Water Balance Analysis

Nictaux Sand Pit Expansion Project

Shaw Group Limited

2 May 2025

→ **The Power of Commitment**

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1. Introduction

GHD Limited (GHD) was retained by the Shaw Group Limited (Shaw) to complete a water balance for the proposed Nictaux Sand Pit Expansion Project (the Project), an expansion of the existing Trimper Sand and Gravel Pit located near Nictaux, Annapolis County, Nova Scotia (NS). The Minister of Environment and Climate Change has granted consent to transfer the existing environmental assessment (EA) approval dated April 20, 2012 for the Trimper Sand and Gravel Pit Expansion Project originally issued to Ivan H. Trimper Construction Ltd. to 4389818 Nova Scotia Limited, a numbered company wholly owned by Shaw. Shaw intends to expand the Project Area (PA) authorized by this EA approval to include extraction of a sand resource located on parcels with the following premises identification numbers (PIDs): 05291448, 05291455, 05286976, 05286984, 05310834, 05286968, 05194030, 05313853, 05059688, and 05058334.

Shaw intends to operate the Project for the purpose of extracting commercial sand at a rate of approximately 475,000 tonnes per year. The proposed land disturbance, shown on Figure 1, is approximately 133 hectares (ha) in area. All sand extracted for the Project will be processed on-site via screening, washing, and classifying for commercial sale. Processing equipment will include screens, conveyors, and crushers. Shaw intend to extract sand from beneath the water table as determined through baseline groundwater elevation monitoring however there will be no pumping required to extract the sand. A barge will be used to extract any material below the water table.

1.1 Purpose of this Report

The water balance presented herein is a preliminary assessment of the predicted effects on surrounding surface watercourses caused by expansion of the sand pit. Three scenarios were analyzed: baseline conditions, operating conditions, and reclamation conditions. Baseline conditions consider the site topography prior to development. Operating conditions consider the PA at full development of the proposed extraction area. Reclamation conditions are representative of the PA after revegetation of disturbed areas. As such, these represent the “post closure” condition as some degree of progressive reclamation will occur during site development.

1.2 Scope and Limitations

This report: has been prepared by GHD for Shaw Group Limited and may only be used and relied on by Shaw Group Limited for the purpose agreed between GHD and Shaw Group Limited as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Shaw Group Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

2. Data Collection

2.1 Topography

A 1-m digital elevation model (DEM) collected from the *Nova Scotia Data Locator – Elevation Explorer* website was used to delineate the baseline catchments (Nova Scotia, 2022). Catchment delineations for the watercourses were produced using the watershed delineation tool within PCSWMM, a hydrologic modelling software.

2.2 Climate Data

GHD obtained water budget data from Environment and Climate Change Canada's (ECCC) Meteorological Service of Canada (MSC) in support of the assessment. The water budget data includes monthly timeseries of temperature, precipitation, rainfall, snowmelt, potential evapotranspiration (PET), and actual evapotranspiration (AET), which are used to calculate the soil storage surplus for the selected soil water holding capacity following the Thornthwaite and Mather water balance methodology. The calculated surplus values were also obtained from ECCC.

The water balance surplus was estimated by ECCC using the most recent version of the water balance model developed by Meteorological Service of Canada (MSC, see Johnstone and Louie, 2008). The MSC's water balance method accounts for snow accumulation and melt (degree day method of USACE, 1956), potential evapotranspiration (Thornthwaite and Mather, 1955), soil storage, actual evapotranspiration, and moisture deficit and surplus. The MSC program calculates a 'water surplus' as the final product, which is the total water available in a given month to run off as surface overland flow and/or infiltrate to the ground and recharge the groundwater table. The MSC water balance model uses continuous daily precipitation and air temperature data. The use of daily data allows for more accurate modelling of snowmelt and snow storage, which are of particular importance in a cold weather/winter climate (Johnstone and Louie, 1983).

The completed time series of monthly water budget data between 1943 and 2021 was provided for the Greenwood A station (Climate ID: 8202000), which is located approximately 9 kilometers northeast of the Site. Average climate data collected from the Greenwood A station is presented in Table 1.

Table 1 Climate Data

Parameter	January	February	March	April	May	June	July	August	September	October	November	December
Temperature[1] (°C)	-5.1	-5.0	-0.8	5.0	11.0	16.0	19.6	18.8	14.4	8.9	4.0	-1.9
Precipitation[1] (millimetres [mm])	109.9	89.5	86.4	80.3	79.9	80.1	79.0	85.4	91.1	96.8	115.5	118.4
AET[1] (mm/d)	2.3	2.1	7.7	27.9	69.0	102.1	109.8	87.9	69.8	40.3	17.1	4.9

2.3 Streamflow Monitoring data

Five surface water monitoring locations were implemented and are described further in the Baseline Surface Water Monitoring Report (GHD, 2025). Four stations are located on Bald Hill Brook, of which three were carried over from previous stations commissioned for the Trimper Gravel pit (SW1 through SW3). The fourth is a new station (SW4) installed in fall 2024, downstream of SW2 on Bald Hill Brook. An additional monitoring station was also installed in spring 2024 at an unnamed ephemeral stream located southwest of the pit (herein termed watercourse 1 [WC1]). Surface water monitoring locations are shown on Figure 1.

Continuous water level loggers were installed at SW4 and SW5 and discrete measurements were taken throughout the year to develop a baseline stage-discharge rating curve. The recorded discrete flow and water level measurements are summarized in Table 2. Each monitoring station only had one usable discrete measurement at this time as SW4 was installed in late 2024 and SW5 was dry for most of the year. Consequently, a rating curve could not be developed for this analysis.

Table 2 2024 Surface Water Quantity Monitoring Summary

Station	Date	Flow (L/s)	Staff Gauge Reading (m)	Water Level Elevation (masl)
SW4	31/Oct/24	2.20	0.09	26.86
SW5	26/Apr/24	0.70	0.255	43.66
	28/Aug/24	Dry		
	30/Oct/24	0.00	0.140	43.55

3. Methodology

3.1 Catchment Delineation

Catchment delineations are presented based on three life-cycle phases of the Project: baseline catchments are shown in Figure 1 and operating and reclamation catchments are shown in Figure 2. Catchment delineations for the assessment points and the monitoring stations in baseline conditions were produced using the watershed delineation tool within PCSWMM, a hydrologic modelling software.

In order to predict operating and reclamation drainage conditions, a modified DEM was produced in a geographic information system (GIS) environment. The proposed extraction area was clipped from the baseline DEM, and the gaps were filled using an interpolation algorithm. GHD understands the sand deposit will be extracted below grade throughout most of the pit, with localized areas that are at grade with the adjacent undisturbed areas. Areas of the pit extracted below grade were assumed to discharge to Bald Hill Brook, WC3, and WC4 under operating and reclamation conditions to maintain pre-development flow conditions to the extent practicable. Areas of the pit matching the surrounding grade were assumed to drain according to regional topography.

Assessment points were placed at the points in watercourses expected to undergo the largest change as a result of Project development. Two additional assessment points were assigned to baseline surface water monitoring stations SW4 and SW5 to allow comparison between predicted and observed conditions.

Contributing drainage areas were delineated for seven assessment points on five watercourses with the potential to be impacted by Project development. The drainage areas for the three conditions are shown in Table 3.

Table 3 Assessment Point Drainage Areas

Assessment Point	Drainage Areas (ha)	
	Baseline Conditions	Operation/Reclamation Conditions
WC1-SW5	54.19	56.69
WC1-DS	85.73	85.06
WC2	274.42	273.75
WC3	123.57	122.47
WC4	176.28	180.61
BHB-SW4	160.25	171.19
BHB-DS	651.04	649.93

3.2 Water Balance

A monthly water balance assessment was performed for all delineated catchments following the methodology developed by Thornthwaite and Mather (1957). The methodology calculates water surplus depths from soil storage, where rainfall and snowmelt are added, and PET is subtracted from the soil storage on a monthly basis.

AET equals PET when there is enough water available within the soil storage to meet the evapotranspiration demand, otherwise, AET equals the amount of water that is available for evapotranspiration. A surplus is calculated when the water holding capacity of the soil storage is exceeded. The surplus is partitioned into infiltration and surface runoff depths using an infiltration factor (described in Section 3.4).

The water holding capacity of each catchment’s soil storage was determined to be 100 mm, which is representative of sand with pasture and/or shrub land cover (Ontario Ministry of Environment, Conservation and Parks (OMECP), 2003). The climate inputs including rainfall, snowmelt, PET, and AET and the computed surplus were obtained from ECCC for the selected soil water holding capacity as described in Section 2.2.

3.3 Infiltration Factor

The infiltration rates for each catchment were estimated using the infiltration factors taken from Table 3.1 of the OMECP Stormwater Management Planning and Design Manual (2003). Calculations using Table 3.1 account for slope, soil types, and vegetation cover when estimating water holding capacity for an area. Each catchment was individually analyzed to determine the slope, land use and soil type drainage factors. If multiple slope or land use segments existed within a watershed then an area-ratio method was used to determine the appropriate infiltration factor. During baseline conditions the catchments were determined to be hilly land with a combination of cultivated land and woodland. Considering these conditions, the following infiltration factors were applied:

– Forested areas – 0.6
– Farmland and pasture – 0.7
– Extraction area – 0.8
– Reclaimed areas – 0.7

3.4 Groundwater Contribution

Streamflow volumes were calculated as the sum of the surface runoff and baseflow volumes. Surface runoff volumes were assumed to equal the total precipitation less the evapotranspiration and infiltration. Baseflow volumes were assumed to equal infiltration volumes. The basis for this assumption is that the groundwater flow divide follows the catchment boundaries, and the water infiltrated within the catchment area appears as baseflow at the corresponding assessment point. It is assumed that there are no or minimal losses of groundwater to a deep aquifer system that crosses the catchment boundaries.

Shaw intends to extract sand from beneath the current water table as established through baseline groundwater elevation monitoring. All sand extracted from beneath the water table will be removed via dredge. As such, sand extraction is not anticipated to result in groundwater drawdown as the pit area will not be dewatered. Following extraction, any pit areas extracted beneath the water table will be left as pit lakes into the reclamation phase, maintaining the adjacent water table elevation.

Freshwater requirements for the wash plant are proposed to be met by withdrawal from an on-site water supply pond. The pond will be constructed by excavating beneath the water table and will be recharged by inflows from the highly permeable sand and gravel aquifer present within the PA. Process water from the wash plant will flow through a water clarifier before being recycled back into the water supply pond.

With the exception of potential losses to evaporation and the water clarifier, all water withdrawn from the supply pond is planned to be recycled within this unconfined closed loop system. Shaw currently employ a similar process water supply system at their Keddy facility. Operations and environmental monitoring completed for the Keddy facility demonstrate consistent water elevations in supply ponds and monitoring wells, confirming the process water supply system is not depleting local groundwater. Considering the similar geological conditions and process proposed for the Project, it was assumed the Project will not result in the loss of baseflow supplying surrounding watercourses.

3.5 Water Balance Calibration

As Bald Hill Brook is a primary receptor of drainage from the Project and SW5 is located on an ephemeral stream with inconsistent flow, SW4 was selected for calibration. The calibration was performed by converting the measured flow rate from October 2024 to an average monthly flow volume and comparing this value with the outputs of the water balance analysis. The catchment infiltration factor was then varied to optimize the percent difference between the calculated and measured values. The ratio between the calibrated infiltration factor and the pre-calibrated value was applied as a factor to scale the infiltration factors of the remaining catchments.

As 2024 was a relatively dry year with a total precipitation volume of 974 mm, only years with comparable precipitation amounts (<1,000 mm) were used for the calibration. The water balance approach described in Section 3.2 was applied to the historical dry years for this comparison. In total, 21 of the 78 years of data had annual precipitation below 1,000 mm. The calculated average October streamflow volume from the historical dry years was 5,891 m^3, with a historical monthly precipitation total of 74.3 mm and a runoff coefficient of 0.050.

Comparatively, the average monthly flow volume for October 2024 was found to be 5,892 m^3, providing an error of -0.3% between the measured and historical average values. The monthly precipitation was 81.2 mm, and the runoff coefficient was 0.045.

As the water balance results for the historical dry years are in good agreement with the observed streamflow measurements, no changes were applied to the infiltration factors for the catchments.

4. Results

The water balance analysis completed for baseline, operating, and reclamation conditions is presented in Tables 2 through 4 respectively. Tables 5 and 7 display the percentage change in area and runoff from baseline conditions to operating, and reclamation conditions, respectively. Negative values in Tables 5 and 6 represent a decrease in the parameter value when compared to baseline conditions, and positive values represent an increase in the parameter value when compared to baseline conditions.

Although the water balance analysis was completed using a monthly timestep, the results provided below are summarized on an annual basis for discussion purposes. Water balance results summarized on a monthly basis are provided in Appendix A.

Table 4 Water Balance - Baseline Conditions

Watershed	Area (ha)	Runoff + Baseflow (cubic metre [m^3])	Infiltration (m^3)
WC1-DS	85.73	490,463	291,132
WC2	274.42	1,586,344	946,360
WC3	123.57	750,679	465,494
WC4	176.28	1,038,320	602,421
BHB-DS	651.04	3,762,463	2,120,441
BHB-SW4	160.25	913,309	534,002
WC1-SW5	54.19	314,326	169,888

Table 5 Water Balance - Operating Conditions

Watershed	Area (ha)	Runoff + Baseflow (m^3)	Infiltration (m^3)
WC1-DS	85.06	486,661	294,507
WC2	273.75	1,571,213	950,987
WC3	122.47	718,350	443,851
WC4	180.61	1,035,573	601,164
BHB-DS	649.93	3,842,628	2,244,453
BHB-SW4	171.19	988,823	596,215
WC1-SW5	54.10	316,040	175,130

Table 6 Operating Conditions Comparison to Baseline Conditions

Watershed	% Area Change	% Runoff + Baseflow Change
WC1-DS	-0.78%	-0.78%
WC2	-0.24%	-0.95%
WC3	2.46%	-0.26%
WC4	-0.89%	-4.31%
BHB-DS	-0.17%	2.13%
BHB-SW4	6.83%	8.27%
WC1-SW5	-0.17%	0.55%

Under operating conditions, marginal decreases in streamflow are anticipated at WC1-SW5, WC1-DS, WC2, WC3, and WC4. These predicted flow reductions are due to either loss of catchment area or increases in pervious area as a result of pit expansion. An increase in streamflow of 8.27% is predicted at assessment point BHB-SW4 due to an increase in its catchment area following pit expansion.

Table 7 Water Balance – Reclamation Conditions

Watershed	Area (ha)	Runoff + Baseflow (m^3)	Infiltration (m^3)
WC1-DS	85.06	486,661	291,687
WC2	273.75	1,577,455	948,167
WC3	122.47	722,427	443,851
WC4	180.61	1,037,628	597,436
BHB-DS	649.93	3,798,508	2,179,793
BHB-SW4	171.19	982,086	583,847
WC1-SW5	54.10	314,908	172,350

Table 8 Reclamation Conditions Comparison to Baseline Conditions

Watershed	% Area Change	% Runoff + Baseflow Change
WC1-DS	-0.78%	-0.78%
WC2	-0.24%	-0.56%
WC3	-0.89%	-3.76%
WC4	2.46%	-0.07%

Table 8 Reclamation Conditions Comparison to Baseline Conditions

Watershed	% Area Change	% Runoff + Baseflow Change
BHB-DS	-0.17%	0.96%
BHB-SW4	6.83%	7.53%
WC1-SW5	-0.17%	0.19%

Predicted streamflow volumes under reclamation conditions are similar to those predicted for operation conditions; marginal changes are the result of changes to land cover following site closure. Under reclamation conditions, marginal decreases in streamflow are anticipated at WC1-DS, WC2, WC3, and WC4. These predicted flow reductions are due to either loss of catchment area or changes to land cover. An increase in streamflow of 7.53% is predicted at assessment point BHB-SW4 due to an increase in its catchment area following pit expansion.

5. Conclusions

The results of this water balance analysis can be used to assess the potential impact of Project development on the receiving environment in terms of the changes in streamflow volumes discharged to nearby watercourses. The results are analyzed for average annual conditions. The water balance analysis was completed under the assumption that the groundwater flow divide follows the catchment boundaries and that water infiltrated within a catchment area appears as baseflow at the corresponding assessment point. For the purposes of this assessment, it was assumed the Project will not result in the loss of baseflow supplying surrounding watercourses as the pit will not be dewatered to facilitate extraction beneath the water table.

At full development, watercourses WC1, WC2, WC3, and WC4 will experience marginal reductions in streamflow ranging from 0.07% at WC3 under reclamation conditions to 4.31% at WC4 under operation conditions. Bald Hill Brook at assessment point BHB-SW4 is predicted to experience increases of 8.27% and 7.53% under operation and reclamation conditions, respectively. The Fisheries and Oceans Canada (DFO) *Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada* (DFO, 2013) describes cumulative flow alterations <10% in amplitude of the actual (instantaneous) flow in the river as having a low probability of detectable impacts to ecosystems that support fisheries. Predicted changes to flow alterations as a result of Project development are all beneath this threshold.

When discussing the results of this water balance it should be noted that potential impacts to watercourses can be further mitigated through surface water management during Project development. Furthermore, the lengthy duration of development will allow the surrounding environment to slowly adjust to changes in the hydrologic regime. As such, the operating conditions scenario represents the worst-case in terms of overall development.

6. References

Nova Scotia. 2025. DataLocator – Elevation Explorer. Retrieved: https://nsgi.novascotia.ca/datalocator/elevation/.

Fisheries and Oceans Canada (DFO). 2013. Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada.

Appendices

Appendix A

Monthly Water Balance Results

Table A.1 Change in Monthly Streamflow Values for the Development Stages for WC1-DS

Month	Baseline	Operation		Reclamation	
	m3	m3	% change	m3	% change
Jan	74,038	73,462	-0.78%	73,462	-0.78%
Feb	64,910	64,406	-0.78%	64,406	-0.78%
Mar	100,560	99,778	-0.78%	99,778	-0.78%
Apr	60,875	60,402	-0.78%	60,402	-0.78%
May	17,968	17,828	-0.78%	17,828	-0.78%
Jun	6,888	6,835	-0.78%	6,835	-0.78%
Jul	2,053	2,037	-0.77%	2,037	-0.77%
Aug	175	174	-0.39%	174	-0.39%
Sep	4,815	4,779	-0.74%	4,779	-0.74%
Oct	19,761	19,611	-0.76%	19,611	-0.76%
Nov	60,419	59,952	-0.77%	59,952	-0.77%
Dec	78,002	77,395	-0.78%	77,395	-0.78%
Annual	490,463	486,661	-0.78%	486,661	-0.78%

Table A.2 Change in Monthly Streamflow Values for the Development Stages for WC2

Month	Baseline	Operation		Reclamation	
	m3	m3	% change	m3	% change
Jan	239,417	237,128	-0.96%	238,072	-0.56%
Feb	209,901	207,894	-0.96%	208,722	-0.56%
Mar	325,183	322,073	-0.96%	323,357	-0.56%
Apr	196,854	194,972	-0.96%	195,748	-0.56%
May	58,104	57,548	-0.96%	57,777	-0.56%
Jun	22,279	22,066	-0.95%	22,154	-0.56%
Jul	6,643	6,580	-0.95%	6,606	-0.56%
Aug	588	585	-0.46%	586	-0.27%
Sep	15,632	15,490	-0.91%	15,549	-0.53%
Oct	64,023	63,426	-0.93%	63,673	-0.55%
Nov	195,477	193,620	-0.95%	194,386	-0.56%
Dec	252,242	249,830	-0.96%	250,825	-0.56%
Annual	1,586,344	1,571,213	-0.95%	1,577,455	-0.56%

Table A.3 Change in Monthly Streamflow Values for the Development Stages for WC3

Month	Baseline	Operation		Reclamation	
	m3	m3	% change	m4	% change
Jan	113,396	108,504	-4.31%	109,121	-3.77%
Feb	99,416	95,127	-4.31%	95,668	-3.77%

Month	Baseline	Operation		Reclamation	
	m3	m3	% change	m4	% change
Mar	154,018	147,373	-4.31%	148,211	-3.77%
Apr	93,237	89,214	-4.31%	89,722	-3.77%
May	27,519	26,332	-4.31%	26,482	-3.77%
Jun	10,543	10,089	-4.31%	10,146	-3.76%
Jul	3,135	3,001	-4.28%	3,018	-3.74%
Aug	230	225	-2.52%	225	-2.20%
Sep	7,276	6,973	-4.16%	7,011	-3.64%
Oct	30,069	28,794	-4.24%	28,954	-3.71%
Nov	92,381	88,413	-4.30%	88,914	-3.75%
Dec	119,457	114,304	-4.31%	114,954	-3.77%
Annual	750,679	718,350	-4.31%	722,427	-3.76%

Table A.4 Change in Monthly Streamflow Values for the Development Stages for WC4

Month	Baseline	Operation		Reclamation	
	m3	m3	% change	m4	% change
Jan	156,001	155,574	-0.27%	155,885	-0.07%
Feb	136,769	136,394	-0.27%	136,667	-0.07%
Mar	211,885	211,305	-0.27%	211,727	-0.07%
Apr	128,268	127,916	-0.27%	128,172	-0.07%
May	37,862	37,759	-0.27%	37,834	-0.07%
Jun	14,578	14,540	-0.27%	14,568	-0.07%
Jul	4,408	4,397	-0.24%	4,406	-0.04%
Aug	718	723	0.70%	724	0.75%
Sep	11,084	11,072	-0.11%	11,091	0.07%
Oct	43,502	43,420	-0.19%	43,501	0.00%
Nov	128,795	128,472	-0.25%	128,724	-0.06%
Dec	164,449	164,001	-0.27%	164,328	-0.07%
Annual	1,038,320	1,035,573	-0.26%	1,037,628	-0.07%

Table A.5 Change in Monthly Streamflow Values for the Development Stages for BHB-DS

Month	Baseline	Operation		Reclamation	
	m3	m3	% change	m4	% change
Jan	564,283	576,415	2.15%	569,738	0.97%
Feb	494,717	505,352	2.15%	499,499	0.97%
Mar	766,425	782,902	2.15%	773,834	0.97%
Apr	463,966	473,941	2.15%	468,451	0.97%
May	136,958	139,902	2.15%	138,281	0.97%
Jun	52,820	53,946	2.13%	53,326	0.96%
Jul	16,057	16,390	2.07%	16,207	0.93%
Aug	3,077	3,092	0.47%	3,084	0.21%
Sep	41,374	42,125	1.82%	41,712	0.82%

Month	Baseline	Operation		Reclamation	
	m3	m3	% change	m4	% change
Oct	159,906	163,068	1.98%	161,327	0.89%
Nov	467,908	477,748	2.10%	472,333	0.95%
Dec	594,971	607,748	2.15%	600,716	0.97%
Annual	3,762,463	3,842,628	2.13%	3,798,508	0.96%

Table A.6 Change in Monthly Streamflow Values for the Development Stages for BHB-SW4

Month	Baseline	Operation		Reclamation	
	m3	m3	% change	m4	% change
Jan	137,674	149,101	8.30%	148,082	7.56%
Feb	120,701	130,720	8.30%	129,826	7.56%
Mar	186,993	202,514	8.30%	201,129	7.56%
Apr	113,199	122,594	8.30%	121,756	7.56%
May	33,412	36,186	8.30%	35,938	7.56%
Jun	12,826	13,886	8.27%	13,792	7.53%
Jul	3,839	4,152	8.17%	4,124	7.44%
Aug	417	430	3.26%	429	2.96%
Sep	9,200	9,908	7.69%	9,845	7.00%
Oct	37,236	40,215	8.00%	39,949	7.29%
Nov	112,742	122,011	8.22%	121,184	7.49%
Dec	145,070	157,105	8.30%	156,032	7.56%
Annual	913,309	988,823	8.27%	982,086	7.53%