifted to the south and upgraded to current safety standards.

Water supply and fire protection can be supplied from groundwater wells located on site. Well testing during the summer drought period in 2013 confirmed a capacity of 46.6 Lps. This can adequately supply over 1,000 units based on 2.6 people per unit and 1,000 L/c-d, consistent with typical current practice in the SLRD. This also holds true for a higher occupancy such as 3.1 people per unit to allow for secondary suites. Even at the SLRD's historic by-law provisions of 4 persons per single family dwelling unit (SFD), 3 units per multiple family dwelling (MFD), and 1,500 L/c-d, the wells can support approximately 850 units depending on the mix of SFD's and MFDs. The water supply system will be contained within the site and include wells, treatment, pumping, a reservoir, and distribution water mains and appurtenances. Connections to the North Britannia water system are desirable for increased reliability and improved operations of both systems.

Sanitary sewage will be collected and conveyed to low points on the site, and pumped through a force main to the North Britannia Wastewater Treatment Plant (WWTP). The internal conveyance system will be constructed as needed to service development phasing. Some elements of the WWTP, such as the outfall, were constructed with capacity for the full OCP build-out population. Other elements such as additional sequencing batch reactors will require expansion as the population and loading increases. WWTP capacity expansion is expected to be required prior to occupancy of South Britannia units.

The site slopes towards and drains into Howe Sound via a single defined drainage crossing of the highway and CN Rail at Thistle Creek, and two crossings of CN Rail at Daisy Creek and an unnamed creek at the south end of the Minaty Bay area. The lower, flatter portions of the site consist of permeable sand and gravel. The development is planned to maintain hydrologic values of the site, with protected watercourses with riparian areas, and re-establishment of disturbed creeks and riparian areas. Rain gardens, swales and ponds are proposed to maximize biofiltration and infiltration.



The lower areas of the site are exposed to potential storm surges from Howe Sound. The design elevation for flood protection measures is 5.6 m including a 1 m allowance for 100 years of sea level rise. Inland of the highway, the lands may be protected by a 5.6 m crest elevation dike (approximately 1.5 m above existing grades) and the buildings should be constructed to a minimum 4.35 m flood construction level (FCL). Buildings on the water side of the dike should be constructed to the full 5.6 m FCL along with adequate erosion protection.

Other Utilities

Electricity – BC Hydro power lines run through the lands on the east side, and a substation that services North Britannia is at the north edge of the site. Modifications to the existing substation or a similar arrangement will be provided for South Britannia.

Gas - There is no gas service at or near the site. A stand-alone system would need to be set up, likely with a storage tank periodically refilled by truck.

Bell Canada is responsible for communication system planning and installation. As for BC Hydro, construction of the civil works (conduit) is the responsibility of the developer.

The cablevision provider is responsible for system planning and design. Generally the provider cable is responsible for all or nearly all costs of the cablevision system.

Conclusion

For the proposed development plans that are consistent with the OCP, site servicing can be provided in a reasonable manner. Concept plans and cost estimates were developed based on development plans by Taicheng's planning team. Water supply is available from wells, sewage treatment capacity is available from planned expansion of the North Britannia WWTP, most of the roads will be on the flatter and easier areas to construct, and the site is planned to maintain or enhance the existing creeks and hydrology of the site. These plans and cost estimate are provided to assist with the economic feasibility assessment and development approval process being led by others.



1. Introduction

Kerr Wood Leidal Associates Ltd. (KWL) is working with the Taicheng Development Corporation on the proposed development of South Britannia Beach, located between Britannia Creek and Furry Creek on the slopes above Howe Sound. This report presents a Conceptual Development Plan for the proposed South Britannia Beach development.

The Conceptual Development Plan is presented in support of rezoning and will be further refined in accordance with the requirements of SLRD Subdivision and Development Servicing Bylaw 741.

Previous water and wastewater related KWL reports for the project are summarized as follows.

- *February 10, 2012, South Britannia Beach – Surface Water Sources for Potential Water Supply and Water System Planning*

This memorandum provided a concept level assessment of surface water sources for the South Britannia Beach domestic water supply to support the proposed Initial Buildout development population of 4,000 people and a potential ultimate development (Phases 1, 2 and 3) population of about 12,600 people. The concept plan provided for using Britannia Creek as the primary source of water supplemented by a new groundwater well located near Thistle Creek. In order to overcome a deficit in supply during the drought months May through October, on-mountain storage within the Britannia creek watershed was proposed.

- *February 21, 2012 Concept Stormwater Management Plan Technical Memorandum*

This memorandum provides a summary of drainage and stormwater criteria applicable to the South Britannia sites, and provides general guidance on design principles to meet the required criteria.

- *March 5, 2012 Concept Flood and Foreshore Protection Technical Memorandum*

This memorandum provides a summary of potential flood issues and provides a preliminary flood protection plan for the conceptual development.

- *May 16, 2012, South Britannia Beach – Water Supply*

This letter addressed review comments of the February 10, 2012 memorandum provided by the SLRD and identified next steps in the approval process.

- *July 25, 2012, South Britannia Beach – Water Supply Update*

This letter responded to Opus Dayton Knight's key review issues relative to the proposed water system plan. It also presented an updated water demand summary based on current planning for the development at that time. The population and water demand was based on 2.6 persons/unit (combined single family and multifamily) as agreed to by SLRD. The water requirements are based on Bylaw 741 (600 l/c-d average and 1,500 l/c-d maximum day) demands.

- *November 14, 2012, Britannia Mine Water Source Assessment*

This report presents a feasibility level assessment to determine the suitability of water from the Britannia Mine Water Treatment plant for use as a water supply for the proposed South Britannia Beach development.



- *March 28, 2013, Ground Water Surface Water and Britannia Mine Water – South Britannia Beach Master Waterworks Plan for Initial and Complete Buildout*

This report presented a feasibility level Master Waterworks Plan for the South Britannia development. The plan was innovative and sustainable, and included features such as water conservation, water reuse, and a non-potable water system for irrigation and toilet flushing.

- *June 2013, South Britannia Beach Master Waterworks and Wastewater Plans – Initial and Complete Buildout*

This report presented a feasibility level Engineering Servicing Plan for the South Britannia development. The plan included a water source review, summary of water demands, water servicing plan, water treatment, a wastewater collection and treatment plan, and drainage and flood considerations. This report is based on KWL's previous studies, as listed above, adapted to the current development plan.



2. Background

2.1 Development Plan

The South Britannia Beach development is located at Britannia Beach, approximately 60 km north of Vancouver, BC between Britannia Creek and Furry Creek – Figure 2-1. The lands are within Electoral Area D of the Squamish Lillooet Regional District (SLRD). The overall development concept plan, Figure 2-2, was developed during the April 22, 2014 design workshop. The plan provides for a mix of single-family residential, multi-family residential (townhouse units) with some commercial and institutional.

The current OCP allows for 1000 development units, the table below summarizes the proposed phasing for South Britannia Beach.

Table 2-1: Proposed Development Phasing

Table 2.1.1 Proposed Development Phasing

Development Type	No. of Residential Units					
	Phase					Total
	1	2	3	4	5	
Residential						
Single Family	234		69	215		518
Multi - Family	106	175	201			482
Total Residential	340	175	270	215		1000
Institutional and Commercial						
Community Resource and Learning Centre	1,600 m ²					1,600 m ²
Transit/Recycling Centre/Co-op bike Rental	150 m ²					150 m ²
Fire And Police/Emergency Centre	500 m ²					500 m ²
Municipal Office	500 m ²					500 m ²
Commercial Hub	1,500 m ²					1,500 m ²
Minaty Bay: Boathouse / Washrooms / Food Concession / Wedding Pavilion		160 m ²				160 m ²
Hotel					100 beds	
Total Institutional and Commercial						4,410 m ²
Notes:						
1. Based on information provided by Paul Turje in an email dated Nov. 20, 2014						



2.2 North Britannia Beach

The North Britannia Beach Development was constructed in 2005. To provide water supply redundancy to both the North and South Britannia Beach developments it may be desirable to connect to the two water systems. The following section summarizes the North Britannia Beach water system.

The existing North Britannia Beach Wastewater Treatment Plant design allowed for the development of South Britannia Beach; therefore it is assumed that the existing wastewater treatment plant will be expanded to accommodate the proposed growth.

Water System

The existing water system was constructed in 2005 to service the new development at North Britannia Beach. Enterprise Geoscience Services Ltd. in their 2005 report *Hydrogeological Report on Construction and Testing of Water Source Wells on the Britannia Creek Fan Aquifer* describes the development of well water sources for North Britannia. The existing water system is described as follows.

- The water system was developed to supply the new North Britannia residential development and the existing and proposed commercial development on the creek fan; the design is based on the criteria from SLRD's Bylaw 741. The estimated maximum day water demand is 26.1 L/s.
- Six production wells were developed on the north side of the Britannia Creek between the highway and the Copper Drive Bridge. The six wells are rated for a total flow of 26.4 L/s and the wells are considered as "groundwater under the influence of surface water".
- These wells pump water to a water treatment building and pump house located near the well field where it is adjusted for PH, disinfected with UV and chlorinated. It is then pumped through a dedicated 200 mm diameter water main to the Britannia North Lower Reservoir (top water level 125 m) located on Copper Drive on the south side of Britannia Creek.
- The Lower Reservoir services North Britannia from about elevation 95 m to sea level through two pressure zones (Zones 1 and 2). A pressure reducing station on Rainbow Lane near the Upper Crescent cul-de-sac services Zone 1, the low-pressure zone. The zones are supplied by a 250 mm water main from the Lower Reservoir.
- Water is pumped from the Lower Reservoir further up Copper Drive to the Upper Reservoir (top water level 247 m) through 150 mm and 250 mm water mains. The Upper Reservoir services the development area from about elevation 217 m to the 95 m elevation in two pressure zones. A pressure reducing station on Copper Drive services Zone 3, the lower of the two zones. Each zone is supplied by a 250 mm water main from the Upper Reservoir.

Wastewater System

North Britannia is serviced by a municipal wastewater collection system that conveys wastewater to a treatment plant located on the north side of Britannia Creek adjacent to Highway 99. The treatment plant was constructed in 2007 and was designed to service the existing and future population of the Britannia Bay Properties (North Britannia Beach) development and adjacent commercial development. An allowance was made during the design stage for future wastewater flows from South Britannia Beach equivalent to about 4,000 people.

Effluent from the treatment plant is discharged by gravity through an outfall into Howe Sound at the southwest corner of the WWTP to a depth of approximately 25 m below low tide.



2.3 Groundwater Source Development

Piteau Associates Engineering Ltd. (the project hydrogeologists) completed the following ground water source studies and investigation work on the South Britannia Beach aquifer.

- Hydrologic Desk Study and Investigation – November 14, 2011;
- Phases 1&2A Groundwater Supply Assessment Report – February 8, 2012;
- Phases 1&2B Groundwater Supply Assessment Report – November 16, 2012;
- Hydrogeologic Assessment for Groundwater Supply; Numerical Groundwater Flow Model Report – March 5, 2013; and
- Hydrogeologic Assessment for Groundwater Supply, Britannia South, Britannia Beach, BC – Phase 3, January 15, 2014.

The relevant findings from these reports include:

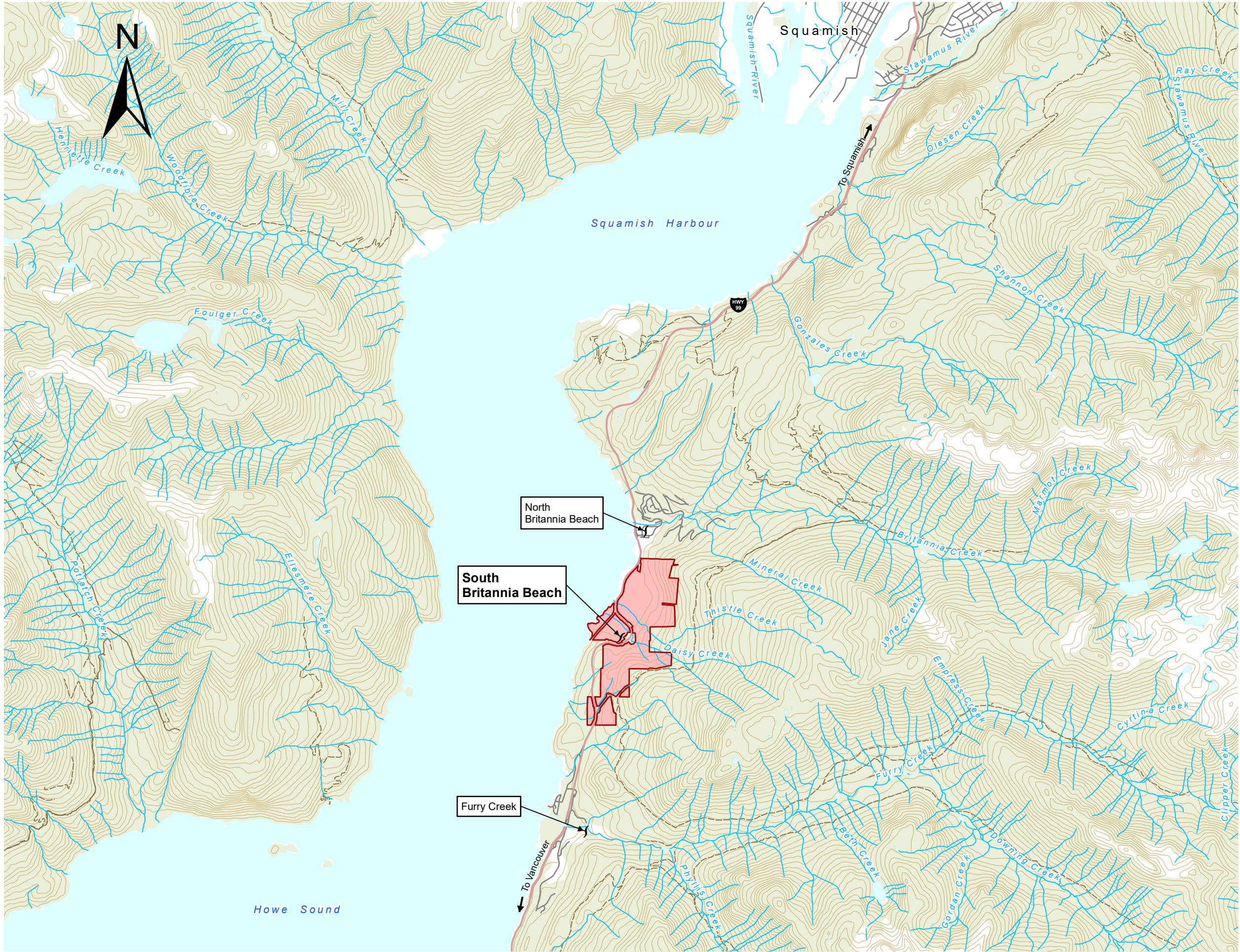
- The South Britannia Beach development is situated on a fan comprised of alluvial and glaciomarine sediments. The sediments extend about 700 m inland from Howe Sound and top out at about 95 m above mean sea level.
- During the South Britannia Beach visit on September 12, 2011, flows in Thistle Creek and Daisy Creek were observed to fully infiltrate into the fan sediments. The lower 170 m of Thistle Creek and 480 m of Daisy Creek were dry.
- A 101-day long extended period aquifer pump test was conducted concurrently for test wells: TW1 and TW2. Piteau's analysis of groundwater level response to pumping indicates that the wells can sustain flows of 26.7 L/s and 19.9 L/s (total capacity of 46.6 L/s) over the summer drought period and throughout the remainder of the year, with negligible risk of salt-water intrusion.
- Water Quality tests indicate that the pumped water met all objectives in Health Canada's Guidelines for Canadian Drinking Water Quality. Potential contaminants of concern such as extractable hydrocarbons, polycyclic aromatic hydrocarbons, volatile organic carbons, and herbicides were not detected in TW1 (during earlier testing) or TW2.
- Based on the proximity to surface water and microbiological tests, groundwater from TW1 and TW2 is likely to be considered groundwater at risk of containing pathogens (GARP) and may therefore require filtration, in addition to a multi-disinfection strategy which typically consisting of ultra-violet light irradiation followed by chlorination.

2.4 References

The following guidelines were referenced during the development of this development plan.

1. Squamish-Lillooet Regional District – Electoral Area D, Subdivision and Development Servicing Bylaw No. 741, 2002; and
2. British Columbia Ministry of Transportation, BC Supplement to TAC Geometric Design, June 2007.

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Author: Jau



**Taicheng Development Corporation
South Britannia Beach**

Legend

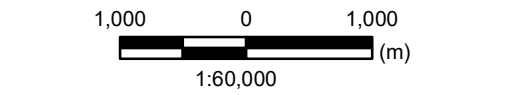
-  South Britannia Beach
-  Existing Road
-  Existing Forestry Road
-  Watercourse

Reference: Topographic map reproduced under licence from Her Majesty the Queen in Right of Canada, with permission of Natural Resources Canada.



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consulting engineers
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Project No. 2957-006	Date November 2014
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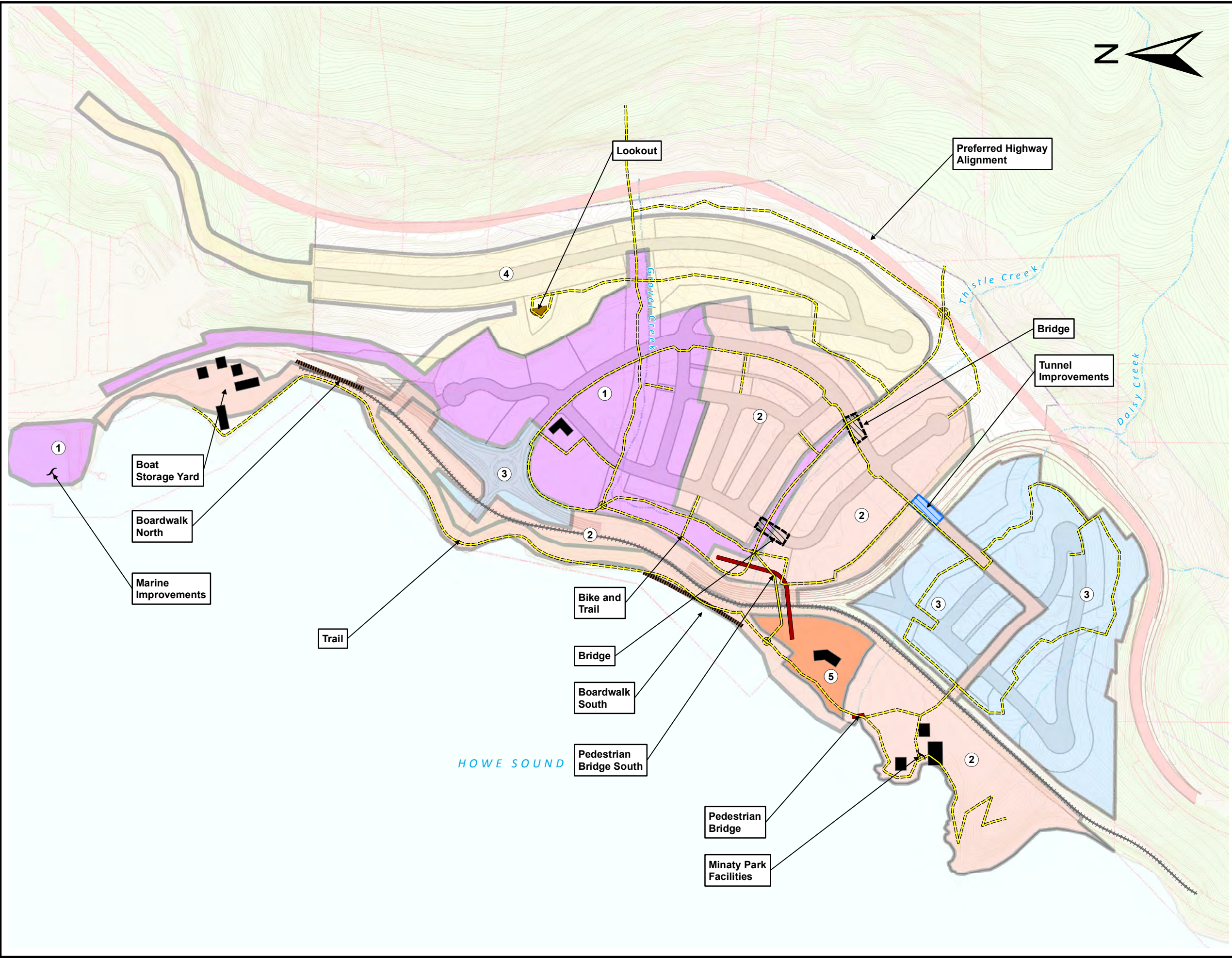
Location Map

Figure 2-1



Figure 2-2

Path: C:\2900-2999\2957-006\430-GIS\MXD-Rp\2957006_Fig2-3_Phasing.mxd Date Saved: 7/2/2014 10:11:21 AM
Author: SScott



Taicheng Development Corporation
South Britannia Beach

Legend

- Existing ROW
- Existing Legal
- Contour from 2006 Aerial Mapping (2m Intervals)
- Existing Watercourse
- Existing Railway

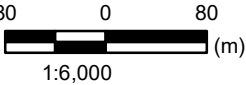
Phase Boundary

- 1
- 2
- 3
- 4
- 5

Reference: Basemap from 2004/2006 Orthophoto

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consulting engineers
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Project No.
2957-006

Date
July 2014

Phasing and
Amenity Plan

Figure 2-3



3. Roads

3.1 Design Criteria

Road design standards for Britannia Beach are set out in SLRD Bylaw 741 and comprise of three classifications for urban local and urban collector roads. The standard provides for 20 m wide right-of-ways and pavement widths from 8.2 to 10.2 m with parking on one or more sides. These standards are generally in conformance with BC Ministry of Transportation and Infrastructure (MOTI) design standards and Geometric Design Standards for Canadian Roads and Streets by the Canadian Roads and Transportation Association.

The Britannia North development that was completed in 2006 utilizes significantly narrower paved roads and right-of-ways.

The SLRD requires that roads be constructed to MOTI design standards. Table 3-1 summarizes the various road parameters for the SLRD and MOTI.

Table 3-1: Road Standards

Location/Design Authority	Drawing or Reference	Right-of-Way Width (m)	Asphalt Pavement Width (excludes curb dimensions) (m)	Road Width (to start of cut and fill) (m)	Parking
SLRD (Bylaw 741)					
Urban Local	TS-U3	20.0	8.2		One side
Urban Local	TS-U2	20.0	10.0		Both sides
Urban Collector	TS-U1	20.0	8.2		One side
MOT – Subdivision Parameters					
Urban Collector	1420 H	Min. 20.0	8.2	10	One side
Urban Local	1420 H & I	Min. 20.0	10.0	11.8	Both sides
Urban Local	1420 H & I	Min. 20.0	8.2	10.0	One side
Cul de sac (150 m)	1420 H & I	TBD	Radius 14.1	Radius 15.0	

The SLRD's standard road cross-sections are included in the Appendix for reference.

3.2 Proposed Road Standards

Planning for the site was conducted with the intention of being able to meet the SLRD and MOTI standards as a minimum, but with a desire to construct more pedestrian friendly and environmentally sustainable features. The minimums can therefore be achieved and exceeded with the planned infrastructure. The proposed road standards are:

1. Urban Collector: This is the main road that will start at the Highway 99 intersection, run through the core of the community, through the one lane tunnel under the highway, and connect back to Highway 99 with a right in, right out connection in the Minaty Bay area. It is intended to be placed in a 22 m right of way with 10.4 m of asphalt for two lanes of traffic plus parking on both sides. The road will have swales in the boulevards.



2. Urban Local: Most of the remaining roads will be Urban Local roads within a 20 m right of way. They include 8.4 m of asphalt for two lanes of traffic and parking on one side. Swales or rain gardens are proposed in the boulevards. A variation of this would not include parking for the connection to North Britannia.
3. Lanes are proposed behind some lots. These will typically be 4.9 m of pavement with gravel shoulders in a 6 m right of way.
4. Gravel Access Roads. Gravel access roads of various widths will be needed to service the water reservoir, water treatment building, and for temporary access to Minaty Bay.

The road layout for the concept development plan is illustrated on Figure 3-1.

The proposed roads sections provide for the following:

- The use of roadside rain gardens on road grades up to 8% in order to promote infiltration of stormwater to ground. Above 8% roads would be constructed with open ditches or a piped stormwater collection system.
- Road grades will be in accordance with MOTI standards. The Phase 3 and 4 preliminary design access roads have been developed using grades up to 12%. Further refinement of the grades will be required to reduce the grade at steep curves as the design evolves.
- Underground utilities in roads will generally include water mains, sanitary sewers, storm drains, street lighting in some areas and BC Hydro and telephone.

3.3 Plan for Pathway – Sidewalk Systems

A comprehensive trail system will be developed throughout the site to link various community developments and to provide access to recreation features. The system offers access for multi-users, with particular emphasis placed on pedestrians, hikers and cyclists. Major paths will be asphalt paved and are proposed to be 3.6 m wide to accommodate cyclists and pedestrians. Paths are routed off-road where practical, and within boulevards where not. Minor trails will be gravel surfaced.

3.4 Highway Improvements and Interconnection

Highway Improvements and Interconnections are addressed in the Bunt Engineering and Hatch Mott & Macdonald technical reports. The lands are currently accessed from a connection to Highway 99.

Phase 1 and Phase 2 of development will use the existing highway entrance with minor improvements. Later phases will require improvements to the existing access, which could include a signalized intersection or a two lane roundabout, plus the construction of a new right-in right-out connection to the southbound lanes of Highway 99 in the Minaty Bay area.

The existing single lane tunnel connection to Minaty Bay consists of a corroding multi-plate structure that will be upgraded by slip-lining the existing structure. Separate auto and pedestrian pavements, lighting and pedestrian safety features will also be included in the upgrade. The tunnel will continue to provide only single-lane access, upgraded by signalization in the final phase of development.

In addition, a right of way allowance has been identified for a future high-level highway bypass located between the BC Hydro right of way and the proposed development area. Construction of the bypass highway is not included in the development plans and the timing is uncertain.



3.5 Site Grading and Bulk Materials

The general site layout is intended to conform the existing grades, but some changes are planned. The most significant changes are due to:

- Setting reasonable grades for road links between set elevations at the highway, tunnel, and rail crossing.
- Providing standard cross-sections for roads cut along steep slopes.
- Providing flood protection.

Estimated cuts and fills are provided in Table 3-2 and illustrated on Figure 3-2.

Table 3-2: Cut and Fill Estimates

Description	Estimated Volume (cubic metres)			Notes
	Cut	Usable	Fill	
Upper Road	24,500	19,600	5,600	Estimated using Civil 3D. Assume 20% poor soils
Lower Road (leading to Upper Road)	25,000	20,000	15,100	Estimated using Civil 3D. Assume 1/4 blasting
Other Site Grading				
Depression north of Thistle Creek			20,000	raise ground or lower creek
Depression south of Thistle Creek			20,000	raise ground or lower creek
North pile	20,000			Was left by gravel miners. Assume poor soils.
Allowance for other poor soils	10,000		10,000	To be determined
Minaty - main road loop	90,000	72,000		Includes level rail crossing
Minaty - south hillside road	60,000	48,000		rises up at max grade from rail crossing
Road Sub-Base			51,300	171,000 square meters of road with 300 mm sub-base
Road Base			25,650	171,000 square meters of road with 150 mm base
Sound Berm/Dike			10,000	900 m of dike
Daisy Creek Training Berm			3,000	200 m of berm
Total	229,500	159,600	157,650	

The accuracy of the items varies. Overall, the existing grades are based on mapping from aerial photos with 2 m contours. No survey or Lidar was conducted or available for this work. The finished grades are approximated based on architectural concept layouts.

The upper road and the main road quantities were estimated using Civil 3D. While this tool is good at estimating quantities, the results are still limited to the accuracy of the mapping data and concept plans. The remaining quantities were estimated by scaling the areas of interest and determining average cuts or fills required over the areas.



The three main cuts are for the upper road (and the lead up to it), the Minaty roads, and the removal of a large protrusion near the north end of the site next to the hillside. The largest cuts are planned for the Minaty area due to need to provide a level rail crossing and the maximum slopes that can run from this crossing to the adjacent areas. The North pile was not removed during the historic gravel mining operation. We therefore assume that the quality of material is therefore poor and it cannot be used for structural fill. Similarly, there may be some other pockets of poor soils with unknown volumes.

The estimated quantity of material to be removed is higher than the amount of fill required. For the large cut areas in Minaty, a large percentage of the material is assumed to be usable as structural fill. Subtracting the amount of potentially unusable soils, the estimated cuts and fills are balanced. The actual quality of the soils must still be confirmed.

Four potential sources for bulk site fills are:

- Imported barged material;
- Imported local sources trucked to site;
- Excavated material from the site; and
- Processed material from the site.

Both Lafarge and Lehigh operate large quarries on the Sunshine Coast and can provide bulk supply of uniform, quality construction aggregates delivered by the barge load. Materials include pit run structural fills as well as crushed granite for road base and sub-base. Part of the cost of delivery will be offloading and delivering the material to the site. This would normally be done by using a local ramp with a loader and trucks running between the ramp and site. For larger quantities, a conveyor over the highway may be practical.

Local sources of structural fill are also often available. The location, cost, and quality may vary. The quality of the material should be confirmed and the material should be placed to acceptable geotechnical standards for use as structural fill.

The site has long been used as a source of structural fill in the area. It therefore is likely that a large portion of the cut areas will contain materials suitable for structural fill. This has yet to be confirmed by geotechnical investigation.

The excavated site materials may also be suitable for road construction and other construction aggregates. Gravels could be screened for structural fill, backfill, and road construction materials. Blasted material could be used for riprap or crushed and screened for road base and sub-base material. For added value, the upper road and adjacent properties may be set ups for larger scale blasting, both as a source of construction aggregates, and to create flatter building sites.

The best source of construction aggregates will depend on the quality of the material that remains on site. If the majority is good, then it will be most economical to use material excavated on site. Prior to development, free structural fill may be added to raise the site subject to meeting geotechnical standards for both the material and placement. Achieving higher site grades is generally a positive addition to the site for drainage and flood protection. Higher silt content material may be used for the dikes/berms subject to similar conditions.

3.6 Street Lighting

The urban collector road that runs between the two highway connections is proposed to have standard illumination and uniformity levels from Davit poles. The urban local roads are proposed to follow “Dark Sky” principles with overhead lighting at intersections and low-level pedestrian lighting along pathways for safety. Lighting is not proposed for lanes or gravel access roads.



3.7 Summary

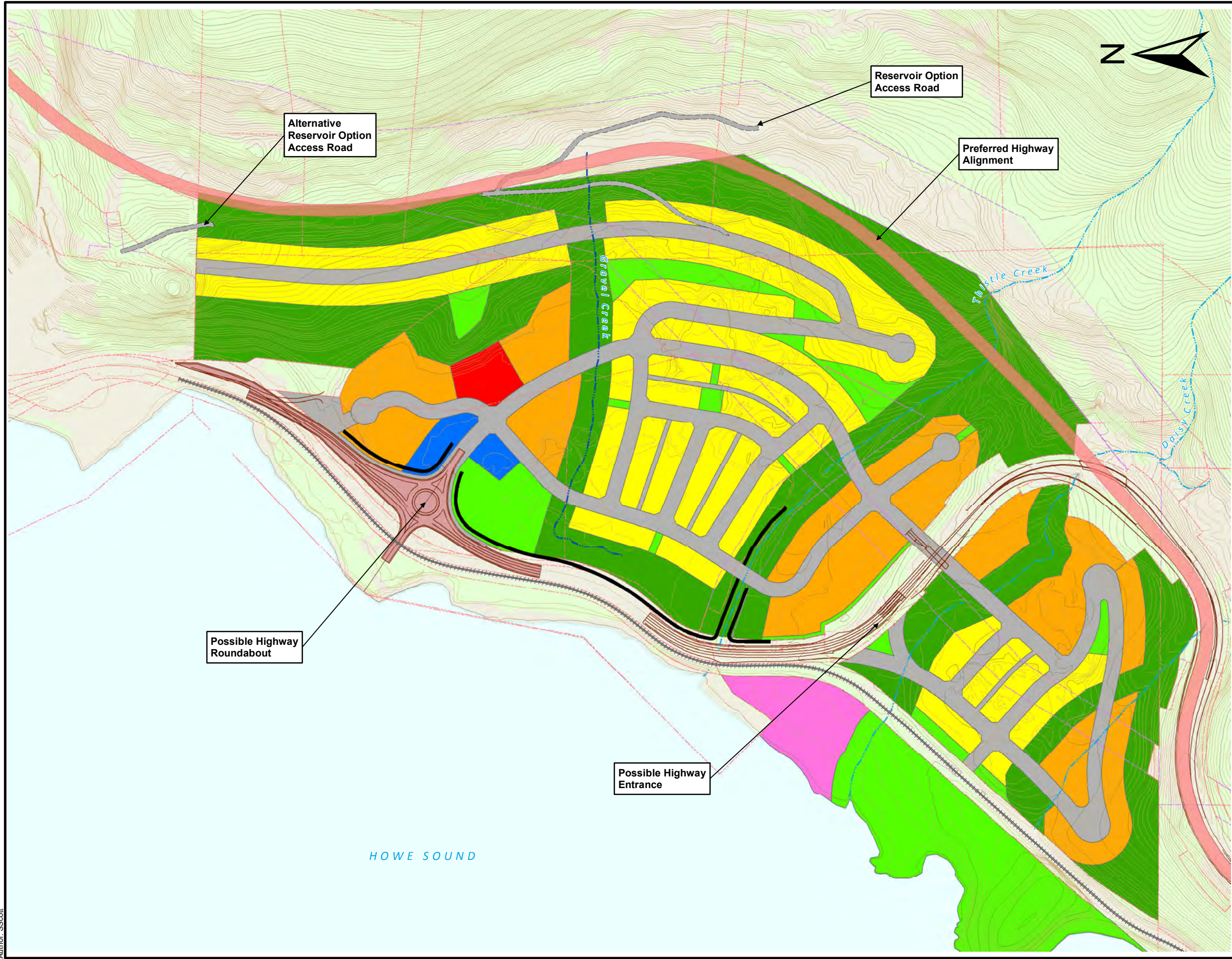
The concept plan for roads for the South Britannia Beach development plan has been prepared using sustainable smart growth principles. The concept road plan, profiles and cross sections demonstrate that most of the land can be accessed by road at road grades up to 12%. Further refinement of the grades through curves will be addressed at the preliminary design stage.

The proposed highway improvements will facilitate improved highway access and egress to the Village Center and Minaty Bay.

At the preliminary design stage further planning should be completed for upslope development parcels using LIDAR mapping (aerial laser mapping) with one meter contours. The steep terrain of some of the lands will require extensive regrading to stabilize over-steep slopes left by gravel extraction and to create areas with lower slopes suitable for development.

Taicheng Development Corporation should obtain SLRD and MOTI approval for any variations to their design standards before proceeding to preliminary design.

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**Taicheng Development Corporation
South Britannia Beach**

Legend

- Existing ROW
- Existing Legal
- Contour from 2006 Aerial Mapping (2m Intervals)
- Existing Watercourse
- Existing Railway
- Possible Creek Realignment
- Proposed Sound Barrier Berm/Dike

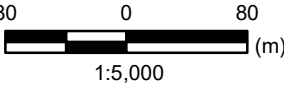
Proposed Land Use

- Commercial
- Tourist Commercial
- Institutional
- Mixed Residential
- Single-Family
- Park
- Environmental
- Right-of-Way

Reference: Basemap from 2004/2006 Orthophoto

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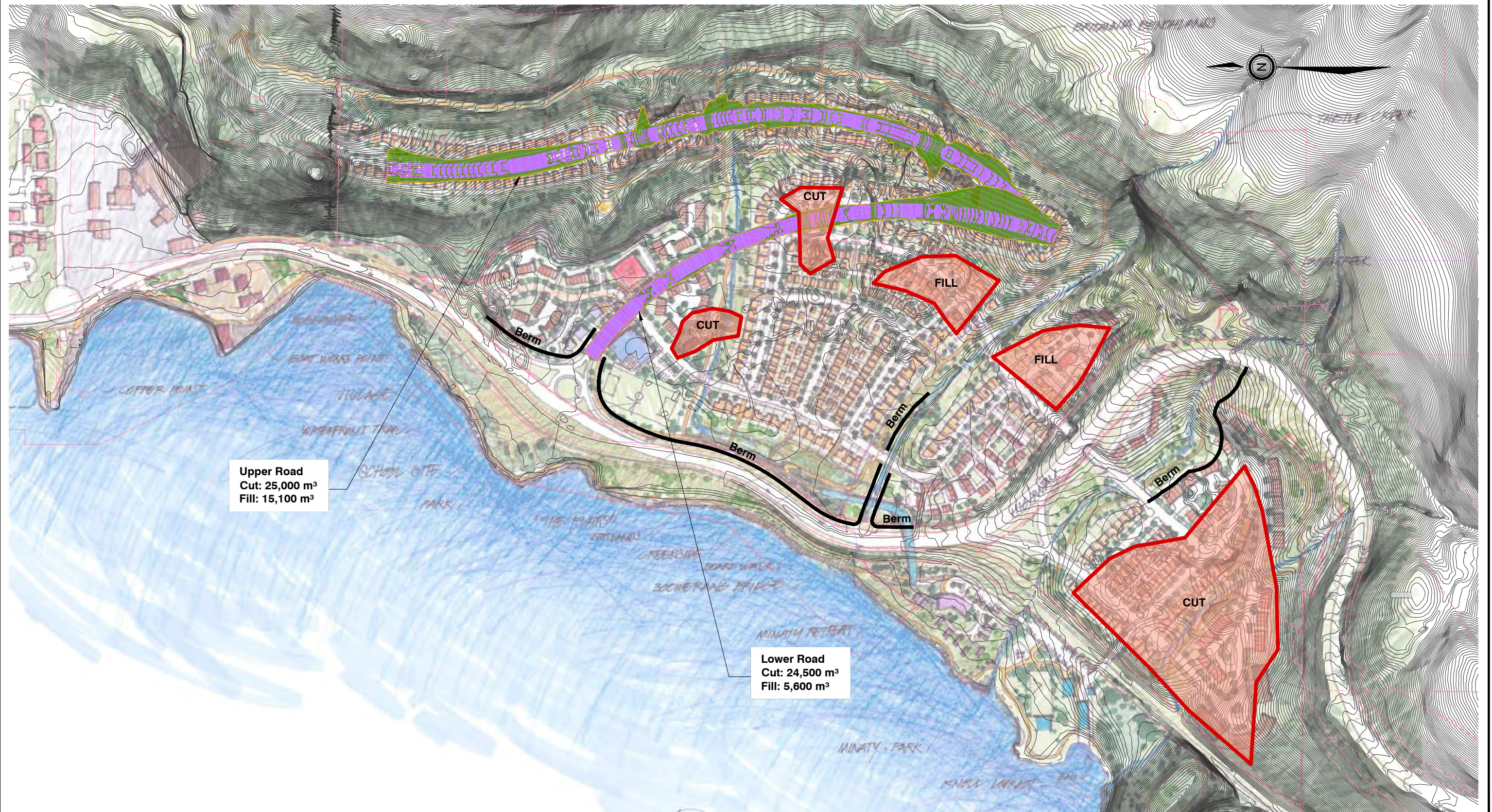
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Project No. 2957-006	Date July 2014
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**Roads, Highway
Entrances and
Lot Layout**

Figure 3-1



Hillside Roads Cut and Fill



4. Waterworks

4.1 Design Criteria

The domestic drinking water demand design criteria in the SLRD Subdivision and Development Bylaw 741 for Electoral Area D are:

- Average Day Demand (ADD) = 600 L/ca/day;
- Maximum Day Demand (MDD) = 1,500 L/ca/day; and
- Peak Hour Demand (PHD) = 2,700 L/ca/day.

The water demand criteria for industrial, commercial and institutional (ICI) users are:

- Average 8 hr. Demand (ADD) = 0.7 L/s/ha;
- Maximum Day Demand (MDD) = 1.0 L/s/ha; and
- Peak Hour Demand (PHD) = 2.0 L/s/ha.

Occupancy rates as defined in the bylaw are:

- Single family residential and duplex = 4 occupants per unit; and
- Multi-family = 3 occupants per unit.

Based Workshop #7 April 16, 2013 with the SLRD, the maximum day demand design criteria were reduced from 1,500 L/ca/d to 1,000 L/ca/d and the average occupancy per unit was reduced to 2.6 occupants per unit.

As a safety factor the average occupancy was increased to 3.1 occupants per unit. The current assumption is subject to future adjustment.

4.2 Water Demands

The water demands forecast for 1,000 residential units (i.e., population of 3,100) and 4,410 m² of commercial and institutional space are summarized below. The estimated maximum day demand (MDD) of 38.6 L/s is less than the available water supply capacity of 46.6 L/s.

Table 4-1: Water Demand Forecast Complete Buildout Development

Demand Scenario	Average Day Demand, ADD (L/s)			Maximum Day Demand, MDD (L/s)		
	Residential ¹	ICI ²	Total	Residential ³	ICI ⁴	Total
1,000 residential units & 4,410 m ² of ICI	21.5	2.0	23.5	35.8	2.8	38.6
Notes: 1. Based on 600 l/ca/d Average Day Demand. 2. Based on 2.8 ha and 0.7 L/s/ha. Area was calculated from Land Use & Phasing Figure Nov 14. 3. Based on 1,000 l/ca/d Maximum Day Demand. 4. Based on 2.8 ha and 1.0 L/s/ha. Area was calculated from Land Use & Phasing Figure Nov 14.						

The project will incorporate water conservation best management practices that may reduce both the supply/treatment and the resulting sewage collection/treatment flow rates from the criteria values. Drinking water flows should be monitored to aid in the design and operation of the water treatment plant and the water system.



4.3 Water Source

Groundwater Supply

An extended period aquifer pump test conducted by Piteau Associates Engineering found that the two wells (TW1 and TW2), can sustain flows of 26.7 L/s and 19.9 L/s (total capacity of 46.6 L/s), respectively, over the summer drought period and throughout the remainder of the year, with negligible risk of salt water intrusion.

4.4 Water Treatment

Regulatory Requirements

Vancouver Coastal Health considers a GARP source to require the same level of treatment as surface water unless water quality data demonstrates otherwise. Surface water sources are required to meet the *Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia*, which is published by the Ministry of Health and has been adopted by all regional health authorities.

Surface water treatment typically includes filtration and disinfection. Generally, GARP sources in British Columbia have been able to demonstrate that due to some bank filtration, turbidity and organics levels are sufficiently low to allow for effective UV disinfection for *Giardia* and *Cryptosporidium*, which qualifies the source for exclusion from filtration. There are two sets of criteria Vancouver Coastal Health may use when evaluating a filtration exclusion. The first set of criteria is published in the BC Drinking Water Treatment Objectives and is summarized in Table 4-2. The second set of criteria is published by Health Canada in the Guidelines for Canadian Drinking Water Quality (GCDWQ). Technical Document on Turbidity and is summarized in Table 4-3.

Table 4-2: Filtration Exclusion Criteria from BC Drinking Water Treatment Objectives (2012)

i.	Overall inactivation is met using a minimum of two disinfections , providing 4-log reduction of viruses and 3-log reduction of <i>Cryptosporidium</i> and <i>Giardia</i> .
ii.	The number of <i>E. coli</i> in raw water does not exceed 20/100 mL * in at least 90% of the weekly samples from the previous six months. * if <i>E. coli</i> data are not available, less than 100/100 mL of total coliform
iii.	Average daily turbidity levels measured at equal intervals (at least every four hours) immediately prior to where the disinfectant is applied, are around [or below] 1 NTU but do not exceed 5 NTU for more than two days in a 12-month period.
iv.	A watershed control program is maintained that minimizes the potential for fecal contamination in the source water.



Table 4-3: Filtration Exemption Considerations, GCDWQ (2012)

Vulnerabilities Assessment
Ensure a detailed current understanding of hazards inherent to the water source. This may include sources of microbial or chemical contaminants, activities that may impact the water source and historic information on fluctuations in source water quality, which may affect the chosen approach to treatment over time. These characteristics of the watershed or wellhead area should be well documented and maintained in such a way as to inform ongoing risk management considerations.
Source Water Protection
A thorough understanding of measures being taken by all stakeholders to protect the source water should be maintained and documented over time. This would include the policies and regulatory requirements of agencies such as conservation authorities, municipal and provincial governments and local stakeholder groups, as well as permitted activities or land use in the area, potential sources of contaminants and threats to source water quality.
Inspection and Verification
Undertake adequate inspection and preventative maintenance from source to tap on a regular basis. Activities should be well documented such that a history of maintenance, upgrades and optimization approaches can be demonstrated over time. This includes the verification of the proper function and integrity of monitoring devices, treatment and distribution components.
Treatment
Whether or not filtration technology is in place, the drinking water treatment process must still achieve a minimum 3-log reduction of <i>Giardia lamblia</i> cysts and <i>Cryptosporidium</i> oocysts and a 4-log reduction of viruses. Utilities using surface water or Ground Water Under the Direct Influence of Surface Water (GUDI) that are considering not using filtration will need to treat source waters for all three types of organisms (protozoa, viruses and bacteria), using a multi-disinfectant strategy. A possible strategy includes (1) ultraviolet irradiation or ozone to inactivate cysts/oocysts, (2) chlorine to inactivate viruses, and (3) chlorine or chloramines to maintain a residual in the distribution system. Consideration may also be given to strategies that may enhance robustness at the treatment stage. For example, these may include pre-sedimentation or other control strategies for intermittent increases in source water turbidity. The drinking water treatment process will also need to be operated to minimize the formation of disinfection by-products.
Distribution
The distribution system should be appropriately designed, maintained and monitored in accordance with established best practice, and a disinfectant residual should be maintained throughout the distribution system.
Contingency or Emergency Response Planning
Also recommended is a well-developed site-specific response plan for episodes of elevated source water turbidity brought about by extreme weather or other unforeseen changes in source water quality that may challenge the drinking water treatment system in place.



As shown in Table 4-2 sufficient water quality data is required to demonstrate that criteria i to iii are met. Therefore, a water quality monitoring program that includes frequent microbiological sampling and continuous turbidity data recording is required. Additionally, to meet Criterion #1, ultraviolet transmittance (UVT) data should be collected to demonstrate that a UV reactor validated for the UVT conditions would provide an effective barrier for inactivation of protozoa such as *Giardia* and *Cryptosporidium*.

Multi-barrier disinfection with UV and chlorine is also suggested in Table 4-3 as a possible strategy to provide adequate disinfection without filtration. The other considerations listed in Table 4-3 list many of the best management practices for any utility regarding source water protection, asset management, and emergency response planning.

Note that the granting of an exclusion of filtration is at the discretion of the Drinking Water Officer at Vancouver Coastal Health, who may also consider other criteria when evaluating a filtration exclusion application.

Design

The design flow for a new water treatment plant is currently based on the capacity of the source (46.6 L/s). The sizing of the treatment plant will be refined once the conceptual development plan and design criteria have been accepted by the SLRD. Construction will be phased and the design flow rate will be adjusted to reflect measured demands.

Based on the existing water quality data, it was assumed that a filtration exemption may be granted by the Vancouver Health Authority; therefore the concept for the water treatment process is based upon the following:

- Ultraviolet Light Disinfection; and
- Secondary chlorine disinfection.

Redundancy is provided within the treatment process with two UV disinfection reactors, each also sized for MDD. A water treatment building of approximately 50 m² is envisioned for housing the various components of the facility including:

- Chemical feed room;
- Water treatment process area; and
- Controls.

4.5 Water Distribution

The concept water system servicing plan is shown on Figure 4-1. The plan provides for the following:

- Water supply from TW1 and TW2 wells;
- A dedicated water supply main to the water treatment plant;
- Provision of a new water treatment plant to treat the well water; assuming filtration exemption. The plant is proposed to be located in an open space above Phase 2 at approximately 20 m elevation and will occupy one of the residential lots;
- Water from the treatment plant will be pumped through a dedicated water main to a new South Britannia Beach reservoir located on the hillside above the development at an elevation of about 90 m elevation. A dedicated water main is required from the treatment plant to the reservoir to provide chlorine contact time;



- The new two-celled reservoir, sized for 1,000 residential units and a MDD of 1,000 L/ca/d is 2,375 m³ based on a fire flow of 150 L/s for commercial and institutional type buildings. Reservoir sizing will be refined at the preliminary design stage and may be reduced in capacity;
- Water supply to the development area will be provided from the reservoir through a network of water mains that will be looped for operational redundancy. The reservoir will service one pressure zone between 90 m and sea level;
- The water system delivery main size is governed by fire flows and is estimated to be 350 mm; the distribution mains are expected to comprise a backbone of 300 mm mains supported with 250 mm and 200 mm service mains; and
- Planning will also provide for future connection to the North Britannia Beach water system.

4.6 Reservoir

Design Criteria

Design standards for drinking water reservoirs are set out in SLRD Bylaw 741. The standards that are relevant for conceptual design are:

- Reservoirs are to be reinforced concrete designed in accordance with American Concrete Institute's Manual of Environmental Engineering Concrete Structures ACI 350R-2001;
- Structures are to be below ground and covered or up to 4 m above ground;
- If reservoir volume is greater than 2,300,000 litres, 2 cells are required each containing one half of total required volume and capable of being drained and filled independently. If reservoir volume is less than 2,300,000 litres, 1 cell is sufficient provided an adequate temporary supply can be maintained during reservoir cleaning;
- The Owner's Engineer is to review the need for re-chlorination based on demand forecasts; and
- Access roads less than 0.5 km long must be paved.

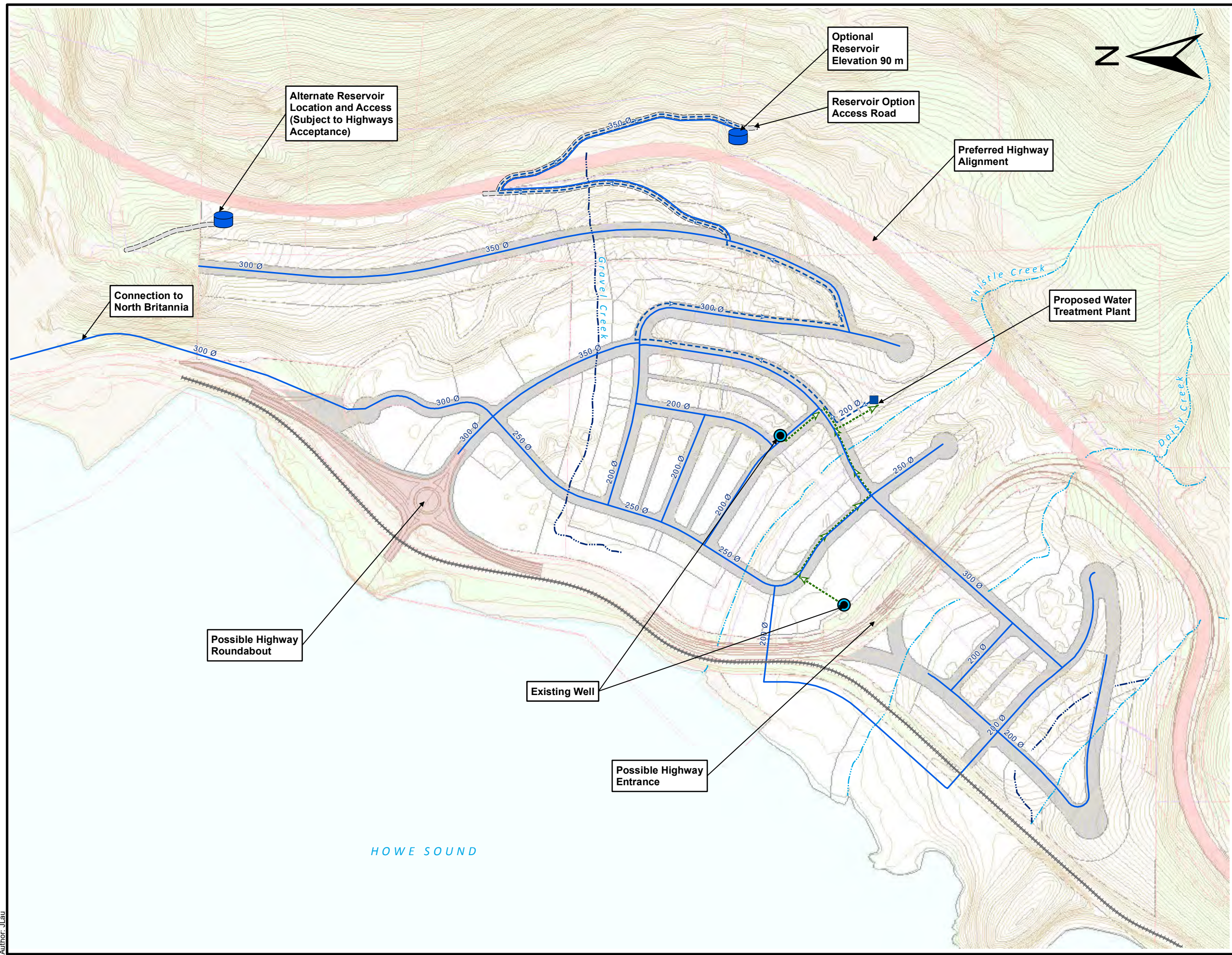
Reservoir Size and Siting

Reservoir capacity shall not be less than the greater of:

- The one day average annual consumption for the service area; or
- The total Storage Requirement A+B+C where:
 - A = Fire storage to meet the Fire Underwriters Survey Guidelines with not less than the fire flows for the highest fire demand in the service area as specified in these design criteria
 - B = Equalization Storage of 25% of maximum day demand of service area
 - C = Emergency Storage of 25% of A + B.

Prior to commencing detailed design, approval from the Manager of Utilities must be obtained for reservoir siting and other design considerations, including but not limited to: site access, overflow and drainage, reservoir cleaning protocols, water quality, controls and rate of filling.

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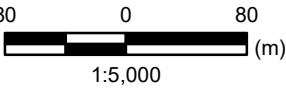
Legend

- Existing ROW
 - Existing Legal
 - Contour from 2006 Aerial Mapping (2m Intervals)
 - Existing Watercourse
 - Existing Railway
 - Possible Creek Realignment
 - Potential Lot Layout
- Water System**
- Proposed Watermain
 - Proposed Supply Main
 - Proposed Well Supply Main

Reference: Basemap from 2004/2006 Orthophoto

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consulting engineers
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Project No.
2957-006

Date
November 2014

Water System

Figure 4-1



5. Wastewater

5.1 Design Criteria

The sanitary sewer design criteria in the SLRD Subdivision and Development Bylaw 741 for Electoral Area D are:

Average Daily Dry Weather Flow:

- Residential = 350 L/ca/day; and
- Commercial and institutional = 40,000 L/ha/day.

Peak Dry Weather Flow

The peaking factor shall be:

- Population < 500 = 3.5;
- Population 500 to 2,000 = 3; and
- Populations >2,000 = 80% of Harmon factor.

Infiltration and Inflow allowance is 11,200 L/ha/day.

Based the Workshop #7 April 16, 2013 the average occupancy per unit was reduced to 2.6 occupants per unit. As a safety factor the average occupancy rate is increased to 3.1 occupants per unit for the conceptual design; however the occupancy rate is subject to future adjustment.

5.2 Sanitary Flows

South Britannia Beach is planned for 1,000 residential units, including secondary suites, and 40,000 sq.ft of commercial and institutional space. The design population equivalents and flows are shown in Table 5-1 below, along with the existing and planned 2007 WWTP design values.

Table 5-1: Design Population and Flows for Britannia WWTP

Criteria	North Britannia (2007 Design and Construction)	South Britannia (2007 Allowance)	South Britannia (Current Estimate)
Units	-	-	1,000
Population Equivalent	2,042	4,000	3,420
Average Dry Weather Flow (m ³ /d)	715	1,400	1,197

Note: Population equivalent includes 2.8 ha of ICI development. Area was calculated from Land Use & Phasing Figure Nov 14.

Table 5-2 provides the estimated design flow based on the design populations at South Britannia.



Table 5-2: Estimated Design Flow

Criteria	Application	South Britannia Beach
Average Dry Weather Flow (ADWF) ¹	Typical low flow design condition.	1,197 m ³ /day
2 x Average Dry Weather Flow (2 x ADWF) ²	Treatment process design condition.	2,394 m ³ /day
Peak Dry Weather Flow (PDWF)	Design criteria for SBR plant including hydraulic design of SBR Tanks and decants.	3,250 m ³ /day ³
Peak Wet Weather Flow (PWWF)	This includes I&I and governs hydraulic design of the headworks and outfall.	3,698 m ³ /day ⁴
Notes: 1. Based on 350 L/cap/d of wastewater according to the SLRD subdivision servicing bylaw. 2. Two times ADWF basis of WWTP design under the MWR. 3. Based on calculated 80% Harmon peaking factor of 2.715. 4. Based on catchment area of 40.0 ha and infiltration allowance of 11,200 L/d/ha. Area was calculated from Land Use & Phasing Figure Nov 14.		

For the purpose of this assignment, the planning and cost estimating has been carried out based on the 350 L/cap/d unit rate. It is important to note that water conservation can reduce the wastewater treatment equipment size and process footprint.

Wastewater flow monitoring should be carried out to refine the wastewater per capita unit rate to assist in sizing the WWTP components and reduce the risk of overdesigning the WWTP.

5.3 Sanitary Collection System

The concept sanitary collection system is shown on Figure 5-1. The plan provides for the following:

- Three sanitary lift stations:
 - LS No. 1 – Will be located near the main entrance of the development, and will pump flows from Phases 1, 2 and 4 to the North Britannia Wastewater Treatment Plant via a sanitary force main;
 - LS No. 2 – Will be located in Phase 3, and will pump flows from Phase three into the Phase 2 gravity system; and
 - LS No. 3 – will pump sanitary flow from the ocean front development into the LS No. 2.
- A sanitary force main will collect pump wastewater from the three lift stations to the North Britannia Wastewater Treatment Plant; and
- Wastewater will be collected through a series of collection mains, which will flow by gravity to the sanitary lift stations.



5.4 Wastewater Treatment and Disposal

North Britannia – Existing WWTP

The existing Britannia Beach wastewater treatment plant (WWTP) is located at North Britannia Beach on the north side of Britannia Creek adjacent to Highway 99. The treatment plant was constructed in 2007 and was designed and constructed to service the existing and future population of the Britannia Bay Properties development and adjacent commercial development (North Britannia). An allowance was made during the design and construction for future wastewater flows from South Britannia).

The existing treatment plant provides secondary treatment and consists of the following components:

- Headworks including coarse screening, fine screening, flow measurement and distribution;
- Sequencing batch reactors (SBR);
- Ultraviolet disinfection;
- Odour control; and
- Biosolids treatment including aerobic digestion, thickening, dewatering, and disposal.

The existing WWTP is currently sized to handle an average dry weather flow (ADWF) of 715 m³/d of wastewater with an influent BOD5 and TSS load of 200 mg/L from North Britannia. Space is available for construction of new SBRs adjacent to the existing facility to handle an additional ADWF of up to 1,400 m³/d for flows from South Britannia. Upgrades to other treatment processes including headworks, biosolids handling, and disinfection would be required to handle the additional flow.

Effluent is discharged by gravity outfall into Howe Sound. The outfall, at the southwest corner of the WWTP, extends to a depth of approximately 25 m below low tide. The outfall was designed to convey both the maximum design flow from North Britannia as well as flow from the future South Britannia Beach development. The design capacity of the existing outfall is approximately 127 L/s (11,000 m³/d).

The Britannia WWTP was designed to accommodate additional wastewater flows as follows:

- Space for the addition of an automatic fine screen in the over flow channel;
- Space for the addition of a grit removal tank and grit classifier, if deemed necessary based on operating experience;
- Spool pipes with blind flanges provided for future flow distribution;
- Space for additional SBR tanks and aerobic digesters on the north side of the existing tanks;
- Blower concrete pads and electrical room for future motor control centers (MCCs) and control panels; and
- Upsized power supply to the plant.

Regulatory Requirements

Both provincial and federal wastewater regulations apply to the Britannia WWTP. These regulations are as follows:

- Provincial: Municipal Wastewater Regulation (MWR); and
- Federal: Wastewater Systems Effluent Regulations (WSER).

An overview of the key requirements from these regulations is documented in the following sections.



The existing WWTP was registered under the BC Municipal Sewage Regulation (MSR) in 2007. This regulation was replaced by the Municipal Wastewater Regulation in April 2012. The requirements outlined in the existing registration are valid for the design of the existing WWTP.

The MWR requires secondary treatment of twice the average dry weather flows (ADWF) to ensure that effluent parameters do not exceed 45 mg/L BOD₅ and 45 mg/L TSS. Wastewater volumes in excess of twice the average dry weather flows only require primary treatment so that effluent does not exceed 130 mg/L BOD₅ and 130 mg/L TSS. A summary of the MWR effluent quality requirements applicable to the Britannia WWTP is provided in Table 5-3.

Table 5-3: Summary of MWR Effluent Quality Requirements at Britannia WWTP for Discharge to Water

Item	Design Criteria	Target
Effluent Quality Requirements		
A	Treatment Requirement for flows up to 2 X ADWF	Secondary
B	Biochemical Oxygen Demand (BOD ₅) up to 2 X ADWF	≤45 mg/L
C	Total Suspended Solids (TSS) up to 2 X ADWF	≤45 mg/L
D	Treatment Requirement for Flows in Excess of 2 X ADWF	Fine screening
E	Biochemical Oxygen Demand (BOD ₅) for Effluent in Excess of 2 X ADWF	≤130 mg/L
F	Total Suspended Solids (TSS) for Effluent in Excess of 2 X ADWF	≤130 mg/L
G	Effluent Disinfection for all flows	≤200 MPN/100 ml in the effluent based on 30-day geometric mean

Note: All of the design effluent criteria are based on the requirements of the MWR.

Wastewater from South Britannia Beach that is discharged to the marine environment will need to be treated to the above standards to meet the secondary treatment requirements stipulated in MWR.

The Wastewater Systems Effluent Regulations (WSER) is a federal wastewater regulation effective June 29, 2012. The WSER applies to wastewater treatment systems across Canada that discharge municipal wastewater effluent to water at an average daily volume of greater than or equal to 100 m³. The WSER applies to the Britannia wastewater treatment plant.

Deleterious substances and their limits are defined in the WSER as shown in Table 5-4 below:

Table 5-4: WSER Effluent Quality Requirements at Britannia WWTP for Discharge to Water

Parameter	Effluent Quality
Carbonaceous BOD	< 25 mg/L, average
Suspended solids	< 25 mg/L, average
Total residual chlorine	< 0.02 mg/L, average, if chlorine used at WWTP
Un-ionized ammonia	< 1.25 mg N/L, at 15°C ± 1°C, maximum

Wastewater effluent discharged from the Britannia WWTP will be required to meet the above criteria, and is separate from any requirements stipulated in the provincial wastewater regulations. Both the MWR and WSER apply separately to the Britannia WWTP.



Thus, based on both the WSER and MWR, the following wastewater effluent quality requirements after secondary treatment apply to the Britannia WWTP for discharge to water at all wastewater flows:

Table 5-5: Britannia WWTP Effluent Quality Requirements for Discharge to Water

Parameter	Effluent Quality
Carbonaceous BOD	< 25 mg/L, average (BOD ₅ not to exceed 45 mg/L)
Suspended solids	< 25 mg/L, average and not to exceed 45 mg/L
Effluent disinfection	≤ 200 MPN/100ml in the effluent based on 30-day geometric mean
Total residual chlorine	< 0.02 mg/L, average, if chlorine is used at WWTP
Un-ionized ammonia	< 1.25 mg N/L, at 15 °C ± 1 °C, maximum

5.5 Proposed Wastewater Treatment System

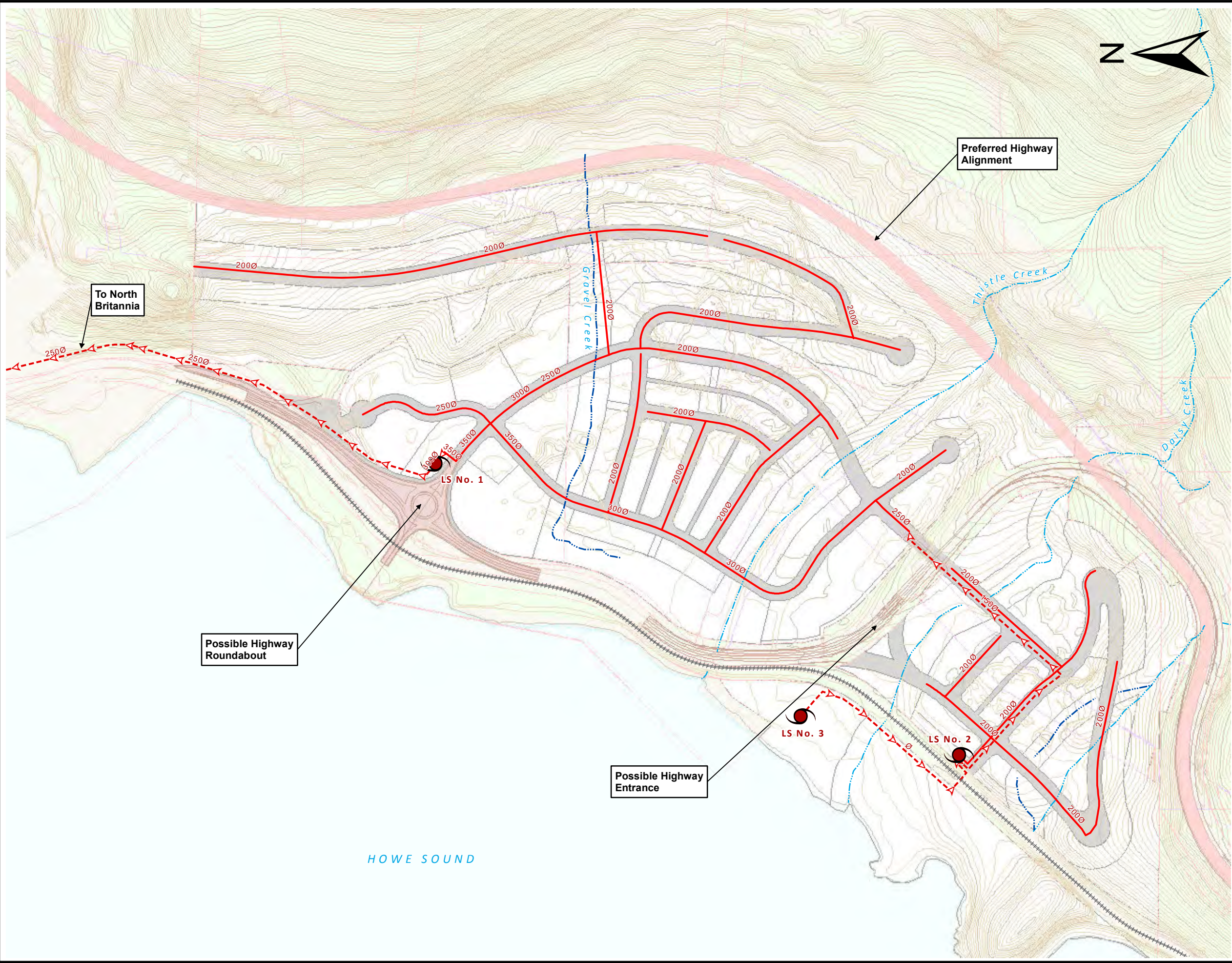
To take advantage of existing infrastructure and allowances detailed in Section 5.2, the proposed treatment plant process for secondary treatment of wastewater from South Britannia will use the same process. In the first phase of the development the process will consist of the following components:

- Headworks including coarse screening (existing), fine screening, flow measurement and distribution;
- Sequencing batch reactors;
- UV disinfection;
- Odour control; and
- Biosolids treatment including aerobic digestion, thickening, dewatering, and disposal.

At the current planned build out of 1,000 units at South Britannia, additional outfall capacity will not be required to handle peak wet weather flows from North and South Britannia. The capacity of the outfall is approximately 11,000 m³/d based on gravity flow. The design peak wet weather flow from North Britannia is 2,350 m³/d and the estimated peak wet weather flow for South Britannia is 3,698 m³/d, for a total estimated peak weather flow of 6,048m³/d, which is 55% of the outfall capacity.

These improvements may be made incrementally over the phases of development. However, the actual timing of improvements will depend also on North Britannia development, actual flows and plant performance. It would be reasonable for funding of the improvements to be required proportional to the population added in each phase. However, the timing of such funding is negotiable with the SLRD. Preliminary discussions indicate that improvements are subject to a pre-established latecomer's fee arrangement.

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Author: Jiau



**Taicheng Development Corporation
South Britannia Beach**

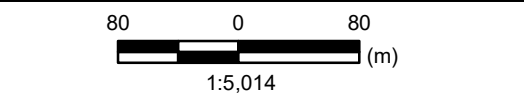
Legend

- Existing ROW
- Existing Legal
- Contour from 2006 Aerial Mapping (2m Intervals)
- Existing Watercourse
- Existing Railway
- Possible Creek Realignment
- Sanitary System**
- Proposed Sanitary Main
- Proposed Sanitary Forcemain
- Proposed Pump Station

Reference: Basemap from 2004/2006 Orthophoto

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consulting engineers
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Project No. 2957-006	Date November 2014
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**Waste Water
Collection System**

Figure 5-1



6. Drainage

6.1 Design Criteria

The drainage criteria from the SLRD Subdivision and Development Bylaw 741 for Electoral Area D are:

- Minor Systems: 10-year return period event for storm sewers, culverts and channels; and
- Major Systems: 100-year return period event for surface flood paths, swales and roadways.

In keeping with the Taicheng's desire to use best management practices, stormwater management planning will endeavour to use source controls as the primary mechanism for mitigating the negative impacts of land development.

Department of Fisheries and Oceans Canada

Stormwater generated within the site will discharge to sensitive fisheries habitat, the Fisheries and Oceans Canada (DFO) *Urban Stormwater Guidelines and Best Management Practices for Protection of Fish and Fish Habitat*, Draft 2001 are also applicable to this development site. The DFO criteria can be summarized as follows:

Table 6-1: DFO Stormwater Guidelines

Volume Reduction: 6-month/24 hour post-development volumes from impervious areas are not discharged and are infiltrated to ground. If infiltration is not possible, the rate-of-discharge from volume reduction Best Management Practices (BMPs) will be equal to the calculated release rate of an infiltration system.
Water Quality Control: Collect and treat the volume of the 24-hour precipitation event equalling 90% of the total rainfall from impervious areas with suitable BMPs. Rate of discharge will not be greater than required to provide suitable hydraulic retention time as to maximize the effectiveness of the specific BMP.
Rate Control or Detention: Post-development flows match the volume, shape and peak instantaneous rates of pre-development flows for the 6-month/24 hour, 2-year/24-hour, and 5-year/24 hour precipitation events.

All three stormwater objectives will be required for the upslope development areas tributary to creek channels. Lowland detention and volume reduction will probably not be required as the storm water discharge will be at creek outlets at the ocean. The applicable technologies for stormwater treatment are summarized in the following table.

Table 6-2: DFO Stormwater Criteria and Applicable Technologies

Stormwater Criteria		Stormwater Technologies/BMPs
Water Quality Treatment	• Collect and treat 90% of annual rainfall (6-month, 24-hour event) • Remove 80% TSS • Remove 95% floatable free oil	• Source controls including biofiltration • Constructed wetlands • Oil and grit separators • Construction practices, e.g. sediment and erosion control • Settling and wet detention ponds • Operational BMPs such as street sweeping



6.2 Concept Plan for Environmental Protection

The purpose of this section is to relate the criteria developed in the previous section to the proposed surfaces to be constructed in South Britannia Beach and recommend typical source controls that can be used for design.

Source Controls can be defined as land development practices and standards that reduce the impact to the natural environment. The basic objectives are to minimize impervious surfaces, maximize hydraulic disconnects, disburse runoff, and conserve natural features. They can provide the following:

- The **hydrological** function of capturing runoff rates and volumes for frequently occurring, small events by maximizing flow path lengths, increasing surface roughness, promoting infiltration, evaporation and transpiration, and detaining flows; and
- **Pollutant removal** through physical and biological treatment processes that occur in the plant and soil complex such as filtration, decomposition, ion exchange, adsorption and volatilization.

The proposed source controls for the Site will be designed to capture the rainfall 6-month event to the extent possible. Stormwater quality will be addressed through the filtering benefits of source controls and regional facilities. Detention and infiltration facilities will maintain flows to the pre-development conditions, where necessary. Applicable stormwater management systems are summarized in Table 6-3.

Table 6-3: Summary of Drainage Surfaces and Stormwater Systems

No.	Surface Description	Stormwater System
1.	Public Areas (Village Centre)	• Direct roof runoff to garden areas and encourage infiltration into the ground or direct flow to infiltration facilities. • Use porous surfaces and rain gardens in pedestrian areas. • Treat precipitation falling on truck loading and shipping areas prior to discharge; where possible cover these areas to avoid runoff. • Store runoff and reuse for irrigation.
2.	High Density Development (Multi-family Cluster Housing)	• Apply amended soil to all disturbed pervious areas, with the minimum depth required for landscaping. • Direct roof runoff to French Drains or rock pit with major flows directed to down-slope yard where possible¹. • Store runoff and reuse for irrigation.
3.	Lower Density Development (Single-family Lots)	• Apply amended soil to all disturbed pervious areas, with the minimum depth required for landscaping. • Disconnect roof leaders. • Store runoff and reuse for irrigation. • Direct roof run-off to rock pit with excess flows to drainage collection system.
4.	High Density Roads (Town Centre Roadways)	• Use catch basins and curb cutouts to direct runoff from Town Centre roadways to off-line treatment and infiltration areas. These areas could include rain gardens or underground facilities.
5.	Low Density Roads (Local and Collector Roads)	• Construct engineered ditch or swale on both sides of road system, where possible, to capture the 6 month rainfall. • Convey runoff from on-lot French drains with excess road runoff to infiltration facilities or regional detention and treatment facilities.



No.	Surface Description	Stormwater System
6.	Parking Lots	Construct infiltration swales to capture and treat runoff from parking areas. Install localized infiltration to capture the 6 month rainfall.
7.	Constructed Parks	Provide 300 mm of topsoil cover.
8.	Undeveloped Forested Area	- Preserve and protect. - Use ditches beside trails to convey major flows.
Note: 1. Other means of infiltration will be provided as part of the road system when disconnecting the roof drains is not possible.		

Drainage to ground will consider the underlying geology; bedrock will limit the use of infiltration systems.

6.3 Regional Facilities – Water Quality and Quantity

A central regional stormwater treatment facility at the southwest corner of the site is proposed, in accordance with the DFO criteria, to capture and treat runoff from the Village Centre that is discharged to the ocean at the outlet of Thistle Creek. A constructed wetland or a regional infiltration facility is the proposed method of water quality treatment. In addition, several neighbourhood infiltration facilities could be included to provide for volume reduction for the 2 and 5-year storms.

Siting and sizing of the wetland and/or infiltration facilities will be completed during preliminary design, once infiltration tests have been conducted for the site.

6.4 Groundwater Base Flow Protection

Base flows are extremely important to the health of the existing creek systems. Consequently, the concept stormwater management plan proposes the following measures to maintain groundwater base flows:

- Extensive use of infiltration facilities;
- Use of trench dams in utility construction to prevent the diversion of groundwater away from natural drainage flow paths; and
- Extensive use of amended soils on pervious areas. This additional soil will help to retain rainfall on site and ensure a slow release of cool base flows at critical durations.

6.5 Minor and Major Conveyance Systems

The Minor Drainage System is intended to remove runoff from the 10-year storm without causing inconvenience or flooding. This will consist of a system of inlets, ditches, pipes and culverts. Drainage will generally discharge into the local creeks, prior to flowing to the ocean. Figure 6-1 indicated the conceptual drainage conveyance system. Note that the conceptual drainage system consists mainly of a piped drainage network. During preliminary design after road grades and infiltration tests have been completed the use of swales and/or rain gardens should be reviewed. The use of swales or rain garden may eliminate the need to treat drainage prior to release into the creeks.

The Major Drainage System is intended to convey flow that exceeds the runoff from a 10-year storm event and will be designed to accommodate up to the 100-year storm. Roads and graded on-lot swales will form the major conveyance system for large storm events and drain by gravity to local creeks and ocean outlets.



The Village Centre piped drainage system will collect stormwater from roads and services and discharge to a wetland treatment pond or regional infiltration facility.

Generally the storm sewer grades in the development will follow the road grades and topographic constraints. Sizing of the drainage conveyance system will be finalized during preliminary design, once road grades have been established and infiltration tests have been completed.

6.6 Flood Protection

Creek Flood Hazard

The Taicheng Lands are traversed by a number of unnamed watercourses, as well as two larger, named watersheds: Thistle Creek and Daisy Creek. In addition to these named creeks, there are three other creeks that cross the site. From north to south, these shall be referred to as:

- Gravel Creek (flows through the old gravel pit);
- No Name Creek (flows along the south side of the fan, to the south of Daisy Creek); and
- South Creek (flows off the Howe Sound slopes).

The 2012 KWL report estimated peak flows for each of these creeks, based on a regional stream flow analysis. The table below summarizes the results of the analysis.

Table 6-4: Summary of Estimated Peak Flows

Creek	Drainage Area (km ²)	Mean Annual Flood (m ³ /s)	200-Year RP Instantaneous Peak Flow (m ³ /s)
Gravel Creek	1.0	1.3	9.2
Thistle Creek	2.1	2.5	17
Daisy Creek	3.3	3.7	25
Unnamed Creek	0.22	0.36	2.5
South Creek	0.56	0.81	5.5

Creek flood hazards have been previously described in KWL (2012). The recommendations regarding flood construction level (FCL) made in the 2012 KWL report remain in effect, and are presented in Section 4.1 of the 2012 report. In general, the berms and lands adjacent must remain or be raised to ensure a sufficient conveyance capacity in the creek channels to convey a 200 year flow. Allowances for debris torrents are discussed in subsequent paragraphs.

Preliminary culvert sizing is provided in Figure 6-1. Preliminary sizing was based on conveying the 200-year instantaneous peak flow with a headwater to culvert depth ratio of less than 1.2. Final culvert/bridge sizing should be based on the designated flood, and should consider other issues such as:

- Provision of fish passage;
- Sedimentation allowance; and
- Debris flows.



It is noted that some of the existing culverts and crossings cannot convey the estimated 200-year return period flood, and would need to be upgraded during the site development.

Gravel Creek does not have a defined channel, which could allow for floodwaters to overtop the existing banks. It is proposed to relocate Gravel Creek and Unnamed Creek, as indicated in Figure 6-1. Relocation of the creeks will allow a defined channel and riparian area to be established for both creeks.

Preliminary sizing of the lower Gravel Creek channel indicates that a trapezoidal channel would need to be approximately 3.6 m wide, 1.2 m deep, with 2H:1V side slope (Mannings $n = 0.02$, Channel Slope 1.9%, freeboard = 600 mm) in order to convey the 200-year storm event.

A training berm was recommended along the left bank of Daisy Creek to address the potential overbank flooding.

Prior to detailed design of creek crossings and channels, the following items are recommended:

1. A channel survey (profiles and regular cross-sections) should be conducted for all creeks;
2. Detailed review of record information for Gravel Creek and development of a detailed catchment model should be undertaken; and
3. A catchment model and confirmation of peak water levels be undertaken for Thistle Creek and Daisy Creek.

The completion of the above items may reduce the potential crossing and channel size, and will also indicate potential flood risk areas.

Coastal Flood Hazard

A concept-level coastal flood elevation was presented in KWL (2012) based on then recently-released guidance provided by the BC Ministry of Environment on incorporating climate change and sea level rise in management of coastal flood hazards and land use (Ausenco Sandwell, 2011a¹ and 2011b²).

The concept-level flood elevation presented in the 2012 KWL report was based on information provided in Ausenco Sandwell (2011b) for the Squamish River Delta, incorporating sea level rise to the Year 2100 time horizon. The Squamish River Delta is relatively near to the Taicheng Lands: located about 9 km to the north. The Year 2100 FCL for the Squamish River Delta presented in Ausenco Sandwell (2011b) is 5.6 m CGD³ (which includes freeboard).

The intent of the guidance is that professionals account for relatively long-term sea level rise processes when considering coastal flood hazard protection. Many structures, once constructed, can be expected to remain in place for 80 to 100 years and therefore the FCL must consider future sea level rise. Although the Ausenco Sandwell reports remain the most current guidance from the Province relating to the incorporation of climate change impacts into coastal flood hazard assessments, they have not yet been incorporated into existing legislation around flood hazard management.

For regional context, the FCL established by law for the Strait of Georgia is 1.5 m above the natural boundary. The FCL adopted for the nearby Furry Creek development is 3.5 m.

¹ Ausenco Sandwell, 2011a. Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use: Draft Policy Discussion Paper. Report prepared for the BC Ministry of Environment. 45 pp + appendices.

² Ausenco Sandwell, 2011b. Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use: Guidelines for Management of Coastal Flood Hazard Land Use. Report prepared for the BC Ministry of Environment. 22 pp + appendices.

³ CGD: Canadian Geodetic Datum.



Coastal FCL Components

The method to develop the coastal FCL that is being advocated by the Province is a summation of allowances to account for the various components of coastal flood hazard, including:

- tide;
- storm surge and wind set-up;
- sea level rise;
- wave effect; and
- freeboard.

Components of the coastal FCL for the Squamish River Delta are summarized in Table 6-5, below.

The independent combination of probabilities associated with the tide and storm surge condition results in an overall lower probability associated with the combined water level; however, as stated in Ausenco Sandwell (2011a), this is consistent with the approach that has been applied in BC to development of sea dikes (i.e., a high tide condition plus a 1-in-200-year storm surge).

Table 6-5: Preliminary Year 2100 Coastal FCL Estimate for Squamish River Delta

Water Level Component	Ausenco Sandwell (2011b) Estimate
Tide	2.05 ¹
Storm Surge	1.3 ²
Wind Set Up	
Sea Level Rise	1.0 ³
Wave Effect	0.65 ⁴
Freeboard	0.6
Total (FCL)	5.60
Notes:	
1. Higher High Water Large Tide: the average of the highest high waters, one from each of 19 years of predictions.	
2. Estimated 500-year return period storm surge plus allowance for local wind set. Return period based on consideration of extensive foreshore development in downtown Squamish, industrial development and high ecological values (Ausenco Sandwell, 2011a).	
3. Recommended allowance for global sea level rise to 2100 time horizon. Regional adjustment = 0 m. Should be confirmed by analysis.	
4. Allowance for wave run-up on natural gravel – pebble beach shoreline.	

Site-specific differences between the Squamish River Delta and the Taicheng Lands would likely lead to differences in two of the components:

- **Storm surge (and wind set-up):** a lower return period could be justified based on less dense development; and
- **Wave effect:** assessment of wave effects is necessarily site-specific and the general allowance provided in Ausenco Sandwell (2011b) does not represent the Taicheng Lands site.

All other components of Table 6-4 would be applicable to the Taicheng Lands site.



Storm Surge

The estimated 1-in-500-year return period storm surge (plus wind set up) for the Squamish River Delta is 1.3 m (Table 6-4). Ausenco Sandwell (2011a) suggests that a higher return period storm surge (1-in-500-year return period) be adopted for areas of dense coastal development due to the associated higher consequence of flooding in these areas. However, for less densely settled regions, the 1-in-200-year storm surge is recommended.

Corresponding 1-in-200-year return period values are not provided by Ausenco Sandwell (2011b), but it is estimated that using the lower return period value would yield a modest decrease in the storm surge/wind setup allowance (perhaps on the order of 0.05 m).

Engineering analysis to estimate the 200-year return period storm surge and wind setup would be required.

Wave Effect

The wave effect component is intended to allow for the rise in the static water level associated with waves (wave set-up) as well as the dynamic effect of waves running up a shoreline. The suggested guidance in Ausenco Sandwell (2011b) is to use 50% of the estimated wave run-up as the wave allowance. Site-specific engineering is required to estimate the wave run-up, which varies greatly depending on the estimated deep-water wave, shoreline geometry and composition.

It is understood that the residential development on the northern part of the Taicheng Lands is planned to be located on the landward side of the highway. No habitable buildings are planned for the area between the highway and the ocean. Based on available topographic data, the elevation of the highway fronting the Taicheng Lands grades upward from north to south: starting at 4 m in the northernmost part of the site, reaching 5 m near the current entrance to the gravel pit, and reaching 6 m about 100 m north of the Thistle Creek crossing. The highway itself is about 15 m wide, with a variable width of land on the ocean side (ranging from 0 m wide to about 70 m wide). Thistle Creek is culverted through the highway.

In the short term, the elevation of the tide plus storm surge is about 3.3 m. Considering the elevation of the highway, in the near term it appears unlikely that waves would break across the highway. Closer to the year 2100 time horizon, the elevation of the tide plus storm surge plus sea level rise allowance is estimated at 4.25 m. The rail, highway, and a proposed dike with a crest elevation of 5.6 m would address wave effects and freeboard. This would permit the structures behind this dike to be constructed to an FCL of 4.25 m. Any buildings outside of this proposed dike should be constructed to an FCL of 5.65 m.

4.35

6.7 Debris Torrents

Thurber Engineering completed an interim geotechnical assessment of the proposed South Britannia Beach Development in January 2012. The findings from the report that pertained to the potential for debris flow at Daisy and Thistle Creek are summarized below. Additional details can be found in the Village at Britannia Beach Interim Geotechnical Assessment Draft Report, January 2012.

Potential avulsion or diversion points on Thistle Creek should be securely blocked off by erosion resistant earthworks. Alternatively, small sediment basins, racks and culverts could be provided on the crossings of all potential avulsion paths.

A 1997 debris flow assessment of Thistle Creek concluded that the potential for Thistle Creek to form a debris flow was negligible. A limited volume of debris (1,000 m³) could be generated, but would likely



deposit on the bench upstream of the transmission line. A 2,000 m³ debris basin was recommended for the Sea to Sky improvements, but it was not constructed by the Ministry of Transportation and Highways.

The sea to sky improvements constructed a 25,000 m³ debris storage basin for Daisy Creek. The low probability debris flow for daisy creek was estimated in 1983 at 24,000 m³, but downgraded to 17,500 m³ in 1997. In the event of a larger event on Daisy Creek, the debris basin would be overtopped and debris would spill over the highway and into the development. The report recommended “that all residential units on the south side of the Highway inside the Highway 99 loop be provided with a concrete foundation wall to 1 m above ground level on the uphill side. This will serve to protect the buildings from debris run-out.” An alternative may be to reconstruct the debris basin to contain a larger event, but this is likely more difficult and expensive. These recommendations were irrespective of the training berm recommended to contain water flows.

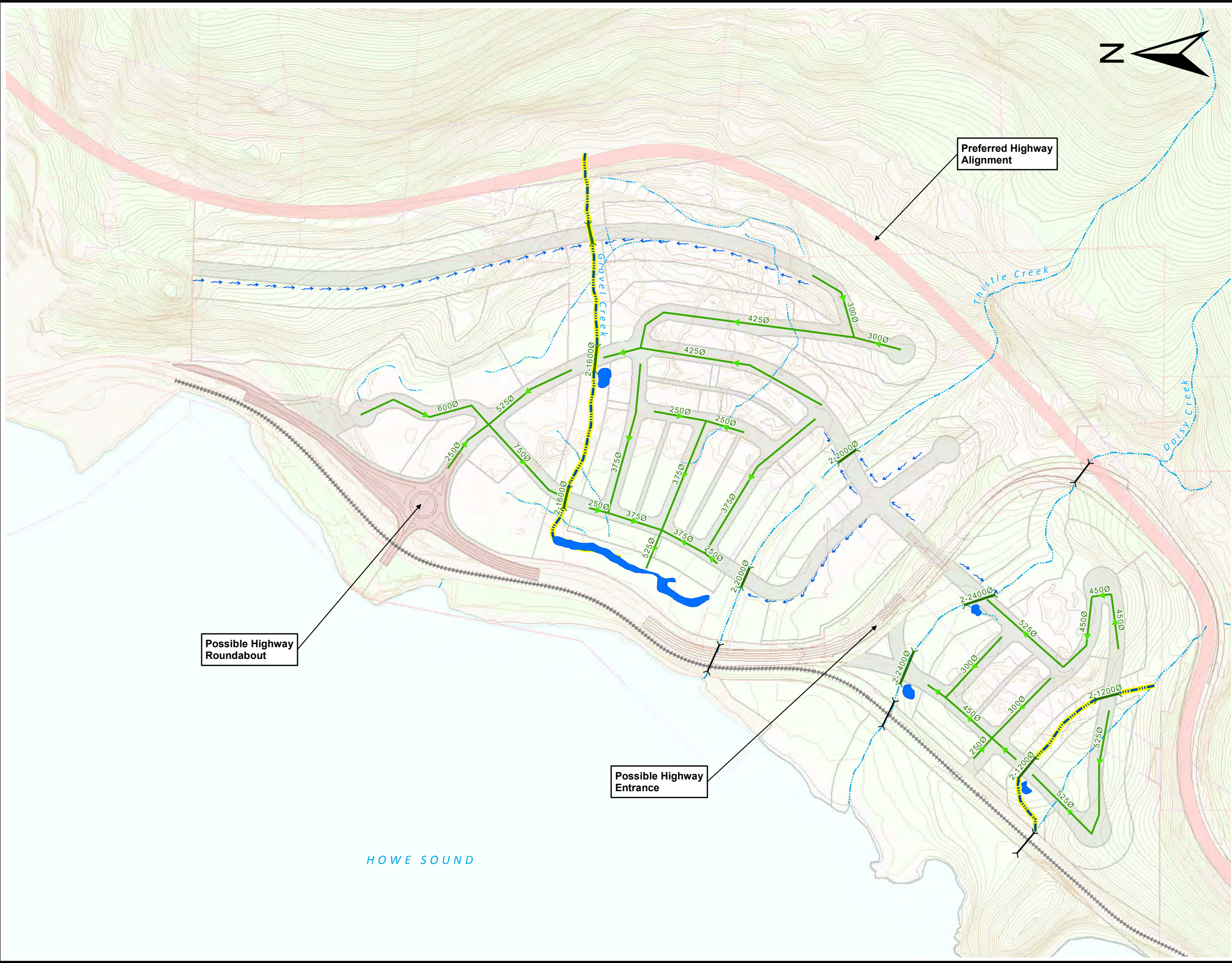
6.8 Summary

The stormwater management concepts described above for South Britannia Beach will meet the relevant sections from the DFO stormwater criteria and are consistent with SLRD’s Bylaw requirements. As planning of the development advances these design concepts should be further refined at the preliminary design stage.

The site slopes towards and drains into Howe Sound via a single defined drainage crossing of the highway and CN Rail at Thistle Creek, and two crossings of CN Rail at Daisy Creek and an unnamed creek at the south end of the Minaty Bay area. The lower, flatter portions of the site consist of permeable sand and gravel. The development is planned to maintain hydrologic values of the site, with protected watercourses with riparian areas, re-establishment of disturbed creeks and riparian areas, and rain gardens, swales and ponds to maximize biofiltration and infiltration.

The lower areas of the site are exposed to potential storm surges from Howe Sound. The design elevation for flood protection measures is 5.6 m including a 1 m allowance for 100 years of sea level rise. Inland of the highway, the lands may be protected by a 5.6 m crest elevation dike (approximately 1.5 m above existing grades) and the buildings should be constructed to a minimum 4.35 m flood construction level (FCL). Buildings on the water side of the dike should be constructed to the full 5.6 m FCL along with adequate erosion protection.

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Author: J Lau



**Taicheng Development Corporation
South Britannia Beach**

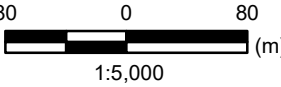
Legend

- Existing ROW
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- Contour from 2006 Aerial Mapping (2m Intervals)
- Existing Watercourse
- Existing Railway
- Existing Culvert
- Drainage System**
- Proposed Culvert or Bridge
- Proposed Drainage Main
- Proposed Rain Garden / Swale
- Proposed Channel Realignment
- Proposed Drainage Treatment Facility

Reference: Basemap from 2004/2006 Orthophoto

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Project No. 2957-006	Date October 2014
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**Conceptual
Drainage Conveyance
System**

Figure 6-1



7. Other Infrastructure

Other utilities include hydroelectric power, gas, and telecommunications.

7.1 Electricity

BC Hydro is responsible for the power system planning, design and installation, with construction of associated civil works the responsibility of the Developer. Demand loads for system design are estimated on the basis of building types and projected energy uses.

BC Hydro power lines run through the lands on the east side, and a substation that services North Britannia is at the north edge of the South Britannia site. Modifications to the existing substation or a similar arrangement are expected to be provided for South Britannia. Costs and details must be negotiated with BC Hydro.

The BC Hydro system will generally be constructed in the boulevard behind the curb line or in the road shoulder in the public road right-of-way otherwise common rights-of-way are required over private roads. Major structures such as pull boxes, transformers and switching kiosks will be located in boulevards with protection provided from snow removal equipment.

7.2 Gas

Gas would normally be supplied by FortisBC Energy Inc. Both system design and installation is the responsibility of FortisBC, with gas requirements estimated on the basis of building types and projected energy uses. There is currently no gas service at or near the site. A stand-alone system would need to be set up, likely with a storage tank periodically refilled by truck. Gas mains, if installed, will generally be constructed in the road boulevard behind the curb line.

Inquiries were made with FortisBC with the following response.

"There are many factors that come into play when looking at the cost of providing gas service to the development. In general, extensions to gas mains are made with the future in mind, and consider gas consumption to the development in the first 5 years, as well as future opportunities to connect customers. So it is likely that the entire cost of the main extension would not have to be borne by the developer. The contribution to the main extension could be in the form of a payment by the developer or could be borne by the eventual users in the rates paid. Or some combination. Some of the variables would be the total load, buildout timeline, building uses, site layout etc. We would be pleased to work with you as these details become available. We have reason to think that a Liquefied Natural Gas (LNG) solution may make more sense for this site, given its relative isolation. That is an option we would like to discuss with you further when the time is right. Note that servicing this project would take some time, likely in the 2 – 3 year range, so we would like to be involved with the planning process early."

We understand that gas service is not being pursued for the site.

7.3 Telecommunications

Bell Canada is responsible for communication system planning and installation. As for BC Hydro, construction of the civil works is the responsibility of the developer.

Telecommunications are typically installed in common trenches with the power conduit. Similar to BC Hydro, Bell Canada requires common rights-of-way over private roads, clearances to major structures and access for maintenance. The cablevision provider is responsible for system planning and design. Generally the provider cable is responsible for all or nearly all costs of the cablevision system.



8. Report Submission

Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

This document is a copy of the sealed and signed hard copy original retained on file. The content of the electronically transmitted document can be confirmed by referring to the filed original.

Michelle Revesz, P.Eng.
Project Engineer

Reviewed by:

Colin Kristiansen, P.Eng.
Project Manager



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Revision History

Revision #	Date	Status	Revision	Author
3	November 5, 2014	Final	Added cut/fill, creek data, stormwater plan, revised water	MDR/CAK
2	July 2, 2014	Final	Incorporated client comments	MDR
1	June 27, 2014	Draft	Incorporated client comments	MDR
0	May 30, 2014	Draft		MDR/CAK

13 FLOOD PROTECTION

This document is a concept flood and foreshore protection study conducted by Ker Wood Leidal & Associates in 2012. Note that the flood construction level recommended by KWL in this report was modified in the Turje report by removal of the wave runup protection component for Development Area A.

The shoreline protection options in this report are largely irrelevant to the current development proposal.



Technical Memorandum

DATE: March 5, 2012

YOUR FILE: 2957.001-300

TO: Cary Zhou, Taicheng Development Corporation
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CC: Ron Lea, MAIBC, CP
FROM: Erica Ellis, M.Sc., P.Geo

RE: **SOUTH BRITANNIA BEACH**
Concept Flood and Foreshore Protection
Our File 2957.001-300

1. Introduction

Kerr Wood Leidal Associates Ltd. (KWL) has been retained by Taicheng Development Corporation to provide engineering services for South Britannia Beach, (the Site).

This technical memo summarizes concept-level design requirements for the following considerations:

- creek crossings;
- flood protection works; and
- shore protection works.

2. Background

2.1 South Britannia Beach

The Site is located approximately 60 km north of Vancouver, BC on the Sea to Sky Highway between Britannia Beach and Furry Creek on the slopes above Howe Sound. Furry Creek is the nearest community, about 3 km to the south. The development is located within the Squamish Lillooet Regional District (SLRD), in Electoral Area D.

2.1.1 Creeks

The proposed development is traversed by a number of unnamed watercourses, as well as two larger, named watersheds: Thistle Creek and Daisy Creek (refer to Catchment Boundaries Figure 1). In addition to these named creeks, there are three other creeks that cross the Site. From north to south, these shall be referred to as:

- Gravel Creek (flows through the old gravel pit);
- No Named Creek (flows along the south side of the fan, to the south of Daisy Creek); and



- South Creek (flows off the Howe Sound slopes).

Creeks crossing the Site and existing works are shown on Figure 2.

3. Flood Issues

3.1 Peak Flow Estimates

Stream gauges are not located on any of the creeks within the property; therefore a regional stream flow analysis was conducted to estimate the 200-year return period peak instantaneous flow for the creeks located within the project Site. The table below summarizes the results of the analysis.

Table 3-1: Summary of Estimated Peak Flows

Creek	Drainage Area (km ²)	Mean Annual Flood (m ³ /s)	200-yr RP Instantaneous Peak Flow (m ³ /s)
Gravel Creek	1.0	1.3	9.2
Thistle Creek	2.1	2.5	17
Daisy Creek	3.3	3.7	25
Unnamed Creek	0.22	0.36	2.5
South Creek	0.56	0.81	5.5

3.2 Site Visit

A field visit was conducted on October 26, 2011 to review the watercourses crossing the South Britannia Beach, as well as existing crossings and flood protection works. Present were Erica Ellis and David Matsubara (both of KWL). Mr. Tony Mahood provided access to the Site and an overview of the roads and drainages.

A brief description of observations is provided below, and a summary table of culverts and crossings is provided in Table 3-2.

3.2.1 Field Observations

Gravel Creek

According to Mr. Mahood, drainage from the north-west part of the slopes was formerly routed to a man-made ditch slightly downslope of the Hydro Right-of-Way (ROW), and into Thistle Creek. However, some years ago an additional channel was cut to divert flow from this ditch down onto the lower fan surface. The channel, which is referred to as Gravel Creek, is shown on Figure 2. The estimated catchment boundary is shown in Figure 1. Photos 1 and 2 show the creek on the lower fan.

The creek is relatively small but not well confined downstream of the existing road crossing. Anecdotal reports suggest that during high flow events, water over tops the channel and inundates a large portion of the low-lying ground adjacent to the channel. No culvert crossing under Highway 99 was located for Gravel Creek and highway as-built drawings were not available to be able to confirm whether or not the creek can drain to the ocean. At the time of the field visit, the creek appeared to flow into a substantial body of ponded water; plants in this area were water-tolerant, suggesting that the ground is wetted for a large portion of the year.



Based on preliminary hydraulic analysis, the existing culvert crossing on the fan (Figure 2) appears to be too small to convey the estimated 200-year return period instantaneous peak flow (Table 3-1). However, peak flows may be overestimated for this catchment since it is likely that a large portion of incident rainfall on the lower fan surface would infiltrate rather than running off. Subsequent phases of work should include a review of highways drainage infrastructure and detailed hydraulic modelling of the creek.

Thistle Creek

Thistle Creek is the second largest catchment on the Site (Figure 1). It drains the steep slopes above the Development and, according to Mr. Mahood, discharges over a steep falls before flowing onto the fan. A review of historic air photographs suggests that this creek flowed through the active gravel mining operation, and that the channel on the lower fan is likely to have been substantially altered as a result.

At the fan apex and downstream, the creek is well-confined between both the higher, historic fan surface (at the east and south margin of the gravel mining operation), and by man-made berms of native material (sand, gravel and cobble) (Photo 4). The berms are large (2 m to 4 m high), vegetated and appear to be relatively stable. However, it should be noted that the berms are not protected against erosion (except by vegetation), and the material is erodible.

The creek crosses under an existing road on the fan, as well as Highway 99 and the railway. Preliminary hydraulic calculations were performed to check the capacity of the berms, and the Highway 99/railway crossing. The bermed section appears to have sufficient conveyance capacity to contain the estimated 200-year return period flood (Table 3-1), as does the culvert.

Daisy Creek

Daisy Creek is the largest catchment that drains through the Site (Figure 1). The creek has been previously assessed during the course of the Highway 99 upgrades and flood protection and debris containment works have been constructed on the channel upstream of Highway 99.

A review of the creek morphology upstream of the Hydro ROW suggests that it may be subject to geomorphic events such as debris floods or debris flows. Thurber Engineering has been retained to review geochemical and geomorphic hazards associated with the creeks and on the Site. It is assumed that the existing flood protection works in place upstream of Highway 99 are sufficient to mitigate this risk.

Downstream of Highway 99, Daisy Creek is not well confined on the left bank, and an existing location of bank erosion at a low point on the bank was noted in the field (Figure 2 and Photo 5). Floodwaters would likely escape the channel at this location; the bank is about 1 m above the channel bed, and deeply undercut. Based on existing topography, it is uncertain whether overbank flow would be redirected back into the channel, and therefore there is the potential for overbank flows to impact development adjacent to the creek.

The creek flows under an existing bridge on the fan, a bridge under the railway and then exits to the ocean through a concrete box culvert. The railway bridge appears to have limited conveyance due to deposition of sediment (there is about 1 m of clearance between the bridge and the channel bed, Photo 6). The culvert at the ocean outlet is in poor condition: rebar is exposed and protruding from the channel bed (Photo 7), and there is a drop to the beach elevation (Photo 8), which would be a barrier to fish passage.

Preliminary hydraulic calculations indicate that the railway bridge crossing is likely undersized compared to the estimated 200-year return period discharge, particularly given that on-going deposition of sediment is likely to occur at this location. If flow were to escape the channel at this point, it appears that it would



flow over the right bank and along the railway. In addition, the culvert at the ocean appears to be too small to convey the estimated 200-year return period flood.

Unnamed Creek

An unnamed creek flows to the south of Daisy Creek, along the southern, inside edge of the Highway 99 bend (Figure 2). This creek appears to drain the local slopes to the south-east of the highway, as indicated in Figure 1. The creek was not examined during the field

visit, except for the outlet at the ocean (Photo 9). Existing topographic information suggests that the creek is well confined down to the railway crossing. Downstream of the railway the exact route of the channel is less certain, and should be refined during detailed design.

South Creek

The last major creek to flow through the Site has been named South Creek (Figure 1). It drains the steep slopes on the south-east side of Highway 99, at the southern limit of the development. Based on limited field observations, the catchment appears to consist of small creeks flowing in relatively deep, well-confined channels (e.g. ravines). No crossings were reviewed on South Creek.

Table 3-2: Summary of Observed Creek Crossings and Culverts from Field Visit

Creek	Culvert or Crossing	Location
Gravel Creek	Culvert 1.2 m dia. CMP	Existing road crossing, on fan.
Thistle Creek	Culverts	Under FSR (including tributaries)
	Bridge	Above Hydro ROW
	Bridge	On fan.
	Culvert 3 m×2 m concrete box	Under Highway 99 / railway.
Daisy Creek	Culverts	Under FSR (including tributaries)
	Culverts	Under Highway 99
	Bridge	On fan.
	Bridge	Under railway.
	Culvert 1.8 m×1.8 m concrete box	At ocean, under existing road.
Unnamed Creek	Culvert / Bridge	At ocean, under existing road.

3.3 Summary of Potential Flood Issues

Based on the field visit and preliminary hydraulic calculations, potential flood issues are summarized in the following table.



Table 3-3: Summary of Potential Flood Issues for South Britannia Beach

Creek	Location	Potential Flood Issue
Gravel Creek	Existing road crossing, on fan.	Culvert may not be able to convey the Q200.
Gravel Creek	Channel upstream of Highway 99.	Lack of channel confinement: overbank flooding likely. Provision and state of outlet under Highway 99 is uncertain.
Daisy Creek	Left bank, downstream of Highway 99.	Eroding bank with potential for overbank flooding.
Daisy Creek	Railway crossing.	Culvert likely not able to convey the Q200. Potential sedimentation issues.
Daisy Creek	Culvert at ocean.	Culvert likely not able to convey the Q200. Culvert in poor condition.

4. Flood Protection Plan

The BC Ministry of Environment has established guidelines for development in flood prone areas: ***Flood Hazard Area Land Use Management Guidelines***, 2004 (the "Guidelines"). This document addresses official community planning, bylaws, development permits, subdivision approval, and a number of other development issues. These Guidelines shall be used to develop the flood protection plan for the Site.

The Guidelines outline a number of definitions that will be used throughout this section, and include:

- **watercourse:** any natural or man-made depression with well defined bank and a bed 0.6 metres or more below the surrounding land serving to give direction to a current of water at least six (6) months of the year or having a drainage area of 2 square kilometres or more upstream of the point of consideration;
- **natural boundary:** the visible high watermark of any lake, river, stream or other body of water where the presence and action of the water are common and usual and so long continued in all ordinary years as to mark upon the soil of the bed of the lake, river, stream or other body of water a character distinct from that of the banks thereof, in respect to vegetation, as well as in respect to the soil itself (Land Act, Section 1).
- **flood construction level:** The Designated Flood Level plus the allowance for the freeboard and is used to establish the elevation of the underside of a wooden floor system or top of the concrete slab for habitable buildings. In the case of a manufactured home, the ground level or top of concrete or asphalt pad, on which it is located, shall be equal to or higher than the above described elevation. It also established the minimum crest level of a Standard Dike. Where the Designated Flood level cannot be determined or where there are overriding factors, an assessed height above the natural boundary of the water-body or above the natural ground elevation may be used.
- **flood proofing:** The alteration of land or structures either physically or in use to reduce flood damage and includes the use of building setback from water bodies to maintain a floodway and to allow for potential erosion. Flood proofing may be achieved by all or a combination of the following:



1. building on fill, provided such fill does not interfere with flood flows of the watercourse, and is adequately protected against floodwater erosion;
 2. building raised by structural such as foundation walls, columns, etc.;
 3. a combination of fill and structural means.
- **smaller streams:** not meeting the definition of watercourse where the designated flood can otherwise be estimated to be less than $80 \text{ m}^3/\text{s}$, the watercourse has not had a significant history of flooding and or bank erosion, and the watercourse is not located on an alluvial or colluvial fan; and
 - **very small stream:** not meeting the definition of watercourse where there is no history of flooding and or bank erosion, and the watercourse is not located on an alluvial or colluvial fan.

Of the five catchments on the Site, Gravel Creek, No Name Creek and South Creek all have watersheds smaller than 2 km^2 , and therefore would not meet the criteria to be designated as 'watercourses'. These catchments would likely be considered 'smaller streams' under the Guidelines. In addition, preliminary peak flow estimates for both Thistle Creek and Daisy Creek are much less than $80 \text{ m}^3/\text{s}$, and therefore it is likely that these creeks also would be considered 'smaller streams' under the Guidelines.

The historical fan has been heavily modified by previous gravel mining and only remnants of the fan surface are still visible on the Thistle Creek side of the highway. On the other side of the highway, Daisy Creek is relatively well incised in the fan except at one location.

Based on the Guidelines, this section presents a flood protection plan to address creek hazards based on the above criteria. The plan includes consideration of various elements of the proposed development, including:

- structural flood protection measures (e.g. training berms)
- creek crossings and culverts;
- setbacks;
- site grading; and
- flood construction level (FCL).

These items are discussed individually in the sections below.

4.1 Structural Measures

Of the identified flood issues at the Site, structure measures are proposed to address the potential overbank flooding on the left bank of Daisy Creek, downstream of Highway 99. A berm is proposed along the left bank. The proposed berm alignment is shown in Figure 3. The berm would have to be outside the RAR/SLRD setback, and a right-of-way should be established for access and maintenance.

A typical cross-section of the berm is shown on Figure 4. The berm crest height should be set based on the estimated design flood profile, with an allowance for sedimentation and freeboard (see Section 4.4). Hydraulic modeling will be required to establish the flood profile at the design stage.

4.2 Crossings

All culverts and bridge crossings on the Site should be sized to convey the designated flood, without headwatering. In addition, the design should consider other issues such as:

- provision of fish passage; and
- sedimentation allowance;



The proposed design for the Site has not yet been finalized and therefore road alignments are not yet known. It is noted that some of the existing culverts and crossings cannot convey the estimated 200-year return period flood, and would need to be upgraded during the site development.

4.3 Setbacks

Creek setbacks are required to ensure that buildings are located a safe distance away from the creek, and to provide a sufficient riparian corridor for fish, wildlife and aesthetic purposes. The Guidelines outline the minimum setback for flood protection, while the Riparian Areas Regulation specifies setbacks based on the nature of the watercourse flow regime and consideration of fish habitat.

Setbacks of various widths are required by different agencies, as summarized below:

- **For flood protection:** under the Guidelines, a 'watercourse' requires a building setback of 30m, which may be reduced to 15m for 'smaller streams'.
- **For Riparian Area Regulation (RAR):** either a 30m setback or a detailed assessment that could result in a setback width usually equal to 3 times the active channel width.
- **For Zoning:** the SLRD provides creek setback requirements in the Electoral D Zoning Bylaw No. 540, 1994, adopted on June 27, 1994. Principal buildings and accessory buildings require a minimum setback of 25m and 15m, respectively.

As summarized above, the setback width is likely to be in the order of 25 to 30m for buildings on the Site development. A more detailed RAR assessment could potentially reduce the setback width to around 15 m to 20m for smaller creeks, but this would have to be approved by the SLRD.

Based on the RAR assessment, if it is determined that the development will not cause any harmful alteration, disruption or destruction of fish habitat (HADD), the SLRD will need to approve the development setbacks. If the assessment determines that the development is a HADD, approval will be required from Fisheries and Oceans Canada (DFO).

At this preliminary stage of the project, a 30m setback on all creeks has been assumed. Setbacks are indicated on Figure 3.

It should be noted that although land uses of some types (e.g. parks) may be permitted within the setback area, in general no development is permitted. Flood protection works must be located outside the RAR creek setback.

4.4 Site Grading and Flood Construction Level

4.4.1 Flood Construction Level

Based on the provincial "Flood Hazard Area Land Use Management Guidelines"¹, the flood construction level for "smaller streams" should be set at an elevation greater than 1.5m above the natural boundary of the watercourse. Flood construction levels are typically assigned at the lot scale. However, at this preliminary stage of the proposed development, the Site design has not been finalized and therefore only high-level guidance can be provided regarding grading and flood construction level.

¹ Ministry of Water, Land and Air Protection, 2004. Flood Hazard Area Land Use Management Guidelines. 31 pp + appendices.



It is anticipated that the low area at the location of the former gravel pit will need to be raised to meet the FCL, as indicated in Figure 3. In general, the Site should consider the coastal FCL (discussed in the following section) as the minimum FCL, which will likely govern in the western portions of the South Britannia Beach. Hydraulic modeling should be used to establish design flood profiles for the creeks that flow through the Site. The FCL for the creeks would be established as: design flood depth + sedimentation allowance (if required) + freeboard.

A preliminary hydraulic analysis has been carried out for the three largest catchments on the Site Development for the estimated 200-year return period flows in Table 3-1. As indicated in Figure 5, the depth of flow for the 200-year return period flood could vary from anywhere between about 0.5m to almost 1.4m, depending on the creek and the channel geometry.

A sedimentation allowance should be considered for both Thistle Creek and Daisy Creek, and possibly Gravel Creek, to account for deposition of sediment that might occur during the design flood. In addition, a nominal freeboard of 0.6m should be added on top of the flood depth and sedimentation allowance, to account for uncertainty.

Also of concern is the potential for flooding from the adjacent Britannia Creek watershed, which is subject to debris floods. Overbank floodwaters from Britannia Creek potentially could travel along Highway 99 and reach the Site. However, setting the minimum the Site FCL equal to the coastal FCL should avoid potential flooding from Britannia Creek since the resulting elevations are likely to be higher than the existing highway grade (roughly 4m to 5m). This should be confirmed at the detailed design stage.

4.4.2 Site Grading

Where sloping ground occurs on the flood prone areas of the development, lot-specific site grading will also be required to ensure that any overbank flood flows could be safely routed across a lot and through the development without being impeded, or being directed towards a structure. Site grading at a larger scale should include consideration of the possibility for flooding over and along roads.

At this preliminary stage of the project, only one floodway is proposed to deal with potential conveyance issues at the railway crossing of Daisy Creek. As indicated on Figure 3, the floodway will take overbank flow from the channel and route it along the railway then down the existing road to the ocean. Further consideration should be given to site grading when the proposed development plan is closer to being finalized. Additional floodways on the lower areas of the Site will likely be required.

In addition, the Development may wish to consider providing an outlet channel for Gravel Creek into lower Thistle Creek, to reduce the potential of flooding from Gravel Creek. Approval for these works will be required by the Ministry of Environment, and Fisheries Oceans Canada (DFO) and potentially the Ministry of Transportation and Highways.

4.5 Recommendations

The recommendations for the Flood Construction Plan section are summarized below.

- 1) A channel Survey (profiles and regular cross-sections) should be conducted for all creeks.
- 2) Detailed review of record information for Gravel Creek and development of a detailed catchment model should be undertaken.
- 3) A catchment model and confirmation of peak water levels be undertaken for Thistle Creek and Daisy Creek.



- 4) A training berm should be constructed along the left bank of Daisy Creek to address the potential overbank flooding. The berm would be constructed outside the RAR/SLRD setback, and a right-of-way should be established for access and maintenance.
- 5) All new creek crossings need to be designed to convey the 200-year return period flood, without headwatering. Designs need to consider fish passage and sedimentation allowances.
- 6) A 30m creek setback for the site development can be assumed for conceptual design. A detailed RAR assessment will need to be completed to determine the required Creek setbacks.
- 7) For upland areas the FCL is estimated to be 1.1m to 2.0m above the creek channel, including 0.6m freeboard but not including a sedimentation allowance. Sedimentation within Thistle Creek, Daisy Creek and possibly Gravel Creek could occur during the design flood. It is recommended that a sedimentation allowance be estimated for these creeks.
- 8) Lower Gravel Creek could be developed into a habitat area that discharges into Thistle Creek at the highway to minimize the cost and challenges associated with a new crossing under Highway 99.
- 9) The minimum site FCL should be the coastal FCL. Detailed design should confirm that the site FCLs also minimize the likelihood of overbank flooding from the adjacent Britannia Creek watershed.

5. Coastal Flooding and Shoreline Protection

5.1 Coastal Flood Construction Level (FCL)

Guidance has recently been provided by the BC Ministry of Environment on incorporating climate change and sea level rise in management of coastal flood hazards and land use (Ausenco Sandwell, 2011a² and 2011b³). Ausenco Sandwell (2011b) includes preliminary design water levels and flood construction levels for the Squamish River Delta incorporating sea level rise (2100 time horizon), which is relatively near to South Britannia Beach. These values are provided in Table 5-1.

² Ausenco Sandwell, 2011a. Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use: Draft Policy Discussion Paper. Report prepared for the BC Ministry of Environment. 45 pp + appendices.

³ Ausenco Sandwell, 2011b. Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use: Guidelines for Management of Coastal Flood Hazard Land Use. Report prepared for the BC Ministry of Environment. 22 pp + appendices.



Table 5-1: Preliminary Year 2100 Coastal FCL Estimate for Squamish River Delta

Water Level Component	Ausenco Sandwell (2011b) Estimate
Tide	2.05 ^a
Storm Surge	1.3 ^b
Wind Set Up	
Sea Level Rise	1.0 ^c
Wave Effect	0.65 ^d
Freeboard	0.6
TOTAL (FCL)	5.60
Notes: a. Higher High Water Large Tide: the average of the highest high waters, one from each of 19 years of predictions. b. Estimated 500-year return period storm surge plus allowance for local wind set. Return period based on consideration of extensive foreshore development in downtown Squamish, industrial development and high ecological values (Ausenco Sandwell, 2011a). c. Recommended allowance for global sea level rise to 2100 time horizon. Regional adjustment = 0 m. Should be confirmed by analysis. d. Allowance for wave runoff on natural gravel – pebble beach shoreline.	

Based on the preliminary estimate in Table 5-1, the coastal FCL for the Site is likely to be around 5.6 m elevation. However, a more detailed, site-specific analysis will be required to properly estimate the coastal FCL for the site. Among other things, the coastal analysis will consider:

- the proposed shoreline character (orientation, gradient and materials);
- the desired return period for the development (e.g. 1 in 200-years, or greater);
- the deep-water storm surge for the desired return period; and
- the wave climate experienced at the site (i.e. prevailing winds, shoreline characteristics, and wave-shoreline interactions).

The preliminary FCL in Table 5-1 makes a nominal allowance for wave effect, based on runoff on a natural beach. Wave runoff on steep, rocky headlands may be 1m to 2m in elevation; the allowance for larger runoff can add substantially to the FCL. Site specific values should be assessed in a detailed coastal engineering analysis.

5.2 Coastal Flood Protection

Most of the area to the west of Highway 99, at the north end of the Site, is at an elevation of between 4m and 5m. Toward the south, the 5m contour is located somewhere between the shore and the railway. Based on the preliminary FCL presented in Section 5.1, it is apparent that parts of the shorefront will have to be raised to meet the coastal FCL, which is likely to be around 5.6m or greater.

In addition, it is suggested that a right-of-way be established for a future dyke along the shoreline of the development to address coastal flood hazard beyond the year 2100 time horizon. Global sea level rise is projected to continue into the future, and is likely to accelerate (Ausenco Sandwell, 2011a). The sea level rise allowance in Table 5-1 is 1.0m, which is the recommended allowance for the year 2100 time horizon. The current recommendation for sea level rise for the year 2200 time horizon is 2m (i.e. an additional



metre above the year 2100 time horizon allowance). Therefore, consideration must be given to mitigation of future coastal flood hazard beyond the year 2100 time horizon.

Since buildings are anticipated to have a life-span of about 80 to 100 years, the additional sea level rise allowance may be incorporated into the building FCL as the site is redeveloped in the future. However, this would require re-construction of the existing buildings to meet the higher FCL.

Alternatively, future coastal flood hazard may be mitigated through the provision of flood protection infrastructure such as dykes. Construction of a future dyke would require sufficient land along the waterfront to be set aside and remain undeveloped for this purpose.

Future flood protection works could be incorporated into the existing highway and railway rights of way considering that these transportation networks will need to be reconstructed to mitigate the impact of future sea level rise. However, it should be noted that beyond the year 2100 planning horizon, any habitable structures built on the ocean-side of the future dyke will need to be raised to meet the year 2200 FCL. This is likely to be more of a concern on the south end of the Site, as the railway is located about 120 m back from the current shoreline and it is anticipated that much of this shorefront area will be developed.

For planning purposes, we have designated on Figure 3, the highway and railway rights-of-way for future flood protection works.

5.3 Shoreline Protection Options

5.3.1 Options

Shoreline protection can range from very rigid structures to very flexible structures. Ocean and wave forces, especially in exposed waters, can be substantial and often shoreline protection is designed to allow some foreseeable damage and ongoing maintenance. The available types of shoreline protection techniques are rather limited and generally include: seawalls, uniform riprap revetments, intermittent structures, and engineered shorelines. Listed in order from most rigid to most flexible, possible shoreline protection options normally seen in the British Columbia include:

- concrete seawalls;
- steel sheet pile walls;
- vinyl sheet pile walls;
- riprap bank protection;
- riprap groynes and spurs (longshore protection);
- off-shore berms (wave dissipation);
- floating breakwaters;
- engineered beaches (graded slopes and sediment); and
- naturalized shorelines with some boulder elements.

Vertical structures such as concrete and sheet pile seawalls offer a vertical protective system that minimizes the footprint, but also limits development of any intertidal flora and fauna. Concrete walls are generally used for higher wave energy areas, while sheet piles are very often seen in calmer protected areas and harbours. There is very little flexibility in these systems and therefore they require robust design criteria for longer design lives and less maintenance.

Riprap bank protection is a more flexible system that can be used in any wave environment, high energy or low energy. As a slope, the approach requires a larger footprint, but the slope offers an important



range of intertidal areas for both flora and fauna. Riprap will require maintenance periodically, and is often designed to see some foreseeable damage in high energy environments.

Intermittent structures, such as groynes, spurs or off-shore berms are structures to address undesired wave and sediment transport processes. These structures are used in site-specific areas to limit processes, but usually not stop them entirely. As intermittent structures, the areas of disturbance for the structures along with capital costs are lower, while a need for ongoing maintenance still remains.

Engineered beaches and naturalized shorelines follow the Green Shores principles more closely. The four Green Shores principles are:

1. Preserve the integrity or connectivity of coastal processes;
2. Maintain or enhance habitat diversity and function;
3. Minimize or reduce pollutants to the marine environment; and
4. Reduce cumulative impacts to the coastal environment.

5.3.2 South Britannia Beach Shoreline

On South Britannia Beach, the shoreline north of Thistle Creek is composed of high eroding sand banks, with a history of site-specific, non-engineered bank protection works (a mixture of rock riprap, concrete, and other debris). The intertidal area extends to the current toe of bank and accumulates floating large wood debris. This section of bank is exposed to a relatively high-energy wave climate, which results in on-going erosion.

South of Thistle Creek, the shoreline is comprised of coarser sand, gravel and boulder deposits, with bedrock outcrops, and the shoreline contains two small bay areas. There is similar erosion in this area to the area to the north, but rates and extents of erosion appear to be lower either due to the exposure to waves or the resistance of the bank material.

Bank protection concepts for the Site may range from seawall concepts near the proposed marina area, to a variety of riprap bank protection works in areas to the south to provide additional habitat benefit. Potential opportunities include:

- development of subtidal fish habitat in and around riprap revetments, pile groups, and seawalls (e.g. spawning habitat for forage fish);
- development of intertidal pocket marsh areas over riprap revetments in lower energy sheltered areas;
- increasing biodiversity of high intertidal or riparian fringe areas (e.g. development of dune grass pockets);
- establishing a long-term, mature riparian zone in natural areas.

These elements could be constructed over riprap revetments or other works using bioengineering techniques, or standard revegetation approaches. Examples of these approaches are provided in the photo appendix (Photos 10 through 12).



5.4 Summary and Recommendations

- 1) Site-specific coastal engineering analysis is required to develop the wave components for the FCL and bank protection design. This analysis would likely be included in the coastal analysis for the marina development.
- 2) A Right-of-Way should be established and maintained for a future sea dyke.
- 3) A coastal FCL of 5.6m is foreseeable and should be confirmed with local analysis.
- 4) A range of shore protection options should be considered for the development, in order to protect high risk areas, protect the existing eco-system, and provide new environmental resources.

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Revision History

Revision #	Date	Status	Revision	Author
0	Nov. 23, 2011	Draft		DM/EE
1	Mar. 5, 2012	Final	Update name, edit text.	KF/EE



Appendix A - Photographs



Photo 1: Gravel Creek, looking upstream from road crossing on fan.



Photo 2: Gravel Creek looking downstream, about 70 m downstream of the crossing.



Photo 3: Thistle Creek, looking upstream from bridge on fan.



Photo 4: Thistle Creek, looking across the creek from the right bank at existing berms.



Appendix A – Photographs



Photo 5: Daisy Creek, looking downstream at low point on left bank (center of frame).



Photo 6: Daisy Creek, looking downstream at railway crossing. Note reduced conveyance due to deposition of sediment.



Photo 7: Daisy Creek culvert at ocean. Note poor condition of culvert bottom, with exposed rebar.



Photo 8: Daisy Creek culvert at ocean, looking upstream. Note drop at culvert outlet.



Appendix A - Photographs



Photo 9: Unnamed Creek, looking upstream at ocean outlet (culvert under bridge).



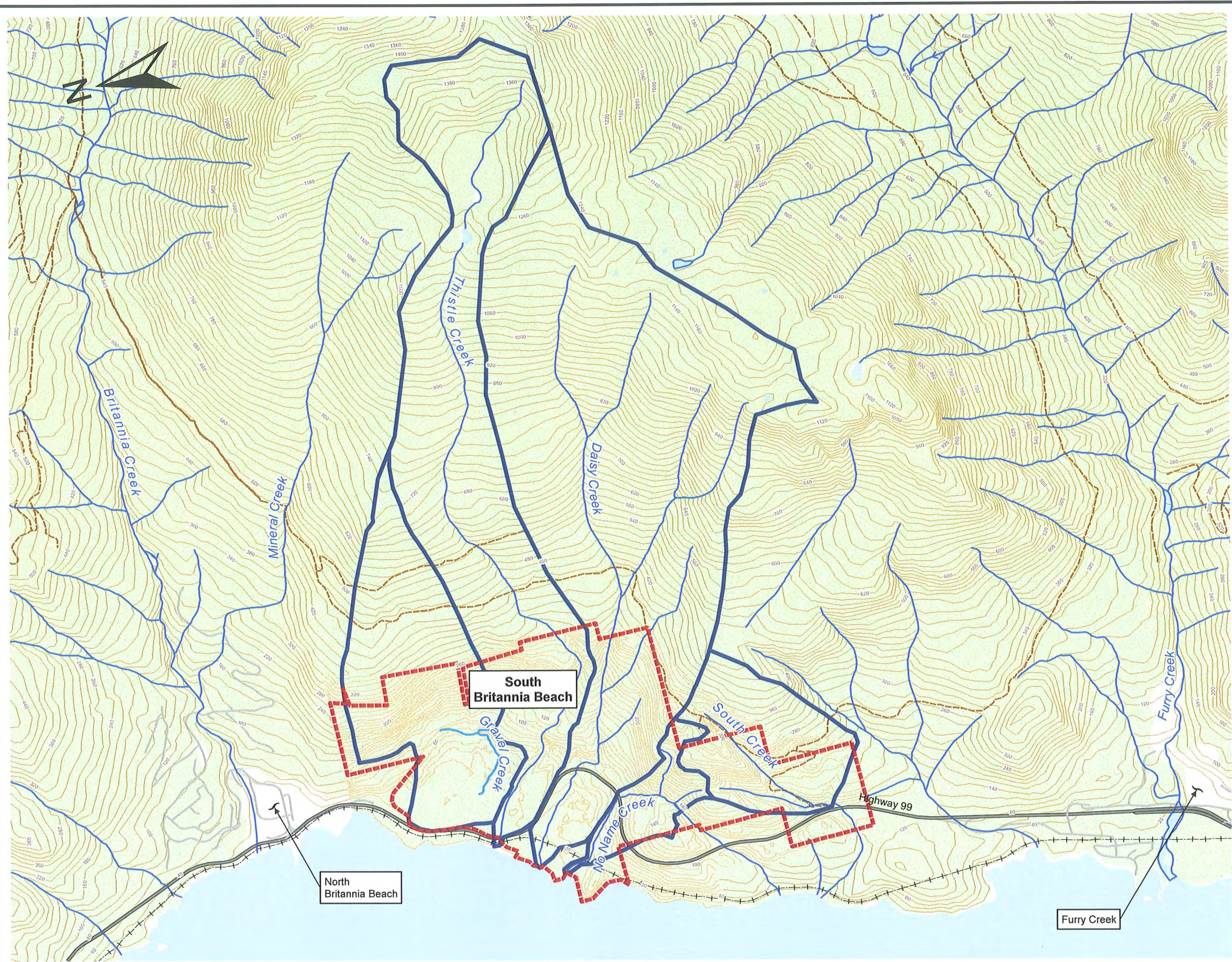
Photo 10: Example of coastal shoreline protection for larger waves using boulders and bioengineering.



Photo 11: Example of coastal shoreline protection using large rock and plantings.



Photo 12: Example of engineered marsh bench.



Taicheng Development Corporation South Britannia Beach Flood Management

Legend

- South Britannia Beach
- Catchment Boundary
- 10 m Contour (TRIM)
- 20 m Contour (TRIM)
- Watercourse
- Ditch
- Railway
- Forestry Road
- Paved Road
- Highway

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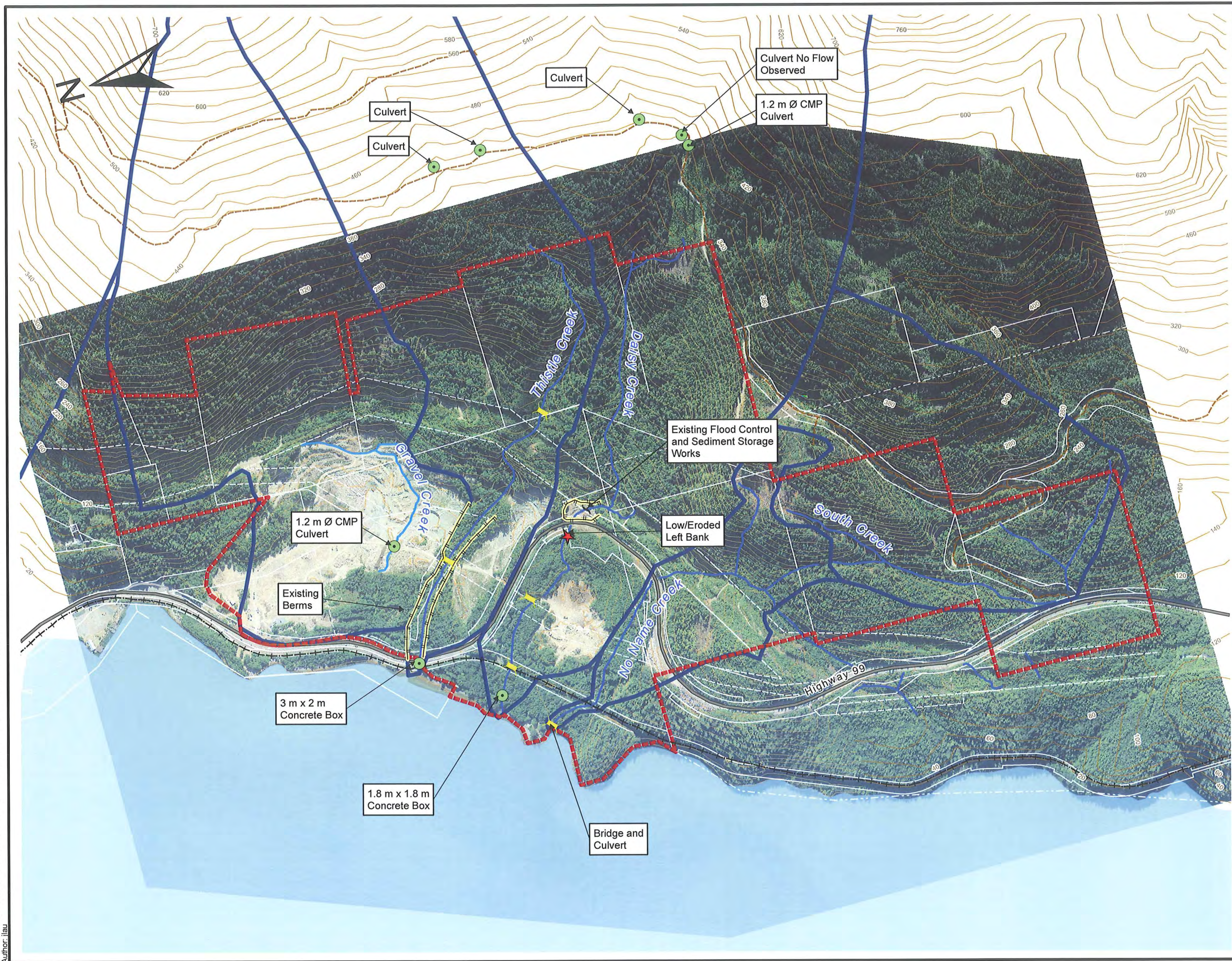
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Catchment Boundaries

Figure 1

Path: Q:\2900-2999\2957-001\430-GIS\MXD-Rp\2957001_FloodManagement_TechMemo_Fig2.mxd Date Saved: 2/28/2012 5:58:33 PM
Author: lau



**Taicheng Development Corporation
South Britannia Beach
Flood Management**

Legend

- South Britannia Beach
- Catchment Boundary
- 10 m Contour (TRIM)
- 20 m Contour (TRIM)
- Watercourse
- Ditch
- Railway
- Forestry Road
- Paved Road
- Highway
- Bridge
- Culvert

Reference: 2006 Orthophoto provided by client.
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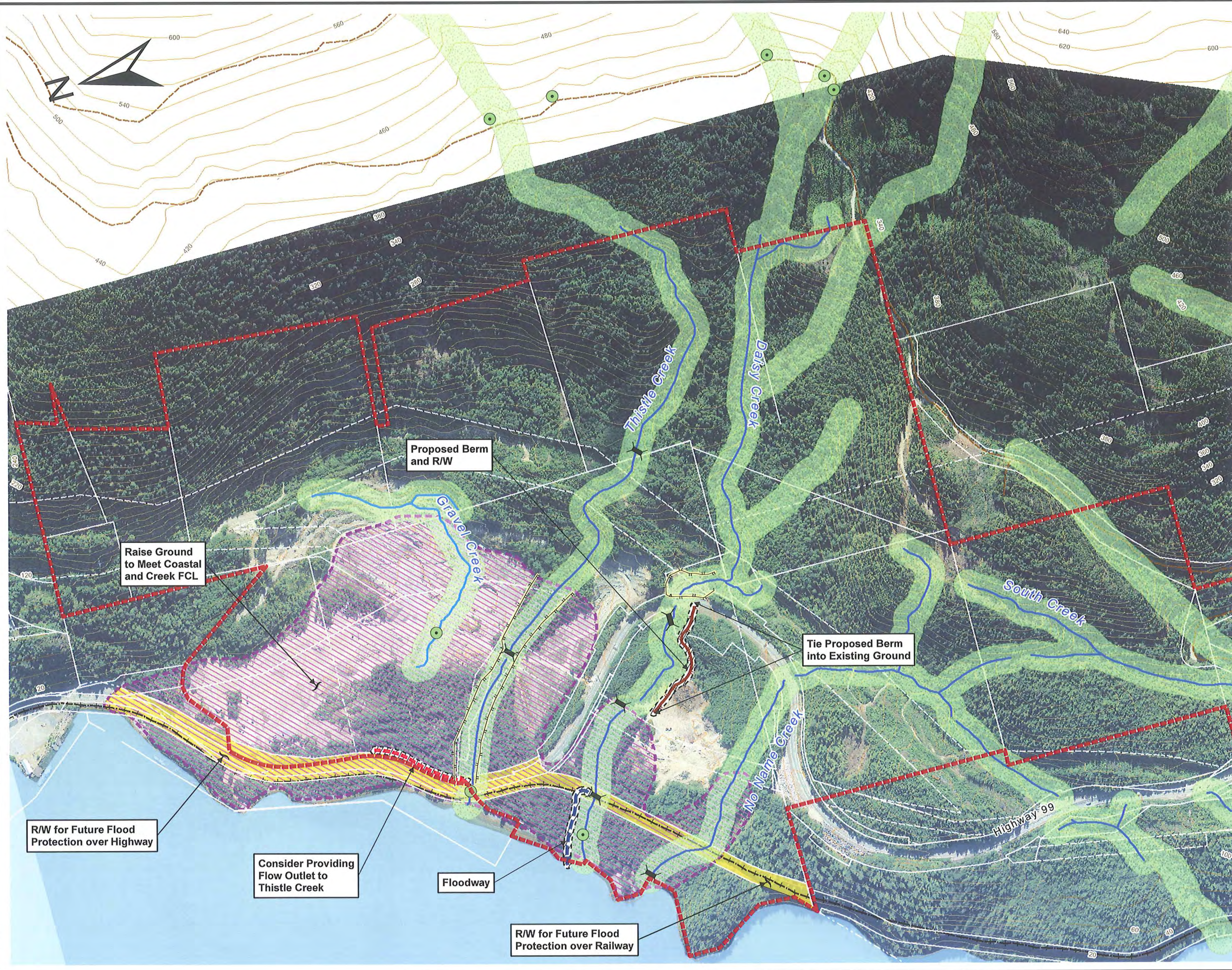
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Project No. 2957-001	Date February 2012
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**Creek Crossings
and Existing Works**

Figure 2

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Author: jlu



**Taicheng Development Corporation
South Britannia Beach
Flood Management**

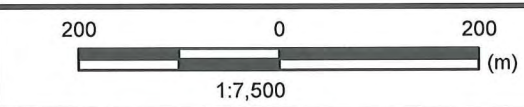
Legend

- South Britannia Beach
- 10 m Contour (TRIM)
- 20 m Contour (TRIM)
- Watercourse
- Ditch
- Railway
- Forestry Road
- Bridge
- Culvert
- Existing Flood Protection Works
- Riparian Buffer (30 m)
- Proposed 15 m Wide ROW
- Proposed Berm
- Proposed Diversion
- Proposed Floodway
- Area to be Raised - Coastal FCL

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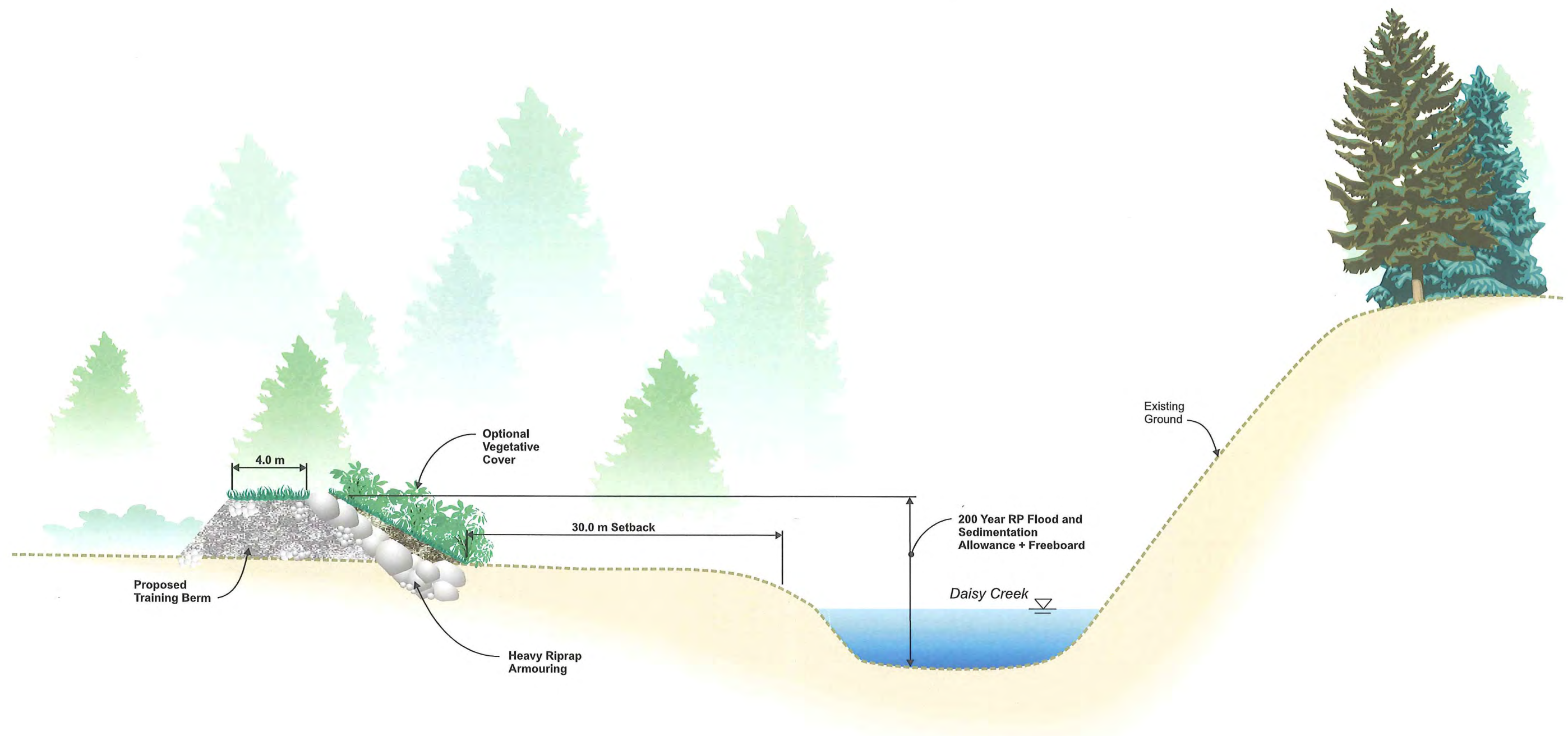
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**Proposed
Flood Protection Works**

Figure 3



Typical Berm Cross-Section, Looking Downstream
N.T.S.

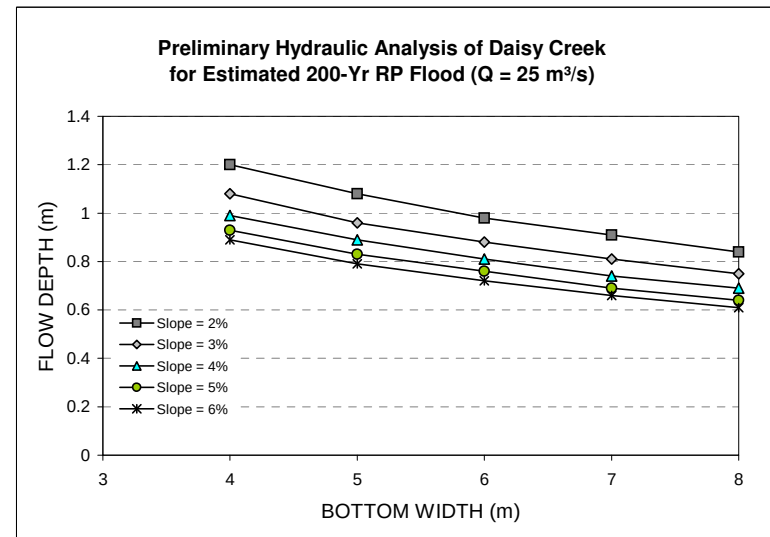
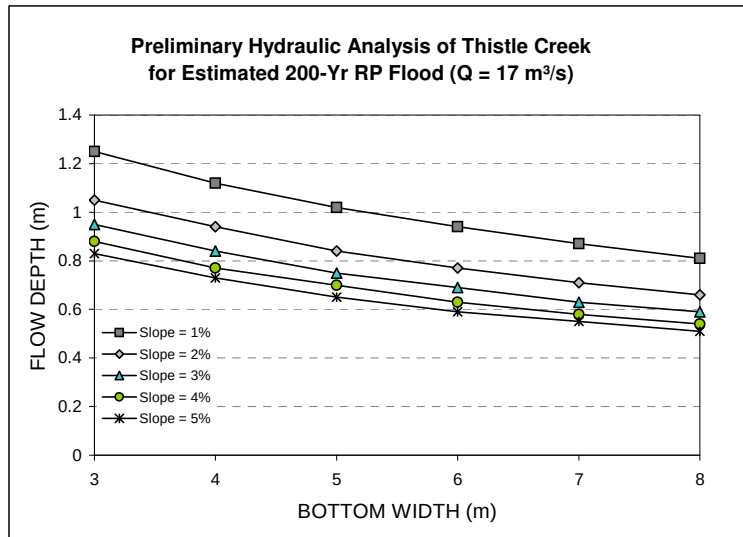
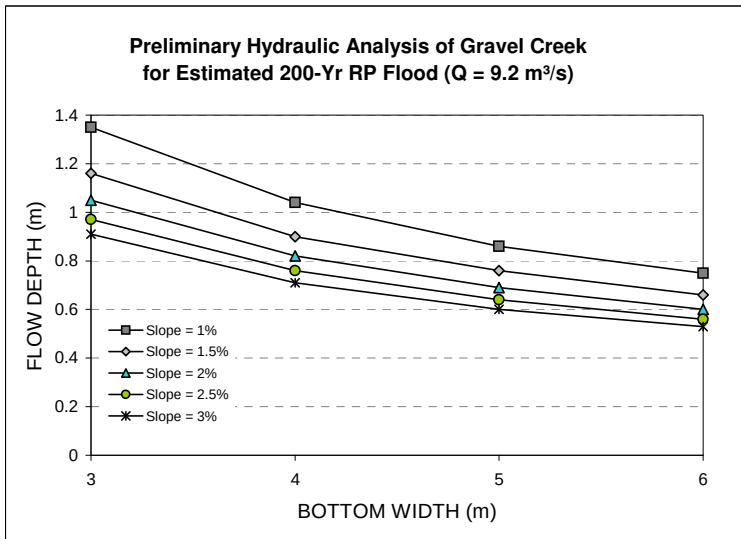


Figure 5