**SNC-LAVALIN INC.**

1140 De Maisonneuve West Blvd
Montreal, QC
Canada H3A 1M8
Tel: (514) 393-1000
Fax: (514) 390-2765

# MEMORANDUM

Certifiée ISO 9001

| | | | |
|---|---|---|---|
| **TO :** | Mariana Trindade | **DATE :** | July 18, 2016 |
| **C.C. :** | Marie-Hélène Paquette | | |
| **FROM :** | Patrick Scholz | **REF. :** | 636766-0000-4HER-0002 |
| **SUBJECT :** | Answers to Environment Canada questions | | |

## 1.0 OBJECT

Following questions from Environment Canada about water balance computations made for the Howse project, the following tasks were performed:

1. A new column was added to the water balance tables to provide the “all-encompassing” runoff coefficients, i.e. runoff coefficients that incorporate all water abstractions including evapotranspiration.
2. To support and validate the observation that local hydrology differs from the regional hydrology (Hydrological Atlas of Canada [Environment Canada, 1978], and The Hydrology of Labrador [Rollings, 1997]) hydrometric data obtained in the vicinity of Howse project is analyzed.

## 2.0 ADDITION OFA RUNOFF COEFFICIENT COLUMN

Because water balance computations made for all considered watersheds in the Howse project are based on the same assumptions, the same monthly runoff coefficient values are used for all watersheds for a given typical year (wet, average or dry). The following columns present monthly runoff coefficients adopted for typical wet, average, and dry years:

| Month | Runoff Coefficient (ET included) | | |
|---|---|---|---|
| | Wet [-] | Average [-] | Dry [-] |
| Jan | 0.0 | 0.0 | 0.0 |
| Feb | 0.0 | 0.0 | 0.0 |
| Mar | 0.0 | 0.0 | 0.0 |
| Apr | 0.6 | 0.1 | 0.1 |
| May | 5.5 | 7.4 | 2.9 |
| Jun | 0.0 | 0.0 | 0.0 |
| Jul | 0.2 | 0.1 | 0.2 |
| Aug | 0.1 | 0.1 | 0.0 |
| Sep | 0.2 | 0.2 | 0.2 |
| Oct | 0.2 | 0.4 | 0.4 |
| Nov | 0.0 | 0.0 | 0.3 |
| Dec | 0.0 | 0.0 | 0.0 |
| **Year** | 0.7 | 0.6 | 0.5 |

Specific tables for all the watersheds considered for the water balance computations are given in file “Monthly water balance_Howse.xlsx”.

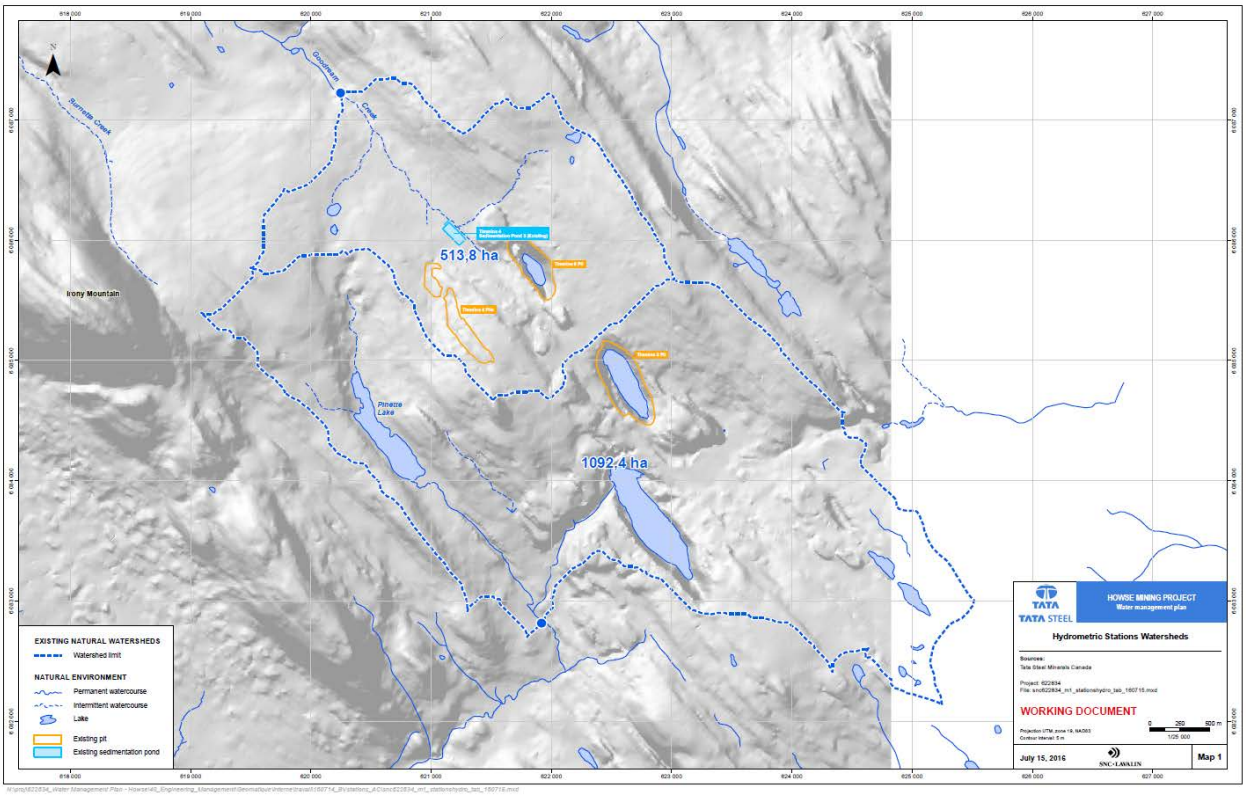
## 2.1 Local Hydrometric Data Analyses

Discharge data from two local hydrometric stations was provided by Environment Canada:

| Station Name | Station Number | Available Data | Drainage Area [km²] |
|---|---|---|---|
| Elross Creek below Pinette Lake Inflow | 03OB007 | Oct 2011 - Dec 2014 | 11.9 |
| Goodream Creek 2 km North-West of Timmins 6 | 03OB006 | Jan 2012 - Dec 2014 | 4.8 |

The two stations have watershed sizes of the same order of magnitude than the watersheds analyzed as part of the Howse project, and they are located in the same area. Therefore, they are representative of the project site watersheds.

First, the drainage area values were checked based on available topographic data of the area. Drainage areas of the same order of magnitude (± 8%) were found:




Then, available water level and discharge data was analyzed. It was found that water level and discharge time series were not synchronized. Therefore, data was adjusted by shifting them in time, to insure the data series would be synchronized. Graphs of this data were drawn together with hydro-meteorological data (precipitation and temperature) to check data validity.

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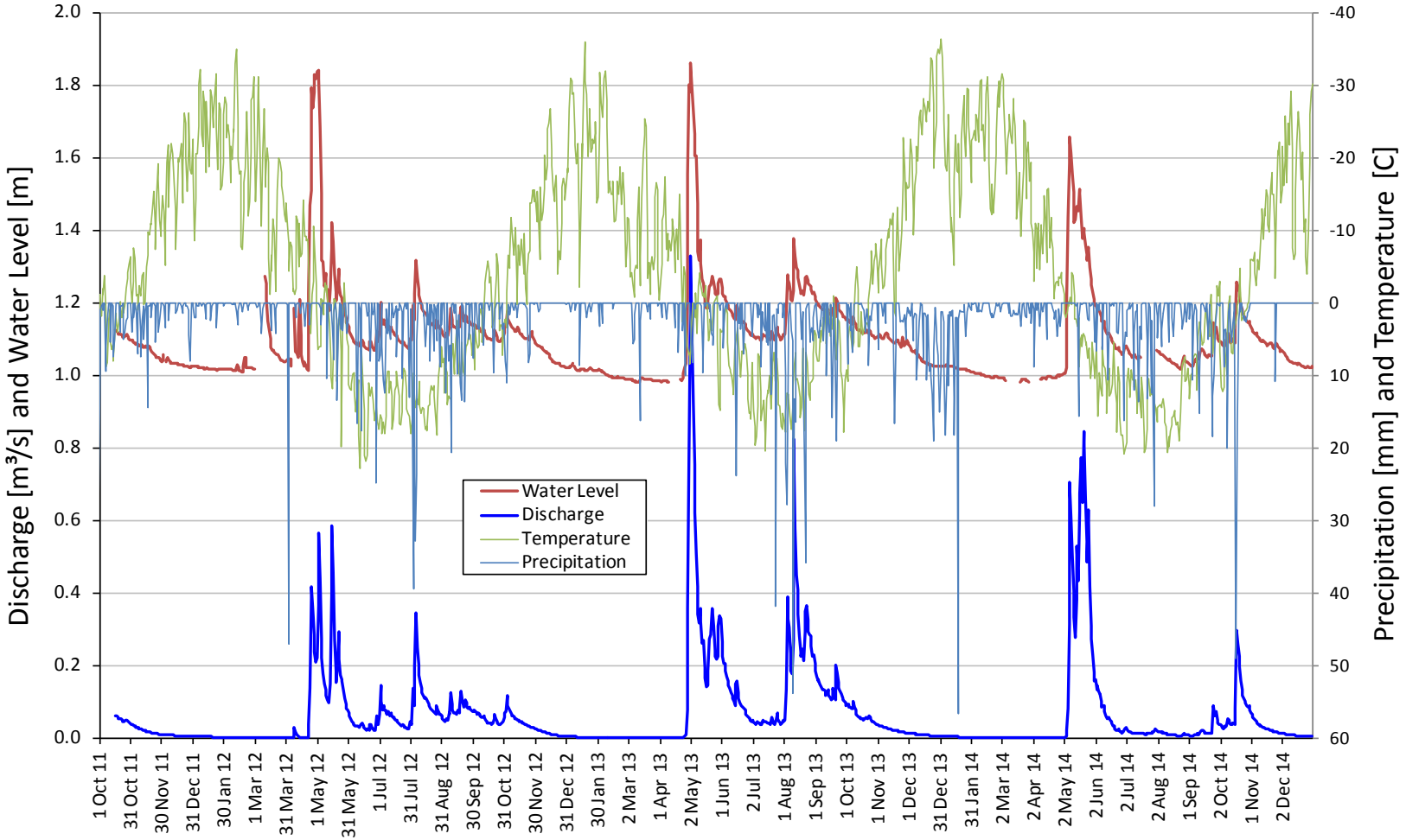
Station 03OB007 (Elross Creek below Pinette Lake Inflow)



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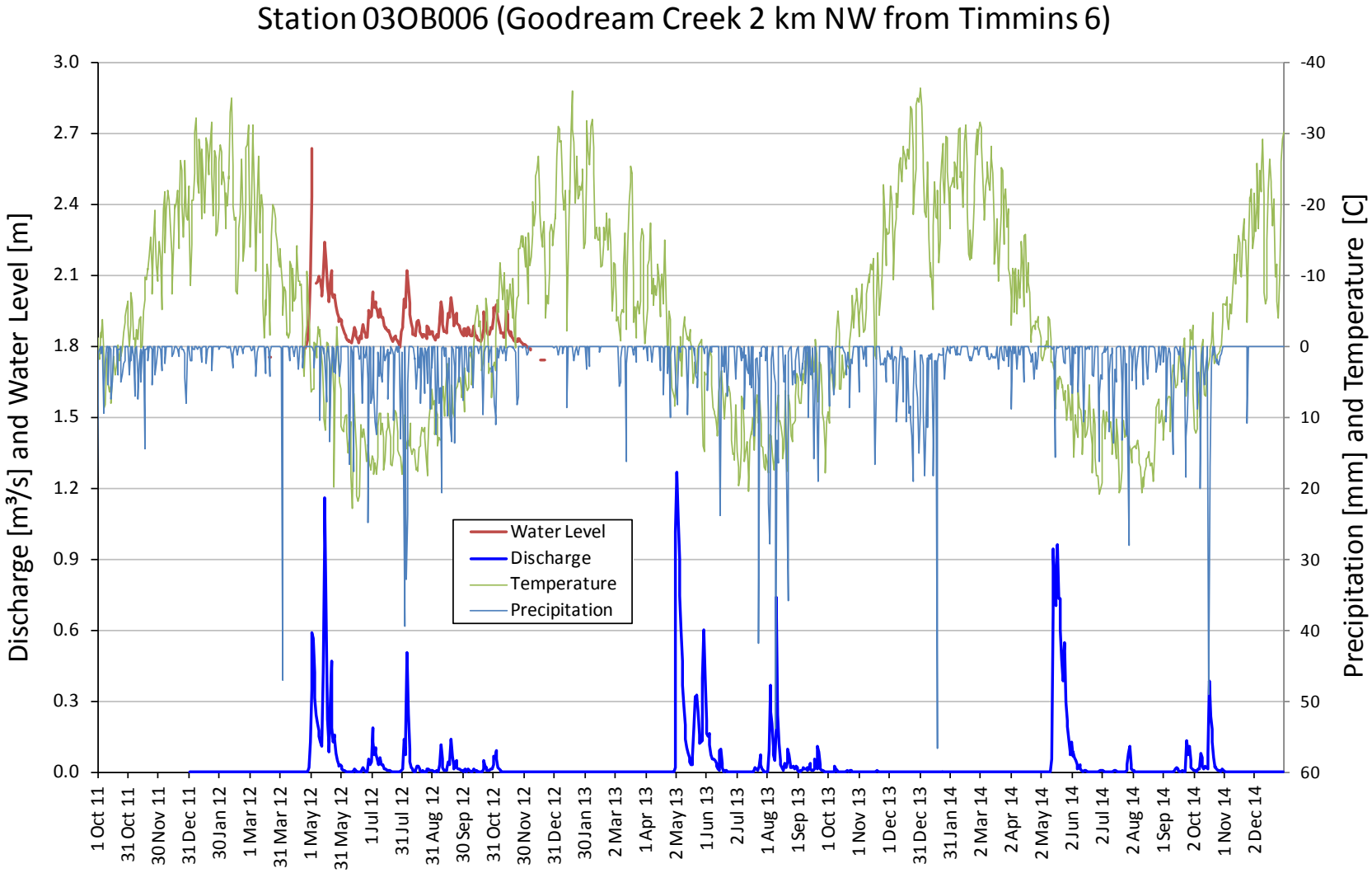
Station 03OB006 (Goodream Creek 2 km NW from Timmins 6)
Discharge [m³/s] and Water Level [m]
Precipitation [mm] and Temperature [C]
Water Level
Discharge
Temperature
Precipitation
3.0
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0.0
-40
-30
-20
-10
0
10
20
30
40
50
60
1 Oct 11
31 Oct 11
30 Nov 11
31 Dec 11
30 Jan 12
1 Mar 12
31 Mar 12
1 May 12
31 May 12
1 Jul 12
31 Jul 12
31 Aug 12
30 Sep 12
31 Oct 12
30 Nov 12
31 Dec 12
30 Jan 13
2 Mar 13
1 Apr 13
2 May 13
1 Jun 13
2 Jul 13
1 Aug 13
1 Sep 13
1 Oct 13
1 Nov 13
1 Dec 13
31 Dec 13
31 Jan 14
2 Mar 14
2 Apr 14
2 May 14
2 Jun 14
2 Jul 14
2 Aug 14
1 Sep 14
2 Oct 14
1 Nov 14
2 Dec 14

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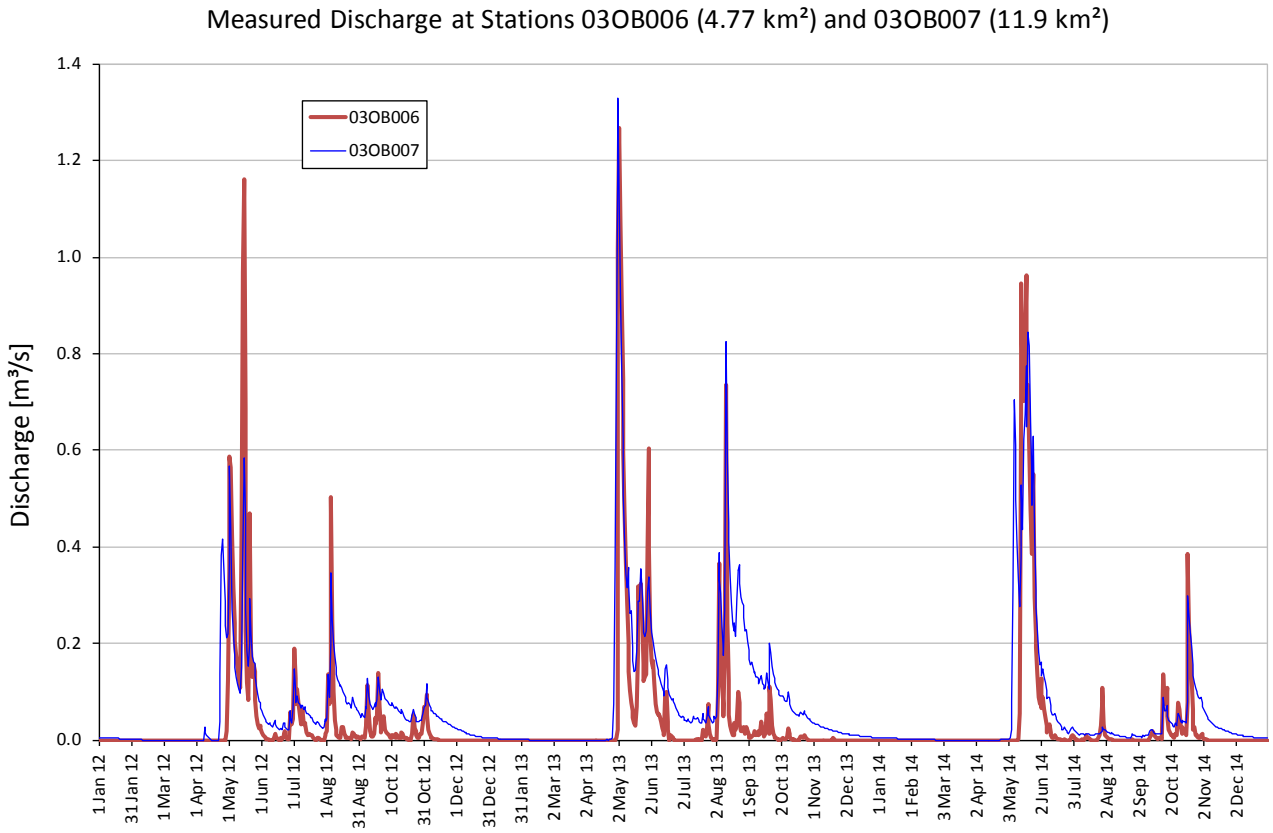
It can be observed on the two previous graphs that:

- Water level and discharge time series are synchronized.
- Summer flood peaks are synchronized with important precipitation events.
- Most of the spring freshet happens during the month of May.

Then, discharge data for both hydrometric stations was compared:




From this graph, it can be observed that flood peaks are generally larger for station 03OB006 than for station 03OB007. This, in spite of station 03OB006 having a drainage area approximately half of that from station 03OB007. Also, flood peak recession is faster for station 03OB006 than it is for station 03OB007. These two observations can be explained by the existence of two lakes, including Pinette Lake, located within station 03OB007 watershed. It can also be observed that both watersheds have no base flow during the winter, and that 03OB006 is an intermittent creek during the summer as well.

(These are examples of specificities that contribute to explain why such small watersheds don't behave exactly like the larger watersheds typically used to develop regional data presented in documents such as the Hydrological Atlas of Canada [Environment Canada, 1978], or The Hydrology of Labrador [Rollings, 1997]. Other watershed specificities could be: soil type, land use, average elevation, no dam, etc.)

Then, runoff coefficients were estimated, on a monthly and annual time step. First, precipitation depths were computed based on data from Environment Canada meteorological station Schefferville A. Then, runoff volumes were computed as daily discharges multiplied by the amount of time per considered period. Then, runoff depths

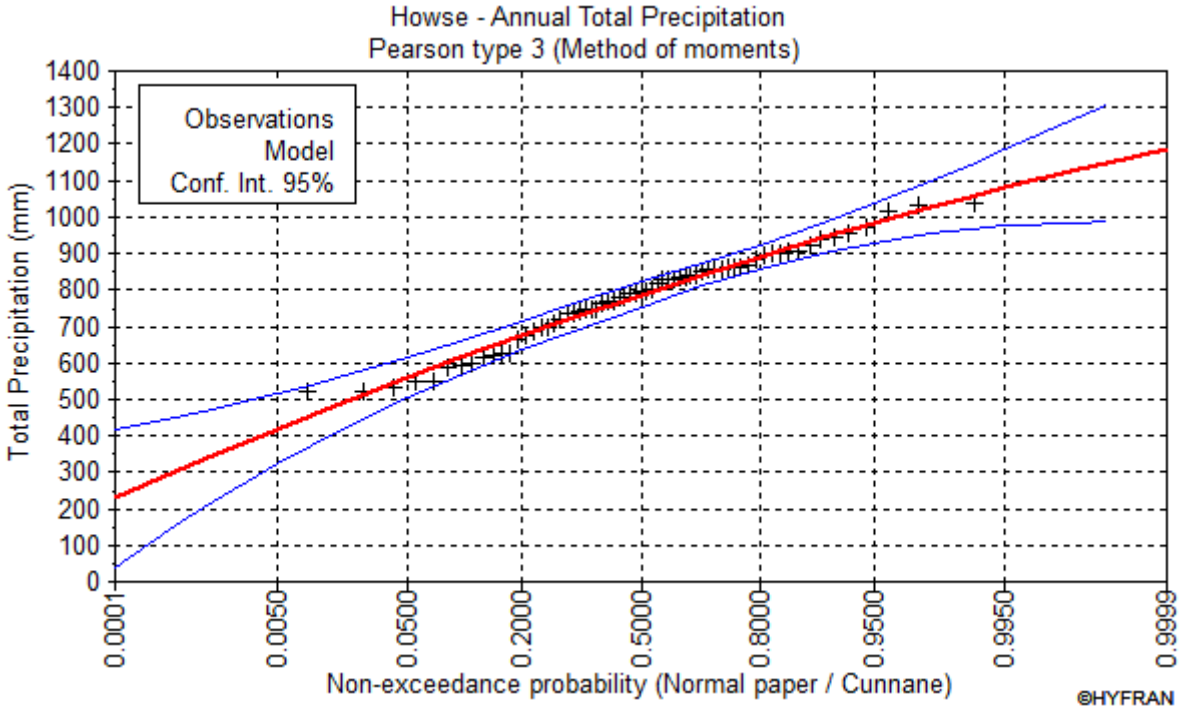
were obtained by dividing runoff volumes by the watershed drainage area. Finally, runoff coefficients were obtained by dividing runoff depths by precipitation depths.

Computed annual runoff coefficients are given for both hydrometric stations (complete year only) and compared with the adopted long term average runoff coefficient:

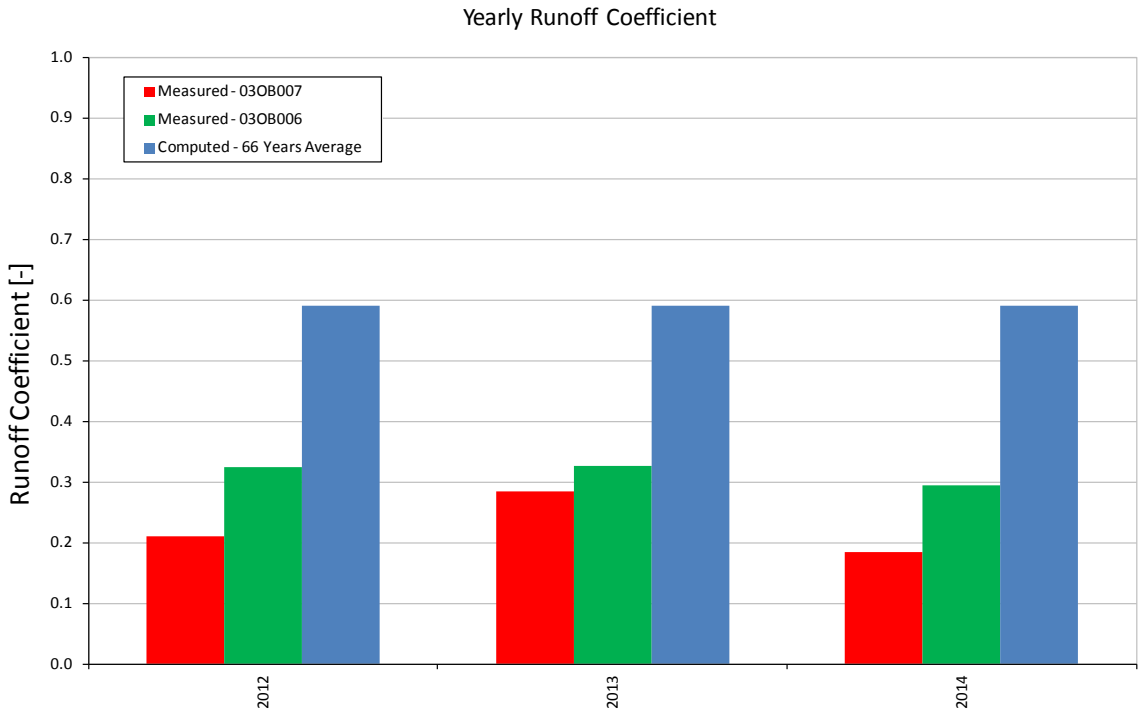
| Year | Runoff volume | | Runoff [mm] | |
|---|---|---|---|---|
| | 03OB007 [m³] | 03OB006 [m³] | 03OB007 [mm] | 03OB006 [mm] |
| 2012 | 1 847 923 | 1 144 195 | 155 | 240 |
| 2013 | 3 056 141 | 1 409 521 | 257 | 295 |
| 2014 | 1 753 402 | 1 121 904 | 147 | 235 |

| Year | Precipitation | | Runoff Coefficient | | |
|---|---|---|---|---|---|
| | Depth [mm] | T [year] | 03OB007 [-] | 03OB006 [-] | 66 years Avg [-] |
| 2012 | 740 | 2-3 dry | 0.21 | 0.32 | 0.59 |
| 2013 | 905 | 5-10 wet | 0.28 | 0.33 | 0.59 |
| 2014 | 798 | 2-3 wet | 0.18 | 0.29 | 0.59 |

Estimated yearly precipitation return periods were obtained from a frequency analyses performed on annual precipitation, during the period 1949-2014 (66 years), using a Pearson type 3 probability distribution with the method of moments:




Yearly and monthly runoff coefficients for both hydrometric stations and the long term average adopted values are presented on the following graphs:




From the above analyses, even if available local discharge data is limited, it can be seen that:

- Observed local annual runoff depths, during the period from 2012 to 2014, vary between approximately 150mm and 300mm.
- Local annual runoff depths are smaller than regional values from the literature (650mm to 700mm). This is normal because regional values are representative of much larger watersheds, having specific average characteristics that are different from the smaller local watersheds. Very large watersheds behave differently, in terms of hydrology, than very small watersheds.
- The adopted computed annual runoff depth of 460mm is conservative. This value is based on 66 years of hydro-meteorological data and is intended to be representative of the long term average value for a typical average year.