MEMORANDUM

DATE: December 17, 2018 Project #: P09006

TO: Michael Paletta, Penta Properties Inc.

FROM: Nava Pokharel, M.Sc., P. Eng., & Kevin Hollingworth, P.Eng.

Subject: Wetland Water Balance Addendum to the Environmental Impact Assessment of Eagle Heights

1. Background

Metropolitan Consulting Inc. (MCI) prepared a detailed stormwater management (SWM) report in August 2018 in support of the proposed draft plan redline application of the Eagle Heights lands. At that time hydrogeologic assessment for the existing wetlands located within Tributary 5W and Tributary 6W was not yet available. Terra-Dynamics Consulting Inc. (Terra Dynamics) has since completed the hydrogeology report of the Eagle Heights Lands.

This memorandum has been prepared to provide a detailed water balance analysis for the each wetland identified in the Environmental Impact Assessment (EIA) prepared by SAVANTA Inc. using the field data collected by Terra Dynamics. It is noted that the wetlands identified by SAVANTA are outside the NEP area, therefore this analysis does not apply to the lands north of the hydro corridor previously draft approved in 1997.

2. Hydrological Modeling

A continuous hydrological model was created for the Eagle Heights Project area using GAWSER (Guelph All-Weather Sequential Events Runoff) program. The model was calibrated using on-site measured rainfall and flow information.

A 65 year time-series (November 1, 1950 to October 31, 2015) of meteorological inputs (e.g. daily maximum and minimum air temperatures, daily rainfall and snowfall depths, and hourly rainfall depths) of Hamilton RBG CS (6153301) was applied to the hydrologic model for existing conditions. For detail information about the GAWSER modelling and hydrological analysis, the reader is referred to *Eagle Heights Property Hydrological Study and Storm water Management Report, Metropolitan Consulting Inc., August 2018.*

3. Water Balance Evaluations

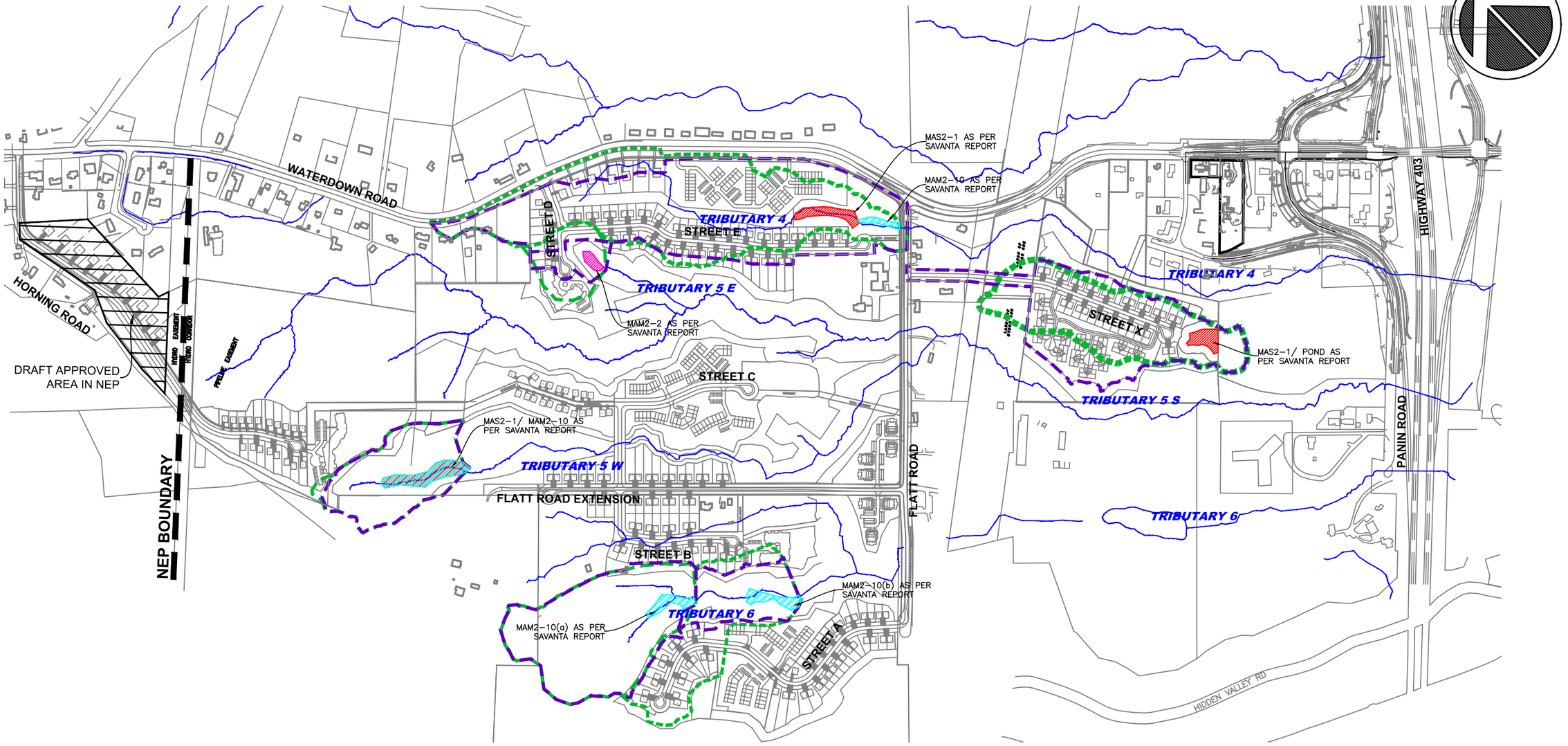
The water balance can be expressed with the following equation:

Precap = ET + Runoff + Base flow + Losses (or net storage)

where 'Precap' represents the total precipitation (rainfall plus snowfall), ET is the combined evapotranspiration and sublimation total, 'Runoff' is the mean annual runoff, 'Base flow' is the portion of the infiltrated water that returns to the stream, and 'Losses' signifies the amount of infiltrated water that does not return to the receiving stream. The 'Losses' total also includes water stored in the system and is also referred to as the 'net storage' term. For instance, the positive totals for 'Losses' during the winter months (e.g. December to April) represents snow on the ground, whereas the negative values during the summer months (e.g. May to August) denotes water pulled from soil- water

storage. Total Flow' is the sum of 'Runoff' and 'Base flow'. Water balance evaluation is done in average monthly volume (m^3) basis.

Water balances for each wetland in existing and proposed conditions will be further discussed in the following sections.



WETLAND	Pre-Development Drainage Area (ha.)	Post-Development Drainage Area (ha.)	Pre-Development % Impervious	Post-Development % Impervious
Tributary 4N MAS2-1/ MAM2-10	10.19	10.86	2%	33%
Tributary 4S MAS2-1/ POND	4.97	6.01	0%	32%
Tributary 5E MAM2-2	1.45	0.74	0%	12%
Tributary 5W MAS2-1/ MAM2-10	3.22	3.14	0%	0%
Tributary 6 MAM2-10 (a)	5.69	5.78	0%	0%
Tributary 6 MAM2-10 (b)	9.94	7.66	0%	0%

LEGEND
- MAS2-1 WETLANDS
- MAM2-2 WETLANDS
- MAM2-10 WETLANDS
- PRE DEVELOPMENT TRIBUTARY DRAINAGE AREAS
- POST DEVELOPMENT TRIBUTARY DRAINAGE AREAS

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PROJECT
EAGLE HEIGHTS HYDROLOGICAL STUDY AND SWM REPORT

DWG
DRAINAGE CONDITION OF WETLANDS

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FIGURE 1

3.1. Tributary 4 North (MAS2-1 and MAM2-10)

MAS2-1 and MAM2-10 are located within Tributary 4 just north of Flatt Road as shown in Figure 1. In existing conditions these wetlands have about 10.19 ha drainage. Figure 2 shows the post development sub catchment 406 SWM storage outlets just downstream of MAS2-1. Sub catchment 409, which is a cluster housing condominium development, SWM storage outlets to the downstream end of MAS2-1.

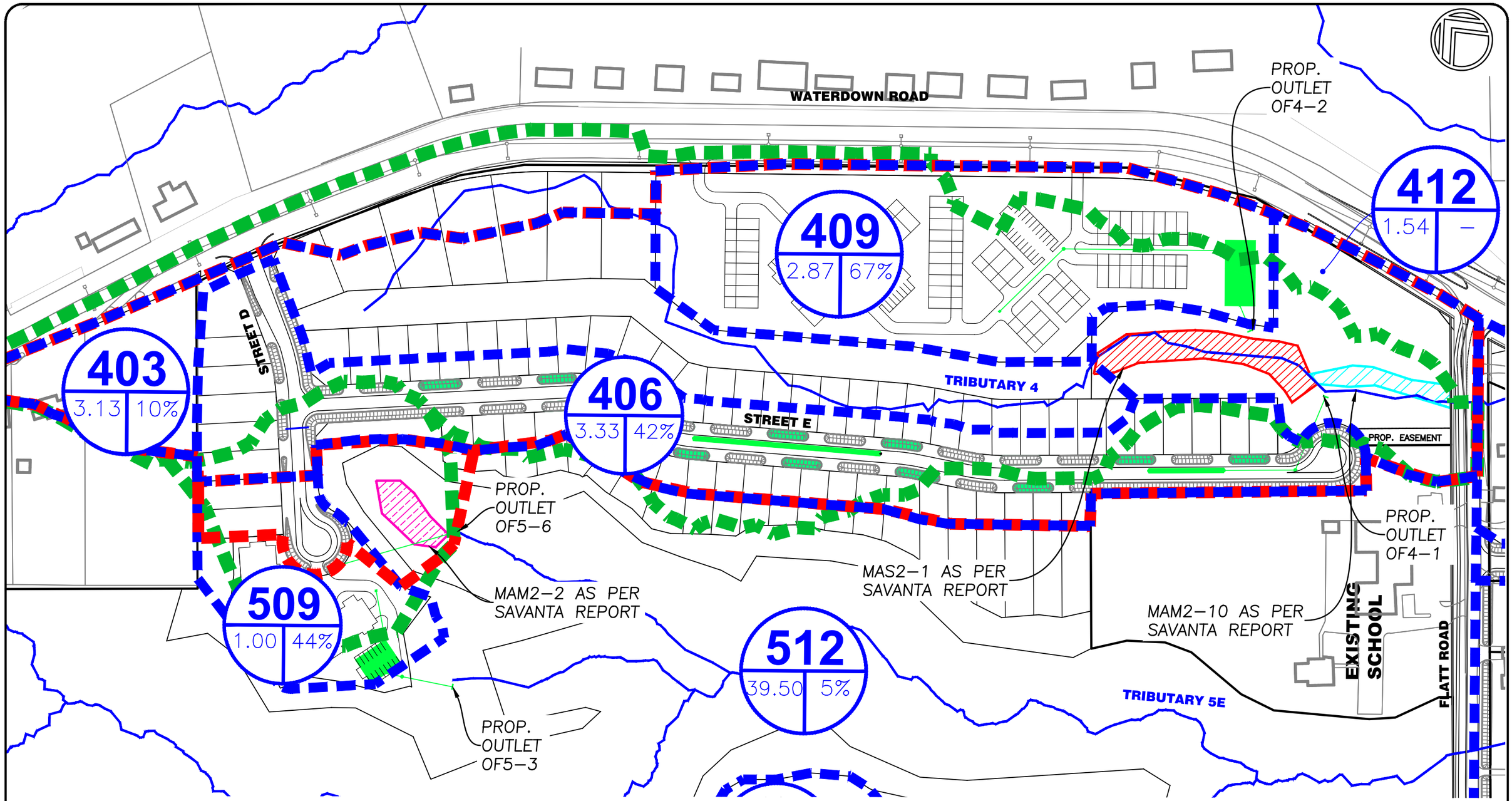
Figure 3 and Table 1 show the average monthly water balance in existing conditions and for the post development conditions. As it shows, the total post development runoff volume is generally higher than the existing condition runoff volume.

The excess post development runoff discharged to these wetlands will be reduced through number of ways. Sub catchment 409 is a condominium block with cluster housing units. The excess runoff from this area will be collected in an underground storage system in spring time and later used for lawn irrigation in summer months. If the runoff from Sub catchment 409 is minimized with a cistern system then runoff from sub catchment 403, 406 and 412 will be discharged through these wetlands without requiring further controls.

As mentioned earlier, Sub catchment 406 SWM storage outlets just downstream of Wetland MAS 2-1 as shown in Figure 2. Therefore, wetland MAS2-1 receives runoff only from Sub catchments 403 and 412. Figure 4 shows that in summer months the runoff from post development Sub catchment 403 & 412 is close to the existing conditions.

If runoff from Sub catchment 409 is stored in an underground cistern and used for lawn irrigation, then Wetland MAM 2-10 will receive runoff only from Sub catchment 403, 406 and 412 from June to September. Figure 4 and Table 2 show Monthly Water Balance of Wetland (MAM 2-10).

In Sub catchment 406, bioretention cells are proposed be built as LID measures within the road side ditches. The positive effect of these bioretention cells has not been considered in the hydrological model and the water balance analysis. Any positive effects of these LID measures (Biorentention cells) will be an added advantage.



LEGEND

- POST DEVELOPMENT DRAINAGE BOUNDARY
- PRE DEVELOPMENT TRIBUTARY DRAINAGE AREA
- POST DEVELOPMENT TRIBUTARY DRAINAGE AREA
- STORM SUPERPIPE
- STORM PIPE
- INFILTRATION TRENCH
- PROPOSED CULVERT
- ON–SITE STORAGE
- MAS2–1 WETLANDS
- MAM2–2 WETLANDS
- MAM2–10 WETLANDS

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HYDROLOGICAL STUDY
AND SWM REPORT

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OVERALL STORM DRAINAGE TO WETLANDS IN TRIBUTARY 4N

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FIGURE 2

Figure 3 Monthly Water Balance for Wetlands Tributary 4 MAS 2-1

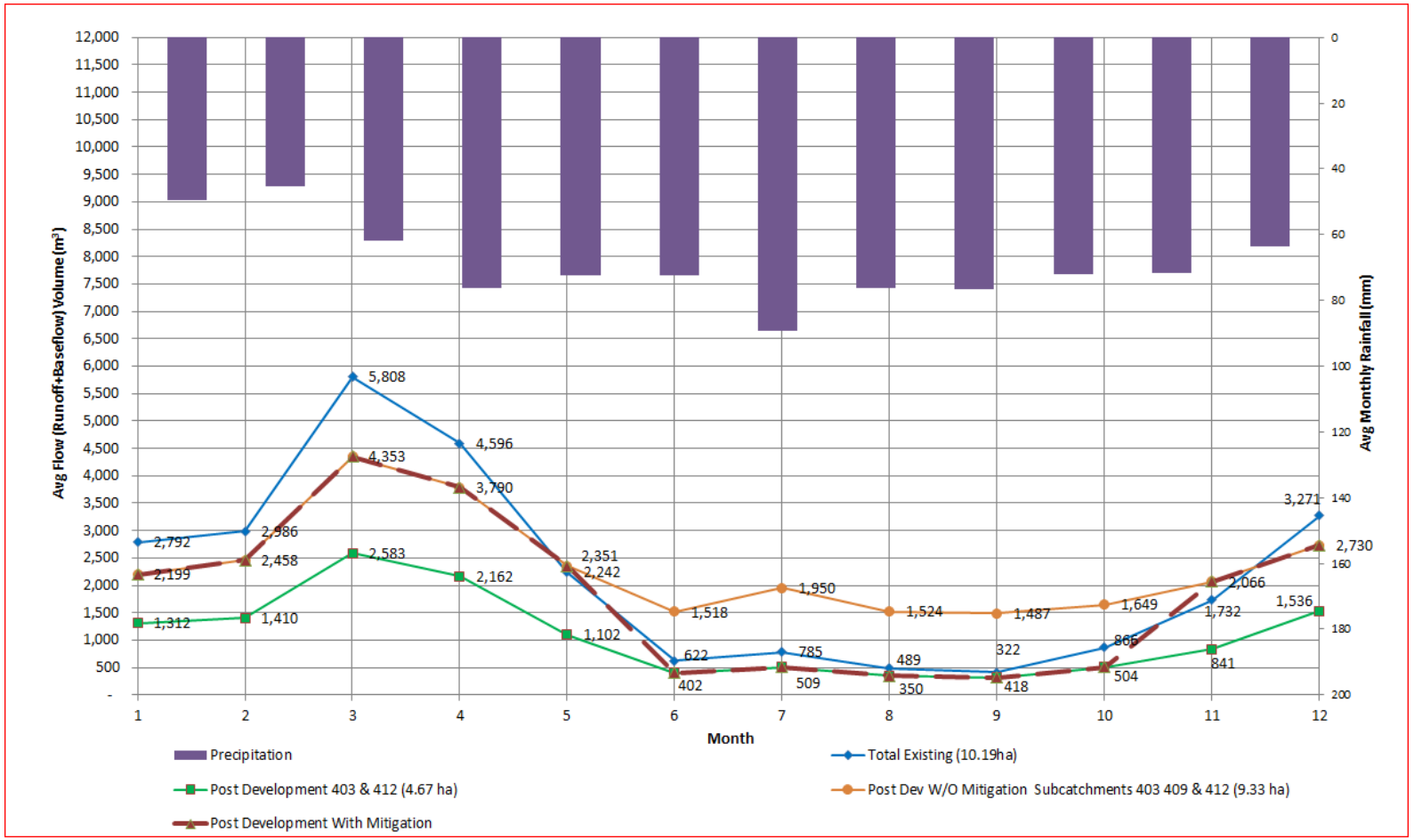


Table 1 Monthly Water Balance for Wetlands Tributary 4 MAS 2-1

Month	Existing (10.19 ha)	Proposed Without Mitigation (9.33 ha)	Proposed with Mitigation (9.33 ha)
	(m3)	(m3)	(m3)
JAN	2,792	2,199	2,199
FEB	2,986	2,458	2,458
MAR	5,808	4,353	4,353
APR	4,596	3,790	3,790
MAY	2,242	2,351	2,351
JUN	622	1,518	402
JUL	785	1,950	509
AUG	489	1,524	350
SEP	418	1,487	322
OCT	866	1,649	504
NOV	1,732	2,066	2,066
DEC	3,271	2,730	2,730
Total	**26,606**	**28,076**	**22,034**

Figure 4: Monthly Water Balance of Wetland (MAM 2-10) in Tributary 4 North

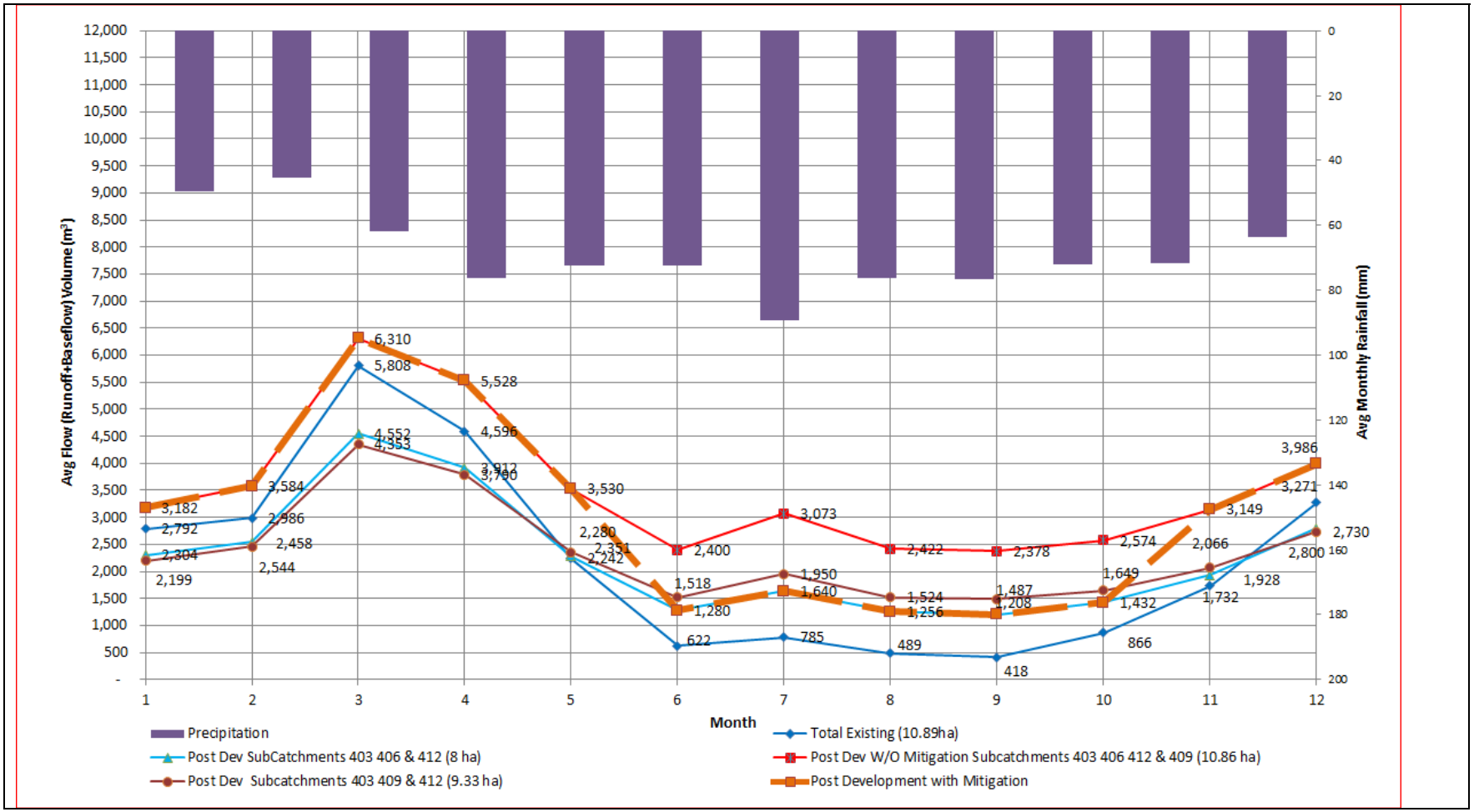


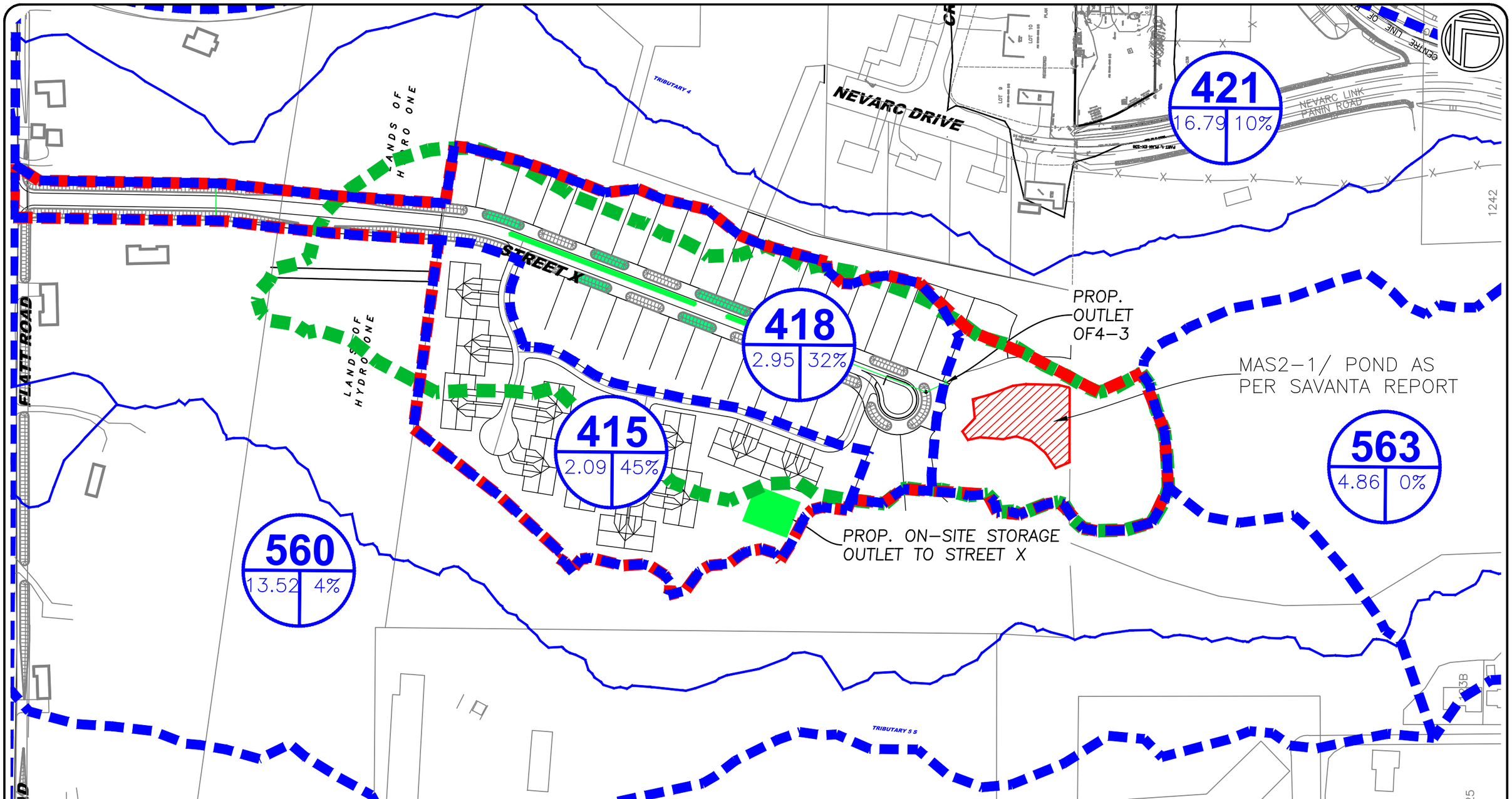
Table 2 Monthly Water Balance of Wetland (MAM 2-10) in Tributary 4 North

Month	Existing (10.19 ha)	Proposed Without Mitigation (10.86 ha)	Proposed with Mitigation (10.86 ha)
	(m3)	(m3)	(m3)
JAN	2,792	3,182	3,182
FEB	2,986	3,584	3,584
MAR	5,808	6,310	6,310
APR	4,596	5,528	5,528
MAY	2,242	3,530	3,530
JUN	622	2,400	1,280
JUL	785	3,073	1,640
AUG	489	2,422	1,256
SEP	418	2,378	1,208
OCT	866	2,574	1,432
NOV	1,732	3,149	3,149
DEC	3,271	3,986	3,986
Total	**26,606**	**42,115**	**36,084**

3.2. Tributary 4 South (MAS2-1/ Taylor Pond)

MAS 2-1/Pond is located within Tributary 4S of the proposed development which was previously referred as “Taylor Property”. Figure 5 shows the location of these wetlands and existing and post development drainage areas. Figure 6 shows the existing condition monthly water balance. The pond has low permeability soils (clay till and shale) and is primarily surface water fed (Terra-Dynamics 2018).

In this case, post development monthly runoff will be significantly higher than the existing condition runoff volume. An appropriate engineering solution (e.g. split manhole) will be explored in the detail design stage that matches the exiting condition water balance at these wetlands as much as practically possible. The excess runoff volume in post development condition will be diverted through a channel and connected downstream of the Taylor Pond Outlet as shown in Figure 7. The footprint of the proposed diversion channel is about 0.082 ha which is situated entirely outside the wetland area.



LEGEND

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- PRE DEVELOPMENT TRIBUTARY DRAINAGE AREA
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- MAM2-10 WETLANDS

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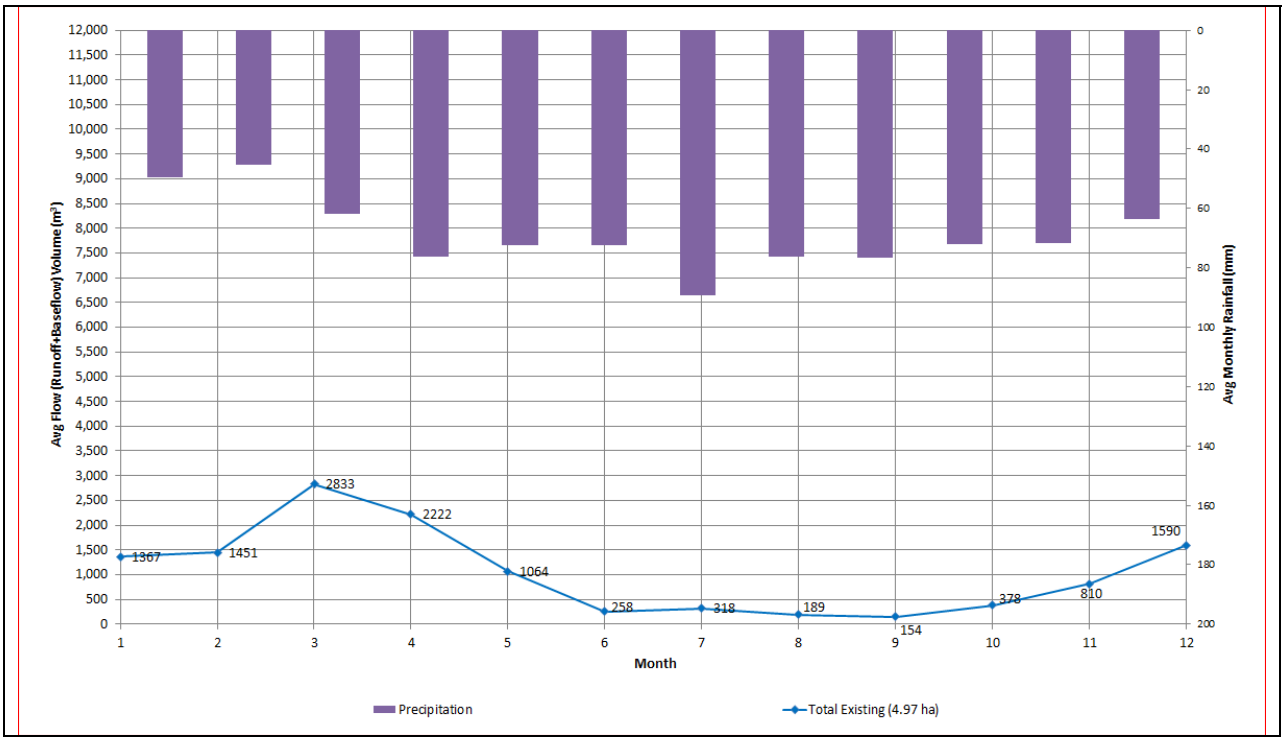
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FIGURE 5

Figure 6 **Existing Condition Monthly Water Balance of Wetland MAS 2-1 & Taylor Pond**



EX. CHANNEL

MATCH TO EX. GROUND
WITH MAX. 3:1 SLOPE

PROP. 1m WIDE FLAT
BOTTOM CHANNEL @ 1.92%

PROP. HEADWALL

PROP. 250mmø STM

PROP. SPLITTER MANHOLE

PROP. 1800x2400mmø STM

PROP. 250mmø STM

PROP. 250mmø STM

PROP. HEADWALL

STREET X

EX. WETLAND

27 28 29 30 31 32

10 11 12 13 14

0+540 0+520 0+500 0+480 0+460 0+440 0+420 0+400 0+380 0+360 0+340 0+320 0+300 0+280 0+260 0+240

121.00 121.25 121.50 121.75 122.00 122.25 122.50 122.75 123.00 123.25 123.50 123.75 124.00 124.25

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PROPOSED FLAT BOTTOM
CHANNEL FROM STREET X

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FIGURE 7

3.3. Tributary 5 East MAM2-2

This wetland/marshy area is located just south of proposed Street D in Tributary 5 East drainage as shown in Figure 1. In the existing condition this feature has about 1.45 ha drainage with 0% percent impervious area. In the post development conditions drainage area is 0.74 ha with 12% impervious area.

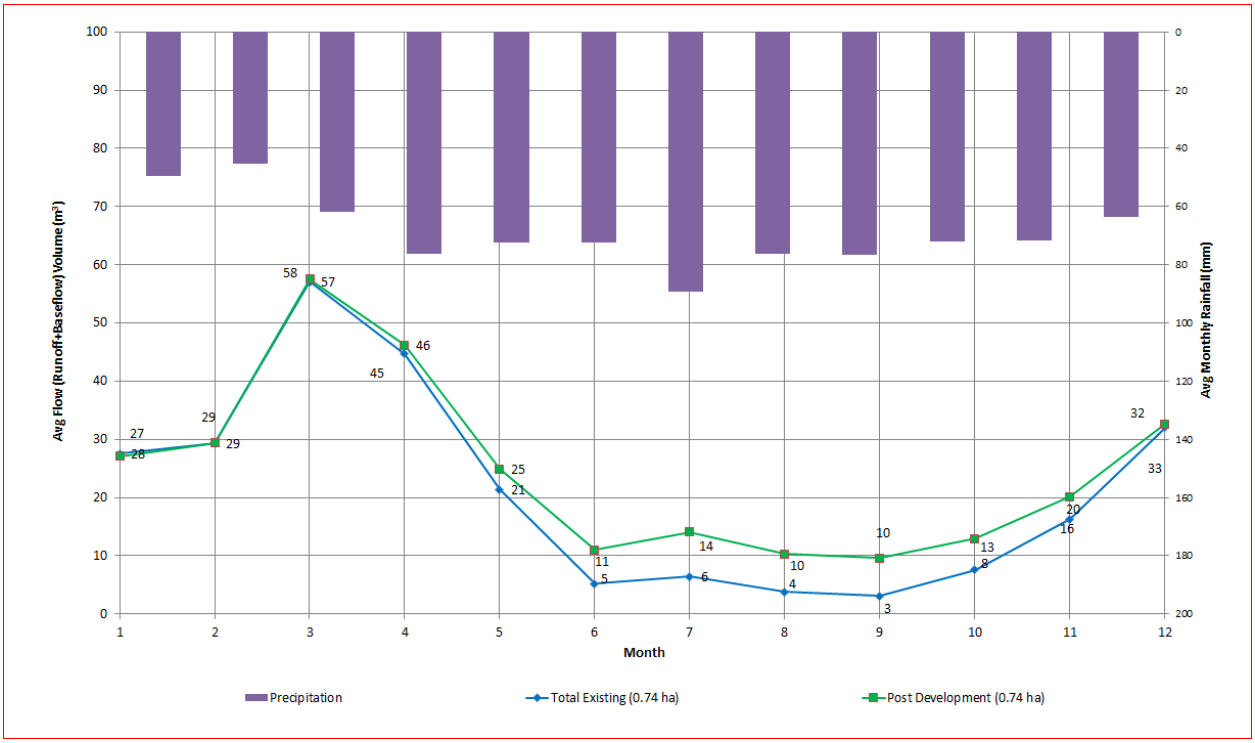
Table 3 and Figure 8 show the existing and post development conditions monthly water balance. The drainage area in post development is less than in the existing condition but due to increase in percentage impervious area, runoff volumes in winter months are similar in existing and post development conditions. In summer months post development runoff volume is slightly higher than the existing condition.

As per the recent hydrogeology report by Terra-Dynamics Consulting Inc. *(Hydrogeology Assessment of the Eagle Heights Lands, Burlington, ON, October 25, 2018),* there is very little or no groundwater contributions to these wetlands.

Table 3 Monthly Water Balance of Wetland (MAM 2-2) in Tributary 5 East

Month	Existing (1.45 ha)	Proposed (0.74 ha)
	(m^3)	(m^3)
JAN	28	27
FEB	29	29
MAR	57	58
APR	45	46
MAY	21	25
JUN	5	11
JUL	6	14
AUG	4	10
SEP	3	10
OCT	8	13
NOV	16	20
DEC	32	33
Total	**254**	**296**

Figure 8 Monthly Water Balance of Wetland (MAM 2-2) in Tributary 5 East



3.4. Tributary 5 West MAS 2-1/ MAM 2-10

Pre-development Tributary 5 West contains a Cattail mineral shallow marsh/forb mineral meadow marsh community. No amphibian breeding habitat is present (Savanta 2018). Terra-Dynamics (2018) determined that a significant amount of flow for Tributary 5 West is from the forested areas to the northwest. The upper slopes of this wetland catchment are silty sand and slowly release groundwater to this tributary (Terra Dynamic 2018).

As shown in Figure 1, there is very little change in drainage area of these wetlands - post development 3.14 ha compared to 3.22 ha pre development. Therefore, the proposed Eagle Heights development will have no impacts on these wetlands.

3.5. Tributary 6 West MAM 2-10 (a) and MAM 2-10 (b)

Pre-development, Tributary 6 contains two forb mineral meadow marsh communities; none of these wetlands support amphibian breeding habitat (Savanta 2018). Terra-

Dynamics (2018) determined that the most significant flow for Tributary 6 West was located in the forested lands north of the two wetlands. During spring freshet, a small amount of groundwater seepage is expected from the slope of the tributary where the silty sand layer meets the slope edge (Terra-Dynamics 2018).

As shown in Figure 1, there is very little change in pre and post development drainage area of MAM 2-10(a). Pre-Development drainage is 5.69 ha and post development is 5.78 ha, which is about a 2 % increase in drainage area in post development condition. Therefore, water balance analysis for MAM 2-10(a) was not conducted. In the case of MAM 2-10 (b), post development drainage area reduces to 7.66 (ha) from 9.94 (ha) which is about a 23 % reduction. Table 4 and Figure 9 show the existing and post development conditions monthly water balance of MAM 2-10(b).

Terra-Dynamics identified that the majority of flow to Tributary 6 West comes from the forested lands north of the wetlands, and not from the tablelands that are proposed for development. Therefore, the proposed tableland development is not expected to negatively impact the wetland water balance for the two riparian wetlands in the Tributary 6 West riparian corridor (H. Whitehouse (SAVANTA), personal communication, December 11, 2018).

Figure 9: Monthly Water Balance of Wetland (MAM 2-10(b) in Tributary 6

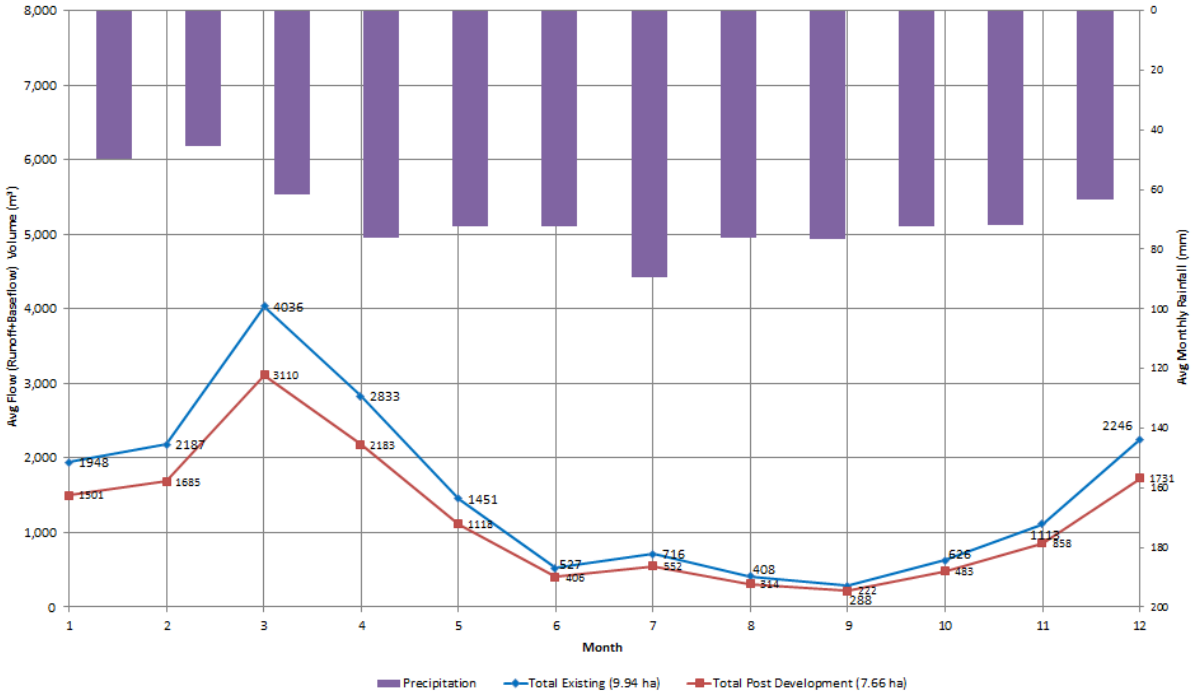


Table 4 Monthly Water Balance of Wetland (MAM 2-10(b) in Tributary 6

Month	Existing (9.94ha)	Proposed (7.66ha)
	(m^3)	(m^3)
JAN	1948	1501
FEB	2187	1685
MAR	4036	3110
APR	2833	2183
MAY	1451	1118
JUN	527	406
JUL	716	552
AUG	408	314
SEP	288	222
OCT	626	483
NOV	1113	858
DEC	2246	1731
Total	**18,379**	**14,163**

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4. Conclusions

The hydrogeology report of Eagle Heights was not available at the time of submission of MCI SWM Report and Environmental Impact Assessment (EIA) in August 2018. Terra –Dynamics Consulting Inc. has since completed the hydrogeologic report of Eagle Heights, Hydrogeologic Assessment of the Eagle Heights Lands, Burlington, ON, October 25, 2018. This letter report summarizes water balance analysis of wetlands incorporating that hydrogeologic information.

The wetlands located in Tributary 4 (MAS2-1), (MAM2-10) & MAS2-1/Pond, and Tributary 5E (MAM2-2) are only surface runoff fed and have no ground water contribution. The wetland located in Tributary 5 west (MAS2-1/ MAM2-10) is a groundwater fed wetland but there is very little change in pre and post development drainage for this wetland.

Mitigation measures (e.g. on-site storage, flow diversion channel) have been proposed in the wetlands that receive no groundwater discharge and have change in drainage areas due to proposed development in order to reduce the impacts on these wetlands.

The wetland located in Tributary 5W, MAS2-1 / MAM 2-10 is both surface and ground water fed wetland and there is very little effect of the proposed development on this wetland.

The wetlands located in Tributary 6, (MAM 2-10 (a) and MAM 2-10(b), receive significant groundwater from the upstream area. Terra-Dynamics identified that the majority of flow to Tributary 6 West comes from the forested lands north of the wetlands from groundwater contribution. Therefore, the proposed tableland development is not expected to negatively impact the wetland water balance for the two riparian wetlands in the Tributary 6 West riparian corridor.



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