Report ©

on water balance investigations made in frame of Etobicoke-Mimico Task Force in February – July 2000,

prepared By Rimma Vedom

Reason:

- ☞ To share my experience in water balance composition using Etobicoke watershed as a pattern
- ☞ to perform WRIM- my vision of water balance as a management tool for a Conservation Authority
- ☞ to meet professional peoples, to learn "hot" problems, to be involved…

Acknowledgements

I am very appreciative to **Beth Williston** and **Don Haley** for giving me such a good possibility to do something useful (I hope my report will bring a lot of fresh thoughts and solutions): to learn you and introduce myself. I thank very much **Robert Klimas,** City of Etobicoke, for our meeting and following information of water consumption, supply and sewage systems. I have lots of warm words for **Jaine Pilot** (Pilot Performance Resources Management Inc.), who has brought me into Etobicoke-Mimico Task Force and continued to support me in my "free drifting".

Thanks!

Copies of the report are distributed to:

Beth Williston and Don Haley (TRCA)	- 2;	Robert Klimas (City of Etobicoke)	- 1;
Jaine Pilot (Pilot Performance Inc.)	- 1;	Sonja Meek (CWRA)	- 1.
James Li and Doug Banting (Ryerson Polytechnic University)			- 1;

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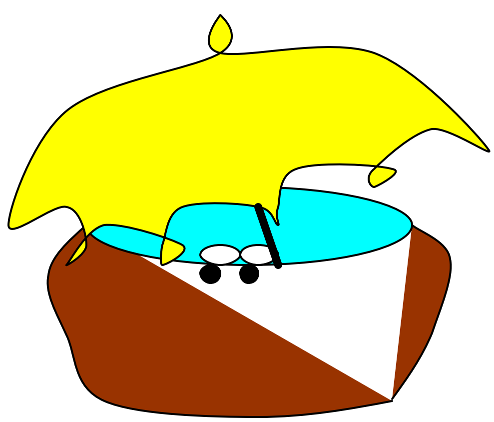

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Water Resources Inventory Model © is the result of my previous hydrological experience and nova-days understanding of Canadian environmental problems.

WATER RESOURCES INVENTORY MODEL (WRIM)
has three main parts:

1. Natural Water Resources

Natural Water balance residual
(Evapotranspiration)

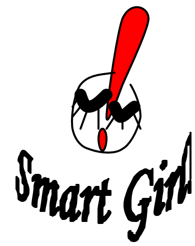
Water input
- *River runoff from upper area*
- *Precipitation*

Water output
1. *River runoff to downstream*
2. *Ground water table changing*
3. *Soil moisture changing*

2. Man Developed Water Resources

Human activities and land use

1. *Virgin area*
2. *Agricultural*
3. *Residential*
4. *Office/Commercial*
5. *Industrial*
6. *Government*
7. *Recreational*
8. *Sewage System*

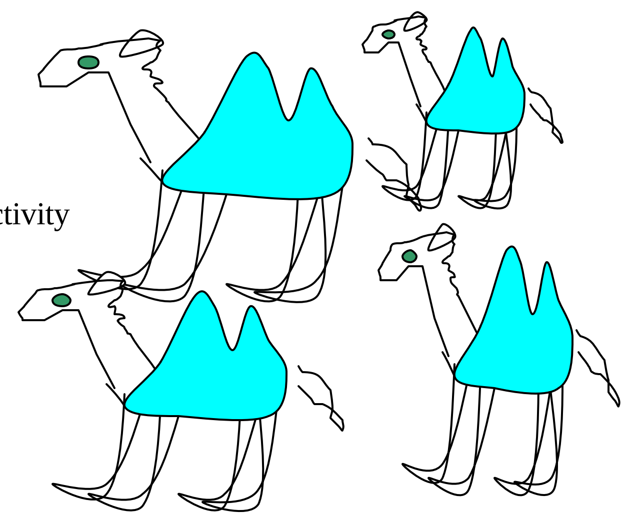


3. Drainage basin Condition

Topography
Geology
Hydrography
Physiography
Storm water system

Based on measured data and obtained relations, WRIM estimates month water budged along Etobicoke Creek and within boarders of Caledon, Brampton, Mississauga and Etobicoke as following:

1. Precipitation
2. River runoff
3. Changing of ground water storage
4. Changing of soil moisture storage
5. Evapotranspiration
6. Water volume used in each area of human activity (based on existing consumption norms):
   - Residential
   - Government
   - Business/Commercial
   - Industrial



Hard work...

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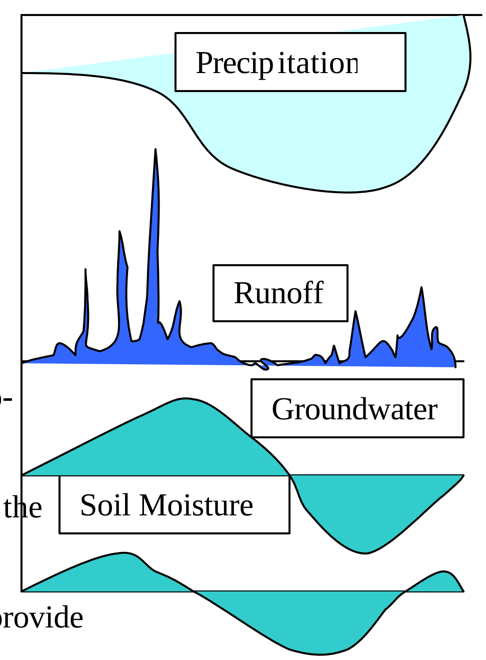
NATURAL WATER RESOURCES (long-term)

Under Natural Water Resources (NWR) in this investigation I mean the part of total water resources that changes yearly and monthly due to natural reason (global water cycle). The water balance equation gives the best description of NWR. Depending on time resolution the water balance equation has different components. Due to cyclic character of water regime (following by climate round year cycle), the year water balance has the simplest equation, because every year nature starts from the same point and returns to this approximately the same time.

Yearly estimation

The basic equation for yearly water balance is (unit measurement is million cub. m or mm):

$$P - R \pm dG \pm dSM = E$$



Where P - year precipitation
R - year runoff
dG – changing of ground water storage
dSM - changing of soil moisture storage
E - evapotranspiration

For long-term averages the components dG and dSM aspire to 0. And this equation has the following appearance:

$$P - R = E$$

Yearly water balances can be an excellent background for any ecological and economical analysis through years showing trends in each of these areas (analytical tool). Statistics of storms and stormwater are the excellent addition to this: how many storms in the average year, how big the average storm, how big are storms of different probabilities, how much water can be collected from each roof, how much as minimum should be to avoid erosion, to provide recharge into groundwater, etc. This is already management…

The monthly water balance is an operative tool on routine base.

Monthly estimation

The common full equation for monthly water balance can be expressed as following:

$$P - R \pm dS \pm dW \pm dC \pm dU \pm dG \pm dSM = E$$

Where

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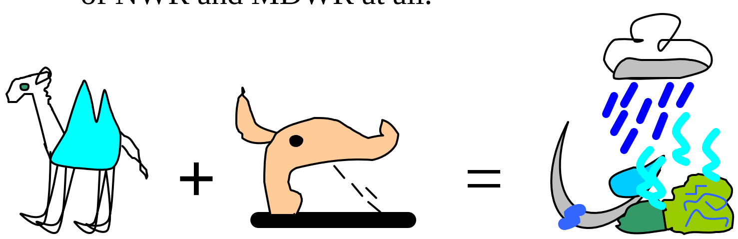
dS – changing of water storage in snow cover
dW - changing of water storage in lakes, ponds, reservoirs and swamps
dC - changing of water storage in glaciers
dU - changing of water storage in underground waters

Choosing of equation for calculation depends on the real situation (land and water use), conditions (climate and geology) and the available data and money (Isn't a water balance wonderful?).
For my investigation I used the components that have more or less even distribution within watershed (not sporadical):

$$P - R \pm dG \pm dSM = E$$

MAN DEVELOPED WATER RESOURCES (MDWR)

Under the Man Developed Water Resources (MDWR) I mean that part of total water resources, which is temporarily allocated into man developed systems. Total water resources are not equal the simple sum of NWR and MDWR at all.



Depending on goal of investigation the MDWR can be presented as the followings:

1. **Total amount of MDWR on watershed**

(to see how much water has totally been managed for examined period. Municipalities, Conservation Authorities and corresponding departments of Natural Resources should be interested in this information on routine base).

1. Virgin area (MDWR = 0)
   - Meadows, woods, lakes, wetlands
2. Agricultural
   - Type, used land, amount of units, amount of people involved
   - Place, type and amount of water supplies
   - Sewage system, treatment, disposal
3. Residential Sector
   - Type, used land, amount of units, amount of people involved
   - Place, type and amount of water supplies
   - Sewage system, treatment, disposal
4. Office/Commercial

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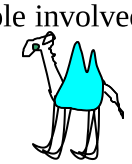
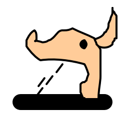
- Type, used land, amount of units, amount of people involved
- Place, type and amount of water supplies
- Sewage system, treatment, disposal

5. Industrial
   - Type, used land, amount of units, amount of people involved
   - Place, type and amount of water supplies
   - Sewage system, treatment, disposal
6. Government
   - Type, used land, amount of units, amount of people involved
   - Place, type and amount of water supplies
   - Sewage system, treatment, disposal

7. Recreational
   - Type, used land, amount of units, amount of people involved
   - Place, type and amount of water supplies
   - Sewage system, treatment, disposal
8. Sewage system (as a separate system)
9. Storm water systems (as a separate system)

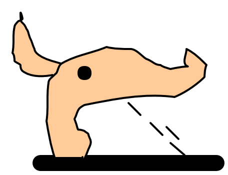




MDWR, due to their managerial origin, can be estimated precisly: they all go through pipes, tanks, vessels, water meters. The problem is just to present them in certain format and to organise "information delivering channel" on routine base (let say monthly).

2. **Interactive part of MDWR** (to know places and degree of interaction between natural and man developed water resources. This is interesting item for Conservation Authorities and a Ministry of Environment)

- sources of water supply
- sewage system (sludge disposal, water outputs)
- storm water system (including management practices)
- areas of land watering or water evaporating (agricultural, residential, industrial, recreational lawns and any type of artificial pond or reservoir).



This part is not so definite, but it can be estimated eventually and iteratevely, i.e. after several approaches.

Examined period of estimation for MDWR is very important, because the main arguments for them are population, land and water use, and technology.

Types of result presentation

Presentation of results depends on goals and users. They are followings:

1. For right and left bank of each plot along river (creek) length (to identify location of source. In case of source of pollution or contamination, **to transform a non-pointed source into pointed one**)
2. Accumulated amount within boarder of each city (to identify degree of event within municipality)
3. Accumulated amount within whole watershed (to identify degree of total impact on Lake Ontario)

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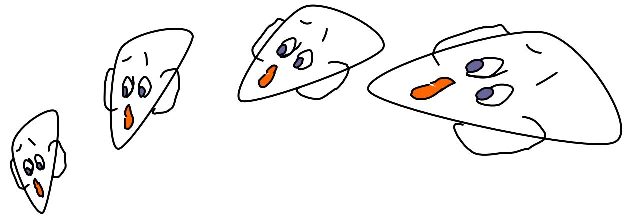
How to start?



To estimate changing of any parameter along river length, Etobicoke Creek (main course) was arbitrarily divided into numerous of plots in such way that each city or county has several of them, to see changing within a city (Table 1). There are 34 defined plots on Etobicoke Creek in our case. I should say that I conducted this division using my previous experience: I was oriented on tributaries. But here, in Canada, there is much better to do it orienting on roads due to their very rhythmical network.
Next step is estimation of

DRAINAGE BASIN CONDITION

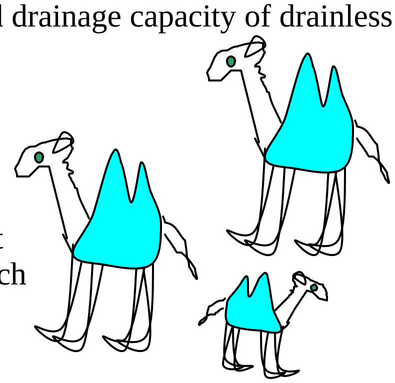
for each river plot. I didn't have other information than in State Report. So all my estimations and calculations, based on maps from this report, are pretty approximate from professional point of view. But it is the excellent illustrative material.

Hydrography
Dividing into subcatchments

For each plot the subcatchment area was estimated using the map 5 from State Report as well as drainless and drainage areas of each side of the creek. (Fig 1.)
Caledon has 12 subcatchments (it was not necessary, but I kept it as it was from the beginning), Brampton has 8, Mississauga 9 and Etobicoke – 5. Fig. 2-4 show all three forms of result presentation of such division.

Topography
There isn't topographical map in State Report, so slopes of plots and catchments were not obtained (they are needed to obtain hydrophysical characteristics of deposits and drainage capacity of drainless and drainage areas of each subcatchment and whole watershed).

Geology
For estimation of geological features of each subcatchment, maps 7 (Overburden Aquifers) and 8 (Surficial Geology) from State Report were used. Deposits, taken into account, are following: till moraine, silt clay, silt sand, fine sand, medium/coarse sand, gravel. Percentage of each deposit was obtained for every single subcatchment (Fig. 5) as well as occupied areas along creek length (Fig. 6). Both charts show specific area on the left bank (plots 11 – 17 and 30) – Brampton Esker.



This is the kind of moraine that needs very special attention and treatment. This is a huge underground reservoir, which needs to be protected as a water storage.

Hydrophysics
A specific yield for each deposit was taken according to Reference book for hydrogeologist, 1987.

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They are (%): till moraine – 10, silt clay – 1.1, silt sand – 3.5, fine sand - 12, medium/coarse sand - 23, gravel – 30. Based on fig. 6 and this information it is very easy to estimate how much water releases from drainage basin if water table decreases on 1 m (fig. 7). Comparing with fig. 6 it is possible to see clear how much more water gives Brampton Esker than any other deposit.

Physiography
Under this term I put all kinds of surface on watershed: open, wood, road, roofs, lawns, etc. Of cause, the first approach to such kind of assessment should be virgin, industrial, residential, agricultural, etc. Using tourist maps by MapArt Publishing Corporation some estimations were conducted for Etobicoke watershed (see fig. 8).

Storm water system
This is the alternative to hydrography and should be taken into account when subcatchment areas are determined. So, it is left useless in this investigation.

YEAR WATER BALANCE

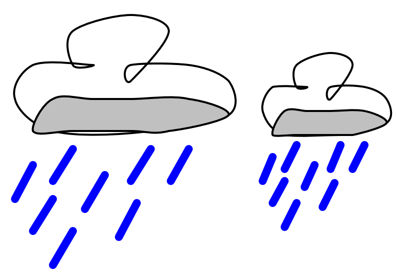
Year water balance, as I mentioned before, very good analytical and planning tool. Comparison of year runoff with water consumption through years gives the picture of changing of sources for municipal water in space and time (groundwater, underground water, river, reservoir, lake etc.), changing of technologies, ecological and economical problems and water prices.

P – R = E

Where P - year precipitation
R - year runoff
E - evapotranspiration

For long-term year water balance, changing of groundwater and soil moisture storage is accepted to be equal to 0. And this is very determine point to start water quantity estimations.

Precipitation



Distribution of precipitation within watershed was obtained using data of only two available stations with long-term estimations, one of which is not representative for this watershed (Toronto Island). But in this case the approximate value is enough, because real or more exact numbers can be obtained later (in real estimations).
So, what gives us knowledge of amount of precipitation along creek length?
Water and snow are excellent adsorbent, solvent and transport for pollution from the air to soil.

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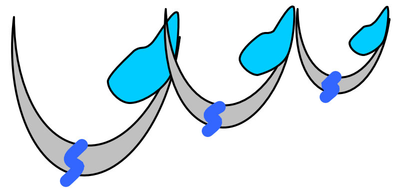
Used data: Toronto Island and Pearson Airport
(Climate Norms 1961-90 from Environment Canada)

For this case spatial distribution of precipitation along river length was estimated as the linear interpolation between two mentioned station with further extrapolation upstream with the same proportions.

Runoff



To estimate river flow distribution along river length the real observation data were used. Hydrometrical station Etobicoke I (1967-1997) – 204 km^2 and Etobicoke II (1966-93) – 62.3 km^2. Daily data were transformed into year long-term averages. Then interpolation between station's modules (l/s·km^2) were made (fig. 9). Runoff module is used in the former Soviet Hydrological School. Runoff module (module) is amount of water (in litres) from 1 sq. km of drainage area per second. Normally, the year module (long-term estimations) does not depend on drainage area (Bogoslovsky and all, 1984) nor has very slight clinging toward downstream (for medium and big watersheds). Our case has opposite ratio, and it is characterised high drainage capacity of the watershed.
Using `Usable storage – Outflow Method` `(Water Resources Fluctuation)` © the long-term year module for outflow from the Heart Lake was obtained – 7.5 l/s km2 (for Etobicoke 2 – 9.9 l/s km2, Etobicoke 1 – 11.1 l/s km2).

To extrapolate runoff volume upstream to the creek beginning, the same ratio was used as interpolated.

Evapotranspiration

Evapotranspiration was obtained as a residual of precipitation after subtraction the runoff volume. Nobody needs evapotranspiration itself (except scientists). But this is a key point for the analysis and comparison of adjoined areas, watersheds, basins with lack of hydrological information or different degrees of economical and demographical development.

Table 2 is the illustration of obtained result as well as used methods. Fig. 10 shows changing of ratio between runoff and evapotranspiration along river length.
And this should be explained, because the evapotranspiration of upper part of watershed includes amount of infiltrated water, which recharges the deeper groundwater. The downstream runoff includes the same amount, which is inclined from this water into the creek.
It means that if you estimate water balance along river length, you should take into account ground water influence even for long-term year estimations, because it affects the change of the "runoff-evapotranspiration" ratio along river length signiphicantly. But in this particular case I didn't take it into account, just mentioned about that

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(not only this!).

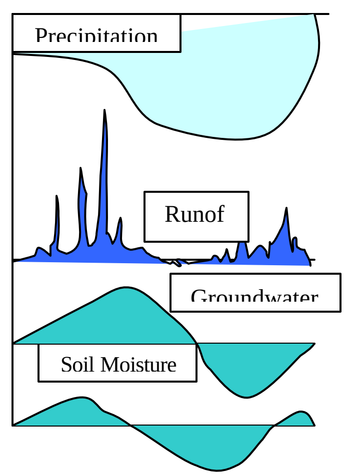
Take it easy!

Finally, we have got the water balance for each plot, each city and whole watershed (see table 2).

City	Precipitation	Runoff	Evapotranspiration
Caledon	771 mm	293 mm	478 mm
Brampton	772 mm	310 mm	462 mm
Mississauga	773 mm	325 mm	448 mm
Etobicoke	774 mm	337 mm	437 mm

Monthly water balance

If for year long-term estimations we accept that ground water and soil moisture changing from season to season, from month to month return to the initial point, and finally can be taken into account as 0, for monthly long-term definitions we should know ground water table fluctuation around the year. As well as soil moisture variations. So, the simplified monthly water balance equation for long-term estimation looks as following:



$P - R \pm dG \pm dSM = E$

Where P – precipitation
R – river runoff
dG – changing of ground water storage
dSM - changing of soil moisture storage
E - evapotranspiration

Precipitation

Monthly precipitation were estimated the same way as year's one.
So long-term monthly precipitation is presented in table.3
And again, if you add some storm water statistics for each subcatchment in each month: volume of water from roof of 100 m2 for storms of different probabilities and how often in can happened, or duration and frequency of droughts (for lawn watering), - this is already some management.

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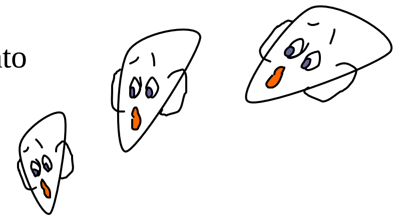
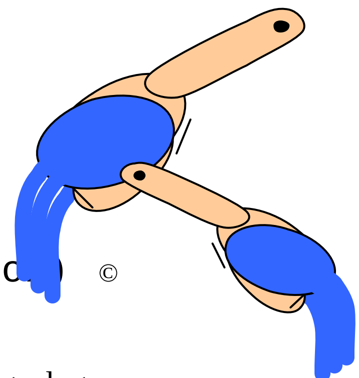
Runoff

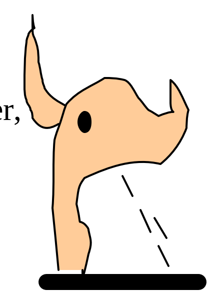


Daily discharges for Etobicoke 1 and Etobicoke 2 stations were converted into real time monthly averages and then again into the averages of monthly averages (long-term monthly averages). The distribution of the module along creek length was estimated for each month (see fig. 9). And this is very interesting correlation between two available stations. For months with low runoff the module of upper station is lower than down one. And this is character for high infiltration capacity of underlying deposits. Correlation for spring months is opposite, which characterises fullness of drainage basin and some kind of impermeability for additional precipitation. And this is very likely for watersheds with low infiltration capacity as well (silt clay, clay, silt sand, impermeable bedrock).

Changing of ground water storage



I didn't have any data about even depth to water table. But Robert Klimas told me that they don't care about ground water because it lower that 3 m below earth surface. It is a clue and very important one: the estimation of water table altitude can be done using `Usable storage – Outflow Method` `(Water Resources Fluctuatio)` © developed by author and described in Report on Beverly Swamp. The Method describes the relation between lake hydrological and hydrogeological regimes depending on its relative size and surrounding geology. According to this method the water table amplitude (long-term) in the creek mouth (Lake Ontario) is 0,4 m. Heart Lake is the point for headwater area. To assess its water table amplitude, it is necessary to know surrounding deposits (Brampton Esker, sand and gravel) and depth to ground water table (> 3 m, I took as 3,5 m). So, long-term year water table fluctuation for Heart Lake's area is approximately 0.7 m.



The next step is to estimate monthly distribution of water table fluctuation. There are three limitations for this: the first one is vertical – long-term amplitude, the second one is horizontal – it should start and finish at the same point, and third one is different time shifts between Heart Lake and Ontario Lake due to difference between sizes and average latitudes. I took it very approximately is equal to 1 month.
So, I repeat the points taking into account for estimation of water table fluctuations for the Etobicoke mouth and Heart Lake areas:

- ☞ For Heart Lake area: amplitude 0.7 m, depth – 3.5 m, half of month later than runoff cycle.
- ☞ For the mouth: amplitude 0.4 m, depth – 3.5 m, time shift – one month later than for Heart Lake.

What was the next step? Interpolation and extrapolation along the creek length for right and left sides of the creek. Results? Look at fig. 12!

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Changing of soil moisture storage

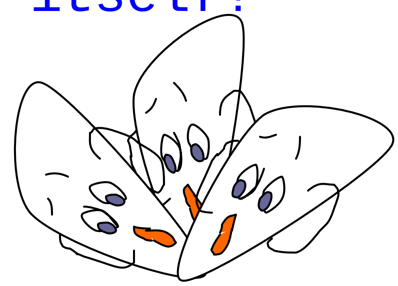
For estimation of this water balance component, we have already had some information obtained in last paragraph. It is the size of the unsaturated layer, its monthly fluctuations and hydrophysical features. But I don't have real water content and its spatial and temporal changing. So…

If you have real data – put it in!

If you have real data – put it in!

I have had some information of soil moisture deficit for Beverly Swamp… Yes, it is absolutely different microclimate… especially the water table depth that affects soil moisture very much. The average depth of water table in Beverly Swamp is 0.3 m, but deposits are the same – moraines, different kinds, and big assortment! And what?

Very often, the way of getting result is much more important than result itself!



So… I guess that as a very rough prototype it can be used, at list its changing from month to month.
May be it is not very good … (see fig. 13) but it is good enough to finish!

Evapotranspiration

If you do not forget, the evapotranspiration I estimated as the residual of all above.
I have got the Monthly Water Balance of Etobicoke Creek.
All components are given in mm.

Component	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Precipitation	45	43	57	64	66	69	77	85	74	62	68	63	773
Runoff	17	27	70	48	21	14	15	19	21	17	27	31	327
G/w storage Changing	5	-17	-14	8	12	14	14	12	5	-5	-15	-19	0
S/m storage Changing	-10	-15	-20	-30	35	30	25	5	5	-5	-10	-10	0
Evapotrans.	22	-15	-48	-3	90	98	103	81	63	36	16	3	446

I have got components' distribution along the creek length!

You can see it with me (fig.14). Wait a minute!…
"You have too much minuses!… It means condensation?!"
Yes, I agree that result itself is not very good. But I didn't

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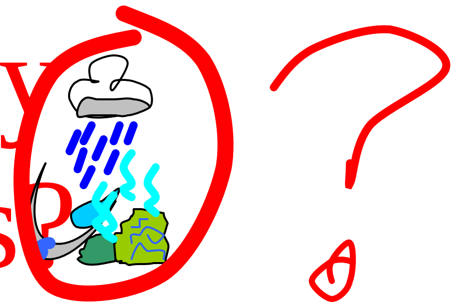
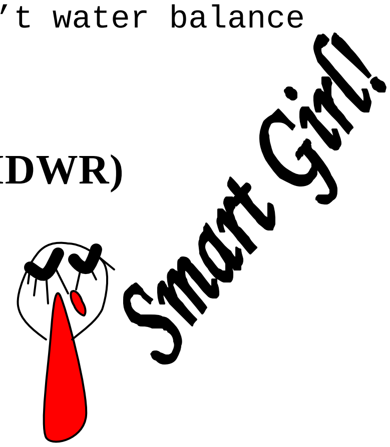
take into account snow cover, reservoirs and ponds, lakes, etc.

But who can say how wrong it is?



What are the criteria of the truth? Only the real data are. This is a statement number one. And the second one: I am not finished jet with water balance… `Isn’t water balance wonderful?`



MAN DEVELOPED WATER RESOURCES (MDWR)

… Not everything…just

Interactive part of MDWR

… Not everything, again… just some examples…

Because of water balance structure. Practically all used water for Brampton, Mississauga and Etobicoke comes from the Lake Ontario … and sewage water goes back to the Lake Ontario (Robert Klimas). Caledon has the separated system. It means that most of used water doesn’t participate in water balance of the Etobicoke watershed - just interactive part does.

Some examples for water consumption are: water consumption (use) in residential area, water consumption by schools, golf clubs, fitness clubs, swimming pools and restaurants (from each kind of human activity).
I’ve got the number of each of these species for each subcatchment from mentioned already MapArt maps and Yellow Pages (Fig. 15). This information, especially concerning restaurants, is very rough. But any municipality has complete information about every single customer in area of its responsibility and how much water it takes. I’ve just estimated it very-very roughly (fig. 16).

For water consumption in residential area I estimated distribution of population according to occupied area by residential sector. But it is not right for each subcatchment because buildings in each area are very different and population is distributed different way as well. Still, total information may be very close to reality (fig. 17 and table 4).

The interactive part of this estimation is presented by lawn watering item. It is a little bit overestimated (I took 1l per 1sq.m of lawn per dry day). But still it is pretty interesting information. If you add golf club lawns, industrial and government lawns, it will be may be much more than 2.5 mln.m3/year. And

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these places are sources of water contamination – pesticides, fertilities. And you know when they are treated.

So, I hope it was not very boring.

So, you can plan monitoring network using water balance estimations (placing and timing), WRIM particularly. Municipalities and Natural Resources for planning and developing, Environment – for effective protection (this knowledge gives the material for norms and regulations establishing and improving).

Isn't Water balance wonderful?!

Rimma Vedom, Report

#419, Sherobee Rd., Miss ON L5A 3P8 Phone, fax: (905) 306 9782

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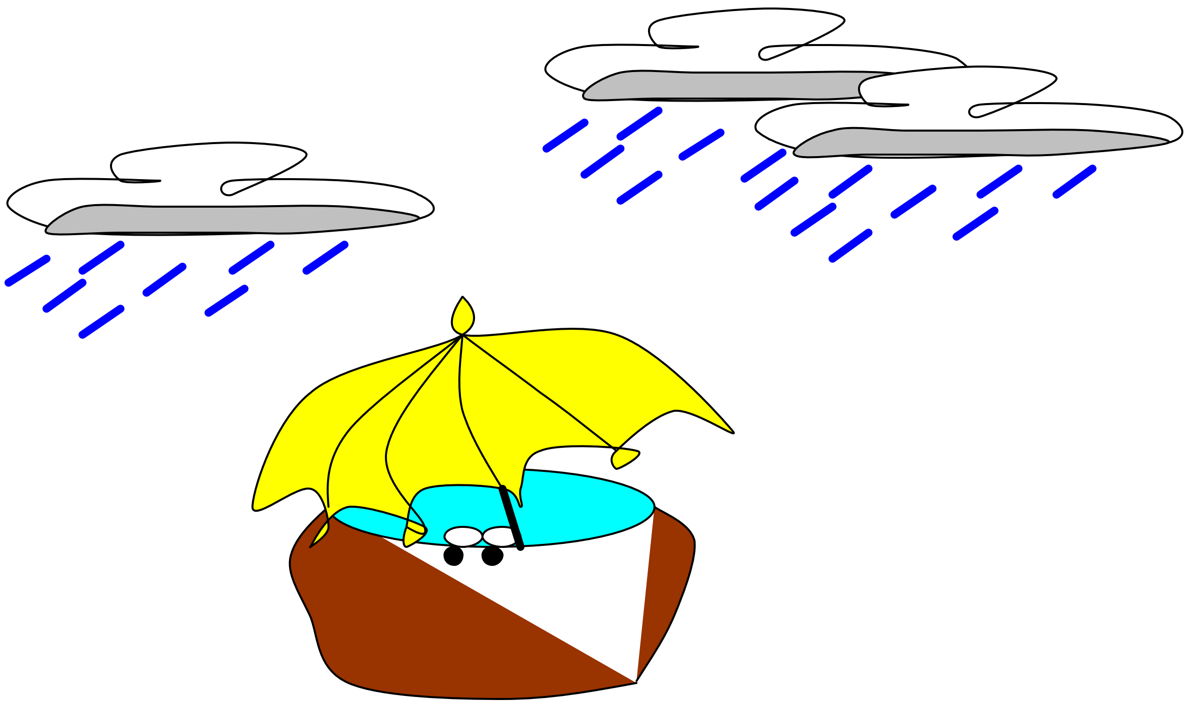

Rimma Vedom, Report

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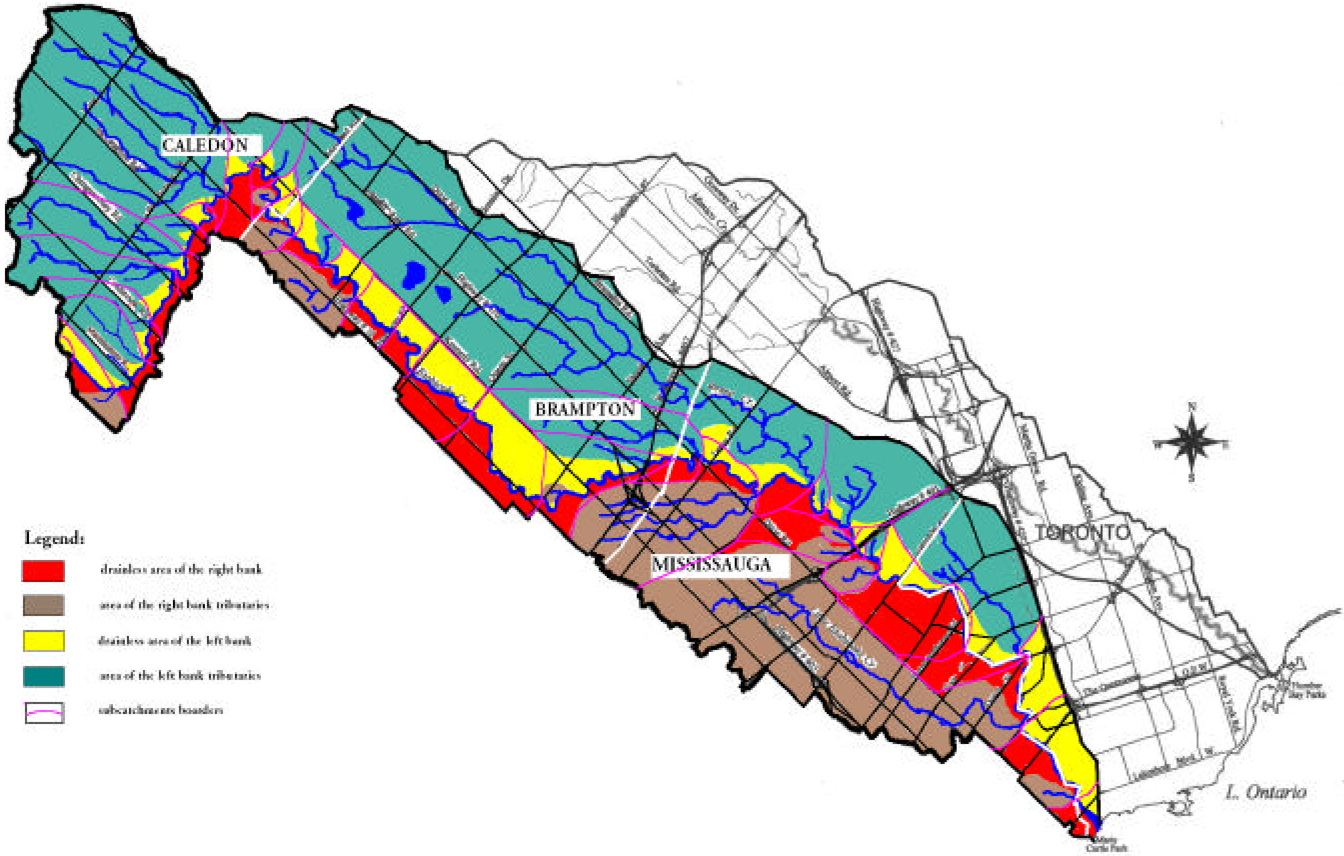
Plots boarders

City	Plot number	Etobicoke Cr. plots boarders		
		Upstream	Downstream	
		km from mouth		*in term of addresses*
Caledon	1	w/s boarder	61	Heritage Rd.
	2	61	59.2	Mississauga Rd.
	3	59.2	57.8	Creditview Rd.
	4	57.8	56.2	
	5	56.2	54	Chinquacousy Rd.
	6	54	52.9	McLaughlin Rd.
	7	52.9	51.7	
	8	51.7	50.7	
	9	50.7	49.6	Hurontario St.
	10	49.6	48	Royal Valley Dr.(NE corn.)
	11	48	47.1	Royal Valley Dr.(SE corn.)
	12	47.1	45.5	Mayfield Rd.
Subtotal:	1-12	15.5	15.5	w/boarder - Mayfield Rd.
Brampton	13	45.5	45	cont. Mc Arthur Hts.
	14	45	43.2	cont. Dawnridge Tr.
	15	43.2	41.1	NW corner of Camden Park
	16	41.1	39.1	Bovaird Dr.
	17	39.1	36.6	Williams Pkwy
	18	36.6	34.1	Queen st.E
	19	34.1	30.1	Steels Ave.E
	20	30.1	24.7	Hwy 407
Subtotal:	13-20	20.8	20.8	Mayfield Rd. - Hwy 407
	1-20	36.3	36.3	w/boarder - Hwy 407
Mississauga	21	24.7	23.7	Dixie Rd.
	22	23.7	21.4	NW corner of Greenbelt
	23	21.4	19.3	Spring Cr. mouth
	24	19.3	18	meander between Brit.&Shawson
	25	18	17.1	Luke Rd. S end
	26	17.1	16.6	Hwy 401, S side
	27	16.6	16.2	Right unnamed Trib.
	28	16.2	15.6	Matheson Rd.
	29	15.6	14.4	Eglinton Ave.
Subtotal:	21-29	10.3	10.3	Hwy 407 - Eglinton Ave.
	1-29	46.6	46.6	w/boarder - Eglinton Ave.
Etobicoke	30	14.4	10.4	S boarder of Markland Wod Golf
	31	10.4	8.2	S boarder of Nelson Park
	32	8.2	4.9	Qweensway E
	33	4.9	1.4	S boarder of Toronto Golf Club
	34	1.4	lake w/front	L.Ontario waterfront
Subtotal:	30-34	14.4	14.4	Eglinton Ave. - L.Ontario w/f
Total:	1-34	61	61	w/boarder - L.Ontario w/f



Etobicoke Creek watershed

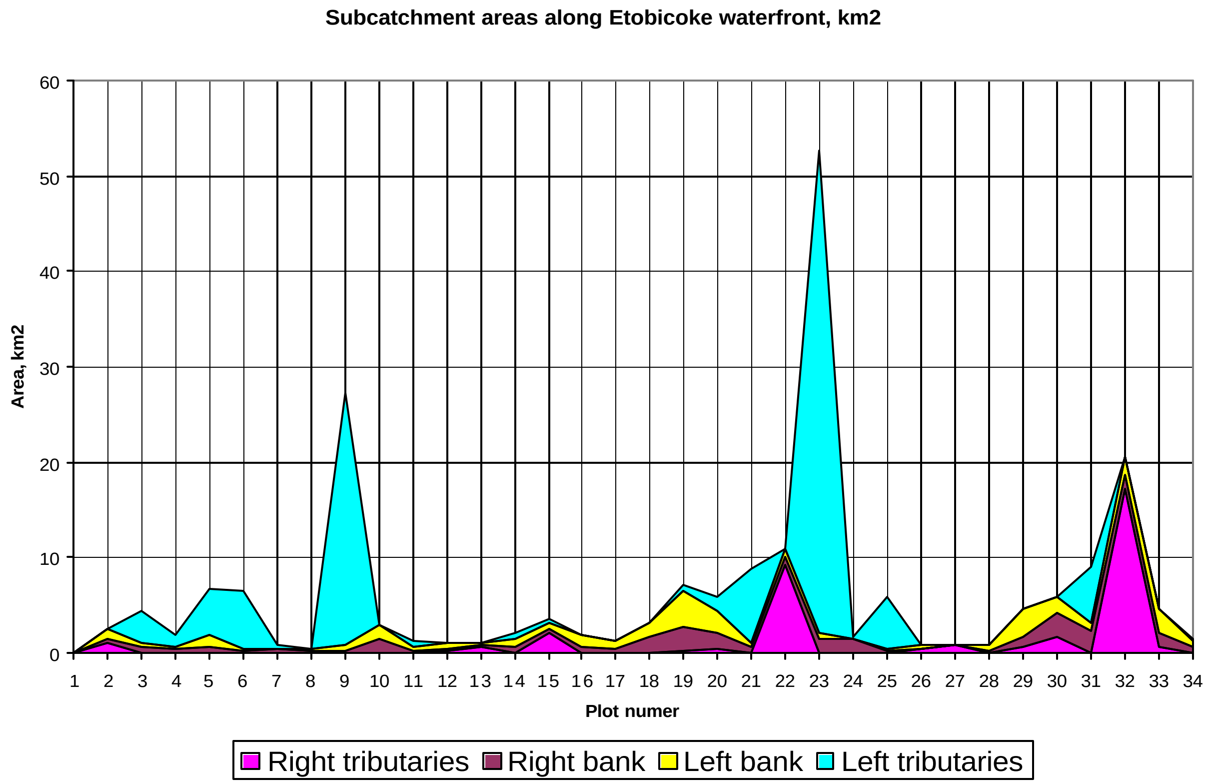


Fig.2. Watershed division into 34 subcatchments

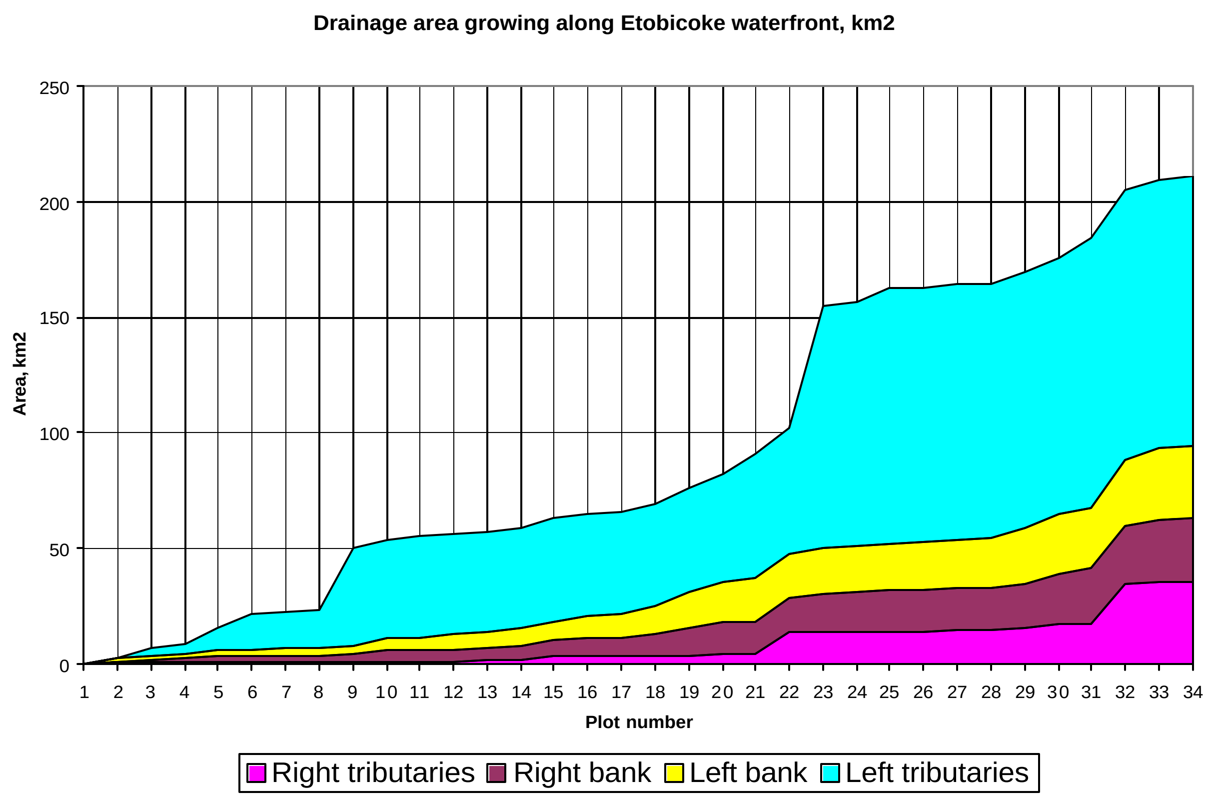


Fig. 3. Watershed area accumulation along Etobicoke Creek

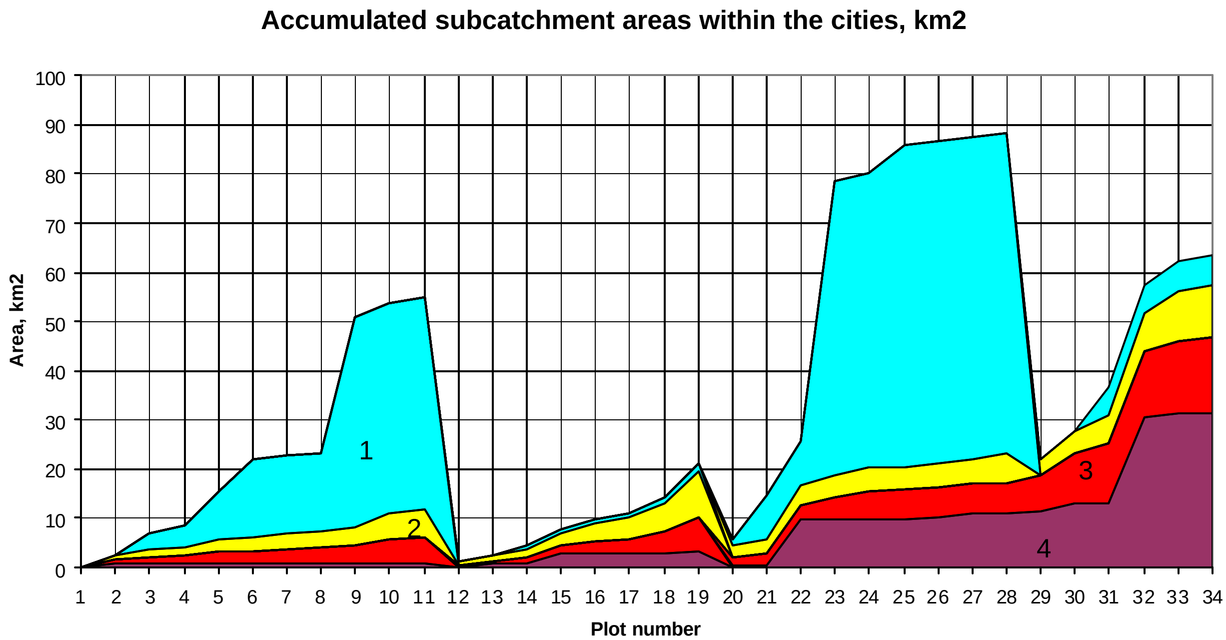


Fig. 4. Watershed area accumulated within cities: 1:12 – Caledon; 13:20 – Brampton; 21:28 of the left side and 21:34 of right side – Mississauga; 30:34 at left side – Etobicoke (GTA).

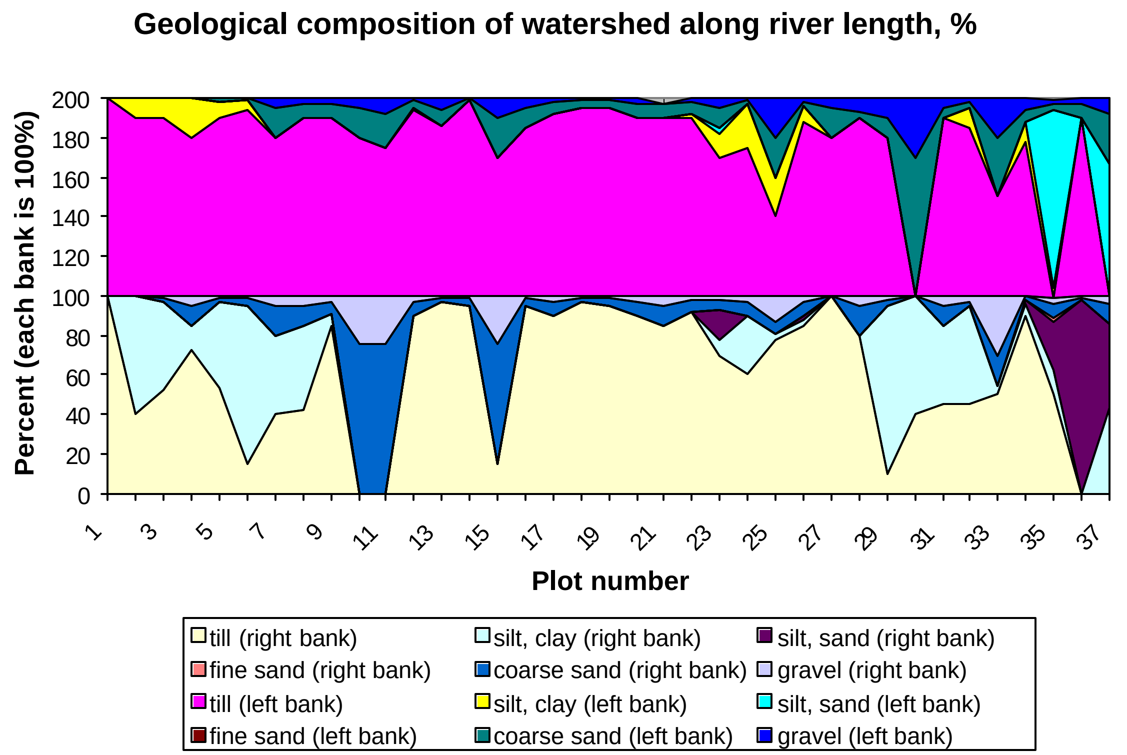


Fig. 5. Geological composition of watershed (right and left sides: 100 + 100%)

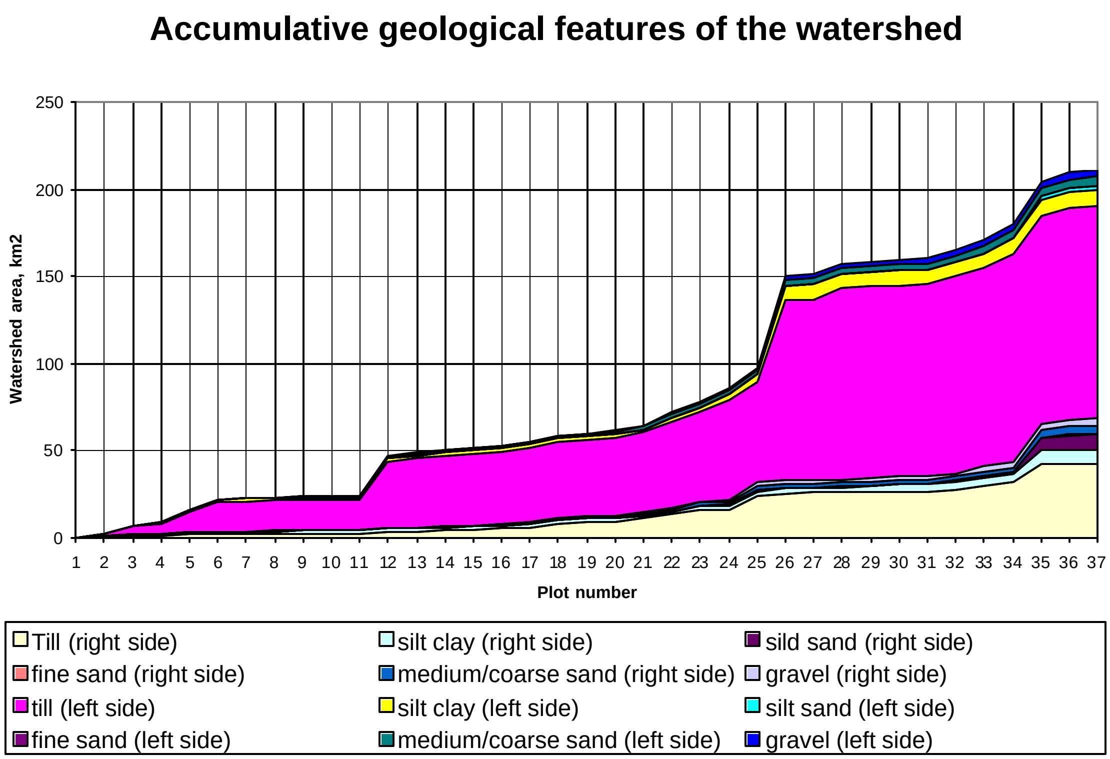


Fig. 6. Accumulative geological features of the watershed (km^2).

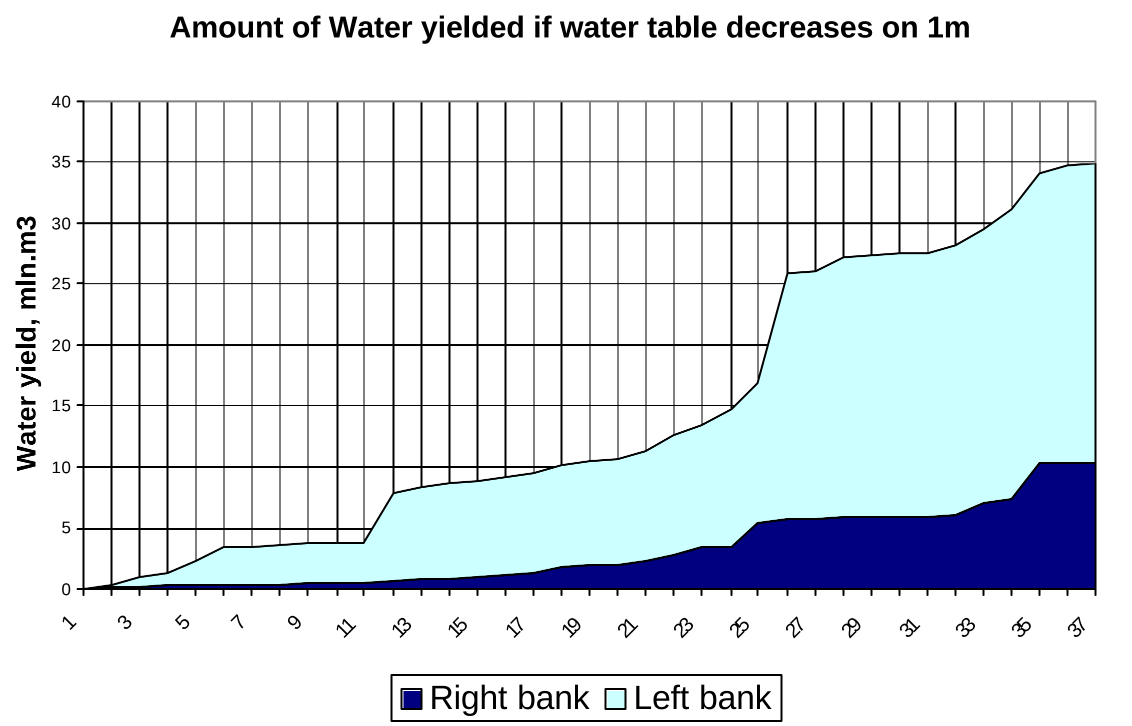


Fig. 7. Amount of water (groundwater discharge) yielded if water table decreases on 1 m.

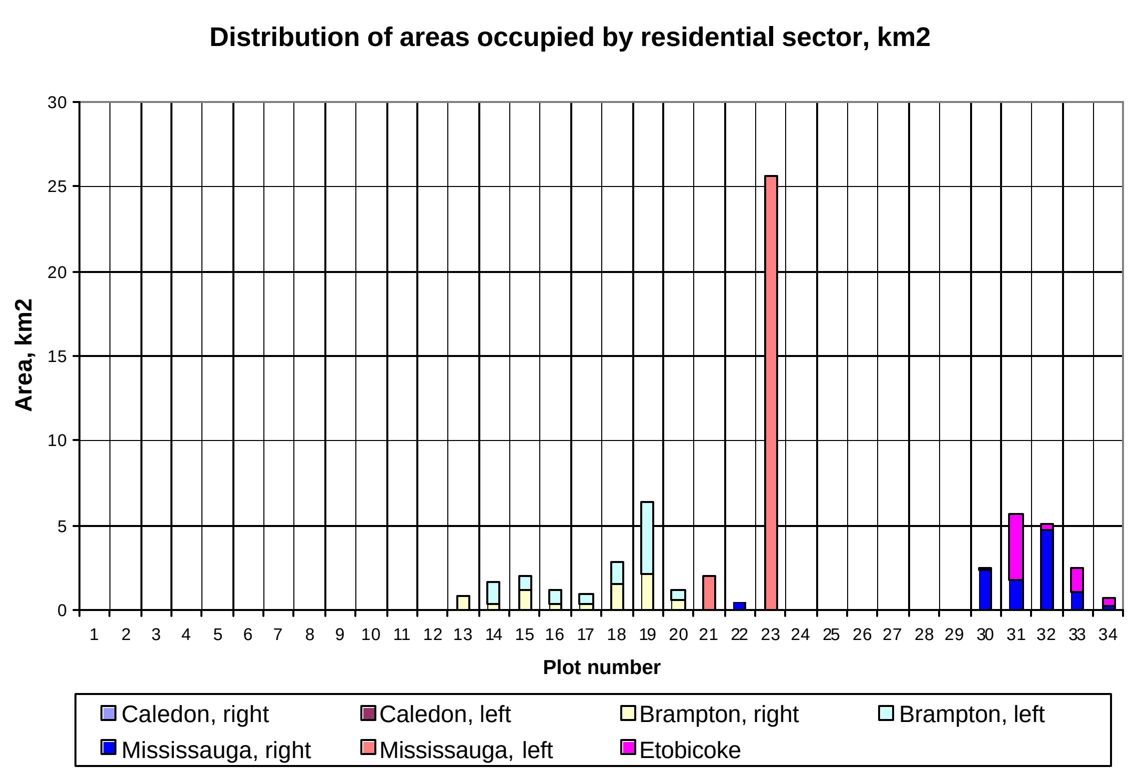


Fig. 8. Distribution of residential sector areas along Etobicoke watershed

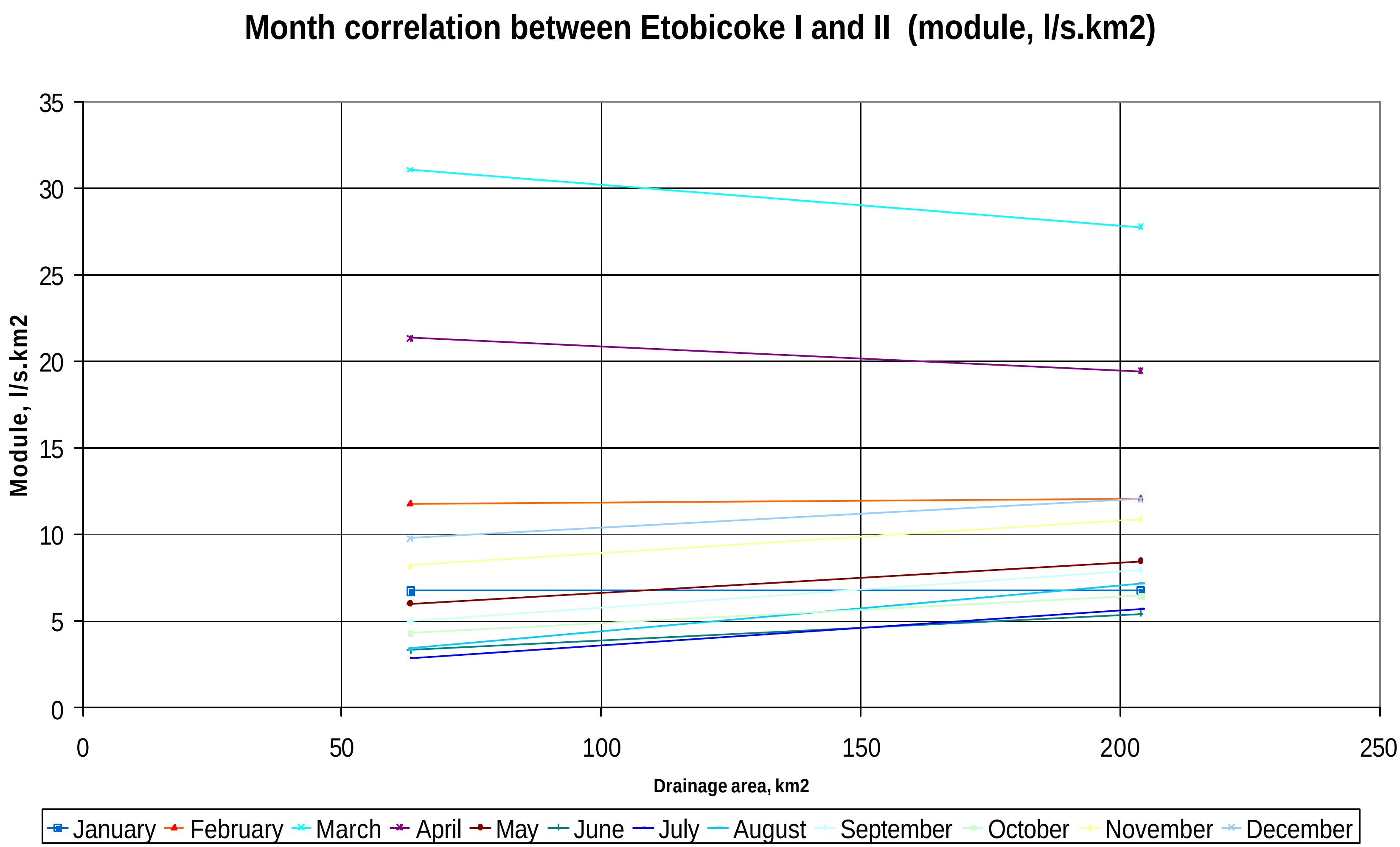


Fig. 9. Monthly correlation between specific flow at Etobicoke 1 and 2

Prepared by R. Vedom

Table 2. Year water balance along Etobicoke Ck.

City	Plot number	Precipitation ml.m3 Right side	Precipitation ml.m3 Left side	Runoff ml.m3 Right side	Runoff ml.m3 Left side	Evapotranspiration ml.m3 Right side	Evapotranspiration ml.m3 Left side	Water balance in mm Precipitation	Water balance in mm Runoff	Water balance in mm Evapotranspiration
Caledon	1	0.03	0.03	0.008	0.008	0.001	0.001	914	283	631
	2	1.28	0.91	0.398	0.285	0.88	0.629	913	285	629
	3	0.55	3.46	0.172	1.088	0.375	2.373	911	286	624
	4	0.36	1.27	0.115	0.403	0.248	0.869	909	288	621
	5	0.63	5.52	0.203	1.768	0.431	3.756	906	290	616
	6	0.27	5.59	0.087	1.808	0.183	3.779	901	292	609
	7	0.31	0.42	0.103	0.138	0.212	0.284	899	293	605
	8	0.22	0.23	0.074	0.077	0.151	0.157	898	295	603
	9	0.23	24.08	0.077	8.047	0.154	16.03	888	297	592
	10	1.32	1.32	0.448	0.448	0.869	0.869	878	299	579
	11	0.24	0.96	0.081	0.331	0.156	0.634	877	300	576
	12	0.35	0.61	0.121	0.212	0.229	0.401	876	302	573
Subtotal:	1-12	5.794	44.413	1.888	14.61	3.888	29.78	897	293	605
Brampton	13	0.80	0.18	0.28	0.064	0.525	0.12	875	304	571
	14	0.52	1.31	0.183	0.459	0.341	0.852	874	306	568
	15	2.18	0.87	0.769	0.308	1.411	0.564	872	308	564
	16	0.65	1.04	0.232	0.371	0.421	0.673	870	309	561
	17	0.43	0.61	0.156	0.218	0.279	0.39	869	311	558
	18	1.39	1.30	0.5	0.469	0.887	0.832	867	313	555
	19	2.33	3.89	0.849	1.416	1.483	2.472	864	315	549
	20	1.72	3.27	0.633	1.202	1.086	2.064	859	316	543
Subtotal:	13-20	10.035	12.472	3.602	4.506	6.433	7.967	869	310	559
	1-20	15.829	56.886	5.49	19.12	10.32	37.75	886	300	586

Prepared by R. Vedom.

Table 2. Year water balance along Etobicoke Ck.

Mississauga		21	0.56	7.01	0.207	2.608	0.349	4.397	854	318	536
right bank		22	8.47	0.85	3.199	0.32	5.276	0.528	847	320	528
21-34		23	1.24	42.35	0.482	16.5	0.756	25.85	825	322	504
		24	1.13	0.24	0.453	0.097	0.677	0.145	807	323	483
		25	0.16	4.54	0.065	1.837	0.096	2.706	804	325	479
		26	0.40	0.24	0.163	0.098	0.237	0.142	802	327	475
		27	0.64	0.01	0.263	0.003	0.378	0.005	801	329	473
		28	0.16	0.52	0.066	0.215	0.094	0.306	801	330	470
		29	1.28	2.48	0.532	1.03	0.746	1.446	799	332	467
Subtotal:	21-29		14.038	58.229	5.429	22.71	8.609	35.52	816	325	490
	1-29		29.867	115.12	10.92	41.83	18.93	73.27	864	308	557
Etobicoke		30	3.34	0.53	1.403	0.534	1.937	-0	795	334	461
left bank		31	3.32	5.29	0.772	2.249	2.546	3.044	790	336	454
30-34		32	1.79	1.60	6.277	0.692	-4.48	0.907	780	337	442
		33	14.34	2.00	0.709	0.882	13.63	1.123	771	339	432
		34	1.61	0.54	0.239	0.239	1.368	0.3	769	341	428
Subtotal:	30-34*		24.399	9.9688	9.4	4.596	15	5.373	781	337	443
Total:	1-34		54.266	125.08	20.32	46.42	33.93	78.64	852	312	540

*Plots 30-34 on right bank belong to Mississauga

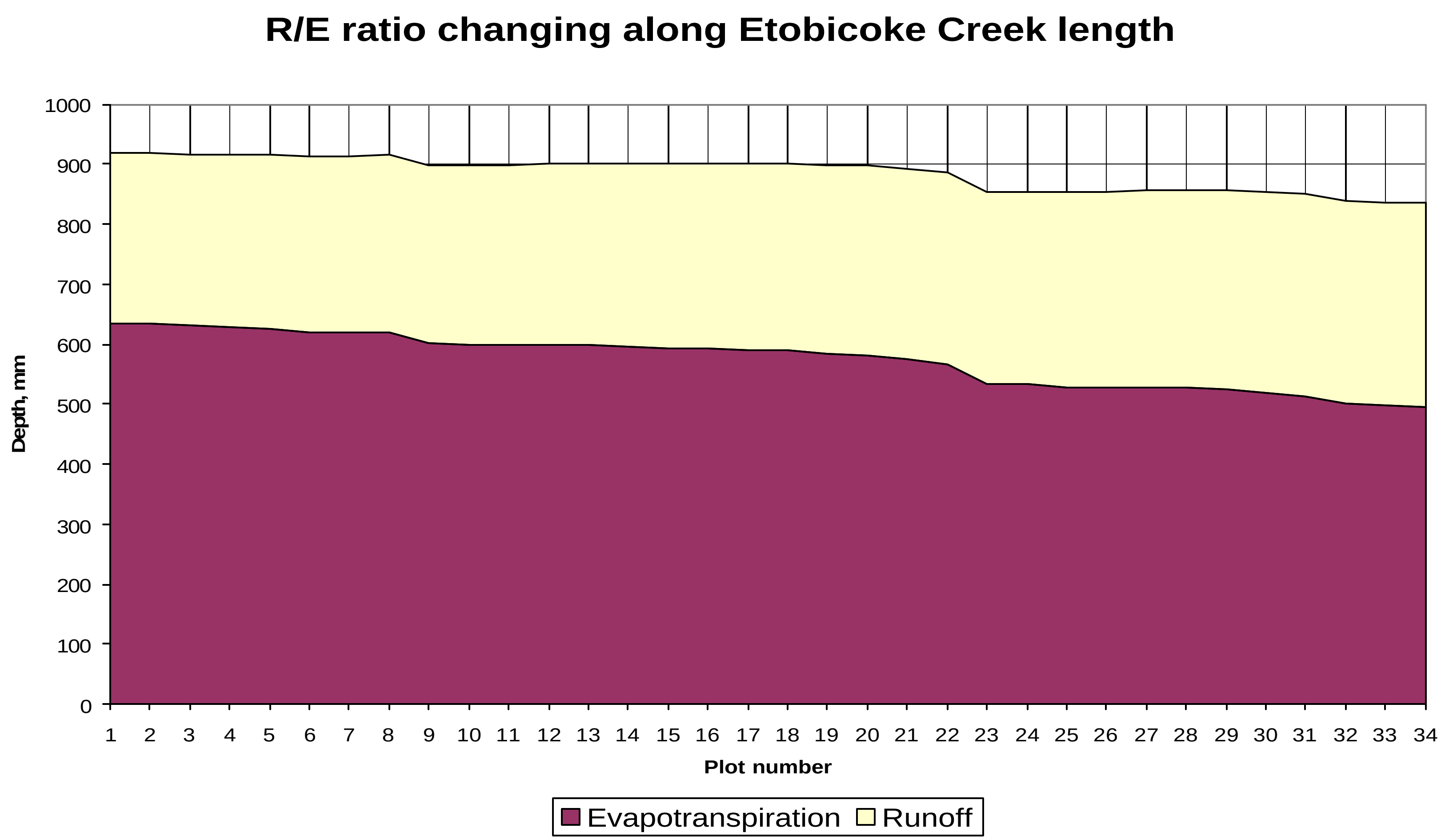


Fig. 10. Runoff/Evapotranspiration ratio changing along Etobicoke Creek

Table 3. Monthly distribution of precipitation along Etobicoke Creek

City	Plot number	Precipitation, mm Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Caledon	1	38.8	40.7	53.5	65.4	65	70	86.3	89.6	72.6	66	69.2	56.3
	2	39.1	41	53.7	65.4	65.1	69.9	85.8	89.3	72.7	65.8	69.3	56.8
	3	39.5	41.2	53.9	65.3	65.1	69.9	85.2	89	72.8	65.7	69.3	57.3
	4	39.9	41.5	54.1	65.2	65.2	69.8	84.7	88.7	72.9	65.5	69.4	57.8
	5	40.3	41.8	54.3	65.1	65.3	69.7	84.2	88.4	73	65.3	69.5	58.3
	6	40.7	42	54.5	65	65.3	69.7	83.6	88.1	73.1	65.2	69.5	58.8
	7	41	42.3	54.7	65	65.4	69.6	83.1	87.8	73.2	65	69.6	59.3
	8	41.4	42.6	54.8	64.9	65.4	69.6	82.5	87.5	73.2	64.8	69.6	59.9
	9	41.8	42.8	55	64.8	65.5	69.5	82	87.2	73.3	64.7	69.7	60.4
	10	42.2	43.1	55.2	64.7	65.5	69.4	81.5	86.9	73.4	64.5	69.8	60.9
	11	42.6	43.4	55.4	64.6	65.6	69.4	80.9	86.6	73.5	64.3	69.8	61.4
	12	42.9	43.6	55.6	64.6	65.6	69.3	80.4	86.4	73.6	64.2	69.9	61.9
Subtotal:	1-12	40.9	42.2	54.6	65	65.3	69.7	83.4	88	73.1	65.1	69.6	59.1
Brampton	13	43.3	43.9	55.8	64.5	65.7	69.3	79.8	86.1	73.7	64	69.9	62.4
	14	43.7	44.2	56	64.4	65.7	69.2	79.3	85.8	73.8	63.8	70	62.9
	15	44.1	44.4	56.2	64.3	65.8	69.1	78.8	85.5	73.9	63.7	70.1	63.4
	16	44.5	44.7	56.3	64.2	65.8	69.1	78.2	85.2	73.9	63.5	70.1	64
	17	44.8	45	56.5	64.2	65.9	69	77.7	84.9	74	63.3	70.2	64.5
	18	45.2	45.2	56.7	64.1	65.9	69	77.1	84.6	74.1	63.2	70.2	65
	19	45.6	45.5	56.9	64	66	68.9	76.6	84.3	74.2	63	70.3	65.5
	20	46	45.8	57.1	63.9	66.1	68.8	76.1	84	74.3	62.8	70.4	66
Subtotal:	13-20	44.7	44.8	56.4	64.2	65.9	69.1	78	85	74	63.4	70.2	64.2
	1-20	42.4	43.2	55.3	64.7	65.5	69.4	81.2	86.8	73.5	64.4	69.8	61.1
Mississauga	21	46.4	46	57.3	63.8	66.1	68.8	75.5	83.7	74.4	62.7	70.4	66.5
right bank	22	46.7	46.3	57.5	63.8	66.2	68.7	75	83.4	74.5	62.5	70.5	67
30-34	23	47.1	46.6	57.6	63.7	66.2	68.7	74.4	83.1	74.5	62.3	70.5	67.6
	24	47.5	46.8	57.8	63.6	66.3	68.6	73.9	82.8	74.6	62.2	70.6	68.1
	25	47.9	47.1	58	63.5	66.3	68.5	73.4	82.5	74.7	62	70.7	68.6
	26	48.3	47.4	58.2	63.4	66.4	68.5	72.8	82.2	74.8	61.8	70.7	69.1
	27	48.6	47.6	58.4	63.4	66.4	68.4	72.3	82	74.9	61.7	70.8	69.6
	28	49	47.9	58.6	63.3	66.5	68.4	71.7	81.7	75	61.5	70.8	70.1
	29	49.4	48.2	58.8	63.2	66.5	68.3	71.2	81.4	75.1	61.3	70.9	70.6
Subtotal:	21-29	47.9	47.1	58	63.5	66.3	68.5	73.4	82.5	74.7	62	70.7	68.6
	1-29	44.1	44.4	56.2	64.3	65.8	69.1	78.8	85.5	73.9	63.7	70.1	63.4
Etobicoke	30	49.8	48.4	59	63.1	66.6	68.2	70.7	81.1	75.2	61.2	71	71.1
left bank	31	50.2	48.7	59.1	63	66.6	68.2	70.1	80.8	75.2	61	71	71.7
30-34	32	50.5	49	59.3	63	66.7	68.1	69.6	80.5	75.3	60.8	71.1	72.2
	33	50.9	49.2	59.5	62.9	66.7	68.1	69	80.2	75.4	60.7	71.1	72.7
	34	51.3	49.5	59.7	62.8	66.8	68	68.5	79.9	75.5	60.5	71.2	73.2
Subtotal:	30-34*	50.5	49	59.3	63	66.7	68.1	69.6	80.5	75.3	60.8	71.1	72.2
Total:	1-34	44.9	45	56.6	64.1	65.9	69	77.5	84.8	74.1	63.3	70.2	64.6

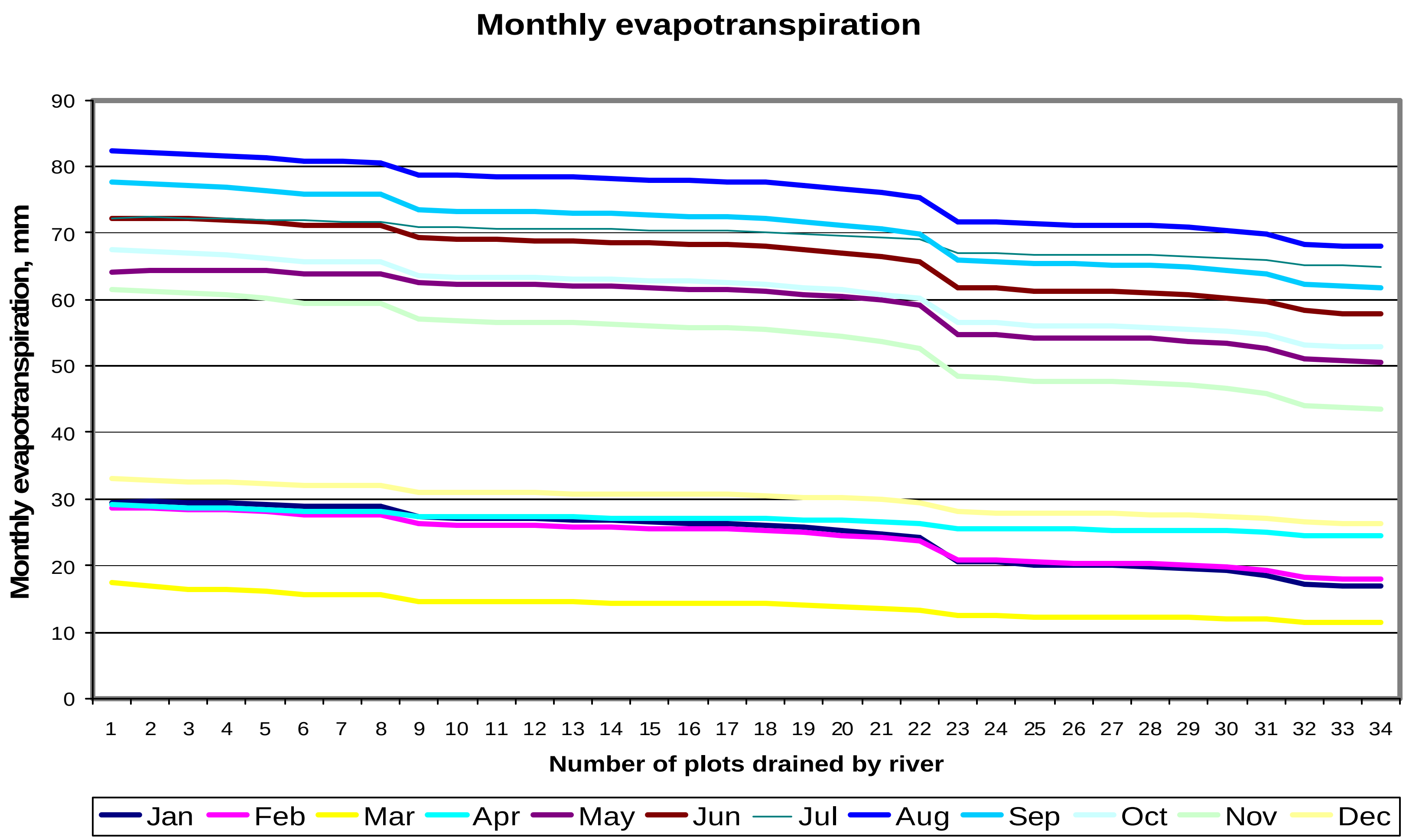


Fig. 14. Monthly evapotranspiration changing along Etobicoke watershed (this figure was obtained in 2001 by Equilibrium Water Balance Model application)

Prepared by R. Vedom

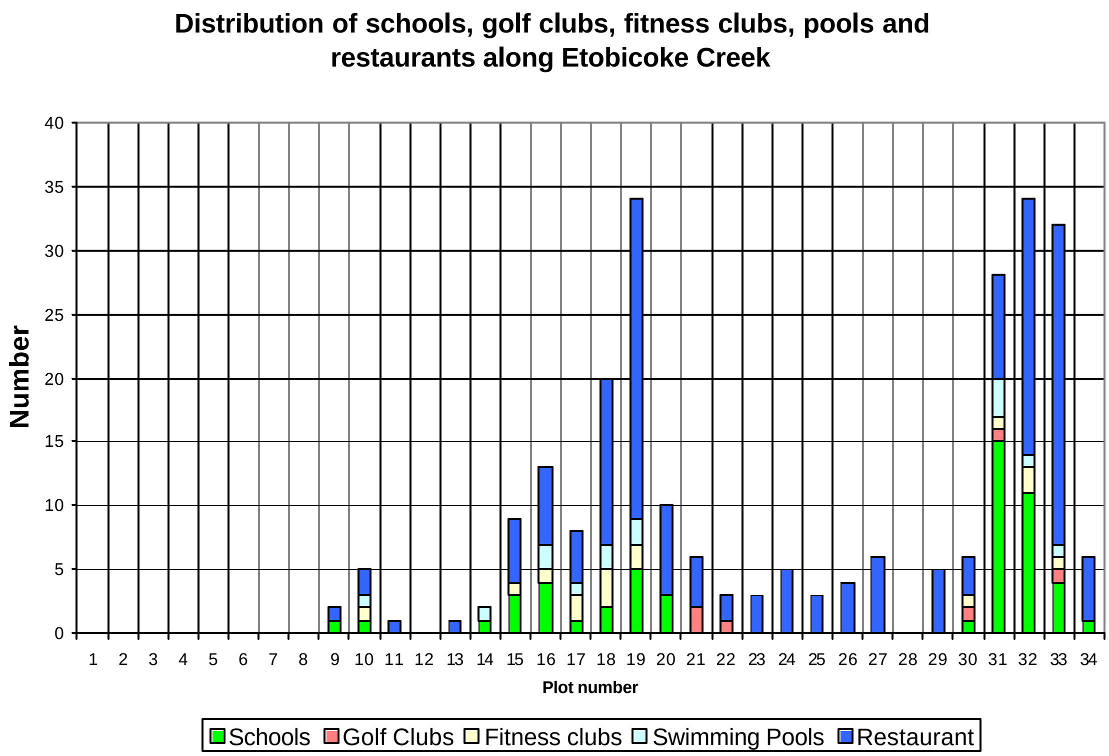


Fig. 15. Distribution of schools, golf clubs, fitness clubs, swimming pools and restaurants along the creek

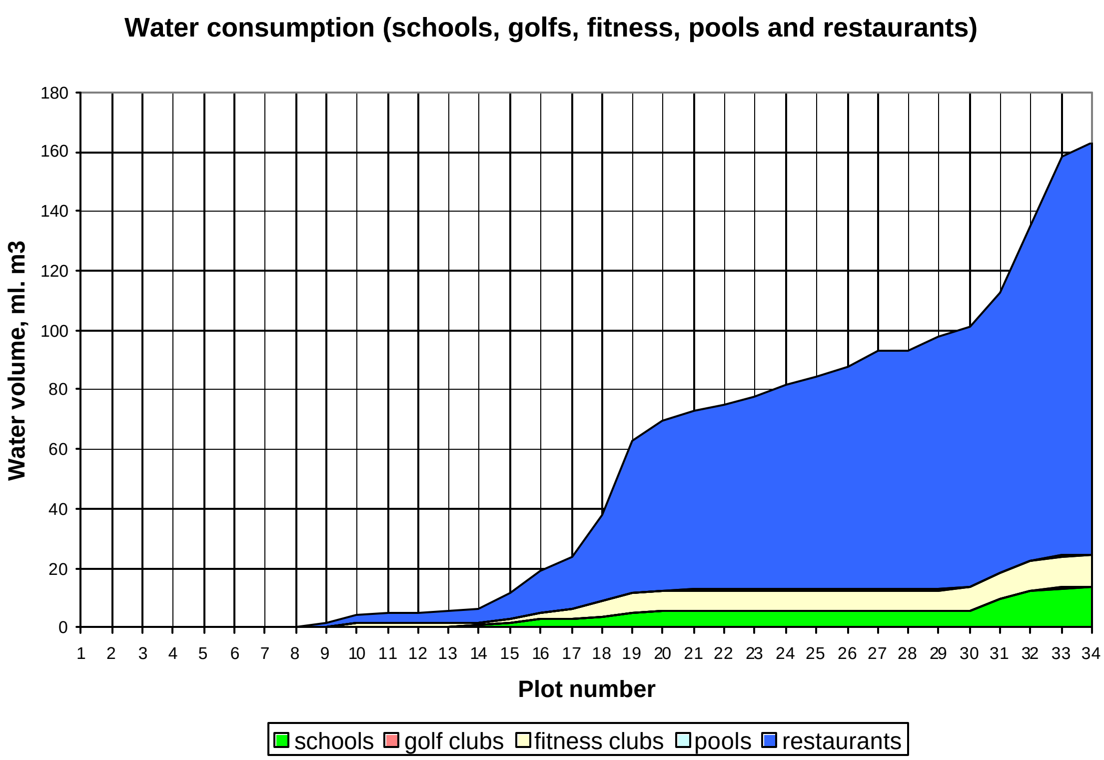


Fig. 16. Accumulated water use along the creek

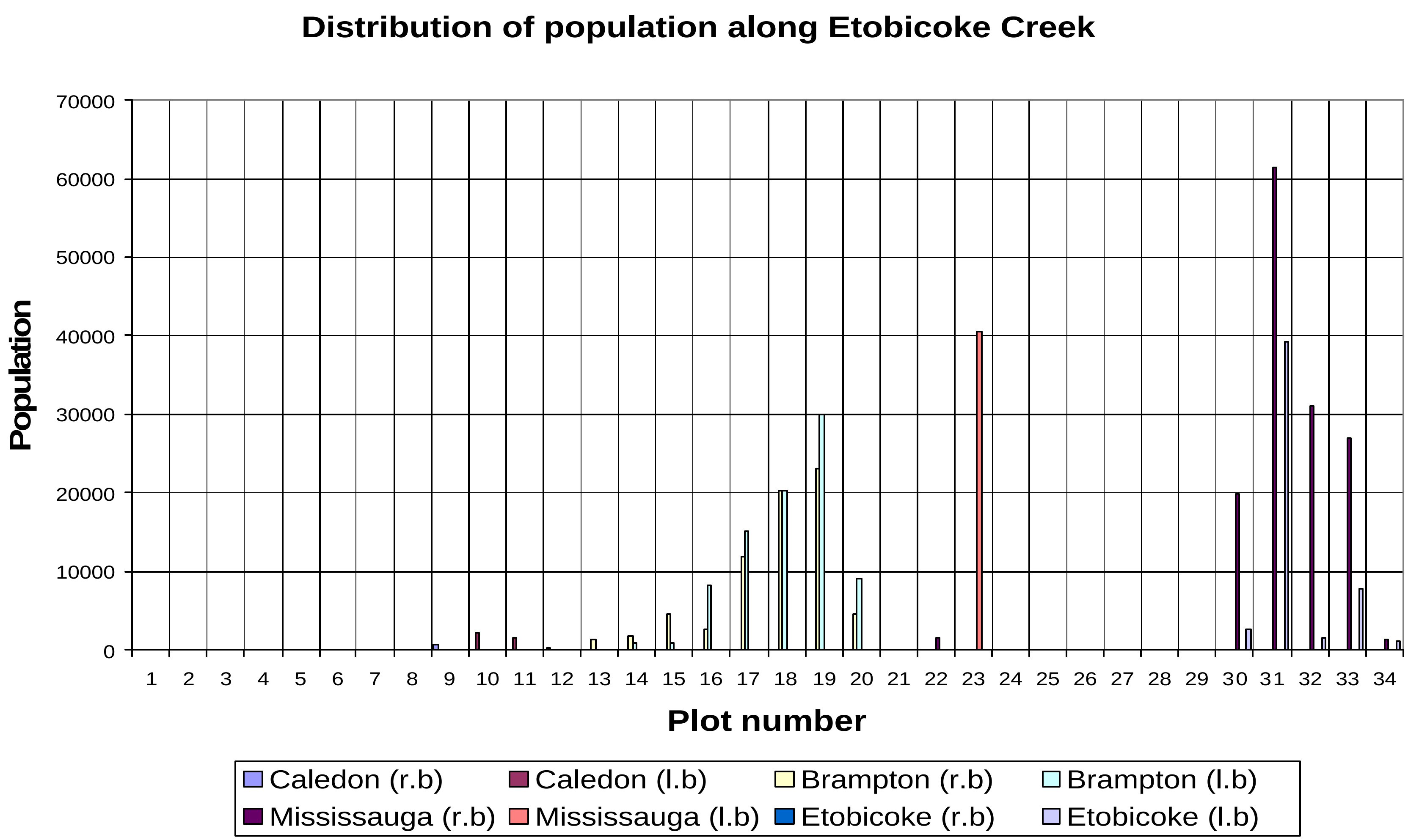


Fig.17. Distribution of population along the creek on both sides within each city

