**REPORT**

# Rascal Stream Fishway Hydrotechnical Assessment

Submitted to:

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## APPENDICES

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Rascal Stream Watershed – Supplemental Hydrometric Assessment

**APPENDIX B**
Rascal Stream East and Rascal Stream West – Supplemental Fish Habitat Assessment, Summer 2017

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Rascal Stream East and Rascal Stream West – Supplemental Fish Habitat Assessment, Summer 2019

**APPENDIX D**
Rascal Stream Hydraulic Model Results

# 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by Sabina Gold & Silver Corp. (Sabina) in 2017 to complete a hydrotechnical assessment of the Rascal Stream and Rascal watershed to understand changes in fish habitat due to the proposed diversion of Rascal Stream for the Back River Project (the Project). The study area includes Rascal Stream and its upstream watersheds upstream of Goose Lake (the Site). The hydrologic and hydraulic modeling was completed in January 2018, based on available design options. This assessment presents the results and discussion for selected design options and the synthesis of supplemental field data collected in 2017, 2018, and 2019 (summarized in Appendix A), including validation of the modeling results.

As part of the proposed construction works for the Project, Sabina intends to extend the existing all-weather airstrip servicing the Goose Property. This extension would intersect with Rascal Stream East (RSE) and Main Goose Pit Stream (Goose Stream) that currently flow northeast into Goose Lake, where there is the potential to negatively impact the Arctic Grayling (Thymallus arcticus) population associated with Rascal Stream. Two options are being considered to mitigate effects of the all-weather airstrip extension and Project infrastructure (Sabina 2017), named Scenario 1 and 2 as described below.

The first design scenario models culverts under the airstrip extension to maintain existing channel alignments (i.e., hydrologic connectivity to upper sections of RSE), combined with the installation of fish barriers on Goose Stream Reach 3 and RSE Reach 4 (Sabina 2017). The barriers are intended to prevent fish in Gosling Pond 1 and upper RSE from entering lower sections of RSE, where flows will be modified due to mining infrastructure at headwater locations east of the airstrip. The fish barriers are a potential mitigation feature to prevent fish from using a spawning area where Project-related effects may reduce habitat quality and result in stranding and egg mortality (i.e., create an ecological trap for Arctic Grayling). This design scenario is referred to as Scenario 1 in this report and reflects the existing channel alignments (as shown on Figure 1).

The second design scenario models berms on Goose Stream Reach 3 and RSE Reach 4 (Sabina 2017), southwest of the proposed airstrip extension, to divert all flows from RSE and Gosling Pond 1 through Rascal Stream West (RSW) to Goose Lake (Sabina 2017). The basic premise of this mitigation concept is the use of berms to redirect flows from potentially low-quality habitats to higher-quality habitats where they can be used by spawning Arctic Grayling. The installation of berms would result in the modification or re-alignment of RSE (upper section of Reach 4), creating what was previously termed the ‘Rascal Fishway’. This scenario is referred to as Scenario 2 in this report (as shown on Figure 2). This modification is expected to mitigate effects of altered habitat east of the airstrip due to mining infrastructure, including lower sections of RSE, by improving fish passage conditions from Goose Lake to upper RSE through RSW and by increasing available habitat for spawning and rearing through increased flows.

During the environmental review of the Project by Fisheries and Oceans Canada (DFO 2017), a modification to the second design scenario was also considered to further improve the productivity of the system for Arctic Grayling. This conceptual design was the installation of a berm to divert flows from RSW Reach 7, just downstream of Rascal Lake outlet, to RSE Reach 5. The diversion was intended to divert flows from relatively poor-quality habitat in RSW Reach 7, where flows are dispersed over a boulder garden, to upper RSE (Reach 4 and 5) where flow augmentation has the potential to enhance the spawning capacity of habitat (Sabina 2017). However, based on a qualitative evaluation of data collected in 2017 (Appendix B), long-term benefits of the RSW Reach 7 diversion to the overall productive capacity of the system were uncertain, possibly realized only during below-average flow conditions. Therefore, the present hydrotechnical assessment is focused on Scenario 1 and 2.

## 1.1 Objectives

A re-alignment study for Rascal Stream was completed in 2014 by Rescan Environmental Services Ltd. (Rescan), based on hydrological and hydraulic data provided by SRK Consulting (Canada) Inc. (SRK), to assess potential effects on Arctic Grayling habitat (Rescan 2014a and SRK 2015). The 2014 re-alignment study examined the construction of two berms to divert RSE and Goose Stream discharges to Gosling Pond 1 (Scenario 2).
In addition, a Rascal Stream Fish Passage Mitigation memorandum was produced (Sabina 2017) in response to the environmental review of the Project by DFO.

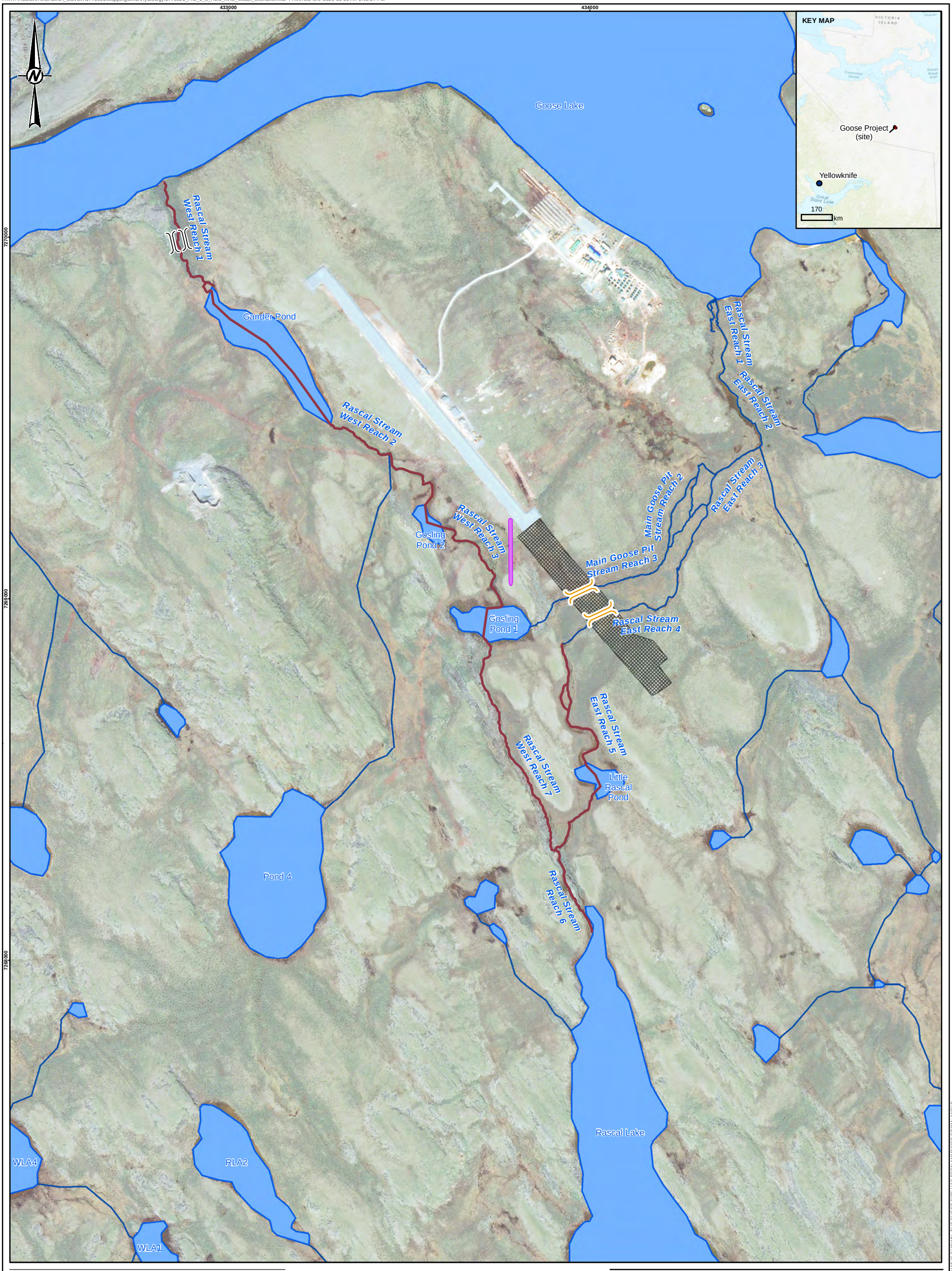
The objectives of Golder's scope of work are to:

- Summarize the baseline data collected from the fish habitat and hydrometric field programs in Summer 2017, 2018 and 2019;
- Update and refine the hydrologic regime considering data available at the time of the 2018 modeling for the Rascal Stream reaches to fill identified data gaps;
- Update the existing hydraulic model (summarized in Rescan 2014a) to refine the potential impact assessment on stream flows (including depths and velocities) in response to the proposed design alternatives for Rascal Stream, including alignment scenarios not previously modeled;
- Complete a high-level validation of the hydrologic and hydraulic model results with 2018 and 2019 hydrometric field data (summarized in Appendix A); and
- Provide a qualitative discussion of the predicted changes in stream flows (depths and velocities) within Arctic Grayling habitat.

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**LEGEND**

- PROPOSED ALL-WEATHER ROAD CULVERT
- PROPOSED AIRSTRIP CROSSING BOX CULVERT
- WATERCOURSE
- PROPOSED AIRSTRIP EXTENSION
- WATERBODY

**PROPOSED BERMS**

- CONTAINMENT BERM

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**REFERENCE(S)**

1. HYDROLOGY LAYERS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED, REVISED BY GOLDER ASSOCIATES LTD.
PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
SABINA GOLD & SILVER CORP.

PROJECT
BACK RIVER PROJECT ENVIRONMENT AND PERMITTING

TITLE
**HEC-RAS MODEL SCENARIO 1**

CONSULTANT
GOLDER

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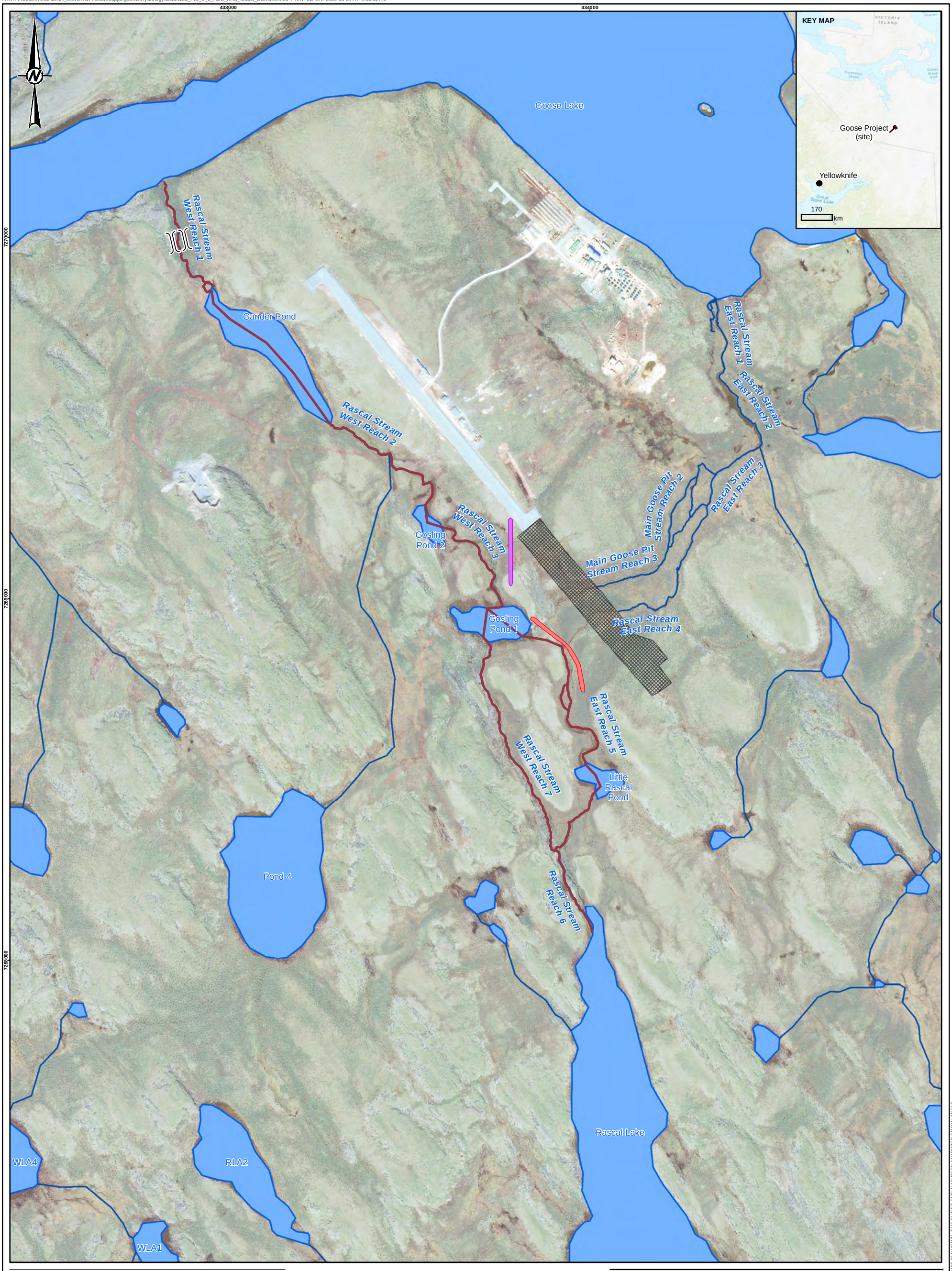
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**LEGEND**

- PROPOSED ALL-WEATHER ROAD CULVERT
- WATERCOURSE
- PROPOSED AIRSTRIP EXTENSION
- WATERBODY

**PROPOSED BERMS**

- CONTAINMENT BERM
- DIVERSION BERM

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**REFERENCE(S)**

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**HEC-RAS MODEL SCENARIO 2**

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# 2.0 METHODS

## 2.1 Field Program

Rascal Stream field programs were completed to supplement field data available in the Final Environmental Impact Statement (FEIS) (Sabina 2015) and the FEIS Addendum (Sabina 2017). A combined field program was completed in August 2017, June 2018, and June 2019 for water quality, fish habitat, and hydrology.

During this field program, hydrometric data to support the hydrological assessment of Rascal Stream was collected. A summary of the hydrology field programs and results is presented in Appendix A. Tasks carried out during the hydrology field program included an aerial reconnaissance, water level and cross-section surveys, and discharge measurements at select lake outlets and along Rascal Stream.

In addition to the hydrometric data collected, a fish and fish habitat assessment was carried out on 6 August 2017 at RSW and RSE and on 20 June 2019 along RSW Reach 1. A 650-m long section of RSW and a 760-m long section of RSE were assessed as part of the 2017 field program and a 405-m long section of RSW Reach 1 was assessed in 2019. A summary of the 2017 habitat assessment and results is included in Appendix B and a summary of the 2018 field program and the 2019 habitat assessment and results are included in Appendix C.

## 2.2 Hydrologic Model Setup and Calibration

The GoldSim modeling platform was used to simulate the long-term hydrological regime at the Wolf Lake, Rascal Lake, and downstream watersheds that discharge to Goose Lake based on a daily input and reporting period. GoldSim is a commercially available, general-purpose model developed by the GoldSim Technology Group. The hydrological model simulation was carried out for the period 1959 to 2014, based on the available climate data available at the time of the 2018 modeling. Sections 2.2.1 to 2.2.5 describe the methods used to derive data inputs and calibrate the hydrological model. A daily model is used to provide a derived set of stream flows useful for derivation of means, extremes, variability, and trends.

### 2.2.1 Climate Data

#### *2.2.1.1 Temperature*

A long-term time series of daily air temperature for the Project extending from 1959 to 2014 was derived using temperature records from three regional climate stations operated by Environment Canada and temperature records from the local Goose Property and George Property meteorological stations. Note that George Property, which is also part of the Back River Project, is an additional advanced exploration camp located approximately 60 km northwest of the Goose Property. Station information is provided in Table 1.

**Table 1: Regional and Local Climate Stations used to Derive Air Temperature Record**

| Station Name | Operated by | Latitude (north) | Longitude (west) | Elevation (masl) | Air Temperature Record Used |
|---|---|---|---|---|---|
| Goose | Sabina Gold & Silver Corp. | 65°33' | 106°26' | 277 | Aug 2004-June 2014 |
| George | Sabina Gold & Silver Corp. | 65°55' | 107°27' | 355 | Aug 2004-June 2014 |
| Contwoyto Lake (ID 2200850) | Environment Canada | 65°29' | 110°22' | 451 | 1959-1981 |
| Lupin (ID 22026HN) | Environment Canada | 65°46' | 111°15' | 490 | 1982-2014 |
| Kugluktuk A (ID 2300902) | Environment Canada | 67°49' | 115°08' | 23 | 1978-2014 |

A = airport; masl = metres above sea level; ID = identification; ° = degree; ' = minute.

The data for the local stations (Goose and George) was provided by Sabina and was summarized in the 2004 to 2014 Meteorology Baseline Report (Sabina 2014). The baseline data report (Sabina 2014) indicated that air temperatures were very similar at the two stations; therefore missing days in the temperature record for Goose were filled with daily air temperatures recorded at the George Station. No correction for station location was applied to the Goose or George daily temperature records.

Data sets for Contwoyto Lake and Lupin were joined to create a combined record spanning 56 years, referred to as the “Lupin Combined” data set. The station at Contwoyto Lake was discontinued in 1981, and the nearby station at Lupin was established in 1982. Golder (2008) concluded that the records could be combined, given the proximity of the two stations (50 km apart). A difference of approximately 1 degree Celsius (°C) in mean annual temperature at Contwoyto Lake (1959 to 2006) and mean annual temperature at Lupin (1982 to 2006) was attributed to the different periods of record.

Daily air temperatures for both the Lupin Combined time series and the Kugluktuk time series correlate well with the local combined Goose and George time series. A linear correlation of the overlapping records (2004 to 2014) yielded a coefficient of determination ($R^2$) of 0.9785 for Lupin Combined and 0.9389 for Kugluktuk, correlated to the local Site daily temperature time series.

Linear regression equations were derived to estimate Site temperatures from Lupin Combined temperatures or Kugluktuk temperatures for the purpose of extending the Site record and filling missing data.

Temperatures at the Goose Lake Property ($T_G$) were estimated from Lupin Combined temperatures ($T_{LC}$) using the following equation:

$$T_G = 1.0119 * T_{LC} + 0.183$$

Temperatures at the Goose Lake Property ($T_G$) were estimated from Kugluktuk temperatures ($T_K$) using the following equation:

$$T_G = 1.0283 * T_K - 0.557$$

To summarize the method, a long-term (1959 to 2014) time series of daily air temperature for the Site was derived from regional and local temperature records by the following:

- estimating temperatures at Site from Lupin Combined temperatures from 1959 to July 2004;
- when available, local daily temperatures from Goose and George station were used for 2004 to 2014;
- estimating missing data in the Site records from Lupin Combined temperatures from August 2004 to 2014; and
- filling missing data in both the Lupin Combined and Site records with Kugluktuk temperatures from 1978 to 2014.

#### *2.2.1.2 Precipitation*

##### 2.2.1.2.1 Mean Annual Precipitation

The Back River Hydrology Report (SRK 2015) estimated a mean annual precipitation of 256 mm/year before correction for undercatch factors using a regional analysis and an undercatch adjusted mean annual precipitation of 412 mm/year. It is widely known that undercatch can be an important factor affecting precipitation measurements in the Canadian North, leading to underestimates of actual precipitation due to wind-induced undercatch, wetting losses, and evaporative losses. Undercatch factors vary by the state of precipitation (snow, rain, mixed) (SRK 2015), by meteorological station location (e.g., exposure) and instrumentation. The variability in undercatch factors can be seen in Figure 2.3 of the Back River Hydrology Report (SRK 2015).

Due to the significant variability in station-specific undercatch factors, Golder recommends that the regional analysis should not be completed on uncorrected mean annual precipitation, but rather for undercatch corrected mean annual precipitation, which reflects the actual expected precipitation. In addition, Golder recommends that the linear regression relationship for regional climate stations use the latitude of the station, rather than the station elevation as used in SRK 2015. Regional trends in mean annual precipitation are influenced primarily by latitude (Lemmen et al. 2008), rather than station elevation, as orographic lift is not the main driver for precipitation trends in the region due to the region's low topographic relief.

Environment Canada prepared an Adjusted Precipitation Dataset, corrected for precipitation undercatch, for climate change analysis (Environment Canada 2013), and corrected precipitation data for Lupin Combined, Yellowknife, Baker Lake, and Cambridge Bay Stations are included in this dataset. See Table 2 in Section 2.2.1.2.2 for station information.

Figure 3 shows the regional trend for undercatch-corrected long-term data records, considering station latitude. The linear regression is completed for three regional stations (Yellowknife, Baker Lake and Lupin Combined); however, it does not consider Cambridge Bay due to its significantly lower mean annual precipitation, and estimates a corrected mean annual precipitation of 327 mm at the Site. In addition to the undercatch adjusted long-term data records for Environment Canada Stations, mean annual precipitation values (adjusted for undercatch) previously estimated for regional mining projects are also included. As shown on Figure 3, the Site adjusted mean annual precipitation of 327 mm estimated as part of this study fits well within the regional data.

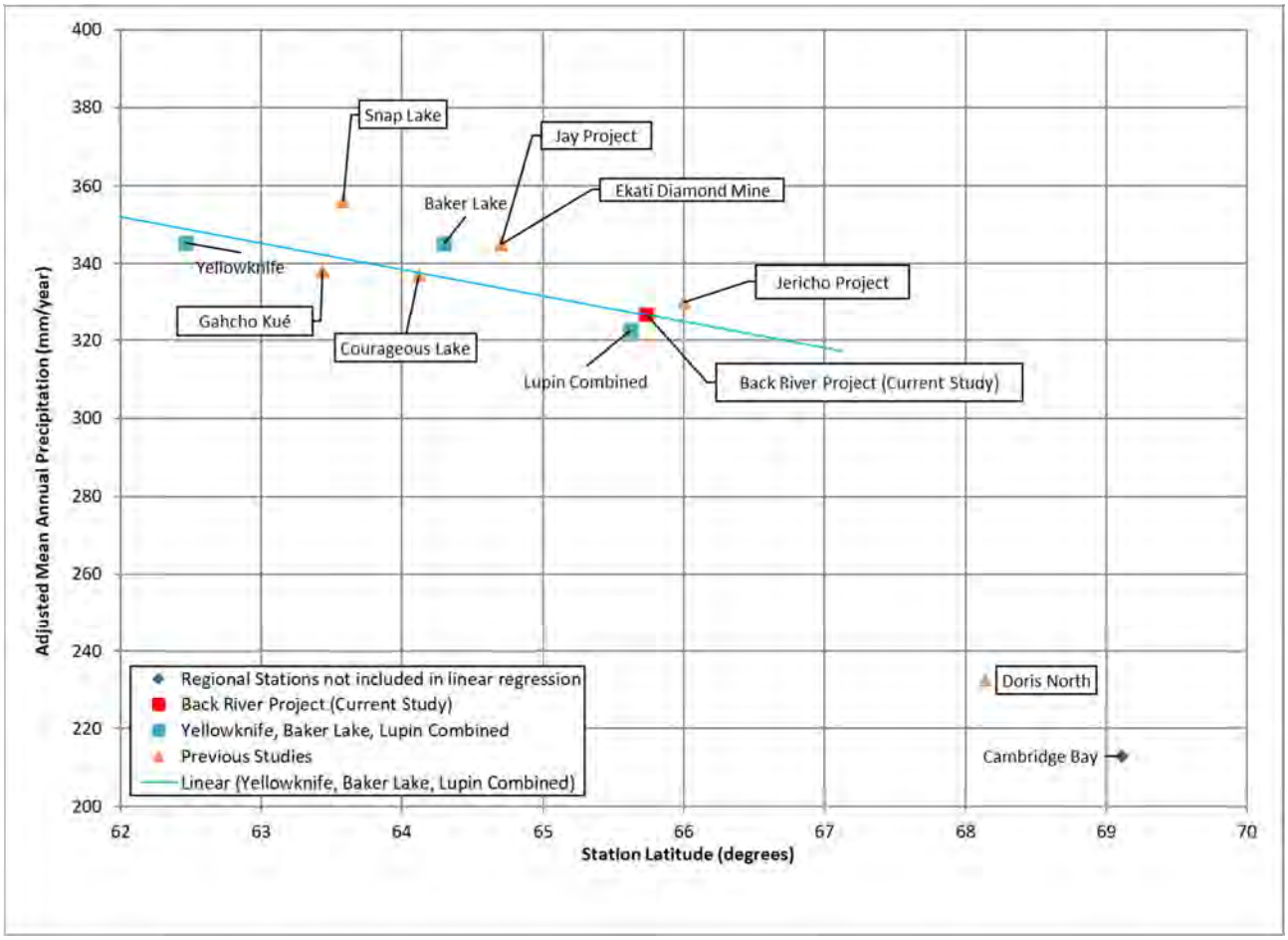



**Figure 3: Regional Undercatch Corrected Mean Annual Precipitation**

Note: Mining project undercatch-adjusted mean annual precipitation sources include:

Snap Lake Diamond Project Baseline (Golder 2002)
Ekati Diamond Mine Environmental Agreement and Water Licence Annual Report (ERM 2016)
Jericho Project Supplemental Climate and Hydrology (SRK 2003)
Jay Project Baseline (Golder 2014)
Gahcho Kué Climate and Hydrology Baseline (Golder 2010)
Doris North Hydrology Baseline Update (Golder 2009)
Courageous Lake Prefeasibility Study (Tetra Tech 2012)

#### 2.2.1.2.2 Daily Precipitation

A long-term time series of daily precipitation (rainfall and snowfall) for the Project extending from 1959 to 2014 was derived using temperature records from five regional climate stations operated by Environment Canada and temperature records from the local Goose and George meteorological stations. Station information is provided in Table 2.

**Table 2: Regional and Local Climate Stations used to Derive Precipitation Record**

| Station Name | Operated by | Latitude (north) | Longitude (west) | Elevation (masl) | Air Temperature Record Used |
|---|---|---|---|---|---|
| Goose | Sabina Gold & Silver Corp. | 65°33' | 106°26' | 277 | Aug 2004-June 2014[(a)] |
| George | Sabina Gold & Silver Corp. | 65°55' | 107°27' | 355 | Aug 2004-June 2014[(a)] |
| Contwoyto Lake (ID 2200850) | Environment Canada | 65°29' | 110°22' | 451 | 1959-1981 |
| Lupin (ID 22026HN) | Environment Canada | 65°46' | 111°15' | 490 | 1982-2014 |
| Ekati A (ID 220N001) | Environment Canada | 64°42' | 110°37' | 468 | 1997-2014 |
| Coppermine (ID 2300900) | Environment Canada | 67°50' | 115°07' | 9 | 1959-1977 |
| Kugluktuk A (ID 2300902) | Environment Canada | 67°49' | 115°08' | 23 | 1977-2014 |

a) Snowfall only measured at Goose or George stations from March 2012 to June 2014 (Sabina 2014).
A = airport; masl = metres above sea level; ID = identification; ° = degree; ' = minute.

The data for the local stations (Goose and George) was provided by Sabina and was summarized in the 2004 to 2014 Meteorology Baseline Report (Sabina 2014). Rainfall and snowfall data collected at the Goose and George stations were considered representative for the Rascal Stream watershed and were not adjusted for location.

Precipitation datasets for Contwoyto Lake and Lupin were joined to create a combined record (i.e., Lupin Combined), as these stations are located within 50 km of each other. Golder (2008) attributed differences in mean annual precipitation at Contwoyto Lake (1959 to 1981) and Lupin (1982 to 2006) to the natural wet and dry cycles in precipitation over time, rather than to differences in location. The monthly magnitudes and distributions of precipitation were also similar. Datasets for Coppermine and Kugluktuk A stations were joined to create a combined record (i.e., Kugluktuk Combined), consistent with previous studies (SRK 2015).

Undercatch correction factors applied to the daily data series (where not corrected for undercatch by Environment Canada), used regional average undercatch factors provided in previous studies (SRK 2015). All long-term undercatch corrected station data was then adjusted for location based on a factor to equate the long-term mean annual cumulative precipitation to 327 mm to agree with the Site derived mean annual precipitation.

To summarize the method, a long-term (1959 to 2014) time series of daily precipitation (corrected for undercatch) for the Site was derived from regional and local temperature records by the following:

- estimating precipitation at Site from Lupin Combined adjusted precipitation from 1959 to July 2004, and until 2012 for snowfall records;
- when available, local daily precipitation from Goose and George station were used for 2004 to 2014;
- estimating missing data in the Site records from Lupin Combined adjusted precipitation from August 2004 to 2014; and
- filling missing data in both the Lupin Combined and Site records with Kugluktuk Combined adjusted precipitation from 1978 to 2014.

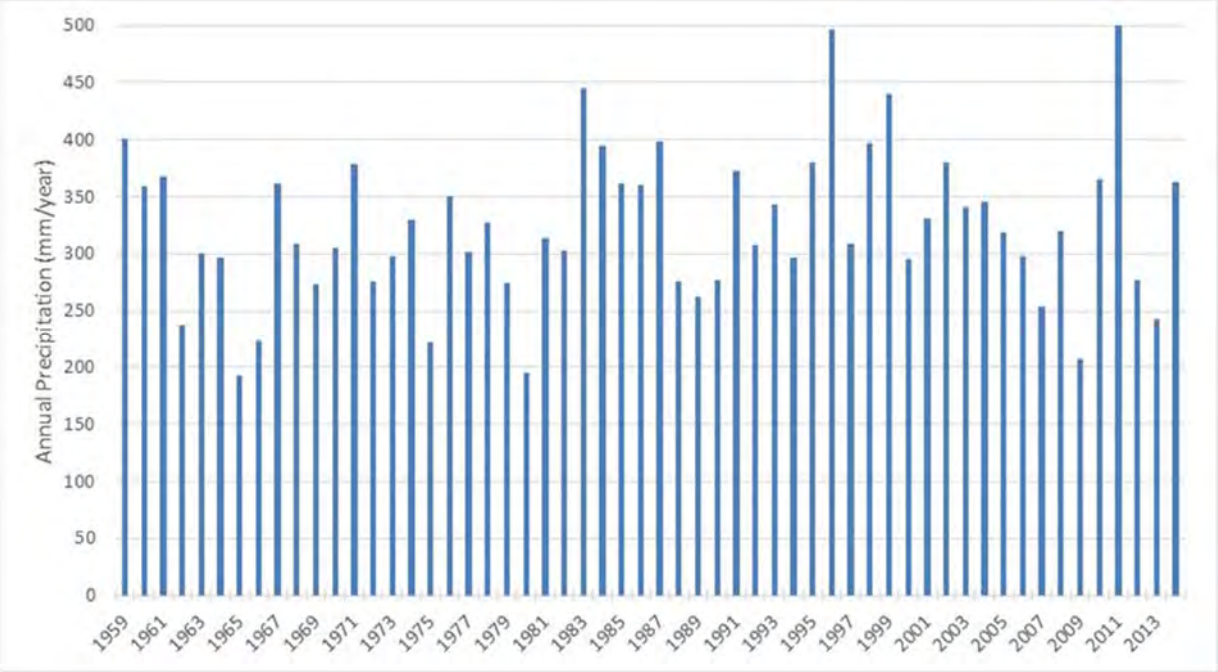



**Figure 4: Annual Precipitation (1959 to 2014)**

a) Uncertainty in 2011 annual precipitation of 538 mm due to the combination of records at local Site and regional stations.

### *2.2.1.3 Evaporation*

The long-term mean annual lake evaporation at the Site was previously estimated as 324 mm/year and the mean monthly distribution of evaporation from seven regional stations was applied to the estimated site annual evaporation to provide monthly evaporation values for modeling purposes (SRK 2015). The long-term mean annual evaporation and monthly distribution of evaporation previously reported were used, along with available evaporation records, to derive a long-term time series (1959 to 2014) of daily evaporation for the Site.
Available records included three regional climate stations; one operated by AANDC, one by Environment Canada, and the other by Dominion Diamond to support the existing Ekati mine. Local station data from the Goose Lake micro-meteorological station was directly used for 2012 and 2013. Station information is provided in Table 3.

**Table 3: Regional and Local Climate Stations used to Derive Lake Evaporation Record**

| Station Name | Operated by | Latitude (north) | Longitude (west) | Elevation (masl) | Evaporation Record Used |
|---|---|---|---|---|---|
| Goose Lake Micro-meteorological Station | Sabina Gold & Silver Corp. | 65°32' | 106°26' | 270 | June to September monthly data 2012-2013 |
| Polar Lake (Ekati) | Dominion Diamond Ekati Corporation | 64°48' | 110°56' | ~479 | monthly data 1998-2011; 2014 |
| Salmita | AANDC | 64°03' | 111°10' | - | monthly/annual data 1994-2010 |
| Norman Wells A (ID 2202800 & 2202801) | Environment Canada | 65°17' | 126°48' | 72.5 | annual data 1964-2003 |

A = airport; masl = metres above sea level; AANDC = Aboriginal Affairs and Northern Development Canada; ID = identification; ~ = approximately; - = not available; ° = degree; ' = minute.

Estimated monthly evaporation rates at the Polar Lake Station for the period 1998 to 2011 and 2014, published in Ekati Mine AEMP reports, were available. Monthly data for the Polar Lake Station was estimated from recorded climatic data using the Penman Equation and from pan evaporation measurements.

Annual evaporation rates at Salmita from 1994 to 2010 were provided by Environment Canada in December 2013, and are based on AANDC Water Resources Evaporation Studies from 1992 to 2013. Annual evaporation rates were estimated from climatic data using the Penman Equation. Salmita is the regional station closest to the Project used as part of this study.

Monthly and annual evaporation rates at Norman Wells Airport (Norman Wells A) from 1964 to 2003 were also sourced from Environment Canada. Data was calculated from pan evaporation measurements. Golder (2008) noted a strong correlation between lake evaporation rates at Salmita and pan evaporation rates at Norman Wells A during the open-water season for the overlapping period of record (1994 to 2003). A correction factor of 0.75 is often applied to convert pan evaporation values to lake evaporation to account for greater pan evaporation, due to low pan volumes and higher thermal conductance of the pan sides (Chow et al. 1988). Correlations of concurrent observations showed lake evaporation at Salmita to be less than pan evaporation at Norman Wells A by a relatively consistent percentage of 20%, which is consistent with the expected value of 25%.

The long-term records for each regional station used in the analysis were corrected for location so that the long-term mean annual evaporation of the derived data set was equal to 324 mm/year, consistent with the previous study (SRK 2015). Available data was used in the following order to infill the time series: local data from the Goose Lake Micro-meteorological Station, Polar Lake (Ekati) data, then Salmita data, and lastly the monthly evaporation at Norman Wells A. It should be noted that no evaporation data was available during 1959 to 1963, therefore the long-term monthly distribution was used. Daily evaporation from 1959 to 2014 was derived by distributing monthly totals equally over the number of days in each month. The derived annual time series for lake evaporation at the Site is presented below in Figure 5.

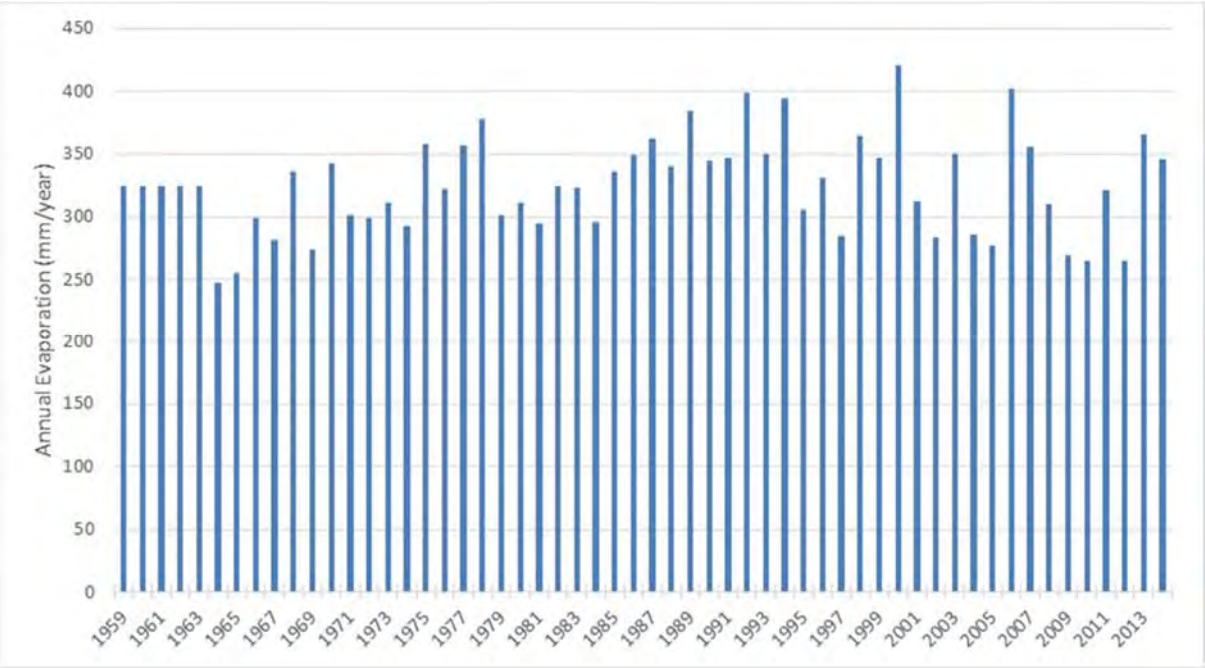



**Figure 5: Derived Annual Lake Evaporation at the Site (1959 to 2014)**

### 2.2.2 Watershed Characteristics

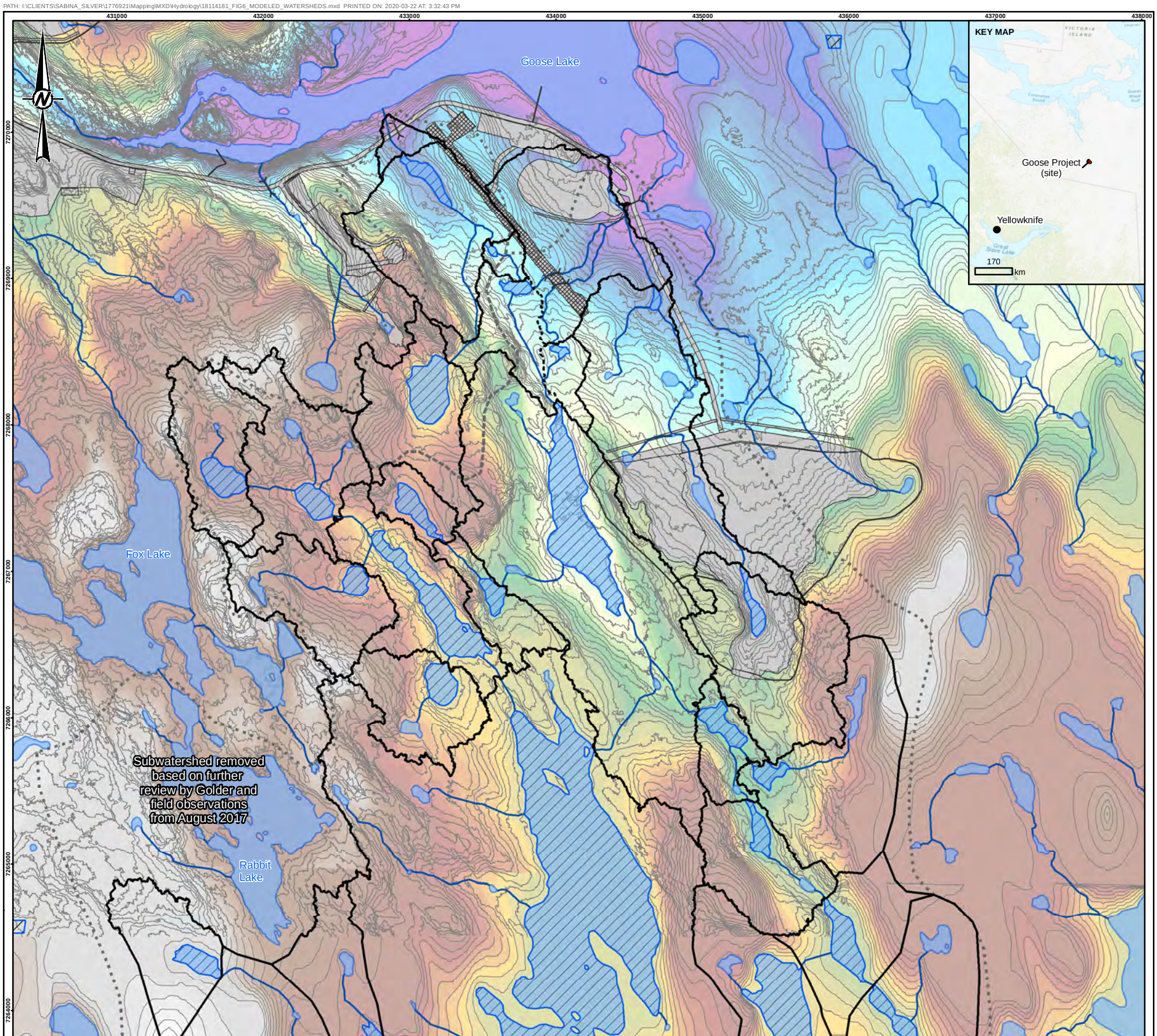
Watershed delineation was based on available LiDAR Digital Elevation Models (DEM) data obtained from Sabina, and for areas where LiDAR DEM was not available, from DEM data obtained from GeoGratis (Natural Resources Canada 2017). The modeled watersheds are presented in Figure 6. A total of 33 watersheds were modeled, and local watershed, lake, tributary, and land areas are presented in for each modeled watershed.

**Table 4: Local Watershed, Lake, Tributary, and Land Areas of Modeled Watersheds (ha)**

| Name[a] | Local Watershed | Lake | Tributary | Land | Name[a] | Local Watershed | Lake | Tributary | Land |
|---|---|---|---|---|---|---|---|---|---|
| Gander | 84.7 | 3.5 | 0.0 | 81.2 | RLB7 | 162.7 | 6.2 | 4.8 | 151.7 |
| East Goose | 88.6 | 0.0 | 0.2 | 88.4 | WLA1 | 68.8 | 15.2 | 0.0 | 53.6 |
| EG3 | 96.8 | 2.7 | 0.0 | 94.1 | WLA2 | 50.2 | 4.7 | 1.2 | 44.3 |
| EG2 | 139.4 | 0.0 | 4.3 | 135.1 | WLA3 | 62.2 | 2.8 | 1.1 | 58.3 |
| West Goose | 7.9 | 0.0 | 0.0 | 7.9 | WLA4 | 76.4 | 4.2 | 1.2 | 71.0 |
| Gosling_1 | 35.0 | 1.5 | 0.0 | 33.5 | WLA5 | 54.5 | 5.4 | 0.1 | 48.9 |
| Gosling_2 | 6.6 | 0.5 | 0.0 | 6.2 | WLB1 | 127.3 | 5.9 | 0.3 | 121.2 |
| Little_Rascal | 13.1 | 0.7 | 0.0 | 12.4 | WLB2 | 38.3 | 9.1 | 0.0 | 29.2 |
| Pond_4 | 66.1 | 9.8 | 0.0 | 56.3 | WLC1 | 164.1 | 33.7 | 0.0 | 130.4 |
| Rascal | 265.9 | 28.2 | 1.5 | 236.2 | WLC2 | 162.1 | 48.0 | 0.5 | 113.5 |
| RLA1 | 29.1 | 2.7 | 0.0 | 26.4 | WLC4 | 122.2 | 21.6 | 2.7 | 97.9 |
| RLA2 | 20.2 | 4.4 | 0.0 | 15.7 | WLD1 | 100.4 | 11.8 | 1.0 | 87.6 |
| RLB1 | 24.6 | 4.6 | 0.3 | 19.7 | WLD2 | 62.7 | 4.9 | 0.0 | 57.8 |
| RLB3 | 98.7 | 2.5 | 2.4 | 93.8 | WLD_Lake | 74.2 | 5.5 | 0.2 | 68.5 |
| RLB4 | 53.4 | 3.2 | 0.6 | 49.6 | WLD3 | 50.6 | 4.0 | 0.0 | 46.6 |
| RLB5 | 57.6 | 7.0 | 0.0 | 50.6 | Wolf | 855.5 | 224.0 | 4.0 | 627.6 |
| RLB6 | 176.1 | 19.6 | 7.4 | 149.2 | | | | | |

[a] Lakes and their corresponding watersheds were assigned arbitrary names if they were not already named. Naming convention indicates which branch of contributing lakes and which lake they are contributing to – names starting with RL contribute to Rascal Lake and names starting with WL contribute to Wolf Lake.

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**LEGEND**

- CONTOUR (1 m INTERVAL)
- WATERCOURSE
- WATERSHED BOUNDARY
- WATERSHED BOUNDARY WITH SPLIT FLOW
- AIRSTRIP AND PROPOSED EXTENSION
- SABINA GOOSE LAKE PROJECT INFRASTRUCTURE
- SRK WATERSHED BOUNDARY (2015)
- SUBWATERSHED TERMINAL WATERBODY
- WATERBODY

0 750 1,500

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**NOTE(S)**

SUBWATERSHED TERMINAL WATERBODIES ARE INCLUDED AS STORAGE ELEMENTS IN THE GOLDSIM WATERSHED MODEL.

**REFERENCE(S)**

1. WATERSHED BOUNDARIES BASED ON ANALYSIS OF RECENT LIDAR DIGITAL ELEVATION MODELS (DEM) DATA PROVIDED BY CLIENT AND CANADIAN DEM DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. REVISED FROM SRK (2015).
2. HYDROLOGY LAYERS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED, REVISED BY GOLDER ASSOCIATES LTD. BASED ON REVIEW OF DEM AND FIELD OBSERVATIONS FROM AUGUST 2017.

PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
SABINA GOLD & SILVER CORP.

PROJECT
BACK RIVER PROJECT ENVIRONMENT AND PERMITTING

TITLE
**MODELED WATERSHEDS**

CONSULTANT
GOLDER

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| DESIGNED | NG |
| PREPARED | CC/MP |
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### 2.2.3 Runoff

#### *2.2.3.1 Snowmelt*

Snowmelt is generated predominantly by melting of the accumulated snowpack during the period of spring freshet. In the model, snowfall from the derived climate data accumulates as snowpack during fall and winter when temperatures are below freezing. A 25% reduction was applied to the modeled snowpack to represent sublimation losses. This 25% reduction was based on review of available reported sublimation estimates from similar geographic settings.

Snowmelt was modeled as beginning when the daily mean temperature rises above a base temperature, and the snowmelt depth is based on a melt factor to provide a ratio of snowmelt depth to the degrees above the base temperature. The snowmelt rate is determined by Equation 1.

**Equation 1:Snowmelt Equation**

$$\text{Daily Snowmelt Runoff} = R_{cs} \times M_f \times (T - T_b)$$

Where:

$R_{cs}$= Snowmelt runoff coefficient (dimensionless);

$M_f$ = Melt factor (mm/°C);

T = Mean daily air temperature (°C); and

$T_b$ = Base temperature (°C).

A base temperature of -1°C and a melt factor of 2.3 mm/°C was applied, based on experience with similar projects.

#### *2.2.3.2 Runoff Coefficients*

The ground surface in the area is predominantly composed of bedrock, cobbles and boulders, with a mixture of tundra vegetation that generally consists of mosses and willows. The terrain is uneven and there is high potential for depressions and pools that reduce discharge of runoff to nearby major waterbodies. During snow covered and frozen ground conditions, limited infiltration potential and surface storage are available, and therefore a majority of precipitation and snowmelt contributes to surface runoff in these ground conditions. Based on a review of available reported runoff coefficients for tundra environments, the following runoff coefficients were applied:

- Runoff Coefficient for Water Area – 1.0
- Runoff Coefficient for Land Area (Bare Ground) – 0.5
- Runoff Coefficient for Land Area (Snow Covered/Frozen) – 0.85
- These runoff coefficients account for infiltration and evapotranspiration losses

### 2.2.3.3 Lake Outlets

#### 2.2.3.3.1 Lake Outlet Freezing and Opening

The formation of ice in winter constricts outflow channels and reduces lake discharge rates. The outlets for the lakes modeled as watersheds are expected to be constricted with ice and freeze completely from approximately November to May each year.

A numerical relationship between lake outlet discharge and cumulative degree days was estimated to account for ice formation in the freezing period in the model. The degree-day method was used to simulate the effect of ice conditions on discharge at each lake outlet. Degree-days are added above or below a base temperature of 0°C based on daily derived mean temperatures, which typically begin to exceed 0°C at the end of May.

The degree-day method determined the timing of outlet freeze-up in the fall and outlet break-up in the spring (Table 5). The modeling parameters initially estimated based on experience at other northern mining sites, and then adjusted to calibrate to the available hydrometric monitoring data for the Project. The 2013 Hydrology Baseline Report by Rescan (Rescan 2014c) mentions the onset of spring freshet on May 23 and that streams were assumed to be frozen on October 20 at the Project. Therefore, lake outlet openings are assumed to be, on average, near the end of May and lake outlet closings are assumed to be at the middle to end of October, which is reflected in the degree-day values presented below.

**Table 5: Model Parameters for Break-Up and Freeze-Up Degree Day Method**

| Model Element | Degree Days |
|---|---|
| Outlet Break-Up – Start of partial opening | 7.5 |
| Outlet Break-Up – Fully open | 30 |
| Outlet Freeze-Up – Start of partial closing | -1 |
| Outlet Freeze-Up – Fully closed | -125 |

#### 2.2.3.3.2 Lake Outlet Open-Water Rating Curve

Lake outlet stage-discharge rating curves of each modeled lake were derived based on cross-sectional survey data collected during the field visit and visual observations of high water level marks for selected lakes in the Wolf Lake and Rascal Lake watersheds. Individual hydraulic models were created for each of the surveyed lake outlets in one-dimensional (1-D) HEC-RAS modeling software based on the collected cross-sectional survey data. A range of discharge values, from 0.1 to 5.0 $m^3/s$, were simulated in the lake outlet models to produce an estimated relationship between the lake water levels and lake outlet discharge, thereby creating a lake outlet open-water rating curve for each of the surveyed lake outlets.

For those lakes where cross-sectional data was not available, lake outlet stage-discharge rating curves were estimated using lake outlet stage-discharge rating curves for lakes with similar drainage area and lake to land ratio.

### 2.2.4 Rascal Stream Split

Approximately 200 m downstream of the Rascal Lake outlet, Rascal Stream splits into multiple channels, with RSW Reach 7 flowing west towards Gosling Pond 1, and RSE Reach 5 flowing east towards Little Rascal Lake. At Gosling Pond 1, there are two observed outlets and corresponding channels, where Goose Stream Reach 3 flows east out of Gosling Pond 1 and intersects with RSE Reach 4, and RSW Reach 3 flows north to Gosling Pond 2. Goose Stream Reach 3 and RSW Reach 3 are shown in Figure 1.

Discharge from Rascal Lake enters Goose Lake via two different flow paths, as shown in Figure 1, through RSW Reach 1 via Gosling Ponds 1 and 2 and Gander Pond, and through RSE Reach 1, which has combined flows from Goose Stream and upstream reaches of RSE. Discharge monitoring data for hydrometric station GL-H3, corresponding to RSW Reach 1 near the mouth, and station WL-H1, corresponding to RSE Reach 1 near the mouth was available from 2011 to 2013 (Rescan 2012a, 2012b, 2014c). Additionally, Rescan (2014a) previously estimated that approximately 70% of the water in Rascal Lake discharges to Goose Lake via RSE, while the remaining 30% discharges to Goose Lake via RSW during spring freshet. Based on field observations from August 2017, monitoring data for hydrometric stations GL-H3 and WL-H1 from 2011 to 2013 (Rescan 2012a, 2012b, and 2014c), and previous observations from Rescan, proportions between the two different flow paths were estimated as presented in Table 6. The flow split proportions shown in Table 6 do not include 2018 and 2019 field discharge measurements and are based on the above information available at the time of the 2018 modeling.

**Table 6: Estimated Rascal Stream Split Proportions (%) for 2018 Modeling**

| Month | Split from RS Reach 6 | | Split from Gosling Pond 1 | | Overall Approximate Resulting Flow Split | |
|---|---|---|---|---|---|---|
| | RSE Reach 5 | RSW Reach 7 | RSW Reach 3 | Goose Stream Reach 3 | RSW Reach 1 | RSE Reach 3[(a)] |
| May | 30 | 70 | 60 | 40 | 35 | 65 |
| June | 55 | 45 | 60 | 40 | 30 | 70 |
| July | 95 | 5 | 70 | 30 | 5 | 95 |
| August | 100 | 0 | 70 | 30 | 5 | 95 |
| September | 60 | 40 | 70 | 30 | 25 | 75 |
| October | 90 | 10 | 70 | 30 | 10 | 90 |

(a) downstream of confluence of Goose Stream Reach 3 and RSE Reach 4

### 2.2.5 Calibration

Site-specific continuous climate and discharge data are available for the Project in 2011, 2012, and 2013; therefore, calibration of the hydrological model was based on that period. Hydrometric monitoring data was available from the 2011, 2012 and 2013 baseline reports for the Project, prepared by Rescan (Rescan 2012a, 2012b, and 2014c). Daily recorded discharges and hydrographs at two hydrometric monitoring stations near Goose Lake, GL-H3 and WL-H1, were used for the model calibration.

To calibrate the hydrological model, model results were compared to key characteristics of the recorded hydrographs at the two monitoring stations and the general hydrological regimes for similar geographical areas. Model inputs, such as melt factor, runoff coefficients, sublimation, and break-up and freeze-up degree days, were calibrated to the monitored data and available hydrological data for similar northern areas. Key characteristics that were used to calibrate the model include:

- Outlet opening and closing timing;
- Timing and magnitude of peak freshet discharges;
- Response to summer/fall precipitation events; and
- Annual water yield.

### 2.2.6 Validation using 2018 and 2019 Field Data

#### *2.2.6.1 Hydrological Flow Splits*

Validation of Rascal Stream flow split proportions, which are used as inputs in the hydrological model is based on measured flows collected during field programs. The flow split proportion at each downstream reach was determined as a percentage of total discharge upstream during the 2018 and 2019 field programs. The total discharge upstream was calculated by the sum of the discharge measurements in each of the downstream split reaches.

#### *2.2.6.2 Hydrological Estimates of 2-Year Discharges*

Validation of the approximate 2-year discharge (bankfull flow) output from the hydrological model at various locations using the 2019 measured discharges was completed, which, based on visual observation, appear to be representative of bankfull condition. A comparison of the modeled and measured discharges was made at locations where both modeled and measured discharges were available. Discharge measurements were taken at seven locations within the Rascal Stream watershed from 19-20 June 2019. This included six locations within the Rascal Stream network (Rascal Stream Reach 6, Rascal Stream East Reach 5, Rascal Stream West Reach 7, Rascal Stream East Reach 4, Main Goose Pit Stream Reach 3, Rascal Stream West Reach 3), and one near the Gander Pond Outflow (RSW1) (Appendix A, Figure A-1).

#### *2.2.6.3 Hydraulic Estimates of 2-Year Discharge Flow Conditions*

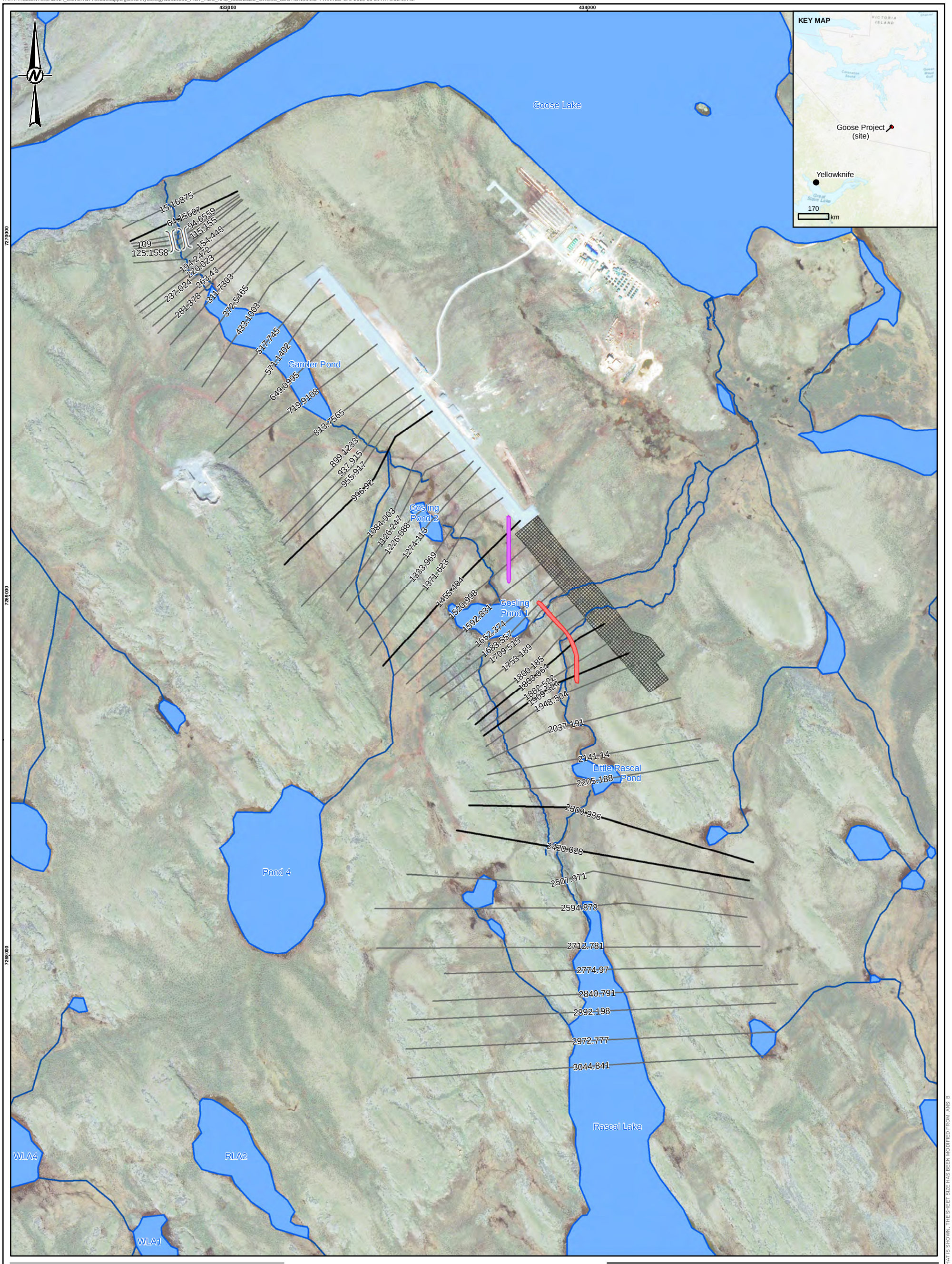
Validation of the hydraulic model velocity and wetted width outputs using measured average velocities and wetted widths during the 2019 field program was completed, with the assumption that bankfull (2-year discharge) conditions were present during the 2019 field program. During the 2019 field program, all of the watercourses were subject to relatively high flows at the time of assessment, and therefore, discharge locations were selected in the most suitable areas where flows were mainly channelized, instream obstacles such as debris and boulders were limited, and the channel reach was mainly straight. However, flooded shallow water was present throughout most of the study area, adding uncertainty to measurements of velocities at some discharge locations.

## 2.3 Hydraulic Model Review and Setup

### 2.3.1 HEC-RAS Model Review

The existing one-dimensional (1-D) HEC-RAS hydraulic model developed by SRK in 2014 for the Rascal Stream re-alignment study was obtained from Sabina for review and revision by Golder. The model is set up to represent proposed modifications to the Rascal Stream west of the airstrip (Scenario 2 as described in Section 2.3.2).
A review of the existing previous HEC-RAS model was carried out to understand the model, including set-up, geometry, and reaches, before making modifications. Following the review, the following observations were made regarding the existing model:

- The existing model considered the re-aligned Rascal Stream West, with two 2.5-m by 2.5-m box culverts crossing the all-weather road before discharging into Goose Lake (Scenario 2 as described in Section 2.3.2). Golder used this model as the base hydraulic model setup for the Project, and made modifications to the existing model for the additional design scenarios.
- The model has a total of 54 cross-sections extending upstream into Rascal Lake (cross-section #3044.841) and downstream to RSW Reach 1 confluence with Goose Lake (cross-section #15.169). The modeled cross-sections are shown in Figure 7, with cross-sections drawn to the 100-year flooding extents provided by Rescan (2014a). Bathymetry data was not incorporated into the model, therefore, cross-sections for all waterbodies do not capture the true lake bottom, and therefore hydraulic outputs are not considered representative at the lake or pond locations.
- Modeled cross-section #2507.971 corresponds to Rascal Lake outlet and modeled cross-section #1753.189 corresponds to Gosling Pond 1 inlet. The RSW and RSE flow split is fully captured by the model, which begins downstream of the Rascal Lake outlet at modeled cross-section #2420.028.
- The model is not set up to model the existing condition of RSE Reach 4, as the model's focus is on modifications to Rascal Stream west of the airstrip. Therefore, any simulated results for RSE Reach 4 under Scenario 1 are not representative of the channel's hydraulic conditions.
- The model incorporates the proposed diversion and containment berms located southwest of the proposed airstrip extension. The diversion berm is located between modeled cross-sections #1909.324 and #1683.557, between Little Rascal Pond and Gosling Pond 1 and is intended to divert RSE Reach 4 and Goose Stream Reach 3 into Gosling Pond 1, therefore eliminating the east outlet at Gosling Pond 1.
The containment berm is intended to contain potential channel overflows between Gosling Pond 1 and Gosling Pond 2 from flooding the airstrip embankment and is located between modeled cross-section #1520.998 and #1455.404.
- Two 2.5-m by 2.5-m box culverts with lengths of 16.8 m are modeled between cross-sections #115.155 and #94.656 at the all-weather road crossing. The box culverts are embedded 15 cm below the existing ground to allow placement of substrate layer. A Manning's n value of 0.04 is used to represent the culvert roughness, which is aligned with proposed placement of boulders with minimum diameter of 0.4 m within the culverts to reduce velocities (Rescan 2014a). The modeled culverts have entrance and exit loss coefficients of 1, and were kept unchanged assuming ideal condition with no energy loss. While corrugated steel pipe culverts were also considered in previous modeling, box culverts were used in the 2018 modeling following the recommendation of previous studies (Rescan 2014a).




**LEGEND**

- PROPOSED ALL-WEATHER ROAD CULVERT
- WATERCOURSE
- PROPOSED AIRSTRIP EXTENSION
- WATERBODY

**HEC-RAS MODELED CROSS-SECTIONS**

- CROSS-SECTION
- SELECTED REPRESENTATIVE CROSS-SECTION

**BERMS**

- Containment Berm
- Diversion Berm

**REFERENCE(S)**

1. HYDROLOGY LAYERS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED, MODIFIED BY GOLDER ASSOCIATES LTD.
PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
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PROJECT
BACK RIVER PROJECT ENVIRONMENT AND PERMITTING

TITLE
**HEC-RAS MODELED CROSS-SECTIONS**

CONSULTANT
GOLDER

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| DESIGNED | NG |
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### 2.3.2 Design Scenarios

Two scenarios were modeled to characterize water surface elevations, flow depths, and velocities over a range of potential discharges from June to September, and the 2-year and 100-year flood events. The two scenarios, as discussed in the introduction, are:

- **Scenario 1, Original Alignment with Airstrip Culverts** (Figure 1): This scenario simulates the natural alignment of Rascal Stream where no re-alignment work is done to RSE Reach 4 and Goose Stream Reach 3.
  - Rascal Lake discharges into both RSW Reach 7 and RSE Reach 5 from Rascal Stream Reach 6.
  - RSW Reach 7 flows north into Gosling Pond 1 and continues to Goose Lake through Gosling Pond 2 and Gander Pond.
  - RSE Reach 5 flows northeast under the proposed airstrip extension where it joins with the east outflow from Gosling Pond 1 (Goose Stream Reach 3), and discharges into Goose Lake.
  - Two box culverts are modeled to convey flows of RSW Reach 1, near Goose Lake, under the all-weather road that runs east to west along the south side of Goose Lake. It is acknowledged that since the 2018 modeling, a clear-span bridge has been installed under the all-weather haul road and this crossing is discussed further in the conclusions.
  - Two additional box culverts are modeled to convey the channel flows from RSE Reach 4 and Goose Stream Reach 3 under the airstrip extension, using their existing alignment, thereby minimizing watercourse disturbance.
  - The main purpose of this design scenario is to describe the flow conditions for the proposed culverts with the existing Rascal Stream alignment, as well as understanding the baseline hydraulics for upstream sections of RSW and RSE.
- **Scenario 2, RSE and Goose Stream Diversion using Berms** (Figure 2): This scenario simulates the diversion of RSE Reach 4 into Gosling Pond 1 and the diversion of the Goose Stream Reach 3 from Gosling Pond 1 such that all flows upstream of the proposed airstrip are conveyed to Goose Lake through Rascal Stream West.
  - This scenario involves construction of re-alignment berms between Little Rascal Pond and Gosling Pond 1 to divert RSE Reach 4 and Goose Stream Reach 3 discharges to Gosling Pond 1, and a containment berm between Gosling Ponds 1 and 2 to prevent potential flooding of the airstrip embankment during extreme flood events.
  - Two 2.5-m by 2.5-m box culverts are modeled to convey flows under the all-weather road as described in Scenario 1.
  - The main purpose of this design scenario is to describe the effects of the diverted flows from RSE and Goose Stream to downstream RSW, including the proposed culvert crossings and the ‘Rascal Fishway’.

### 2.3.3 Channel and Floodplain Geometry

The Project is located in northern tundra above the tree line, and based on observations during the field programs, the terrain is generally flat and marshy with poorly-defined channel banks. Photographs of the Project area are included in Appendix A.

SRK's HEC-RAS hydraulic model used a channel and floodplain roughness of 0.029 for the entire study reach. Golder was unable to collect field data suitable for calibration of Manning's n during the field programs; therefore the Manning's n value of 0.029 was retained for the HEC-RAS hydraulic model in this study. It should be noted that during low-flow simulations, a Manning's n value of 0.029 may underpredict the channel roughness due to the relatively large substrate size compared to flow depths.

The hydraulic model does not include bathymetry for lakes and ponds within the modeling domain. Modeled hydraulic parameters at lakes and ponds within the domain are not expected to be representative of the expected conditions in the waterbodies. However, changes in water depths and velocities with the potential to impact fish migration and habitat are expected to be most sensitive within the stream channels (excluding isolated channels), rather than within the modeled waterbodies.

### 2.3.4 Design Flows

Frequency and statistical analyses of the GoldSim hydrological model results were completed for key discharges downstream of Rascal Lake to provide inputs to the hydraulic model. The following were examined:

- 2-year and 100-year design discharges; and
- $50^{th}$ percentile discharges for the months of June, July, August, and September.

The above listed discharges were examined at the following locations:

- Scenario 1 – Rascal East Channel and Rascal West Channel, Gosling Pond 1 East Outlet and Gosling Pond 1 North Outlet, and Combined East Channel; and
- Scenario 2 – Rascal Outlet and Rascal Stream Mouth at Goose Lake.

Based on the key discharges derived from the hydrological model results, a range of flows from June to September, corresponding to the open-water season, was also simulated to account for various flow conditions within the various channel reaches along the Rascal Stream.

The 1-in-2-year and 1-in-100-year flood events were also simulated to assess expected channel characteristics under approximate bankfull and extreme flow events.

### 2.3.5 Boundary Conditions and Calibration

Channel and floodplain geometry in the hydraulic model is representative of the proposed Rascal Stream re-alignments and is therefore not representative of existing conditions; therefore, surveyed flow measurements and/or water level measurements for existing Rascal Stream conditions are limited to validation of the selected Manning's n roughness values of the hydraulic model. Therefore, a channel slope for normal depths of 0.005 m/m upstream and downstream boundary conditions were used, which is the same as the SRK model.

### 2.3.6 Representative Modeled Cross-Sections

Hydraulic modeled results, including water levels, channel velocities, water top widths, and maximum and average water depths, are summarized for modeled cross-sections to understand hydraulic conditions under each design scenario. Representative modeled cross-sections were selected to reduce the number of result tables to be presented in the report and to emphasize hydraulics (i.e., channel velocity and flow depth) that are critical to fish passage. Table 7 summarizes the selected representative modeled cross-sections.

**Table 7: Representative Modeled Cross-Sections**

| Reach Name | Cross-Section Number | Applicable Design Scenario(s) | Length of Reach[a] (m) | Cross-Section Setting |
|---|---|---|---|---|
| RSW Reach 7 | 2420.028 | 1 / 2 | 740 | ■ Boulder garden with wide and ill-defined channel with potential of low flow depth<br>■ Reach extends from Rascal Stream split to Gosling Pond 1 |
| RSW Reach 7 | 1909.324 | 1 / 2 | | ■ More defined and confined channel compared to upstream section of RSW Reach 7 with potential of high channel velocity<br>■ Reach extends from Rascal Stream split to Gosling Pond 1 |
| RSE Reach 5 | 2300.936 | 1 / 2 | 545[b] | ■ Defined and narrow channel section with potential of high channel velocity<br>■ Reach extends from Rascal Stream split to below Little Rascal Pond |
| RSE Reach 4[c][d] | 1948.504 | 2 | 805 | ■ Defined and narrow channel section with no diversion berm to contain and divert flows<br>■ Reach extends from Rascal Reach 5 to upstream of the proposed diversion berm |
| RSE Reach 4[d] | 1833.064 | 2 | | ■ Channel with diversion berm to the east to restrict flows in its natural condition resulting in potential high channel velocity |
| RSW Reach 3 | 1455.404 | 1 / 2 | 535 | ■ Channel with diversion berm to the east to restrict flows in its natural condition resulting in potential high channel velocity<br>■ Reach between Gosling Pond 1 and Gosling Pond 2 |
| RSW Reach 2 | 996.92 | 1 / 2 | 255 | ■ Defined and narrow channel section downstream of Gosling Pond 2 with potential of high channel velocity<br>■ Reach between Gosling Pond 2 and Gander Pond |
| RSW Reach 1 | 64.15607 | 1 / 2 | 385 | ■ Defined by a narrow channel with potential high channel velocity.<br>■ This cross section is downstream of the clear-span bridge with unknown dimensions. |

a) Reach lengths are reported by Rescan (2014a). Cross-sections are chosen to be generally representative of the reach, however, hydraulic parameters are variable along the reach, as discussed and shown in the results section.
b) Length of Little Rascal Pond is excluded from the representative reach length of modeled cross-section #2300.936.
c) Modeled cross-section #1948.504 is included only to present results for the 2-year and 100-year flood events.
d) Modeled cross-sections #1948.504 and #1833.064 both are representative of the same reach, where cross-section #1948.504 is included to inform design of the diversion berm.

# 3.0 RESULTS AND DISCUSSION

## 3.1 Hydrological Model Results

The mean annual water yield for the Rascal Lake watershed based on the hydrological model from 1959 to 2014 is 153 mm/year. There is generally high variability of observed annual water yields, which range from estimated values of about 150 mm/year to 250 mm/year for regional hydrometric stations (SRK 2015) and 35 mm/year to 620 mm/year for Goose Property hydrometric stations (Rescan 2014c). Based on high variability and the short period of record for on-Site observations, regional values were used to validate the estimated long-term water yields. The long-term mean annual water yield of 153 mm/year modeled in this study also closely agrees with the previously estimated mean annual water yields for the Goose Property of 149 mm/year (SRK 2015).

Results for the 2-year and 100-year mean daily peak discharges are discharges are presented in Table 8. A summary of Scenarios 1 and 2 are presented in Section 2.3.2.

**Table 8: 2-Year and 100-Year Design Discharges**

| Return Period | 2-year ($m^3/s$) | | 100-year ($m^3/s$) | |
|---|---|---|---|---|
| **Reach Name** | **Scenario 1 (S1)** | **Scenario 2 (S2)** | **Scenario 1 (S1)** | **Scenario 2 (S2)** |
| RSW Reach 7 | 1.29 | 1.29 | 2.35 | 2.35 |
| RSE Reach 5 | 1.36 | 1.36 | 2.75 | 2.75 |
| RSW Reach 3[(a)] | 0.80 | 2.76 | 1.45 | 5.14 |
| Goose Stream Reach 3 | 0.53 | - | 0.97 | - |
| RSE Reach 3[(c)] | 1.89 | - | 3.72 | - |

[(a)] Modeled flows for West Goose (Mouth West, located downstream of RSW Reach 1) was used to represent the flows downstream of the Gosling Pond 1, including RSW Reach 3, RSW Reach 2, and RSW Reach 1, for Scenarios 2. For Scenario 1, flows for Gosling North (RSW Reach 3) are used to represent RSW Reach 3 in table above.

[(b)] Downstream of confluence of Goose Stream Reach 3 and RSE Reach 4 (downstream of Gosling Pond 1).

"-" = Goose Stream Reach 3 and RSE Reach 3 are eliminated in Scenario 2, therefore, Goose Stream Reach 3 and RSE Reach 3 receive no flows.

Results for the June (excluding zero flows prior to lake outlet channels opening), fall (July to September), July, August, and September discharges are discharges are presented in Table 9 to Table 13 or a range of percentile flows. These are provided for reach lengths specific to each design scenario. In Scenario 2, where a diversion berm has been constructed and flow is diverted from the east channels, Goose Stream Reach 3 and RSE Reach 3 discharges are equal to 0 $m^3/s$.

Based on the results below, Scenario 2 indicates an increase in discharge at RSW Reach 3 and downstream when compared to Scenario 1. On comparison of the $10^{th}$ to $90^{th}$ percentile flows for the two months with the highest average flows, June and September, Scenario 2 discharges are between 3.5 and 4.1 times greater than Scenario 1. Increases in the $50^{th}$ percentile discharges during the lower flow months of July and August are about 3 to 30 times due to the Scenario 1 low flows in RSW 3 to RSW 1, representative of the existing flow regime.

**Table 9: June Percentile Discharges**

| Percentile | 10th (m³/s) | | 25th (m³/s) | | 50th (m³/s) | | 75th (m³/s) | | 90th (m³/s) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Reach Name** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** |
| RSW Reach 7 | 0.062 | 0.062 | 0.18 | 0.18 | 0.30 | 0.30 | 0.50 | 0.50 | 0.86 | 0.86 |
| RSE Reach 5 | 0.076 | 0.076 | 0.22 | 0.22 | 0.36 | 0.36 | 0.61 | 0.61 | 1.06 | 1.06 |
| RSW Reach 3[(a)] | 0.041 | 0.17 | 0.11 | 0.41 | 0.18 | 0.68 | 0.31 | 1.14 | 0.53 | 2.00 |
| Goose Stream Reach 3 | 0.027 | - | 0.073 | - | 0.12 | - | 0.20 | - | 0.35 | - |
| RSE Reach 3[(b)] | 0.10 | - | 0.29 | - | 0.48 | - | 0.82 | - | 1.41 | - |

[(a)] Modeled flows for West Goose (Mouth West, located downstream of RSW Reach 1) was used to represent the flows downstream of the Gosling Pond 1, including RSW Reach 3, RSW Reach 2, and RSW Reach 1, for Scenarios 2. For Scenario 1, flows for Gosling North (RSW Reach 3) are used to represent RSW Reach 3 in table above.
[(b)] Downstream of confluence of Goose Stream Reach 3 and RSE Reach 4 (downstream of Gosling Pond 1).
"-" = Goose Stream Reach 3 and RSE Reach 3 are eliminated in Scenario 2, therefore, Goose Stream Reach 3 and RSE Reach 3 receive no flows.

**Table 10: July Percentile Discharges**

| Percentile | 10th (m³/s) | | 25th (m³/s) | | 50th (m³/s) | | 75th (m³/s) | | 90th (m³/s) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Reach Name** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** |
| RSW Reach 7 | 0.005 | 0.005 | 0.008 | 0.008 | 0.012 | 0.012 | 0.019 | 0.019 | 0.025 | 0.025 |
| RSE Reach 5 | 0.10 | 0.10 | 0.15 | 0.15 | 0.22 | 0.22 | 0.35 | 0.35 | 0.47 | 0.47 |
| RSW Reach 3[(a)] | 0.004 | 0.11 | 0.006 | 0.16 | 0.009 | 0.24 | 0.015 | 0.38 | 0.021 | 0.51 |
| Goose Stream Reach 3 | 0.002 | - | 0.002 | - | 0.004 | - | 0.006 | - | 0.009 | - |
| RSE Reach 3[(b)] | 0.11 | - | 0.15 | - | 0.23 | - | 0.36 | - | 0.48 | - |

[(a)] Modeled flows for West Goose (Mouth West, located downstream of RSW Reach 1) was used to represent the flows downstream of the Gosling Pond 1, including RSW Reach 3, RSW Reach 2, and RSW Reach 1, for Scenarios 2. For Scenario 1, flows for Gosling North (RSW Reach 3) are used to represent RSW Reach 3 in table above.
[(b)] Downstream of confluence of Goose Stream Reach 3 and RSE Reach 4 (downstream of Gosling Pond 1).
"-" = Goose Stream Reach 3 and RSE Reach 3 are eliminated in Scenario 2, therefore, Goose Stream Reach 3 and RSE Reach 3 receive no flows.

**Table 11: August Percentile Discharges**

| Percentile | 10 th (m³/s) | | 25 th (m³/s) | | 50 th (m³/s) | | 75 th (m³/s) | | 90 th (m³/s) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Reach Name** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** |
| RSW Reach 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RSE Reach 5 | 0.083 | 0.083 | 0.10 | 0.10 | 0.16 | 0.16 | 0.25 | 0.25 | 0.34 | 0.34 |
| RSW Reach 3[(a)] | 0 | 0.085 | 0.0 | 0.11 | 0.0 | 0.18 | 0.002 | 0.26 | 0.008 | 0.36 |
| Goose Stream Reach 3 | 0 | - | 0.0 | - | 0.0 | - | 0.001 | - | 0.003 | - |
| RSE Reach 3[(b)] | 0.084 | - | 0.11 | - | 0.16 | - | 0.25 | - | 0.34 | - |

[(a)] Modeled flows for West Goose (Mouth West, located downstream of RSW Reach 1) was used to represent the flows downstream of the Gosling Pond 1, including RSW Reach 3, RSW Reach 2, and RSW Reach 1, for Scenarios 2. For Scenario 1, flows for Gosling North (RSW Reach 3) are used to represent RSW Reach 3 in table above.
[(b)] Downstream of confluence of Goose Stream Reach 3 and RSE Reach 4 (downstream of Gosling Pond 1).
"-" = Goose Stream Reach 3 and RSE Reach 3 are eliminated in Scenario 2, therefore, Goose Stream Reach 3 and RSE Reach 3 receive no flows.

**Table 12: September Percentile Discharges**

| Percentile | 10 th (m³/s) | | 25 th (m³/s) | | 50 th (m³/s) | | 75 th (m³/s) | | 90 th (m³/s) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Reach Name** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** |
| RSW Reach 7 | 0.026 | 0.026 | 0.043 | 0.043 | 0.074 | 0.074 | 0.11 | 0.11 | 0.16 | 0.16 |
| RSE Reach 5 | 0.039 | 0.039 | 0.065 | 0.065 | 0.11 | 0.11 | 0.17 | 0.17 | 0.24 | 0.24 |
| RSW Reach 3 | 0.019 | 0.067 | 0.031 | 0.11 | 0.054 | 0.19 | 0.080 | 0.29 | 0.11 | 0.41 |
| Goose Stream Reach 3 | 0.008 | - | 0.013 | - | 0.023 | - | 0.034 | - | 0.048 | - |
| RSE Reach 3[(a)] | 0.047 | - | 0.078 | - | 0.13 | - | 0.20 | - | 0.29 | - |

[(a)] Modeled flows for West Goose (Mouth West, located downstream of RSW Reach 1) was used to represent the flows downstream of the Gosling Pond 1, including RSW Reach 3, RSW Reach 2, and RSW Reach 1, for Scenarios 2. For Scenario 1, flows for Gosling North (RSW Reach 3) are used to represent RSW Reach 3 in table above.
[(b)] Downstream of confluence of Goose Stream Reach 3 and RSE Reach 4 (downstream of Gosling Pond 1).
"-" = Goose Stream Reach 3 and RSE Reach 3 are eliminated in Scenario 2, therefore, Goose Stream Reach 3 and RSE Reach 3 receive no flows.

### 3.1.1 Validation using the 2018 and 2019 Field Data

#### *3.1.1.1 Hydrological Flow Splits*

The estimated flow split proportion used in the hydrological model (originally presented in Table 6), as well as the measured 2018 and 2019 field program flow split proportions for the month of June, are shown in Table 13. To generally represent freshet flows, the modeled flow splits for the month of May are also presented.

**Table 13: Comparison of Flow Split Proportions from Hydrological Model and 2018 and 2019 Field Measurements**

| Month | Split from RS Reach 6 (%) | | Split from Gosling Pond 1 (%) | | Overall Approximate Flow Split (%) | |
|---|---|---|---|---|---|---|
| | RSE Reach 5 | RSW Reach 7 | RSW Reach 3 | Goose Stream Reach 3 | RSW Reach 1 | RSE Reach 3[(a)] |
| May (Hydrologic Model) | 30 | 70 | 60 | 40 | 35 | 65 |
| June (Hydrologic Model) | 55 | 45 | 60 | 40 | 30 | 70 |
| June (2018) | 37 | 63 | 50 | 50 | 42 | 58 |
| June (2019) | 59 | 41 | 76 | 24 | 35 | 65 |

a) Downstream of confluence of Goose Stream Reach 3 and RSE Reach 4

Based on the flow split proportions presented above and the spot measurements of discharge during field programs:

- The hydrological model flow splits for Rascal Stream Reach 6 into RSE Reach 5 and RSW Reach 7 used to represent freshet flows in May and June are in general agreement with the June 2018 and June 2019 measured flow splits.
- The hydrological model flow splits for Gosling Pond 1 into RSW Reach 3 and Goose Stream Reach 3 used to represent freshet flows in May and June are in general agreement with the June 2018 and June 2019 measured flow splits.
- The overall resulting hydrological model flow splits used to represent freshet flows in May and June are in general agreement with the June 2018 and June 2019 measured flow splits.
- Overall, the methods used to setup the model flow splits for May and June freshet flows are validated based on limited discharge measurements during the 2018 and 2019 field programs.

#### 3.1.1.2 Hydrological Estimates of 2-Year Discharges

The hydrological model estimates for bankfull conditions (2-Year Mean Daily Peak Discharge) for Scenario 1 are shown in Table 8. Overall, the following comparisons and validations can be made:

- The 2019 measured field discharges for Rascal Stream West Reach 7, Rascal Stream West Reach 3, and Main Goose Pit Stream Reach 3 vary by 30% - 38% from the hydrological model estimates. The 2019 measured field discharges for Rascal Stream East Reach 5 and Rascal Stream East Reach 3 vary by 1% - 6 % to the hydrological model. Overall, the measured field flows are in general agreement to the hydrological model estimates.

The 2019 field observations indicated approximately bankfull conditions, therefore, the field discharges for Rascal Stream East Reach 5 and Rascal Stream East Reach 3 validated the range of estimated bankfull flows.

#### 3.1.1.3 Hydraulic Estimates of 2-Year Discharge Flow Conditions

The measured discharges, wetted width, and average velocity during the June 2019 field visit are shown in Table 14. The cross-section range represents the range of cross sections that 2019 discharge locations are between.

**Table 14: Measured 2019 Field Program Data and Modeled Data for 2-Year Discharges**

| Reach | Cross Section Range / (Closest Cross Section) to the 2019 measurements | Modeled Discharge ($m^3/s$) | Modeled Wetted Width (m) | Modeled Average Velocity (m/s) | 2019 Measured Discharge ($m^3/s$) | 2019 Measured Wetted Width (m) | 2019 Measured Average Velocity (m/s) |
|---|---|---|---|---|---|---|---|
| Rascal Stream Reach 6 | 2594.878 - (2507.971) | 1.29 | 124.41 - 62.93 | 0.33 - 0.54 | 2.663 | 29.2 | 0.38 |
| Rascal Stream East Reach 5 | 2420.028 - (2300.936) | 1.36 | 22.61 - 40.64 | 0.84 - 0.60 | 1.450 | 44.6 | 0.27 |
| Rascal Stream West Reach 7 | (2300.936) – 2141.14 | 1.29 | 19.89 – 34.79 | 0.87 - 0.70 | 0.993 | 27.8 | 0.19 |
| Main Goose Pit Stream Reach 3 | (1709.515) | 0.53 | n/a | n/a | 0.398 | 24.6 | 0.19 |
| Rascal Stream East Reach 4 (culvert) | (1800.185) | 1.36 | n/a | n/a | 1.526 | 12.2 | 0.66 |
| Rascal Stream West Reach 3 | (1520.998) – 1455.404 | 0.80 | 15.30 – 44.61 | 0.26 - 0.42 | 1.284 | 43.0 | 0.19 |
| Rascal Stream West Reach 2 | 996.92 | 0.80 | 10.3 | 0.70 | n/a | n/a | n/a |
| Rascal Stream West Reach 1 | (263.430) – 220.023 | 0.80 | 66.54 – 33.93 | 0.36 - 0.60 | 1.023 | 10.7 | 0.40 |

"n/a" = Not applicable. Cross-sections and select results are not applicable for culverts modeled outside of the HEC-RAS model

Based on the June 2019 field photos in Appendix A and Appendix C, it is visually estimated that bankfull conditions (approximately 2-year flood event) existed during the 2019 site visit. Based on the measured and modeled data in Table 14, the following conclusions can be made:

- By comparing the discharges for each reach, bankfull conditions produced from the HEC-RAS model (Scenario 1) generally agree with the 2019 measured bankfull discharge.
- The hydraulic model wetted widths ranged from 10.3 m to 124.4 m and the 2019 measured wetted widths ranged from 10.7 m to 44.6 m. The cross sections inputted into the hydraulic model were cut using LiDAR, therefore, it was possible that the channel embedment was not fully captured, resulting in flatter cross-sections in some areas. Shallower cross sections would result in more floodplain inundation from the hydraulic model output and larger top widths.
- The 2019 measured average velocity ranged from 0.19 m/s to 0.66 m/s and the hydraulic model average velocity ranged from 0.26 m/s to 0.87 m/s, therefore, the measured average velocity is generally representative to the modeled average velocity.

## 3.2 Hydraulic Model Results

### 3.2.1 Range of Flows during Fish Production Season

A range of flows representative of potential flow conditions during open-water season from June to September was assessed for the two design scenarios. The range of flows considered for the model are 0.02 to 1.55 $m^3/s$, generally modeled in increments of 0.05 $m^3/s$. The lower flow bound was estimated as the $5^{th}$ percentile of September flows; and the higher flow bound was estimated as the $97^{th}$ percentile of June flows. Hydraulic results, including water levels, channel velocities, water top widths, and maximum and average water depths, for the two scenarios at selected representative modeled cross-sections (refer to Table 7) are summarized in Appendix D. Hydraulic results at culvert crossings under the proposed airstrip extension are also presented.

### 3.2.2 2-Year and 100-Year Design Discharges

The 2-year and 100-year flood events were modeled to assess expected flow characteristics under approximate bankfull conditions and an extreme flood event. Hydraulic results including: water levels, channel velocities, water top widths, and maximum and average water depths under the 2-year and 100-year flood events for Scenario 1 are summarized in Section 3.2.2.1 and Scenario 2 are summarized in Section 3.2.2.2. Comparisons between the two design scenarios for channel velocities and average water depths for representative modeled cross-sections are presented in (Section 3.2.2.3).

#### *3.2.2.1 Scenario 1*

Hydraulic results for Scenario 1 are summarized in Table 15 for Rascal Stream under the 2-year flood event, and Table 16 under the 100-year flood event using representative cross-sections.

In Scenario 1, a containment berm is proposed to the east of RSW Reach 3 between Gosling Pond 1 and Gosling Pond 2, to prevent flooding of the airstrip embankment. Cross-section #1455.404 at RSW Reach 3 has a simulated water level of 291.31 m during the 100-year flood event near the proposed containment berm.

It is noted that Rascal Stream has the highest velocity of 1.91 m/s during the 2-year flood event at modeled cross-section #94.6559, in RSW Reach 1 at the box culvert outlets. At the representative cross-sections, the highest velocity of 1.36 m/s during the 2-year event in the natural channel occurs in RSW Reach 1 at cross-section #64.15607 due to constricted narrow channel section. Modeled water depths during the 2-year flood event are lowest in RSE Reach 3 (0.04 m) where depths were less than half of the depths reported for RSW Reach 7.

Results for RSE Reach 4 are not presented because the model is not set up to model the natural condition of RSE Reach 4, as described in (Section 2.3.1).

**Table 15: Scenario 1 – Hydraulic Results for Rascal Stream for the 2-Year Flood Event**

| Reach Name | Cross-Section Number | 2-Year Discharge | Water Level | Channel Velocity | Average Velocity | Water Top Width | Maximum Water Depth | Average Water Depth |
|---|---|---|---|---|---|---|---|---|
| | | ($m^3/s$) | (m) | (m/s) | (m/s) | (m) | (m) | (m) |
| RSW Reach 7 | 2420.028 | 1.29 | 298.04 | 0.40 | 0.40 | 82.8 | 0.09 | 0.04 |
| RSW Reach 7 | 1909.324 | 1.29 | 295.45 | 0.67 | 0.67 | 39.9 | 0.08 | 0.05 |
| RSE Reach 5 | 2300.936 | 1.36 | 296.84 | 0.60 | 0.60 | 40.6 | 0.09 | 0.06 |
| RSW Reach 3 | 1455.404 | 0.80 | 291.29 | 0.42 | 0.42 | 44.6 | 0.04 | 0.04 |
| RSW Reach 2 | 996.92 | 0.80 | 289.88 | 0.70 | 0.70 | 10.3 | 0.13 | 0.11 |
| RSW Reach 1 | 64.15607 | 0.80 | 282.05 | 1.36 | 1.36 | 11.4 | 0.05 | 0.05 |
| RSE Reach 4 (culvert) | n/a | 1.36 | n/a | 1.31[(a)] | n/a | n/a | n/a | 0.31 |
| Goose Stream Reach 3 (culvert) | n/a | 0.53 | n/a | 0.95[(a)] | n/a | n/a | n/a | 0.17 |

[(a)] Reported velocity for culverts is the velocity at the culvert outlet, where highest velocity is observed in each culvert crossing.
"n/a" = Not applicable. Cross-sections and select results are not applicable for culverts modeled outside of the HEC-RAS model.

**Table 16: Scenario 1 – Hydraulic Results for Rascal Stream for the 100-Year Flood Event**

| Reach Name | Cross-Section Number | 100-Year Discharge | Water Level | Channel Velocity | Average Velocity | Water Top Width | Maximum Water Depth | Average Water Depth |
|---|---|---|---|---|---|---|---|---|
| | | ($m^3/s$) | (m) | (m/s) | (m/s) | (m) | (m) | (m) |
| RSW Reach 7 | 2420.028 | 2.35 | 298.05 | 0.49 | 0.49 | 85.6 | 0.10 | 0.06 |
| RSW Reach 7 | 1909.324 | 2.35 | 295.48 | 0.78 | 0.78 | 49.2 | 0.11 | 0.06 |
| RSE Reach 5 | 2300.936 | 2.75 | 296.88 | 0.70 | 0.70 | 49.5 | 0.13 | 0.08 |
| RSW Reach 3 | 1455.404 | 1.45 | 291.31 | 0.52 | 0.52 | 45.4 | 0.06 | 0.06 |
| RSW Reach 2 | 996.92 | 1.45 | 289.95 | 0.78 | 0.78 | 11.9 | 0.20 | 0.16 |
| RSW Reach 1 | 64.15607 | 1.45 | 282.11 | 1.12 | 1.12 | 12.6 | 0.11 | 0.10 |
| RSE Reach 4 (culvert) | n/a | 2.75 | n/a | 1.64[(a)] | n/a | n/a | n/a | 0.50 |
| Goose Stream Reach 3 (culvert) | n/a | 0.97 | n/a | 1.17[(a)] | n/a | n/a | n/a | 0.25 |

[(a)] Reported velocity for culverts is the velocity at the culvert outlet, where highest velocity is observed in each culvert crossing.
"n/a" = Not applicable. Cross-sections and select results are not applicable for culverts modeled outside of the HEC-RAS model.

#### *3.2.2.2 Scenario 2*

Hydraulic results for Scenario 2 are summarized in Table 17 for the Rascal Stream under the 2-year flood event, and Table 18 under the 100-year flood event. In addition to the containment berm discussed in Scenario 1, a diversion berm is proposed to divert flows into Gosling Pond 1 and through RSW. The RSE diversion berm is proposed southwest of the airstrip near RSE Reach 4, between Little Rascal Pond and Gosling Pond 1.

Modeled cross-section #1948.504 at RSE Reach 4, just upstream of the modeled diversion berm, has a water level of 294.74 m, resulting in a freeboard with the natural ground less than 0.3 m. Cross-section #1455.404 at RSW Reach 3 has a simulated water level of 291.39 m during the 100-year flood event near the proposed containment berm.

Box culverts at modeled cross-section #109 at RSW Reach 1 have a simulated velocity of 1.86 m/s and flow depth of 0.31 m during the 2-year flood event at culvert outlet, and a simulated velocity of 2.29 m/s and flow depth of 0.47 m during the 100-year flood event at culvert outlet. The culvert outlet velocities are observed as the highest velocities along Rascal Stream for Scenario 2.

**Table 17: Scenario 2 – Rascal Stream Hydraulic Results for the 2-Year Flood Event**

| Reach Name[a] | Cross-Section Number | 2-Year Discharge | Water Level | Channel Velocity | Average Velocity | Water Top Width | Maximum Water Depth | Average Water Depth |
|---|---|---|---|---|---|---|---|---|
| | | ($m^3/s$) | (m) | (m/s) | (m/s) | (m) | (m) | (m) |
| RSE Reach 4 | 1948.504 | 1.36 | 294.68 | 0.56 | 0.56 | 25.9 | 0.16 | 0.09 |
| RSE Reach 4 | 1833.064 | 1.36 | 293.10 | 0.73 | 0.73 | 21.2 | 0.10 | 0.09 |
| RSW Reach 3 | 1455.404 | 2.76 | 291.34 | 0.66 | 0.65 | 46.7 | 0.09 | 0.09 |
| RSW Reach 2 | 996.92 | 2.76 | 290.04 | 0.68 | 0.68 | 39.9 | 0.29 | 0.10 |
| RSW Reach 1 | 64.15607 | 2.76 | 282.16 | 1.45 | 1.45 | 13.56 | 0.16 | 0.14 |

[a] Results for RSW Reach 7 and RSE Reach 5 are the same as in Scenario 1, refer to Table 15.
"n/a" = Not applicable. Select results are not applicable for culverts modeled outside of the HEC-RAS model.

**Table 18: Scenario 2 – Rascal Stream Hydraulic Results for the 100-Year Flood Event**

| Reach Name[a] | Cross-Section Number | 100-Year Discharge | Water Level | Channel Velocity | Average Velocity | Water Top Width | Maximum Water Depth | Average Water Depth |
|---|---|---|---|---|---|---|---|---|
| | | ($m^3/s$) | (m) | (m/s) | (m/s) | (m) | (m) | (m) |
| RSE Reach 4 | 1948.504 | 2.75 | 294.74 | 0.67 | 0.67 | 34.4 | 0.22 | 0.12 |
| RSE Reach 4 | 1833.064 | 2.75 | 293.14 | 0.98 | 0.98 | 22.8 | 0.14 | 0.12 |
| RSW Reach 3 | 1455.404 | 5.14 | 291.39 | 0.81 | 0.81 | 48.5 | 0.14 | 0.13 |
| RSW Reach 2 | 996.92 | 5.14 | 290.09 | 0.84 | 0.84 | 41.9 | 0.34 | 0.15 |
| RSW Reach 1 | 64.15607 | 5.14 | 282.22 | 1.86 | 1.86 | 14.8 | 0.22 | 0.19 |

[a] Results for RSW Reach 7 and RSE Reach 5 are the same as in Scenario 1, refer to Table 16.
"n/a" = Not applicable. Select results are not applicable for culverts modeled outside of the HEC-RAS model.

#### *3.2.2.3 2-Year and 100-Year Flood Event Results Summary*

Table 19 summarizes the channel velocities and average water depths for each representative modeled cross-section under the two design scenarios for the 2-year flood event, and Table 20 summarizes the channel velocities and average water depths for the 100-year flood event.

**Table 19: Channel Velocities and Average Water Depths for the 2-Year Flood Event**

| Reach Name | Cross-Section Number | Channel Velocity (m/s) | | Average Water Depth (m) | |
|---|---|---|---|---|---|
| | | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| RSW Reach 7 / RSE Reach 5 | 2420.028 | 0.40 | 0.40 | 0.04 | 0.04 |
| RSW Reach 7 | 1909.324 | 0.67 | 0.67 | 0.05 | 0.05 |
| RSE Reach 5 | 2300.936 | 0.60 | 0.60 | 0.06 | 0.06 |
| RSE Reach 4 | 1948.504 | n/a | 0.56 | n/a | 0.09 |
| RSE Reach 4 | 1833.064 | n/a | 0.73 | n/a | 0.09 |
| RSW Reach 3 | 1455.404 | 0.42 | 0.65 | 0.04 | 0.09 |
| RSW Reach 2 | 996.92 | 0.70 | 0.68 | 0.11 | 0.10 |
| RSW Reach 1 | 64.15607 | 1.36 | 1.45 | 0.05 | 0.14 |

"n/a" = HEC-RAS model is not set up to simulate hydraulic conditions of RSE Reach 4 under its natural stage.

**Table 20: Channel Velocities and Average Water Depths for the 100-Year Flood Event**

| Reach Name | Cross-Section Number | Channel Velocity (m/s) | | Average Water Depth (m) | |
|---|---|---|---|---|---|
| | | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| RSW Reach 7 / RSE Reach 5 | 2420.028 | 0.49 | 0.49 | 0.06 | 0.06 |
| RSW Reach 7 | 1909.324 | 0.78 | 0.78 | 0.06 | 0.06 |
| RSE Reach 5 | 2300.936 | 0.70 | 0.70 | 0.08 | 0.08 |
| RSE Reach 4 | 1948.504 | n/a | 0.67 | n/a | 0.12 |
| RSE Reach 4 | 1833.064 | n/a | 0.98 | n/a | 0.12 |
| RSW Reach 3 | 1455.404 | 0.52 | 0.81 | 0.06 | 0.13 |
| RSW Reach 2 | 996.92 | 0.78 | 0.84 | 0.16 | 0.15 |
| RSW Reach 1 | 64.15607 | 1.12 | 1.86 | 0.10 | 0.19 |

"n/a" = HEC-RAS model is not set up to simulate hydraulic conditions of RSE Reach 4 under its natural stage.

The following comparisons between Scenario 1 and Scenario 2 were made after reviewing the channel velocities and flow depths profiles for the 2-year flood flow as hydraulic conditions under the 2-year flood event are related to fish habitat assessment:

- In general for Scenario 2, greater channel velocities and maximum flow depths are observed downstream of Gosling Pond 1 than Scenario 1, due to increase in flows from diverted discharges from RSE Reach 4 and Goose Stream Reach 3. Due to low channel banks and floodplains, the changes in the average flow depths are negligible.
- Velocity at RSW Reach 3 modeled cross-section #1455.404 increased to 0.65 m/s (i.e., Scenario 2) from 0.42 m/s (i.e., Scenario 1), and flow depth increased by 0.05 m in Scenario 2.
- Negligible changes in the channel velocity and average flow depth at RSW Reach 2 modeled cross-section #996.92, with maximum flow depths increasing by 0.09 m.

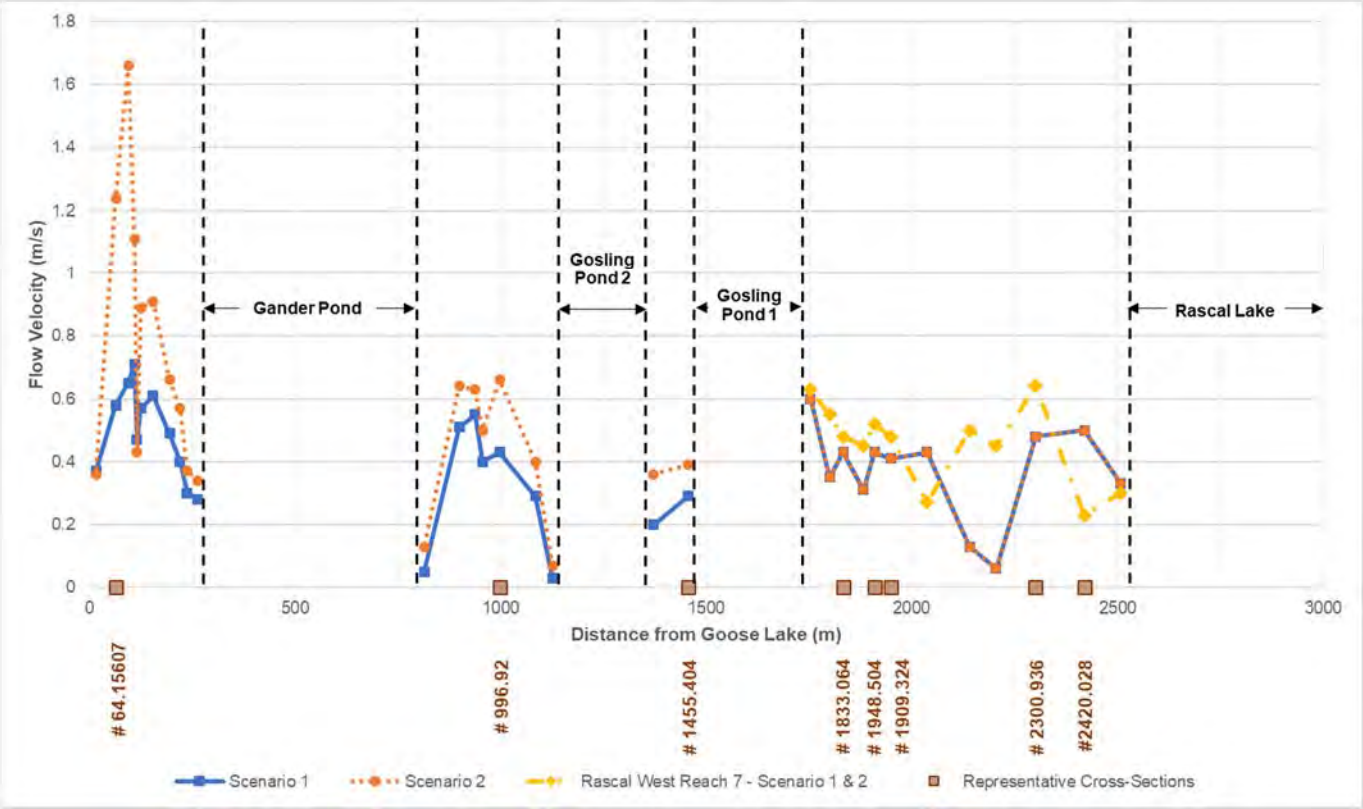
- Velocity at RSW Reach 1 modeled cross section #64.15607 increased to 1.45 m/s (i.e., Scenario 2) from 1.36 m/s (i.e., Scenario 1), the average flow depth increased by 0.09 m in Scenario 2 and the maximum velocity increased by 0.11 m in Scenario 2.

### 3.2.3 Monthly 50th Percentile Discharge during Open Water Season

The estimated 50th percentile discharges in June through September were modeled to assess changes in channel velocities and average flow depths under the two scenarios. Plots for Scenario 1 (blue linework) and Scenario 2 (orange linework) include RSE Reach 5, and the yellow linework represents RSW Reach 7 for Scenario 1 and 2. Cross section #115.155 to cross section #94.6559 are affected by the modeled box culverts, and the hydraulic model results for this section are not necessarily representative of the clear span bridge of unknown dimension installed in this area instead of the modeled culverts.

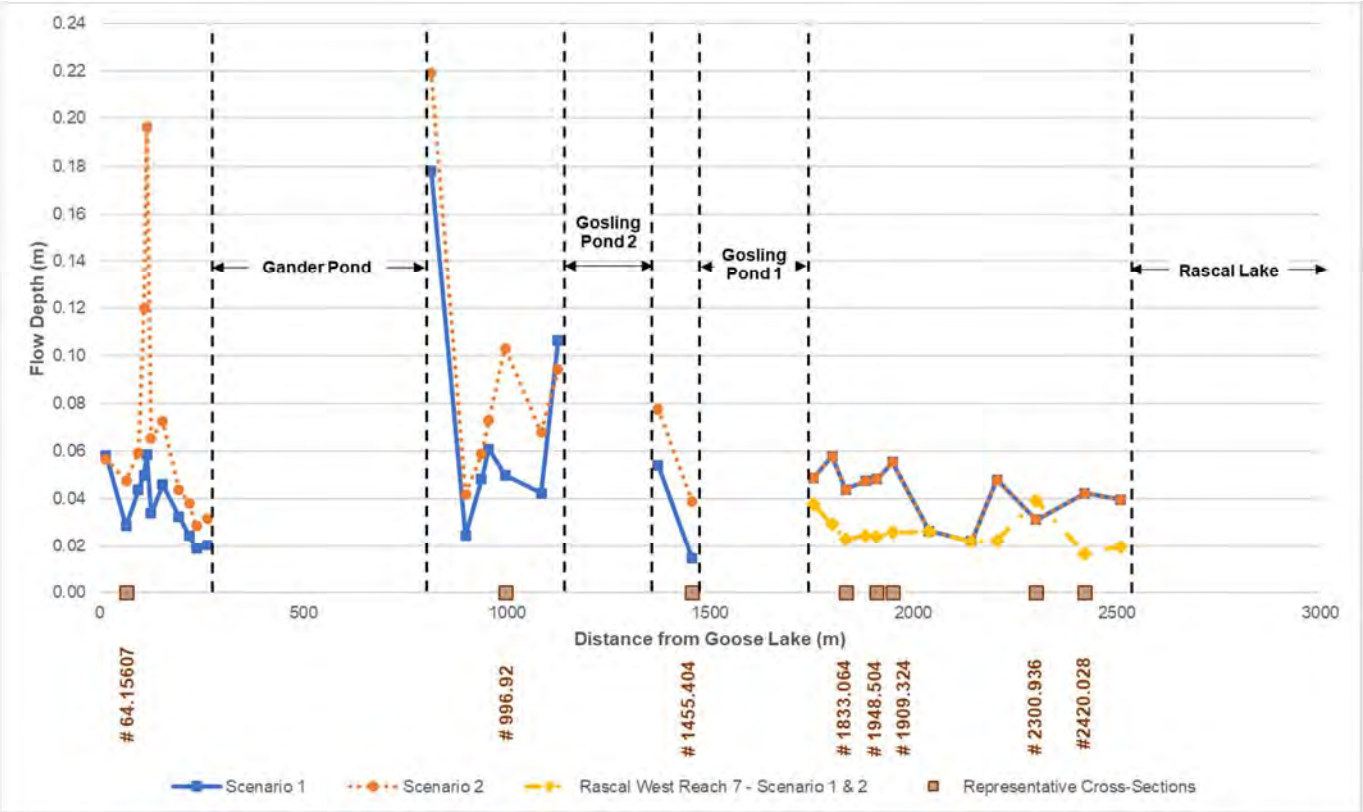
#### *3.2.3.1 June 50th Percentile Discharge*

Channel velocity profiles for June 50th percentile discharges are presented in Figure 8, and average flow depth profiles for June 50th percentile discharges are presented in Figure 9.




*Note: Hydraulic results (i.e., channel velocities) are not presented for waterbodies, because modeled cross-sections for lakes and ponds are not representative as bathymetry data were not incorporated into the hydraulic model.*

**Figure 8: Channel Velocity Profiles for June 50th Percentile Discharge**

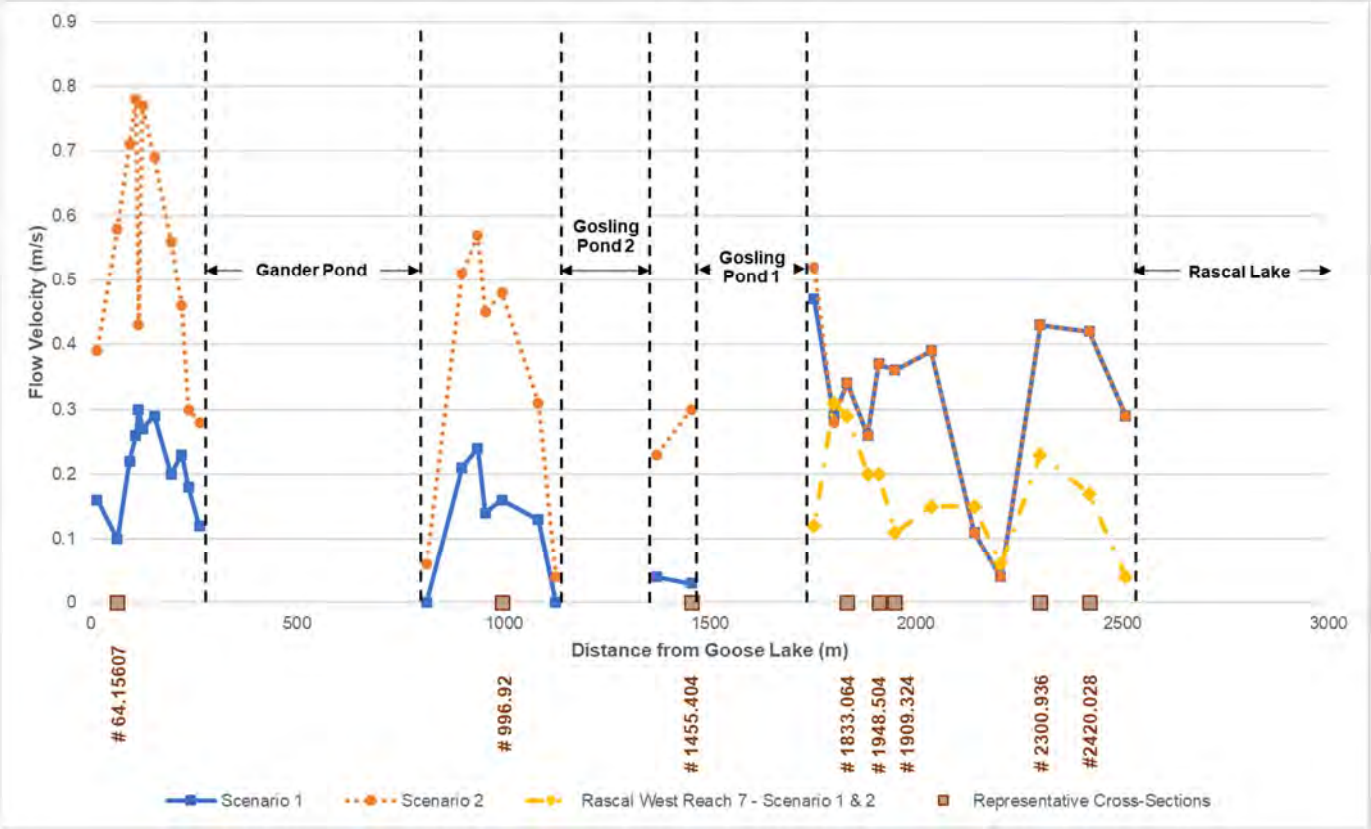



*Note: Hydraulic results (i.e., average flow depths) are not presented for waterbodies, because modeled cross-sections for lakes and ponds are not representative as bathymetry data were not incorporated into the hydraulic model.*

**Figure 9: Flow Depth Profiles for June 50th Percentile Discharge**

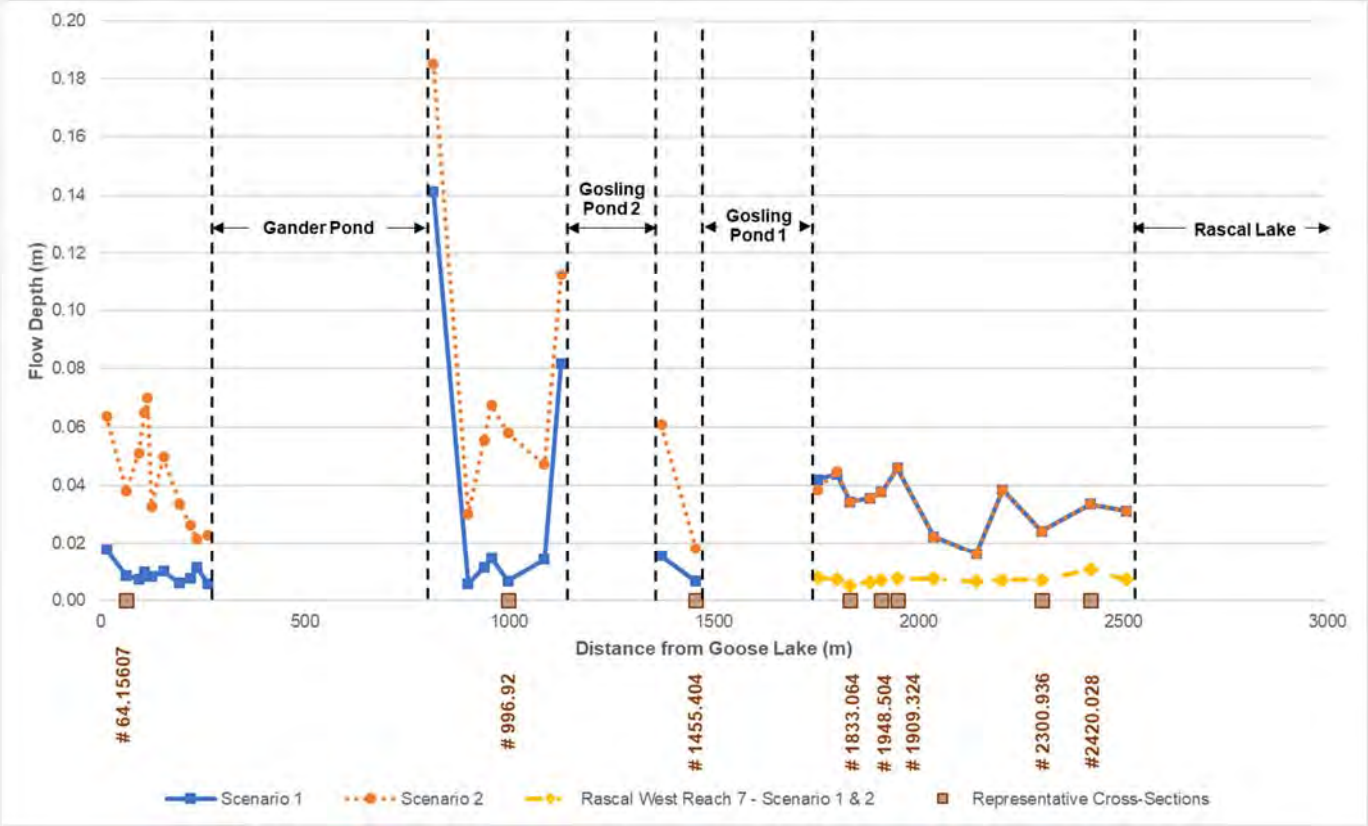
### 3.2.3.2 July 50th Percentile Discharge

Channel velocity profiles for July 50th percentile discharges are presented in Figure 10, and average flow depth profiles for July 50th percentile discharges are presented in Figure 11.




*Note: Hydraulic results (i.e., channel velocities) are not presented for waterbodies, because modeled cross-sections for lakes and ponds are not representative a bathymetry data were not incorporated into the hydraulic model.*

**Figure 10: Channel Velocity Profiles for July 50th Percentile Discharge**

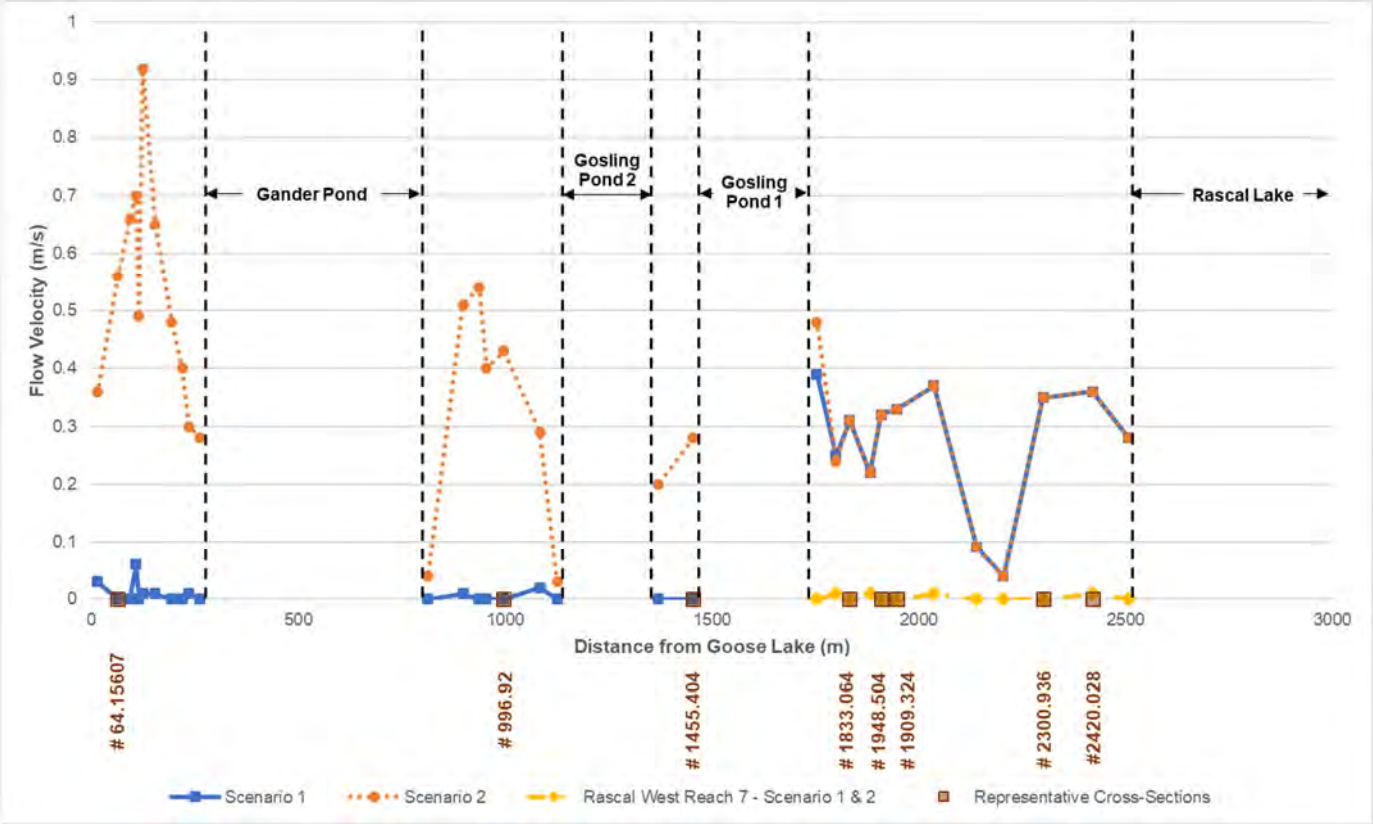



*Note: Hydraulic results (i.e., average flow depths) are not presented for waterbodies, because modeled cross-sections for lake and ponds are not representative as bathymetry data were not incorporated into the hydraulic model.*

**Figure 11: Flow Depth Profiles for July 50th Percentile Discharge**

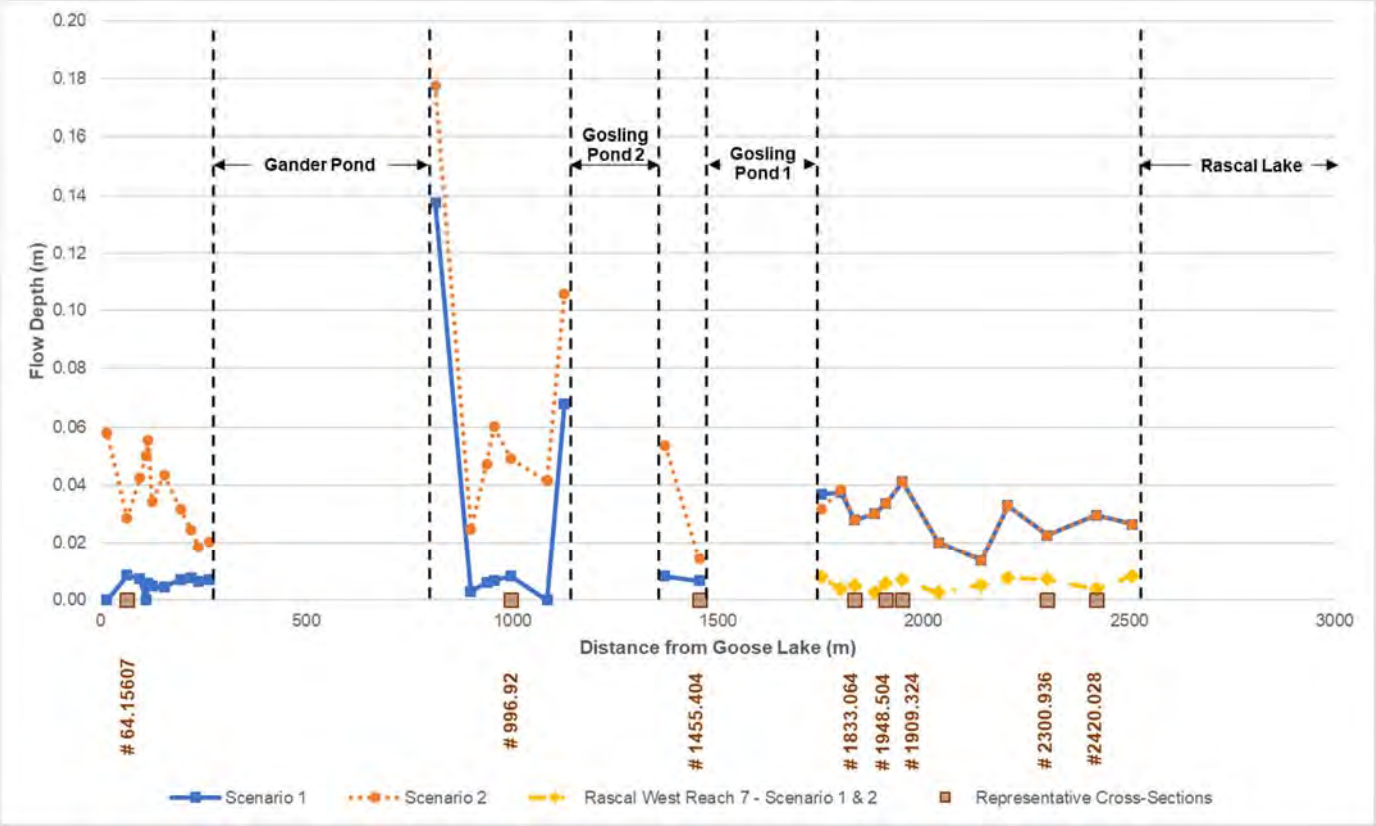
### 3.2.3.3 August 50th Percentile Discharge

Channel velocity profiles for August 50th percentile discharge are presented in Figure 12, and average flow depth profiles for August 50th percentile discharge are presented in Figure 13.




*Note: Hydraulic results (i.e., channel velocities) are not presented for waterbodies, because modeled cross-sections for lake and ponds are not representative as bathymetry data were not incorporated into the hydraulic model.*

**Figure 12: Channel Velocity Profiles for August 50th Percentile Discharge**

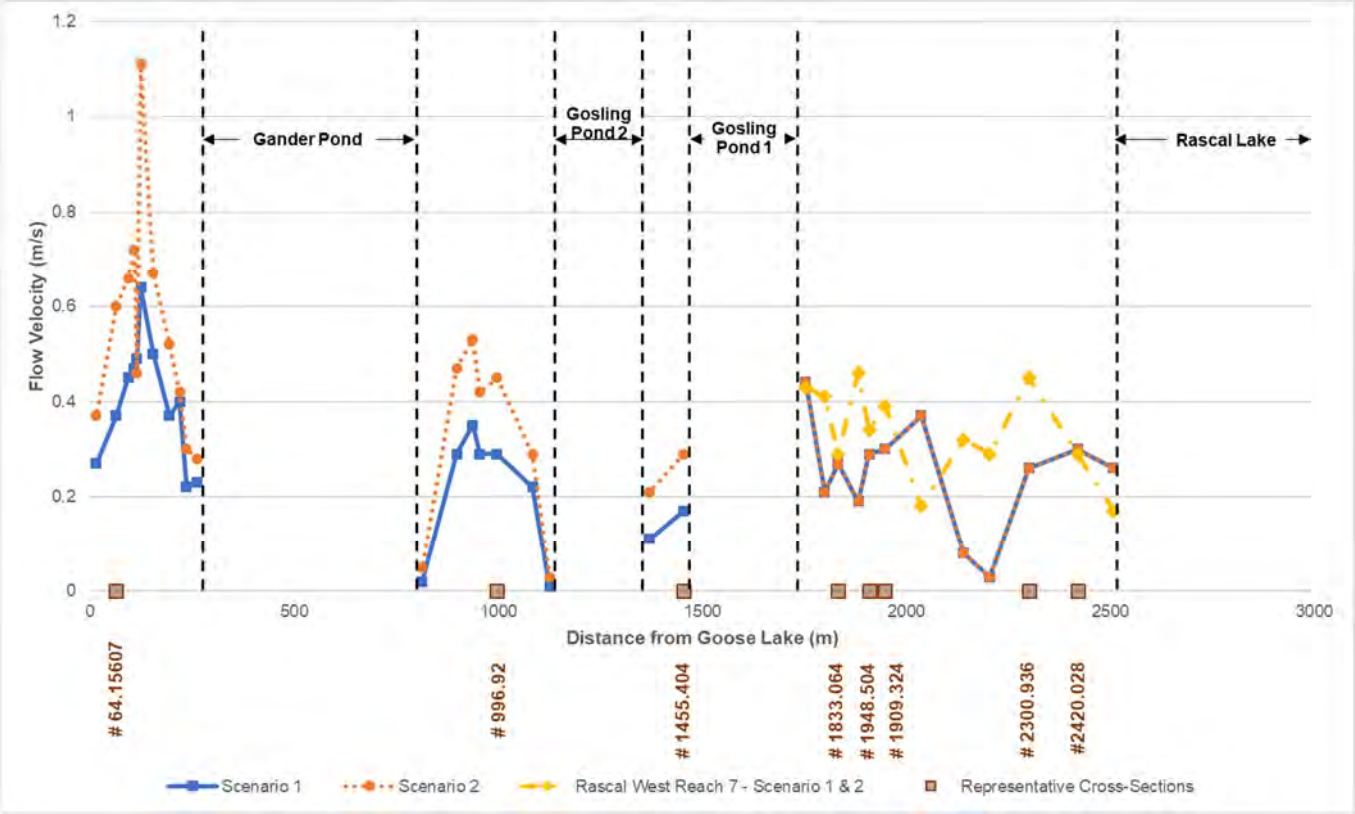



*Note: Hydraulic results (i.e., average flow depths) are not presented for waterbodies, because modeled cross-sections for lake and ponds are not representative as bathymetry data were not incorporated into the hydraulic model.*

**Figure 13: Flow Depth Profiles for August 50th Percentile Discharge**

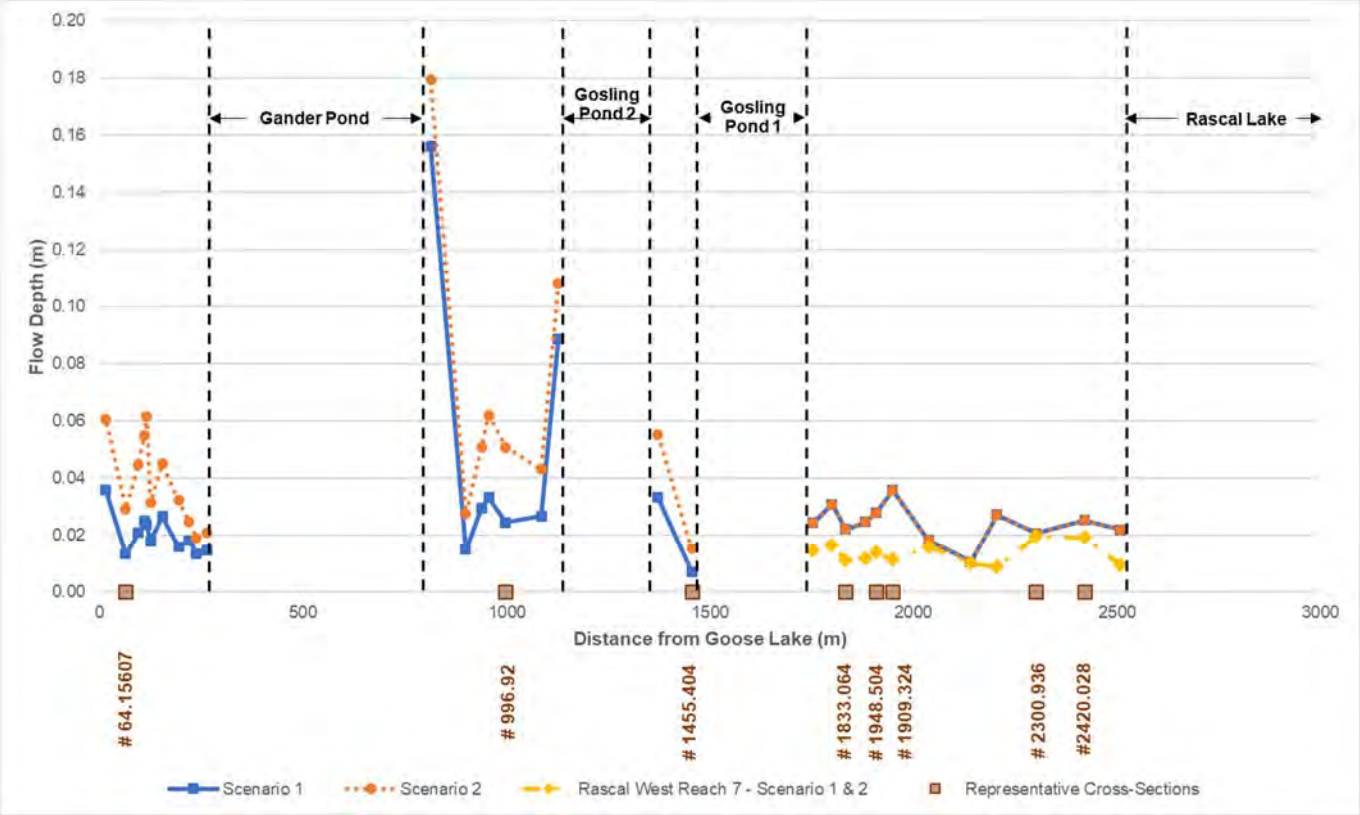
### 3.2.3.4 September 50th Percentile Discharge

Channel velocity profiles for September 50th percentile discharges are presented in Figure 14, and average flow depth profiles for September 50th percentile discharges are presented in Figure 15.




*Note: Hydraulic results (i.e., channel velocities) are not presented for waterbodies, because modeled cross-sections for lake and ponds are not representative as bathymetry data were not incorporated into the hydraulic model.*

**Figure 14: Channel Velocity Profiles for September 50th Percentile Discharge**




*Note: Hydraulic results (i.e., average flow depths) are not presented for waterbodies, because modeled cross-sections for lake and ponds are not representative as bathymetry data were not incorporated into the hydraulic model.*

**Figure 15: Flow Depth Profiles for September 50th Percentile Discharge**

### 3.2.3.5 50th Percentile Results Summary

The following observations are based on the channel velocity and flow depth profiles for the 50th percentile monthly discharges at the modeled cross-sections:

- For the 50thpercentile June modeled discharges:
  - Scenario 1 channel velocities in the natural channel are typically less than 0.6 m/s. Scenario 2 channel velocities increase downstream of Gosling Pond 1 from Scenario 1 to 1.2 m/s in RSW Reach 1 in natural channels and to 1.6 m/s at the box culvert outlets, but channel velocities are within 0.3 m/s of Scenario 1 conditions for RSW Reach 2 and 3.
  - Scenario 1 average depths are below 0.06 m in all reaches except RSW Reach 2 where average channel depths are up to 0.18 m. Scenario 2 average depths increase from Scenario 1 downstream of Gosling Pond 1 by approximately 0.02 m in the natural channel and at the box culvert inlets by up to 0.14 m.

- For the 50th percentile July modeled discharges:
  - Scenario 1 channel velocities in the natural channel are less than 0.5 m/s. Scenario 2 channel velocities increase downstream of Gosling Pond 1 from Scenario 1 to 0.7 m/s in RSW Reach 1 in natural channels and to 0.8 m/s at the box culverts, with channel velocities within 0.4 m/s of Scenario 1 conditions for RSW downstream of Gosling Pond 1.
  - Scenario 1 average depths are below 0.05 m in all reaches except RSW Reach 2 where average channel depths are up to 0.14 m. Scenario 2 average depths increase from Scenario 1 downstream of Gosling Pond 1 by approximately 0.04 m in the natural channel and at the box culvert inlets by up to 0.05 m.
- For the 50th percentile August modeled discharges:
  - Scenario 1 channel velocities in the natural channel are less than 0.4 m/s upstream of Gosling Pond 1 and below 0.1 m/s downstream of Gosling Pond 1. Scenario 2 channel velocities increase downstream of Gosling Pond 1 from Scenario 1 to 0.7 m/s in RSW Reach 1 in natural channels and to 0.9 m/s at the box culverts, with channel velocities of less than 0.6 m/s for RSW Reach 2 and 3.
  - Scenario 1 average depths are below 0.04 m in all reaches except RSW Reach 2 where average channel depths are up to 0.14 m. Scenario 2 average depths increase from Scenario 1 downstream of Gosling Pond 1 by approximately 0.04 m in the natural channel and at the box culvert inlets by up to 0.05 m.
- For the 50th percentile September modeled discharges:
  - Scenario 1 channel velocities in the natural channel are less than 0.5 m/s upstream of RSW Reach 1 and less than 0.6 m/s in the natural channel in RSW Reach 1. Scenario 2 channel velocities increase downstream of Gosling Pond 1 from Scenario 1 to 0.7 m/s in RSW Reach 1 in natural channels and to 1.1 m/s at the box culverts, with channel velocities of less than 0.6 m/s for RSW Reach 2 and 3.
  - Scenario 1 average depths are below 0.04 m in all reaches except RSW Reach 2 where average channel depths are up to 0.16 m. Scenario 2 average depths increase from Scenario 1 downstream of Gosling Pond 1 by approximately 0.02 m in the natural channel and at the box culvert inlets by up to 0.03 m.

### 3.2.4 Sedimentation and Erosion

Increased sedimentation and erosion may occur downstream of Rascal Fishway and the all-weather airstrip extension from activities including culvert, berm, or the Rascal Fishway diversion channel construction and due to increased discharges in RSW downstream of the diversion. The design scenarios each have a different sedimentation and erosion potential, as are described below.

**Scenario 1**: includes potential for erosion and sedimentation at the proposed culverts under the airstrip extension due to construction, however the hydrologic regime is unchanged, and therefore long-term changes in the geomorphic regime are not expected. At the all-weather road crossing, a clear span bridge was installed and because the hydrologic regime is unchanged, long-term changes in the geomorphic regime are not expected in RSW Reach 1 (also see post-construction monitoring results in Appendix C). Mitigation measures identified in previous studies (ERM 2017), which include winter construction, placement of sediment curtains (placed in an overlapping pattern to allow for fish passage) to minimize downstream conveyance of any mobilized sediment, and culvert maintenance are appropriate mitigation measures for potential erosion and sedimentation due to installation of the proposed culverts under the airstrip extension.

**Scenario 2:** includes the diversion of RSE to RSW upstream of Gosling Pond 1 (within RSE Reach 4) consisting of constructed berms and the Rascal Fishway diversion channel, which may cause sedimentation and erosion due to construction activities. In addition, the diversion of flows from RSE to RSW at the proposed airstrip extension have the potential to increase erosion potential and sediment mobilization along channel bed and banks in RSW downstream of the diversion. Potential erosion and sedimentation effects from construction are anticipated to be short-term in nature, primarily during the freshet and first year following construction. Potential erosion and sedimentation effects from the increased flows downstream of the diversion are anticipated to be medium-term in nature, but generally limited to above average hydrological conditions during late May and June (high flow periods). The greatest effects are anticipated in the first year after construction is complete, with potential erosion and sedimentation occurring during years two and three as the channel establishes a new geomorphic regime (potential bed degradation or channel widening) under high flow events. Rascal Stream is generally gravel, cobble and boulder dominated, with well-vegetated areas present, where soils are expected to be bound together by a well-established root mass. Flows are expected to be dispersed over the shallow flow path and energy is expected to be dissipated because of the gravel, cobble, and boulder dominated bed therefore resulting in a low erosion potential of the streambed and banks on a reach-scale. Furthermore, natural settling of eroded and mobilized sediment will occur in the three in-stream ponds (Gander, Gosling 1, and Gosling 2) before discharge into downstream locations where there is spawning habitat potential for Arctic Grayling (i.e., RSW Reach 1). The three ponds are expected to settle any mobilized bedload and a large portion of suspended sediment due to the low velocities within the ponds. This will result in an overall lowering of suspended sediment in Rascal Stream both downstream of the ponds and at the inlet to Goose Lake.

Recommendations for mitigation measures and monitoring for the potential erosion and sedimentation under Scenario 2 includes the following:

- A Rascal Stream monitoring program to assess the effects from erosion and sedimentation is recommended to assess channel performance and to determine if adaptive management measures are required.
- If the three in-stream ponds do not provide adequate settlement of suspended sediment or local uncontrolled erosion is observed, as determined through a monitoring program, adaptive management mitigation measures may be considered. This may include the placement of sediment curtains (placed in an overlapping pattern to allow for fish passage) in the three ponds or in Goose Lake to minimize downstream conveyance of any mobilized sediment or site-specific channel or bank armouring using gravel or boulders may also be considered at identified high-velocity locations on RSW Reach 1 in the vicinity of the existing bridge crossing. Site-specific channel or bank armouring is anticipated to be completed manually to avoid construction disturbance in the natural channels.

# 4.0 CONCLUSION AND RECOMMENDATIONS

This study provides a hydrotechnical assessment of the Rascal Stream and the Rascal Stream re-alignment (or diversion) options being considered as part of the Project. The results of this study refine and further the previous hydrotechnical assessments completed for the Rascal Stream re-alignment and fish passage studies (Rescan 2014a and ERM 2017). The results of this study are intended to serve as the basis for future design, fish passage, and mitigation design studies, as required. This study includes the following:

- A summary of the baseline data collected in 2017, 2018, and 2019 to support the hydrologic, hydraulic, and fish and fish habitat assessments of the potential re-alignments or diversions along Rascal Stream;
- The methods and results of a GoldSim hydrologic model of the Rascal Lake and Wolf Lake watersheds to simulate the hydrologic regime in Rascal Stream accounting for upstream attenuation;
- The methods and results of hydraulic modeling of two scenarios using a modified version of a previously developed HEC-RAS model, including profiles of predicted depths and velocities along the modeled reaches. The results include the predicted depths and velocities over the complete range of expected flows; and
- A discussion of the changes in stream flow depths and velocities throughout the reaches of Rascal Stream over the complete range of expected flows. This hydrotechnical information is expected to provide the information required to complete a detailed fish migration assessment and design of monitoring or potential mitigation for Rascal Stream. High-level results include:
  - No changes to Rascal Stream are anticipated upstream of the diversion. Predicted changes at the all-weather road in this report are based on two 2.5-m x 2.5-m box culverts, and therefore the installation of a clear span bridge is expected to reduce the reported increases in velocity immediately at the culvert outlets and pooling at the culvert inlets. The magnitude of reduction in velocities due to the installation of a clear-span bridge compared to the modeled culverts is currently unknown, as the geometry of the clear-span bridge has not been modeled.
  - The area with the highest modeled velocities under existing flows (Scenario 1) and the greatest modeled changes in velocities under diverted flows (Scenario 2) is downstream of the all-weather road crossing in RSW Reach 1. Not considering the locations specific to the modeled box-culvert geometry, under a 2-year discharge, maximum modeled velocity at RSW Reach 1 increased to 1.45 m/s (Scenario 2) from 1.36 m/s (Scenario 1).
  - Channel velocities for Scenario 2 in reaches downstream of Gosling Pond 1 (RSW Reaches 1, 2, and 3) are estimated to increase by up to 0.09 m/s under the 2-year event and by up to 0.74 m/s for the 100-year event, compared to the existing conditions.
  - Average water depths for Scenario 2 in reaches downstream of Gosling Pond 1 (RSW Reaches 1, 2, and 3) are estimated to increase by up to 0.09 m under the 2-year and 100-year events compared to the existing conditions.

- For the natural channel downstream of Gosling Pond 1 (RSW Reaches 1, 2 and 3, not including the modeled box culvert outlets), Scenario 2 50$^{th}$ percentile flows for all months result in channel velocities less that the existing conditions bankfull flow (2-year) channel velocities. This indicates that for average conditions, the anticipated flow velocities below the diversion are within the range of existing channel forming velocities and average diverted flows are therefore not expected to result in reach scale erosion and sedimentation.
- For the natural channel downstream of Gosling Pond 1 (RSW Reaches 1, 2 and 3), the additional diverted flows in Scenario 2 provide increased water levels compared to existing conditions, with relative changes greatest during the lower flow months (July to September).

In addition to the results provided in this report, the following recommendations are made for future consideration:

- The HEC-RAS hydraulic model currently represents an uncalibrated model with high-level validation of hydrologic and hydraulic indices. Calibration of hydraulic model parameters, such as the Manning's n roughness value, present challenges in boulder gardens with dispersed interstitial boulder flow, however, calibration information at select suitable locations may increase the confidence in the model results.
- The detailed design of diversion berms or alignment berms should consider the updated hydraulic model results from this study.
- Given the relatively high velocities predicted at the RSW Reach 1 crossing under Scenario 1, the suitability of flows for Arctic Grayling movements should be further evaluated for the upstream spawning migration of adult Arctic Grayling from Goose Lake during the spring spawning (freshet) period.
- Under Scenario 2, velocity mitigation may be required at the RSW Reach 1 all-weather road crossing and possibly at downstream constrictions in RSW Reach 1 depending on post-construction flow monitoring results. To maintain suitable conditions for upstream movements of Arctic Grayling from Goose Lake, velocity mitigation may include the strategic, site-specific (non-mechanized) repositioning of natural boulders in the stream. Repositioning may include rock riffles to create upstream pools with slower-moving water or rock clusters installed below chutes or drops to create steps and reduce potential barriers for migrating fish.

## 5.0 CLOSURE

We trust the above meets your needs, if you have any questions or concerns, please do not hesitate to contact the undersigned.

Yours Truly,

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# 7.0 STUDY LIMITATIONS

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

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Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities

**APPENDIX A**

# Rascal Stream Watershed – Supplemental Hydrometric Assessment

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# A-1.0 INTRODUCTION

This appendix presents the hydrology reconnaissance and hydrometric data collected during the 2017, 2018 and 2019 field programs as part of the hydrological assessment of Rascal Stream and the Rascal Stream watershed for the Project.

The purpose of the 2017 field program was to:

- Verify watershed boundaries;
- Observe conditions at key waterbodies in the Wolf Lake and Gander Pond watersheds;
- Undertake photographic and leveling surveys of selected lake outlets; and
- Measure stream discharges at selected lake outlets.

The purpose of the 2018 and 2019 field programs was to:

- Opportunistically join with the fish and fish habitat field programs to increase understanding of the hydrology and hydraulics downstream of Rascal Lake;
- Undertake photographic surveys of selected reaches;
- Observe conditions at the selected reaches; and
- Measure stream discharges at selected stations to improve understanding of the flow apportionment downstream of Rascal Lake to Rascal Stream West (RSW) and Rascal Stream East (RSE).

Section A-2.0 presents a summary of the hydrometric activities and of the lake outlets that were visited in 2017.

Section A-3.0 presents a summary of the hydrometric activities in 2018 and 2019 and a map of the stations that were visited in 2017, 2018 and 2019.

Section A-4.0 presents the results of the water level surveys and discharge measurements, photographs and field observations collected at selected lake outlets and stations.

# A-2.0 2017 FIELD SUMMARY

The August 2017 field program included the following hydrometric activities:

- An aerial reconnaissance of selected waterbodies was carried out to observe watershed boundaries and lake outlet characteristics on 6 August 2017.
- Water level and cross-section surveys were carried out on 6, 11 and 12 August 2017, at selected lake outlets using Real-time Kinematic Global Positioning System (RTK-GPS) survey equipment, not referenced to established benchmarks. Collected cross-sections were used in the analysis, but are not presented in this report.
- Discharge measurements were taken at selected lake outlets using a Sontek Flowtracker velocity current meter.

- Photographs were taken at each selected lake outlet during the surveys.
- At Rascal Lake and Wolf Lake outlets, temporary benchmarks were established near the outlets to support future water level surveys:
  - An existing Canada Lands Survey benchmark was identified at Rascal Lake outlet and surveyed as a temporary benchmark to support future water level surveys.
  - At Wolf Lake outlet, a temporary benchmark was established on a nearby boulder for future use.

Locations of selected lake outlets and the data collected at each outlet are as summarized in Table A-1. Lake locations are shown in Figure 7 of the main report. Locations downstream of the Rascal Lake Outlet are shown in Figure A-1.

**Table A-1: 2017 Field Lake Outlet Locations and Data Collected**

| Lake[a] | Watershed | Coordinates (m, UTM Zone 13, NAD83)[b] | | Data Collected |
|---|---|---|---|---|
| | | Northing | Easting | |
| Wolf | Wolf Lake | 7265786 | 434259 | Survey and Discharge |
| Rascal | Rascal Lake | 7268171 | 433979 | Survey and Discharge |
| Gosling 1 | Gander Pond | 7268997 | 433755 | Survey |
| Gosling 2 | Gander Pond | 7269324 | 433559 | Survey |
| Little Rascal | East Goose | 7268529 | 433994 | Survey |
| Pond 4 | Gander Pond | 7268429 | 433265 | Survey |
| Gander | Gander Pond | 7269851 | 432954 | Survey |
| WLA1 | Wolf Lake | 7266433 | 433545 | Survey |
| WLB1 | Wolf Lake | 7263194 | 434771 | Survey |
| WLC1 | Wolf Lake | 7262399 | 434366 | Survey |
| WLC2 | Wolf Lake | 7262172 | 433315 | Survey |
| WLC4 | Wolf Lake | 7262299 | 432217 | Survey |
| WLD1 | Wolf Lake | 7263854 | 432847 | Survey |
| RLA1 | Rascal Lake | 7266857 | 433658 | Survey |
| RLB1 | Rascal Lake | 7266051 | 437958 | Survey |
| RLB5 | Rascal Lake | 7264786 | 435823 | Survey |
| RLB6 | Rascal Lake | 7264329 | 435651 | Survey |

[a] Lakes were assigned arbitrary names if they were not already named. Naming convention indicates which branch of contributing lakes and which lake they are contributing to – names starting with RL contribute to Rascal Lake and names starting with WL contribute to Wolf Lake.
[b] Coordinates are not referenced to survey monuments and should be considered approximate

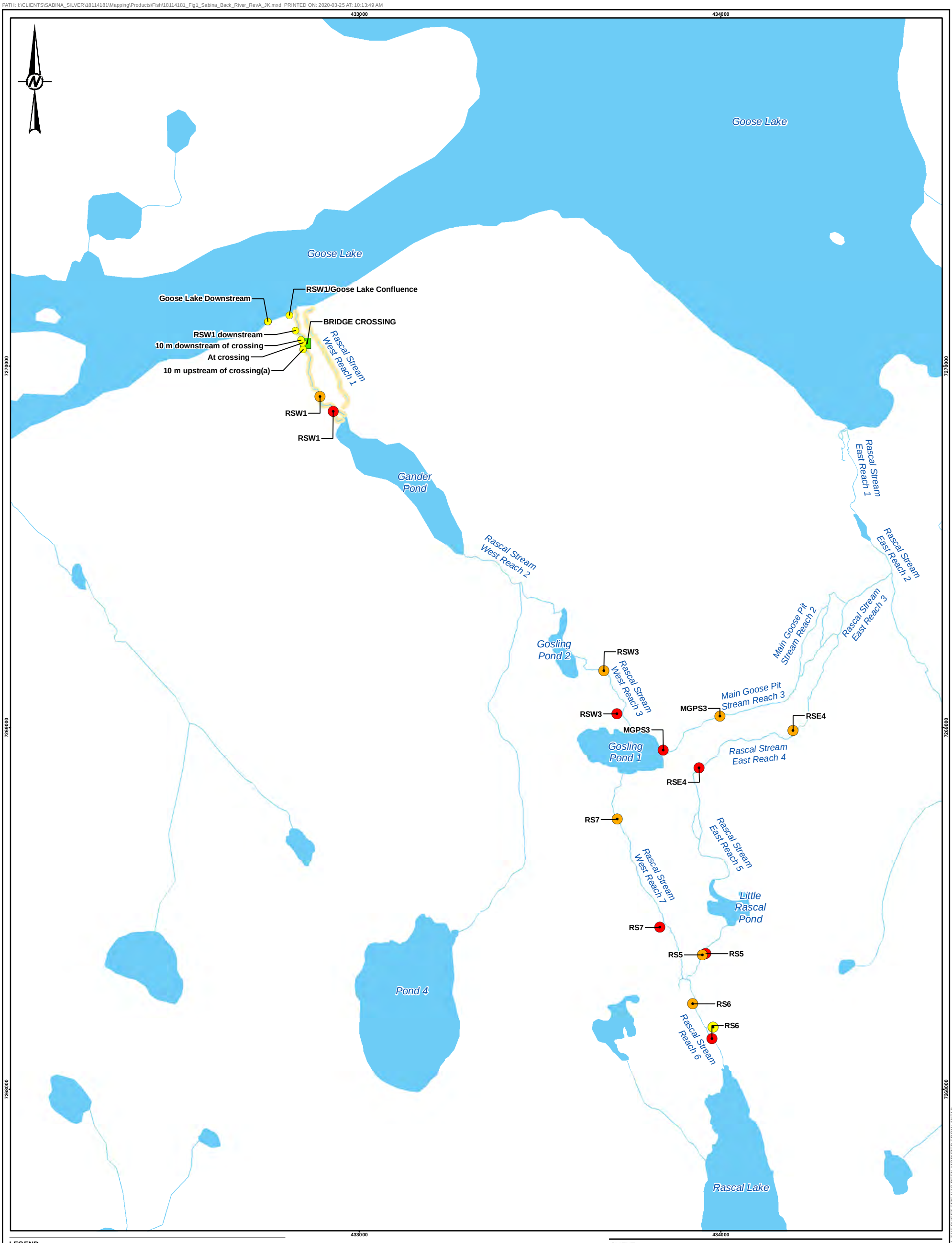
## A-3.0 2018 AND 2019 FIELD SUMMARY

The June 2018 and June 2019 field programs included the following hydrometric activities:

- Discharge measurements at 7 selected locations in both 2018 and 2019 using a Marsh-McBirney™ flow meter. Six locations were within the Rascal Stream network (Rascal Stream Reach 6, Rascal Stream East Reach 5, Rascal Stream West Reach 7, Rascal Stream East Reach 4, Main Goose Pit Stream Reach 3, Rascal Stream West Reach 3), and one was near the Gander Pond Outflow (RSW1). At each discharge location, a minimum of 20 paired velocity and depth measurements were taken across the stream wetted width.
- Photographs were taken at each station at the time of the discharge measurement.

The discharge measurement locations are shown in Figure A-1. In addition, station coordinates are provided in Table A-3.

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**LEGEND**

- DISCHARGE LOCATION (2017)
- DISCHARGE LOCATION (2018)
- DISCHARGE LOCATION (2019)
- TURBIDITY SAMPLING LOCATION
- BRIDGE CROSSING
- WATERCOURSE
- GANDER POND OUTFLOW SIDE CHANNEL
- FISH HABITAT ASSESSMENT
- WATERBODY

0 200 400
1:10,000 METRES

**NOTE(S)**
(A) CONTROL SITE; ALL SITES COMPARED TO THIS SITE

**REFERENCE(S)**
HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. WATERCOURSE WAS UPDATED BASED ON CLIENT IMAGERY. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 13N DATUM: NAD 83

CLIENT
Sabina

PROJECT
SABINA BACK RIVER PROJECT, AQUATIC BASELINE SYNTHESIS REPORT, NUNAVUT CANADA

TITLE
**DISCHARGE MEASUREMENT LOCATIONS AND BRIDGE CROSSING LOCATION AT RASCAL STREAM**

CONSULTANT
GOLDER

| | |
|---|---|
| YYYY-MM-DD | 2020-06-30 |
| DESIGNED | ZC |
| PREPARED | DR |
| REVIEWED | CV |
| APPROVED | NS |

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 18114181 | 4000/4020 | 0 | A-1 |

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
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# A-4.0 RESULTS

## A-4.1 2017 Field Measurements

The results of water level surveys and discharge measurements are presented in Table A-2. Lake Locations are shown in Figure 6 of the main report.

**Table A-2: 2017 Field Program Lake Outlet Stage and Discharge Data**

| Lake | Stage (m)[a] | Discharge ($m^3/s$) |
|---|---|---|
| Wolf | 0.34 | 0.0064 |
| Rascal | 0.16 | 0.031 |
| Gosling 1 | 0.32 | - |
| Gosling 2 | 0.12 | - |
| Little Rascal | 0.09 | - |
| Pond 4 | 0.29 | - |
| Gander | 0.05 | - |
| WLA1 | 0.06 | - |
| WLB1 | 0.14 | - |
| WLC1 | 0.28 | - |
| WLC2 | 0.06 | - |
| WLC4 | -[b] | - |
| WLD1 | -[b] | - |
| RLA1 | 0.24 | - |
| RLB1 | 0.23 | - |
| RLB5 | 0.19 | - |
| RLB6 | 0.17 | - |

[a] Stage values provided are based on the difference between the water level elevation surveyed and the estimated zero flow elevation (the lake sill) for the lake outlet
[b] Observed water level was below the zero flow elevation.
"-" = Not measured as part of the 2017 hydrometric program

## A-4.2 2018 and 2019 Field Measurements

The results of discharge measurements during the 2018 and 2019 field programs are presented in Table A-3. Station locations are shown in Figure A-1.

**Table A-3: 2018 and 2019 Field Program Station Discharge Data**

| Year | Station | UTM Coordinates (m, Zone 13, NAD83) [a] | | Discharge (Q) ($m^3/s$) |
|---|---|---|---|---|
| | | Easting | Northing | |
| 2018 | Rascal Stream Reach 6 | 433922 | 7268236 | 2.051 |
| | Rascal Stream East Reach 5 | 433949 | 7268372 | 0.788 |
| | Rascal Stream West Reach 7 | 433714 | 7268747 | 1.370 |
| | Rascal Stream East Reach 4 | 434200 | 7268992 | 0.552 |
| | Main Goose Pit Stream Reach 3 | 433998 | 7269031 | 0.522 |
| | Rascal Stream West Reach 3 | 433677 | 7269157 | 0.530 |
| | Rascal Stream West Reach 1 | 432892 | 7269915 | 0.775 |
| 2019 | Rascal Stream Reach 6 | 433976 | 7268140 | 2.663 |
| | Rascal Stream East Reach 5 | 433959 | 7268375 | 1.450 |
| | Rascal Stream West Reach 7 | 433832 | 7268448 | 0.993 |
| | Rascal Stream East Reach 4 | 433940 | 7268889 | 1.526 |
| | Main Goose Pit Stream Reach 3 | 433841 | 7268938 | 0.398 |
| | Rascal Stream West Reach 3 | 433713 | 7269038 | 1.284 |
| | Rascal Stream West Reach 1 | 432928 | 7269875 | 1.023 |

[a] Coordinates are not referenced to survey monuments and should be considered approximate

## A-4.3 2017 Photographs and Observations

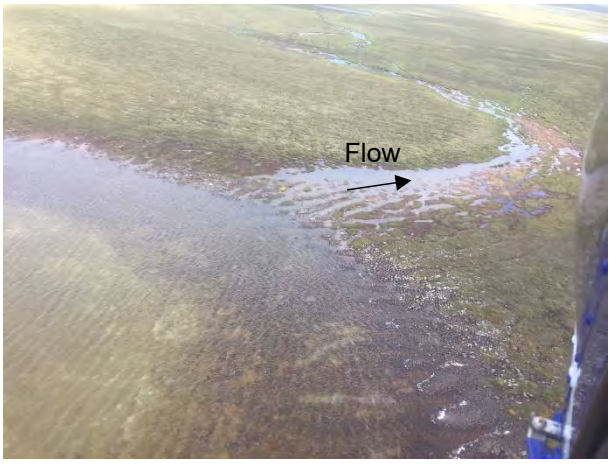
In general, the following were noted during the 2017 field program:

- Annual lake level fluctuation at all lakes visited appears to be limited, with high water marks generally approximated to be 0.3 to 1 m above the observed water level at the time of field program.
- Upper watershed lakes (i.e., tributary lakes to Wolf Lake and Rascal Lake watersheds) were observed to be generally very shallow, likely not more than 2 m deep at their deepest points, with the exception of Wolf Lake, which appeared to be deeper.
- Lake outlets are not generally conveyed through one confined channel, with most lake outlets comprised of a braided channel configuration through boulder gardens with observed interstitial boulder flow.
- Streams connecting some of the lakes appeared to be dry at the time of the field program, indicating that some lakes were not flowing at this time.

- Rascal Stream flow splits into one main west channel (RSW) and braided east channels (RSE) downstream of Rascal Lake outlet and upstream of Gosling Pond 1. RSW consists of boulder gardens, and at the time of the field program, had no observable flow, although interstitial boulder flow may have been present. RSE had visible surface flow, and the braided channel beds are comprised a thin layer of organics and fines overlying gravel, cobbles, and boulders. Due to channel configuration, the discharge measurements taken at RSW and RSE may not be representative (i.e., minor braids of RSE not captured, interstitial flow not captured in boulder garden of RSW). Based on field observations, RSE generally appeared to carry higher flows than RSW.
- Gosling Pond 1 has two outlets, one discharging north towards Gosling Pond 2 (also considered RSW), and one discharging east, designated as Goose Stream Reach 3, that joins together with RSE. Based on field observations, the north outlet appears to be the primary outlet, while the east outlet is secondary, although the east outlet may carry higher proportions of flow in freshet when the lake level is higher, compared to the flow apportionment in summer and fall. The channels described above are shown in Figures 1 and 2 of the main report.
- RSE, downstream of Little Rascal Pond, and Goose Stream Reach 3 do not have a confluence upstream (west) of the airstrip, and there are two defined channels that flow at the proposed airstrip extension location.
- In the Rascal Re-alignment Hydraulic Model memo (Rescan 2014c), Rabbit Lake (north of WLD3 watershed and west of Wolf Lake Watershed) contributes to the Rascal Lake watershed via the Wolf Lake watershed. During the aerial reconnaissance and ground survey, no outlet was observed from this lake flowing east to Wolf Lake, but it was rather observed to flow to the northwest. Therefore, this lake and its watershed have been removed from the drainage areas used for this Project, as shown in Figure 6 of the main report.

Photographs from the hydrological assessment are shown in Table A-4.

**Table A-4: 2017 Field Program Photographs**

| | |
|---|---|
|  |  |
| **Photo A-1: View of Wolf Lake outlet looking downstream (6 August 2017)** | **Photo A-2: View of Wolf Lake and outlet looking South (11 August 2017)** |

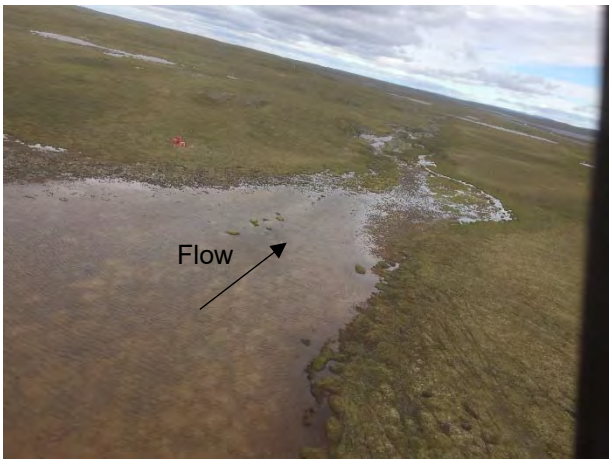



**Photo A-3: View of Rascal Lake outlet looking downstream (6 August 2017)**



**Photo A-4: View of Rascal Lake looking Southwest (6 August 2017)**



**Photo A-5: View of Canada Lands Survey Benchmark encountered at Rascal Lake Outlet (6 August 2017)**



**Photo A-6: View of Temporary Benchmark established at Wolf Lake Outlet (11 August 2017)**

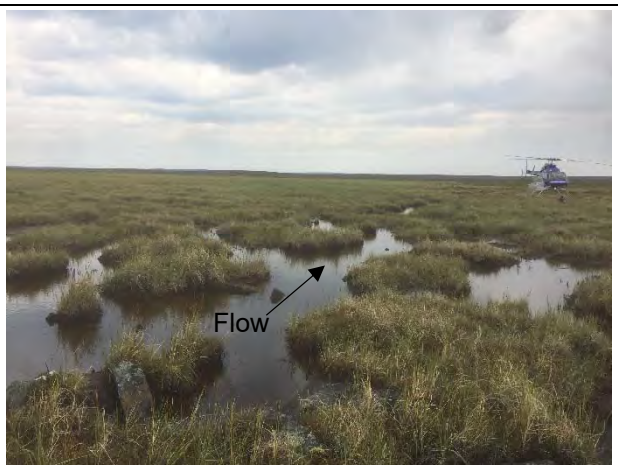



**Photo A-7: View of RLA1 outlet looking downstream (16 August 2017)**

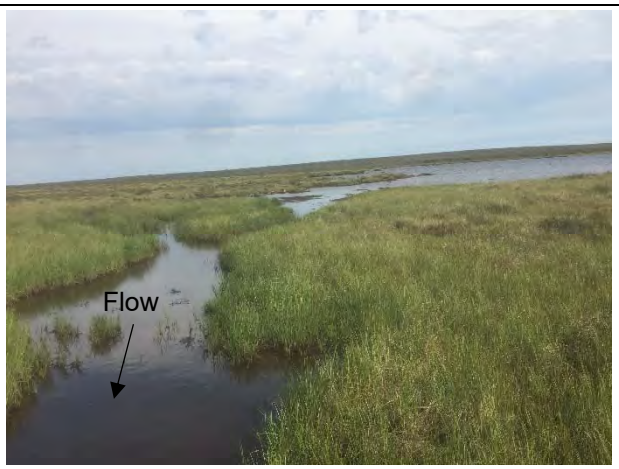



**Photo A-8: View of RLB1 outlet looking upstream (16 August 2017)**




**Photo A-9: View of RLB5 outlet looking upstream (16 August 2017)**




**Photo A-10: View of RLB5 outlet looking upstream (16 August 2017)**

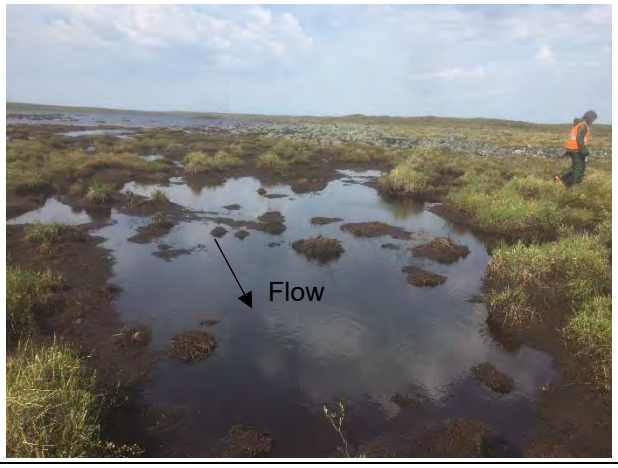



**Photo A-11: View of WLA1 outlet looking upstream (16 August 2017)**

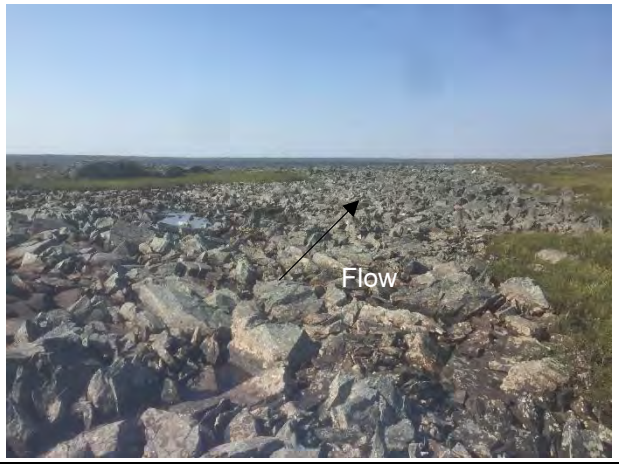



**Photo A-12: View of WLB1 outlet looking downstream (16 August 2017)**




**Photo A-13: View of WLC1 outlet looking at left downstream bank (16 August 2017)**

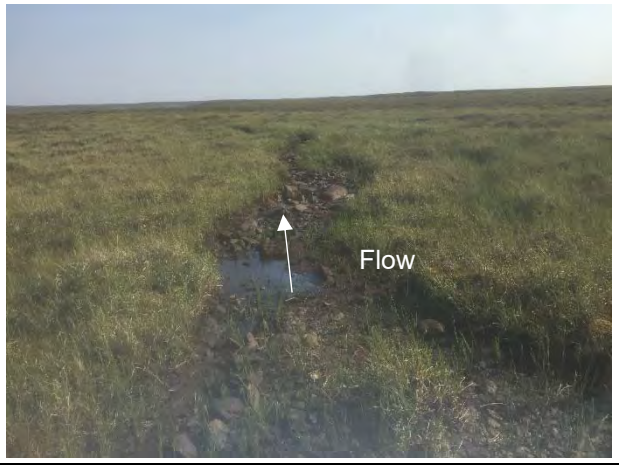



**Photo A-14: View of WLC2 outlet looking downstream (16 August 2017)**

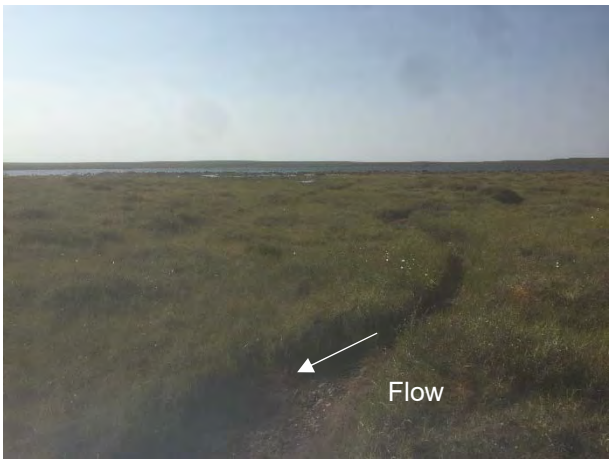



**Photo A-15: View of WLC4 outlet looking upstream (16 August 2017)**

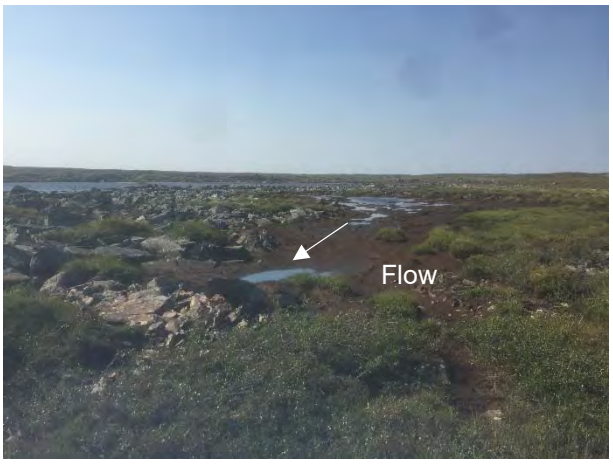



**Photo A-16: View of WLD1 outlet looking upstream (16 August 2017)**

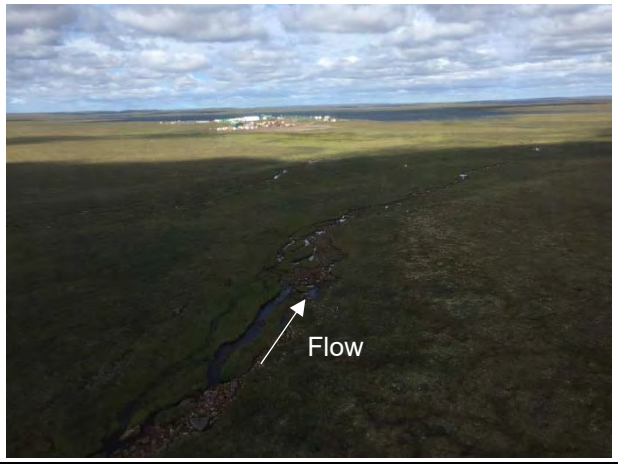



**Photo A-17: View of RSE and Goose Stream Reach 3 near the proposed airstrip extension looking downstream (6 August 2017)**

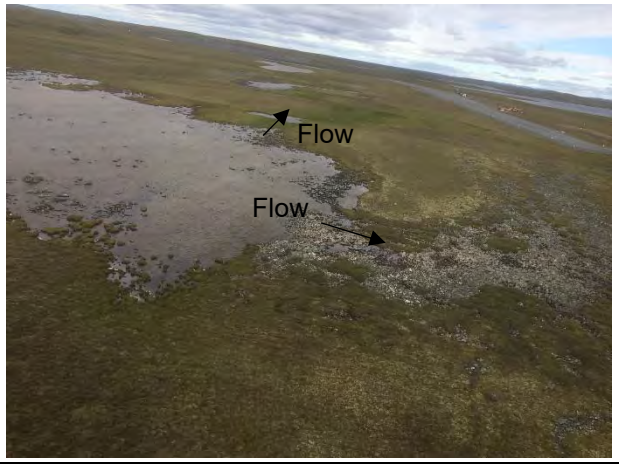



**Photo A-18: View of Gosling 1 Pond and its East and North outlets looking North (6 August 2017)**

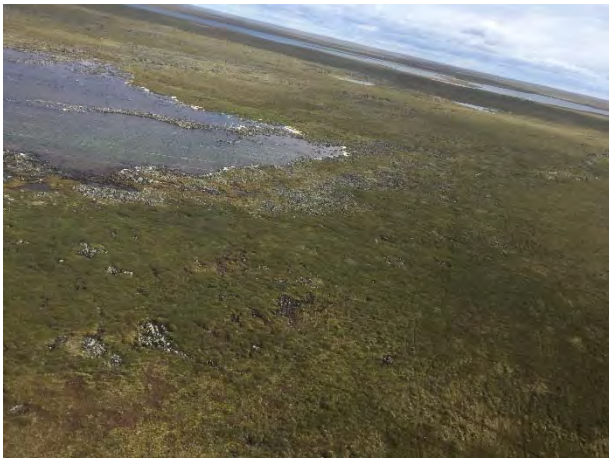


**Photo A-19: View of Potential Outlet of Lake to the North of WLD3 watershed and West of Wolf Lake Watershed looking Northeast (6 August 2017)**



**Photo A-20: View of Potential Outlet of Lake to the North of WLD3 watershed and West of Wolf Lake Watershed looking East, no visible channel or outlet observed (12 August 2017)**

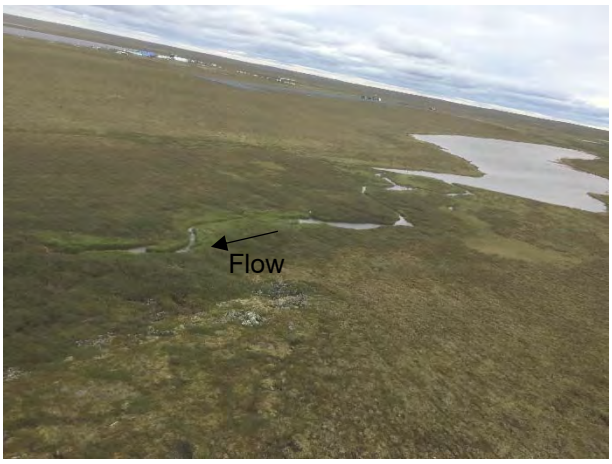



**Photo A-21: View of Gander Pond and Existing Airstrip looking Southeast (6 August 2017)**




**Photo A-22: View of Gosling 2 Pond Outlet and Gander Pond Looking North towards Goose Lake (6 August 017)**

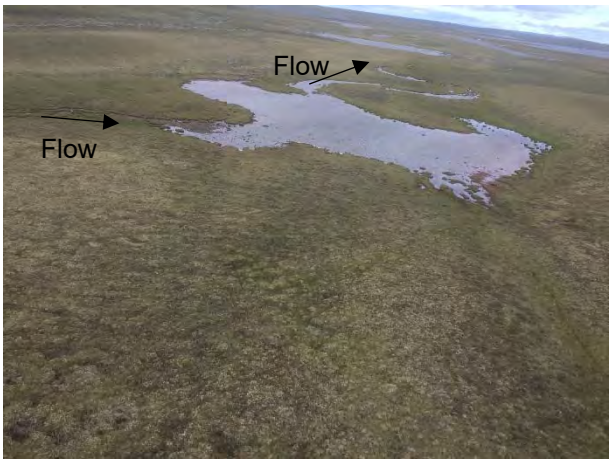



**Photo A-23: View of Little Rascal Pond and RSE looking Northeast (6 August 2017)**

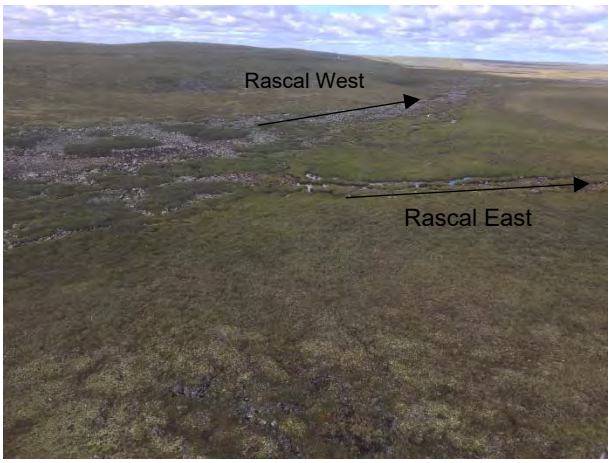



**Photo A-24: View of Rascal Stream flow split Looking Northwest (6 August 2017)**

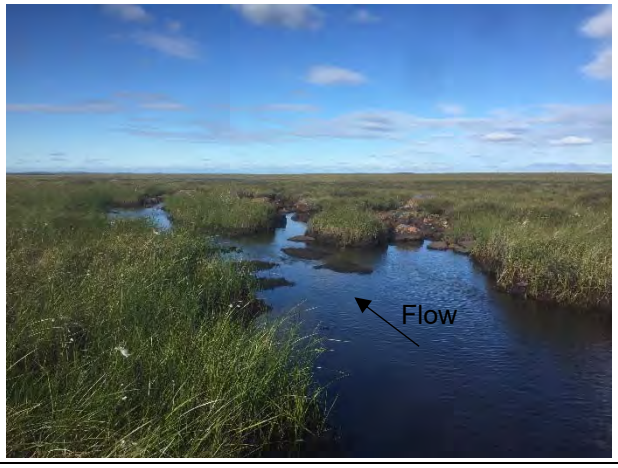



**Photo A-25: View of RSE looking Downstream (6 August 017)**




**Photo A-26: View of RSW looking Upstream from Gosling 1 Pond (6 August 2017)**

## A-4.4 2018 and 2019 Photographs and Observations

In general, the following observations were noted during the 2018 and 2019 field programs:

- The observed flow conditions in June 2018 and June 2019 appeared to be generally representative of bankfull conditions.
- The reaches are not generally conveyed through a single channel, with most comprised of a braided channel configuration or the channel being overtopped.
- The discharge station in Rascal Stream Reach 6 (RS6) was located approximately 120 m north of Rascal Lake in a straight reach. In 2019, RS6 was flooded with flows overbank on RDB (Photo A-27). Substrate was dominated by cobbles and boulders. Rock piles and grass species were present along the LDB and RDB, respectively.
- The discharge location in Rascal Stream East Reach 5 (RSE5) was located approximately 120 m southwest of Little Rascal Pond. In 2019, RSE5 was flooded during the survey with unconfined flow on both banks and multiple flow pathways (Photo A-28). Substrate was dominated by grasses in flooded region and cobble and boulders in the main channel. Vegetation patches and islands were present throughout.
- In 2019, the discharge location in Rascal Stream West Reach 7 (RSW7) was located within a boulder garden with moderately defined banks and flooding causing flow over grasses along the RDB (Photo A-29). Substrate was dominated by cobble and boulders with vegetation islands along the RDB.
- The discharge location in Rascal Stream East Reach 4 (RSE4) was located 430 m north of Little Rascal Pond. In 2019, RSE4 was in flood with well defined banks and flow over flooded grasses (Photo A-30). Substrate was dominated by cobbles and boulders within the main channel. Vegetation piles were present along the LDB and RDB.
- The discharge location in Main Goose Pit Stream Reach 3 (MGPS3) was located at the eastern outflow of Gosling Pond 1 where flows were confined to three channels with minimal instream obstacles and well-defined banks (Photo A-31). In 2019, substrate was dominated by cobbles, with boulders present creating flow obstacles.
- The discharge location in Rascal Stream West Reach 3 (RSW3) was located 50 m north of Gosling Pond 1. In 2019, RSW3 was in flood during the assessment with well-defined banks and flow observed over flooded grasses along both banks (Photo A-32). Substrate was dominated by gravel and cobble.
- The discharge location in RSW1 was located at the northern outflow to Gander Pond in a location where high flows were within widened channel banks (Photo A-33). In 2019, substrate was dominated by sand. Submerged riparian vegetation was present along RDB.

Photographs from the hydrological assessment are shown in Table A-5.

**Table A-5: 2018 and 2019 Field Program Photographs**

| | |
|---|---|
|  |  |
| **Photo A-27: View upstream towards discharge location at RS6 (20 June 2019)** | **Photo A-28: View downstream towards discharge location along main channel section at RS5 (21 June 019)** |
|  |  |
| **Photo A-29: View downstream towards discharge location at RS7 (21 June 2019)** | **Photo A-30: View upstream towards discharge location at RSE4 (20 June 2019)** |



**Photo A-31: View downstream towards discharge location at MGPS3 (21 June 2019)**



**Photo A-32: View downstream towards discharge location at RSW3 (20 June 2019)**



**Photo A-33: View downstream towards discharge location at RWS1 (20 June 2019)**



**Photo A-34: View of flooded area upstream of bridge crossing in riffle habitat at RSW1 (20 June 2019)**



**Photo A-35: View downstream towards bridge crossing in riffle habitat at RSW1 (20 June 2019)**



**Photo A-36: View upstream towards bridge crossing at Run 2 habitat type at RSW1 (20 June 2019)**



**Photo A-37: View of flooded area downstream of bridge crossing in riffle habitat at RSW1 (20 June 2019)**



**Photo A-38: Gander Pond outlet side channel downstream of bridge looking downstream (20 June 2019)**



**Photo A-39: View downstream at discharge location at RS6 (14 June 2018)**



**Photo A-40: View downstream at discharge location at RS5 (14 June 2018)**



**Photo A-41: View downstream at discharge location at RS7 (14 June 2018)**



**Photo A-42: View downstream at discharge location at RSE4 (13 June 2018)**



**Photo A-43: View downstream at discharge location at MGPS3 (13 June 2018)**



**Photo A-44: View upstream at discharge location at RSW3 (13 June 2018)**



**Photo A-45: View downstream at discharge location at RWS1 (14 June 2018)**

**APPENDIX B**

# Rascal Stream East and Rascal Stream West – Supplemental Fish Habitat Assessment, Summer 2017

# Table of Contents

**B-1.0 INTRODUCTION ..... 2**

**B-2.0 FISH HABITAT ASSESSMENT ..... 4**

**TABLES**

Table B-1: Qualitative Assessment of Rascal Stream West Reach 7 Diversion on Arctic Grayling ..... 6

# B-1.0 INTRODUCTION

This appendix presents the fish and fish habitat data collected concurrently with the collection of hydrometric data during the 2017 field study as part of the evaluation of Rascal Stream and the Rascal Stream watershed for the Back River Project (the Project). The Rascal Stream watershed is where Sabina intends to extend the existing all-weather airstrip servicing the Goose Property (Figure B-1). This extension would intersect with Rascal Stream East (RSE) and Main Goose Pit Stream that currently flow northeast into Goose Lake, where there is the potential to affect the Arctic Grayling (*Thymallus arcticus*) population associated with Rascal Stream (Figure B-1).
Two main options are being considered to mitigate effects of the all-weather airstrip extension and Project infrastructure (Sabina 2017).

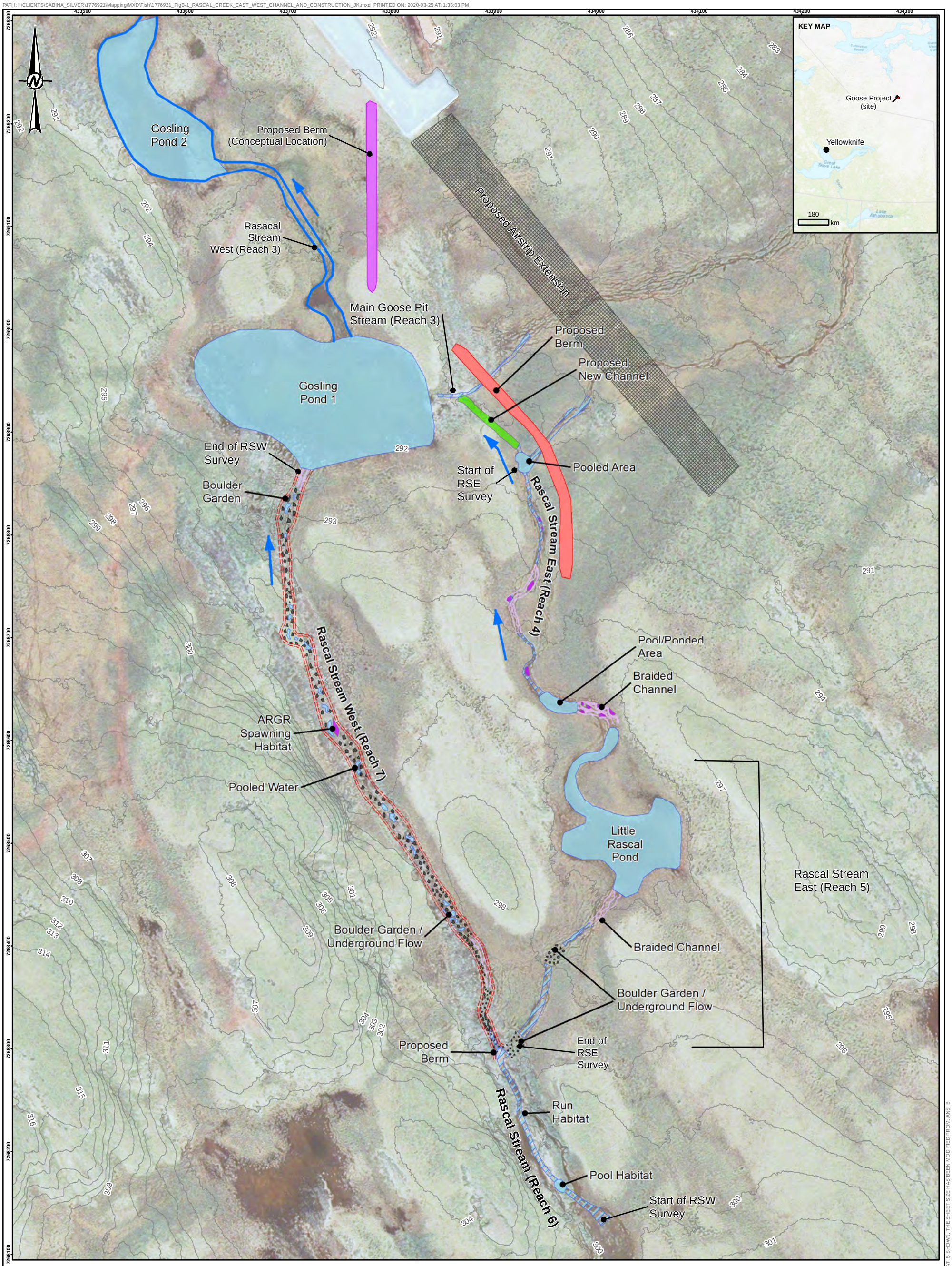
The first design scenario is the installation of culverts under the airstrip extension too maintain existing channel alignments (i.e., hydrologic connectivity to upper sections of RSE), combined with the installation of fish barriers on Main Goose Pit Stream Reach 3 and RSE Reach 4 (Sabina 2017). These barriers are intended to prevent fish from Gosling Pond 1 and upper RSE from entering lower sections of RSE, where flows will be modified due to mining infrastructure at headwater locations east of the airstrip. The fish barriers are a potential mitigation feature to prevent fish from using a spawning area where Project-related effects may reduce habitat quality and result in stranding and egg mortality (i.e., create an ecological trap for Arctic Grayling).

The second design scenario is the installation of berms on RSE and Main Goose Pit Stream (southwest of the proposed airstrip extension) to divert all flows from RSE and Gosling Pond 1 through RSW to Goose Lake (Sabina 2017). The basic premise of this mitigation concept is the use of berms to redirect flows from potentially poor-quality habitats to higher-quality habitats where they can be utilized by spawning Arctic Grayling.
The installation of berms would result in the modification of RSE (upper section of Reach 4), creating what was previously termed the ‘Rascal Fishway’. This modification is expected to mitigate effects of altered habitat east of the airstrip due to mining infrastructure, including lower sections of RSE, by improving fish passage conditions from Goose Lake to upper RSE through RSW, and by increasing available habitat for spawning and rearing through increased flows.

During the environmental review of the Project by Fisheries and Oceans Canada (DFO 2017), a modification to the second design scenario was also considered to further improve the productivity of the system for Arctic Grayling. This conceptual design was the installation of a berm to divert flows from RSW Reach 7, just downstream of Rascal Lake outlet, to RSE Reach 5. The diversion was intended to move flows from relatively poor-quality habitat in RSW Reach 7, where flows are dispersed over a boulder garden, to upper RSE (Reach 4 and 5) where flow augmentation has the potential to enhance the spawning capacity of habitat (Sabina 2017).
As part of the evaluation of the potential benefits of the diversion, habitat surveys were performed in August 2017 for RSE and RSW. These surveys collected observational data on the following:

- Dominant habitat features and habitat quality for Arctic Grayling in RSW Reach 7
- Dominant habitat features and habitat quality for Arctic Grayling in RSE (including Reach 4 and 5) immediately upstream of the proposed “Rascal Fishway”
- Incidental observations of any fish present in the stream sections assessed for habitat type and quality.

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**LEGEND**

- CONTOUR (1 m INTERVAL)
- EDGE OF WATERCOURSE (NOT SURVEYED)
- PROPOSED BARRIER
- FLOW DIRECTION
- POTENTIAL HABITAT LOSS
- ARCTIC GRAYLING (ARGR) SPAWNING HABITAT
- BOULDER GARDEN
- BRAIDED CHANNEL
- POND / POOLED WATER
- RUN HABITAT
- PROPOSED AIRSTRIP EXTENSION
- PROPOSED NEW CHANNEL

**PROPOSED BERMS**

- CONTAINMENT BERM
- DIVERSION BERM

0 80 160
1:3,500 KILOMETRES

**REFERENCE(S)**

CONTOURS (LIDAR) AND IMAGERY (DATED 2012-11-11) PROVIDED BY CLIENT.
INSET SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
SABINA GOLD & SILVER CORP.

PROJECT
BACK RIVER PROJECT

TITLE
**RASCAL STREAM FISH HABITAT**

CONSULTANT
GOLDER

| | |
|---|---|
| YYYY-MM-DD | 2020-06-30 |
| DESIGNED | AE |
| PREPARED | JG/MP |
| REVIEWED | CV |
| APPROVED | CS |

| PROJECT NO. | CONTROL | REV. | FIGURE |
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# B-2.0 FISH HABITAT ASSESSMENT

## *Rascal Stream West*

Previous assessments of upper RSW characterized this section as dominantly boulder garden with poor to fair spawning habitat for Arctic Grayling (Sabina 2017). This stream was determined to be potentially impassible to upstream movements of fish during low flow periods due to the abundance of large, closely packed boulders. These findings are also consistent with observations made by the Golder field crew during their habitat assessment conducted on 6 August 2017 (Photo B-1).

The habitat assessment was conducted on a 650-m long reach of RSW (Reach 7), starting at the confluence with RSE, approximately 200 m downstream from the outflow of Rascal Lake, and ending at the inflow of RSW into Gosling Pond 1 (Figure B-1). Immediately downstream of the outflow of Rascal Lake, the channel was well defined, cobble dominated (95%) with fines (5%) sub-dominant, submergent aquatic algae (20%) and flowed in a straight pattern (Photo B-2). This section had an average bankfull width of approximately 2 m and an average depth of 0.2 m. This channelized section splits into RSE and RSW, and immediately downstream of the split, RSW flows into a boulder garden (Photo B-3). Approximately 60 m downstream of the boulder garden, several braided channels emerge (Photo B-4). Each of the braided channels had an average bankfull width of approximately 1 m and an average depth of 0.4 m. The substrate consisted primarily of cobble (75%) with boulders (20%) and some gravel (5%). The braided channel section continued for approximately 60 m before flowing into another boulder garden (Photo B-5). Throughout this boulder garden, several pools were observed (Photo B-6) as well as one 2 m by 1 m raised section of gravel (Photo B-7). The boulder garden continued for approximately 450 m, then formed into several braided channels that flowed for approximately 55 m before flowing into Gosling Pond 1 (Photo B-8).

Fish were frequently observed throughout the pools and braided sections of the assessed section of RSW. Incidental visual observations included an estimated 50 juvenile Arctic Grayling. However, at the time of the assessment, connectivity was limited, and it is highly likely that these fish were stranded and unable to migrate to Gosling Pond 1 or Rascal Lake. Fish habitat throughout RSW at the time of the assessment was generally poor for rearing and migratory functions based on the lack of connectivity and channelization, and the frequency of closely packed large boulders in the boulder gardens which would present a barrier to fish movement under low flows. The braided sections may provide some rearing habitat during high and moderate water level periods, but access would be limited by the boulder gardens during low water periods in the watercourse. Only a single gravel bar was observed that has the potential to serve as spawning habitat for Arctic Grayling during spring conditions. However, it was elevated from the level of what could be considered the channel bed, and was characterized by terrestrial vegetation on the edge. The presence of vegetation would indicate that most of the gravel bar has been above water for most of the open water season. Sufficient depth was not observed anywhere in this section of RSW to be utilized as overwintering habitat.

## *Rascal Stream East*

The fish habitat assessment of Racal Stream East was conducted on 6 August 2017, on a 760-m long reach of RSE (Reach 4 and 5), starting from the confluence with RSW, approximately 200 m downstream from the outflow of Rascal Lake, and ending at the proposed construction of the ‘Rascal Fishway’ (Figure B-1). At the time of the assessment, the first 25 m of RSE (Reach 5) flowed through a boulder garden with no flow or channelization observed (Photo B-9). The channel then splits into three channels, each with an average bankfull width of approximately 0.8 m and an average depth of 0.2 m (Photo B-10). The substrate was comprised of cobble (80%)

with boulders (10%) and gravel (10%). These three channels continue for approximately 75 m at which point braiding becomes more extensive and flows are primarily subsurface over a distance of 25 m before returning to the surface and flowing into Little Rascal Pond (Photos B-11 and B-12). The outflow of Little Rascal Pond consisted of a section of braided channels with an average bankfull width of approximately 1 m and an average depth of 0.3 m (Photo B-13). The substrate was comprised of mainly cobble (60%) with gravel (30%) and boulders (10%). Approximately 60 m downstream of Little Rascal Pond (Reach 4), the braided outflow became a single channel for approximately 115 m (Photo B-14), then braided for approximately 50 m before water flowed through a single channel again. Substrate in all of these sections was comprised primarily of cobble (60%) with boulder (20%) and gravel (20%). Throughout RSE downstream of Little Rascal Pond (upper section of Reach 4), several gravel bars were observed, all 1 to 3 m in length (Photo B-15). At the site of the proposed 'Rascal Fishway', RSE takes a 90 degree turn to the northeast where the proposed airstrip extension will be constructed (Photo B-16). The section of land through which the 'Rascal Fishway' will be constructed is relatively flat with few boulders and vegetated with grasses and shrubs (Photo B-17). The reach of Main Goose Pit Stream (Reach 3) that would flow into Gosling Pond 1 after the completion of the Rascal Fishway consisted of a boulder garden (Photo B-18).

Fish were frequently observed throughout the habitat assessment of RSE. Incidental visual observations included an estimated 35 juvenile Arctic Grayling, 1 adult Arctic Grayling, 5 Slimy Sculpin (*Cottus* cognatus) and 5 Burbot (*Lota lota*). Observations of fish were not as frequent in the surveyed sections of RSE as in RSW, however, the detectability of fish was likely lower in RSE versus RSW. RSE was characterized by more cover and connectivity, which suggests that any fish present had more opportunity to hide and escape as the crew moved throughout the stream. Several gravel bars were observed, particularly in the section of RSE downstream of Little Rascal Pond (upper Reach 4), and these sections were deemed fair to good-quality spawning habitats for Arctic Grayling. Rearing habitat throughout the reach was of good quality, with boulders providing the majority of the cover. Both the section immediately downstream of where Rascal Stream flow splits into RSE and RSW and the section immediately upstream of the inflow to Gosling Pond 1 were boulder gardens, and would function as barriers to upstream fish movements at times of low water. Recommendations for 'Rascal Fishway' above Gosling Pond 1 include the manipulation of boulders to create a passable channel for fish during a range of flow conditions. Sufficient depths for overwintering habitat were not observed anywhere in the surveyed section of RSE.

## B-3.0 CONCLUSION

Although most of RSW Reach 7 may provide poor-quality habitat for spawning Arctic Grayling, sections of the reach may provide suitable habitat for foraging and migrating juvenile fish depending on flow conditions for a given year. Assuming there is sufficient flow for the downstream outmigration of juveniles in late summer, the diversion of flows from RSW Reach 7 to RSE Reach 5 would result in losses of suitable rearing habitat, which may negatively impact the Arctic Grayling production. However, during a low-flow year and the absence of a high precipitation event in late summer, fish using RSW Reach 7 for rearing or as a corridor for downstream movements are expected to be restricted resulting in mortalities during ice freeze-up (Table B-1). Under these conditions, the potential diversion of flows from RSW Reach 7 to RSE Reach 5 will improve juvenile recruitment to the local population.

The assessed upper sections of RSE (Reach 5 and upper Reach 4) were deemed to provide fair to good quality spawning habitat and good quality rearing habitat for Arctic Grayling under baseline conditions. Based on a qualitative evaluations of habitat, an increase in flows in upper sections of RSE may increase available habitat for spawning and rearing Arctic Grayling, and therefore, the diversion of flows from RSW Reach 7 to RSE Reach 5 has the potential to increase productivity of the local population, particularly during a low precipitation year (Table B-1).

In conclusion, the installation of the RSW Reach 7 berm has the potential to increase the quality and abundance of habitat for spawning and rearing Arctic Grayling, while reducing the risk of juvenile mortality during outmigrations. However, the overall long-term benefits of the diversion to fish production is uncertain and may only be minor in magnitude. It is recommended that alternative mitigations are considered for RSW Reach 7 to enhance the productivity capacity of Rascal Stream, specifically low-flow channels in boulder gardens where flows are dispersed.

**Table B-1: Qualitative Assessment of Rascal Stream West Reach 7 Diversion on Arctic Grayling**

| Flow Scenarios | Baseline Conditions | | Diversion Predictions |
|---|---|---|---|
| | RSW Reach 7[(a)] | RSE Reach 5 and Upper Reach 4[(b)] | Overall Net Effect |
| Below-Average Flows | Poor quality rearing habitat<br>Low juvenile survival | Fair to good quality spawning and rearing habitat<br>Low to moderate juvenile mortality | Increase in quality and abundance of overall habitat<br>Higher juvenile survival |
| Average Flows | Poor to fair quality rearing habitat<br>Low to moderate juvenile survival | Fair to good quality spawning habitat and good quality rearing habitat<br>High juvenile survival | Potential increase in quality and abundance of overall habitat<br>Potential increase in juvenile survival |
| Above-Average Flows | Fair to good quality rearing habitat<br>High juvenile survival | High quality spawning and rearing habitat<br>High juvenile survival | Decrease in quality and abundance of rearing habitat<br>No change in juvenile survival |

[(a)] RSW Reach 7 has limited potential for spawning Arctic Grayling given the lack of suitable substrate in the reach; key functions of the reach may include rearing and migration habitat during above-average flow years.
[(b)] RSE Reach 5 and upper Reach 4 functions may include spawning, rearing, and migration habitat.



**Photo B-1: Aerial overview of boulder gardens comprising RSW (Reach 7) (August 2017)**



**Photo B-2: Section of Rascal Stream downstream of Rascal Lake, before flow split to RSW and RSE, looking upstream (August 2017)**



**Photo B-3: RSW (Reach 7) boulder garden immediately downstream of confluence with RSE, looking downstream (August 2017)**



**Photo B-4: RSW (Reach 7) braided channels flowing out of first boulder garden, looking downstream (August 2017)**



**Photo B-5: RSW (Reach 7), braided channels flowing into boulder garden, looking downstream (August 2017)**



**Photo B-6: Representative photo of pools found throughout the boulder gardens on RSW (Reach 7) (August 2017)**



**Photo B-7: 'Perched' gravel bar observed on RSW (Reach 7); note the terrestrial vegetation (August 2017)**



**Photo B-8: RSW (Reach 7), braided channels flowing out of boulder garden and into Gosling Pond 1 (in background) (August 2017)**



**Photo B-9: Boulder garden, first 25 m of RSE (Reach 5) immediately downstream of the Rascal Stream flow split (Reach 7), looking downstream (August 2017)**



**Photo B-10: RSE (Reach 5), braided channels flowing out of boulder garden, looking downstream (August 2017)**



**Photo B-11: RSE (Reach 5), approximately 25 m long section of underground flow, looking downstream (August 2017)**



**Photo B-12: RSE (Reach 5), braided channels flowing into Little Rascal Pond (in background), looking downstream (August 2017)**



**Photo B-13: RSE (Reach 4), representative photo of braided channel sections downstream of Little Rascal Pond, looking downstream (August 2017)**



**Photo B-14: RSE (Reach 4), representative photo of single channel sections downstream of Little Rascal Pond, looking downstream (August 2017)**



**Photo B-15: RSE (Reach 4), representative photo of gravel bars (potential Arctic Grayling spawning habitat) found throughout Reach 4 and Reach 5 (August 2017)**



**Photo B-16: RSE (Reach 4) where creek turns 90 degrees to the northeast, red line representative of approximate airstrip extension location, looking downstream (August 2017)**



**Photo B-17: Proposed approximate path of Rascal Fishway (in red), looking north (August 2017)**



**Photo B-18: Main Goose Pit Stream (Reach 3), boulder garden section immediately upstream of the stream outlet from Gosling Pond 1 (in background), looking west (August 2017)**

# B-4.0 REFERENCES

DFO (Fisheries and Oceans Canada). 2017. Final Written Submission – Final Environmental Impact Statement Addendum. Submitted to the Nunavut Impact Review Board (NIRB). April 24, 2017.

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**APPENDIX C**

# Rascal Stream East and Rascal Stream West – Supplemental Fish Habitat Assessment, Summer 2019

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# C-1.0 INTRODUCTION

This appendix presents the fish and fish habitat data collected concurrently with the collection of hydrometric data during the 2019 field study as part of the evaluation of Rascal Stream and the Rascal Stream watershed for the Back River Project (the Project). The primary task of the 2019 study was to survey fish habitat conditions during spring flows at the newly constructed bridge crossing over the lower reach (Reach 1) of Rascal Stream West (RSW), also referred to as Gander Pond Outflow.

The 2019 study of fish habitat conditions collected environmental data on the following:

- Dominant habitat types and habitat quality for Arctic Grayling in RSW Reach 1
- Physical dimensions and composition substate of each habitat unit
- Nephelometric turbidity unit (NTUs) measurements
- Photographs of delineated habitat units and potential barriers to fish movements

The 2019 field study also collected supplemental hydrological measurements on spring flow conditions upstream of the newly construction bridge crossing to inform the evaluation of water management options related to the all-weather airstrip expansion. Hydrometric data are summarized in Appendix A of the 'Rascal Stream Fishway Hydrotechnical Assessment'.

# C-2.0 RASCAL STREAM WEST - FISH HABITAT

A detailed fish habitat survey was completed at the bridge crossing on Rascal Stream West Reach 1 (RSW1) on 20 June 2019. The survey covered a 405-m section of stream extending from the outlet of Gander Pond (310 m upstream of the bridge crossing) to the confluence with Goose Lake (95 m downstream of the bridge crossing). Instream habitat was classified into distinct habitat units, corresponding to areas of similar habitat type as defined in O'Neil and Hildebrand (1986). Measurements of the physical dimensions at each habitat unit included wetted width, channel length, bank-full width and water depth. Composition substrate (based on Wentworth scale) and availability of instream cover were visually estimated as a percentage of the total area within each habitat unit. Left and right downstream bank (LDB and RDB) stability, fish habitat potential, and potential barriers to fish movement were recorded and documented by photographs. Nephelometric turbidity units (NTUs) were measured within the survey area using a LaMotte 2020; six measurements were taken downstream of the bridge crossing, one at the bridge crossing, and one measurement at a reference location upstream of the bridge crossing (locations are reported in (Table C-1). Additional *in situ* water quality variables that were measured at the bridge crossing included temperature (°C), conductivity (µS/cm), and pH. A scoping level visual assessment of a previously undescribed secondary outflow channel was also completed; the secondary channel was a 318 m section from Gander Pond to Goose Lake (Figure A-1 in Appendix A).

**Table C-1: Rascal Stream West reach 1 Turbidity Measurements, 20 June 2019**

| Site | UTM Coordinates (m, 13V NAD83) | | NTU #1 | NTU #2 | NTU #3 | Average |
|---|---|---|---|---|---|---|
| | Easting | Northing | | | | |
| 10 m upstream of crossing[(a)] | 432845 | 7270046 | 0.4 | 0.43 | 0.42 | 0.42 |
| At crossing | 432844 | 7270064 | 0.45 | 0.51 | 0.45 | 0.47 |
| 10 m downstream of crossing | 432839 | 7270072 | 0.34 | 0.33 | 0.35 | 0.34 |
| RSW1 downstream | 432824 | 7270098 | 0.47 | 0.44 | 0.49 | 0.47 |
| RSW1/Goose Lake Confluence | 432807 | 7270141 | 0.57 | 0.56 | 0.60 | 0.58 |
| Goose Lake Downstream | 432748 | 7270123 | 0.45 | 0.44 | 0.46 | 0.45 |
| Goose Lake Downstream | 432748 | 7270123 | 0.57 | 0.63 | 0.49 | 0.56 |
| Goose Lake Downstream | 432748 | 7270123 | 0.86 | 0.65 | 0.65 | 0.72 |

[(a)] Control site; all sites compared to this site.
Note: No exceedances were noted.
UTM = Universal Transverse Mercator; NTU = Nephelometric Turbidity Unit; - = not applicable.

Based on the habitat assessment, RSW1 was described as a small permanent watercourse with a neutral channel form, well-defined banks, and unconfined by valley walls. Riparian vegetation was dominated by shrubs and grasses with small areas of bare ground noted around the bridge crossing. The watercourse was in a flooded condition during the survey assessment with observations of flows over the stream banks at numerous locations (e.g., Photo C-8). Calculated discharge at the time of the survey was 2.66 $m^3/s$. Water temperature was 3.6 °C, conductivity was 33 microseimens per centimetre (µs/cm), and pH was 5.60 at the time of the assessment. There were no obvious upstream-downstream trends in turbidity (NTU) values, which ranged from 0.34 to 0.72.

Four habitat types were present in RSW1: run, riffle, pool and cascade. The surveyed reach is suitable to provide low to moderate spawning and rearing habitat for Arctic Grayling. The detailed habitat data of the survey reach is provided in Table C-2.

Upstream of the crossing, four habitat types were present; shallow depth (<0.5 m) run, riffle, pool and cascade habitats. The stream gradient changed from a flat channel with confined flows near the Gander Pond outlet to a moderate gradient where high velocities were observed near the crossing (Photo C-8). Mean maximum water depths ranged from 0.45 m to approximately 1 m, mean wetted width ranged from 3.5 to 29 m, and bank-full width ranged from 6 to 29 m. Substrate was dominated by sand and gravel with smaller portions of cobble, boulder, and organics. Instream cover was dominated by depth and turbulence in the channel centres and submerged riparian vegetation along the banks. Stable, fully vegetated channel banks were present throughout most of the reach. A small, isolated bank area of slumping was noted in the cascade section. There is a 0.7 m drop in height at a location within the cascade section that may act as a potential barrier to upstream movements of fish during lower flows.

The bridge crossing was located over a riffle habitat unit with constricted flows and relatively high velocities (Photo C-9). Mean maximum water depth was 0.45 m, with a mean bankfull and wetted width of 2.5 m. Substrate was dominated by sand and gravel with patches of cobble in the channel centre. Instream cover was limited to depth and turbulence and patches of submerged riparian vegetation along the banks. Channel banks were partially vegetated and stabilized by boulder armouring with no visible signs of erosion. Bank height at the left downstream bank was 0.7 m and right downstream bank was 0.6 m, respectively.

Three habitat types were present downstream of the crossing: run, riffle, and pool (Photo C-10). The reach had a downward sloping gradient causing high velocities with flooding over the lower downstream bank (Photo C-11). Mean maximum water depth ranged from 0.04 to 0.7 m, wetted width ranged from 3.5 to 27 m, and bank-full width ranged from 4.5 to 27 m. Substrate was dominated by sand and gravel with smaller portions of cobble, and boulder. Instream cover was dominated by depth and turbulence in the channel centres and submerged riparian vegetation along the banks. The channel banks were fully vegetated, well-defined and stable with no noted erosion. A steep drop with a height of 0.55 m, located near Goose lake Inflow, may act as a potential barrier to fish movement under lower flows.

The Gander Pond outflow secondary channel was a small intermittent watercourse with defined banks and channelized, low flows (Photo C-12). This watercourse may dry completely after the spring freshet is complete. Average water depth was 0.2 m, with an average wetted width of less than 1 m. Upstream of the bridge crossing, substrate was dominated by cobble and boulders. Bank vegetation consisted of low-lying grass and sparse patches of shrubs. Downstream of the bridge crossing, predominate substrate was fines with patches of gravel. Instream cover included submerged and overhanging vegetation. Bank vegetation consisted mainly of shrubs.

## Table C-2: Rascal Stream West Reach 1 Habitat Assessment, 20 June 2019

| ID# | Habitat Unit Location [c] | Habitat Unit Type [d] | Unit Length (m) | Water Depth (m) | | | Wetted Width (m) | | | Bank-full Width (m) | | | Substrate (% area) | | | | | Instream Cover (% area) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Max | Mean Max | ΔB-W | Min | Max | Mean | Min | Max | Mean | Or | Sa | Gr | Co | Bo | SU | WD | D/T | SRV | OV |
| 33 | D | R3 | 31 | 0.46 | 0.04 | 0.04 | 2 | 37 | 27 | 2* | 37 | 27 | - | 80 | 14 | 1 | 5 | - | 2 | 15 | 5 | 4 |
| 34[a] | D | RF | 9 | 0.48 | 0.30 | 0.04 | 12 | 15 | 13 | 12* | 15 | 13 | - | 85 | 15 | - | - | - | 2 | 20 | | 3 |
| 36 | D | P3 | 10 | 0.65 | 0.45 | 0.40 | 7 | 9 | 8 | 7* | 9 | 8 | - | 90 | 10 | - | - | - | 7 | 5 | 3 | 5 |
| 35 | D | R3 | 6 | 0.54 | 0.48 | 0.50 | 6 | 8 | 7 | 9* | 11 | 8 | - | 85 | 12 | 3 | | - | 3 | 2 | 5 | 3 |
| 37 | D | P2 | 8 | 1.00 | 0.70 | 0.50 | 2 | 7 | 5 | 4* | 11 | 9 | - | 95 | 5 | - | - | - | 5 | 40 | 2 | - |
| 38 | D | R2 | 12 | 0.66 | 0.57 | 0.20 | 3 | 4 | 3.5 | 4 | 5 | 4.5 | - | 85 | 13 | 2 | | - | 1 | - | 15 | 1 |
| 39 | R | R2 | 15 | 0.76 | 0.68 | 0.25 | 4 | 6 | 5 | 4 | 6.5 | 5.5 | - | 90 | 10 | - | - | - | - | - | 30 | - |
| 40 | C | RF | 8 | 0.76 | 0.45 | 0.15 | 2 | 3 | 2.5 | 2 | 3 | 2.5 | - | 80 | 15 | 5 | - | - | - | 10 | 7 | - |
| 41 | R | R3 | 15 | 0.6 | 0.50 | 0.30 | 3 | 5 | 4 | 13 | 16 | 14 | - | 75 | 15 | 10 | - | 3 | - | 15 | 7 | 5 |
| 42 | U | RF | 9 | 0.54 | 0.50 | 0.30 | 3 | 4 | 3.5 | 14* | 15 | 14.5 | - | 60 | 15 | 10 | 5 | 3 | - | 15 | - | 3 |
| 44 | U | R3 | 12 | 0.56 | 0.48 | 0.70 | 8 | 9 | 8 | 16* | 17 | 16 | - | 85 | 12 | 3 | - | - | 4 | 3 | 5 | 3 |
| 45 | U | CA | 29 | 0.72 | 0.55 | 0.20 | 8 | 10 | 9 | 11* | 13 | 12 | - | 55 | 23 | 15 | 7 | 5 | 5 | 5 | 2 | 3 |
| 48 | U | RF | 43 | 0.60 | 0.50 | 0 | 26 | 34 | 29 | 26* | 34 | 29 | - | 60 | 20 | 18 | 2 | 3 | 5 | 3 | 2 | 2 |
| 50[b] | U | R3 | 120 | 0.60 | 0.52 | 0 | 3 | 37 | 11 | 3* | 37 | 11 | 5 | 55 | 25 | 3 | 2 | 2 | 5 | 10 | 7 | 5 |
| 56 | U | P2 | 6 | 1.00 | 0.90 | 0.30 | 5 | 7 | 6 | 5 | 7 | 6 | - | 80 | 10 | 5 | 5 | 5 | - | 10 | 3 | 2 |
| 58 | U | R3 | 72 | 0.62 | 0.45 | 0.20 | 3 | 34 | 10 | 4 | 36 | 10 | 10 | 85 | 5 | - | - | - | 3 | - | 20 | 3 |

[a] Drop barrier (Height = 0.55 m; Length = 2.0 m; Width = 2.2 m); [b] Drop barrier (Height = 0.7 m; Length = 2.0 m; Width = 1.5 m); [c] D = Downstream; R = Right-of-way; C = centre line; U = upstream; [d] R3 = Run 3 is a shallow (<0.75 m deep) moderate velocity area with low instream cover; RF = Riffle is a shallow (<0.5 m deep), high velocity and gradient area dominated by coarse substrate ; P3 = Pool 3 is a shallow (<1.0 m deep) low velocity area with low instream cover, not suitable for overwintering; P2 = Pool 2 is 1.0 – 1.5 m deep, low velocity area with high to moderate instream cover and low suitability for overwintering habitat; R2 = Run 2 is 0.75 – 1.0 m deep, moderate to high velocity area with moderate to high instream cover; CA = cascade is a extremely high gradient and velocity area with broken water surface but may be passable to fish; notes: ΔB-W = difference between bank and water; Or = organic; Sa = sand; Gr = gravel; Co = cobble; Bo = boulder; SU = substrate; WD = woody debris; D/T = depth/turbulence; SRV = submerged riparian vegetation; OV = overhanging vegetation; - = not applicable; * = flooding observed over banks



**Photo C-1: View upstream towards discharge location at RS6 (20 June 2019).**



**Photo C-2: View downstream towards discharge location along main channel section at RS5 (21 June 2019).**



**Photo C-3: View downstream towards discharge location at RS7 (21 June 2019).**



**Photo C-4: View upstream towards discharge location at RSE4 (20 June 2019).**



**Photo C-5: View downstream towards discharge location at MGPS3 (21 June 2019).**



**Photo C-6: View downstream towards discharge location at RSW3 (20 June 2019).**



**Photo C-7: View downstream towards discharge location at RWS1 (20 June 2019).**

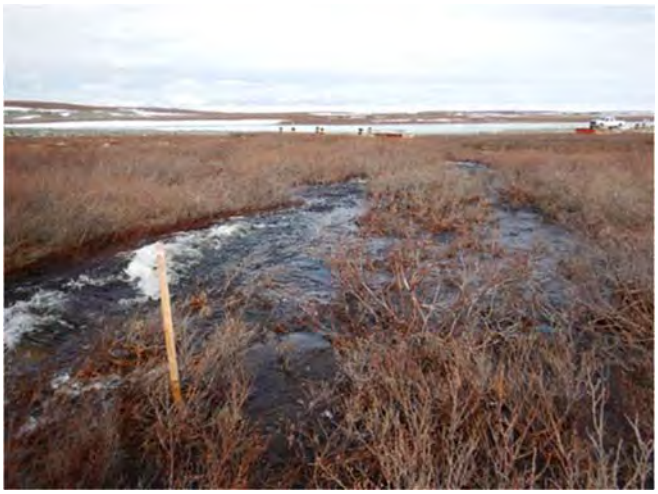


**Photo C-8: View of flooded area upstream of bridge crossing in riffle habitat at RSW1 (20 June 2019).**



**Photo C-9: View downstream towards bridge crossing in riffle habitat at RSW1 (20 June 2019).**



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**Photo C-11: View of flooded area downstream of bridge crossing in riffle habitat at RSW1 (20 June 2019).**



**Photo C-12: Gander Pond outlet side channel downstream of bridge looking downstream (20 June 2019).**

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**APPENDIX D**

# Rascal Stream Hydraulic Model Results

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# D-1.0 INTRODUCTION

This appendix presents the 1-D HEC-RAS hydraulic modeling results for Scenario 1 (existing conditions) and Scenario 2 (Rascal Stream Diversion) to accommodate the proposed airstrip extension at the Goose Property. Main Report Figures 1 and 2 show the existing channel alignment and proposed scenario alignments as described in Sections D-2.0 to D-3.0 and the modeled cross-sections are shown in Figure 7 of the main report.

# D-2.0 SCENARIO 1 – ORIGINAL ALIGNMENT WITH CULVERT MODIFICATIONS

Scenario 1 represents the existing alignment of the Rascal Stream where Rascal Stream Reach 6 flow splits into two channels, Rascal Stream West (RSW) Reach 7 and Rascal Stream East (RSE) Reach 5; and flows from RSE and Main Goose Pit Stream (Goose Stream) Reach 3, east outlet of Gosling Pond 1, are conveyed under the proposed airstrip extension through installed culverts. Flow splits for RSW and RSE vary month to month during open water season from late May to mid-to-late October, resulting in different hydraulic conditions within the channels.

Hydraulic results for: water levels, channel velocities, water top widths, and maximum and average water depths and flow statistics, are presented in Table D-1 for modeled cross-section #2420.028 and Table D-2 for #1909.321, which are representative modeled cross-sections for hydraulic conditions at RSW Reach 7. These two modeled cross-sections were selected either because the cross-section has very shallow flow depth (i.e., cross-section #2420.028 due to wide channel width), or has high channel velocity (i.e., cross-section #1909.321 with small cross-sectional flow area) which can affect fish passage and production.

Hydraulic results for modeled cross-section #2300.936, representative of hydraulic conditions at RSE Reach 5, are shown in Table D-3. This modeled cross-section was selected because of its high channel velocity where the channel geometry is more confined. The model is not setup to model the existing condition of RSE Reach 4, as the model's focus is on modifications to Rascal Stream west of the airstrip; therefore, no representative cross-section was chosen for RSE Reach 4 between Little Rascal Pond and the proposed airstrip extension under existing alignment.

Gosling Pond 1 has two outlet channels, one that flows north, RSW Reach 3, and one that flows east, Goose Stream Reach 3. A containment berm is proposed east of RSW Reach 3, between Gosling Ponds 1 and 2, to prevent flooding of the airstrip embankments and is included in the model for this scenario. Modeled cross-section #1455.404, representative of RSW Reach 3, was selected to show high flow velocities downstream of Gosling Pond 1 with the containment berm present. Hydraulic model results for this modeled cross-section are summarized in Table D-4. Additional modeled cross-section #996.92 at RSW Reach 2 was selected as the confined channel resulting in high flow velocity which can impact fish production, and hydraulic results are summarized in Table D-5.

At the time of the 2018 assessment, two box culverts were proposed for RSW Reach 1 to convey flows under the all-weather service road (Rescan 2014a). The box culverts were modeled as 2.5 m by 2.5 m with 150 mm infilled substrate layer, as the preference was to install box culvert instead of corrugated steel pipe (Rescan 2014a). Hydraulic results for RSW Reach 1 are provided for cross-section #64.15607 in Table D-6 for Scenario 1 and are expected to be representative of the general Reach 1 conditions. It is now understood that instead of box culverts,

a clear-span bridge was installed along RSW Reach 1 under the all-weather service road. However, a survey with bridge and channel dimensions was not available and re-modeling of the road crossing was not included in this scope of work.

Two box culverts are also proposed to convey flows from RSE Reach 4 and Goose Stream 3 under the proposed airstrip extension. Table D-7 summarizes the modeled hydraulic results for RSE Reach 4 culvert crossing (Airstrip South Culvert), and Table D-8 summarizes the modeled hydraulic results for Goose Stream Reach 3 culvert crossing (Airstrip North Culvert).

**Table D-1: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 7, Cross-Section #2420.028**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 297.98 | 0.21 | 7.60 | 0.03 | 0.01 | 27 | 7 | 0 | 29 | 3 | 24 | 31 | 1 |
| 0.05 | 297.99 | 0.27 | 10.54 | 0.04 | 0.02 | 27 | 0 | 0 | 21 | 3 | 31 | 31 | 9 |
| 0.10 | 298.00 | 0.28 | 18.18 | 0.05 | 0.02 | 26 | 0 | 0 | 10 | 4 | 31 | 31 | 20 |
| 0.15 | 298.01 | 0.18 | 77.20 | 0.06 | 0.01 | 24 | 0 | 0 | 3 | 6 | 31 | 31 | 27 |
| 0.20 | 298.01 | 0.21 | 77.56 | 0.06 | 0.01 | 21 | 0 | 0 | 1 | 9 | 31 | 31 | 29 |
| 0.25 | 298.01 | 0.22 | 77.95 | 0.06 | 0.01 | 17 | 0 | 0 | 1 | 13 | 31 | 31 | 29 |
| 0.30 | 298.01 | 0.23 | 78.32 | 0.06 | 0.02 | 15 | 0 | 0 | 0 | 15 | 31 | 31 | 30 |
| 0.35 | 298.01 | 0.24 | 78.75 | 0.06 | 0.02 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.40 | 298.02 | 0.25 | 78.98 | 0.07 | 0.02 | 11 | 0 | 0 | 0 | 19 | 31 | 31 | 30 |
| 0.45 | 298.02 | 0.26 | 79.29 | 0.07 | 0.02 | 9 | 0 | 0 | 0 | 21 | 31 | 31 | 30 |
| 0.50 | 298.02 | 0.28 | 79.46 | 0.07 | 0.02 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 0.55 | 298.02 | 0.29 | 79.76 | 0.07 | 0.02 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 0.60 | 298.02 | 0.29 | 80.03 | 0.07 | 0.03 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.65 | 298.02 | 0.31 | 80.20 | 0.07 | 0.03 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.70 | 298.02 | 0.31 | 80.48 | 0.07 | 0.03 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.75 | 298.03 | 0.32 | 80.81 | 0.08 | 0.03 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.80 | 298.03 | 0.33 | 80.91 | 0.08 | 0.03 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.85 | 298.03 | 0.34 | 81.14 | 0.08 | 0.03 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.90 | 298.03 | 0.35 | 81.22 | 0.08 | 0.03 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |

**Table D-1: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 7, Cross-Section #2420.028**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.95 | 298.03 | 0.36 | 81.39 | 0.08 | 0.03 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.00 | 298.03 | 0.36 | 81.73 | 0.08 | 0.03 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.05 | 298.03 | 0.37 | 81.93 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.10 | 298.03 | 0.37 | 82.13 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.15 | 298.03 | 0.38 | 82.19 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.20 | 298.03 | 0.38 | 82.48 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 298.03 | 0.39 | 82.58 | 0.08 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.30 | 298.04 | 0.41 | 82.64 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.35 | 298.04 | 0.41 | 82.90 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.40 | 298.04 | 0.42 | 82.98 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.45 | 298.04 | 0.42 | 83.14 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.50 | 298.04 | 0.43 | 83.33 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 298.04 | 0.43 | 83.52 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-2: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 7, Cross-Section #1909.324**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 295.38 | 0.33 | 8.67 | 0.01 | 0.01 | 27 | 7 | 0 | 29 | 3 | 24 | 31 | 1 |
| 0.05 | 295.39 | 0.35 | 12.86 | 0.02 | 0.01 | 27 | 0 | 0 | 21 | 3 | 31 | 31 | 9 |
| 0.10 | 295.40 | 0.39 | 17.06 | 0.03 | 0.02 | 26 | 0 | 0 | 10 | 4 | 31 | 31 | 20 |
| 0.15 | 295.40 | 0.42 | 20.07 | 0.03 | 0.02 | 24 | 0 | 0 | 3 | 6 | 31 | 31 | 27 |
| 0.20 | 295.41 | 0.42 | 22.28 | 0.04 | 0.02 | 21 | 0 | 0 | 1 | 9 | 31 | 31 | 29 |
| 0.25 | 295.41 | 0.48 | 22.93 | 0.04 | 0.02 | 17 | 0 | 0 | 1 | 13 | 31 | 31 | 29 |
| 0.30 | 295.41 | 0.50 | 24.23 | 0.04 | 0.02 | 15 | 0 | 0 | 0 | 15 | 31 | 31 | 30 |
| 0.35 | 295.41 | 0.53 | 25.19 | 0.04 | 0.03 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.40 | 295.42 | 0.53 | 26.70 | 0.05 | 0.03 | 11 | 0 | 0 | 0 | 19 | 31 | 31 | 30 |
| 0.45 | 295.42 | 0.53 | 27.92 | 0.05 | 0.03 | 9 | 0 | 0 | 0 | 21 | 31 | 31 | 30 |
| 0.50 | 295.42 | 0.55 | 28.83 | 0.05 | 0.03 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 0.55 | 295.43 | 0.56 | 29.59 | 0.06 | 0.03 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 0.60 | 295.43 | 0.60 | 29.96 | 0.06 | 0.03 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.65 | 295.43 | 0.59 | 31.13 | 0.06 | 0.04 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.70 | 295.43 | 0.62 | 31.35 | 0.06 | 0.04 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.75 | 295.43 | 0.62 | 31.84 | 0.06 | 0.04 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.80 | 295.44 | 0.61 | 32.58 | 0.07 | 0.04 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.85 | 295.44 | 0.63 | 32.75 | 0.07 | 0.04 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.90 | 295.44 | 0.62 | 35.42 | 0.07 | 0.04 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |

**Table D-2: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 7, Cross-Section #1909.324**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.95 | 295.44 | 0.65 | 35.42 | 0.07 | 0.04 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.00 | 295.44 | 0.63 | 36.16 | 0.07 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.05 | 295.45 | 0.65 | 36.39 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.10 | 295.45 | 0.66 | 36.69 | 0.08 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.15 | 295.45 | 0.67 | 37.01 | 0.08 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.20 | 295.45 | 0.69 | 37.04 | 0.08 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 295.45 | 0.68 | 39.51 | 0.08 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.30 | 295.45 | 0.68 | 39.84 | 0.08 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.35 | 295.46 | 0.68 | 40.18 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.40 | 295.46 | 0.69 | 40.50 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.45 | 295.46 | 0.71 | 40.50 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.50 | 295.46 | 0.72 | 40.72 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 295.46 | 0.72 | 41.20 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-3: Scenario 1 – Hydraulic Model Results for Rascal Stream East Reach 5, Cross-Section #2300.936**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 296.77 | 0.13 | 15.91 | 0.02 | 0.01 | 27 | 31 | 31 | 30 | 3 | 0 | 0 | 0 |
| 0.05 | 296.77 | 0.21 | 17.39 | 0.02 | 0.01 | 27 | 31 | 31 | 25 | 3 | 0 | 0 | 5 |
| 0.10 | 296.78 | 0.24 | 20.12 | 0.03 | 0.02 | 27 | 28 | 24 | 17 | 3 | 3 | 7 | 13 |
| 0.15 | 296.78 | 0.33 | 20.66 | 0.03 | 0.02 | 26 | 23 | 17 | 10 | 4 | 8 | 14 | 20 |
| 0.20 | 296.78 | 0.40 | 21.15 | 0.03 | 0.02 | 23 | 18 | 12 | 5 | 7 | 13 | 19 | 25 |
| 0.25 | 296.79 | 0.48 | 21.54 | 0.04 | 0.02 | 21 | 14 | 8 | 2 | 9 | 17 | 23 | 28 |
| 0.30 | 296.79 | 0.46 | 23.19 | 0.04 | 0.03 | 18 | 11 | 5 | 1 | 12 | 20 | 26 | 29 |
| 0.35 | 296.80 | 0.46 | 24.49 | 0.05 | 0.03 | 15 | 8 | 3 | 1 | 15 | 23 | 28 | 29 |
| 0.40 | 296.80 | 0.50 | 24.84 | 0.05 | 0.03 | 14 | 6 | 2 | 0 | 16 | 25 | 29 | 30 |
| 0.45 | 296.80 | 0.50 | 26.05 | 0.05 | 0.03 | 12 | 4 | 1 | 0 | 18 | 27 | 30 | 30 |
| 0.50 | 296.80 | 0.51 | 26.92 | 0.05 | 0.04 | 10 | 2 | 1 | 0 | 20 | 29 | 30 | 30 |
| 0.55 | 296.81 | 0.53 | 27.37 | 0.06 | 0.04 | 9 | 2 | 1 | 0 | 21 | 29 | 30 | 30 |
| 0.60 | 296.81 | 0.55 | 28.01 | 0.06 | 0.04 | 8 | 1 | 1 | 0 | 22 | 30 | 30 | 30 |
| 0.65 | 296.81 | 0.55 | 28.95 | 0.06 | 0.04 | 7 | 1 | 0 | 0 | 23 | 30 | 31 | 30 |
| 0.70 | 296.82 | 0.54 | 29.98 | 0.07 | 0.04 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.75 | 296.82 | 0.57 | 30.27 | 0.07 | 0.04 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.80 | 296.82 | 0.59 | 30.60 | 0.07 | 0.04 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.85 | 296.82 | 0.58 | 31.95 | 0.07 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.90 | 296.82 | 0.58 | 33.36 | 0.07 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |

**Table D-3: Scenario 1 – Hydraulic Model Results for Rascal Stream East Reach 5, Cross-Section #2300.936**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.95 | 296.83 | 0.57 | 35.34 | 0.08 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 1.00 | 296.83 | 0.57 | 36.90 | 0.08 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.05 | 296.83 | 0.57 | 38.08 | 0.08 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.10 | 296.83 | 0.58 | 38.41 | 0.08 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.15 | 296.84 | 0.57 | 39.21 | 0.09 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.20 | 296.84 | 0.58 | 39.52 | 0.09 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 296.84 | 0.59 | 39.88 | 0.09 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.30 | 296.84 | 0.59 | 40.22 | 0.09 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.35 | 296.84 | 0.60 | 40.58 | 0.09 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.40 | 296.84 | 0.60 | 40.99 | 0.09 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.45 | 296.84 | 0.62 | 41.15 | 0.09 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.50 | 296.85 | 0.62 | 41.62 | 0.10 | 0.06 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 296.85 | 0.62 | 42.07 | 0.10 | 0.06 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-4: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 3, Cross-Section #1455.404**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 291.26 | 0.06 | 43.15 | 0.01 | 0.01 | 28 | 4 | 1 | 27 | 2 | 27 | 30 | 3 |
| 0.05 | 291.26 | 0.18 | 43.09 | 0.01 | 0.01 | 27 | 0 | 0 | 16 | 3 | 31 | 31 | 14 |
| 0.10 | 291.26 | 0.23 | 43.24 | 0.01 | 0.01 | 23 | 0 | 0 | 4 | 7 | 31 | 31 | 26 |
| 0.15 | 291.26 | 0.27 | 43.37 | 0.01 | 0.01 | 18 | 0 | 0 | 1 | 12 | 31 | 31 | 29 |
| 0.20 | 291.27 | 0.30 | 43.47 | 0.02 | 0.02 | 14 | 0 | 0 | 0 | 16 | 31 | 31 | 30 |
| 0.25 | 291.27 | 0.32 | 43.58 | 0.02 | 0.02 | 10 | 0 | 0 | 0 | 20 | 31 | 31 | 30 |
| 0.30 | 291.27 | 0.33 | 43.69 | 0.02 | 0.02 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 0.35 | 291.27 | 0.35 | 43.79 | 0.02 | 0.02 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.40 | 291.28 | 0.36 | 43.87 | 0.03 | 0.03 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.45 | 291.28 | 0.37 | 43.99 | 0.03 | 0.03 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.50 | 291.28 | 0.38 | 44.08 | 0.03 | 0.03 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.55 | 291.28 | 0.37 | 44.23 | 0.03 | 0.03 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.60 | 291.29 | 0.39 | 44.30 | 0.04 | 0.03 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 0.65 | 291.29 | 0.40 | 44.36 | 0.04 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 0.70 | 291.29 | 0.41 | 44.45 | 0.04 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 0.75 | 291.29 | 0.42 | 44.52 | 0.04 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 0.80 | 291.29 | 0.42 | 44.61 | 0.04 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 0.85 | 291.30 | 0.43 | 44.68 | 0.05 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 0.90 | 291.30 | 0.43 | 44.78 | 0.05 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-4: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 3, Cross-Section #1455.404**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.95 | 291.30 | 0.44 | 44.84 | 0.05 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.00 | 291.30 | 0.45 | 44.90 | 0.05 | 0.05 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.05 | 291.30 | 0.46 | 44.96 | 0.05 | 0.05 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.10 | 291.30 | 0.47 | 45.03 | 0.05 | 0.05 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.15 | 291.30 | 0.48 | 45.08 | 0.05 | 0.05 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.20 | 291.31 | 0.48 | 45.16 | 0.06 | 0.06 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.25 | 291.31 | 0.49 | 45.22 | 0.06 | 0.06 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.30 | 291.31 | 0.50 | 45.26 | 0.06 | 0.06 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.35 | 291.31 | 0.51 | 45.31 | 0.06 | 0.06 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.40 | 291.31 | 0.51 | 45.38 | 0.06 | 0.06 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.45 | 291.31 | 0.52 | 45.44 | 0.06 | 0.06 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.50 | 291.31 | 0.52 | 45.49 | 0.06 | 0.06 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.55 | 291.32 | 0.53 | 45.54 | 0.07 | 0.06 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |

**Table D-5: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 2, Cross-Section #996.92**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 289.76 | 0.22 | 7.40 | 0.01 | 0.01 | 28 | 4 | 1 | 27 | 2 | 27 | 30 | 3 |
| 0.05 | 289.77 | 0.28 | 7.69 | 0.02 | 0.02 | 27 | 0 | 0 | 16 | 3 | 31 | 31 | 14 |
| 0.10 | 289.79 | 0.35 | 8.01 | 0.04 | 0.03 | 23 | 0 | 0 | 4 | 7 | 31 | 31 | 26 |
| 0.15 | 289.80 | 0.41 | 8.26 | 0.05 | 0.04 | 18 | 0 | 0 | 1 | 12 | 31 | 31 | 29 |
| 0.20 | 289.81 | 0.45 | 8.48 | 0.06 | 0.05 | 14 | 0 | 0 | 0 | 16 | 31 | 31 | 30 |
| 0.25 | 289.82 | 0.49 | 8.68 | 0.07 | 0.06 | 10 | 0 | 0 | 0 | 20 | 31 | 31 | 30 |
| 0.30 | 289.82 | 0.52 | 8.86 | 0.07 | 0.07 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 0.35 | 289.83 | 0.55 | 9.02 | 0.08 | 0.07 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.40 | 289.84 | 0.57 | 9.18 | 0.09 | 0.08 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.45 | 289.84 | 0.59 | 9.34 | 0.09 | 0.08 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.50 | 289.85 | 0.61 | 9.49 | 0.10 | 0.09 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.55 | 289.85 | 0.63 | 9.62 | 0.10 | 0.09 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.60 | 289.86 | 0.63 | 9.81 | 0.11 | 0.10 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 0.65 | 289.87 | 0.65 | 9.94 | 0.12 | 0.10 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 0.70 | 289.87 | 0.67 | 10.05 | 0.12 | 0.10 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 0.75 | 289.88 | 0.68 | 10.17 | 0.13 | 0.11 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 0.80 | 289.88 | 0.70 | 10.29 | 0.13 | 0.11 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 0.85 | 289.89 | 0.71 | 10.39 | 0.14 | 0.11 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 0.90 | 289.89 | 0.73 | 10.50 | 0.14 | 0.12 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-5: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 2, Cross-Section #996.92**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.95 | 289.89 | 0.74 | 10.61 | 0.14 | 0.12 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.00 | 289.90 | 0.75 | 10.71 | 0.15 | 0.12 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.05 | 289.90 | 0.78 | 10.75 | 0.15 | 0.12 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.10 | 289.90 | 0.79 | 10.84 | 0.15 | 0.13 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.15 | 289.91 | 0.80 | 10.94 | 0.16 | 0.13 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.20 | 289.91 | 0.81 | 11.04 | 0.16 | 0.13 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.25 | 289.92 | 0.82 | 11.16 | 0.17 | 0.14 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.30 | 289.92 | 0.83 | 11.25 | 0.17 | 0.14 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.35 | 289.93 | 0.84 | 11.34 | 0.18 | 0.14 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.40 | 289.93 | 0.85 | 11.43 | 0.18 | 0.15 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.45 | 289.95 | 0.78 | 11.87 | 0.20 | 0.16 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.50 | 289.95 | 0.77 | 12.02 | 0.20 | 0.16 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.55 | 289.96 | 0.79 | 12.08 | 0.21 | 0.16 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |

**Table D-6: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 1, Cross-Section #64.15607**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 282.01 | 0.23 | 10.45 | 0.01 | 0.01 | 27 | 7 | 0 | 29 | 3 | 24 | 31 | 1 |
| 0.05 | 282.01 | 0.36 | 10.55 | 0.01 | 0.01 | 27 | 0 | 0 | 21 | 3 | 31 | 31 | 9 |
| 0.10 | 282.02 | 0.44 | 10.72 | 0.02 | 0.02 | 26 | 0 | 0 | 10 | 4 | 31 | 31 | 20 |
| 0.15 | 282.03 | 0.52 | 10.84 | 0.03 | 0.03 | 24 | 0 | 0 | 3 | 6 | 31 | 31 | 27 |
| 0.20 | 282.03 | 0.62 | 10.91 | 0.03 | 0.03 | 21 | 0 | 0 | 1 | 9 | 31 | 31 | 29 |
| 0.25 | 282.04 | 0.61 | 11.07 | 0.04 | 0.04 | 17 | 0 | 0 | 1 | 13 | 31 | 31 | 29 |
| 0.30 | 282.04 | 0.66 | 11.16 | 0.04 | 0.04 | 15 | 0 | 0 | 0 | 15 | 31 | 31 | 30 |
| 0.35 | 282.02 | 1.47 | 10.74 | 0.02 | 0.02 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.40 | 282.02 | 1.70 | 10.74 | 0.02 | 0.02 | 11 | 0 | 0 | 0 | 19 | 31 | 31 | 30 |
| 0.45 | 282.05 | 0.86 | 11.28 | 0.05 | 0.05 | 9 | 0 | 0 | 0 | 21 | 31 | 31 | 30 |
| 0.50 | 282.05 | 0.89 | 11.35 | 0.05 | 0.05 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 0.55 | 282.05 | 0.99 | 11.34 | 0.05 | 0.05 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 0.60 | 282.05 | 1.13 | 11.29 | 0.05 | 0.05 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.65 | 282.05 | 1.17 | 11.33 | 0.05 | 0.05 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.70 | 282.05 | 1.26 | 11.34 | 0.05 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.75 | 282.05 | 1.32 | 11.36 | 0.05 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.80 | 282.05 | 1.36 | 11.40 | 0.05 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.85 | 282.06 | 1.40 | 11.43 | 0.06 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.90 | 282.06 | 1.44 | 11.46 | 0.06 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |

**Table D-6: Scenario 1 – Hydraulic Model Results for Rascal Stream West Reach 1, Cross-Section #64.15607**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.95 | 282.06 | 1.47 | 11.50 | 0.06 | 0.06 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.00 | 282.06 | 1.50 | 11.54 | 0.06 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.05 | 282.06 | 1.52 | 11.58 | 0.06 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.10 | 282.07 | 1.54 | 11.62 | 0.07 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.15 | 282.07 | 1.53 | 11.68 | 0.07 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.20 | 282.07 | 1.56 | 11.71 | 0.07 | 0.07 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 282.07 | 1.58 | 11.76 | 0.07 | 0.07 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.30 | 282.08 | 1.57 | 11.82 | 0.08 | 0.07 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.35 | 282.08 | 1.58 | 11.86 | 0.08 | 0.07 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.40 | 282.11 | 1.10 | 12.56 | 0.11 | 0.10 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.45 | 282.11 | 1.12 | 12.61 | 0.11 | 0.10 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.50 | 282.12 | 1.13 | 12.65 | 0.12 | 0.10 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 282.12 | 1.15 | 12.69 | 0.12 | 0.11 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-7: Scenario 1 – Hydraulic Model Results for Rascal Stream East Reach 4, 2.5 m Box Culvert (Airstrip South Culvert)**

| Average Daily Discharge | Upstream Culvert Velocity | Downstream Culvert Velocity | Average Water Depth in Culvert | Upstream Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m/s) | (m/s) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 0.27 | 0.43 | 0.03 | 0.04 | 27 | 31 | 31 | 30 | 3 | 0 | 0 | 0 |
| 0.05 | 0.39 | 0.58 | 0.05 | 0.06 | 27 | 31 | 31 | 25 | 3 | 0 | 0 | 5 |
| 0.10 | 0.50 | 0.73 | 0.08 | 0.10 | 27 | 28 | 24 | 17 | 3 | 3 | 7 | 13 |
| 0.15 | 0.59 | 0.84 | 0.10 | 0.13 | 26 | 23 | 17 | 10 | 4 | 8 | 14 | 20 |
| 0.20 | 0.66 | 0.92 | 0.12 | 0.15 | 23 | 18 | 12 | 5 | 7 | 13 | 19 | 25 |
| 0.25 | 0.72 | 0.99 | 0.14 | 0.18 | 21 | 14 | 8 | 2 | 9 | 17 | 23 | 28 |
| 0.30 | 0.77 | 1.06 | 0.16 | 0.20 | 18 | 11 | 5 | 1 | 12 | 20 | 26 | 29 |
| 0.35 | 0.81 | 1.11 | 0.17 | 0.22 | 15 | 8 | 3 | 1 | 15 | 23 | 28 | 29 |
| 0.40 | 0.85 | 1.16 | 0.19 | 0.24 | 14 | 6 | 2 | 0 | 16 | 25 | 29 | 30 |
| 0.45 | 0.89 | 1.21 | 0.20 | 0.26 | 12 | 4 | 1 | 0 | 18 | 27 | 30 | 30 |
| 0.50 | 0.92 | 1.25 | 0.22 | 0.28 | 10 | 2 | 1 | 0 | 20 | 29 | 30 | 30 |
| 0.55 | 0.96 | 1.29 | 0.23 | 0.30 | 9 | 2 | 1 | 0 | 21 | 29 | 30 | 30 |
| 0.60 | 0.99 | 1.33 | 0.24 | 0.32 | 8 | 1 | 1 | 0 | 22 | 30 | 30 | 30 |
| 0.65 | 1.02 | 1.37 | 0.26 | 0.33 | 7 | 1 | 0 | 0 | 23 | 30 | 31 | 30 |
| 0.70 | 1.04 | 1.40 | 0.27 | 0.35 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.75 | 1.07 | 1.43 | 0.28 | 0.37 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.80 | 1.09 | 1.46 | 0.29 | 0.38 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.85 | 1.12 | 1.49 | 0.30 | 0.40 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.90 | 1.14 | 1.52 | 0.32 | 0.42 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |

**Table D-7: Scenario 1 – Hydraulic Model Results for Rascal Stream East Reach 4, 2.5 m Box Culvert (Airstrip South Culvert)**

| Average Daily Discharge | Upstream Culvert Velocity | Downstream Culvert Velocity | Average Water Depth in Culvert | Upstream Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m/s) | (m/s) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.95 | 1.16 | 1.55 | 0.33 | 0.43 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 1.00 | 1.18 | 1.58 | 0.34 | 0.45 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.05 | 1.20 | 1.60 | 0.35 | 0.46 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.10 | 1.22 | 1.63 | 0.36 | 0.47 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.15 | 1.24 | 1.65 | 0.37 | 0.49 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.20 | 1.26 | 1.68 | 0.38 | 0.50 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 1.27 | 1.70 | 0.39 | 0.52 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.30 | 1.29 | 1.72 | 0.40 | 0.53 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.35 | 1.31 | 1.74 | 0.41 | 0.54 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.40 | 1.32 | 1.76 | 0.42 | 0.56 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.45 | 1.34 | 1.79 | 0.43 | 0.57 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.50 | 1.35 | 1.81 | 0.44 | 0.58 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 1.37 | 1.83 | 0.45 | 0.60 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-8: Scenario 1 – Hydraulic Model Results for Goose Stream Reach 3, 2.5 m Box Culvert (Airstrip North Culvert)**

| Average Daily Discharge | Upstream Culvert Velocity | Downstream Culvert Velocity | Average Water Depth in Culvert | Upstream Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m/s) | (m/s) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 0.27 | 0.43 | 0.03 | 0.04 | 27 | 0 | 0 | 17 | 3 | 31 | 31 | 13 |
| 0.05 | 0.39 | 0.58 | 0.05 | 0.06 | 26 | 0 | 0 | 3 | 4 | 31 | 31 | 27 |
| 0.10 | 0.50 | 0.73 | 0.08 | 0.10 | 18 | 0 | 0 | 0 | 12 | 31 | 31 | 30 |
| 0.15 | 0.59 | 0.84 | 0.10 | 0.13 | 12 | 0 | 0 | 0 | 18 | 31 | 31 | 30 |
| 0.20 | 0.66 | 0.92 | 0.12 | 0.15 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 0.25 | 0.72 | 0.99 | 0.14 | 0.18 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.30 | 0.77 | 1.06 | 0.16 | 0.20 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.35 | 0.81 | 1.11 | 0.17 | 0.22 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.40 | 0.85 | 1.16 | 0.19 | 0.24 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 0.45 | 0.89 | 1.21 | 0.20 | 0.26 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 0.50 | 0.92 | 1.25 | 0.22 | 0.28 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 0.55 | 0.96 | 1.29 | 0.23 | 0.30 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 0.60 | 0.99 | 1.33 | 0.24 | 0.32 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 0.65 | 1.02 | 1.37 | 0.26 | 0.33 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 0.70 | 1.04 | 1.40 | 0.27 | 0.35 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 0.75 | 1.07 | 1.43 | 0.28 | 0.37 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 0.80 | 1.09 | 1.46 | 0.29 | 0.38 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 0.85 | 1.12 | 1.49 | 0.30 | 0.40 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 0.90 | 1.14 | 1.52 | 0.32 | 0.42 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |

**Table D-8: Scenario 1 – Hydraulic Model Results for Goose Stream Reach 3, 2.5 m Box Culvert (Airstrip North Culvert)**

| Average Daily Discharge | Upstream Culvert Velocity | Downstream Culvert Velocity | Average Water Depth in Culvert | Upstream Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m/s) | (m/s) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 0.27 | 0.43 | 0.03 | 0.04 | 27 | 0 | 0 | 17 | 3 | 31 | 31 | 13 |
| 0.95 | 1.16 | 1.55 | 0.33 | 0.43 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.00 | 1.18 | 1.58 | 0.34 | 0.45 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.05 | 1.20 | 1.60 | 0.35 | 0.46 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.10 | 1.22 | 1.63 | 0.36 | 0.47 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.15 | 1.24 | 1.65 | 0.37 | 0.49 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.20 | 1.26 | 1.68 | 0.38 | 0.50 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.25 | 1.27 | 1.70 | 0.39 | 0.52 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.30 | 1.29 | 1.72 | 0.40 | 0.53 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.35 | 1.31 | 1.74 | 0.41 | 0.54 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.40 | 1.32 | 1.76 | 0.42 | 0.56 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.45 | 1.34 | 1.79 | 0.43 | 0.57 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.50 | 1.35 | 1.81 | 0.44 | 0.58 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |
| 1.55 | 1.37 | 1.83 | 0.45 | 0.60 | 0 | 0 | 0 | 0 | 30 | 31 | 31 | 30 |

## D-3.0 SCENARIO 2 – RASCAL STREAM EAST DIVERSION USING RE-ALIGNMENT BERM

Scenario 2 presents the diversion of RSE Reach 4 and Goose Stream Reach 3 to flow northward into Gosling Pond 1, and RSW Reach 7 and RSE Reach 5 remain in their original conditions. Therefore, hydraulic results for RSW Reach 7 and RSE Reach 5 cross-sections are presented for the same modeled cross-sections as in Scenario 1. Table D-9 presents hydraulic results at modeled cross-section #2420.028, Table D-10 presents hydraulic results at modeled cross-section #1909.321, and Table D-11 presents hydraulic results at modeled cross-section #2300.936.

A diversion berm is proposed southwest of the airstrip near RSE Reach 4, which will divert RSE flows north into Gosling Pond 1. In addition to this diversion berm, this scenario includes the construction of 'Rascal Fishway' which connects RSE Reach 4 to Goose Stream Reach 3 just upstream of Gosling Pond 1. Therefore, hydraulics at RSE Reach 4 will be altered as the water is directed to flow north, resulting in increased flow velocity within the channel. Modeled cross-section #1833.064 was chosen to represent hydraulic conditions at RSE Reach 4 with the proposed diversion berm present, and hydraulic results are summarized in Table D-12.

RSW Reach 3, downstream of Gosling Pond 1, has increased flow and corresponding higher flow velocities when compared to Scenario 1, as Gosling Pond 1 no longer discharges to Goose Stream Reach 3 to the east. A containment berm is proposed southwest of the airstrip, on the east side of RSW to mitigate flooding of the airstrip embankment in response to higher flows. Cross-section #1455.404 was selected to represent RSW Reach 3 with the containment berm present, and hydraulic model results are summarized in Table D-13. Hydraulic results for modeled cross-section #996.92 were selected to represent high velocities in RSW Reach 2, and are summarized in Table D-14.

Hydraulic results for RSW Reach 1 are provided for cross-section #64.15607 in Table D-15 for Scenario 2 and are expected to be representative of the general Reach 1 conditions. It is understood that a clear-span bridge was installed along RSW Reach 1 under the all-weather service road, however, a survey with bridge and channel dimensions was not available and re-modeling of the road crossing was not included in this scope of work.

**Table D-9: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 7, Cross-Section #2420.028**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 297.98 | 0.21 | 7.60 | 0.03 | 0.01 | 27 | 7 | 0 | 29 | 3 | 24 | 31 | 1 |
| 0.05 | 297.99 | 0.27 | 10.54 | 0.04 | 0.02 | 27 | 0 | 0 | 21 | 3 | 31 | 31 | 9 |
| 0.10 | 298.00 | 0.28 | 18.18 | 0.05 | 0.02 | 26 | 0 | 0 | 10 | 4 | 31 | 31 | 20 |
| 0.15 | 298.01 | 0.18 | 77.20 | 0.06 | 0.01 | 24 | 0 | 0 | 3 | 6 | 31 | 31 | 27 |
| 0.20 | 298.01 | 0.21 | 77.56 | 0.06 | 0.01 | 21 | 0 | 0 | 1 | 9 | 31 | 31 | 29 |
| 0.25 | 298.01 | 0.22 | 77.95 | 0.06 | 0.01 | 17 | 0 | 0 | 1 | 13 | 31 | 31 | 29 |
| 0.30 | 298.01 | 0.23 | 78.32 | 0.06 | 0.02 | 15 | 0 | 0 | 0 | 15 | 31 | 31 | 30 |
| 0.35 | 298.01 | 0.24 | 78.75 | 0.06 | 0.02 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.40 | 298.02 | 0.25 | 78.98 | 0.07 | 0.02 | 11 | 0 | 0 | 0 | 19 | 31 | 31 | 30 |
| 0.45 | 298.02 | 0.26 | 79.29 | 0.07 | 0.02 | 9 | 0 | 0 | 0 | 21 | 31 | 31 | 30 |
| 0.50 | 298.02 | 0.28 | 79.46 | 0.07 | 0.02 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 0.55 | 298.02 | 0.29 | 79.76 | 0.07 | 0.02 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 0.60 | 298.02 | 0.29 | 80.03 | 0.07 | 0.03 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.65 | 298.02 | 0.31 | 80.20 | 0.07 | 0.03 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.70 | 298.02 | 0.31 | 80.48 | 0.07 | 0.03 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.75 | 298.03 | 0.32 | 80.81 | 0.08 | 0.03 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.80 | 298.03 | 0.33 | 80.91 | 0.08 | 0.03 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.85 | 298.03 | 0.34 | 81.14 | 0.08 | 0.03 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.90 | 298.03 | 0.35 | 81.22 | 0.08 | 0.03 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.95 | 298.03 | 0.36 | 81.39 | 0.08 | 0.03 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |

**Table D-9: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 7, Cross-Section #2420.028**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 1.00 | 298.03 | 0.36 | 81.73 | 0.08 | 0.03 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.05 | 298.03 | 0.37 | 81.93 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.10 | 298.03 | 0.37 | 82.13 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.15 | 298.03 | 0.38 | 82.19 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.20 | 298.03 | 0.38 | 82.48 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 298.03 | 0.39 | 82.58 | 0.08 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.30 | 298.04 | 0.41 | 82.64 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.35 | 298.04 | 0.41 | 82.90 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.40 | 298.04 | 0.42 | 82.98 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.45 | 298.04 | 0.42 | 83.14 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.50 | 298.04 | 0.43 | 83.33 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 298.04 | 0.43 | 83.52 | 0.09 | 0.04 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-10: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 7, Cross-Section #1909.324**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 295.38 | 0.33 | 8.67 | 0.01 | 0.01 | 27 | 7 | 0 | 29 | 3 | 24 | 31 | 1 |
| 0.05 | 295.39 | 0.35 | 12.86 | 0.02 | 0.01 | 27 | 0 | 0 | 21 | 3 | 31 | 31 | 9 |
| 0.10 | 295.40 | 0.39 | 17.06 | 0.03 | 0.02 | 26 | 0 | 0 | 10 | 4 | 31 | 31 | 20 |
| 0.15 | 295.40 | 0.42 | 20.07 | 0.03 | 0.02 | 24 | 0 | 0 | 3 | 6 | 31 | 31 | 27 |
| 0.20 | 295.41 | 0.42 | 22.28 | 0.04 | 0.02 | 21 | 0 | 0 | 1 | 9 | 31 | 31 | 29 |
| 0.25 | 295.41 | 0.48 | 22.93 | 0.04 | 0.02 | 17 | 0 | 0 | 1 | 13 | 31 | 31 | 29 |
| 0.30 | 295.41 | 0.50 | 24.23 | 0.04 | 0.02 | 15 | 0 | 0 | 0 | 15 | 31 | 31 | 30 |
| 0.35 | 295.41 | 0.53 | 25.19 | 0.04 | 0.03 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.40 | 295.42 | 0.53 | 26.70 | 0.05 | 0.03 | 11 | 0 | 0 | 0 | 19 | 31 | 31 | 30 |
| 0.45 | 295.42 | 0.53 | 27.92 | 0.05 | 0.03 | 9 | 0 | 0 | 0 | 21 | 31 | 31 | 30 |
| 0.50 | 295.42 | 0.55 | 28.83 | 0.05 | 0.03 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 0.55 | 295.43 | 0.56 | 29.59 | 0.06 | 0.03 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 0.60 | 295.43 | 0.60 | 29.96 | 0.06 | 0.03 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.65 | 295.43 | 0.59 | 31.13 | 0.06 | 0.04 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.70 | 295.43 | 0.62 | 31.35 | 0.06 | 0.04 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.75 | 295.43 | 0.62 | 31.84 | 0.06 | 0.04 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.80 | 295.44 | 0.61 | 32.58 | 0.07 | 0.04 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.85 | 295.44 | 0.63 | 32.75 | 0.07 | 0.04 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.90 | 295.44 | 0.62 | 35.42 | 0.07 | 0.04 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.95 | 295.44 | 0.65 | 35.42 | 0.07 | 0.04 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |

**Table D-10: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 7, Cross-Section #1909.324**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 1.00 | 295.44 | 0.63 | 36.16 | 0.07 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.05 | 295.45 | 0.65 | 36.39 | 0.08 | 0.04 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.10 | 295.45 | 0.66 | 36.69 | 0.08 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.15 | 295.45 | 0.67 | 37.01 | 0.08 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.20 | 295.45 | 0.69 | 37.04 | 0.08 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 295.45 | 0.68 | 39.51 | 0.08 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.30 | 295.45 | 0.68 | 39.84 | 0.08 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.35 | 295.46 | 0.68 | 40.18 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.40 | 295.46 | 0.69 | 40.50 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.45 | 295.46 | 0.71 | 40.50 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.50 | 295.46 | 0.72 | 40.72 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 295.46 | 0.72 | 41.20 | 0.09 | 0.05 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-11: Scenario 2 – Hydraulic Model Results for Rascal Stream East Reach 5, Cross-Section #2300.936**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 296.77 | 0.13 | 15.91 | 0.02 | 0.01 | 27 | 31 | 31 | 30 | 3 | 0 | 0 | 0 |
| 0.05 | 296.77 | 0.21 | 17.39 | 0.02 | 0.01 | 27 | 31 | 31 | 25 | 3 | 0 | 0 | 5 |
| 0.10 | 296.78 | 0.24 | 20.12 | 0.03 | 0.02 | 27 | 28 | 24 | 17 | 3 | 3 | 7 | 13 |
| 0.15 | 296.78 | 0.33 | 20.66 | 0.03 | 0.02 | 26 | 23 | 17 | 10 | 4 | 8 | 14 | 20 |
| 0.20 | 296.78 | 0.40 | 21.15 | 0.03 | 0.02 | 23 | 18 | 12 | 5 | 7 | 13 | 19 | 25 |
| 0.25 | 296.79 | 0.48 | 21.54 | 0.04 | 0.02 | 21 | 14 | 8 | 2 | 9 | 17 | 23 | 28 |
| 0.30 | 296.79 | 0.46 | 23.19 | 0.04 | 0.03 | 18 | 11 | 5 | 1 | 12 | 20 | 26 | 29 |
| 0.35 | 296.80 | 0.46 | 24.49 | 0.05 | 0.03 | 15 | 8 | 3 | 1 | 15 | 23 | 28 | 29 |
| 0.40 | 296.80 | 0.50 | 24.84 | 0.05 | 0.03 | 14 | 6 | 2 | 0 | 16 | 25 | 29 | 30 |
| 0.45 | 296.80 | 0.50 | 26.05 | 0.05 | 0.03 | 12 | 4 | 1 | 0 | 18 | 27 | 30 | 30 |
| 0.50 | 296.80 | 0.51 | 26.92 | 0.05 | 0.04 | 10 | 2 | 1 | 0 | 20 | 29 | 30 | 30 |
| 0.55 | 296.81 | 0.53 | 27.37 | 0.06 | 0.04 | 9 | 2 | 1 | 0 | 21 | 29 | 30 | 30 |
| 0.60 | 296.81 | 0.55 | 28.01 | 0.06 | 0.04 | 8 | 1 | 1 | 0 | 22 | 30 | 30 | 30 |
| 0.65 | 296.81 | 0.55 | 28.95 | 0.06 | 0.04 | 7 | 1 | 0 | 0 | 23 | 30 | 31 | 30 |
| 0.70 | 296.82 | 0.54 | 29.98 | 0.07 | 0.04 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.75 | 296.82 | 0.57 | 30.27 | 0.07 | 0.04 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.80 | 296.82 | 0.59 | 30.60 | 0.07 | 0.04 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.85 | 296.82 | 0.58 | 31.95 | 0.07 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.90 | 296.82 | 0.58 | 33.36 | 0.07 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.95 | 296.83 | 0.57 | 35.34 | 0.08 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |

**Table D-11: Scenario 2 – Hydraulic Model Results for Rascal Stream East Reach 5, Cross-Section #2300.936**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 1.00 | 296.83 | 0.57 | 36.90 | 0.08 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.05 | 296.83 | 0.57 | 38.08 | 0.08 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.10 | 296.83 | 0.58 | 38.41 | 0.08 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.15 | 296.84 | 0.57 | 39.21 | 0.09 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.20 | 296.84 | 0.58 | 39.52 | 0.09 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 296.84 | 0.59 | 39.88 | 0.09 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.30 | 296.84 | 0.59 | 40.22 | 0.09 | 0.05 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.35 | 296.84 | 0.60 | 40.58 | 0.09 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.40 | 296.84 | 0.60 | 40.99 | 0.09 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.45 | 296.84 | 0.62 | 41.15 | 0.09 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.50 | 296.85 | 0.62 | 41.62 | 0.10 | 0.06 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 296.85 | 0.62 | 42.07 | 0.10 | 0.06 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-12: Scenario 2 – Hydraulic Model Results for Rascal Stream East Reach 4, Cross-Section #1833.064**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 293.01 | 0.16 | 17.89 | 0.01 | 0.01 | 27 | 31 | 31 | 30 | 3 | 0 | 0 | 0 |
| 0.05 | 293.02 | 0.18 | 18.19 | 0.02 | 0.01 | 27 | 31 | 31 | 25 | 3 | 0 | 0 | 5 |
| 0.10 | 293.02 | 0.25 | 18.46 | 0.02 | 0.02 | 27 | 28 | 24 | 17 | 3 | 3 | 7 | 13 |
| 0.15 | 293.03 | 0.30 | 18.66 | 0.03 | 0.03 | 26 | 23 | 17 | 10 | 4 | 8 | 14 | 20 |
| 0.20 | 293.03 | 0.34 | 18.82 | 0.03 | 0.03 | 23 | 18 | 12 | 5 | 7 | 13 | 19 | 25 |
| 0.25 | 293.04 | 0.36 | 19.02 | 0.04 | 0.04 | 21 | 14 | 8 | 2 | 9 | 17 | 23 | 28 |
| 0.30 | 293.04 | 0.40 | 19.16 | 0.04 | 0.04 | 18 | 11 | 5 | 1 | 12 | 20 | 26 | 29 |
| 0.35 | 293.04 | 0.43 | 19.28 | 0.04 | 0.04 | 15 | 8 | 3 | 1 | 15 | 23 | 28 | 29 |
| 0.40 | 293.05 | 0.46 | 19.39 | 0.05 | 0.05 | 14 | 6 | 2 | 0 | 16 | 25 | 29 | 30 |
| 0.45 | 293.05 | 0.48 | 19.50 | 0.05 | 0.05 | 12 | 4 | 1 | 0 | 18 | 27 | 30 | 30 |
| 0.50 | 293.05 | 0.49 | 19.66 | 0.05 | 0.05 | 10 | 2 | 1 | 0 | 20 | 29 | 30 | 30 |
| 0.55 | 293.06 | 0.52 | 19.75 | 0.06 | 0.05 | 9 | 2 | 1 | 0 | 21 | 29 | 30 | 30 |
| 0.60 | 293.06 | 0.53 | 19.90 | 0.06 | 0.06 | 8 | 1 | 1 | 0 | 22 | 30 | 30 | 30 |
| 0.65 | 293.06 | 0.55 | 19.95 | 0.06 | 0.06 | 7 | 1 | 0 | 0 | 23 | 30 | 31 | 30 |
| 0.70 | 293.07 | 0.56 | 20.09 | 0.07 | 0.06 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.75 | 293.07 | 0.59 | 20.15 | 0.07 | 0.06 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.80 | 293.07 | 0.60 | 20.24 | 0.07 | 0.07 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.85 | 293.07 | 0.61 | 20.36 | 0.07 | 0.07 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.90 | 293.08 | 0.63 | 20.43 | 0.08 | 0.07 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.95 | 293.08 | 0.64 | 20.52 | 0.08 | 0.07 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |

**Table D-12: Scenario 2 – Hydraulic Model Results for Rascal Stream East Reach 4, Cross-Section #1833.064**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 1.00 | 293.08 | 0.65 | 20.62 | 0.08 | 0.07 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.05 | 293.08 | 0.67 | 20.66 | 0.08 | 0.08 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.10 | 293.08 | 0.69 | 20.75 | 0.08 | 0.08 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.15 | 293.08 | 0.70 | 20.80 | 0.08 | 0.08 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 1.20 | 293.09 | 0.70 | 20.94 | 0.09 | 0.08 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 293.09 | 0.71 | 21.02 | 0.09 | 0.08 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.30 | 293.09 | 0.73 | 21.07 | 0.09 | 0.08 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.35 | 293.09 | 0.74 | 21.15 | 0.09 | 0.09 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.40 | 293.10 | 0.74 | 21.24 | 0.10 | 0.09 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.45 | 293.10 | 0.77 | 21.25 | 0.10 | 0.09 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.50 | 293.10 | 0.77 | 21.38 | 0.10 | 0.09 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 293.10 | 0.79 | 21.40 | 0.10 | 0.09 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |

**Table D-13: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 3, Cross-Section #1455.404**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 291.26 | 0.06 | 43.15 | 0.01 | 0.01 | 29 | 31 | 31 | 30 | 1 | 0 | 0 | 0 |
| 0.05 | 291.26 | 0.18 | 43.09 | 0.01 | 0.01 | 29 | 31 | 31 | 29 | 1 | 0 | 0 | 1 |
| 0.10 | 291.26 | 0.23 | 43.24 | 0.01 | 0.01 | 28 | 29 | 25 | 24 | 2 | 2 | 6 | 6 |
| 0.15 | 291.26 | 0.27 | 43.37 | 0.01 | 0.01 | 27 | 24 | 18 | 19 | 3 | 7 | 13 | 11 |
| 0.20 | 291.27 | 0.30 | 43.47 | 0.02 | 0.02 | 27 | 19 | 13 | 14 | 3 | 12 | 18 | 16 |
| 0.25 | 291.27 | 0.32 | 43.58 | 0.02 | 0.02 | 26 | 15 | 9 | 10 | 4 | 16 | 22 | 20 |
| 0.30 | 291.27 | 0.33 | 43.69 | 0.02 | 0.02 | 25 | 12 | 5 | 7 | 5 | 19 | 26 | 23 |
| 0.35 | 291.27 | 0.35 | 43.79 | 0.02 | 0.02 | 24 | 9 | 3 | 5 | 6 | 22 | 28 | 25 |
| 0.40 | 291.28 | 0.36 | 43.87 | 0.03 | 0.03 | 23 | 7 | 2 | 3 | 7 | 24 | 29 | 27 |
| 0.45 | 291.28 | 0.37 | 43.99 | 0.03 | 0.03 | 21 | 5 | 1 | 2 | 9 | 26 | 30 | 28 |
| 0.50 | 291.28 | 0.38 | 44.08 | 0.03 | 0.03 | 19 | 3 | 1 | 1 | 11 | 28 | 30 | 29 |
| 0.55 | 291.28 | 0.37 | 44.23 | 0.03 | 0.03 | 18 | 2 | 1 | 1 | 12 | 29 | 30 | 29 |
| 0.60 | 291.29 | 0.39 | 44.30 | 0.04 | 0.03 | 17 | 2 | 1 | 1 | 13 | 29 | 30 | 29 |
| 0.65 | 291.29 | 0.40 | 44.36 | 0.04 | 0.04 | 16 | 1 | 1 | 1 | 14 | 30 | 30 | 29 |
| 0.70 | 291.29 | 0.41 | 44.45 | 0.04 | 0.04 | 14 | 1 | 0 | 0 | 16 | 30 | 31 | 30 |
| 0.75 | 291.29 | 0.42 | 44.52 | 0.04 | 0.04 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.80 | 291.29 | 0.42 | 44.61 | 0.04 | 0.04 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.85 | 291.30 | 0.43 | 44.68 | 0.05 | 0.04 | 12 | 0 | 0 | 0 | 18 | 31 | 31 | 30 |
| 0.90 | 291.30 | 0.43 | 44.78 | 0.05 | 0.05 | 11 | 0 | 0 | 0 | 19 | 31 | 31 | 30 |
| 0.95 | 291.30 | 0.44 | 44.84 | 0.05 | 0.05 | 10 | 0 | 0 | 0 | 20 | 31 | 31 | 30 |

**Table D-13: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 3, Cross-Section #1455.404**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 1.00 | 291.30 | 0.45 | 44.90 | 0.05 | 0.05 | 9 | 0 | 0 | 0 | 21 | 31 | 31 | 30 |
| 1.05 | 291.30 | 0.46 | 44.96 | 0.05 | 0.05 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 1.10 | 291.30 | 0.47 | 45.03 | 0.05 | 0.05 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 1.15 | 291.30 | 0.48 | 45.08 | 0.05 | 0.05 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 1.20 | 291.31 | 0.48 | 45.16 | 0.06 | 0.06 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 1.25 | 291.31 | 0.49 | 45.22 | 0.06 | 0.06 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 1.30 | 291.31 | 0.50 | 45.26 | 0.06 | 0.06 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 1.35 | 291.31 | 0.51 | 45.31 | 0.06 | 0.06 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 1.40 | 291.31 | 0.51 | 45.38 | 0.06 | 0.06 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 1.45 | 291.31 | 0.52 | 45.44 | 0.06 | 0.06 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 1.50 | 291.31 | 0.52 | 45.49 | 0.06 | 0.06 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 1.55 | 291.32 | 0.53 | 45.54 | 0.07 | 0.06 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |

**Table D-14: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 2, Cross-Section #996.92**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 289.76 | 0.22 | 7.40 | 0.01 | 0.01 | 29 | 31 | 31 | 30 | 1 | 0 | 0 | 0 |
| 0.05 | 289.77 | 0.28 | 7.69 | 0.02 | 0.02 | 29 | 31 | 31 | 29 | 1 | 0 | 0 | 1 |
| 0.10 | 289.79 | 0.35 | 8.01 | 0.04 | 0.03 | 28 | 29 | 25 | 24 | 2 | 2 | 6 | 6 |
| 0.15 | 289.8 | 0.41 | 8.26 | 0.05 | 0.04 | 27 | 24 | 18 | 19 | 3 | 7 | 13 | 11 |
| 0.20 | 289.81 | 0.45 | 8.48 | 0.06 | 0.05 | 27 | 19 | 13 | 14 | 3 | 12 | 18 | 16 |
| 0.25 | 289.82 | 0.49 | 8.68 | 0.07 | 0.06 | 26 | 15 | 9 | 10 | 4 | 16 | 22 | 20 |
| 0.30 | 289.82 | 0.52 | 8.86 | 0.07 | 0.07 | 25 | 12 | 5 | 7 | 5 | 19 | 26 | 23 |
| 0.35 | 289.83 | 0.55 | 9.02 | 0.08 | 0.07 | 24 | 9 | 3 | 5 | 6 | 22 | 28 | 25 |
| 0.40 | 289.84 | 0.57 | 9.18 | 0.09 | 0.08 | 23 | 7 | 2 | 3 | 7 | 24 | 29 | 27 |
| 0.45 | 289.84 | 0.59 | 9.34 | 0.09 | 0.08 | 21 | 5 | 1 | 2 | 9 | 26 | 30 | 28 |
| 0.50 | 289.85 | 0.61 | 9.49 | 0.1 | 0.09 | 19 | 3 | 1 | 1 | 11 | 28 | 30 | 29 |
| 0.55 | 289.85 | 0.63 | 9.62 | 0.1 | 0.09 | 18 | 2 | 1 | 1 | 12 | 29 | 30 | 29 |
| 0.60 | 289.86 | 0.63 | 9.81 | 0.11 | 0.10 | 17 | 2 | 1 | 1 | 13 | 29 | 30 | 29 |
| 0.65 | 289.87 | 0.65 | 9.94 | 0.12 | 0.10 | 16 | 1 | 1 | 1 | 14 | 30 | 30 | 29 |
| 0.70 | 289.87 | 0.67 | 10.05 | 0.12 | 0.10 | 14 | 1 | 0 | 0 | 16 | 30 | 31 | 30 |
| 0.75 | 289.88 | 0.68 | 10.17 | 0.13 | 0.11 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.80 | 289.88 | 0.70 | 10.29 | 0.13 | 0.11 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.85 | 289.89 | 0.71 | 10.39 | 0.14 | 0.11 | 12 | 0 | 0 | 0 | 18 | 31 | 31 | 30 |
| 0.90 | 289.89 | 0.73 | 10.50 | 0.14 | 0.12 | 11 | 0 | 0 | 0 | 19 | 31 | 31 | 30 |
| 0.95 | 289.89 | 0.74 | 10.61 | 0.14 | 0.12 | 10 | 0 | 0 | 0 | 20 | 31 | 31 | 30 |

**Table D-14: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 2, Cross-Section #996.92**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 1.00 | 289.90 | 0.75 | 10.71 | 0.15 | 0.12 | 9 | 0 | 0 | 0 | 21 | 31 | 31 | 30 |
| 1.05 | 289.90 | 0.78 | 10.75 | 0.15 | 0.12 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 1.10 | 289.90 | 0.79 | 10.84 | 0.15 | 0.13 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 1.15 | 289.91 | 0.80 | 10.94 | 0.16 | 0.13 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 1.20 | 289.91 | 0.81 | 11.04 | 0.16 | 0.13 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 1.25 | 289.92 | 0.82 | 11.16 | 0.17 | 0.14 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 1.30 | 289.92 | 0.83 | 11.25 | 0.17 | 0.14 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 1.35 | 289.93 | 0.84 | 11.34 | 0.18 | 0.14 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 1.40 | 289.93 | 0.85 | 11.43 | 0.18 | 0.15 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 1.45 | 289.95 | 0.78 | 11.87 | 0.2 | 0.16 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 1.50 | 289.95 | 0.77 | 12.02 | 0.2 | 0.16 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 1.55 | 289.96 | 0.79 | 12.08 | 0.21 | 0.16 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |

**Table D-15: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 1, Cross-Section #64.15607**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 0.02 | 282.01 | 0.23 | 10.45 | 0.01 | 0.01 | 27 | 7 | 0 | 29 | 3 | 24 | 31 | 1 |
| 0.05 | 282.01 | 0.36 | 10.55 | 0.01 | 0.01 | 27 | 0 | 0 | 21 | 3 | 31 | 31 | 9 |
| 0.10 | 282.02 | 0.44 | 10.72 | 0.02 | 0.02 | 26 | 0 | 0 | 10 | 4 | 31 | 31 | 20 |
| 0.15 | 282.03 | 0.52 | 10.84 | 0.03 | 0.03 | 24 | 0 | 0 | 3 | 6 | 31 | 31 | 27 |
| 0.20 | 282.03 | 0.62 | 10.91 | 0.03 | 0.03 | 21 | 0 | 0 | 1 | 9 | 31 | 31 | 29 |
| 0.25 | 282.04 | 0.61 | 11.07 | 0.04 | 0.04 | 17 | 0 | 0 | 1 | 13 | 31 | 31 | 29 |
| 0.30 | 282.04 | 0.66 | 11.16 | 0.04 | 0.04 | 15 | 0 | 0 | 0 | 15 | 31 | 31 | 30 |
| 0.35 | 282.02 | 1.47 | 10.74 | 0.02 | 0.02 | 13 | 0 | 0 | 0 | 17 | 31 | 31 | 30 |
| 0.40 | 282.02 | 1.70 | 10.74 | 0.02 | 0.02 | 11 | 0 | 0 | 0 | 19 | 31 | 31 | 30 |
| 0.45 | 282.05 | 0.86 | 11.28 | 0.05 | 0.05 | 9 | 0 | 0 | 0 | 21 | 31 | 31 | 30 |
| 0.50 | 282.05 | 0.89 | 11.35 | 0.05 | 0.05 | 8 | 0 | 0 | 0 | 22 | 31 | 31 | 30 |
| 0.55 | 282.05 | 0.99 | 11.34 | 0.05 | 0.05 | 7 | 0 | 0 | 0 | 23 | 31 | 31 | 30 |
| 0.60 | 282.05 | 1.13 | 11.29 | 0.05 | 0.05 | 6 | 0 | 0 | 0 | 24 | 31 | 31 | 30 |
| 0.65 | 282.05 | 1.17 | 11.33 | 0.05 | 0.05 | 5 | 0 | 0 | 0 | 25 | 31 | 31 | 30 |
| 0.70 | 282.05 | 1.26 | 11.34 | 0.05 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.75 | 282.05 | 1.32 | 11.36 | 0.05 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.80 | 282.05 | 1.36 | 11.40 | 0.05 | 0.05 | 4 | 0 | 0 | 0 | 26 | 31 | 31 | 30 |
| 0.85 | 282.06 | 1.40 | 11.43 | 0.06 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.90 | 282.06 | 1.44 | 11.46 | 0.06 | 0.05 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |
| 0.95 | 282.06 | 1.47 | 11.50 | 0.06 | 0.06 | 3 | 0 | 0 | 0 | 27 | 31 | 31 | 30 |

**Table D-15: Scenario 2 – Hydraulic Model Results for Rascal Stream West Reach 1, Cross-Section #64.15607**

| Average Daily Discharge | Water Level | Channel Velocity | Water Top Width | Maximum Water Depth | Average Water Depth | Average No. of Days per Month Above Average Discharge | | | | Average No. of Days per Month Below Average Discharge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ($m^3/s$) | (m) | (m/s) | (m) | (m) | (m) | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| 1.00 | 282.06 | 1.50 | 11.54 | 0.06 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.05 | 282.06 | 1.52 | 11.58 | 0.06 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.10 | 282.07 | 1.54 | 11.62 | 0.07 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.15 | 282.07 | 1.53 | 11.68 | 0.07 | 0.06 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.20 | 282.07 | 1.56 | 11.71 | 0.07 | 0.07 | 2 | 0 | 0 | 0 | 28 | 31 | 31 | 30 |
| 1.25 | 282.07 | 1.58 | 11.76 | 0.07 | 0.07 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.30 | 282.08 | 1.57 | 11.82 | 0.08 | 0.07 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.35 | 282.08 | 1.58 | 11.86 | 0.08 | 0.07 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.40 | 282.11 | 1.10 | 12.56 | 0.11 | 0.10 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.45 | 282.11 | 1.12 | 12.61 | 0.11 | 0.10 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.50 | 282.12 | 1.13 | 12.65 | 0.12 | 0.10 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |
| 1.55 | 282.12 | 1.15 | 12.69 | 0.12 | 0.11 | 1 | 0 | 0 | 0 | 29 | 31 | 31 | 30 |




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