Memo

To: Chris Yurchesyn, General Manager, OSCO Aggregates Limited

From: Jonathan Oliver, P.Geo., M.Sc., Project Manager, Dillon Consulting Limited

Date: June 6, 2024

Subject: Pit No. 4 Extension - Water Balance Analysis

Our File: 23-6113-2300

1.0 Introduction

Dillon Consulting Limited (Dillon) was retained to undertake a Water Balance Analysis for the Pit No. 4 Extension in Nova Scotia. The following technical memo provides an overview of the project, our methodology, and data sources as well as a summary of the results of the analysis.

2.0 Background

The following technical memo summarizes the Water Balance Analysis completed for Glenholme Quarry expansion located in the community of Glenholme, Colchester County, Nova Scotia (the Project). The Project location can be seen on Figure 1.

The Project Development Area (PDA) is defined as the area of physical disturbance associated with the Project (also sometimes referred to as the Project footprint). The PDA consists of an area of 77 hectares (ha), encompassing the properties north of the current Pit No. 4 property (Pit 4), as well as the current Pit No. 4 property.

The objective of this memo was to quantify the potential impacts of the quarry development on the surface water runoff to the surrounding watercourses. The Water Balance Report was performed for two (2) stages of quarry life:

1. Existing Conditions (Pre-Development); and
2. Operating Conditions (Post-Development).

2.1.1 Assumptions and Limitations

It is important to note that the following assumptions and limitations were made in the preparation of the Water Balance Analysis.

- Operating conditions assumed full development of approximately 45 hectares;
- The existing Pit 4 and proposed development areas (i.e., new Pits) are assumed to be enclosed watersheds that do not release stormwater to the natural environment; and
- The water balance assumes that groundwater inflow is equal to groundwater outflow; therefore groundwater recharge was not included in this water balance.

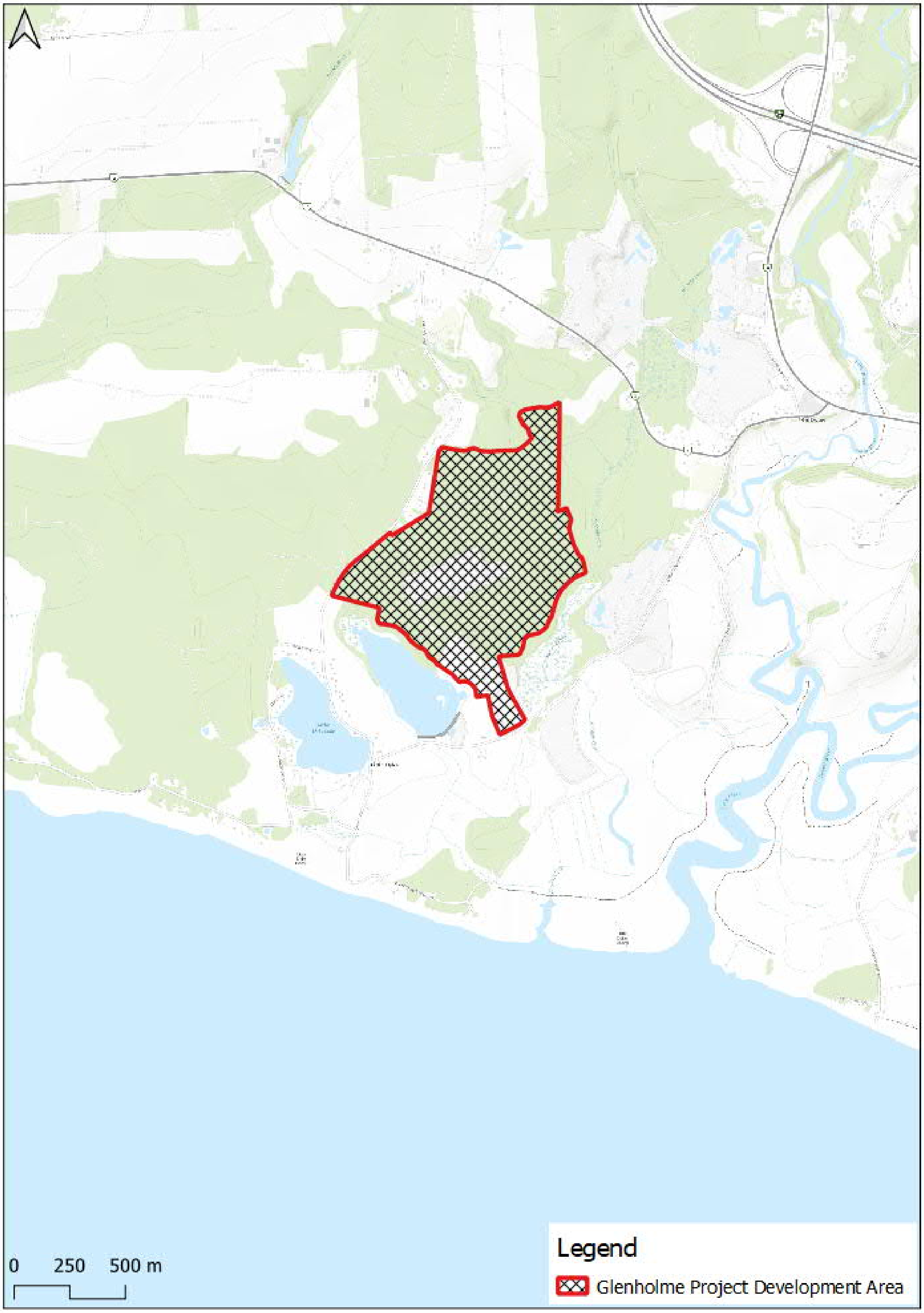

Figure 1: Site location

3.0 Data Collection

The following section outlines the data that was collected to support the Water Balance Analysis.

3.1 Climate Data

Climate data was collected and defined using several different sources as defined below.

3.1.1 Temperature and Precipitation

Average monthly temperatures and precipitations were obtained from the nearby Environment Canada Debert Climate Station (Station ID 82013390) based on Climate Normals between 1991-2020. The station was selected to represent climate conditions on the Site area due its proximity – 7 km north-east of the Site.

3.1.2 Evaporation

Monthly lake evaporation normals were obtained from the Environment Canada Truro Climate Station (Station ID 8205990) based on Climate Normals between 1981-2010. The Truro Station was selected as the closest climate station to the site which records lake evaporation data.

3.1.3 Evapotranspiration

Monthly potential evapotranspiration normals were calculated using Instructions and Tables for computing Evapotranspiration and The Water Balance manual (Thornthwaite and Mather, 1957).

Table 1 presents collected values of temperature, precipitation, evaporation, and potential evapotranspiration that were used in the Water Balance Analysis.

Table 1: Climate Data of the Site area

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Average Temperature[1] [°C]	-6.7	-6.2	-2.0	4.0	9.9	14.8	18.9	18.3	14.2	8.3	3.2	-2.7
Precipitation[1] [mm]	91.0	77.1	81.4	90.4	89.3	98.7	87.5	91.9	118.9	117.5	113.7	121.3
Lake Evaporation[2] [mm]	0.0	0.0	0.0	0.0	2.9	3.4	3.8	3.1	2.3	1.3	0.0	0.0
Heat Index[3]	0.0	0.0	0.0	0.7	2.8	5.2	7.5	7.1	4.9	2.2	0.5	0.0
Unadjusted Potential ET[4] [mm]	0.0	0.0	0.0	0.7	1.7	2.5	3.2	3.1	2.4	1.4	0.6	0.0
Latitude Adjustment[5]	24.0	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5
Adjusted Potential ET[6] [mm]	0.0	0.0	0.0	23.7	65.3	96.8	125.8	112.5	74.9	39.5	14.2	0.0

Notes:
[1] From 1991 to 2020 Canadian Climate Normals Data - Debert Environment Canada Station, ID 82013390
[2] From 1981 to 2010 Canadian Climate Normals Data - Truro Environment Canada Station, ID 8205990

[3] From Thornthwaite and Mather (1957), Table 2
[4] From Thornthwaite and Mather (1957), Table 4
[5] From Thornthwaite and Mather (1957), Table 6, for 45° N latitude.
[6] Unadjusted Potential ET x Latitude Adjustment.

4.0 Methodology

The following sections outline our methodology and approach to defining watershed and infiltration characteristics for the Water Balance Analysis.

4.1 Watershed

The area surrounding the PDA was delineated into three (3) contributing watersheds based on the outfalls downstream of the site as shown in Figure 2. The largest watercourse is McCurdy Creek that drains watershed No. 03 with an area of approximately 343.8 hectares along the east side of the PDA. Two (2) additional watersheds, No. 01 and No. 02 have areas of about 124.2 and 82.2 hectares, respectively, and drain to unnamed watercourses. Watershed No. 01 drains to a tributary of McCurdy creek along the north-east side of the PDA. Watershed No. 02 drains across the north-west part of the PDA and contributes into the existing marsh which is managed by Ducks Unlimited Canada (DUC).

As outlined under the Assumptions and Limitations, the existing area of Pit 4 was considered an enclosed watershed without an outlet to the external stormwater system; water management in the existing Pit 4 is not currently in place. The same assumption was applied to the PDA in that the new quarry development areas would reduce the area of watersheds 01 to 03, and that dewatering will not be required because the project will stay 0.5 m above the water table and infiltration is expected to be high. Table 2 outlines the drainage area of the existing watersheds along with changes in area due to operating conditions. Should dewatering be required during operation, a qualified hydrologist will be engaged to support the design of appropriate water management.

Table 2: Drainage Area Properties for Existing and Operating Conditions

Watershed [-]	Existing Conditions Area[ha]	Operating Conditions Area[ha]	Subtracted Area Area[ha]	Subtracted Area [%]	Outfall [-]
01	124.2	123.1	-1.1	-0.9%	01(McCurdy Creek)
02	82.2	57.5	-24.7	-30.0%	02(DU Marsh)
03	343.8	325.1	-18.7	-5.4%	03(McCurdy Creek)
01+03	468	448.2	-19.8	-4.2%	03(McCurdy Creek)

For each watershed, one outfall was defined downstream of the PDA representing a Point of Interest (POI) as close as possible to the affected areas. In total 3 POIs were defined and numbered respectively to the watersheds – POI 01-03. Outfalls 01 and 03 contribute to McCurdy Creek and Outfall 02 contributes to DU marsh southwest of PDA. Figures 2 to 4 show delineated watersheds, watercourses and POIs.

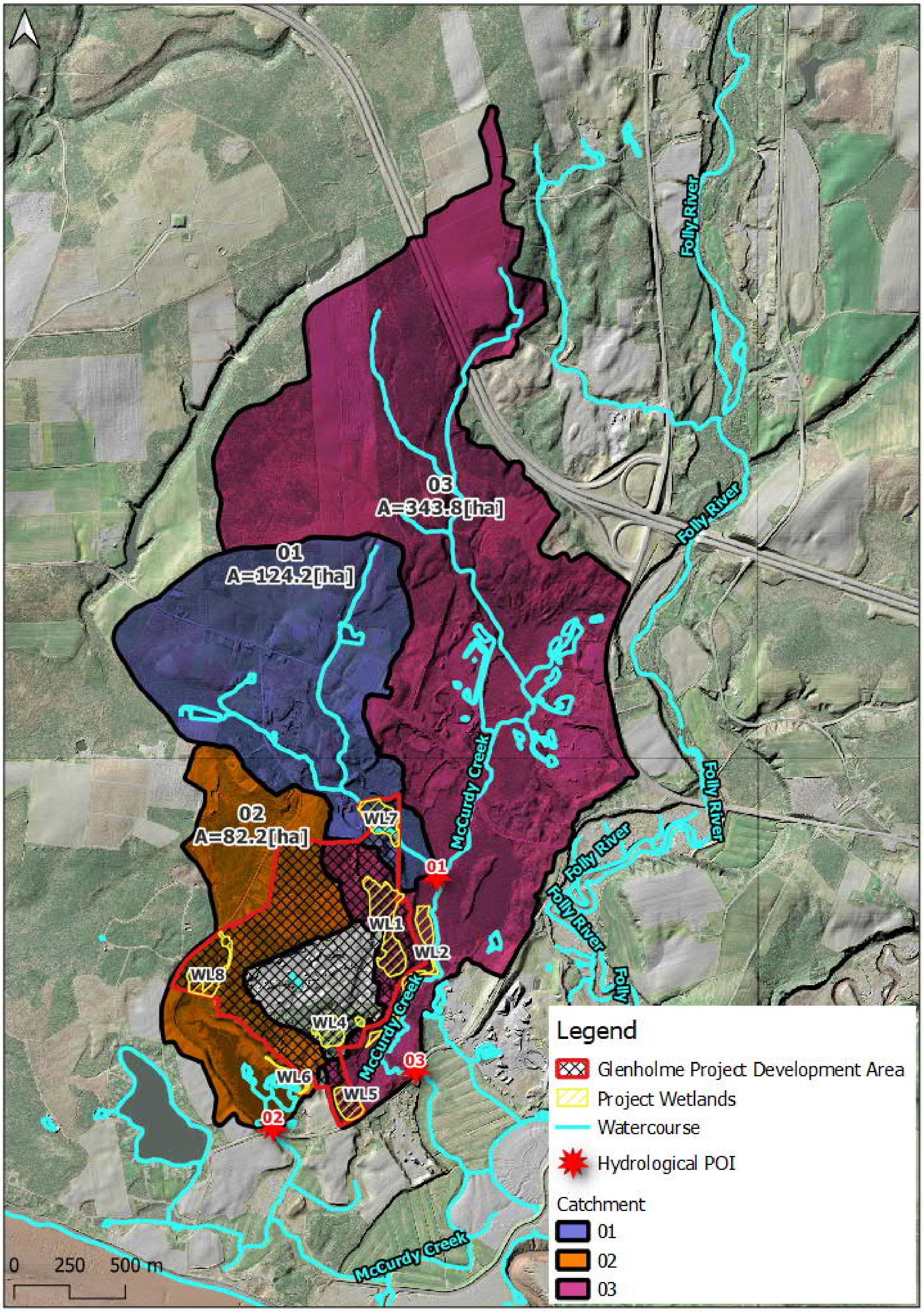

Figure 2: Existing Conditions – General View

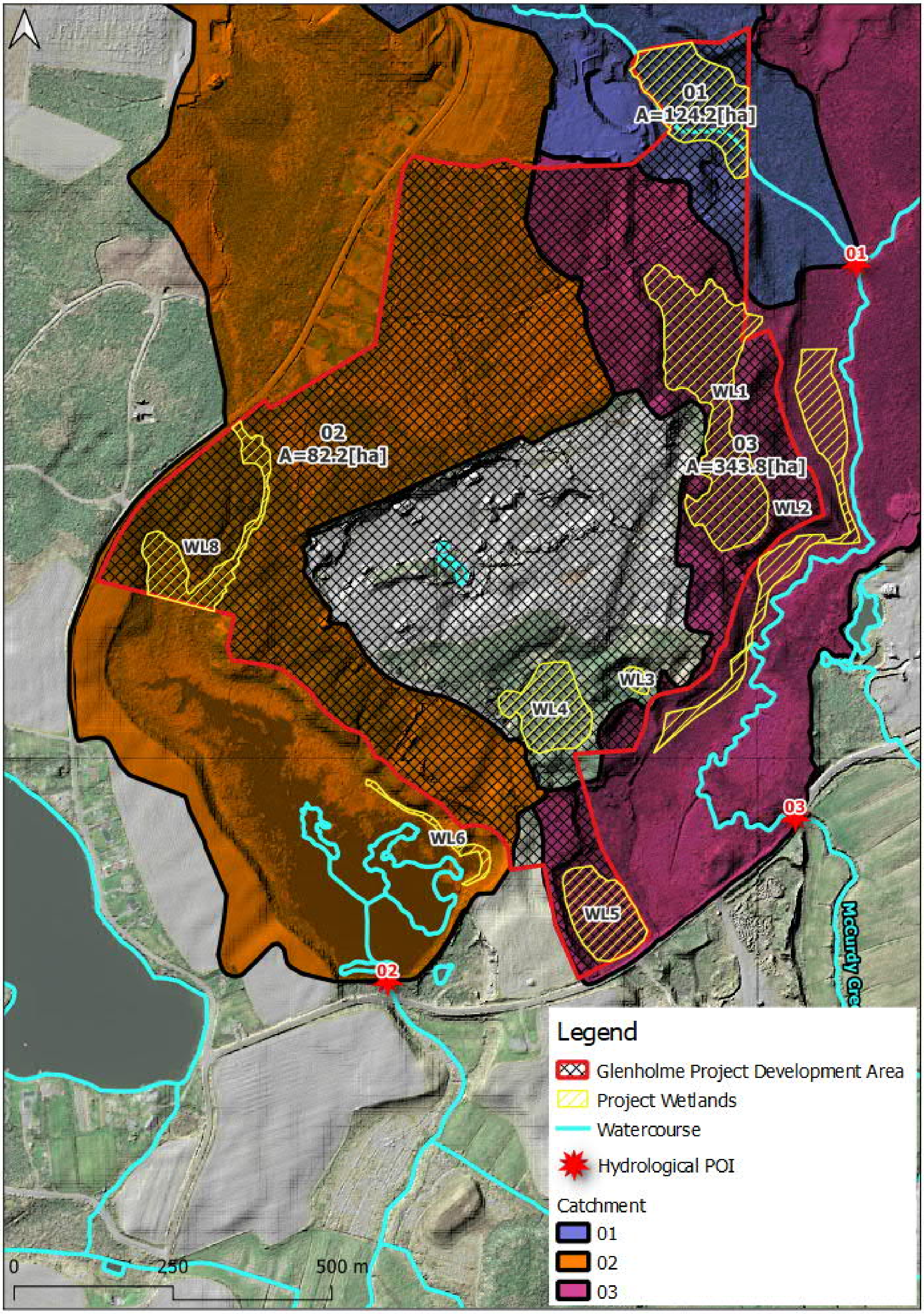

Figure 3: Existing Conditions – Detailed View

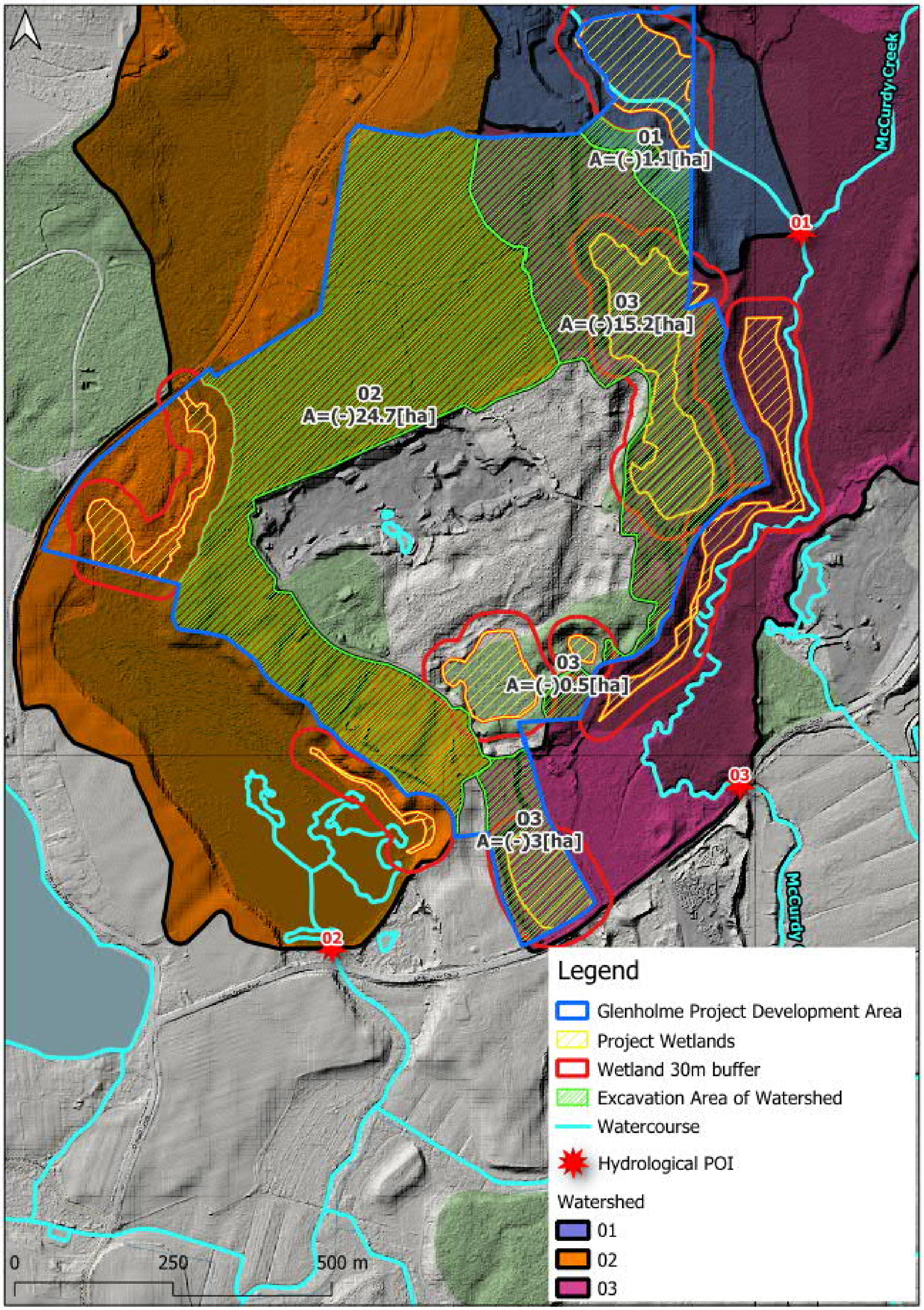

Figure 4: Operational Conditions – Detailed View

4.2 Infiltration

The infiltration parameters were estimated using the infiltration factors taken from the Stormwater Management Planning and Design Manual (OMECP, 2003). Each watershed was individually analyzed to determine weighted properties of topography slopes, soil and cover types. Further details on the infiltration properties are provided below.

4.2.1 Topography/Slopes

Average slope values are between 5.6%-7.4% for all watersheds. Average watershed slopes were determined based on existing LiDAR (2019) from the Nova Scotia GeoNova database (GeoNova, 2019).

4.2.2 Soil Type

Dominant soil types of the watersheds were classified as Well Drained Loamy Sands (Truro, Tu1-2), Well Drained Gravelly Loamy Sands (Herbert, He1-2), Well Drained Sandy Loam (Woodville, Wd1) and some areas of Very Poorly Drained Organic soils (Castley, Ct). Soil type properties were determined based on Detailed Soil Survey of Colchester County, Nova Scotia (Agriculture and Agri-Food Canada, 1991).

4.2.3 Surface Cover

Woodland and cultivated land cover was determined based on the Forest Inventory database (Nova Scotia Department of Natural Resources and Renewables, n.d.)

Table 3 outlines weighted factors and overall infiltration factors for every watershed.

Table 3: Weighted Infiltration Factors

Watershed [-]	Topography Factor[1] [-]	Soil Factor[1] [-]	Cover Factor[1] [-]	Weighted Infiltration Factor [-]
01	0.10	0.33	0.14	0.57
02	0.10	0.37	0.15	0.62
03	0.10	0.33	0.15	0.58

Notes:
Weighted Factors based on Table 3.1, Stormwater Management Planning and Design Manual (Ontario Ministry of Environment, Conservation and Parks, 2003)

Runoff volumes were assumed to equal the total precipitation less infiltration, evaporation of the runoff and evapotranspiration of infiltration. Maximum evaporation volumes (estimated evaporation) were limited to calculated runoff volumes even if potential evaporation volumes were higher. Maximal evapotranspiration volumes were limited to potential evapotranspiration volumes.

5.0 Water Balance Results

Table 4 presents a summary of the results of the Water Balance Analysis under existing and operating conditions. As shown in the table, runoff volumes decreases were proportional to the subtracted area due to operating conditions with a range of about 0.9%-30.0%.

Table 4: Water Balance Analysis Summary

Watershed [-]	Existing Conditions Annual Runoff [m^3]	Operating Conditions Annual Runoff [m^3]	Runoff Change OC/EC [m^3]	Runoff Change OC/EC [%]
01	321,345	318,499	-2,846	-0.9%
02	184,220	128,864	-55,356	-30.0%
03	865,716	818,628	-47,088	-5.4%
01+03	1,187,061	1,137,127	-49,934	-4.2%

Notes:
Existing Conditions (EC); Operating Conditions (OC)

The most affected watershed is No. 02, with its runoff volume contribution to the existing DUC marsh decreasing by about 30% with an estimated value of 55,400 m^3/year. Connectivity in this watershed to the upper reaches of the catchment will be maintained by not developing the pit in WL8 and the area to the west, but the reduction in overall flow may impact the marsh indirectly. If dewatering is implemented in the future, OSCO should consider directing the outflow towards the DUC marsh to support the wetland hydrology there. The estimated overall decrease in runoff to McCurdy Creek (i.e., Watershed 01+03) is about 49,930 m^3/year. Full results can be found in the attached Tables 5 through 6.

6.0 Conclusions

Dillon has prepared this Water Balance Analysis summary for the exclusive use of OSCO and its agents for specific application to the Project. Dillon has used the degree of care and skill ordinarily exercised under similar circumstances at the time the work was performed by reputable members of the environmental consulting profession practicing in Canada. Dillon assumes no responsibility for conditions which were beyond its scope of work. There is no warranty expressed or implied by Dillon.

The material in the report reflects Dillon's best judgement in light of the information available to Dillon at the time of preparation. The information provided in this document is believed to be reliable but is not guaranteed. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

7.0 References

Agriculture and Agri-Food Canada. 1991. Soils of Colchester County, Nova Scotia. Report No. 19, Nova Scotia Soil Survey. Retrieved from: https://sis.agr.gc.ca/cansis/publications/surveys/ns/ns19b/ns19b_report.pdf

GeoNova. 2019. DataLocator – Elevation Explorer. Retrieved from: https://nsgi.novascotia.ca/datalocator/elevation/

Ontario Ministry of the Environment, Conservation and Parks. 2003. Stormwater Management Planning and Design Manual. Retrieved from https://www.ontario.ca/document/stormwater-management-planning-and-design-manual-0

Nova Scotia Department of Natural Resources and Renewables. (n.d.). Forest Inventory – Geographic Information Systems. Retrieved from: https://novascotia.ca/natr/forestry/gis/DL_forestry-cycle1.asp

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Table 5: Water Balance – Existing Conditions

Existing Conditions													
Watershed 01													
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Precipitation[m3]	113,022	95,758	101,099	112,277	110,911	122,585	108,675	114,140	147,674	145,935	141,215	150,655	1,463,945
Infiltration[m3]	64,423	54,582	57,626	63,998	63,219	69,874	61,945	65,060	84,174	83,183	80,493	85,873	834,449
Runoff[m3]	48,599	41,176	43,472	48,279	47,692	52,712	46,730	49,080	63,500	62,752	60,723	64,781	629,497
Potential Evaporation[m3]	0	0	0	0	111,656	126,684	146,308	115,506	88,555	48,438	0	0	637,146
Estimated Evaporation[m3]	0	0	0	0	47,692	52,712	46,730	49,080	63,500	48,438	0	0	308,151
Potential Evapotranspiration[m3]	0	0	0	29,473	81,078	120,164	156,194	139,762	93,001	49,034	17,661	0	686,366
Estimated Evapotranspiration[m3]	0	0	0	29,473	63,219	69,874	61,945	65,060	84,174	49,034	17,661	0	440,439
Runoff Surplus[m3]	48,599	41,176	43,472	48,279	0	0	0	0	0	14,314	60,723	64,781	321,345
Watershed 02 - DU Marsh													
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Precipitation[m3]	74,802	63,376	66,911	74,309	73,405	81,131	71,925	75,542	97,736	96,585	93,461	99,709	968,891
Infiltration[m3]	46,377	39,293	41,485	46,071	45,511	50,301	44,594	46,836	60,596	59,883	57,946	61,819	600,713
Runoff[m3]	28,425	24,083	25,426	28,237	27,894	30,830	27,332	28,706	37,140	36,702	35,515	37,889	368,179
Potential Evaporation[m3]	0	0	0	0	73,898	83,844	96,832	76,446	58,609	32,058	0	0	421,686
Estimated Evaporation[m3]	0	0	0	0	27,894	30,830	27,332	28,706	37,140	32,058	0	0	183,959
Potential Evapotranspiration[m3]	0	0	0	19,506	53,660	79,529	103,375	92,500	61,551	32,453	11,689	0	454,262
Estimated Evapotranspiration[m3]	0	0	0	19,506	45,511	50,301	44,594	46,836	60,596	32,453	11,689	0	311,485
Runoff Surplus[m3]	28,425	24,083	25,426	28,237	0	0	0	0	0	4,644	35,515	37,889	184,220
Watershed 03													
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Precipitation[m3]	312,858	265,070	279,853	310,795	307,013	339,331	300,825	315,952	408,778	403,965	390,901	417,029	4,052,371
Infiltration[m3]	181,458	153,740	162,315	180,261	178,068	196,812	174,479	183,252	237,091	234,300	226,722	241,877	2,350,375
Runoff[m3]	131,400	111,329	117,538	130,534	128,946	142,519	126,347	132,700	171,687	169,665	164,178	175,152	1,701,996
Potential Evaporation[m3]	0	0	0	0	309,076	350,676	404,996	319,734	245,129	134,082	0	0	1,763,694
Estimated Evaporation[m3]	0	0	0	0	128,946	142,519	126,347	132,700	171,687	134,082	0	0	836,280
Potential Evapotranspiration[m3]	0	0	0	81,584	224,433	332,627	432,363	386,878	257,437	135,732	48,888	0	1,899,942
Estimated Evapotranspiration[m3]	0	0	0	81,584	178,068	196,812	174,479	183,252	237,091	135,732	48,888	0	1,235,906
Runoff Surplus[m3]	131,400	111,329	117,538	130,534	0	0	0	0	0	35,583	164,178	175,152	865,716

Table 6: Water Balance – Operating Conditions

Operating Conditions													
Watershed 01													
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Precipitation[m3]	112,021	94,910	100,203	111,282	109,928	121,500	107,713	113,129	146,366	144,643	139,965	149,320	1,450,980
Infiltration[m3]	63,852	54,099	57,116	63,431	62,659	69,255	61,396	64,483	83,429	82,446	79,780	85,113	827,058
Runoff[m3]	48,169	40,811	43,087	47,851	47,269	52,245	46,316	48,645	62,937	62,196	60,185	64,208	623,921
Potential Evaporation[m3]	0	0	0	0	110,667	125,562	145,012	114,483	87,770	48,009	0	0	631,503
Estimated Evaporation[m3]	0	0	0	0	47,269	52,245	46,316	48,645	62,937	48,009	0	0	305,422
Potential Evapotranspiration[m3]	0	0	0	29,212	80,360	119,099	154,811	138,524	92,177	48,600	17,505	0	680,288
Estimated Evapotranspiration[m3]	0	0	0	29,212	62,659	69,255	61,396	64,483	83,429	48,600	17,505	0	436,538
Runoff Surplus[m3]	48,169	40,811	43,087	47,851	0	0	0	0	0	14,187	60,185	64,208	318,499
Watershed 02 - DU Marsh													
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Precipitation[m3]	52,325	44,333	46,805	51,980	51,348	56,753	50,313	52,843	68,368	67,563	65,378	69,748	677,753
Infiltration[m3]	32,442	27,486	29,019	32,228	31,835	35,187	31,194	32,762	42,388	41,889	40,534	43,243	420,207
Runoff[m3]	19,884	16,846	17,786	19,752	19,512	21,566	19,119	20,080	25,980	25,674	24,843	26,504	257,546
Potential Evaporation[m3]	0	0	0	0	51,693	58,650	67,735	53,475	40,998	22,425	0	0	294,975
Estimated Evaporation[m3]	0	0	0	0	19,512	21,566	19,119	20,080	25,980	22,425	0	0	128,682
Potential Evapotranspiration[m3]	0	0	0	13,645	37,536	55,631	72,312	64,705	43,056	22,701	8,177	0	317,762
Estimated Evapotranspiration[m3]	0	0	0	13,645	31,835	35,187	31,194	32,762	42,388	22,701	8,177	0	217,888
Runoff Surplus[m3]	19,884	16,846	17,786	19,752	0	0	0	0	0	3,249	24,843	26,504	128,864
Watershed 03													
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Precipitation[m3]	295,841	250,652	264,631	293,890	290,314	320,874	284,463	298,767	386,544	381,993	369,639	394,346	3,831,954
Infiltration[m3]	171,588	145,378	153,486	170,456	168,382	186,107	164,988	173,285	224,195	221,556	214,390	228,721	2,222,533
Runoff[m3]	124,253	105,274	111,145	123,434	121,932	134,767	119,474	125,482	162,348	160,437	155,248	165,625	1,609,421
Potential Evaporation[m3]	0	0	0	0	292,265	331,602	382,968	302,343	231,796	126,789	0	0	1,667,763
Estimated Evaporation[m3]	0	0	0	0	121,932	134,767	119,474	125,482	162,348	126,789	0	0	790,793
Potential Evapotranspiration[m3]	0	0	0	77,146	212,225	314,534	408,846	365,835	243,435	128,349	46,229	0	1,796,600
Estimated Evapotranspiration[m3]	0	0	0	77,146	168,382	186,107	164,988	173,285	224,195	128,349	46,229	0	1,168,682
Runoff Surplus[m3]	124,253	105,274	111,145	123,434	0	0	0	0	0	33,648	155,248	165,625	818,628