Advancing Non-Conventional Water Resources Management in Mediterranean islands and coastal areas: local solutions, employment opportunities and people engagement

10-11 May 2018 - Seashells Resort, Qwara , Malta

Cyprus Water Management Case Experience with Desalination and Water Reuse

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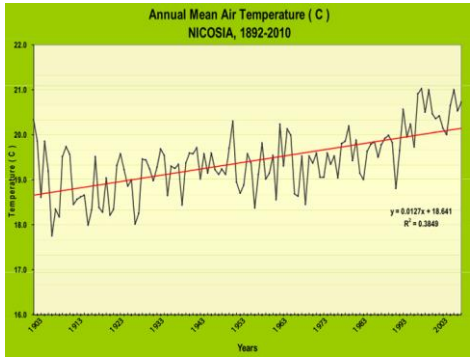
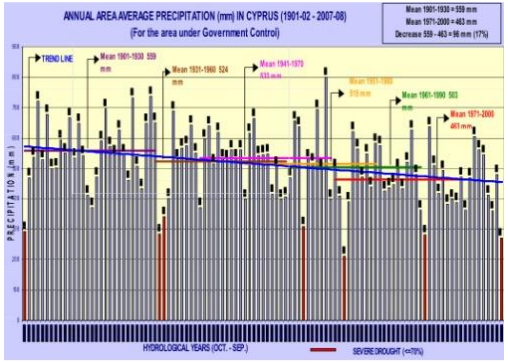
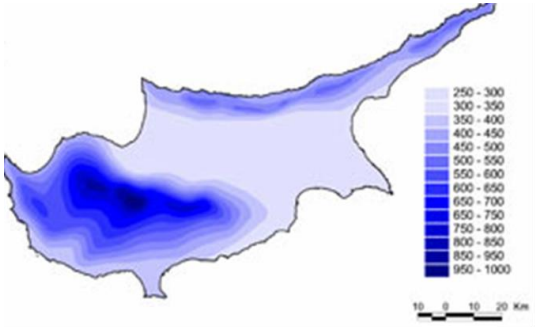
Short description about Cyprus

Cyprus is an island in the Mediterranean Sea

- Area: 9250 Km^2
- Population: 850,000 (under Government control)
- Type of Climate: Semi arid climate
- Cyprus is one of the "water poor" countries of Europe with limited water resources and frequent occurrence of droughts





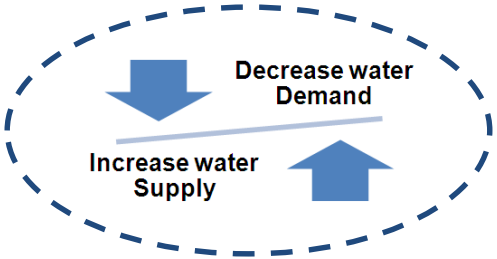


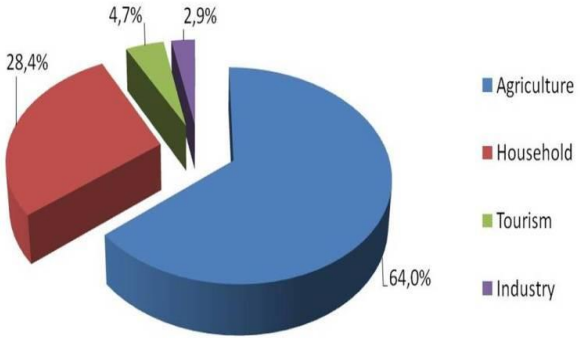
Climate models predict rise in temperature and increase in the intensity and frequency of extreme drought events

Water Management Master Plan

The Republic of Cyprus, during the late sixties started the implementation of a Water Master Plan

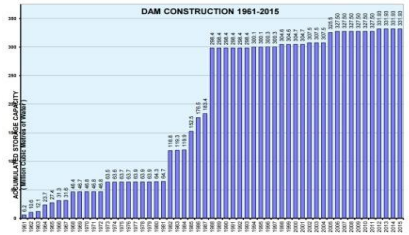
- **Objective**: to satisfy in a sustainable way the different users of water and safeguard human & other life.
- **Measures implemented:** to increase water availability and decrease water demand.





Water balance- mean values in Mm^3 for period 2000-2011

Rainfall:	476 mm
Inflow into groundwater	201
Outflow to the sea	62
Groundwater Balance	139
Inflow into surface storage	82
TOTAL Available (SW+GW)	**221**
SW Releases	60
GW extraction (Pumping)	146
TOTAL Releases/ Extractions	**206**
DEMAND	**250**
DEFICIT	**– 44 (+33*+8**)**



Increased storage capacity through dam construction

Water Demand Management Measures

- **Education and Awareness Campaigns**
- **Leakage Reduction in Distr. Networks**
- **Economic incentives**
- **Water saving devices**
- **Cropping patterns**
- **Improvement of Irrigation Efficiency**
- **Quota control**
- **Water Pricing and Metering**
- **Institutional changes**

- Despite the significant measures, available water was not enough.
- In August 2008 transportation of water from Athens to Limassol with tankers took place: 8 MCM were transferred with a cost of €56 M.

In 1997 Desalination was Introduced

Public-Private Partnerships (PPP)

- By developing partnerships with private-sector entities, the governments can use the private sectors' knowledge, experience and financing capacity to improve the quantity and quality of basic public services.
- Such Public-Private Partnerships, if properly designed and implemented, can present a number of advantages.
- In Cyprus all desalination plants operate under **B**uilt, **O**wn – **O**perate, **T**ransfer (BOOT) Contracts, where private companies using their own funds, undertake the design, construction and operation of the Plants over a fixed period.
- The Government has the obligation to buy a minimum quantity of desalinated water each year over that fixed period.

Pricing of Water Purchased

- **The Unit Price** is made up of four components:
  - C: Capital Expenditure
  - OM: Operation and Maintenance
  - E: Energy
  - SOM: Standby Operation and Maintenance
- **Different Unit Prices** are applied:
  - Unit Price for operation: C + OM + E
  - Unit Price for Stand-by : C + SOM
  - Unit Price for additional quantities: OM + E

Operational Conditions

- The Water Development Department has the option to purchase the desalination plant before the end of the Contract.
- The Contractor will indemnify the Water Development Department for quantities of water which he was not able to deliver.
- The Contractor has the option to produce and deliver the above quantities within the next 3-montly periods
- If he fails to do this a penalty is imposed.
- The penalty is equal to the current purchase cost of desalinated water.

DESALINATION PLANTS IN CYPRUS

	DHEKELIA	LARNACA	DHEKELIA REFURBISHMENT	DHEKELIA EXTENTION
CONTRACT TYPE	BOT	BOT	BOT	BOT
START OF PRODUCTION	1st April 1997	12th July 2001	20th May 2007	18th July 2008
PERIOD	10 Years	10 Years	20 Years	
CAPACITY	40.000 m^3/day	52.000 m^3/day	40.000 m^3/day	50.000 m^3/day
MINIMUM DAILY PRODUCTION (m^3)	-	46.500 m^3	36.000 m^3	45.000 m^3
MINIMUM YEARLY PRODUCTION (m^3)	-	**16.972.500 m^3**	**13.140.000 m^3**	**16.425.000 m^3**
CONTRACT PRICE	€0.92/m^3	€0.68/m^3	€0.64/m^3	€0.82/m^3 *
ADJUSTED PRICE (ELECTRICITY TARRIFF AND LABOR INDEX)	-	-	€1.31/m^3	

* For the extra 10.000 m3/day

DESALINATION PLANTS IN CYPRUS

	MONI	GARYLLIS	PAFOS	LIMASSOL
CONTRACT TYPE	BOOR	BOT	BOOR	BOT
START OF PRODUCTION	22nd December 2008	2009	22nd November 2010	1st July 2012
PERIOD	3 Years	5 Years	3 Years	20 Years
CAPACITY	20.000 m^3/day	13.000 m^3/day	30.000 m^3/day	40.000 m^3/day
MINIMUM DAILY PRODUCTION (m^3)	18.000 m^3/day	11.700 m^3	27.000 m^3/day	36.000 m^3
MINIMUM YEARLY PRODUCTION (m^3)	**6.570.000 m^3**	**3.482.592 m^3**	**9.855.000 m^3**	**1.140.000 m^3**
CONTRACT PRICE	€1.39/m^3	€0.29/m^3	€1.219/m^3	€0.8725/m^3
ADJUSTED PRICE (ELECTRICITY TARRIFF AND LABOR INDEX)	-	€0.35/m^3	€1.70/m^3	€1.27/m^3

DESALINATION PLANTS IN CYPRUS

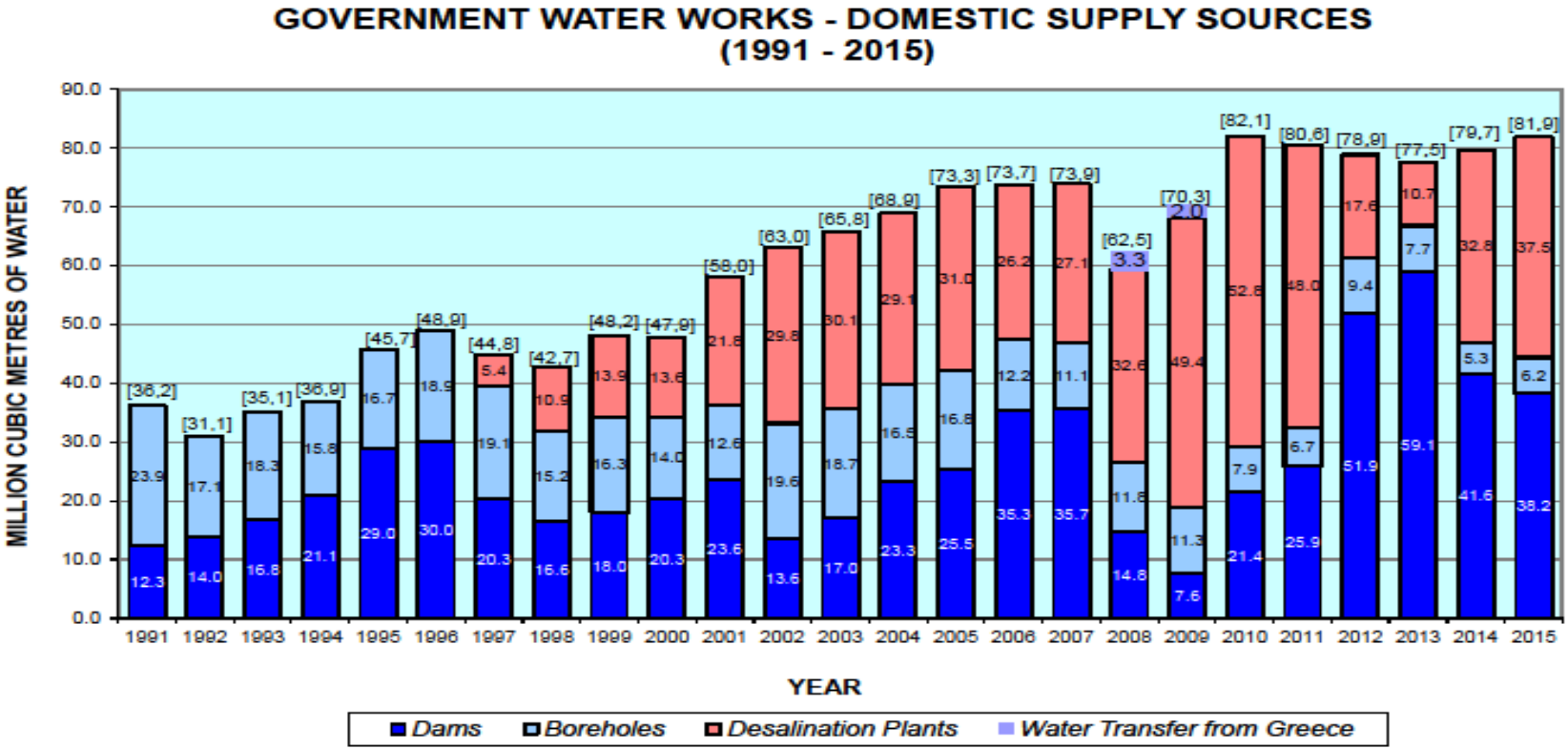
	LARNACA REFURBISHMENT	VASSILIKOS
CONTRACT TYPE	BOT	Purchase contract
START OF PRODUCTION	Summer 2014	Summer 2013
PERIOD	25 Years	20 Years
CAPACITY	60.000 m^3/day	60.000 m^3/day
MINIMUM DAILY PRODUCTION (m^3)	54.000 m^3/day	54.000 m^3/day
MINIMUM YEARLY PRODUCTION (m^3)	**19.710.000 m^3**	**19.710.000 m^3**
CONTRACT PRICE	€0.59/m^3	€0.813/m^3
ADJUSTED PRICE (ELECTRICITY TARRIFF AND LABOR INDEX	€0.82/m^3	€1.10/m^3

Desalination Plants at 2017

DESCRIPTION	DHEKELIA EXTENSION	LARNACA REFURBISHMENT	LIMASSOL	VASSILIKOS
CONTRACT TYPE	BOOT	BOOT	BOOT	Purchase Contract
START OF PRODUCTION	18 July 2008	Summer 2014	1 July 2012	Summer 2013
PERIOD	20 Years	25 Years	20 Years	20 Years
CAPACITY	60.000 m^3/day	60.000 m^3/day	40.000 m^3/day	60.000 m^3/day
MINIMUM DAILY PRODUCTION	54.000 m^3	54.000 m^3	36.000 m^3	54.000 m^3
MINIMUM YEARLY PRODUCTION	19.710.000 m^3	19.710.000 m^3	13.140.000 m^3	19.710.000 m^3
PURCHASE PRICE OF WATER	€0.69/m^3	€0.59/m^3	€0.87/m^3	€0.81/m^3
ADJUSTED PRICE FOR 2016 (ELECTRICITY TARIFF AND LABOR INDEX)	€0.83/m^3	€0.47/m^3	€0.92/m^3	€0.77/m^3

Desalinated Water Production

YEAR	TOTAL COST/YEAR (M €)	PRODUCED QUANTITY (M.C.M.)
2008	65,28	32,6
2009	63,56	49,6
2010	62,36	52,8
2011	74,98	48,7
2012	49,98	17,6
2013	35,24	10,7
2014	36,92	32,8
2015	43,83	38,1
2016	39,27	62,6
TOTALS	**471,4**	**345,5**


GOVERNMENT WATER WORKS - DOMESTIC SUPPLY SOURCES
(1991 - 2015)
MILLION CUBIC METRES OF WATER
YEAR
Dams
Boreholes
Desalination Plants
Water Transfer from Greece
1991 [36,2] 12.3 23.9
1992 [31,1] 14.0 17.1
1993 [35,1] 16.8 18.3
1994 [36,9] 21.1 15.8
1995 [45,7] 29.0 16.7
1996 [48,9] 30.0 18.9
1997 [44,8] 20.3 19.1 5.4
1998 [42,7] 16.6 15.2 10.9
1999 [48,2] 18.0 16.3 13.9
2000 [47,9] 20.3 14.0 13.6
2001 [58,0] 23.6 12.6 21.8
2002 [63,0] 13.6 19.6 29.8
2003 [65,8] 17.0 18.7 30.1
2004 [68,9] 23.3 16.5 29.1
2005 [73,3] 25.5 16.8 31.0
2006 [73,7] 35.3 12.2 26.2
2007 [73,9] 35.7 11.1 27.1
2008 [62,5] 14.8 11.6 32.6 3.3
2009 [70,3] 7.6 11.3 49.4 2.0
2010 [82,1] 21.4 7.9 52.6
2011 [80,6] 25.9 6.7 48.0
2012 [78,9] 51.9 9.4 17.6
2013 [77,5] 59.1 7.7 10.7
2014 [79,7] 41.6 5.3 32.8
2015 [81,9] 38.2 6.2 37.5
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0

Desalination Plants

- The inevitable choice to built Desalination Plants in Cyprus has proved particularly beneficial for the agriculture and salvation for the water supply of urban areas.
- Nevertheless building Desalination Plants is not panacea.
- The environmental impact, mainly because of the emission of greenhouse gases, should not leave us indifferent at times where our planet struggles for survival.

Desalination Plants

- Furthermore the production cost, which is not recovered, at times where the oil price is unstable, should have us seriously concerned.
- It is therefore imperative to continuously seek of ways to increase the efficiency of the existing desalination technologies in such a way so as to reduce the energy consumption, and
- to seek for new methods to produce drinking water by utilizing renewable energy sources.

Water Reuse


ΤΜΗΜΑ ΑΝΑΠΤΥΞΕΩΣ ΥΔΑΤΩΝ
ΥΠΟΥΡΓΕΙΟ ΓΕΩΡΓΙΑΣ, ΦΥΣΙΚΩΝ ΠΟΡΩΝ ΚΑΙ ΠΕΡΙΒΑΛΛΟΝΤΟΣ
ΜΗ ΠΟΣΙΜΟ
NON POTABLE

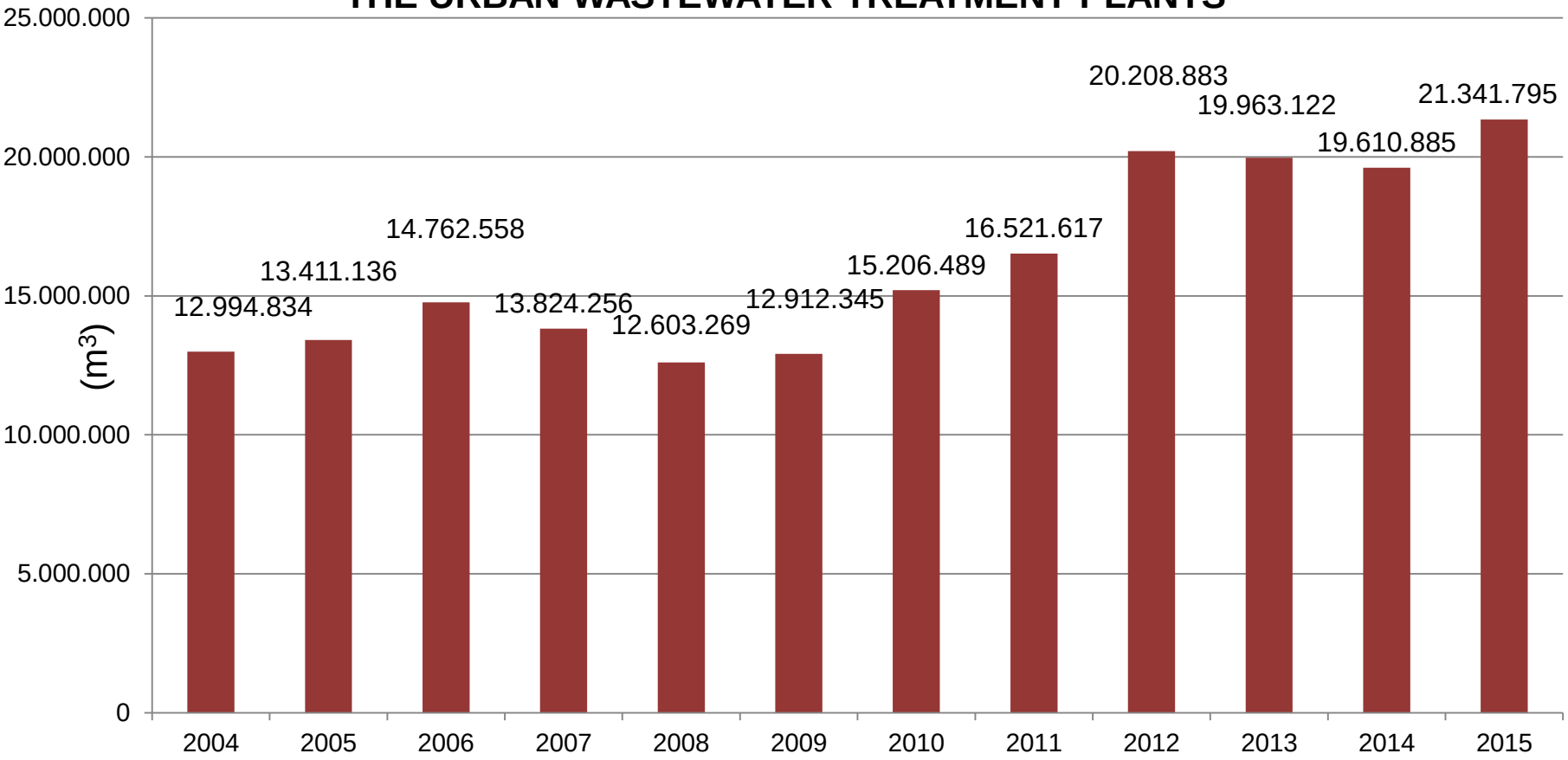
Reuse of Treated Effluent

- In Cyprus the treated effluent from the Urban Waste Water Treatment Plants is used for irrigation and recharge of aquifers.
- Aquifers are used as storage reservoirs mainly in winter. The water from the aquifers is extracted and used for irrigation.
- Irrigation is done under the Code of Good Agricultural Practice.
- During some winter months some quantities are discharged into the sea, as a temporary solution which will end after the implementation of the reuse projects.

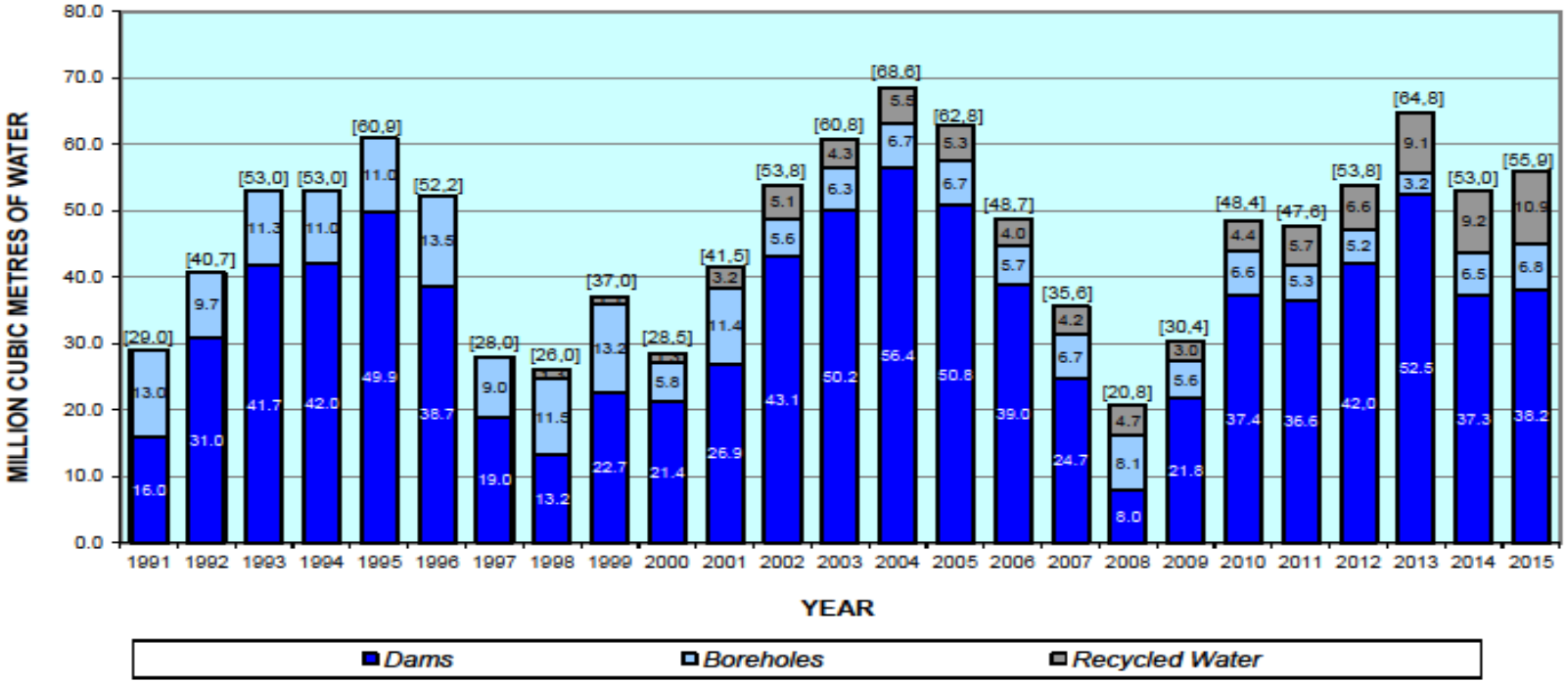
Existing Wastewater Treatment Plants (WWTPs)

	Categories of WWTPs	Number of WWTPs	Total Capacity (m^3/day)
1	Existing Urban WWTPs (>2000 p.e.)	8	165.700
2	Existing Rural WWTPs (> 2000 p.e.) (Type of treatment : Extended Aeration/ Moving Bed Bioreactor-Tertiary Sand Filters-Chlorination with liquid hypochlorite)	6	2.101
3	Existing Rural WWTPs (< 2000 p.e.) (Type of treatment : Extended Aeration-Tertiary Sand Filters-Chlorination with liquid hypochlorite)	6	574
4	Existing WWTPs for Refugee Housing (Type of treatment: Extended Aeration-Tertiary Sand Filters-Chlorination with liquid hypochlorite)	3	560
5	Existing WWTPs for Hospitals (Type of treatment: Extended Aeration-Tertiary Sand Filters-Chlorination with liquid hypochlorite)	3	1.280
6	Existing WWTPs for Military Camps Type of treatment: Contact Stabilisation/Extended Aeration-Tertiary Sand Filters-Chlorination with liquid hypochlorite)	9	684
	TOTAL	35	170.899

ANNUAL QUANTITIES OF TREATED EFFLUENT IN CYPRUS FROM THE URBAN WASTEWATER TREATMENT PLANTS



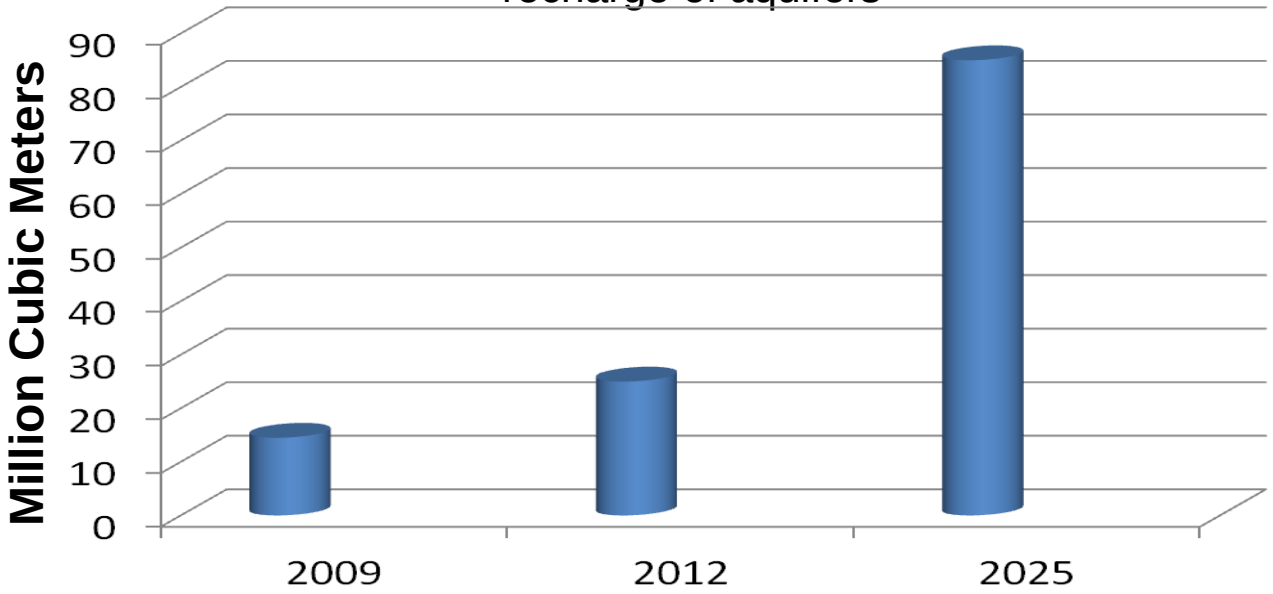
GOVERNMENT WATER WORKS - IRRIGATION SUPPLY SOURCES
(1991 - 2015)



Treated Waste Water Reuse

Tertiary Treatment

Irrigation of agricultural crops and recreational areas either directly or through recharge of aquifers



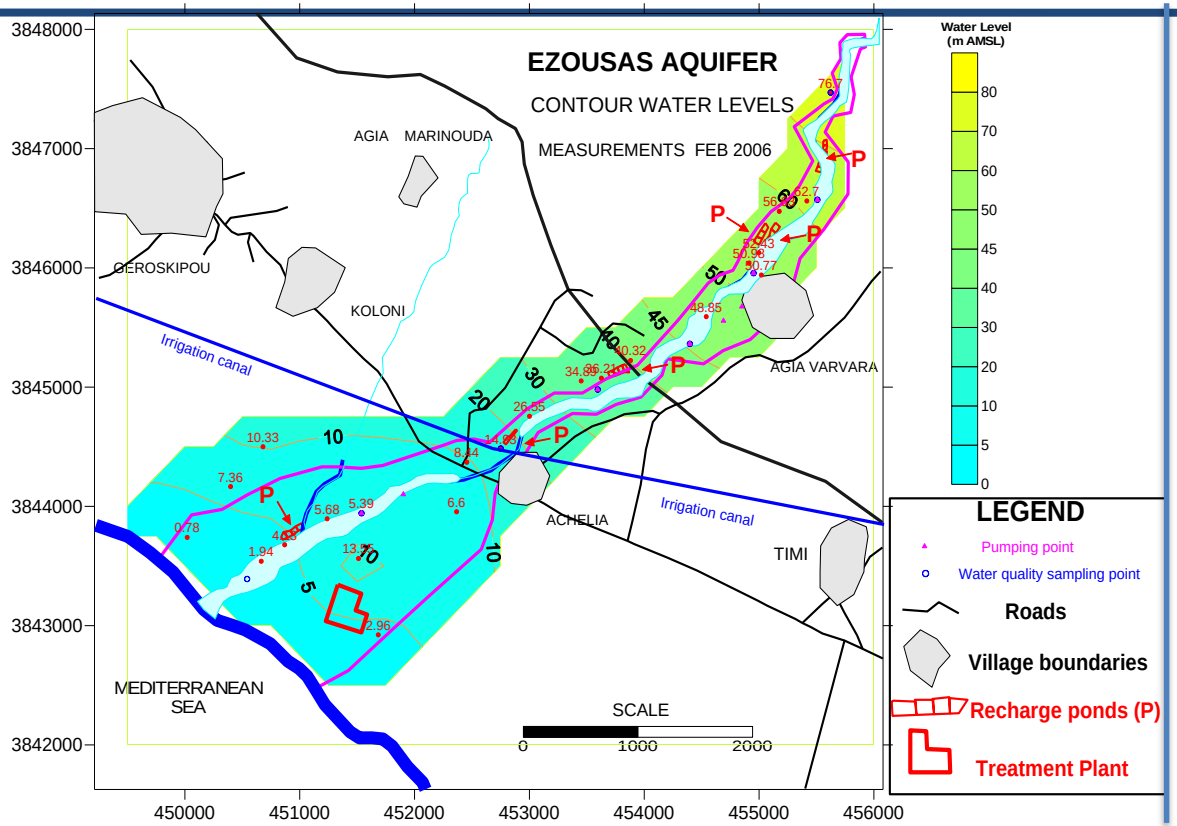
Additional volumes of water for agricultural use

General Comments for the Reuse of Treated Effluent

- The treated effluent is another constant source of water.
- The Government introduced the treated effluent in the Cyprus Water Balance.
- The quality is under control and remains constant.
- The treated effluent is suitable for the majority of the crops.
- The farmers use less quantities of fertilisers because the treated effluent already contains nutrients such as Phosphorous and Nitrogen.
- Almost all the Wastewater Treatment Plants in Cyprus are equipped with Tertiary Treatment, consisting of Sand Filtration and Chlorination in order to achieve higher quality characteristics and use the treated effluent for irrigation safely.

IRRIGATION WITH TREATED EFFLUENT- TYPE OF PLANTS

LIMASSOL PLANT	**LARNACA PLANT**	**PARALIMNI AYIA NAPA PLANT**	**VATHIA GONIA PLANT**
CITRUS FRUITS	COWGRASS	CITRUS FRUITS	COWGRASS
FODDER CROPS AND INDUSTRIAL PLANTS (COWGRASS AND CORN)	CORN	OLIVE TREES	CORN
VEGETABLES	LOLIUM AND SUTAX	POTATOES	BARLEY
PUBLIC GREEN AREAS	PUBLIC GREEN AREAS	PUBLIC GREEN AREAS	FODDER CROPS
	FOOTBALL FIELDS	FOOTBALL FIELDS	GRASS PRODUCTION


EZOUSAS AQUIFER
CONTOUR WATER LEVELS
MEASUREMENTS FEB 2006
AGIA MARINOUDA
GEROSKIPOU
KOLONI
AGIA VARVARA
ACHELIA
TIMI
Irrigation canal
Irrigation canal
MEDITERRANEAN SEA
SCALE
0
1000
2000
Water Level (m AMSL)
80
70
60
50
45
40
30
20
10
5
0
LEGEND
Pumping point
Water quality sampling point
Roads
Village boundaries
Recharge ponds (P)
Treatment Plant
3848000
3847000
3846000
3845000
3844000
3843000
3842000
450000
451000
452000
453000
454000
455000
456000

Water scarcity and droughts increasing in intensity and extent

- Water scarcity and droughts is a major challenge
  - Climate change is expected to make matters worse.
- In Cyprus Desalination Plants cover the drinking water needs of large urban and touristic areas, eliminating dependence on rainfall and giving security and reliability of drinking water supply.
- The treated effluent is another constant source of water and it has been introduced in the Cyprus Water Balance for irrigation purposes.

Taking on the challenge

- There is a need to intensify efforts to prepare for and manage water-related disasters.
- Water saving & efficiency measures must be a priority.
- Despite the many water saving & costly supply enhancement measures, the problem remains.
- All necessary measures are being taken to ensure water security now and in the future through an **integrated multi-objective approach for water management.**

Thank you

From the photographic competition of Water Board of Larnaca 2015 - first prize

Source: Water Development Department Cyprus

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