Closing the (widening) gap between water resources and water needs in the Jordan Basin region: A long term perspective

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11th Annual IWREC Meeting

EFFICIENCY AND WATER CONSERVATION: METHODOLOGIES AND CASE STUDIES

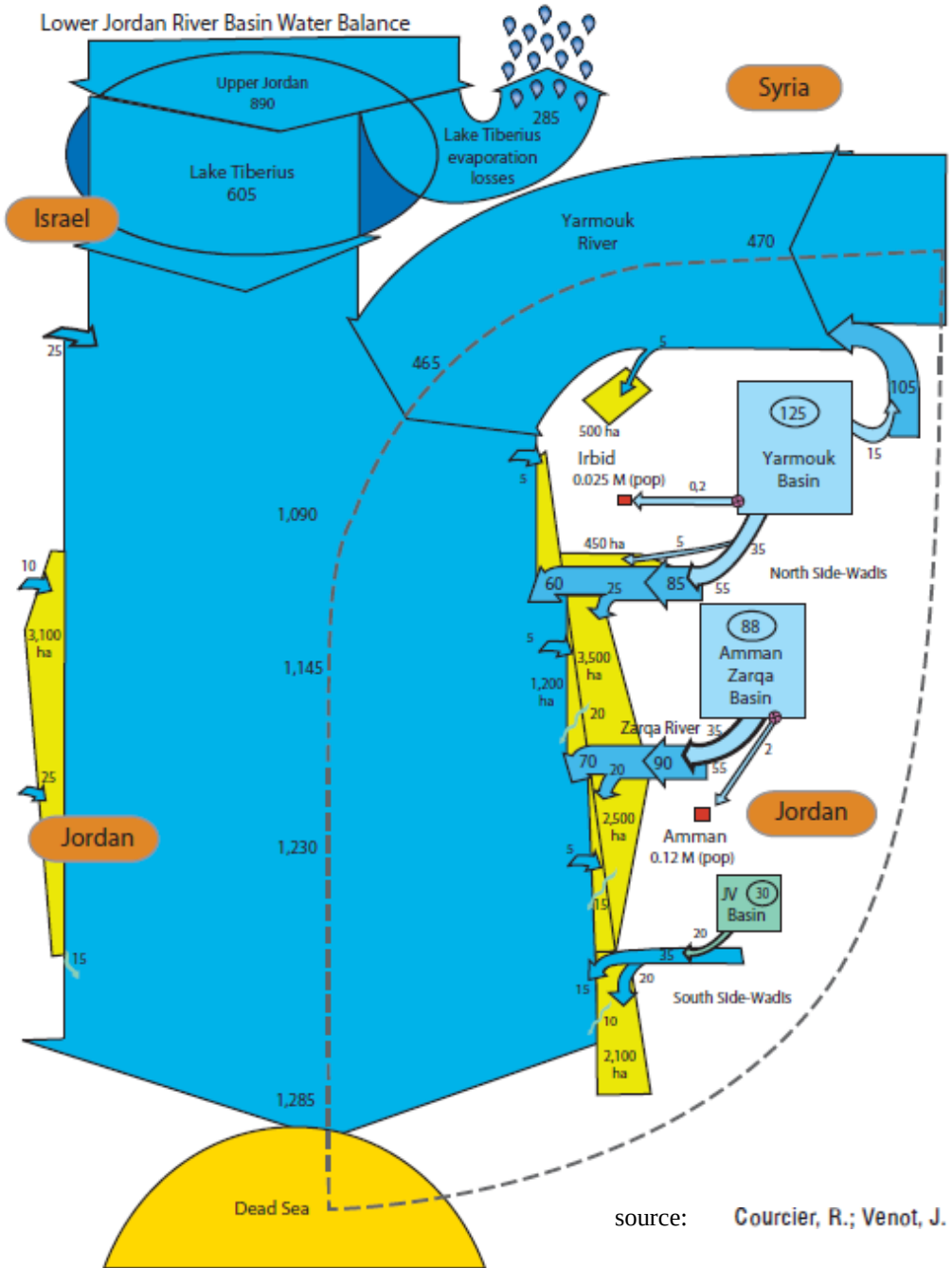
The World Bank, Washington, DC, September 7-9, 2014

Study area


Gaza
Mujib (Arnon)
Amman
Zarqa (Yabok)
Tel Aviv
Yarmouk
(460 MCM/y)
Haifa
Kineret (Sea of Galilee, Lake Tiberius)
(500 - 550 MCM/y)

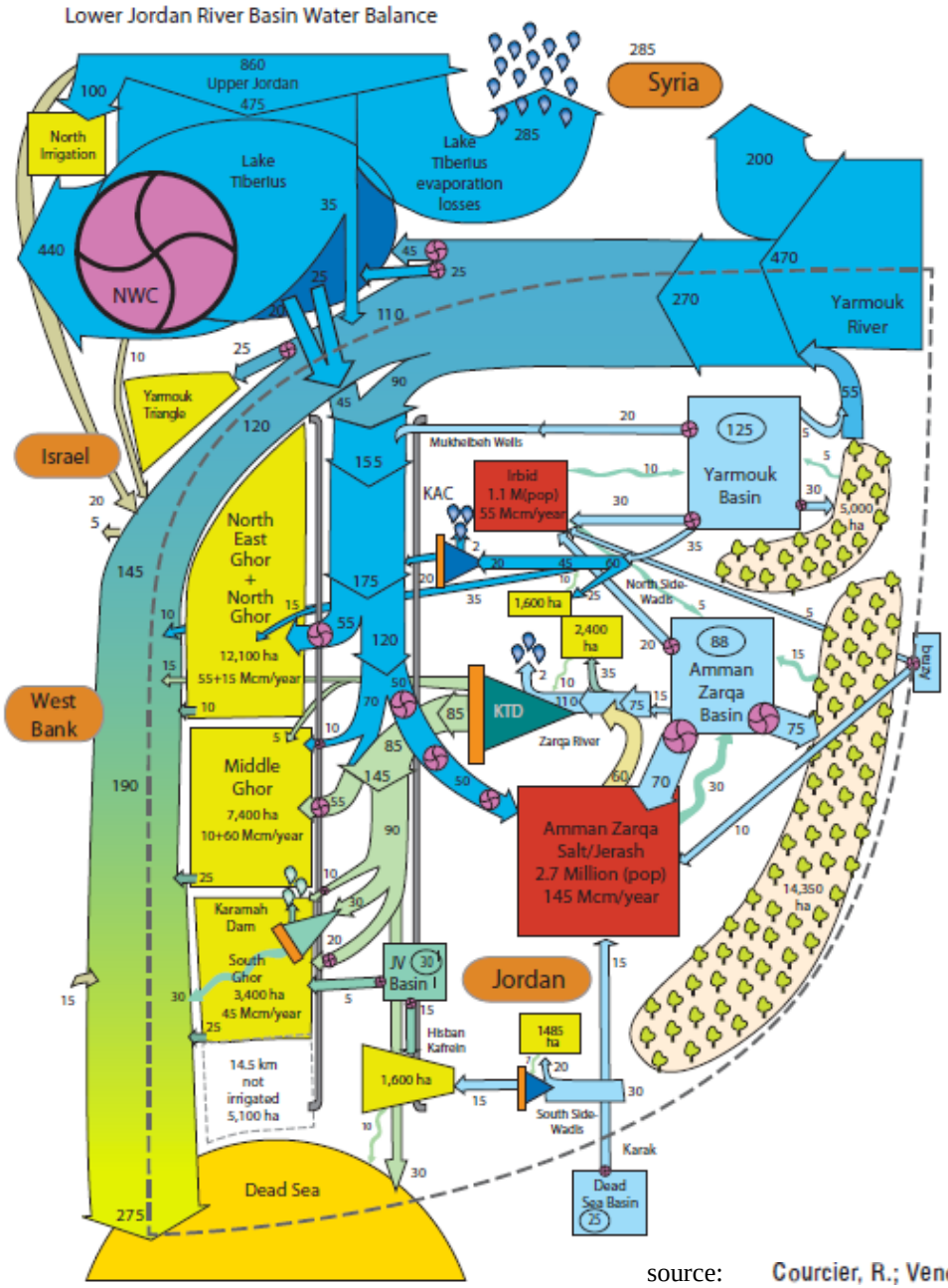
FIGURE 7.
Water resources development in the LJRB around 1950, before the development of major diversion schemes.

Jordan River: 1950 flows



source: Courcier, R.; Venot, J. P.; Molle, F. 2005.

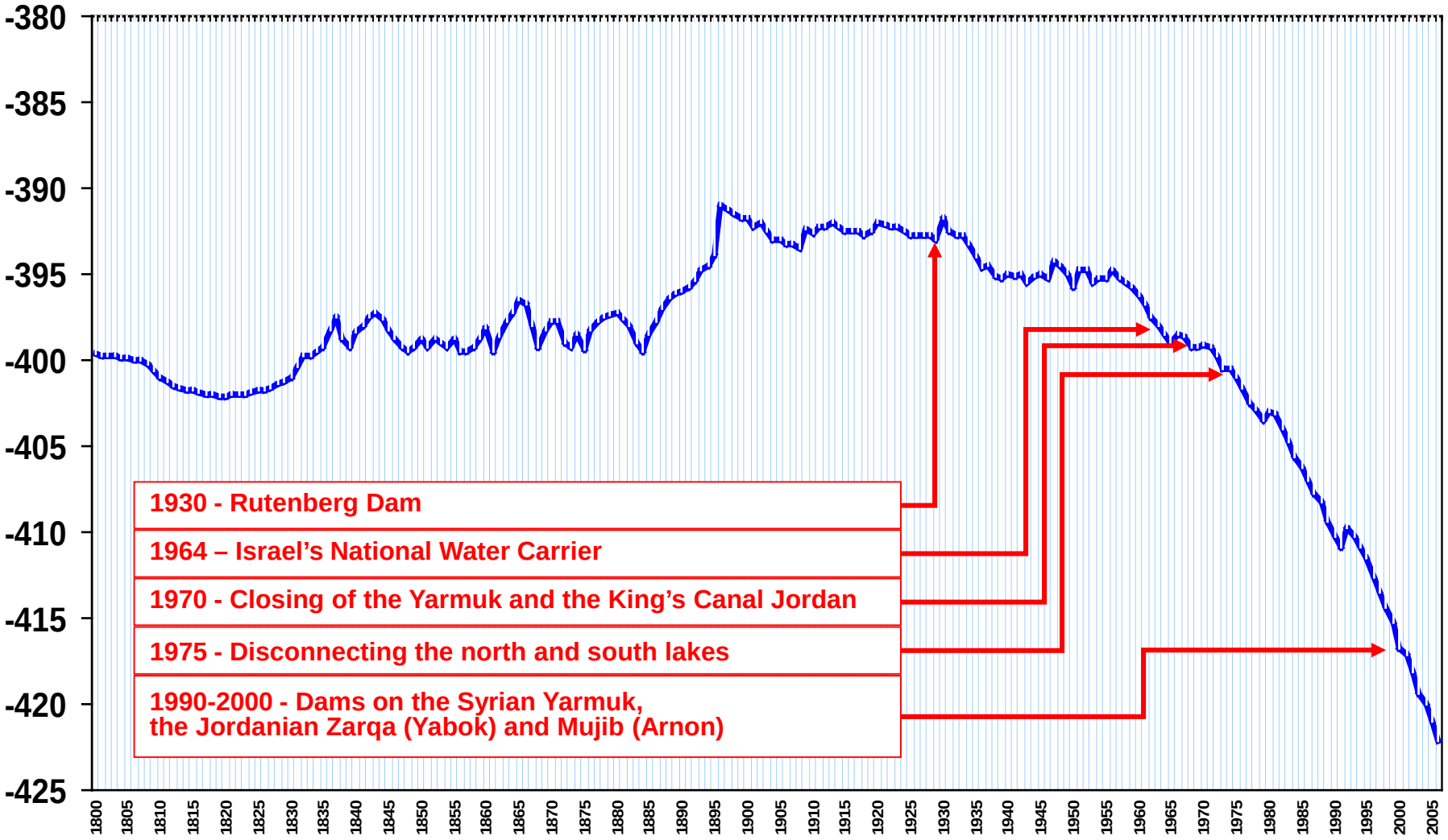
JR: 2000 flows



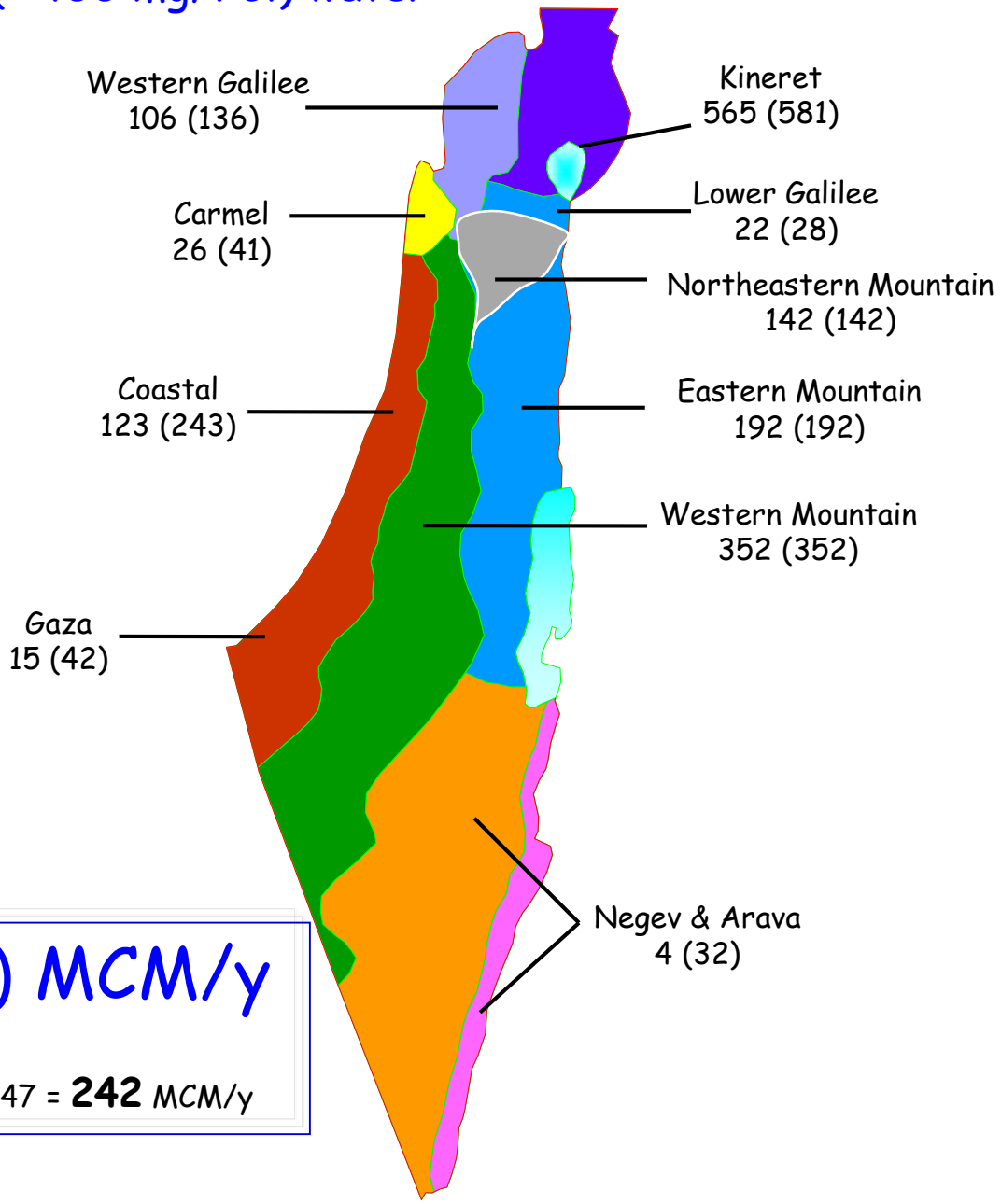
source: Courcier, R.; Venot, J. P.; Molle, F. 2005.

Al Wehdah dam (8 May 2010)

Dead Sea Level 1800-2006



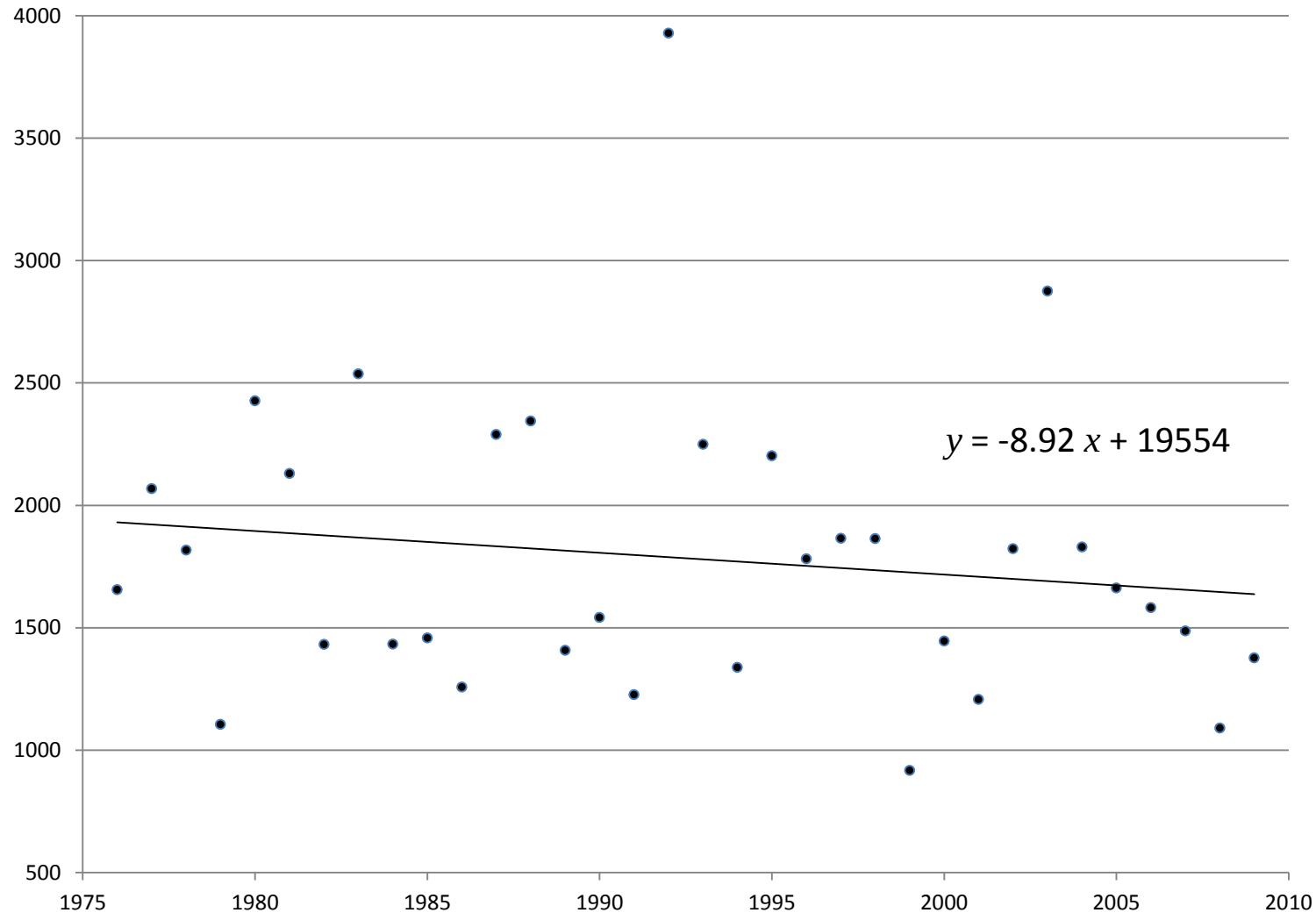
Average annual Natural Recharge 1973 – 2009 (MCM/y)
without (with) brackish (> 400 mg/l Cl) water



Total: 1547 (1789) MCM/y

Brackish (> 400 mg/l Cl): 1789 – 1547 = **242** MCM/y

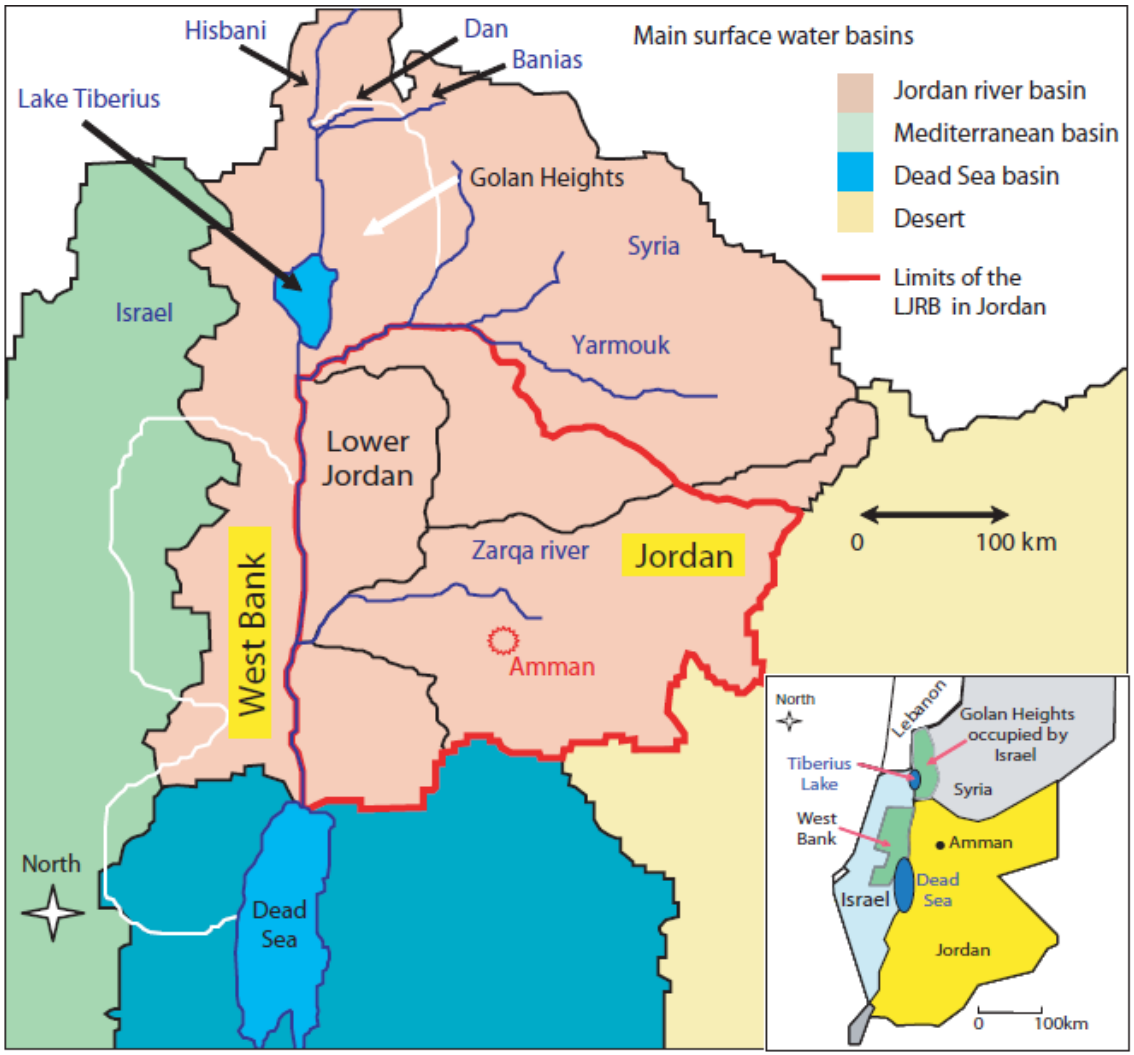
Natural recharge observations west of the Jordan River: 1976 - 2009



Jordan's renewable water

Source	MCM/y
Groundwater (safe yield)	275
Surface Water (by 2022)	365
Artificial recharge (in 2007)	55
1994 Peace Treaty (from Lake Kinneret)	50
Total	**745**

Source: Jordan's Ministry of Water and Irrigation, 2010, *Jordan's Water Strategy, Water for Life, 2008-2022*.



Natural renewable water resources (MCM/y)

Israel and PA: 1789 – 242 = 1547 MCM/y

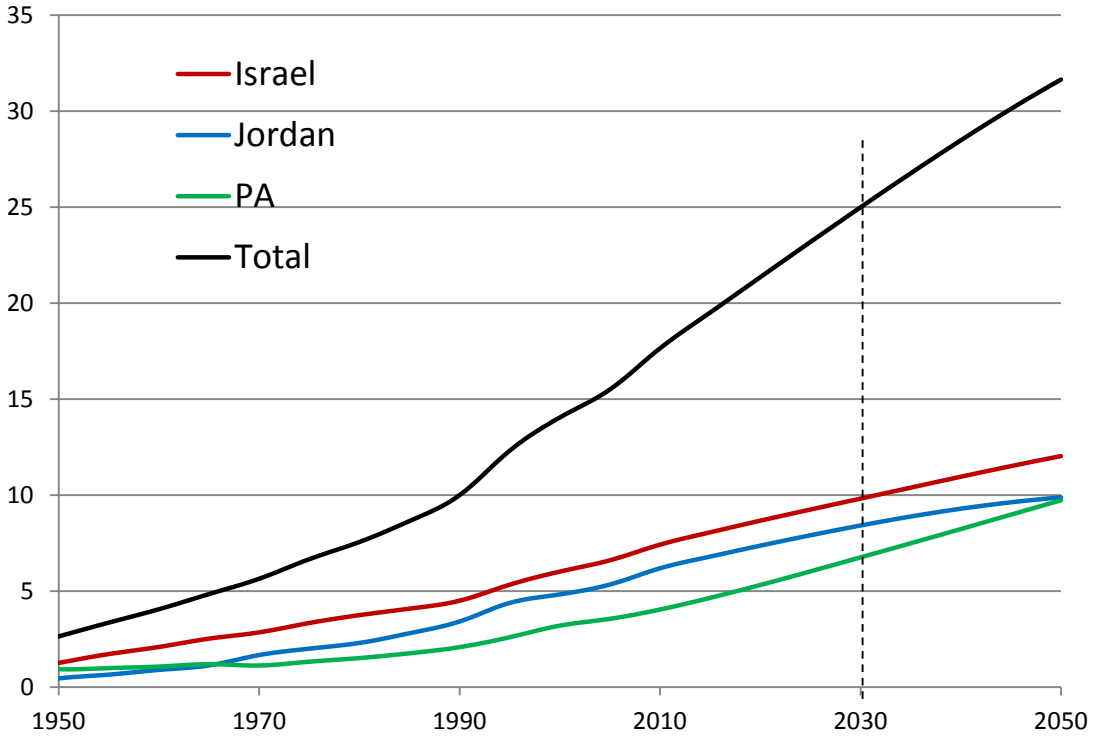
Jordan: 745 MCM/y

Total: 2292 MCM/y

High fluctuations; Declining trends

The arithmetic of water scarcity: m3/person/year

Population (million)



2300 MCM/y

Population (million)	m3/person/year
Today: 18.8	**122**
2030: 25	**92**
2050: >31.6	**72**

(m3/person/y)

1700 ➔ Water stress,

1000 ➔ water scarcity

500 ➔ absolute scarcity

100 ➔ subsistence

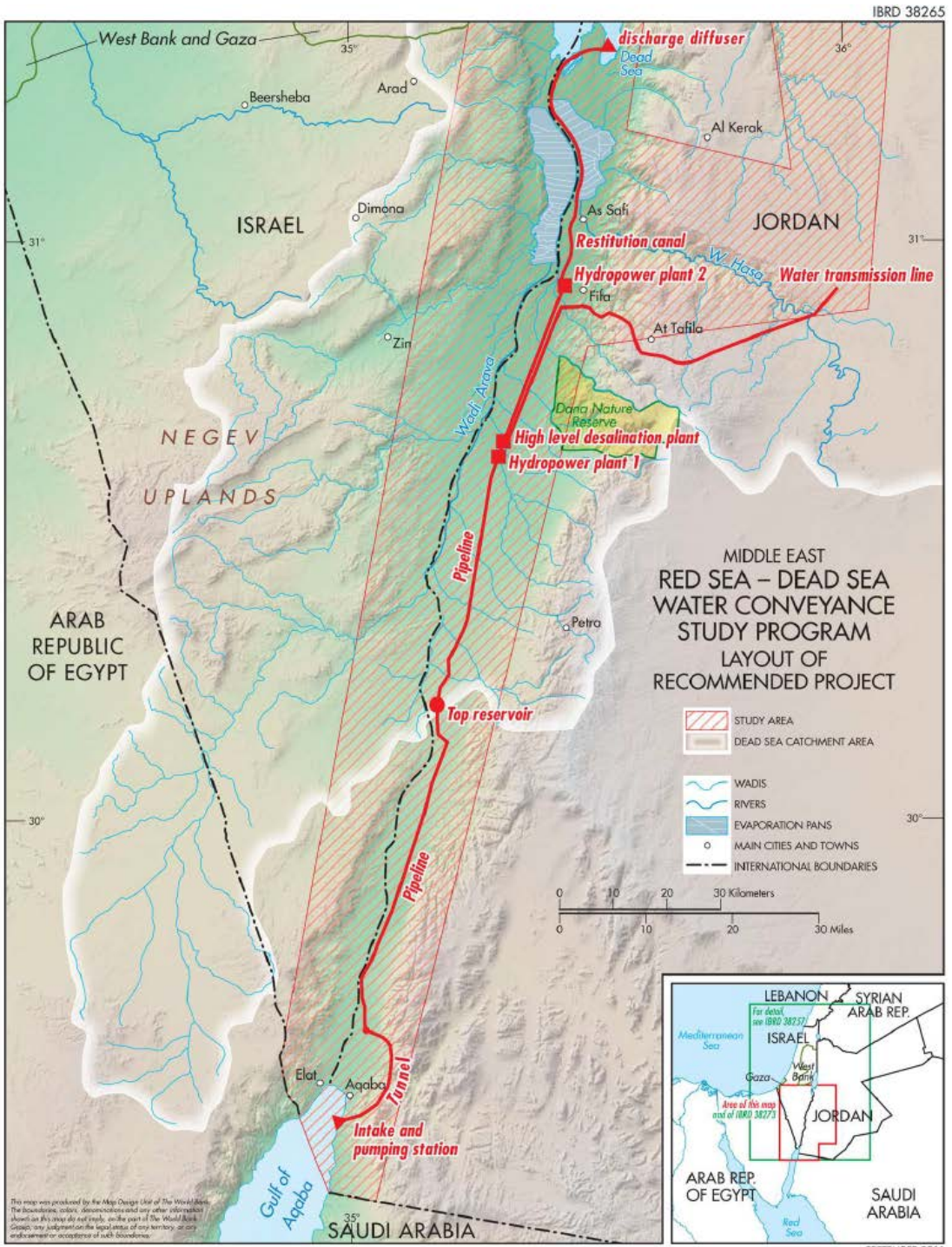
Study area

The proposed Red Sea – Dead Sea project

- Convey 2000 MCM/y from Red Sea to Dead Sea (phased over 40 years)
- Use elevation diff to generate electricity
- Desalinate 850 MCM/y (mostly to Amman)
- Discharge 1150 MCM/y of brine in the Dead Sea

Proposed project

- Phased construction
- Cost > 10 billion $US



Study Program (www.worldbank.org/rds)

1. Coyne et Belleir: Engineering and economic feasibility
2. ERM: Environmental and Social impacts
3. Thetis & Israel Oceanographic and Limnological Research: Gulf of Aqaba impacts (coral's ecosystem)
4. Tahal & Israel Geological Survey: Dead Sea impacts
5. Study of Alternatives

Main findings

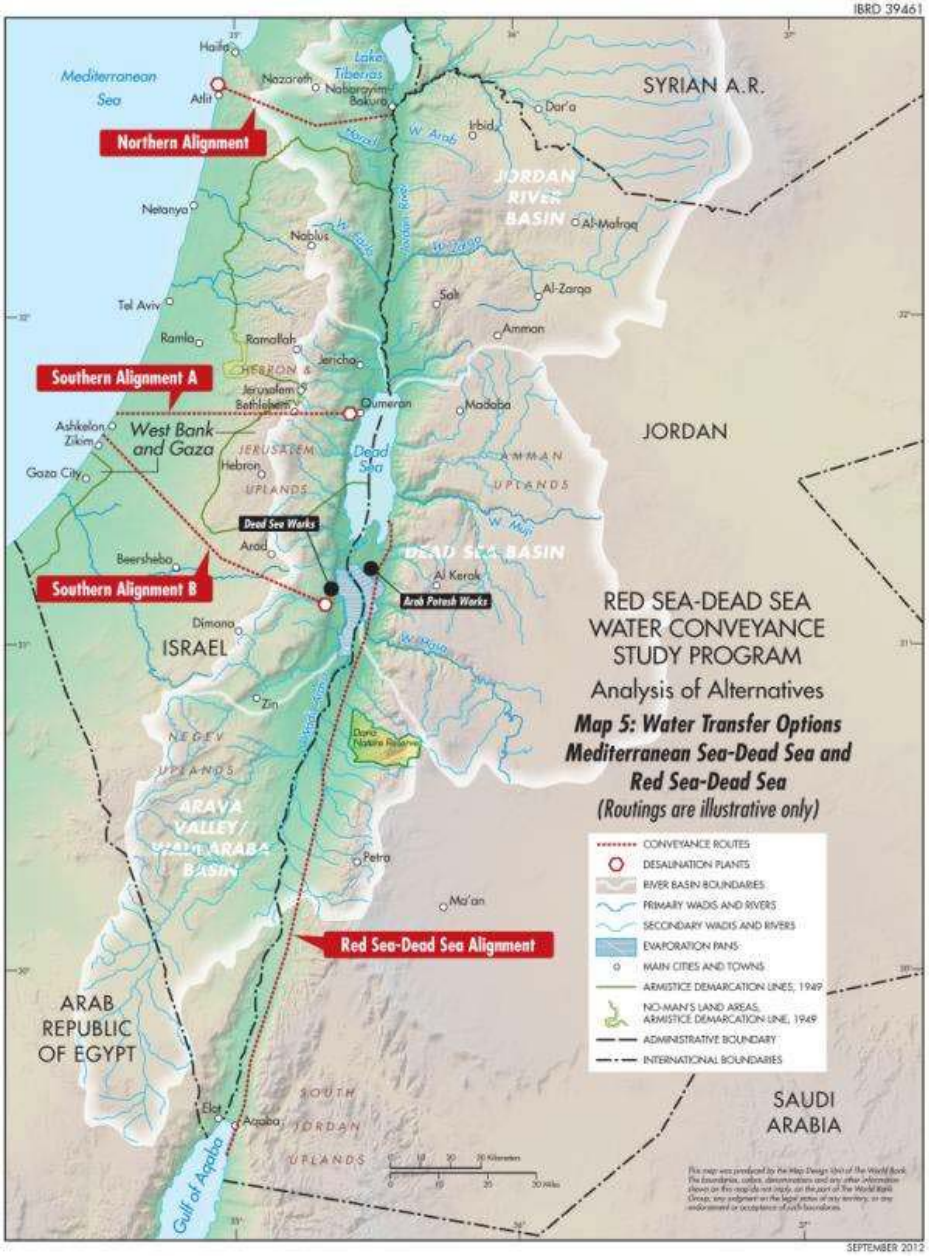
Thetis & IOLR

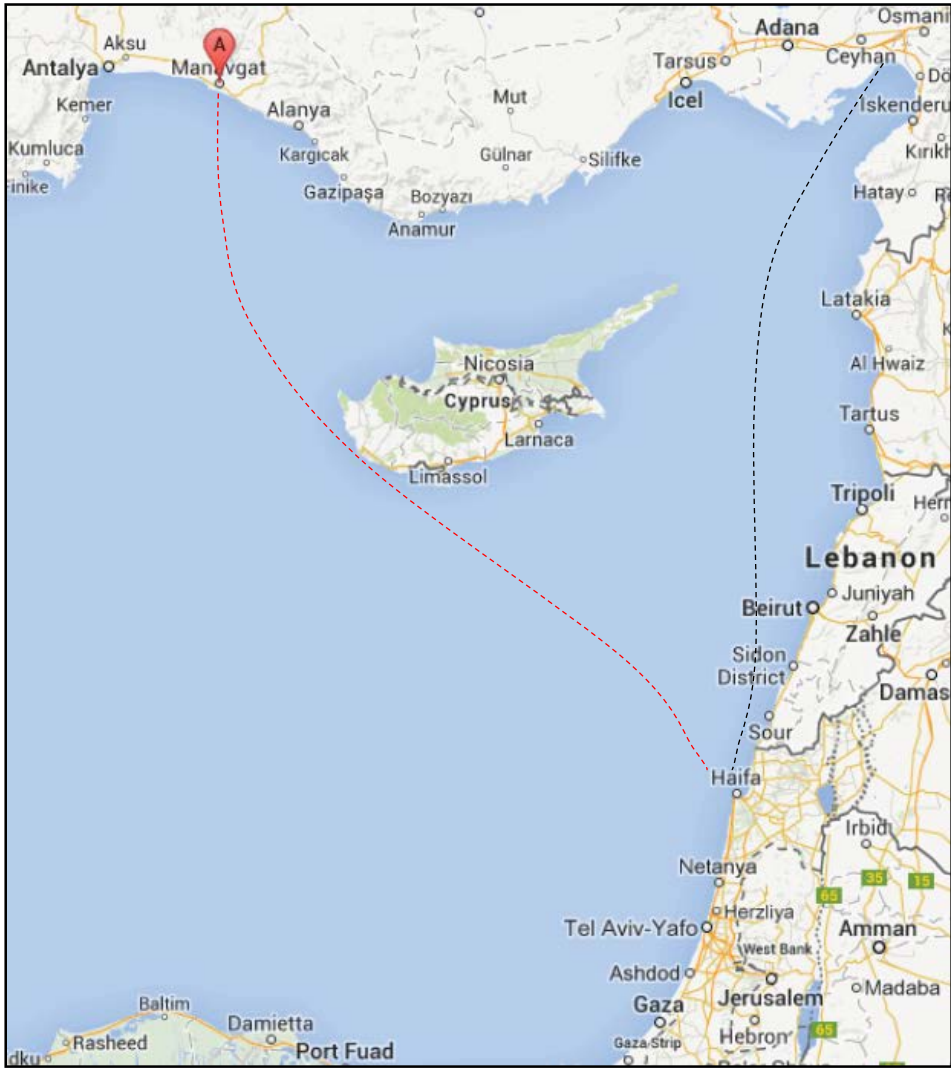
- No impact on coral reef if water is pumped below 140 m from surface

IGS & Tahal:

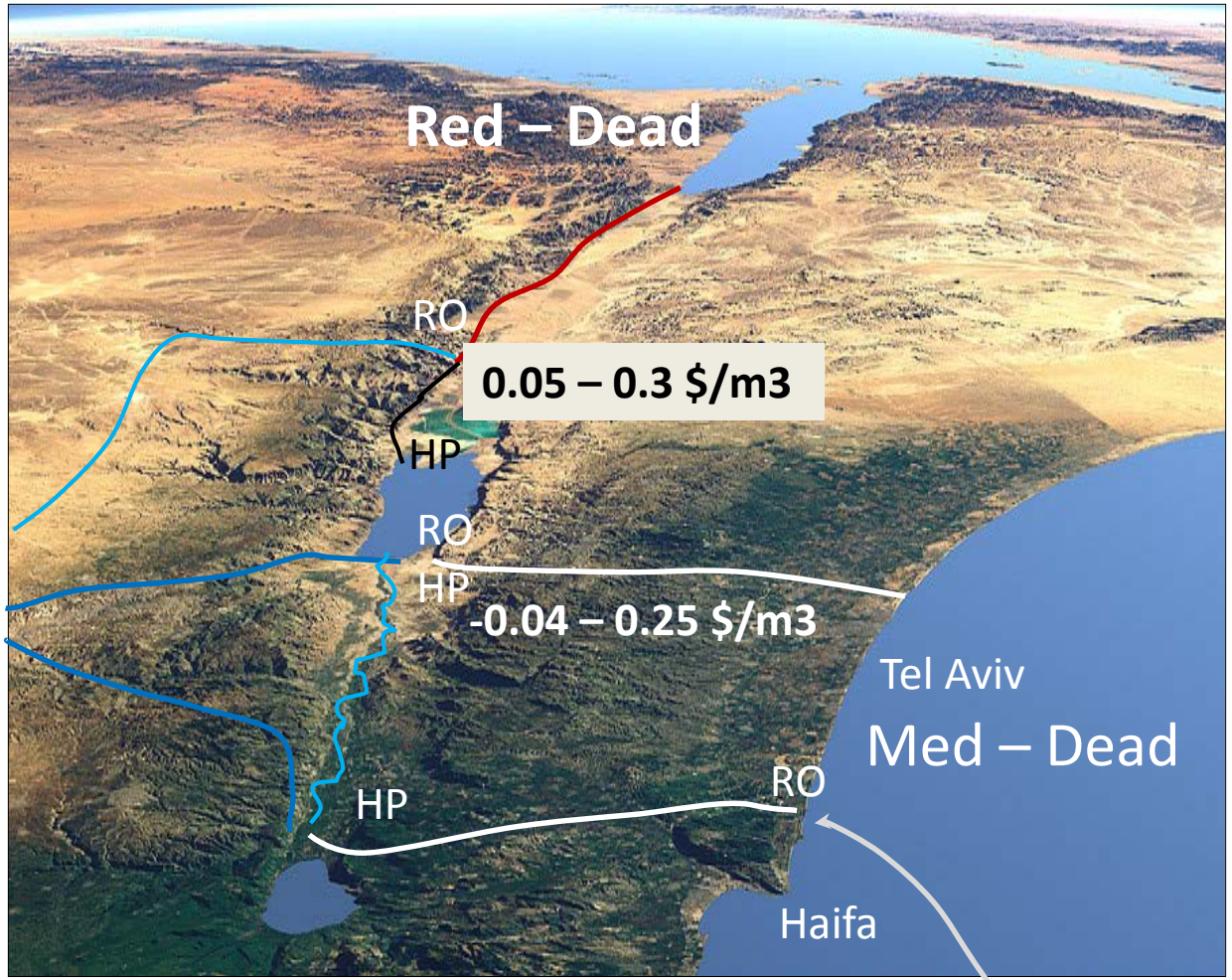
- Need 700 – 800 MCM/y to stabilize DS at 425 mbsl (DS level at the time of study)
- Under BAU, DS will continue to decline (-550 or lower)
- Up to 400 MCM/y of brine discharge:
  - Gypsum crystallization unlikely
  - Major stratification unlikely
  - Algae bloom unlikely

Study of Alternatives





SoA's main findings



1.25 – 1.5 $/m3

Amman

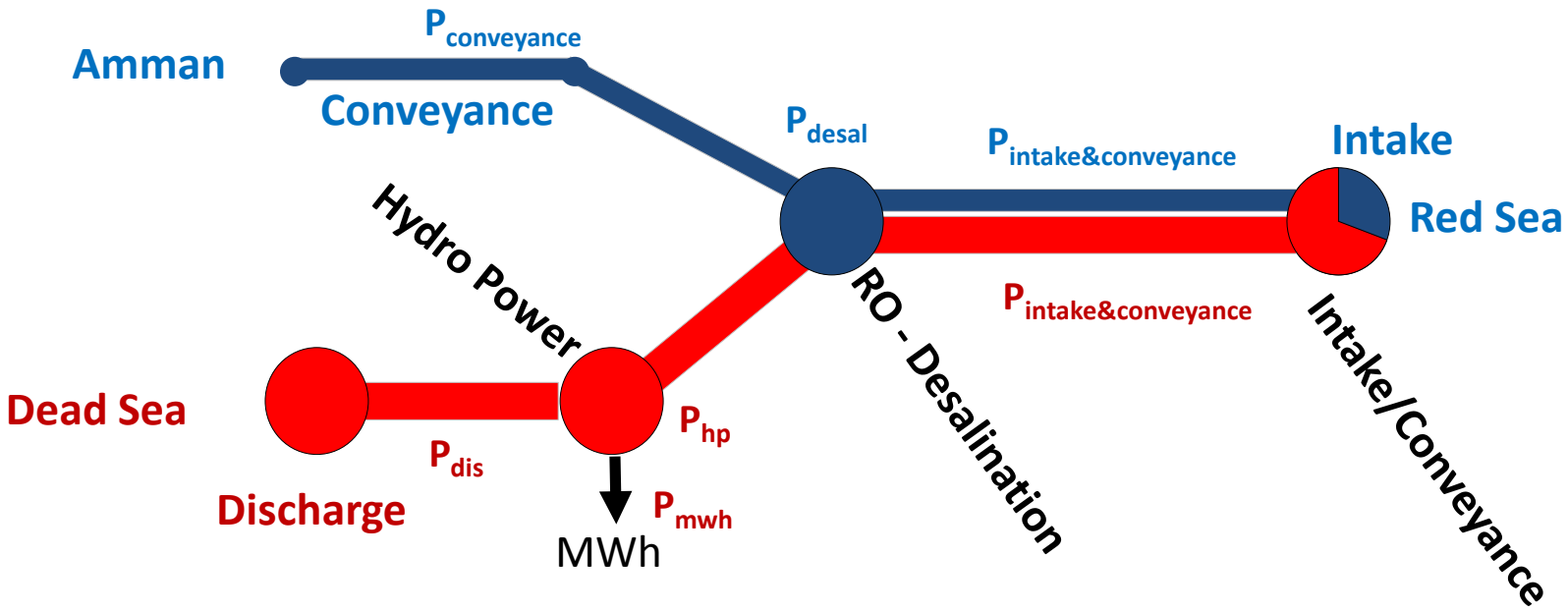
0.95 – 1.14 $/m3

Gaza

Turkey, Croatia

RSDS – cost calculation scheme

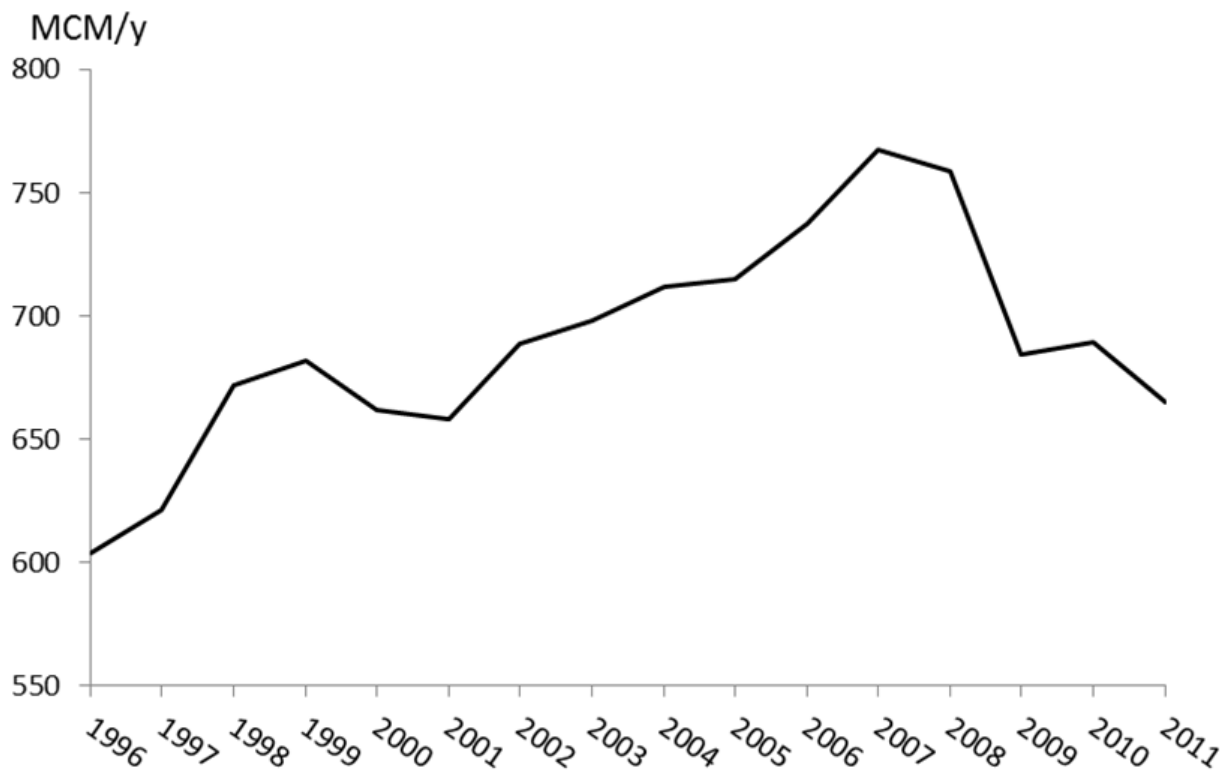
$$P_{Amman} = P_{intake\&conveyance} + P_{desal} + P_{conveyance}$$



$$P_{Dead\text{-}Sea} = P_{dischrge} - P_{mwh} + P_{hp} + P_{intake\&conveyance}$$

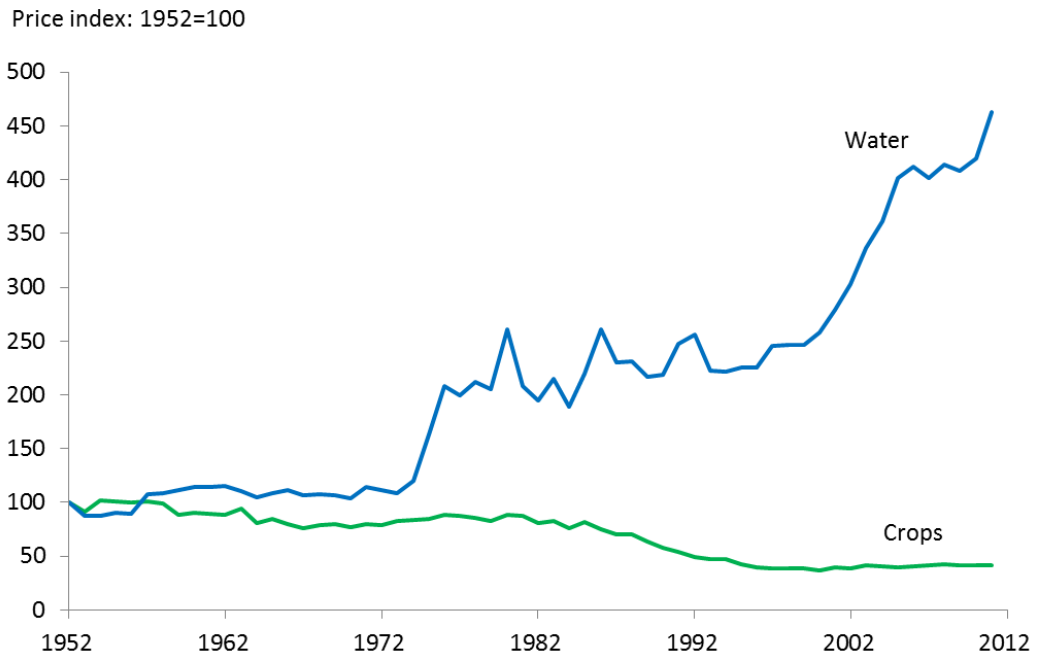
Combined Alternative: Recycling, Conservation , Desalination at Aqaba and Mediterranean

Demand management: domestic water pricing



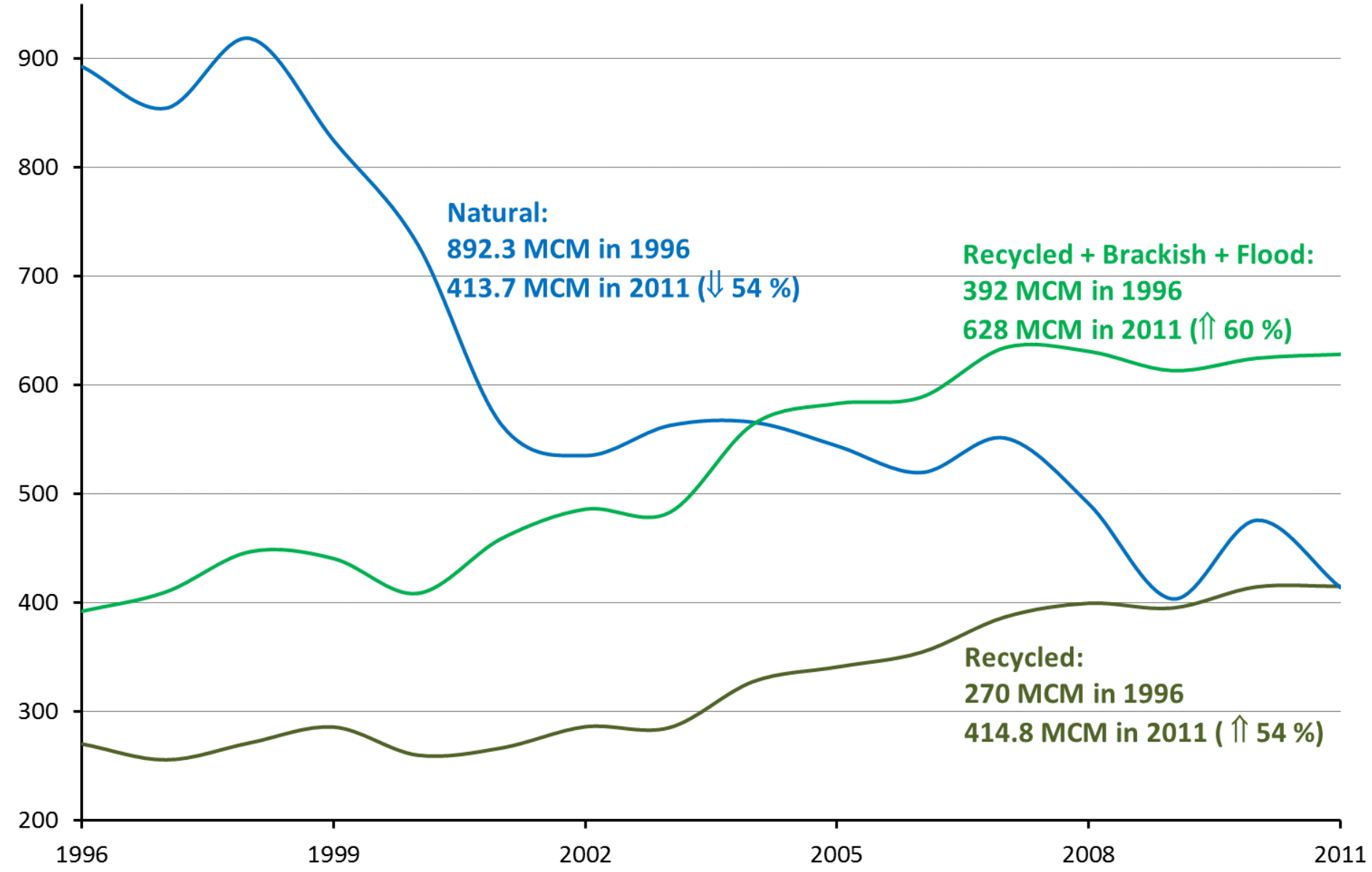
Domestic water consumption (MCM/y) in Israel during 1996 – 2011.
Source: Israel's Water Authority. 2011. Water consumption by sectors: 1996 – 2011 (in Hebrew). http://www.water.gov.il/Hebrew/ProfessionalInfoAndData/Allocation-Consumption-and-production/20112/1996-2011.pdf.

Demand management: irrigation water pricing



Trajectories of the price indices of natural (non-brackish) water in agriculture and of crops' prices during 1952 – 2011 (1952=100, adjusted for consumer price index). Source: Kislev and Tzaban (2013), based on publications of Israel's Central Bureau of Statistics.

Water allocation in Israel's Agriculture: 1996 - 2011



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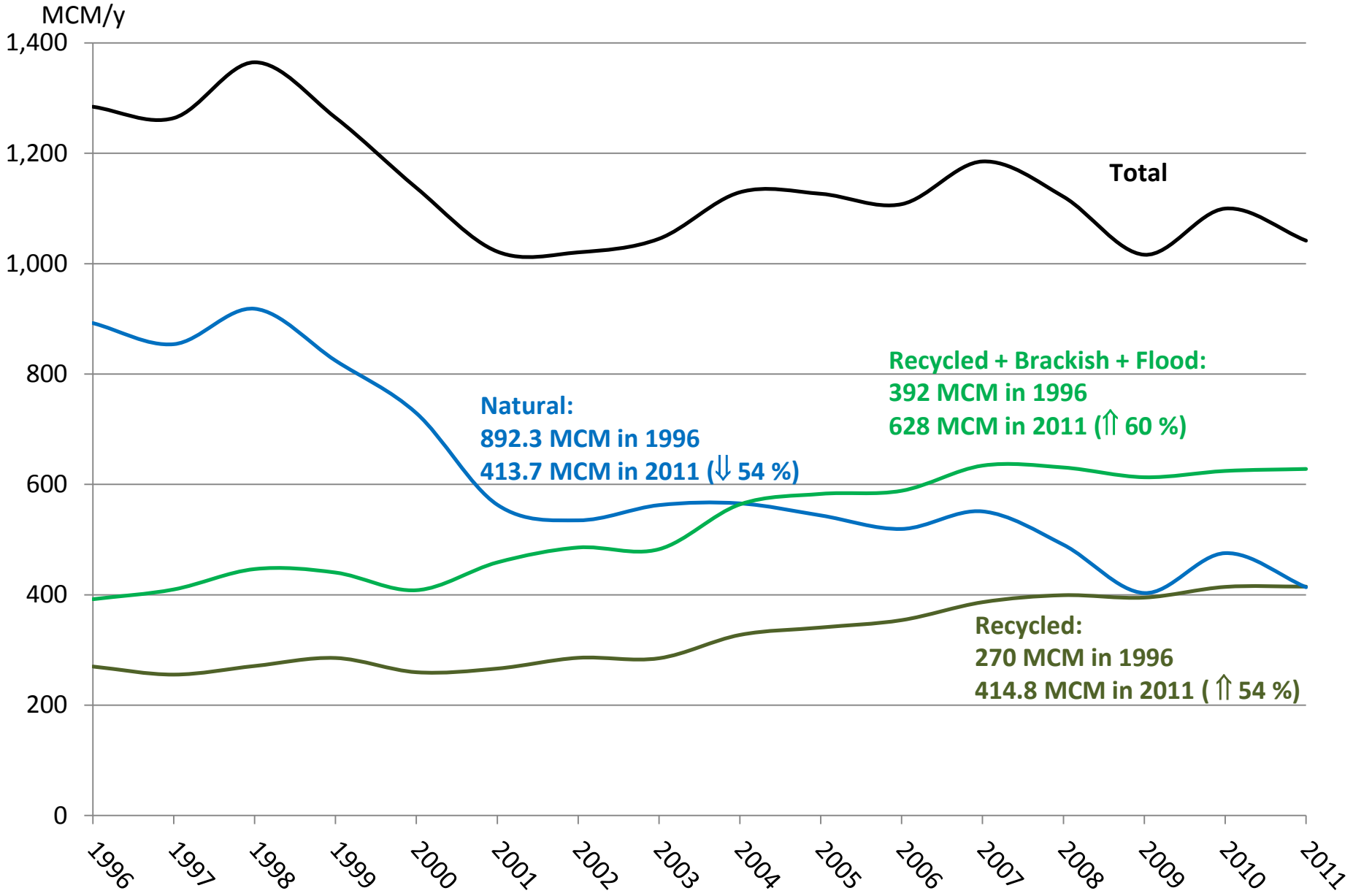
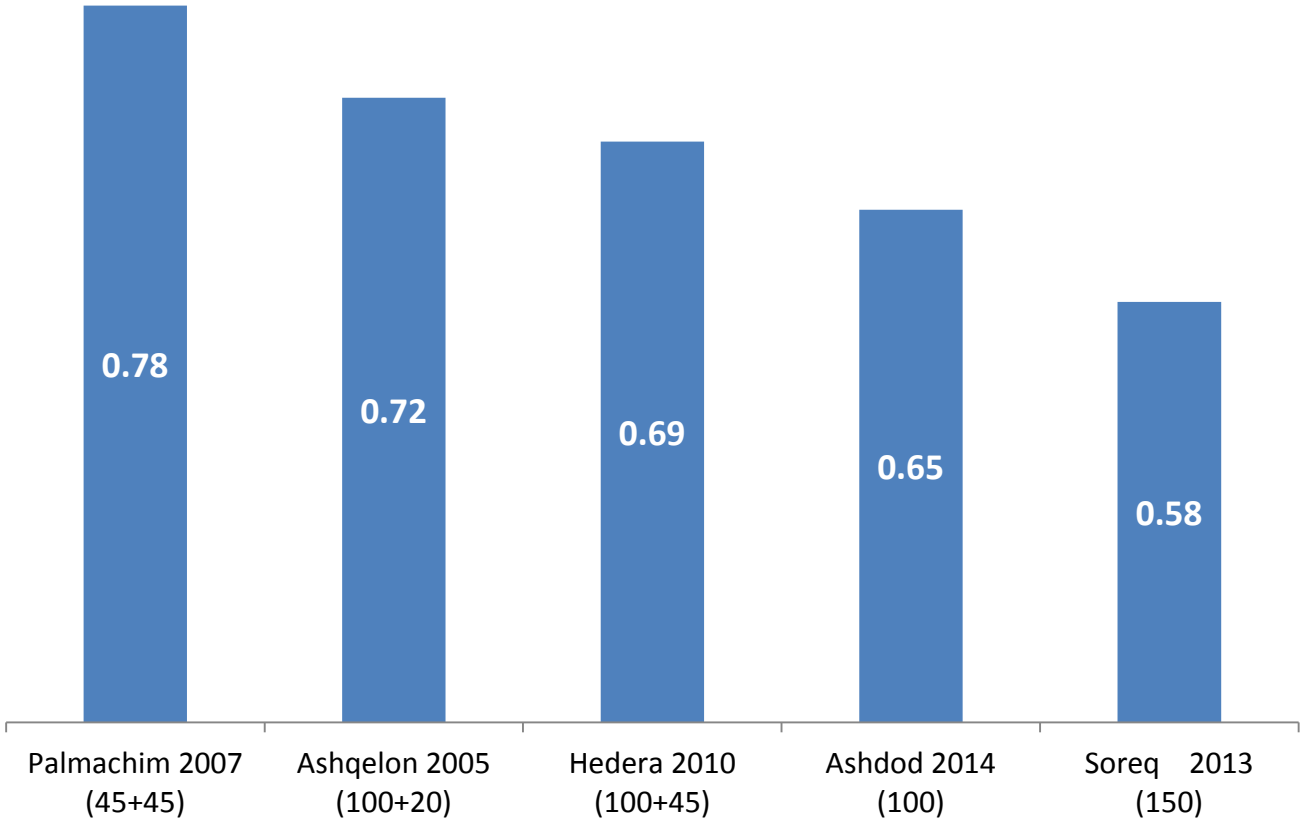
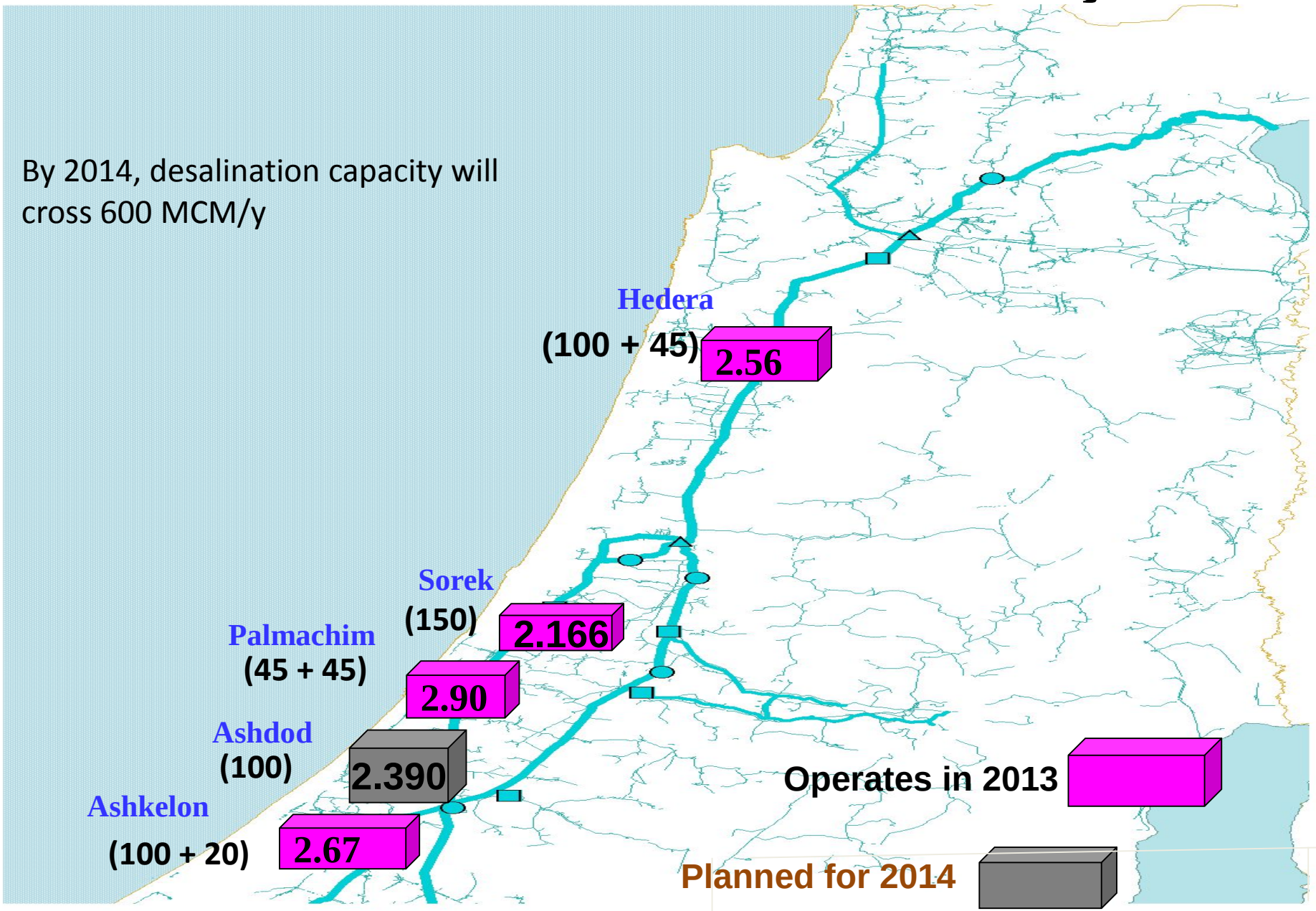


Supply management:
Desalination cost ($/m3 at plant's gate)

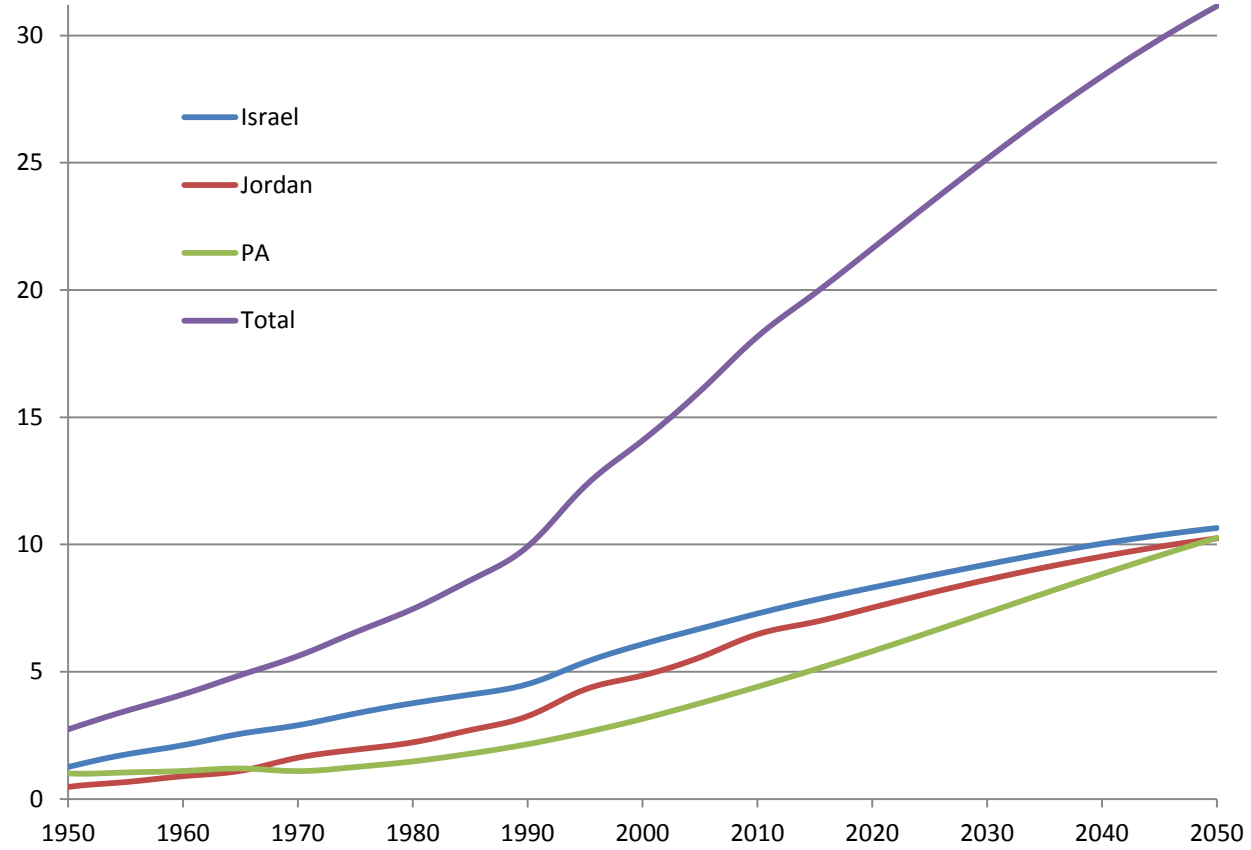
(x-rate: $US 1 = 3.7 NIS)



Israel's desalination (MCM/y)



Population (again)



Israel's water economy's Master Plan

Water Sources (MCM/y)

סך הכל היצע*	השלמה דרושה (3)	(2) Desalination	Brackish desalination	**Recycled**	**Brackish**	(1) Natural	Year
2,131	4	280	23	450	174	1,200	2010
2,672	9	750	50	573	150	1,140	2020
2,765	50	750	60	685	140	1,080	2030
3,571	671	750	70	**930**	**130**	1,020	**2050**

(1) סה"כ העשרה ממוצעת של מים שפירים טבעיים בניכוי איבודים עבור מים שהינם מתחת ל-400 מגכ"ל.

(2) "התפלת מים" – על פי החלטות ממשלה שאושרו.

(3) "השלמה דרושה" = הפרש בין סה"כ צריכת שפירים)טבלה התחתונה(לבין סה"כ מקורות המים השפירים.

300 - 400 MCM/y for environmental purposes (recycled, tertiary)

Agriculture Water consumption (MCM/y)

Total	**Recycled**	**Brackish**	**Natural**	**Year**
1,044	400	144	500	2010
1,138	528	120	490	2020
1,225	645	110	470	2030
1,450	900	100	450	**2050**

Additional water to Jordan (MCM/y):

- **100** from Lake Tiberias
- **100 – 200** from desalination along the northern Mediterranean coast (and/or water importation from Turkey -Manavgat)
- **200 - 300** from desalination in Aqaba – Dead Sea.
- **The 360** MCM/y brine discharged in the Dead Sea will augment the **400** MCM/y of recycled water to the rate needed to stabilize the DS at its current level (avoiding the discharge of brine into the ecologically sensitive Gulf of Aqaba/Eilat)
- **The scale** of this mini Red Sea – Dead Sea project is about 20% of the full scale project

Possible allocations of the desalination between Aqaba and the Dead Sea

Desalination Location	Potable Water (MCM/y)	Brine Discharge in the Dead Sea (MCM/y)	Potable Water Distribution
Aqaba Area	100	120	Aqaba, Eilat and Araba/Arava
Dead Sea Area	200	240	Jordan (mostly Amman) and Palestinian Authority
Total	**300**	**360**	

Recycling, Conservation + Desalination at Aqaba and Mediterranean

- The potential supply of recycled water in the three parties combined four decades from now is likely to reach about 2,500 MCM/y.

- Of this potential supply, about 1,500 – 2,000 MCM/y will be allocated for irrigation (replacing the natural water that will be reallocated for households use). The residual supply of 500 – 1,000 MCM/y will be available for environmental purposes including river restoration.

- About 400 MCM/y could be allocated for LJR and DS restoration.

- A mini Red-Dead project will add about 360 MCM/y of brine in the DS.

- The cost of conveying the recycled water from treatment plants to upper LJR is far from negligible. The elevation difference (400 m to 1400 m) generates opportunities for hydropower generation. Combined with the hydropower profits, the overall conveyance cost will be reduced substantially.

Combined Alternative:
Mini Red – Dead + Desal + Kinneret + Recycled + conservation