NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Memo

Project #2010

To: **Katie Nasswetter, Senior Development Planner, City of Guelph**
Leah Lefler, Environmental Planner, City of Guelph

From: **Jennifer McCarter, Terrestrial and Wetland Biologist, NRSI**

Date: **May 29, 2019**

Re: **Paisley Park Environmental Impact Study – Addendum Letter**
Impact Assessment on Hydrologic Function of the Wetland

In response to comments provided by the City of Guelph with respect to potential runoff from the proposed Paisley Park development area, NRSI used a revised water balance and storm water management model prepared by GM BluePlan to complete a sensitivity analysis, which focused on the sensitivity of the vegetation community and amphibian species within the Guelph Southwest Wetland Complex to changes in hydrology. Based on this analysis, it is anticipated that there will be no significant impact on the wetland west of the proposed development site. Details of the sensitivity analysis are provided below.

Introduction

Natural Resource Solutions Inc. (NRSI) was retained in October, 2017 by Armel Corporation to complete an Environmental Impact Study (EIS) and Tree Inventory and Preservation Plan (TIPP) to support the City of Guelph Official Plan (OP) amendment and Zoning By-law amendment applications for a proposed residential development known as "Paisley Park" at the corner of Paisley Rd and Whitelaw Rd in the City of Guelph. The EIS and TIPP were submitted to the City of Guelph, Grand River Conservation Authority, and County of Wellington for review and comment on August 24, 2018. On April 10, 2019, the following comments from the City of Guelph's Environmental Planning Department were received:

> *"As previously requested in environmental planning comments provided on the EIS TOR, dated February 8, 2018, the application will need to demonstrate (via a feature based monthly water balance) how the development will not negatively impact the hydrologic function of the wetland. To assist with the preparation of a feature based monthly water balance, and interpretation of potential negative impacts to the hydrologic function of the wetland, environmental planning staff offer the following comments:*
>
> - *The predevelopment site should be modelled based on existing catchments. Based on topography, there appears to be at least two catchments, one draining to the wetland*

and one draining towards Whitelaw Road. A feature-based water balance should be prepared based on the wetland's catchment and should include an assessment of the proportion of the catchment comprised by the subject site.

- *Average annual precipitation is estimated to be about 923.3mm for the subject site. The feature-based monthly water balance should identify the volume of runoff directed to the wetland.*
- *The goal of matching flow rates in stormwater management design is based on a watercourse as the receiver, and is not applicable to situations where a wetland is the receiver. For wetlands, matching volume and timing of flows is important.*
- *A hydrograph showing pre- and post-development conditions should be provided.*
- *Discharge rates and flow volumes anticipated to flow from proposed stormwater management facilities under different designed storm events should be provided.*

The results of the feature based monthly water balance should be used to assess potential impacts to wetland hydrology, and changes to vegetation communities (e.g. based on sensitivity of existing vegetation). If negative impacts are confirmed through this analysis, an updated development concept, stormwater management design and supporting Environmental Impact Study that demonstrates the hydrology of the adjacent wetland can be protected will be required to gain environmental planning support of this development application."

The study team has reviewed these comments and, as requested, GM BluePlan has completed additional hydrological analyses, including a feature-based monthly water balance which has been used to assess potential impacts to the wetland hydrology, and changes to the existing vegetation communities (e.g. based on sensitivity of vascular plant species documented within the Subject Property to changes in water levels).

This Addendum letter is to be read in conjunction with the August 24, 2018 EIS (NRSI).

Feature-Based Monthly Water Balance Analysis

GM BluePlan completed a Feature-Based Monthly Water Balance Analysis for the Subject Property and broader wetland catchment area (2019). The entire wetland area is approximately 8ha (at the surveyed wetland limit undertaken in conjunction with GRCA). Normal water storage elevation within the wetland is around 330.00m. Normal storage volume within the wetland area is approximately 3,700 cu m with a surface area of approximately 27,000m^2 or 2.7ha. For a map of the Guelph Southwest Wetland Complex catchment area refer to GM BluePlan's Functional Servicing Brief document (2019).

The water balance was calculated on a monthly basis based on the strategy provided in Instructions and Tables for Computing Potential Evapotranspiration and the Water Balance (Thornthwaite and Mather, 1957). The water balance was calculated for 2 different stormwater management (SWM) approaches:

1. Low Impact Design (LID) SWM which utilizes infiltration structures to collect and infiltrate the runoff generated from the rooftops of the proposed apartment buildings and townhouses. This approach would balance pre- to post-development recharge volumes.

2. Enhanced LID SWM which utilizes infiltration structures as well as a bioretention cell to collect, filter, polish and infiltrate a portion of the storm runoff generated from the driving and parking areas. This approach would balance pre- to post-development recharge volumes as well as runoff volumes discharging to the adjacent wetland.

For full results refer to GM BluePlan's Functional Servicing Brief document (2019).

With the implementation of the first SWM approach, utilizing LID SWM utilizing infiltration structures only (no bioretention cells), the predicted increase in annual runoff volume discharging to the adjacent wetland would be 15,165m^3. Assuming rainfall events occur every 2 to 3 days, resulting in an approximately 156 rainfall events occurring each year, this overall increase in runoff volume translates to a 97m^3 increase in runoff volume, and an increased wetland water depth of 3.6mm, per rainfall event. This represents a very slight increase in water depth in the wetland, however the second SWM approach, utilizing infiltration structures in addition to bioretention cell, more closely matches pre- to post-development runoff volumes.

With enhanced LID SWM implemented within the proposed development, the runoff volumes are not predicted to be significantly different between the existing and post-development conditions. Within the Subject Property, the annual total runoff volume is only 1.3% (150m^3) higher post-development compared to the existing condition (Table 1). Within the entire wetland catchment area, the annual total runoff volume is only 0.2% (151m^3) higher post-development compared to the existing condition (Table 2). Based on rainfall events occurring every 2 to 3 days, and an approximate total of 156 rainfall events occurring each year, the increase in runoff volume within the entire wetland catchment area would be approximately 0.96m^3, or an increased wetland water depth of 0.04mm per rainfall event.

To achieve post-development runoff volumes similar to the existing conditions with the enhanced LID SWM, significantly more water is directed to infiltration galleries/structures as enhanced recharge. Within the development area annual recharge (both natural infiltration and enhanced recharge) is 352.8% (21,847m^3) higher in the post-development condition. Within the entire wetland catchment area annual recharge (both natural infiltration and enhanced recharge) is 62.7% (22,400m^3) higher in the post-development condition.

LID SWM systems influence both recharge and runoff. While it is anticipated that LID SWM systems will be implemented as part of the proposed development, it is important to note that under both proposed SWM scenarios (i.e. with or without enhanced LIDs with a bioretention cell) the fluctuation in the level of the wetland is not dramatically altered.

Table 1. Monthly Water Budget for the Development Area with Enhanced Low Impact Design (LID) Stormwater Management (SWM)

	Recharge				Runoff			
Month	**Existing[1] (m^3)**	**Post-development[2] (m^3)**	**Total Difference (m^3)**	**Total % Difference**	**Existing[1] (m^3)**	**Post-development (m^3)**	**Total Difference (m^3)**	**Total % Difference**
January	136	554	418	307.4%	253	251	-2	-0.8%
February	68	277	209	307.4%	127	125	-2	-1.6%
March	34	138	104	305.9%	63	63	0	0.0%
April	838	2,464	1,626	194.0%	1,556	1,509	-47	-3.0%
May	2,153	6,373	4,220	196.0%	3,998	3,933	-65	-1.6%
June	1,076	4,495	3,419	317.8%	1,999	1,989	-10	-0.5%
July	538	3,646	3,108	577.7%	1,000	1,059	59	5.9%
August	269	3,093	2,824	1049.8%	500	589	89	17.8%
September	147	2,450	2,303	1566.7%	274	358	84	30.7%
October	74	1,676	1,602	2164.9%	137	200	63	46.0%
November	587	2,319	1,732	295.1%	1,090	1,076	-14	-1.3%
December	273	1,109	836	306.2%	506	501	-5	-1.0%
Annual Total	**6,193**	**28,040**	**21,847**	**352.8%**	**11,503**	**11,653**	**150**	**1.3%**

1 - Catchment 20 (10 currently drains to Paisley/Whitelaw Roads)

2 - Combined Recharge and Enhanced Recharge volumes

Table 2. Monthly Water Budget for the Overall Catchment Area with Enhanced Low Impact Design (LID) Stormwater Management (SWM)

	Recharge				Runoff			
Month	**Existing[1] (m^3)**	**Post-development[2] (m^3)**	**Total Difference (m^3)**	**Total % Difference**	**Existing[1] (m^3)**	**Post-development (m^3)**	**Total Difference (m^3)**	**Total % Difference**
January	782	1,200	418	53.5%	1,499	1,497	-2	-0.1%
February	391	600	209	53.5%	750	748	-2	-0.3%
March	195	299	104	53.3%	375	375	0	0.0%
April	4,755	6,381	1,626	34.2%	9,117	9,070	-47	-0.5%
May	12,215	16,435	4,220	34.5%	23,422	23,357	-65	-0.3%
June	6,180	9,599	3,419	55.3%	11,851	11,841	-10	-0.1%
July	3,170	6,278	3,108	98.0%	6,080	6,140	60	1.0%
August	1,658	4,482	2,824	170.3%	3,181	3,270	89	2.8%
September	951	3,254	2,303	242.2%	1,825	1,909	84	4.6%
October	502	2,104	1,602	319.1%	962	1,025	63	6.5%
November	3,361	5,093	1,732	51.5%	6,444	6,431	-13	-0.2%
December	1,564	2,400	836	53.5%	2,999	2,993	-6	-0.2%
Annual Total	**35,724**	**58,125**	**22,401**	**62.7%**	**68,505**	**68,656**	**151**	**0.2%**

1 - Catchment 20 (10 currently drains to Paisley/Whitelaw Roads)
2 - Combined Recharge and Enhanced Recharge volumes

Impact Assessment on Hydrologic Function of the Wetland

To determine whether the proposed stormwater release into the Guelph Southwest Wetland Complex will significantly alter the form or function of the wetland from its pre-development condition, a sensitivity analysis was completed. This analysis focused on the wetland vegetation community present, as well as amphibian species documented within the wetland during the baseline field surveys conducted by NRSI to inform the EIS (2018).

Vegetation Sensitivity Analysis

The wetland plant community was examined for the sensitivity analysis because the plant community is a good indicator of the overall wetland health and because it provides food and critical habitat for invertebrates, herpetofauna and birds. Changes in duration, depth, timing and frequency of water level fluctuations are the main causes affecting a wetland's plant community.

The analysis consisted of comparing the vegetation community data (based on Ecological Land Classification, Lee et al. 1998) and species lists collected by NRSI on October 25, 2017 and June 9, 2018 to information provided in the Toronto Region Conservation Authority (TRCA) "Wetland Water Balance Risk Evaluation" (2017) and the United States (U.S.) National Database of Wetland Plant Sensitivities (Adamus and Danielson 2002). The TRCA (2017) document includes tables that rank vegetation communities and individual species by their sensitivity to hydrologic change. The U.S. Database provides sensitivity rankings for individual species. The database is not a complete list of all wetland plants; however, it does provide information to augment the TRCA's document.

The Freeman Maple Mineral Deciduous Swamp Type (SWD3-3, Map 3 in EIS) immediately adjacent to the Subject Property is an 8ha deciduous treed swamp, surrounded by the deciduous forest community on 3 sides. According to the TRCA (2017) document, Freeman Maple Mineral Deciduous Swamp wetlands have a 'medium' sensitivity to changes in hydrology and are tolerant of 'slight hydrological changes'.

A total of 66 vascular plant species was documented within this swamp community by NRSI in 2017 and 2018. The canopy is dominated by a mixture of young to mid-age and mature Freeman's Maple (*Acer X freemanii*) and Green Ash (*Fraxinus pennsylvanica*). The sub-canopy is dominated by White Elm (*Ulmus americana*), Green Ash, and Freeman's Maple, which are also the dominant species in the understory. The ground cover in the swamp consists of Spotted Touch-me-not (*Impatiens capensis*), Enchanter's Nightshade (*Circaea alpina*), and Jack-in-the-Pulpit. This community has several species of sedges including the Awl-fruited Sedge (*Carex stipata*), Tuckerman's Sedge (*Carex tuckermanii*), Bladder Sedge (*Carex intumescens*), and Graceful Sedge (*Carex gracillima*).

The sensitivities of the vascular plants found within the Freeman Maple Mineral Deciduous Swamp community, according to the TRCA (2017) and Adamus and Danielson (2002) are provided in Table 3.

Only one of the species present within this community, Hop Sedge, a rare vascular plant species in Wellington County (Dougan & Associates 2009), was reported as having a High

sensitivity to changes in hydrology (TRCA 2017), however this species was also reported as being Moderately Tolerant to increases in flood duration (Adamus and Danielson 2002). It is not expected to be impacted by the minimal increase in wetland water levels through the proposed development.

According to the TRCA (2017), 21 species have a Medium sensitivity while 1 other species, Awl-fruited Sedge, has a Low sensitivity to changes in hydrology.

According to Adamus and Danielson (2002), 1 species, Green Ash, is Very Tolerant, 2 species, Freeman's Maple and Silver Maple (*Acer saccharinum*), are Tolerant, 15 species are Moderately Tolerant, and another 20 of the species are Somewhat Tolerant to increases in flood duration.

Based on the information presented in Table 3, the species within the wetland are moderately tolerant to tolerant to changes in hydrology and increased flood duration. The calculated annual changes to runoff volumes contributing to wetland water levels with either proposed LID SWM approach are relatively small (with the first approach (without a bioretention cell) the increased runoff is 15,165m^3, translating into an increased wetland water depth of 3.6mm per rainfall event; with the second approach (with a bioretention cell), the overall runoff is only 150m^3 higher for the Subject Property and 151m^3 higher for the entire wetland catchment area). Therefore, if either LID SWM concept, as designed by GM BluePlan, is implemented and maintained as required, it is expected that the wetland vegetation will be unaffected by the proposed development.

Table 3. Summary of Vegetation Sensitivity to Hydrologic Change for the Freeman Maple Deciduous Swamp Wetland

Scientific Name	Common Name[1]	CC[2]	CW[2]	SRANK[3]	SARO[4]	COSEWIC[5]	SARA Schedule[5]	Wellington County[6]	Wellington/Dufferin County[7]	City of Guelph Status[8]	Wetland Water Balance Risk Assessment – Sensitivity to Changes in Hydrology[9]	U.S. National Database of Wetland Plant Sensitivities - Sensitivity to Flood Duration Increase[10,11]
Acer saccharinum	Silver Maple	5	-3	S5					X		Medium	T
Acer X freemanii	Freeman's Maple										Medium	T
Agrimonia parviflora	Many-flowered Agrimony	4	-1	S4							n/a	n/a
Aralia nudicaulis	Wild Sarsaparilla	4	3	S5					X		n/a	ST
Arisaema triphyllum	Jack-in-the-pulpit	5	-2	S5					X		Medium	MT
Athyrium filix-femina var. angustum	Northern Lady Fern	4	0	S5					X		n/a	MT
Betula alleghaniensis	Yellow Birch	6	0	S5					X		n/a	ST
Boehmeria cylindrica	False Nettle	4	-5	S5					X		Medium	ST
Carex bromoides	Bromelike Sedge	7	-4	S5					X		Medium	n/a
Carex crinita	Fringed Sedge	6	-4	S5					X		Medium	MT
Carex gracillima	Graceful Sedge	4	3	S5					X		n/a	n/a
Carex intumescens	Bladder Sedge	6	-4	S5					X		Medium	ST
Carex lupulina	Hop Sedge	6	-5	S5				R	X	S	High	MT
Carex radiata	Radiate Sedge	4	5	S5							n/a	n/a
Carex stipata	Awl-fruited Sedge	3	-5	S5					X		Low	ST
Carex tuckermanii	Tuckerman's Sedge	7	-5	S4					X		Medium	n/a
Carpinus caroliniana ssp. virginiana	Blue Beech	6	0	S5					X		n/a	n/a
Cicuta virosa	Water-hemlock			S4S5							n/a	n/a
Circaea alpina	Smaller Enchanter's Nightshade	6	-3	S5					X		Medium	ST
Dryopteris carthusiana	Spinulose Wood Fern	5	-2	S5					X		Medium	n/a

Scientific Name	Common Name[1]	CC[2]	CW[2]	SRANK[3]	SARO[4]	COSEWIC[5]	SARA Schedule[5]	Wellington County[6]	Wellington/Dufferin County[7]	City of Guelph Status[8]	Wetland Water Balance Risk Assessment – Sensitivity to Changes in Hydrology[9]	U.S. National Database of Wetland Plant Sensitivities - Sensitivity to Flood Duration Increase[10,11]
Erigeron philadelphicus ssp. philadelphicus	Philadelphia Fleabane	1	-3	S5					X		n/a	n/a
Fragaria vesca ssp. americana	Woodland Strawberry	4	4	S5					X		n/a	n/a
Fraxinus nigra	Black Ash	7	-4	S5					X		Medium	ST
Fraxinus pennsylvanica	Green Ash	3	-3	S5					X		n/a	VT
Galium palustre	Marsh Bedstraw	5	-5	S5					X		Medium	MT
Galium triflorum	Sweet-scented Bedstraw	4	2	S5					X		n/a	ST
Geum aleppicum	Yellow Avens	2	-1	S5					X		n/a	n/a
Geum canadense	White Avens	3	0	S5					X		n/a	ST
Geum laciniatum	Rough Avens		-3	S4				R	X	S	n/a	n/a
Glyceria striata	Fowl Meadow Grass	3	-5	S5					X		n/a	ST
Ilex verticillata	Winterberry	5	-4	S5					X		Medium	MT
Impatiens capensis	Spotted Touch-me-not	4	-3	S5					X		Medium	ST
Lycopus uniflorus	Northern Water-horehound	5	-5	S5					X		Medium	ST
Lysimachia ciliata	Fringed Loosestrife	4	-3	S5					X		n/a	MT
Lysimachia thyrsiflora	Tufted Loosestrife	7	-5	S5					X		Medium	ST
Maianthemum canadense	Wild Lily-of-the-valley	5	0	S5					X		n/a	ST
Maianthemum racemosum ssp. racemosum	False Solomon's Seal	4	3	S5					X		n/a	n/a
Matteuccia struthiopteris var. pensylvanica	Ostrich Fern	5	-3	S5					X		n/a	MT

Scientific Name	Common Name[1]	CC[2]	CW[2]	SRANK[3]	SARO[4]	COSEWIC[5]	SARA Schedule[5]	Wellington County[6]	Wellington/Dufferin County[7]	City of Guelph Status[8]	Wetland Water Balance Risk Assessment – Sensitivity to Changes in Hydrology[9]	U.S. National Database of Wetland Plant Sensitivities - Sensitivity to Flood Duration Increase[10,11]
Onoclea sensibilis	Sensitive Fern	4	-3	S5					X		Medium	MT
Osmunda cinnamomea	Cinnamon Fern	7	-3	S5					X		n/a	MT
Oxalis stricta	Upright Yellow Wood-sorrel	0	3	S5					X		n/a	ST
Parthenocissus vitacea	Woodbine	3	3	S5					X		n/a	n/a
Pilea fontana	Spring Clearweed	5	-3	S4						S	Medium	n/a
Quercus macrocarpa	Bur Oak	5	1	S5					X		n/a	MT
Ranunculus recurvatus var. recurvatus	Hooked Buttercup	4	-3	S5					X		n/a	n/a
Ribes americanum	Wild Black Currant	4	-3	S5					X		n/a	n/a
Ribes cynosbati	Prickly Gooseberry	4	5	S5					X		n/a	n/a
Ribes hirtellum	Smooth Gooseberry	6	-3	S5				R	X	S	Medium	ST
Rubus occidentalis	Thimble-berry	2	5	S5					X		n/a	ST
Rubus pubescens	Dwarf Raspberry	4	-4	S5					X		Medium	ST
Sambucus racemosa ssp. pubens	Red-berried Elderberry	5	2	S5					X		n/a	ST
Solidago flexicaulis	Zig-zag Goldenrod	6	3	S5					X		n/a	ST
Thalictrum dioicum	Early Meadow-rue	5	2	S5					X		n/a	MT
Thelypteris palustris var. pubescens	Marsh Fern	5	-4	S5					X		Medium	MT
Tilia americana	American Basswood	4	3	S5					X		n/a	MT
Toxicodendron rydbergii	Poison-ivy	0	0	S5					X		n/a	n/a
Ulmus americana	White Elm	3	-2	S5					X		n/a	MT

1 – Non-native/exotic species are not included.

2 - Oldham et al. 1995; 3 - MNRF 2018a; 4 - MNRF 2018b; 5 - Government of Canada 2018; 6 - Dougan & Associates 2009; 7 - Riley 1989; 8 - City of Guelph 2012;
9 - TRCA 2017; 10 - Adamus and Danielson 2002. N/A indicates data was not available or the species was not included in the list;
11 - DEC= decrease, U= unaffected; IT= intolerant, ST= somewhat tolerant, MT= moderately tolerant, T= tolerant, VT= very tolerant. N/A indicates data was not available or the species was not included in the list.

Wildlife Sensitivity Analysis

Anurans (frogs and toads) require shallow aquatic habitats for breeding and egg and larval development (BSC 2009). Although some species are more terrestrial as adults (e.g. American Toad), many frog species also live in or near water as adults (BSC 2009). The dependence of anurans on aquatic habitats for key life stages makes them particularly susceptible to changes to local environmental conditions (BSC 2009).

Three species of anurans were documented by NRSI staff within the wetland in 2018 including American Toad (*Anaxyrus americanus*), Gray Treefrog (*Hyla versicolor*), and Wood Frog (*Lithobates sylvatica*). Only the Wood Frog was documented during the Anuran Call Surveys completed in April, May, and June, 2018.

Wood Frogs typically breed in April and May in Ontario, while Gray Treefrogs breed in May and June, and American Toads breed between April and June (BSC 2009). Tadpoles of these 3 species develop in breeding ponds for 2-4 months until they metamorphosize (Pfingsten et al 2013). For successful reproduction and survival of juvenile frogs and toads, the breeding wetland must have a suitably-long hydroperiod. The exact duration of the development period leading up to metamorphosis and juvenile dispersal depends on water temperature, food availability, density of tadpoles, etc. (Pfingsten et al 2013).

According to the TRCA (2017), American Toads have a Medium sensitivity to changes in wetland hydrology, while Gray Treefrogs and Wood Frogs have High sensitivities (Table 4).

Although these species may be sensitive to changes in water levels and hydrology in breeding ponds, during the important breeding and development periods for these 3 species (from April until October), the calculated annual changes to runoff volumes contributing to wetland water levels with either proposed LID SWM approach are relatively small (with the first approach (without a bioretention cell) the increased runoff is 15,165m^3; with the second approach (with a bioretention cell), the overall runoff is only 150m^3 higher for the Subject Property and 151m^3 higher for the entire wetland catchment area). Given that that wetland water levels are predicted to be either slightly deeper (3.6mm, per rainfall event under LID SWM scenario 1) or very similar (0.04mm per rainfall event under LID SWM scenario 2) to existing conditions, if either LID SWM concept, as designed by GM BluePlan, is implemented and maintained as required, it is not anticipated that the predicted water level changes due to the proposed development will negatively impact these species.

Table 4. Summary of Wildlife Sensitivity to Hydrologic Change

Scientific Name	Common Name	SRANK[1]	SARO[2]	COSEWIC[3]	SARA Schedule[3]	Wellington County Status[4]	City of Guelph Status[5]	Wetland Water Balance Risk Assessment - Sensitivity[6]
Anaxyrus americanus	American Toad	S5				X		Medium
Hyla versicolor	Tetraploid Gray Treefrog	S5				X		High
Lithobates sylvatica	Wood Frog	S5				X		High

1 - MNRF 2018a; 2 - MNRF 2018b; 3 - Government of Canada 2018; 4 - Dougan & Associates 2009; 5 - City of Guelph 2012; 6 - TRCA 2017

Conclusions and Recommendations

The project team has reviewed and carefully considered the comments provided from the City of Guelph. The feature-based monthly water balance analysis completed by GM BluePlan demonstrates that the proposed development, including LID SWM (without a bioretention cell) and enhanced LID SWM (with a bioretention cell) infrastructure, will result in minimal changes to the overall annual runoff volume into the Guelph Southwest Wetland Complex (GM BluePlan 2019).

The detailed monthly runoff volumes were used to determine whether the proposed changes in local hydrology will significantly alter the form or function of the Guelph Southwest Wetland Complex from its pre-development condition. According to the sensitivity analysis completed, which focused on the vegetation community and amphibian species within the wetland, it is anticipated that no significant impact will occur due to the proposed development and concomitant changes in local hydrology.

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