Supplementing water supply to Mare aux Vacoas Reservoir in Mauritius

A Feasibility Study

Ken Haumann
PD Naidoo & Associates
Johannesburg, South Africa

13th International Riversymposium

PDNA
PD NAIDOO & ASSOCIATES

Credit

Thulani Magagula : PDNA

Client Acknowledgement

Water Resources Unit

Ministry of Renewable Energy and Public Utilities

Mauritius

Content

- Background
- Problem Definition
- Proposed Solution
- Modelling processes
- Modelling calibration
- System Analysis
- Modelling Results
- Conclusion

Background


MAV
Île Maurice
OCÉAN INDIEN
Île aux Serpents
Île Ronde
Île Plate
Îlot Gabriel
Coin de Mire
Île d'Ambre
Îlot Maunick
Île de l'Est
Île aux Cerfs
Île aux Chats
Île des Roches
Île Camisard
Île Flamants
Île Marianne
Rocher des Oiseaux
Île aux Singes
Île aux Fous
Île aux Fouquets
Îlot Vacoas
Île de la Passe
Île aux Aigrettes
Île des Deux Cocos
Îlot des Deux Cocos
Île aux Bénitiers
Îlot Fourneau
Îlot Sancho
Échelle : 1:372 000
Projection UTM (WGS84 datum)
(km)
(mi)

Mare Aux Vacoas

- The Mare aux Vacoas was built in 1885 at the headspring of the River Tamarin, about 25km to the south of Port Louis, for storage of water for potable water supply.

- Subsequently, as a result of increased demand for water, the reservoir capacity was increased in 1892, 1915, 1928, and finally in 1961 to a storage of 27.63 Mm^3.

- The reservoir has a local catchment area of 19.5 km^2, and is located in a super humid zone with an average annual rainfall of 3200 to 3800mm.

Current average annual inflows into MAV

Feeder	Catchment	Contribution
MAV Catchment		14 Mm^3
Tatamaka Canal Design capacity = 3.12m^3/s	River du Poste	15 Mm^3
Parc aux Cerfs Canal Design capacity = 9.5m^3/s	River Citron	1.75 Mm^3
Pradier Canal Design capacity = 2.63m^3/s	River Anguilles	2.62 Mm^3
	TOTAL	**33.37 Mm^3**

Tatamaka Canal

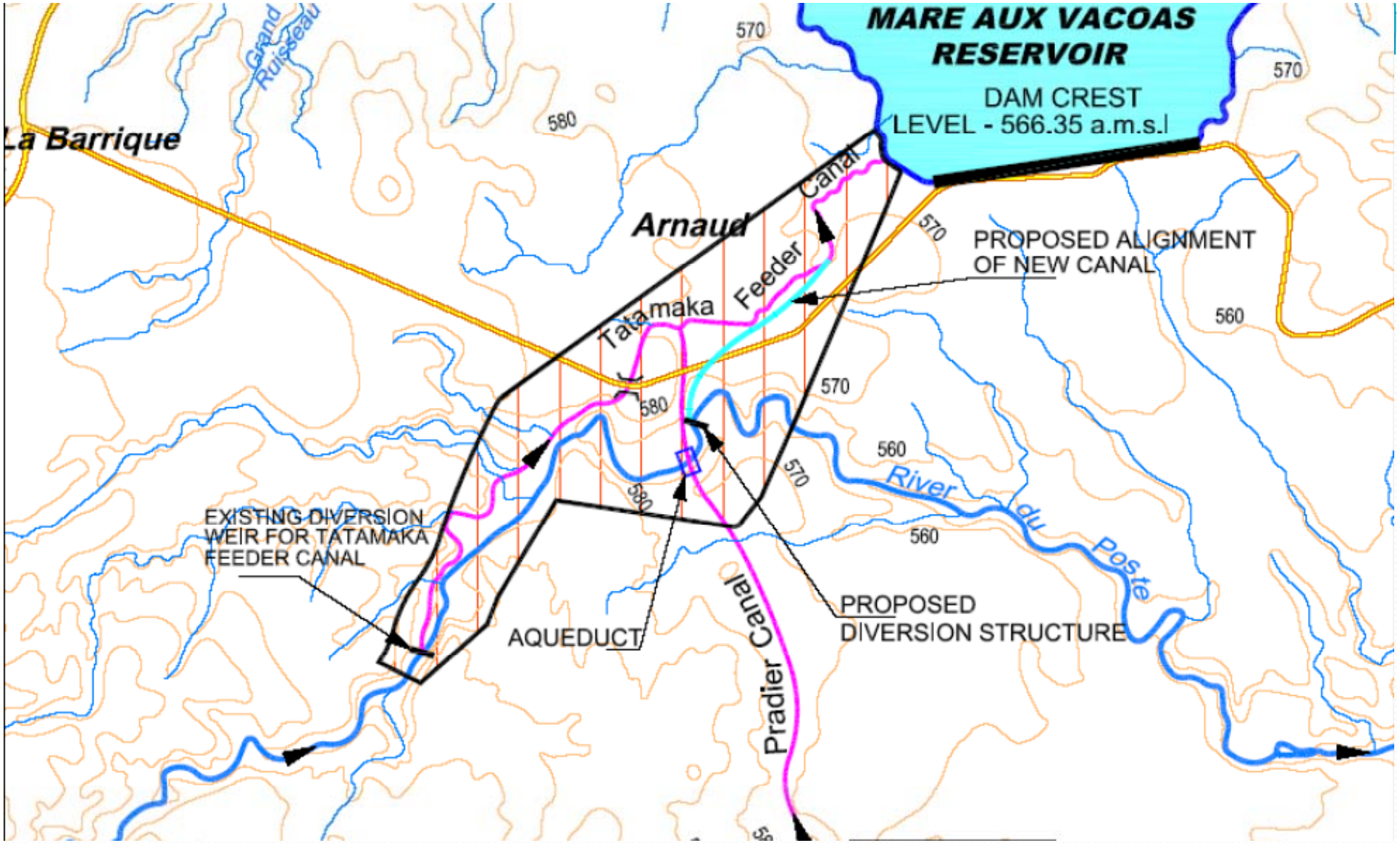
Pradier Canal

Problem Definition

- Average annual yield from the reservoir for period 1995 to 2007 has been 33 Mm^3 or (91.1 Ml/day)
- Prevailing demands are 38 Mm^3/a or (104.9 Ml/day)
- This is causing problems and restrictions have been introduced from September to January
- Anticipated demands are expected to reach 43.8 Mm^3/a (120 Ml/day) by 2025

Proposed Solution

- Surplus flood flows from the River du Poste are currently being lost to the Indian Ocean.
- Propose diverting flood peaks into the MAV


MARE AUX VACOAS
RESERVOIR
DAM CREST
LEVEL - 566.35 a.m.s.l
La Barrique
Grand Ruisseau
Arnaud
Canal
Tatamaka Feeder
PROPOSED ALIGNMENT
OF NEW CANAL
570
580
560
River du Poste
EXISTING DIVERSION
WEIR FOR TATAMAKA
FEEDER CANAL
AQUEDUCT
Pradier Canal
PROPOSED
DIVERSION STRUCTURE

Modelling Processes

STATION CODE	STATION NAME	RECORD SINCE	RECORD LENGTH (YEARS)
J6.CWA	Arnaud	1941	68
T11R.CWA	Good End	1941	68
PTRIN.CWA	Petrin	1987	22
M4R.WRU	Pradier	1993	16
S10.CWA	Mare Longue	1991	18
HI5.SAV	Savinia	1999	10

Rainfall Stations and Data Available (Daily records)

STATION CODE	STATION NAME	START DATE	END DATE	RECORD LENGTH (YEARS)	TYPE OF DATA
J001	Tatamaka Feeder	01-Nov-95	31-Oct-08	13	Daily Values
		Nov-83	Oct-95		Monthly summary
J04	Riv. Du Poste @ La Flora	01-Nov-69	31-Oct-08	39	Daily Values
		Jan-68	Oct-69		Monthly summary
M012	Pradier Canal	01-Nov-02	31-Oct-08	6	Daily Values
J01	Riv. Citron @ Nouvelle France	01-Nov-83	31-Oct-08	25	Daily Values
		Jan-66	Oct-83		Monthly summary
T02	La Marie Conduit	01-Nov-95	31-Oct-08	13	Daily Values
		Nov-91	Oct-95		Monthly summary

Flow Stations and Available Data (Daily records)

Models used

- **HEC-HMS (Hydraulic Engineering Centre - Hydrological Modelling System)**

  Used to model the daily flow data (13 years) and state of the reservoir

- **WRSM2000 (Water Resources System Model)**

  Calibrated from HEC-HMS Model and used to generate the monthly runoff from long-term rainfall records (66 years)

- **STOMSA (STOchastic Model of South Africa)**

  Used results WRSM2000 Model to generate long-term stochastic hydrology to test system yield

- **HEC-RAS (Hydraulic Engineering Centre – River Analysis System)**

  Used to generate a GIS model and test the hydraulic performance of the proposed diversion used to divert peak flows

- **WRYM (Water Resources Yield Model)**

  Generates long-term yield curves for different assurances of supply for a given operating policy (eg. Supplying 120 Ml/day)

Modelling Phases

Phase 1: Model MAV behaviour

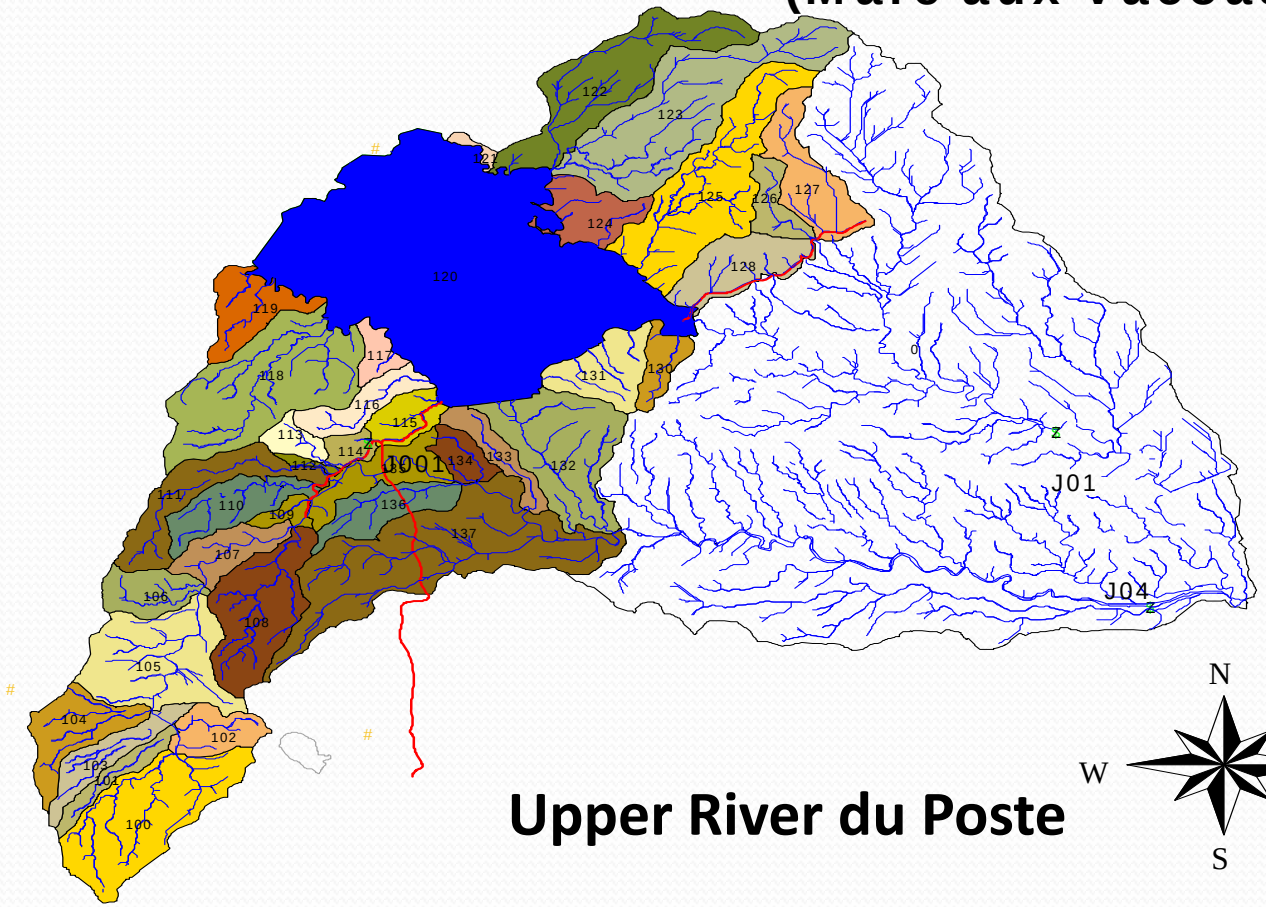
- Determine catchments contributing to the MAV
- Determination of runoff and inflows
- Establish outflows
- Establish reservoir state and evaporation
- Test accuracy of modelling and optimise

Phase 2: System Analysis

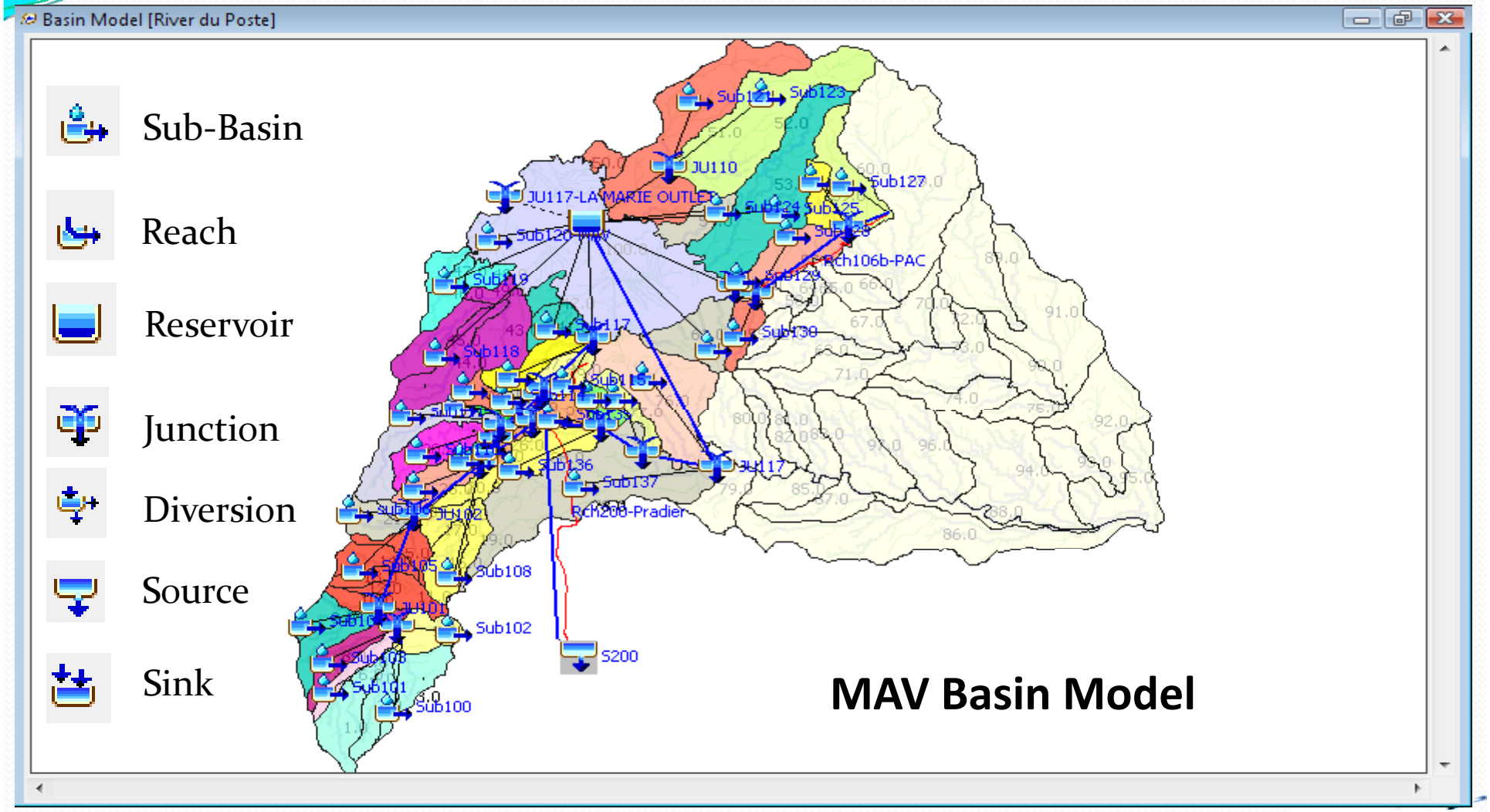
- Setup proposed diversion weir and supply channel properties
- Re-arrange Pradier siphon to optimise flow into the existing canal
- Optimise off-take volume from proposed new weir to MAV
- Analyse system behaviour and related assurance of supply

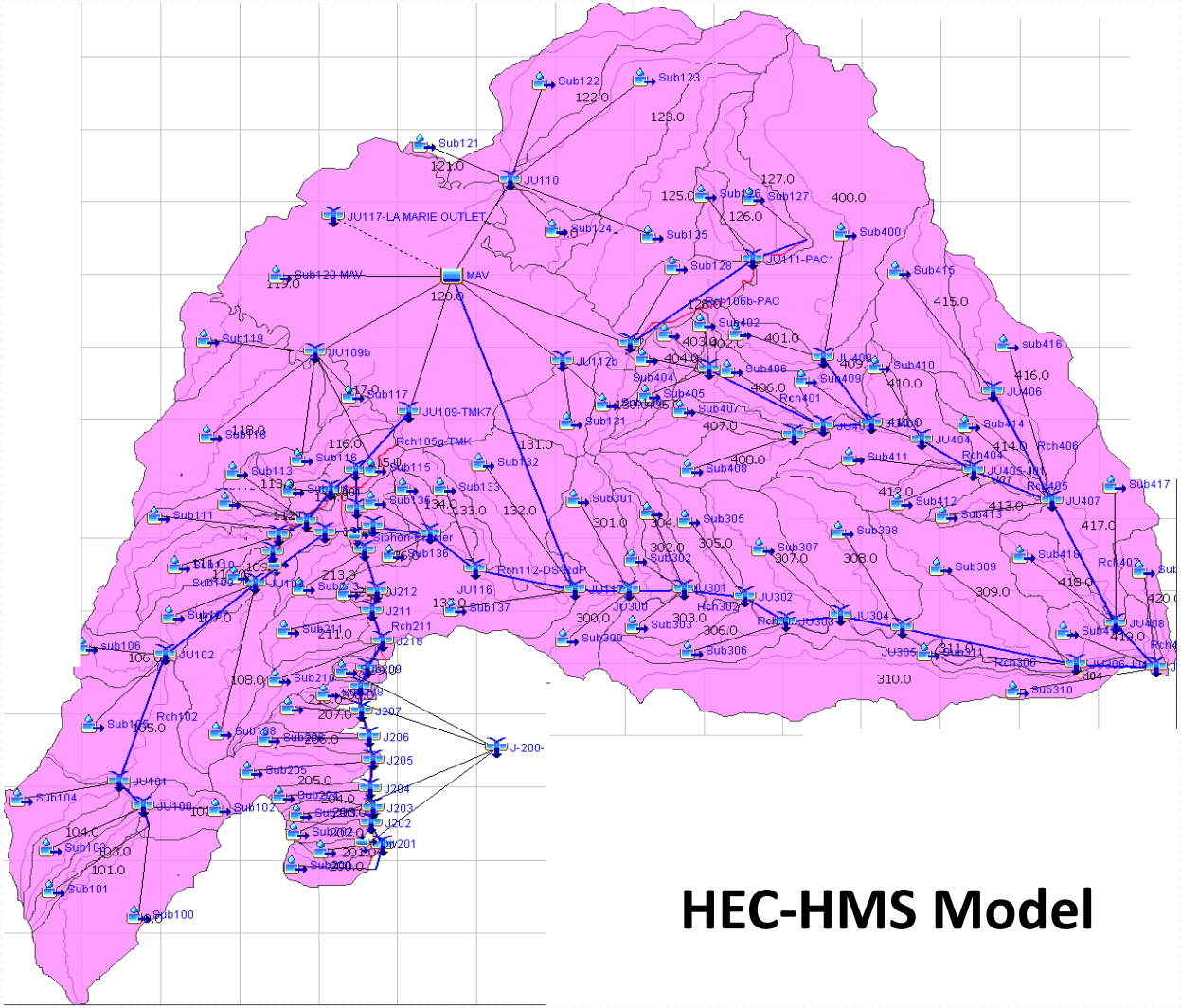
Modelling Calibration

River du Poste Catchment Delineation (Mare aux Vacoas Study)

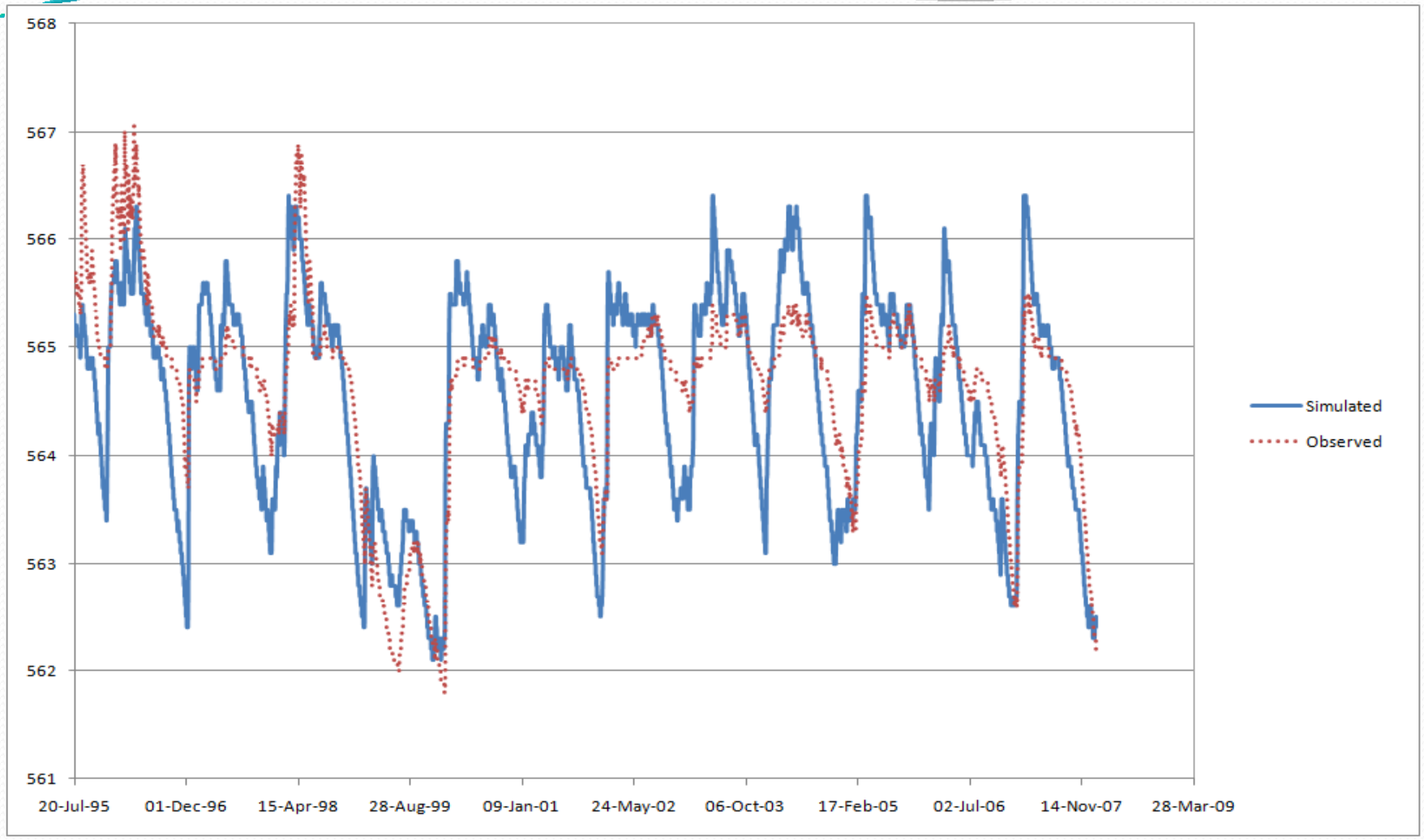


- 31 Catchments Contributing to the MAV
- 6 Catchments downstream of the MAV (River du Poste)
- Total Catchment are contributing to MAV 20.34Km² (inclusive of reservoir- 5.14Km²)


Basin Model [River du Poste]
Sub-Basin
Reach
Reservoir
Junction
Diversion
Source
Sink
JU110
JU117-LAMARIE OUTLET
Sub121
Sub123
Sub127
Sub124
Sub125
Sub126
Rch106b-PAC
Sub129
Sub130
Sub117
Sub118
Sub116
Sub136
Sub137
JU117
Rch208-Pradier
JU102
Sub105
Sub108
JU101
Sub102
Sub103
Sub101
Sub100
S200
MAV Basin Model

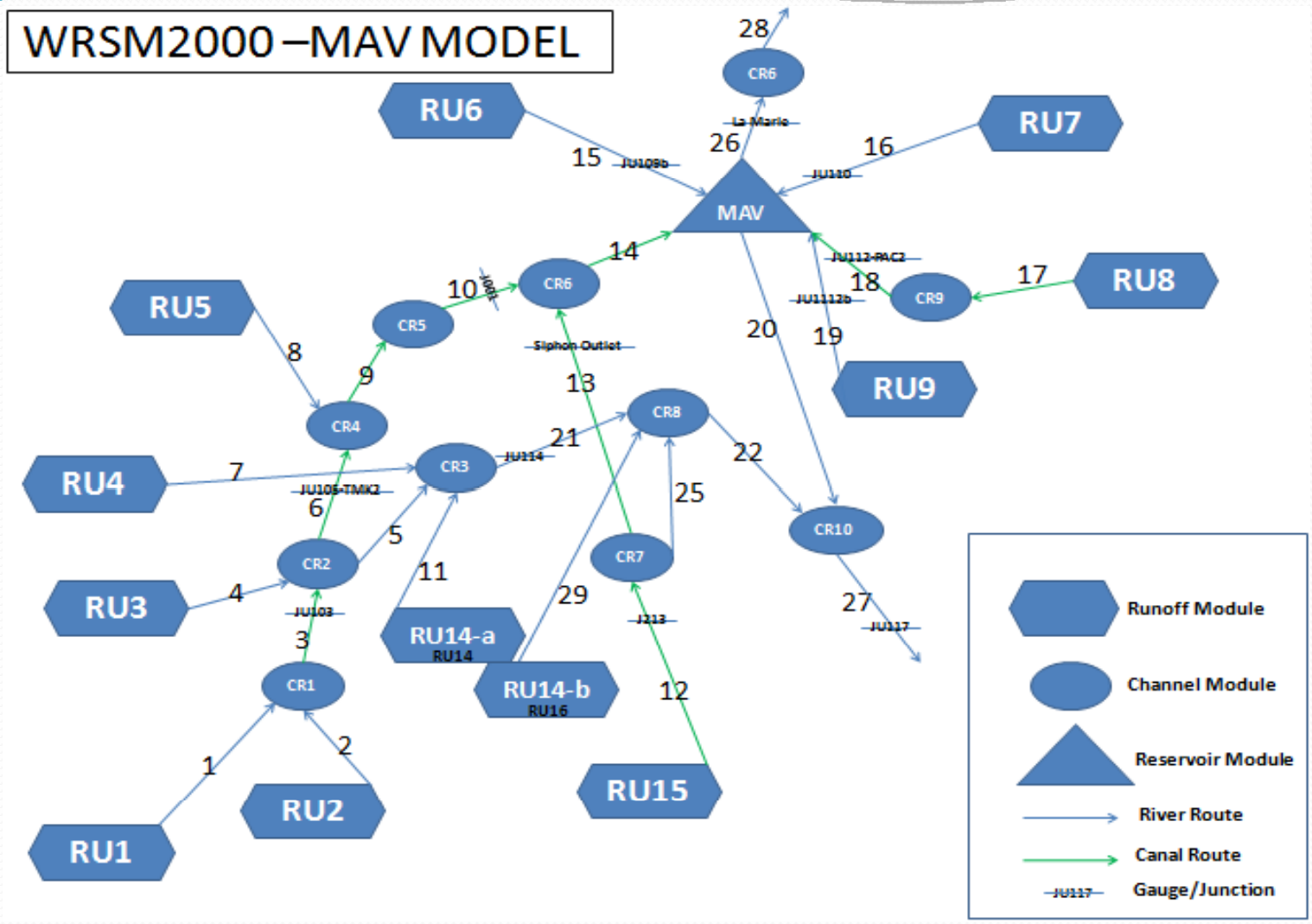


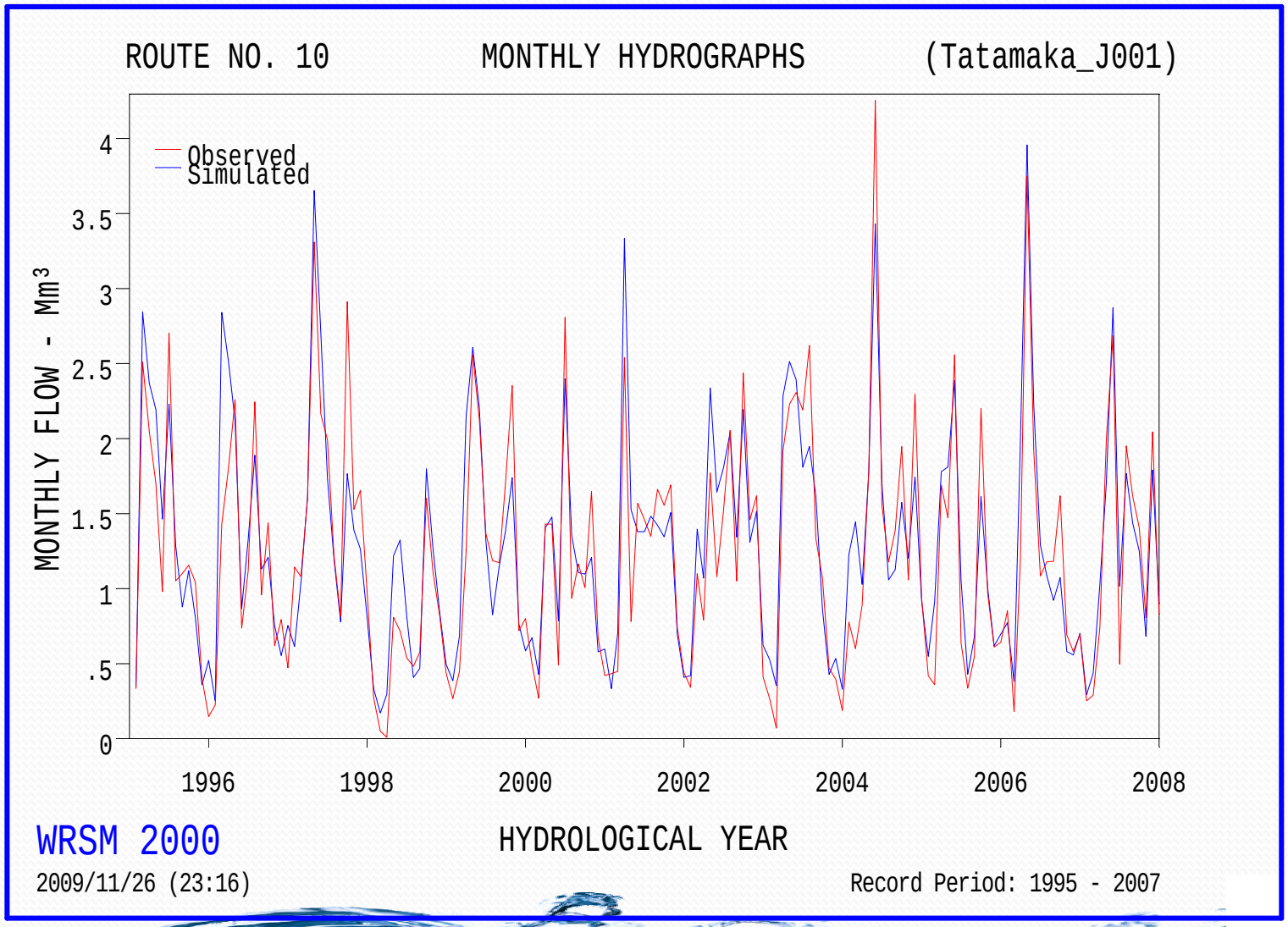
HEC-HMS Model



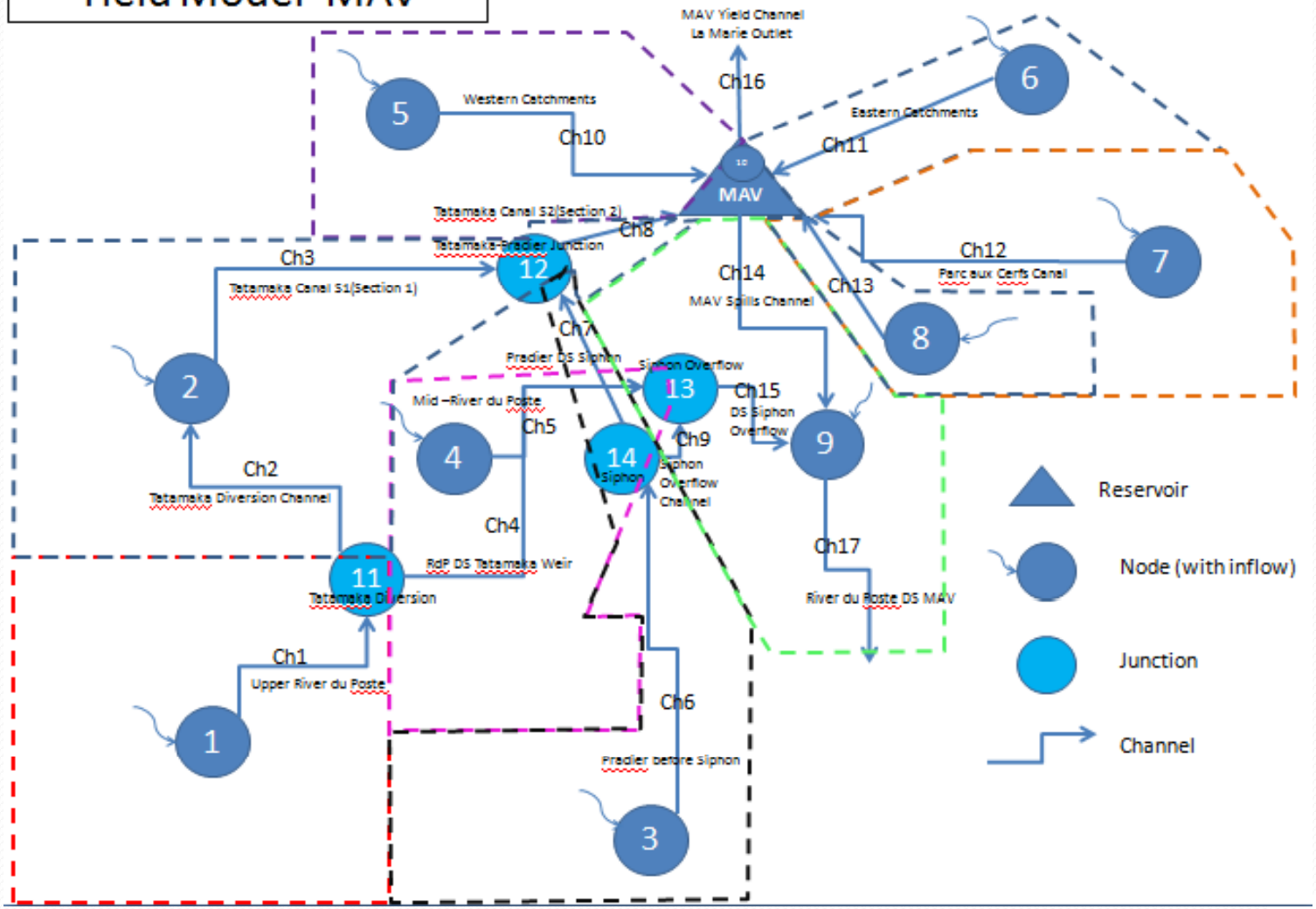
Simulated vs. Observed Water Levels at the MAV (1995-2008)

WRSM2000 –MAV MODEL




ROUTE NO. 10 MONTHLY HYDROGRAPHS (Tatamaka_J001)
Observed
Simulated
MONTHLY FLOW - Mm³
4
3.5
3
2.5
2
1.5
1
.5
0
1996
1998
2000
2002
2004
2006
2008
WRSM 2000
HYDROLOGICAL YEAR
2009/11/26 (23:16)
Record Period: 1995 - 2007

Yield Model -MAV



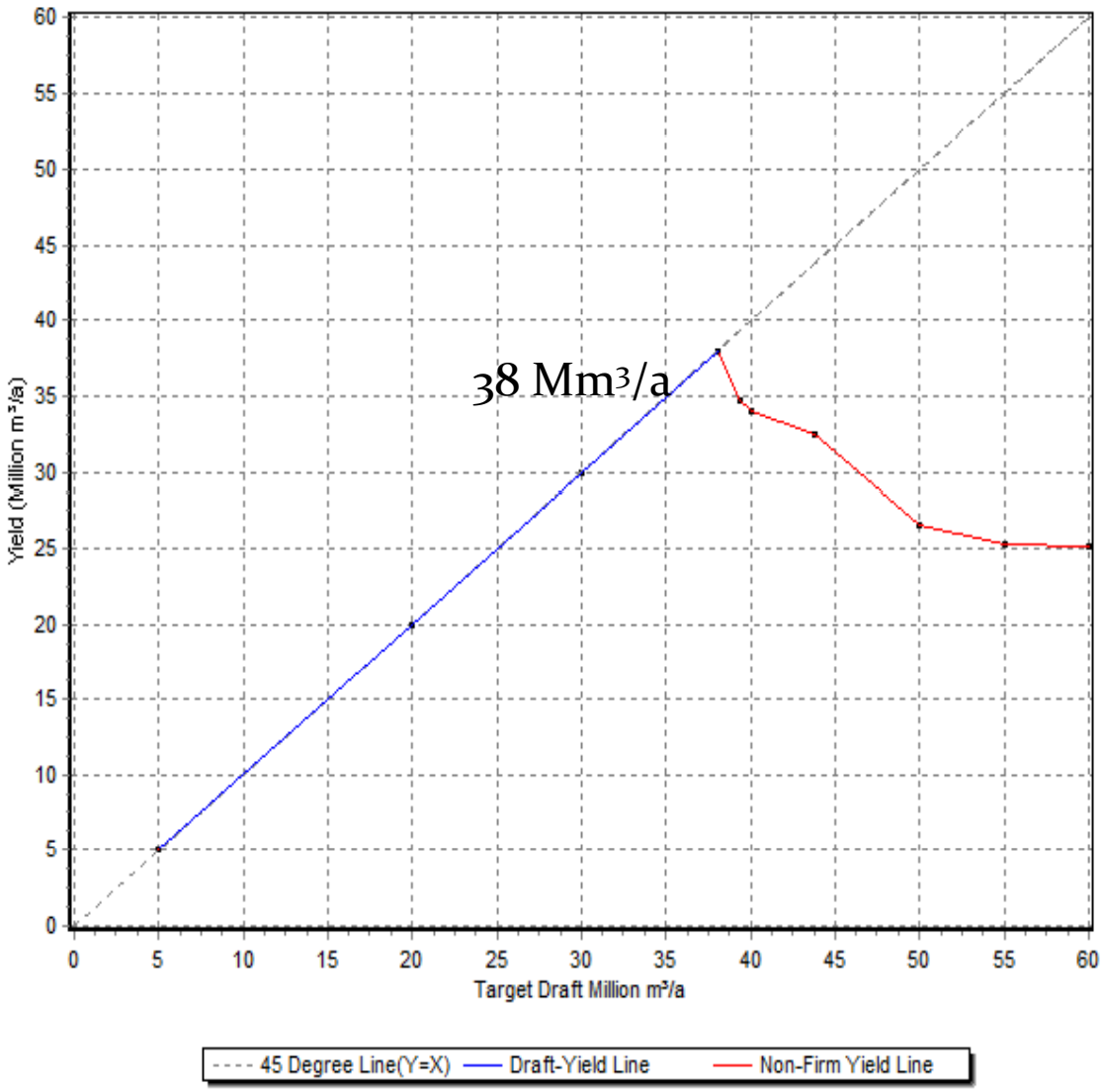
System Analysis

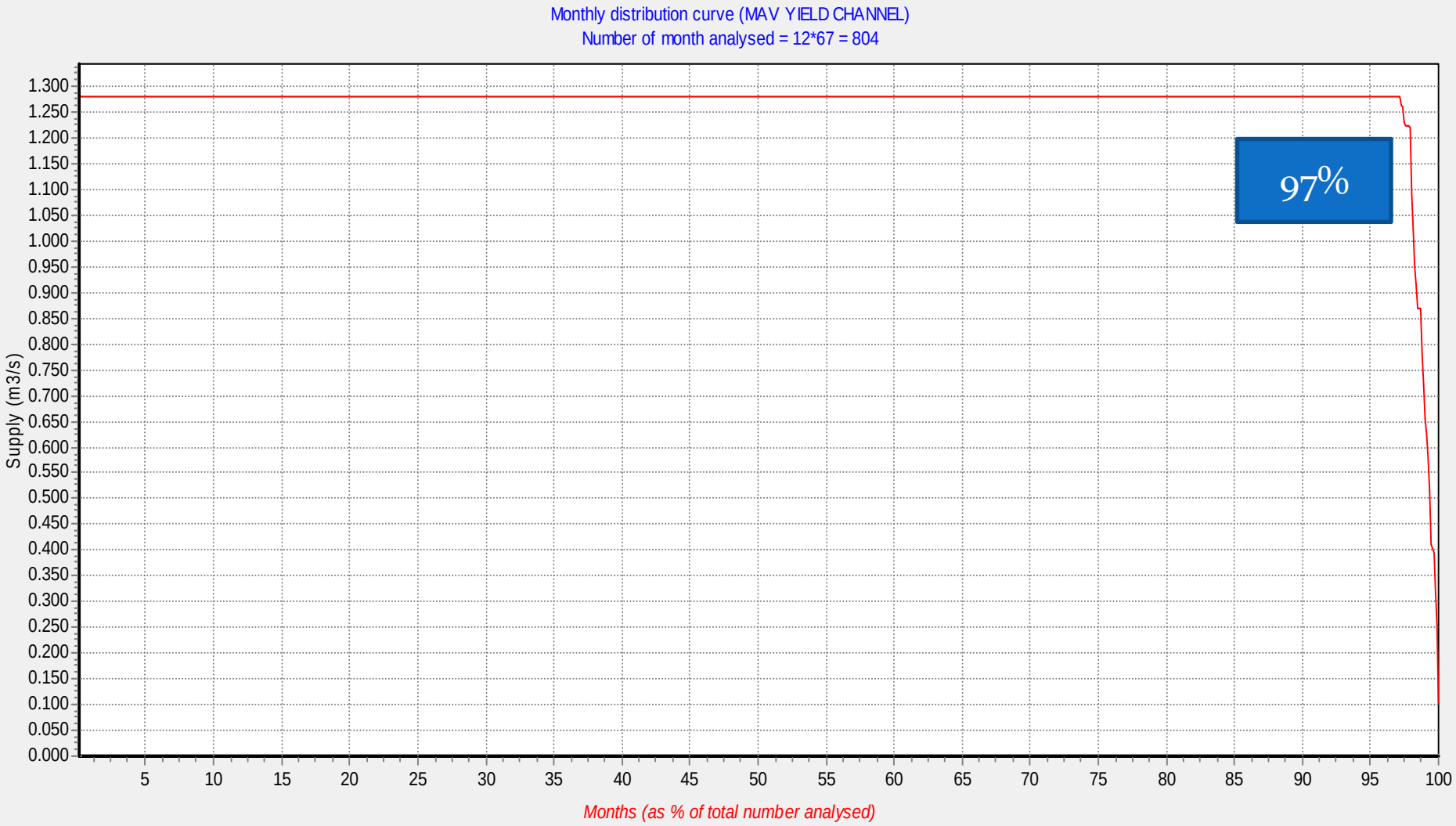
Historical Firm Yield

Highest target draft that can be achieved from the reservoir without reaching the Dead Storage of the reservoir. (System failure)

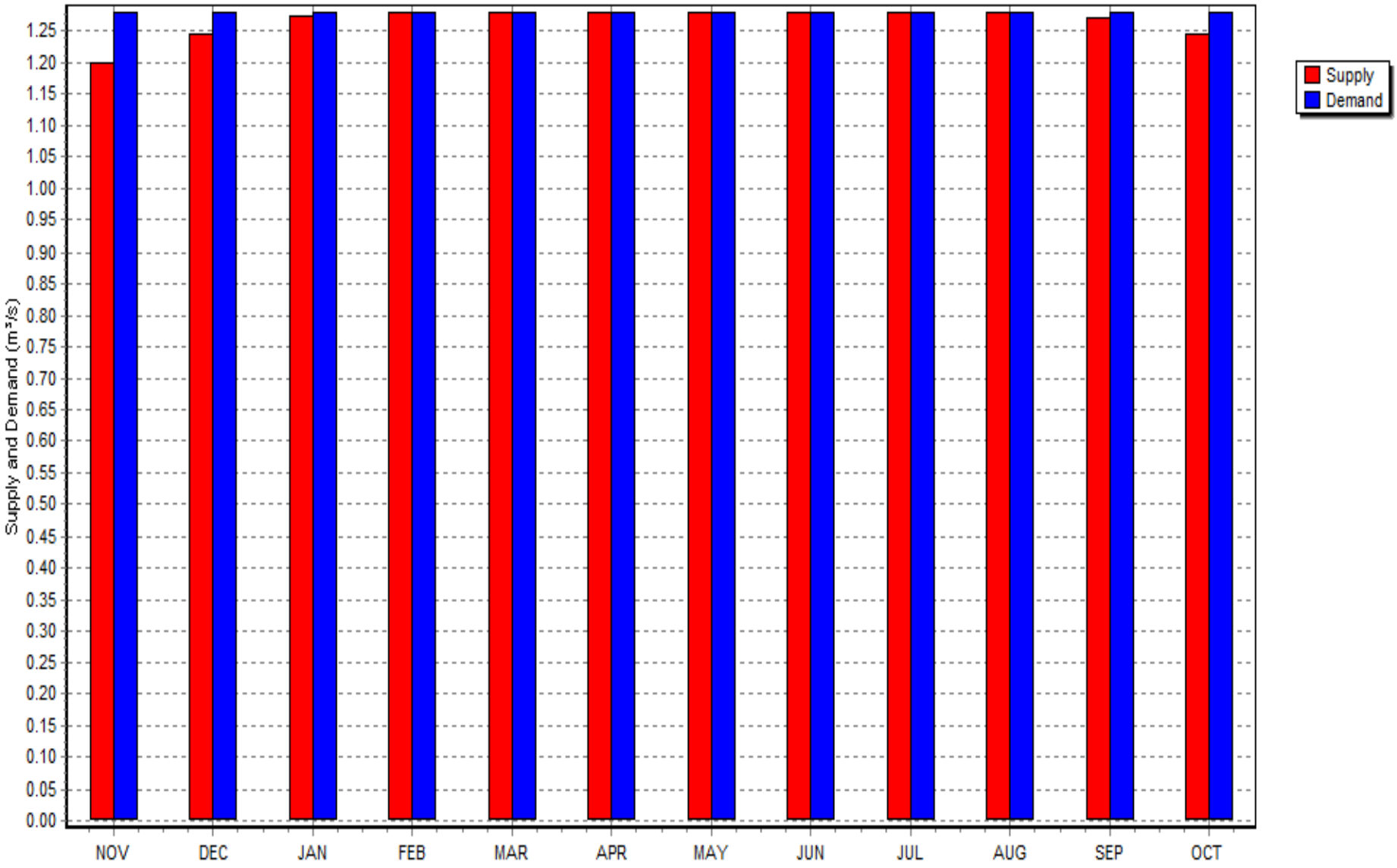
TD (Million m3/a)	Deficits (Proportion)	Yield (Million m3/a)
60.000	0.580	25.200
55.000	0.540	25.300
50.000	0.470	26.500
43.800	0.260	32.412
40.000	0.150	34.000
39.400	0.120	34.672
38.000	0.000	38.000
30.000	0.000	30.000
20.000	0.000	20.000
5.000	0.000	5.000

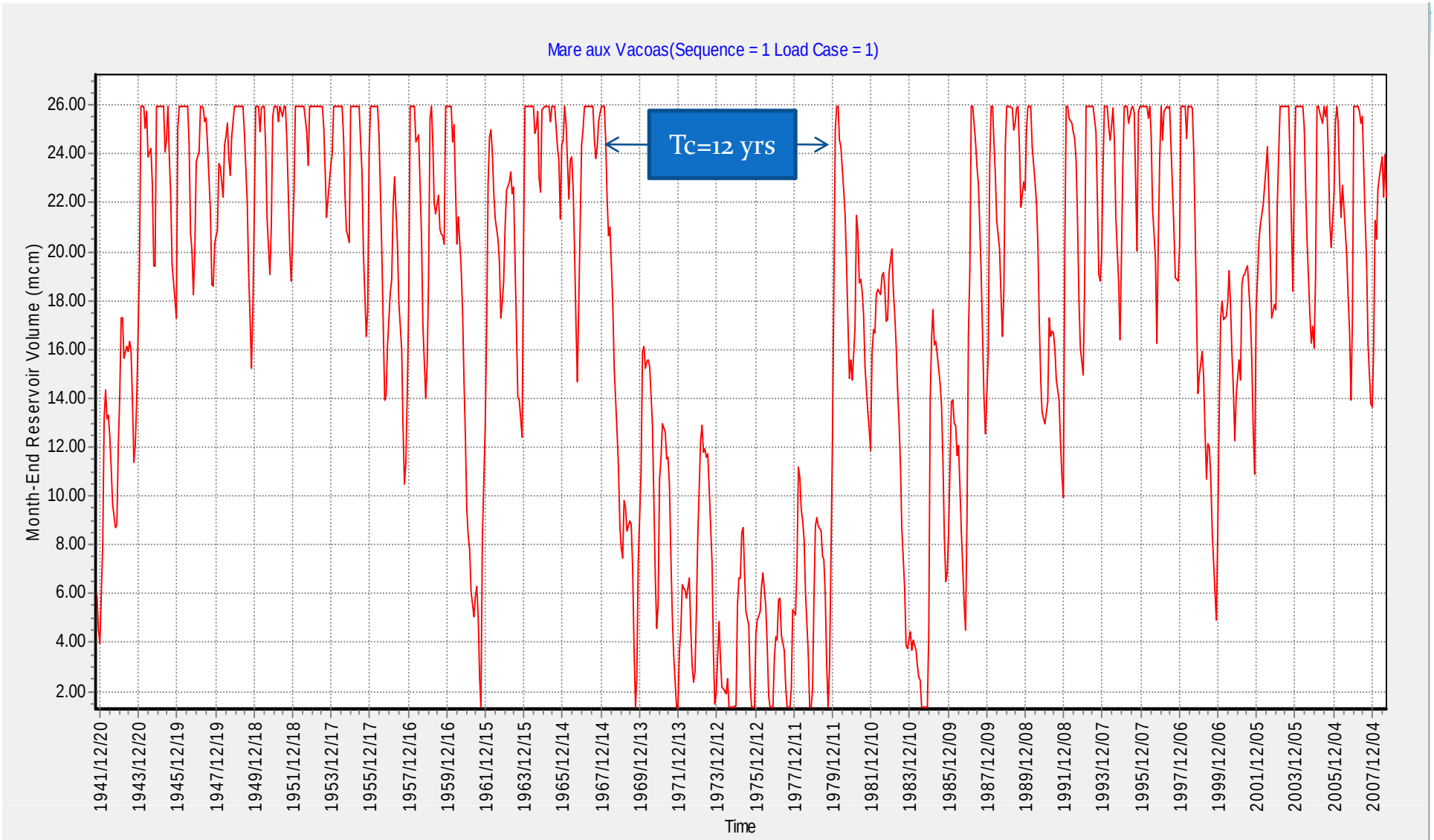
Historical Firm Yield of the Current MAV System



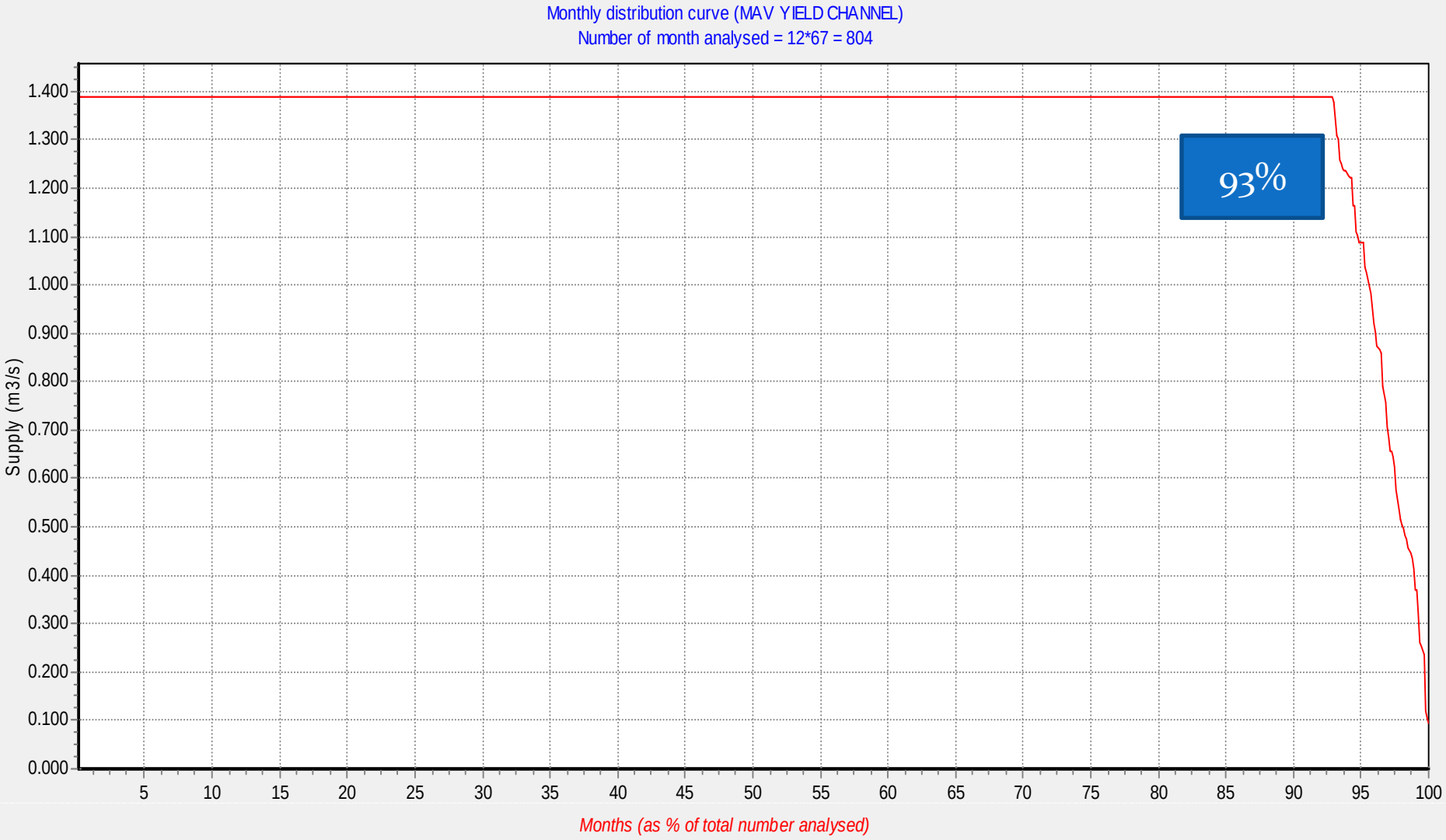


Current system. Current draft = 104.9 Ml/day (38 Mm³/a)


Supply
Demand
Supply and Demand (m³/s)
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT

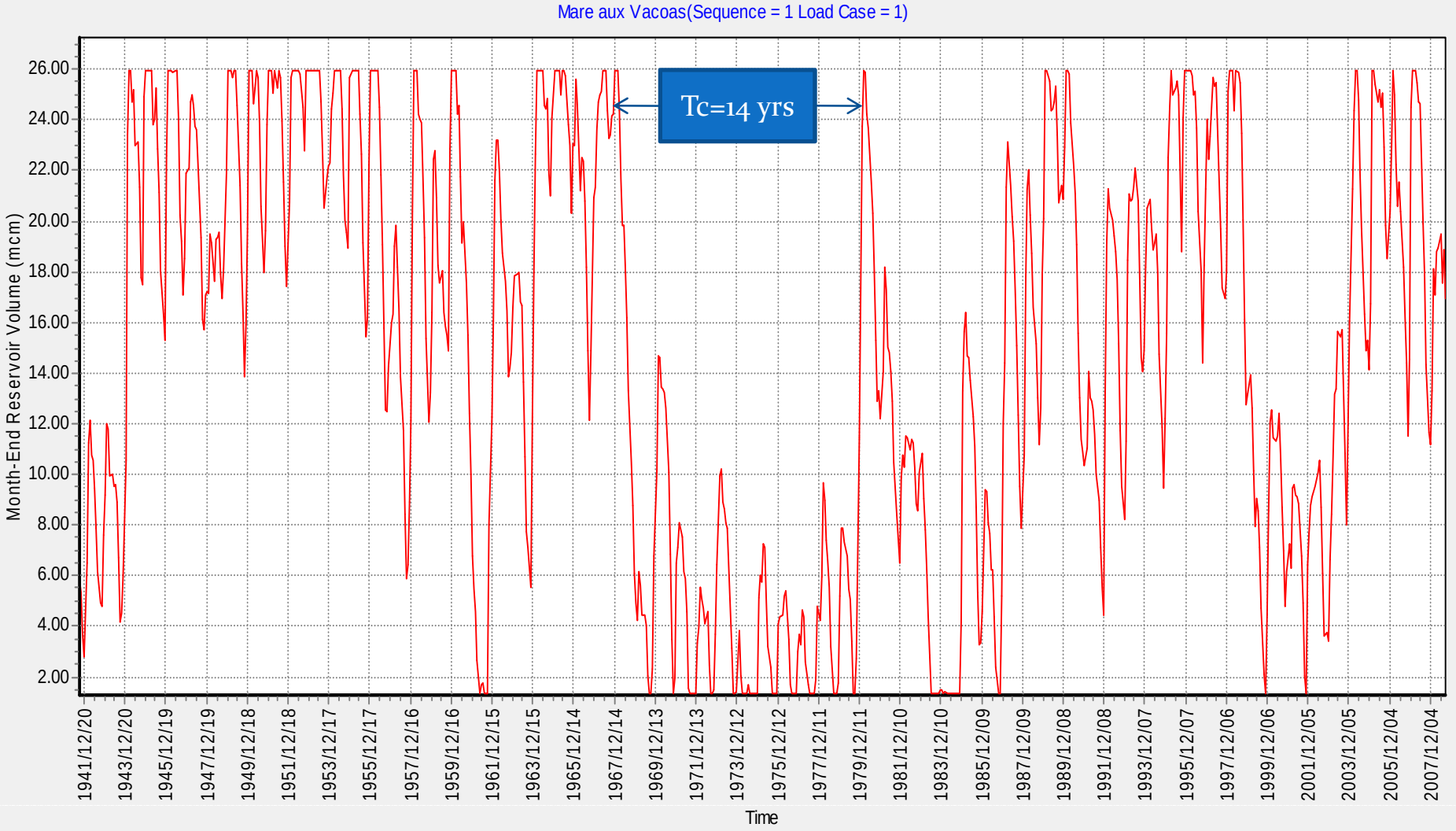


MAV Reservoir Level (when TD = 38Mm³/a)



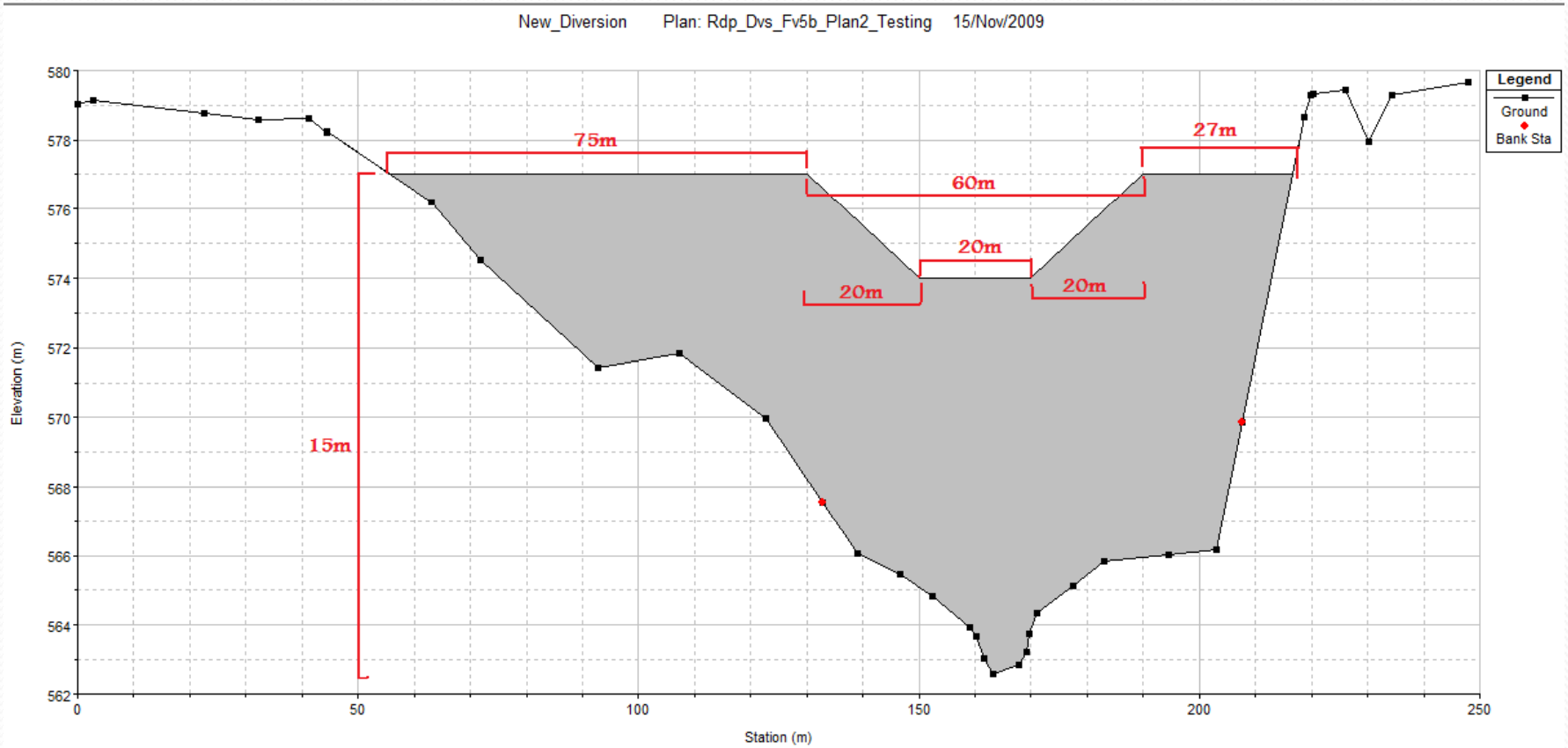
Current system : Target Draft = 120 Ml/day


Supply and Demand (m³/s)
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
Supply
Demand

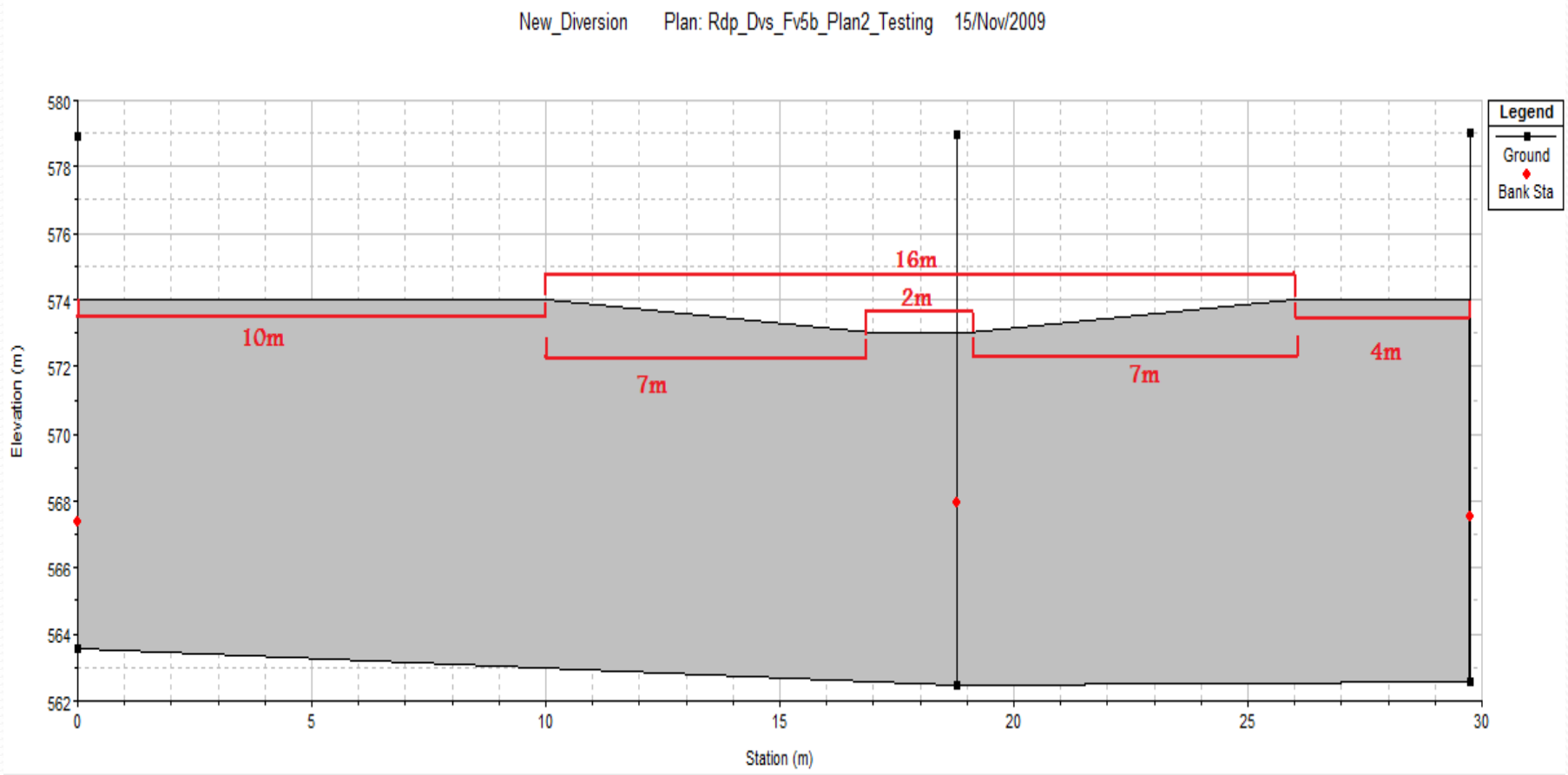


MAV Reservoir Level (when TD = 43.8Mm³/a)

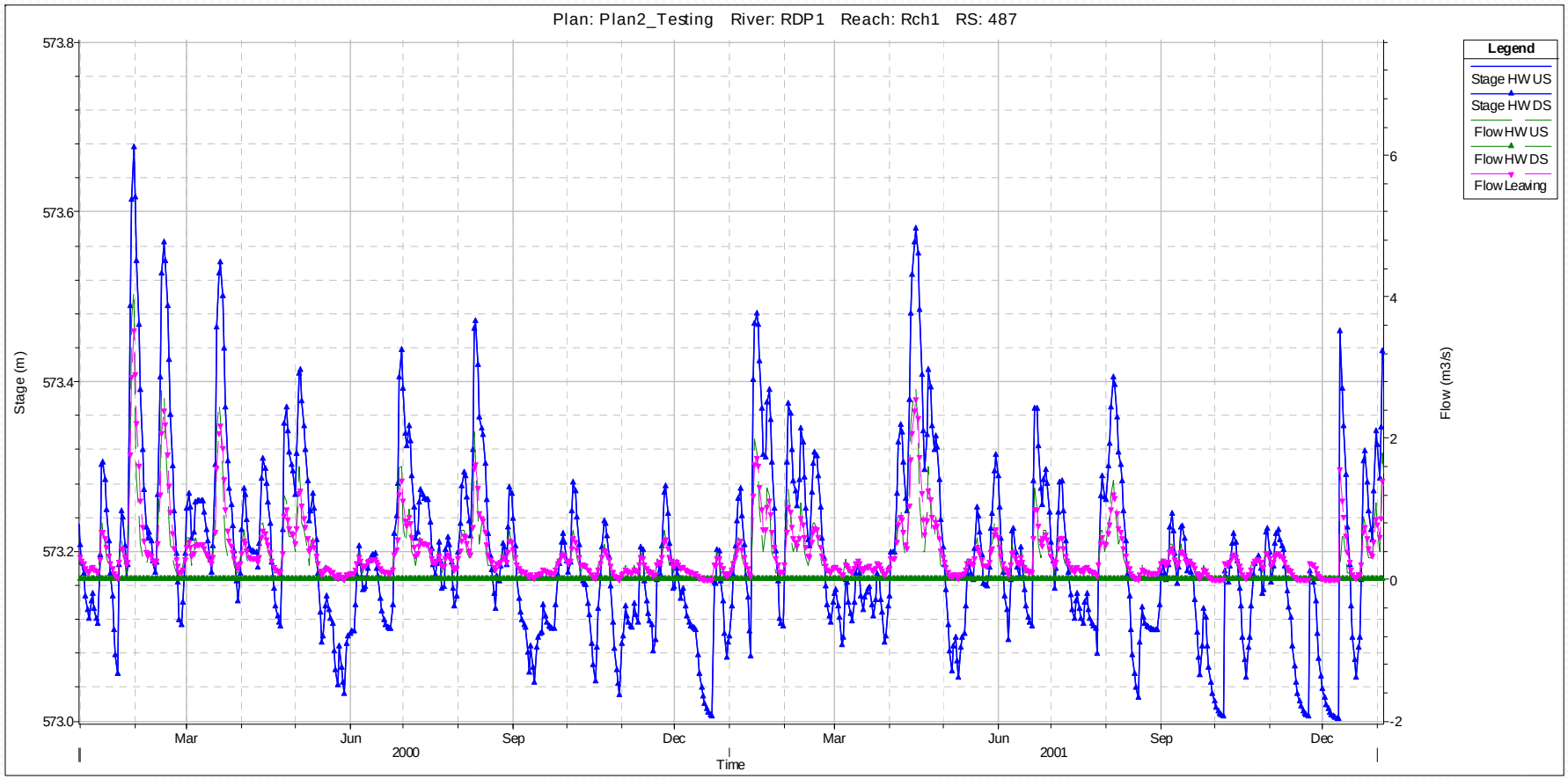
Modelling Results



Proposed (INLINE) Weir at Rivière du Poste downstream of the siphon

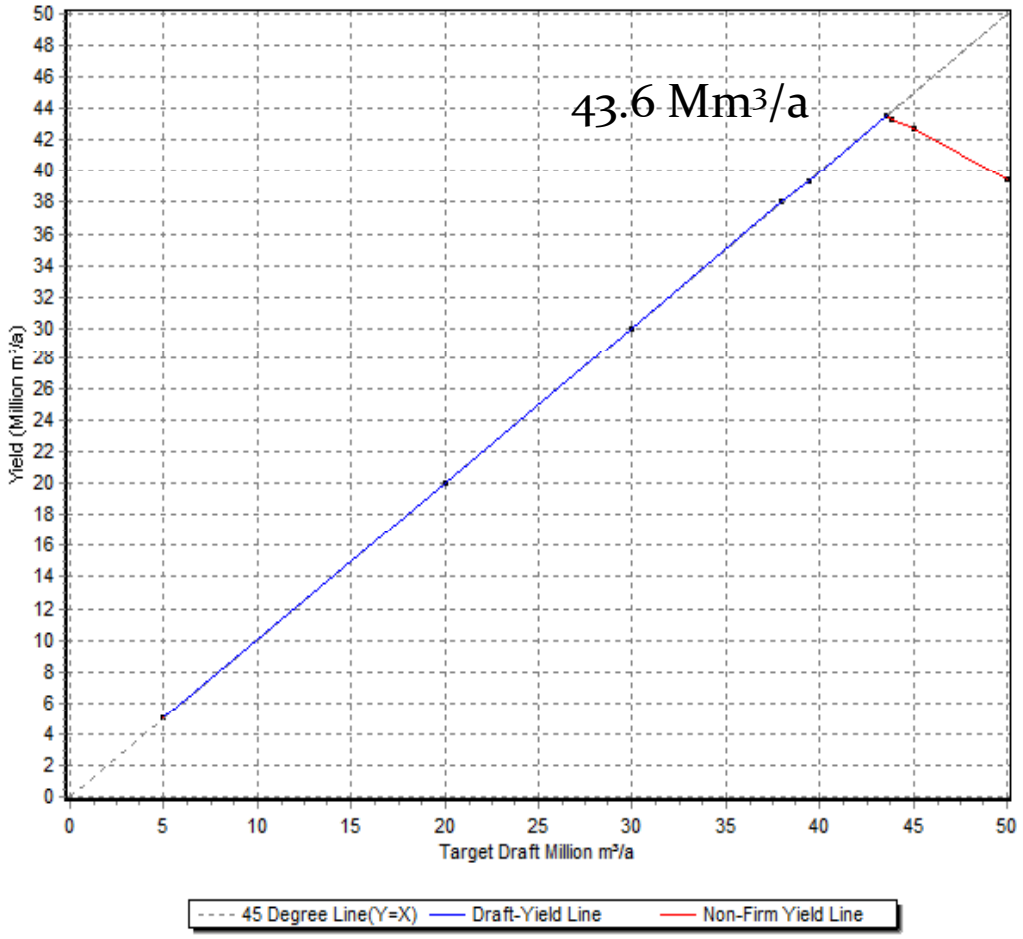


Proposed (LATERAL) Weir at Rivière du Poste downstream of the siphon

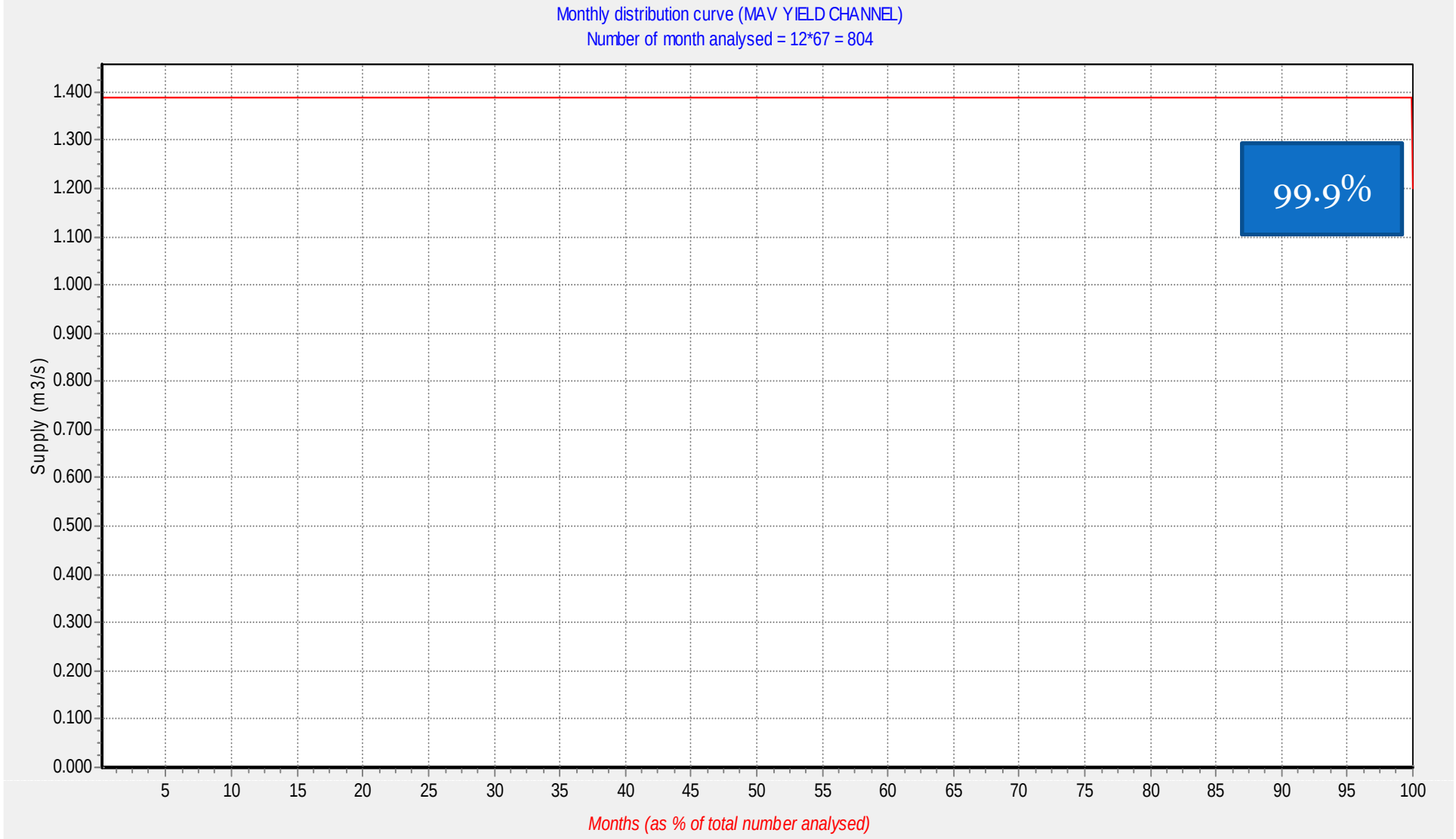


Lateral weir simulated hydrograph

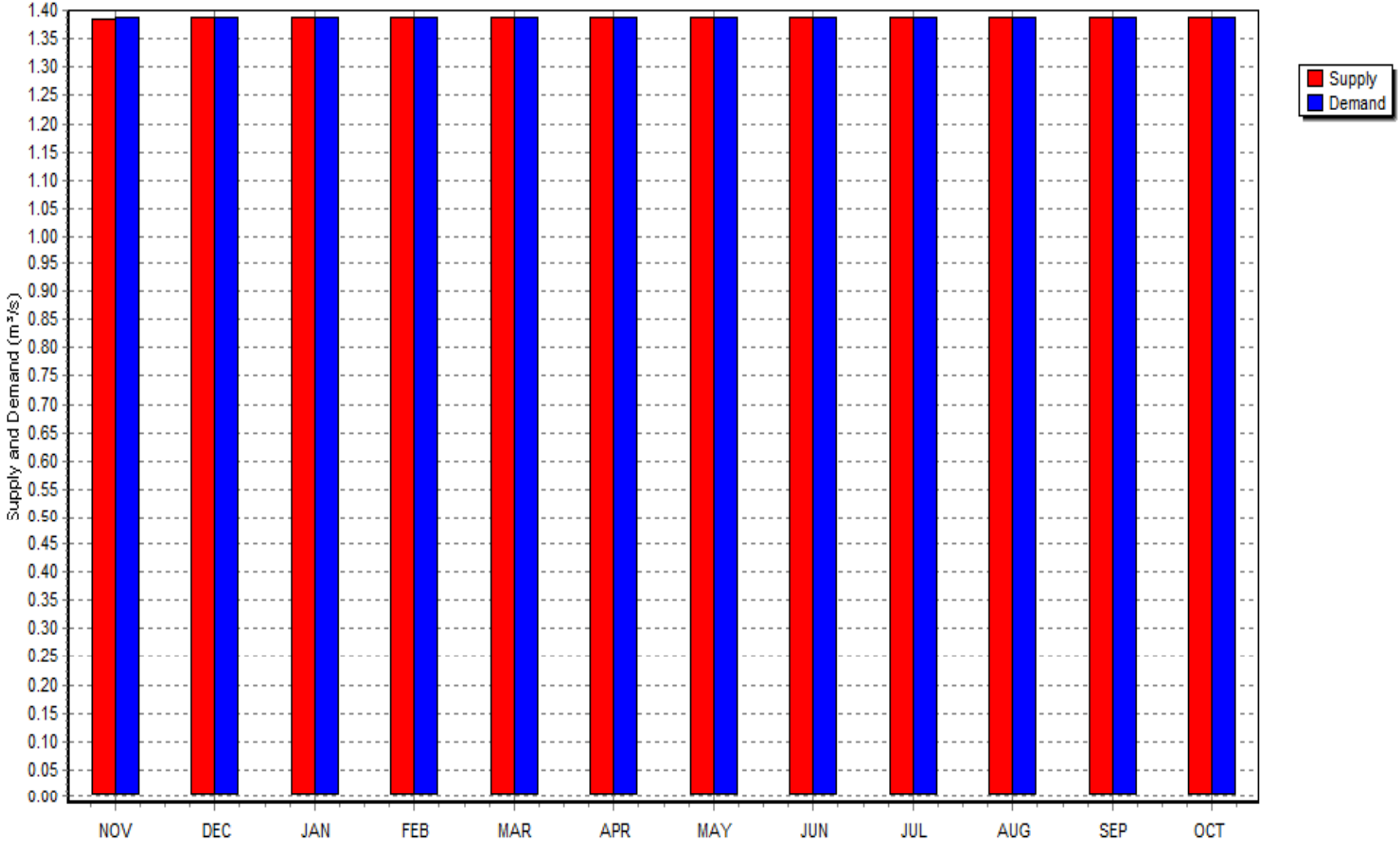
TD (Million m3/a)	Deficits (Proportion)	Yield (Million m3/a)
50.000	0.210	39.500
45.000	0.050	42.750
43.800	0.010	43.362
43.600	0.000	43.600
39.400	0.000	39.400
38.000	0.000	38.000
30.000	0.000	30.000
20.000	0.000	20.000
5.000	0.000	5.000

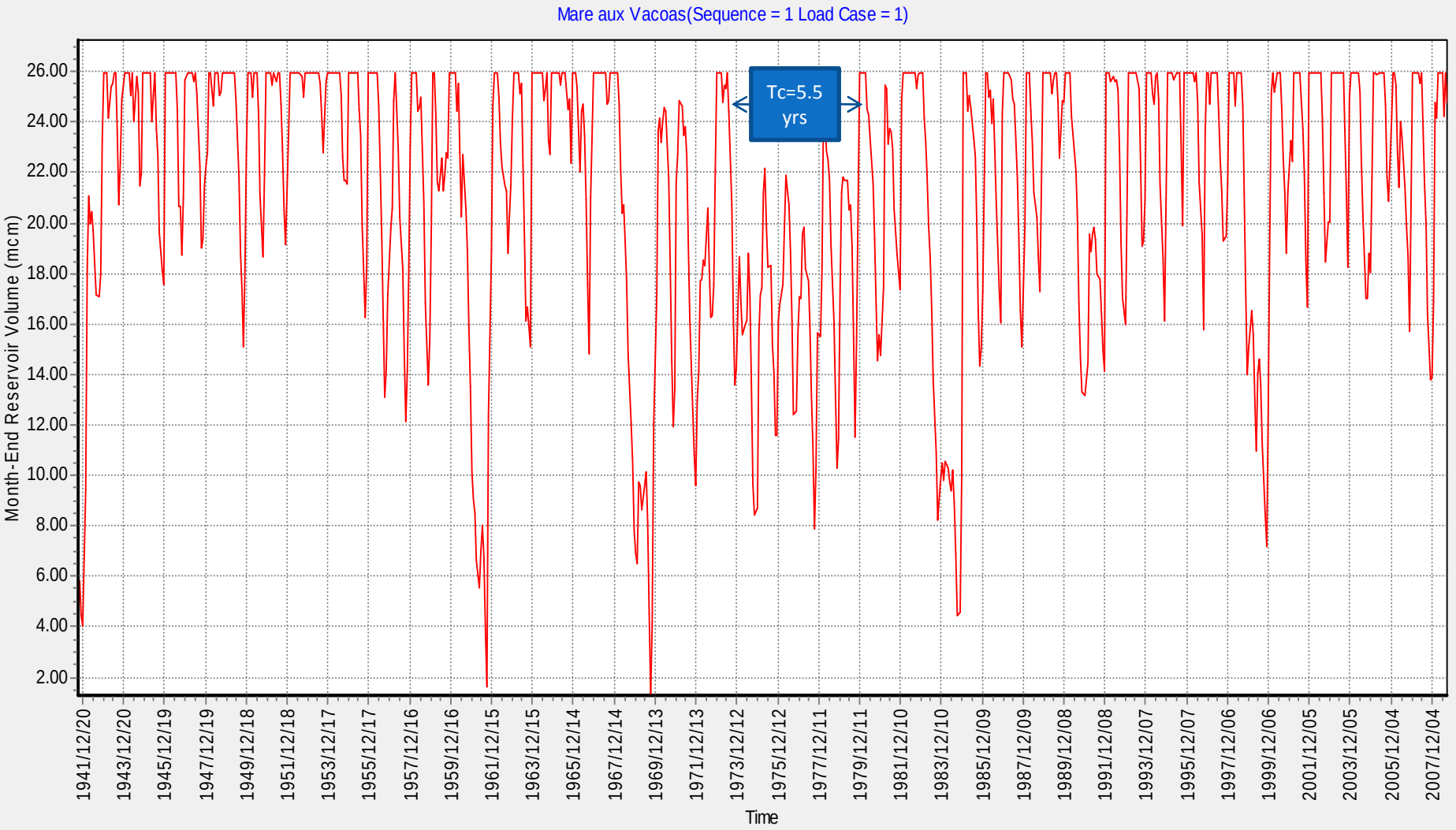


Firm yield of the MAV with the proposed diversion



Augmented MAV Reservoir : Target Draft = 120 Ml/day


Supply and Demand (m³/s)
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
Supply
Demand



Augmented MAV Reservoir Level (when TD = 43.8Mm³/a)

Conclusion

Although the full target draft of 43.8 Mm3/annum is not fully met, augmentation from the proposed diversion weir significantly improves the assurance of supply from 93% to an acceptable 99.9% over the simulation period of 804 months.

The project is now in the detail design phase, and improvements to the Pradier Canal's capture efficiency is likely to further enhance the supply capability to meet the 2025 target demand.

Thank you