

To:	Steve Lines Greenstone Gold Mines GP Inc.	From:	Michelle Fraser and Sheldon Smith Stantec Consulting Ltd.
File:	Hardrock Project 160961223	Date:	August 7, 2018

Reference: Revisions to Phosphorus Mass Loading and Concentration for Kenogamisis Lake Hardrock Project

On July 26, 2018, a teleconference was held with the Ministry of the Environment, Conservation and Parks (MECP), Greenstone Gold Mines GP Inc. (GGM), SLR Consulting Ltd. (SLR), and Stantec Consulting Ltd. (Stantec). The call was to review mass loading and concentration estimates and predictions of phosphorus as presented in the Final Environmental Impact Statement (EIS) / Environmental Assessment (EA) for the Hardrock Project. Based on discussions with MECP, a potential unit error in the concentration data was identified. This memorandum details the review of the data that was used to calculate the mass loading and concentration of phosphorus to Kenogamisis Lake as presented in Tables 10-21 and 10-32 to 10-47 of the Final EIS/EA and the subsequent revisions to those estimates.

Based on the review, revisions were made to the mass loading and concentration estimates and predictions for phosphorus for the Hardrock Project. The revisions are summarized as: at certain surface water stations the mean dissolved phosphorus concentration was used instead of the mean total phosphorus concentration; for groundwater loadings from the historical MacLeod and Hardrock tailings the mean total phosphorous concentration was used instead of the mean dissolved phosphorous concentration; and a unit conversion error for Hardrock Creek and Mosher Lake were identified related to mg/L versus µg/L. The revisions are summarized as follows.

Surface Water Location/Station	Original Baseline Concentration (Mean Dissolved Phosphorus) µg/L	Revised Baseline Concentration (Mean Total Phosphorus) µg/L
Goldfield Creek Tributary Station 22	2.8	9.1
Goldfield Creek Station 20	2.1	6.4
Puppy and Pussy Lakes Station 21	2.9	9.1
Magnet Creek Station 28	3.1	9.6
Barton Bay West Station 2	3.8	14.5
Central Basin East Station 7	3.8	14.8
Outlet Basin Station 11	5.5	9.6

Reference: Revisions to Phosphorus Mass Loading and Concentration for Kenogamisis Lake
 Hardrock Project

Groundwater Source	Original Baseline Concentration (Mean Total Phosphorus) µg/L	Revised Baseline Concentration (Mean Dissolved Phosphorus) µg/L
Historical MacLeod Tailings	624	199
Historical Hardrock Tailings	625	107

For the operational estimate of mass loading from Hardrock Creek and Mosher Lake, the concentration of total phosphorus was not converted in the operational phase from mg/L to µg/L resulting in a mass loading of 0.00056 kg/day and 0.000020 kg/day, respectively. The unit conversion was added, which revised the mass loading of phosphorus from Hardrock Creek to 0.56 kg/day and from Mosher Lake to 0.020 kg/day during operation.

A summary of the revised estimates of mass loading and concentration of phosphorus for Kenogamisis Lake are presented in Table 1 and 2 of Attachment A, respectively. Detailed phosphorous mass loading estimates for all phases of mine life are presented in Table 3 of Attachment A. The methodology for the mass loading and concentration estimates is consistent with that presented in the Final EIS/EA with the above noted revisions. As a result of collaboration between GGM and the Municipality of Greenstone (MoG), the MoG is planning upgrades to the Geraldton Waste Water Treatment Plant (WWTP). For reference, Tables 1 and 2 also present, in a separate column, an estimate of the change in mass loading and concentration of phosphorus based on the planned Geraldton WWTP upgrades. We have assumed the Geraldton WWTP flow and effluent concentration of phosphorus would change from 2,272 m³/day and 550 µg/L in baseline to 3,326 m³/day and 300 µg/L in operations and active closure, to 3,026 m³/day and 300 µg/L in post-closure, respectively.

The revised mass loading of phosphorus for the Outlet Basin in baseline is about 10 kg/day (Table 1, Attachment A). The mass loading of phosphorus to Outlet Basin generally remains unchanged throughout all phases of mine life. In comparison, the mass loading of phosphorus to Outlet Basin that includes the upgrades to the Geraldton WWTP would result in a decrease in mass loading to 9 kg/day during active closure, returning to baseline conditions of 10 kg/day during post closure after accounting for discharge from the pit lake.

The revised concentration of phosphorus of the Outlet Basin remains relatively unchanged throughout all phases of mine life at 12 µg/L. The most significant positive effect to water quality within Kenogamisis Lake results from the planned Geraldton WWTP upgrades. The concentration of phosphorus in Barton Bay East decreases from 25.7 µg/L under baseline conditions to 20.5 µg/L in post closure, approaching the Provincial Water Quality Objective (PWQO) of 20 µg/L. All other basins of Kenogamisis Lake meet the PWQO for phosphorous for all phases of mine life. The improvements of water quality to Kenogamisis Lake with respect to phosphorous meet the intent of Policy 2 objectives.

For reference, Attachment B presents schematic diagrams of mass loading of phosphorus under baseline conditions for each basin of Kenogamisis Lake.

Reference: Revisions to Phosphorus Mass Loading and Concentration for Kenogamisis Lake
Hardrock Project

We trust this meets your current requirements. Should you have any questions, please do not hesitate to contact the undersigned.

Stantec Consulting Ltd.



Michelle Fraser M.Sc., P.Geo.
Hydrogeologist

Phone: (519) 585-7421
michelle.fraser@stantec.com



Sheldon Smith M.E.S., P.Geo..
Senior Hydrologist

Phone: (905) 415-6405
sheldon.smith@stantec.com

Attachment: Attachment A - Tables
Table 1 – Phosphorus Mass Loading, Kenogamisis Lake
Table 2 – Phosphorus Concentration, Kenogamisis Lake
Table 3 – Detailed Phosphorous Mass Loading for Baseline, Operation, Active Closure, and Post Closure, Kenogamisis Lake
Attachment B - Figures
Figure 1 – Summary of Mass Loading – Baseline, Barton Bay West
Figure 2 – Summary of Mass Loading – Baseline, Barton Bay East
Figure 3 – Summary of Mass Loading – Baseline, Southwest Arm of Kenogamisis Lake
Figure 4 – Summary of Mass Loading – Baseline, Central Basin East
Figure 5 – Summary of Mass Loading – Baseline, Outlet Basin

c. Piero Amodeo, Stantec Consulting Ltd
Craig Johnston, SLR Consulting

ATTACHMENT A TABLES

Table 1 - Phosphorous Mass Loading, Kenogamisis Lake

Project Phases	Source of Phosphorus	Total Phosphorus Loadings (kg/d)		
		Original Loadings	Revised Loadings	Revised Loadings with Geraldton WWTP Improvements
Baseline	Goldfield Creek	0.14	0.25	0.25
	Southwest Arm Tributary	0.06	0.06	0.06
	Mosher Lake	0.03	0.03	0.03
	Barton Bay West	0.48	1.14	1.14
	Barton Bay East	1.51	1.91	1.91
	Central Basin East	8.31	8.77	8.77
	Southwest Arm	6.68	6.84	6.84
	Outlet Basin	9.07	10.11	10.11
Operation	Goldfield Creek	0.10	0.14	0.14
	Southwest Arm Tributary	0.17	0.17	0.17
	Mosher Lake	0.03	0.03	0.03
	Barton Bay West	0.48	1.14	1.14
	Barton Bay East	0.52	1.77	1.51
	Central Basin East	7.37	8.72	8.47
	Southwest Arm	6.86	6.96	6.96
	Outlet Basin	8.13	10.06	9.81
Active Closure	Goldfield Creek	0.10	0.14	0.14
	Southwest Arm Tributary	0.19	0.19	0.19
	Mosher Lake	0.03	0.03	0.03
	Barton Bay West	0.48	1.14	1.14
	Barton Bay East	1.11	1.77	1.51
	Central Basin East	7.85	8.37	8.11
	Southwest Arm	6.75	6.57	6.57
	Outlet Basin	8.61	9.71	9.46
Post Closure	Goldfield Creek	0.11	0.16	0.16
	Southwest Arm Tributary	0.34	0.34	0.34
	Mosher Lake	0.04	0.04	0.04
	Barton Bay West	0.48	1.14	1.14
	Barton Bay East	1.26	1.83	1.49
	Central Basin East	8.38	9.04	8.70
	Southwest Arm	7.10	7.21	7.21
	Outlet Basin	9.14	10.38	10.04

Table 2 - Phosphorous Concentrations, Kenogamisis Lake

Project Phases	Source of Phosphorus	Total Phosphorus Concentration (µg/L)		
		Original Concentrations	Revised Concentrations	Revised Concentrations with Geraldton WWTP Improvements
Baseline	Goldfield Creek	2.1	6.4	6.4
	Southwest Arm Tributary	10.7	10.7	10.7
	Mosher Lake	10	10	10
	Barton Bay West	3.8	14.5	14.5
	Barton Bay East	25.7	25.7	25.7
	Central Basin East	14.4	14.4	14.4
	Southwest Arm	9.9	9.9	9.9
	Outlet Basin	12.0	12.0	12.0
Operation	Goldfield Creek	5.8	13.7	13.7
	Southwest Arm Tributary	7.7	7.7	7.7
	Mosher Lake	11.8	11.8	11.8
	Barton Bay West	3.8	14.5	14.5
	Barton Bay East	9.1	24.6	21.1
	Central Basin East	12.8	14.6	14.2
	Southwest Arm	10.2	10.1	10.1
	Outlet Basin	10.9	12.1	11.8
Active Closure	Goldfield Creek	5.8	13.7	13.7
	Southwest Arm Tributary	8.3	8.3	8.3
	Mosher Lake	12.3	12.3	12.3
	Barton Bay West	3.8	14.5	14.5
	Barton Bay East	19.4	24.6	21.1
	Central Basin East	15	14.0	13.6
	Southwest Arm	10.4	9.9	9.9
	Outlet Basin	11.6	11.7	11.4
Post Closure	Goldfield Creek	4.5	11.0	11.0
	Southwest Arm Tributary	12.0	12.0	12.0
	Mosher Lake	14.0	14.0	14.0
	Barton Bay West	3.8	14.5	14.5
	Barton Bay East	21.9	25.2	20.5
	Central Basin East	14.6	14.9	14.3
	Southwest Arm	10.4	10.3	10.3
	Outlet Basin	12.1	12.4	12.0

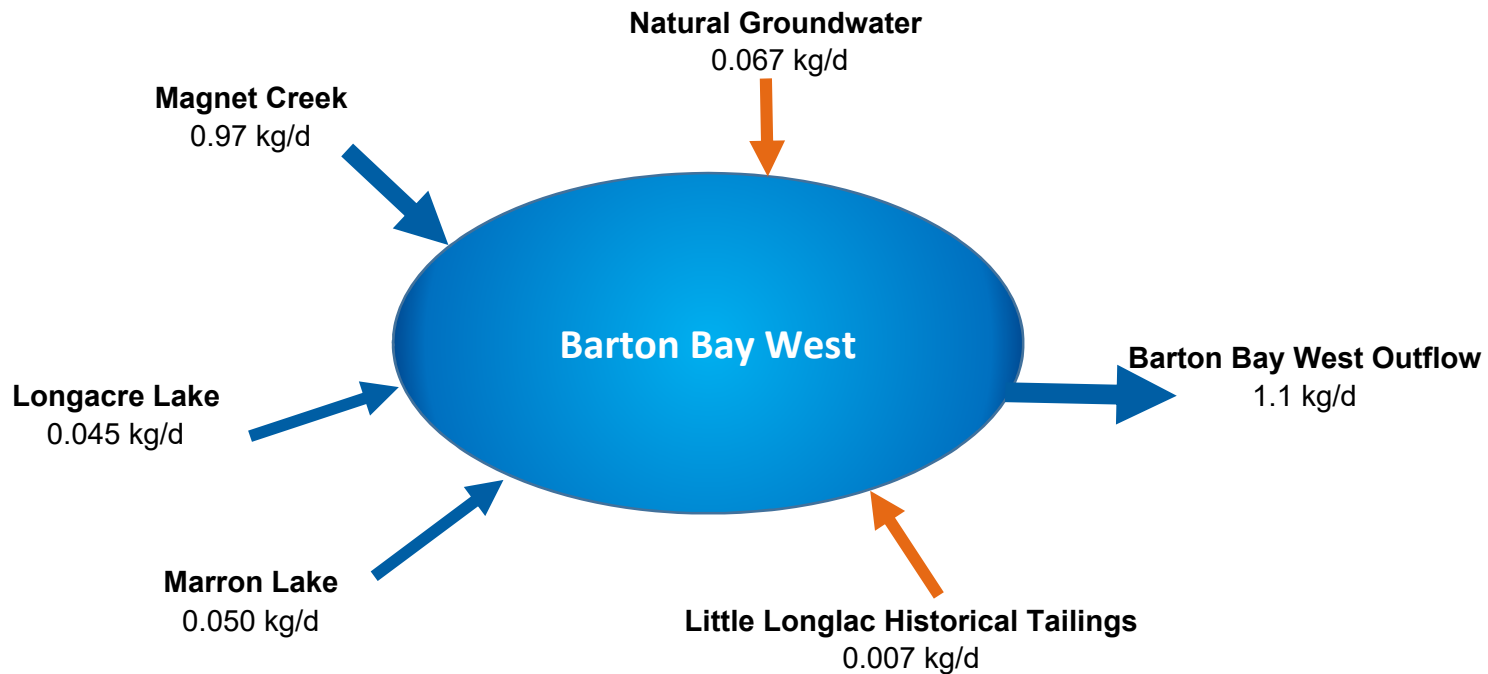
Table 3 - Detailed Phosphorous Mass Loading for Baseline, Operation, Active Closure, and Post Closure, Kenogamisis Lake

Sources of Loading	Baseline Loading kg/day	Operation Loading kg/day	Active Closure Loading kg/day	Post Closure Loading kg/day
Southwest Arm of Kenogamisis Lake				
Kenogamisis River Loadings	6.4	6.4	6.4	6.4
Goldfield Creek Tributary Loadings	0.061	0.054	0.054	0.061
Goldfield Creek Loadings	0.10	0.001	0.001	0.007
Goldfield Lake	-	0.10	0.10	0.10
Southwest Arm Tributary Loadings	0.056	0.038	0.038	0.056
Puppy Lake Loadings	0.026	0.026	0.026	0.026
Pussy Lake Loadings	0.074	0.074	0.074	0.074
Natural Groundwater Loadings	0.16	0.15	0.15	0.14
Total Loadings from Watercourses/Waterbodies (Natural Groundwater Loadings included)	6.8	6.8	6.8	6.8
MacLeod Historical Tailings Loadings	0.002	0.000	0.000	0.000
Hardrock Historical Tailings Loadings	0.004	0.000	0.000	0.001
Total Historical Tailings Loadings	0.006	0.000	0.000	0.001
TMF Pond Loadings to SWAT	-	0.000	0.000	0.12
TMF Seepage Loadings	-	0.004	0.004	0.005
WRS A loadings	-	0.000	0.000	0.002
WRS B loadings	-	0.000	0.000	0.007
WRS C Loadings	-	0.002	0.007	0.016
WRS D Loadings	-	0.014	0.049	0.12
Ore Stockpile Loadings	-	0.000	0.000	0.000
Mine Effluent Loadings	-	0.070	-	-
Sanitary Loadings	-	0.075	-	-
Loading Reduction due to freshwater taking	-	0.000	0.000	-
Open Pit Lake Discharge Loadings	-	-	-	0.13
Total Project Related Loadings	-	0.17	0.000	0.39
Southwest Arm of KL Total Loadings (SW+GW)	6.8	7.0	6.6	7.2
Barton Bay West				
Magnet Creek Loadings	0.97	0.97	0.97	0.97
Longacre Lake Loadings	0.045	0.045	0.045	0.045
Marron Lake Loadings	0.050	0.050	0.050	0.050
Natural Groundwater Loadings	0.067	0.066	0.066	0.067
Total Loadings from Watercourses/Waterbodies (Natural Groundwater Loadings included)	1.1	1.1	1.1	1.1
Little Long Lac Historical Tailings Loadings	0.007	0.007	0.007	0.007
Total Historical Tailings Loadings	0.007	0.007	0.007	0.007
Barton Bay West Total Loadings (SW+GW)	1.1	1.1	1.1	1.1
Barton Bay East				
Hardrock Creek Loadings	0.56	0.56	0.56	0.56
Mosher Lake Loadings	0.021	0.020	0.020	0.020
Natural Groundwater Loadings	0.038	0.024	0.024	0.039
Total Loadings from Watercourses/Waterbodies (Natural Groundwater Loadings included)	0.62	0.61	0.61	0.62
Barton Bay West Total Loadings (SW+GW)	1.1	1.1	1.1	1.1
Little Long Lac Historical Tailings Loadings	0.014	0.014	0.014	0.014
MacLeod Historical Tailings Loadings	0.12	0.000	0.000	0.043
Total Historical Tailings Loadings	0.14	0.014	0.014	0.057
WRS A Loadings	-	0.000	0.000	0.004
Overburden Stockpile Loadings	-	0.000	0.000	0.002
Total Project Related Loadings	-	0.000	0.000	0.005
Barton Bay East Total Loadings (SW+GW)	1.9	1.8	1.8	1.8
Central Basin East (included Loadings from Central Basin West)				
Natural Groundwater Loadings to Central Basin West	-0.007	-0.02	-0.02	-0.007
Natural Groundwater Loadings to Central Basin East	-0.034	-0.02	-0.02	-0.03
Loadings from Watercourses/Waterbodies to Central Basin East	0.037	0.02	0.02	0.02
Total Loadings from Watercourses/Waterbodies (Natural Groundwater Loadings included)	-0.003	-0.01	-0.01	-0.02
Barton Bay East Loadings	1.9	1.8	1.8	1.8
SWA Loadings	6.8	7.0	6.6	7.2
MacLeod Historical Tailings Loadings	0.013	0.000	0.000	0.000
Hardrock Historical Tailings Loadings	0.013	0.000	0.000	0.003
Total Historical Tailings Loadings	0.026	0.000	0.000	0.003
WRS A Loadings	-	0.000	0.000	0.010
Total Project Related Loadings	-	0.000	0.000	0.010
CB East Loadings (SW+GW)	8.8	8.7	8.4	9.0
Outlet Basin				
Barton Bay Loadings	1.9	1.8	1.8	1.8
Southwest Arm of KL Total Loadings	6.8	7.0	6.6	7.2
Central Basin West Loadings	0.019	-0.016	-0.016	0.007
Central Basin East Loadings	0.003	0.006	0.006	-0.013
Loadings from Watercourses/Waterbodies to Outlet Basin	1.3	1.3	1.3	1.3
OB Total Loadings (SW+GW)	10.1	10.1	9.7	10.4

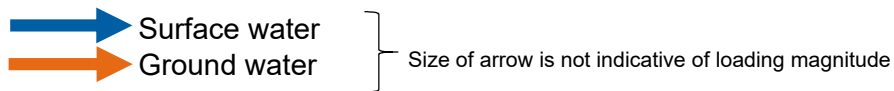
Notes:

- Project component not active / operational
- Mass loading estimate revised compared to Final EIS/EA.

ATTACHMENT B FIGURES



Notes:



Client/Project

Phosphorous Updates
 Hardrock Project
 Greenstone Gold Mines

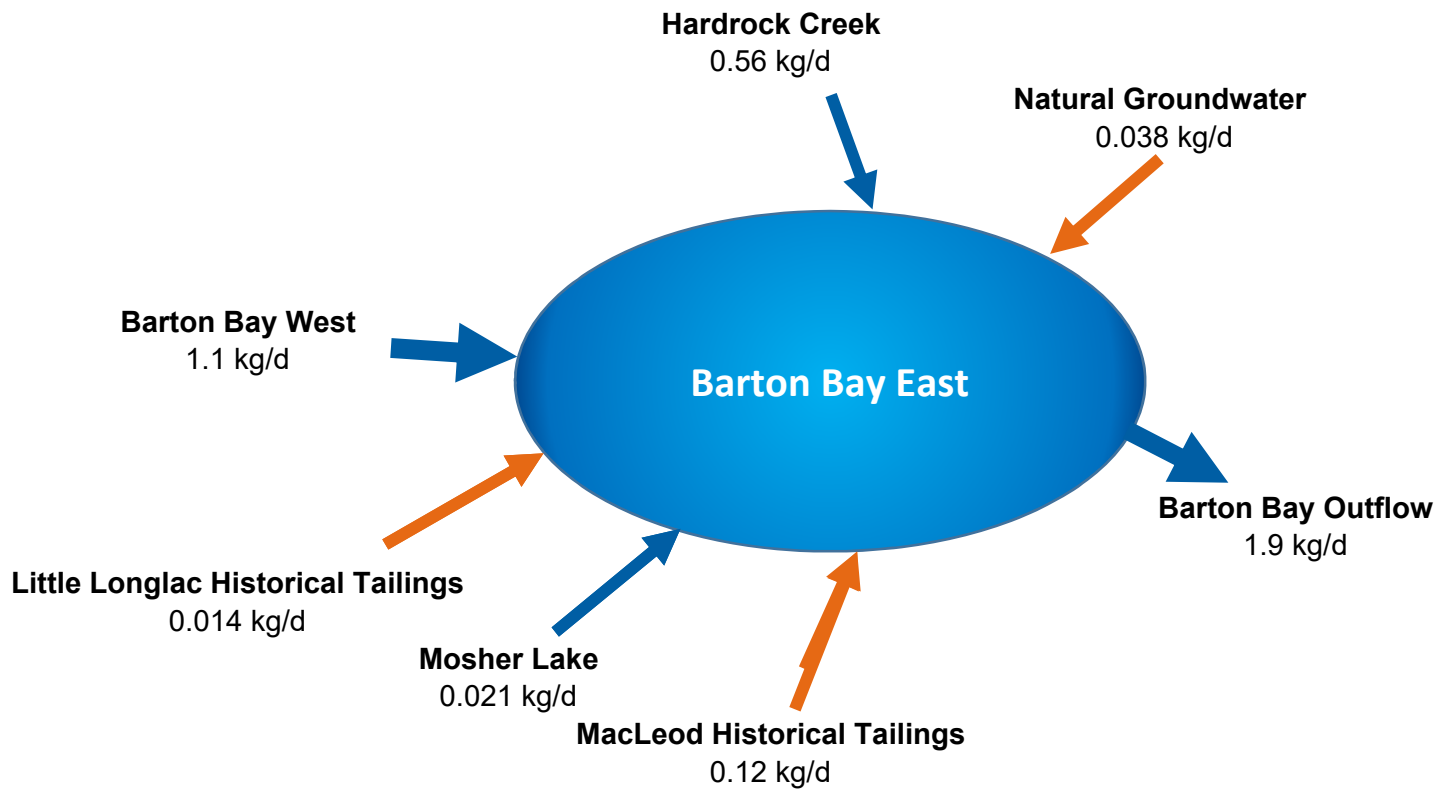
Figure No.

1



Title

**Summary of Mass Loading - Baseline
 Barton Bay West**





Notes:

 Surface water
 Ground water
 } Size of arrow is not indicative of loading magnitude

Client/Project

Phosphorous Updates
 Hardrock Project
 Greenstone Gold Mines

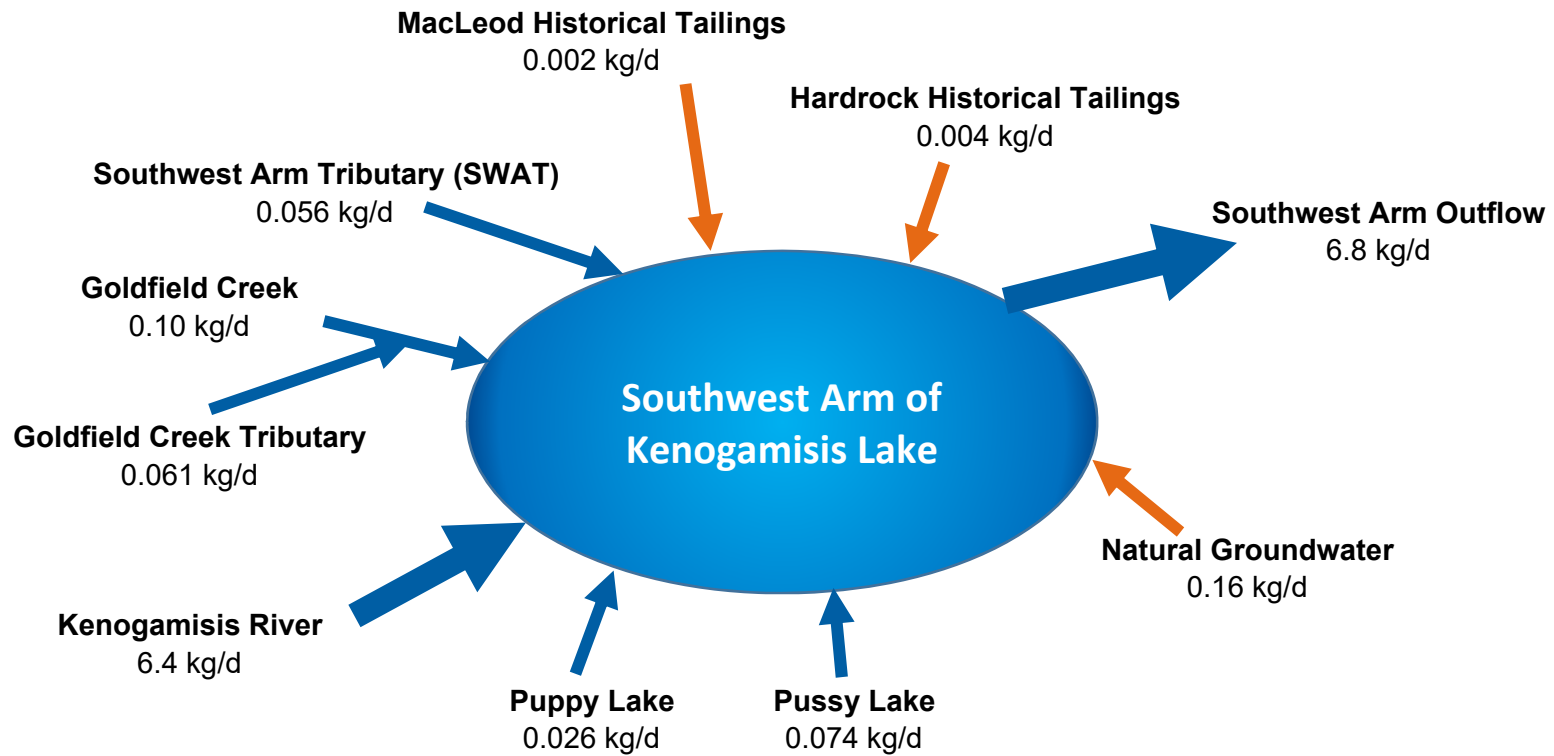
Figure No.

2

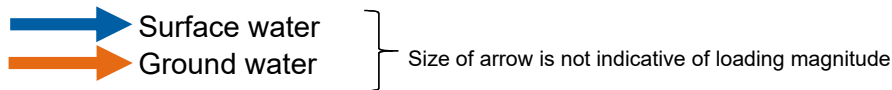
Title

**Summary of Mass Loading - Baseline
 Barton Bay East**





Notes:



Client/Project

Phosphorous Updates
 Hardrock Project
 Greenstone Gold Mines

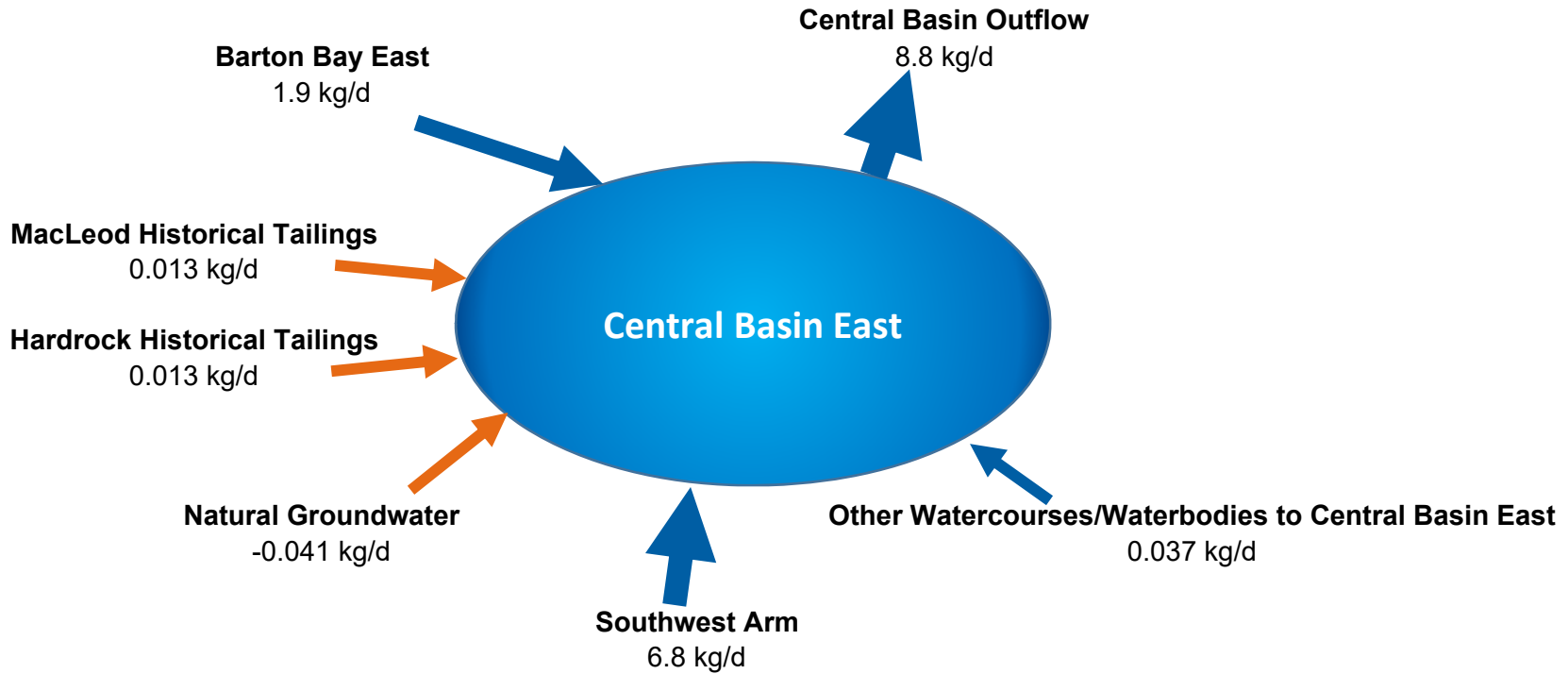
Figure No.

3



Title

**Summary of Mass Loading - Baseline
 Southwest Arm of Kenogamisis Lake**





Notes:

 Surface water
 Ground water

} Size of arrow is not indicative of loading magnitude

Client/Project

Phosphorous Updates
 Hardrock Project
 Greenstone Gold Mines

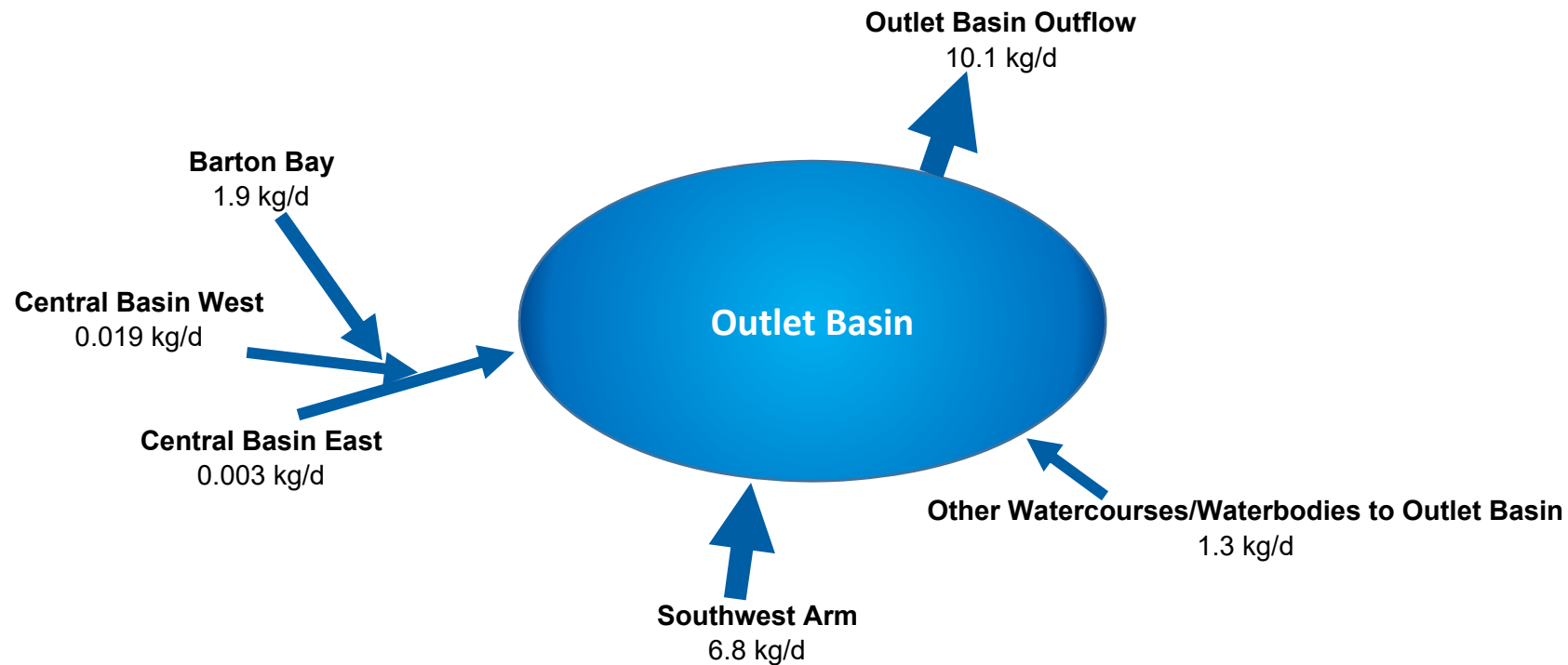
Figure No.

4


Title

Summary of Mass Loading - Baseline
 Central Basin East





Notes:

 Surface water } Size of arrow is not indicative of loading magnitude

Client/Project

Phosphorous Updates
 Hardrock Project
 Greenstone Gold Mines

Figure No.

5

Title

**Summary of Mass Loading - Baseline
 Outlet Basin**

