D.T1.2.3. COLLECTION OF SMART GOVERNANCE SOLUTIONS APPLICABLE IN URBAN CIRCULAR WATER MANAGEMENT

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Summary

1. INTRODUCTION

The present document has been produced with the purpose of gathering smart governance solutions applicable in circular urban water management.

First of all, the existing water related Directives in Europe and the National transposition are introduced even if precise standards or guidelines to regulate water reuse in Europe are actually almost absent. Then, the state of water resources and treated wastewater reuse are analysed for Romania, Italy and France, according to the study “EU-level instruments on water reuse” by the European Commission.

The second part of the deliverable is focused on top-down and bottom-up existing practices and policies that foster water reuse. Due to the shortage of relevant cases in Europe, the Cyprus case is a relevant exception, non-European examples are also presented. In particular, some American Program and Projects and the Indian policy on rainwater harvesting are reported for top-down practices, while two bottom-up examples, from Colombia and the United States respectively, are shown.

2. CURRENT WATER RELATED EUROPEAN DIRECTIVES AND TRANSPOSITIONS

In the absence of European wide standards or guidelines to regulate water reuse in Europe, the EU has developed a portfolio of directives developed to protect the environment and human health, regulate the water cycle and are therefore of major importance for water reuse.

The EU Water Framework Directive establishes a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater. It aims to prevent and reduce pollution, promote sustainable water use, protect and improve the aquatic environment and mitigate the effects of floods and droughts. The overall objective is to achieve good environmental status for all waters. Member States are therefore requested to draw up so-called River Basin Management Plans based on natural geographical river basins, as well as specific programmes of measures to achieve the objectives.

- The Directive on the protection of groundwater against pollution and deterioration provides for specific criteria for the assessment of good chemical status, the identification of significant and sustained upward trends, and the definition of starting points for trend reversals. All threshold values for pollutants (with the exception of nitrates and pesticides, for which the limits are set by specific EU legislation) are set by the Member States.
- The Drinking Water Directive defines essential quality standards for water intended for human consumption. It requires Member States to regularly monitor the quality of water intended for human consumption by using a ‘sampling points’ method. Member States can include additional requirements specific to their territory but only if this leads to setting higher standards. The directive also requires the provision of regular information to consumers. Furthermore, the quality of drinking water has to be reported to the Commission every three years. On 1 February 2018, and in response to the European Citizens’ Initiative ‘Right2Water’, the Commission published a proposal to renew the 20-year-old directive. The reviewed directive would update existing safety standards and improve access to safe drinking water along the lines of the latest recommendations of the World Health Organisation. It would furthermore increase transparency for consumers on the quality and supply of drinking water, thereby helping to reduce the number of plastic bottles through increased confidence in tap water. An EU-wide risk-based water safety assessment should help to identify and address possible risks to water sources already at the distribution level.
- The Bathing Water Directive aims to enhance public health and environmental protection by laying down provisions for the monitoring and classification (in four categories) of bathing water and informing the public about it. During bathing season, Member States have to take samples of bathing water and assess the concentration of at least two specific bacteria once a month at each bathing water site. They have to inform the public through ‘bathing water profiles’ containing for instance information on the kind of pollution and sources that affect the quality of the bathing water. There is a standard symbol for informing the public about the bathing water classification and any bathing prohibition. A summary report on the quality of bathing water is published annually by the Commission and the European Environment Agency (EEA).
- The Environmental Quality Standards Directive establishes limits on concentrations of 33 priority substances presenting a significant risk to, or via, the aquatic environment at EU level and eight other pollutants in surface waters. During a review, 12 new substances were added to the existing list and an obligation was introduced for the Commission to establish an additional list of substances to be monitored in all Member States to support future reviews of the priority substances list.
- The Urban Waste Water Treatment Directive aims to protect the environment from the adverse effects of urban waste water discharges and discharges from industry. The directive sets minimum standards

and timetables for the collection, treatment and discharge of urban waste water, introduces controls on the disposal of sewage sludge, and requires the dumping of sewage sludge at sea to be phased out.

- The Nitrates Directive aims to protect waters from nitrates from agricultural sources. A complementary regulation requires Member States to send a report to the Commission every four years, providing details of codes of good agricultural practice, designated nitrate vulnerable zones (NVZ), water monitoring and a summary of action programmes. Both the directive and the regulation aim to safeguard drinking water and prevent damage from eutrophication.
- The EU Floods Directive aims to reduce and manage the risks posed by floods to human health, the environment, infrastructure and property. It requires Member States to carry out preliminary assessments to identify the river basins and associated coastal areas at risk and then prepare flood risk maps and management plans focused on prevention, protection and preparedness. All of these tasks are to be carried out in accordance with the WFD and the river basin management plans set out therein.
- New rules are under discussion to counter water scarcity by facilitating the reuse of treated waste water for agricultural irrigation - Proposal for a Regulation of the European Parliament and of the Council on minimum requirements for water reuse, which could be potentially interesting for urban areas if used for urban agriculture purposes.

3. STATE OF WATER RESOURCES AND TREATED WASTEWATER REUSE

The study "EU-level instruments on water reuse" by the European Commission reports the state of water resources and treated wastewater reuse for some European countries selected to cover a wide range conditions. The criteria used to select countries were: Water stressed countries (WEI + >20%), Water stressed countries with agricultural water use (conservatively above 5%), Member States that already reuse treated wastewater in irrigation, Member States that have national water reuse guidelines /legislation, Water stressed countries that rely on GW resources (conservatively above 15%) and Member States that already employ groundwater aquifer recharge using treated wastewater. Among all the cases present in the paper, three countries are selected as example: Romania, Italy and France. Romania is chosen because member states with no legal framework for water reuse; the Italian case is shown since Italy is a CWC project partners and France is selected because there is a legislative background for water reuse in agriculture and many information were present in the document.

A. Romania - State of water resources and treated wastewater reuse

Romania's water resources are relatively poor and unevenly distributed in time and space with about 40 billion m^3 being available for use per year. Water demand in Romania in 2014 was 7.21 billion m^3/year. In 2013, the Water Exploitation Index was 15.2 (Eurostat), which is below the European Environment Agency's (EEA) threshold of 20% for water stress.

The balance between water availability and the expected trends for water demand shows no deficit at state level or in the 11 sub-basins; there are only a few river sections with deficits in the Prut - Bârlad basin that should be carefully considered in the future.

Currently treated wastewater reuse is not being practiced in Romania for either irrigation or aquifer recharge. Wastewater reuse in irrigation was launched experimentally as part of research projects, but it is not a mainstream practice. In regard to aquifer recharge, this is currently a prohibited practice, as the Waters Law prohibits injections of wastewater into groundwater. Furthermore, given decreasing water consumption, lack of irrigated agriculture and adequate natural recharge of the most aquifers in Romania, there is low demand for the use of treated wastewater overall.

Agricultural irrigation

The total irrigated area in Romania is 29900 km2 with 85% of the area being irrigated from the River Danube. In reality, (functional) irrigated land accounted for less than 3000 km2 (less than 1% of the total arable land) in the last 5 years (2011-2015), consuming about 1 million m^3 per year. Although Romanian legislation does not forbid the use of treated wastewater in irrigation, there are no specific regulations and standards that govern water reuse. Additionally, the low number of users that are connected to the irrigation system and the relatively low water volume that is used for irrigations at national level does not currently act as an incentive to invest in further technologies. In the long run, the interest in treated water reuse for irrigation might increase, as forecasts predict a significant increase of the number of users connected to the irrigation system, while research has begun to study the conditions under which treated wastewater could be used in agriculture at experimental level.

Aquifer recharge

The groundwater potential in Romania is estimated at 9.6 billion m^3/year. In general terms, groundwater is not overexploited in Romania. In fact, data for 2014 showed that surface water abstraction accounted for around 10 times the volume of water abstracted from groundwater resources.

Furthermore, aquifer recharge using treated wastewater is currently a prohibited practice in Romania with the Waters Law explicitly prohibiting injections of wastewater into groundwater. The current potential for treated wastewater reuse in aquifer recharge, therefore, is effectively non-existent.

B. Italy - State of water resources and treated wastewater reuse

Despite an average annual rainfall of 1 000 mm/year, well above the European average, average freshwater availability for the population (2900 m^3/capita) is one of the lowest among OECD (Organization for Economic Co-operation and Development) countries, due to high evapotranspiration, rapid run-off and limited storage capacity. In addition, available resources are distributed very unevenly across the national territory: 59.1% are in fact in the North, whereas the rest is shared by the Centre (18.2%), the South (18.2%) and the islands (4.5%).

With annual water abstraction making up 31% of available water resources, Italy is classified as a medium-high water-stressed country. Under the Law-decree n. 152, a new legislative set of rules was promulgated on June 12th, 2003 (Ministry Decree, D.M. no 185/03) under which recycled water can be used for (Agenzia per la Protezione dell'Ambiente Tecnici (APAT), 2008):

- Irrigation of crops for human and animal consumption, as well as non-food crops. Irrigation of green and sport areas;
- Urban uses: street washing, heating and cooling systems, toilet flushing; and
- Industrial uses: fire control, processing, washing, thermal cycles of industrial processes (recycled water must not get in contact with food, pharmaceutical products or cosmetics).

Treated wastewater is used mainly for agricultural irrigation. However, the controlled reuse of municipal wastewater in agriculture is not yet developed in most Italian regions and has decreased due to the low quality of water.

Average costs, as calculated by ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) in a survey of several Italian recycling plants (different plants for different uses: urban, industrial, agriculture) range between 0.083 and 0.48 EUR/m^3. As a comparison, the costs of abstracting water from rivers and groundwater bodies is estimated at 0.015-0.2 EUR/m^3. The high cost of recycled water is generally indicated as one of the main barriers to water reuse.

Agricultural irrigation

Nearly 50% of water abstraction is attributed to the agricultural sector.

Irrigated areas are unevenly distributed across the country: 66% of irrigated area is, in fact, concentrated in the relatively water-abundant North, whereas the rest is shared between the Centre (6%) and the South (28%). The three major irrigated crops are maize, rice and vegetables (ISTAT, 2010). Although the irrigated agricultural area only accounts for 19% of the total Utilised Agricultural Area (UAA)(ISTAT, 2010), in terms of production, irrigated agriculture accounts for 50% of total production and 60% of total value added of the agricultural sector, and its products constitute 80% of agricultural exports.

The use of untreated wastewater has been practiced in Italy at least since the beginning of this century, especially on the outskirts of small towns and near Milan. Reuse of untreated wastewater is prohibited in Italy: the legislation requires that all discharges comply with normative standards. Therefore, the reuse of untreated wastewater is illegal and, as such, subject to penal and administrative sanctions. Treated wastewater is used mainly for agricultural irrigation. However, the controlled reuse of municipal wastewater in agriculture is not yet developed in most Italian regions.

Aquifer recharge

Groundwater makes up almost 50% of water abstracted for domestic water supplies (ISTAT, 2012b).

Overexploitation has been reported in the North, in the lower reaches of the Po plain and around Venice, due to industrial and agricultural uses as well as gas and oil extraction. Water availability differs significantly from Northern to Southern Italy. In the North, water is relatively abundant, due to stable and abundant flows in water courses throughout the year. In addition, out of 13 billion m^3 of groundwater available annually, over 70% is located in the North, and particularly in the Po river plain. In contrast, the South of Italy is often subject to long periods without precipitation, resulting in droughts and water rationing.

Over 52% of GWBs are assessed as having good quantitative status, according to Italy's reporting; however, the status is unknown for almost 32%.

At present, artificial aquifer recharge interventions are not common in Italy, and current practice focuses mainly on pilot experimental sites (Regione Emilia Romagna). Existing examples of artificial aquifer recharge are being implemented thanks to EU LIFE and FP7 funding:

- LIFE+ AQUOR (ended in May 15): implementation of artificial aquifer recharge in the Province of Vicenza;
- LIFE+ TRUST (ended in December 2011): research in the aquifer recharge area in the Veneto plain (rivers Isonzo, Tagliamento, Livenza, Piave, Brenta and Bacchiglione);
- LIFE+ WARBO (ended in March 2015): testing of artificial aquifer recharge methods (from rainwater) in the Po Delta and in the Pordenone province; and
- MARSOL – FP7 (on-going): Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought – Pilot sites in Italy: Brenta (Veneto) and Serchio (Liguria).

A recent modification to the Environmental Act – Art. 24, comma 1, Law 97/2013 – clarified some important technical and permitting aspects of aquifer recharge. In particular, these interventions can be authorised provided that they are executed in compliance with the criteria to be established by the Ministry of Environment through a specific Decree – Ministerial Decree 2 May 2016, n.100.

According to Legislative Decree 152/06, wastewater discharge into groundwater bodies is forbidden with some exceptions. Such exceptions include artificial aquifer recharge, provided that this does not compromise the achievement of the environmental objectives established for the specific groundwater body.

Aquifer recharge is established and regulated by the RBMPs and the Water Protection plan. Artificial aquifer recharge is also subject to Environmental Impact Assessment (LIFE AQUOR, 2015).

Artificial aquifer recharge was also included in the National Operational Programme "Governance and systemic actions – European Social Fund 2007-2013 – Axis E Institutional Capacity, Specific Objective 5.5 Reinforce and Integrate the environmental governance system, Action 7A Horizontal actions for environmental integration", as part of models and tools for water resource management (natural water retention measures, aquifer recharge and participatory systems).

At present, no testing of artificial groundwater recharge with treated effluents has been reported: this practice is forbidden in Italy.

C. France - State of water resources and treated wastewater reuse

Although France does not experience serious water stress (with its Water Exploitation Index being around 15.5% for the period 2008-2012 (Eurostat)), the analysis of natural flows in France shows that low water periods are getting more frequent and more serious in the last 40 years (1970-2010), particularly affecting the South of France (ONEMA-French National Agency for Water and Aquatic Environments, 2011). The consumption of water for farming is growing particularly strongly in South-Western France and in the Paris region.

In addition to the growing demand for water for agricultural purposes, some irrigated crops (such as corn) have become more widespread and periodic droughts have occurred. Over the last 20 years droughts events affected the regions traditionally considered to be the wettest, in Western and North-Western France.

In more than one-third of the country, water tables are falling as the autumn and winter rains are no longer making up for the amounts drawn up in spring and summer. Faced with this situation, the authorities have occasionally imposed restrictions on water use, a very unusual practice in France. It is also worth recalling that around fifteen French departments are situated in an area with a Mediterranean climate similar to that of Northern Spain and Italy, well-suited to market gardening, fruit farming and mass tourism.

In France, water reuse systems are already in place, and legally binding standards for reuse are in place for the agricultural sector and water reuse for green and recreational areas.

There are no recent data on the total volume of reused water in France but the latest data from a 2007 report indicate that water reuse was 19,200 m^3/day corresponding to about 7 million m^3/year. At present, there are about 40 reuse schemes in France, most of which are dedicated to irrigation (agriculture, public areas, golf courses and racecourses). Latest available data indicate that around 55 reuse schemes are now in place in the country.

French legislative background for water reuse

In France, water reuse systems are already in place, and legally binding standards for reuse are in place.

The existing standards concern water reuse for irrigation in agriculture and for the irrigation of green and recreational areas. France has adopted the approach based on limit values defined for a range of parameters of the water reused. The requirements for water reuse are strongly linked to the national legislation on the agricultural spreading of sewage sludge: not only the quality of the reuse water shall be monitored, but also the quality of the sewage sludge produced by the WWTP and the quality of the agricultural soils.

In total, 6 water quality parameters are fixed and compliance is checked against the limit values specified by the national legislation on agricultural spreading of sewage sludge.

The standards included in the French legislation are as follows:

- Origin of the wastewater: Treated wastewater from urban WWTPs with a gross organic pollution greater than 1.2 kg of BOD5 per day.
- Allowed uses: Food crops intended for human consumption, consumed raw; food crops intended for human consumption subject to thermal process; grassland; recreational areas (golf courses, forests open to public); Flowers sold cut; Other flowers; Nursery and shrub; Fodder crops; Other cereal crops; Fruit production; Forest exploitation with limited public access.

- Prohibited uses: Irrigation with raw sewage; Irrigation with treated wastewater from WWTPs connected to certain animal by-products processing installations; Irrigation with treated wastewater from WWTPs whose sewage sludge do not comply with limit values specified by the French legislation on agricultural use of sewage sludge; Irrigation with treated wastewater on soils that do not comply with limit values specified by the French legislation on agricultural use of sewage sludge; Irrigation with treated wastewater within the close protection perimeters of drinking water abstraction points (with some exceptions).
- Approach: water quality levels are defined, each with specific numerical limit values for a range of parameters. The required quality level is specified for each use category. The particularity of the French approach is that the monitoring programme to be put in place partly relies on the monitoring of sewage sludge quality and agricultural soils, in accordance with the French legislation on the agricultural use of sewage sludge. Sewage sludge quality is indeed considered to be a reliable indicator of the overall WWTP efficiency with regard to the removal of pathogens and other hazardous substances.
- Parameters: (i) parameters for the reclaimed water: suspended solids, chemical oxygen demand, faecal coliforms, F-specific bacteriophages, spores of sulphate-reducing anaerobic bacteria, E. coli; (ii) Specific parameters for sewage sludge and agricultural soils, in accordance with the French legislation on sewage sludge spreading.
- Monitoring: Minimum required frequencies for the monitoring of the E. Coli parameter, for the different quality levels. The WWTP operator is in charge of implementing a monitoring programme (at the outlet of the WWTP) including: (i) Sampling and analysis of E. Coli according to a specific schedule; (ii) Annual monitoring of all 6 parameters; and (iii) Monitoring of the quality of sewage sludge produced by the WWTP (at least 4 times/year). The WWTP operator shall communicate the monitoring results to the Prefect, the mayors concerned and the users of irrigated land. If one parameter exceeds the limit value, the WWTP operator shall inform the users of irrigated plots, the Prefect and the municipalities concerned. At least every 10 years, the user of irrigated land shall perform an analysis of soil samples targeting the trace elements covered by the French legislation on the agricultural use of sewage sludge. Results shall be communicated to the WWTP operator. Traceability measures: irrigated plot managers have to maintain a register with indications of crop location and type, volumes of reused water, the time during which crops are irrigated with reused water and the results of the monitoring programme (on reclaimed water, sludge and soils).
- Application controls: (i) Several measures required to avoid cross contamination risks between the reclaimed water network and the drinking water network; (ii) Setback distances between areas irrigated with treated wastewater and specific activities; (iii) Maximum authorised land slope; (iv) Spray irrigation cannot be conducted if wind speed exceeds specified values.
- Permitting system: An authorisation shall be granted by the Prefect (local competent authority) before reusing treated wastewater. It can be submitted by the WWTP operator or the owner of irrigated land. The contents of the application file are specified by the regulation.

Agricultural irrigation

Agriculture is the main user of water in France (48% of the water used in 2004). The total agricultural area equipped for irrigation amounts to 27.7 million hectares; however, in 2010, it was reported that irrigation actually occurred on 1.6 million hectares, corresponding to a total water use of 2.7 billion m^3 per year.

The reuse of wastewater for irrigation purposes is still little developed in France. On the one hand, France is hardly facing water scarcity issues – and when it does, scarcity events unfold at the local scale. In fact, water reuse for irrigation is limited to particular regions, such as islands or areas with a high water demand and uses possibly conflicting with potable use. On the other hand, the price of reused water is higher than the price of conventional water, so there is no economic incentive to switch to reused water. In particular, in France, both volumetric and mixed tariffs are applied to the provision of irrigation water. The EEA (2013) reports flat tariffs ranging between 38 and 157 EUR/year, combined with volumetric rates ranging between 0.06 and 0.09 EUR/m^3. Tariffs paid by farmers cover 100% of operation and maintenance costs, but they do not fully cover investment costs: depending on the area, revenues from tariffs cover from 15% to 95% of investments costs (55% on average).

At the end of the 1990s, only around twenty water reuse projects could be found in France; all projects were set up for irrigation of crops, green spaces and golf courses. The largest water recycling project provides irrigation water to 23 km2. More updated data are not available, although it seems that few additional projects have been set up since then. According to an ongoing study by CEREMA (Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement), the number of operating water reuse projects has more than doubled since 2010.

The French population already eats fruits and vegetables imported from countries where water reuse for irrigation is frequent (e.g. Spain). Despite this, a third of the French population declared themselves not ready to eat fruits and vegetables irrigated with recycled water.

Aquifer recharge

The volume of groundwater in France is estimated at 2000 billion m^3 per year, of which 100 billion m^3 per year flow through springs and water courses. About 7 billion m^3 per year are extracted from groundwater through the exploitation of springs, wells and drillings. Half of the water is used for drinking water, covering two thirds of the demand for drinking water (BRGM- Bureau de Recherches Géologiques et Minières, 2016).

Of the 646 groundwater bodies in France, 90.6% were in a good quantitative status in 2013. Water bodies with less than good status are mainly situated in the South-East and the centre, the Mediterranean region as well as the islands Réunion and Mayotte. The main reasons for not reaching good status are overexploitation of the aquifers compared to their recharge, but also salt water intrusion (Réunion, Mediterranean region).

There are no official statistics on artificial groundwater recharge in France. An inventory from the year 2013 listed 75 sites of artificial groundwater recharge on the French national territory. The status of 48 out of them is known with certainty, without certainty for 8 and unknown for 19. Two-thirds of the sites for which the status is known are situated in the (former) regions Nord-Pas-de-Calais, Midi-Pyrénées and PACA. Only about 20 of them are still active today. The techniques applied are either indirect injection (infiltration basins) or direct injection (via drilling).

In most of the known cases of artificial groundwater recharge in France, the primary objective is to support an overexploited groundwater body. The second objective is the improvement of the quality of the groundwater bodies through significantly diminishing the concentrations of certain chemicals by dilution (e.g. nitrates, pesticides). The latter allows for the application of simpler and more economic final treatments to make the water suitable for drinking water purposes.

In almost all cases which are currently active in France, surface water is the source of water used for artificial recharge. This is mainly due to the availability of the resource. Artificial recharge with treated wastewater is not prohibited. However, this is not regulated by existing legislation, as quality requirements and allowed uses of treated wastewater are only regulated for irrigation of crops and green areas.

While direct injection of treated wastewater in the aquifer has never taken place in France, two research projects on indirect infiltration of treated effluent have been carried out by BRGM – the public service provider for the quantitative groundwater management in France – and the company Veolia until 2011 (REGAL and RECHARGE).

4. TOP-DOWN POLICIES TO FOSTER WATER REUSE – CASE STUDIES IN EUROPE

D. Cyprus

Context: Cyprus' natural water resources depends solely on rainfall. The total annual water supply is 3030 million m^3/year, 89% of which is lost in evapotranspiration, leaving 321 million m^3/year as useable water. The percentage of evapotranspiration can reach up to 95% in the driest years. The Water Exploitation Index (in percentage) of approximately 66% (Eurostat, 2016) makes Cyprus the most affected country of the European Union. Water demand is mainly due to domestic water use and agricultural irrigation. Historically, droughts occur every two-to-three years due to lower rainfall. In the last fifty years, however, drought incidences have increased both in magnitude and frequency.
Good Practice: In response to droughts, a series of measures to manage users demand were adopted and encouraged by the Government. Such measures include water rationing, increase of public awareness on water conservation methods and water pricing for improvement of water use efficiency and water saving. In addition, the Government has also created desalination plants and recycling water methods and has increased the use of dams in order to increase the water supply capacity.
Limits: Use of expensive storage infrastructures.
Lesson to be learnt: To our knowledge, Cyprus is the only European country where water reuse provisions are fully integrated into the legislation on urban wastewater treatment and discharge. Scepticism from farmers at the early first stages of implementing water reuse projects then overcome through information/consultation campaigns and education.

Cyprus has a semi-arid climate so it has a limited water resources causing frequent and prolonged droughts. The rainfall are temporally and geographically unevenly distributed exacerbating the situation. Therefore Cyprus has the need to find other water resources to be used in order to satisfy the people demand.

Reuse of treated wastewater (known in Cyprus as “recycled water”) provides additional drought-proof water supply, favours a more local sourcing of water and avoids the use of drinking water quality water where such high quality is not needed. The potential for water reuse depends on the availability and accessibility of wastewater (i.e. the wastewater infrastructure) and the acceptability by potential end-users and consumers.

Cyprus has adopted a ’Not a Drop of Water to the Sea’ policy encouraging the maximum capture of run-off by dam construction and handling of wastewater. Almost 90% of treated wastewater is reused, primarily for the irrigation of agricultural land, parks, gardens and public greens.

In 2011, 12 million m^3/year of recycled water is given for irrigation and about 2.2 million m^3/year for artificial recharge of aquifers (see percentage of water reuse for the different sector in Fig.1). To support what it is said before, the current nationally set objective is to replace 40% of agricultural freshwater requirements by reclaimed water. In fact, between 2004 and 2013, 89% of the treated wastewater was reused and a significant part of this (75.5% in 2013) was used for agricultural irrigation (with orchards being the most irrigated crops, such as citrus and olive trees, but water is also used for fodder crops). As such, reusing treated effluent discharged from wastewater treatment plants to support agricultural irrigation has significant potential to reduce pressure on stressed freshwater sources that are in demand for potable use and to mitigate the overdependence of agriculture on groundwater.

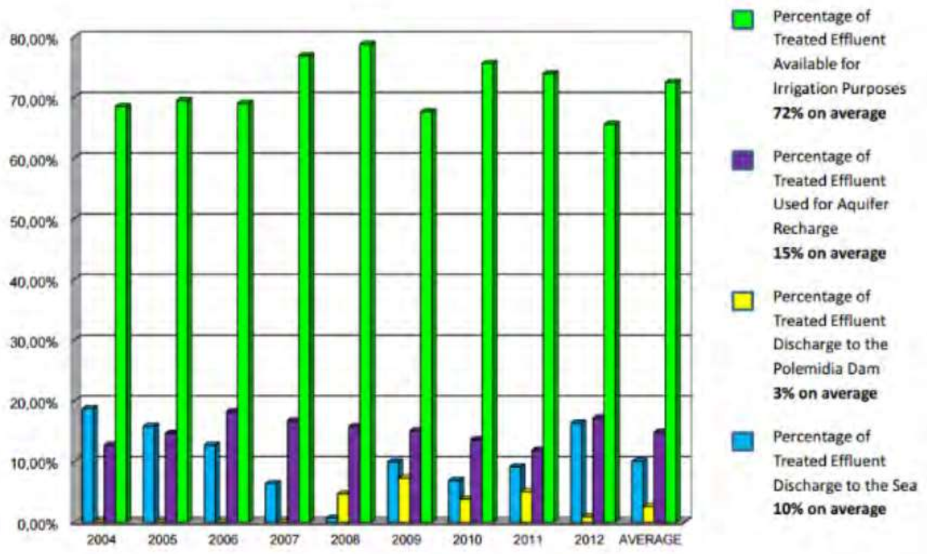

Figure 1 Overview of uses of treated effluent in Cyprus. Source: Ministry of Agricolture, Natural Resources and Environment Water Development River Basin Management Plan, April 2011.

According to information made available by the Water development Department (WDD), the acceptance of using recycled water from farmers was initially slow (period 2002-2005) but in time it has increased significantly.

Acceptance issues were addressed through information / consultation campaigns, education of the farmers in small groups, the adoption of regulation and a code of conduct, financial incentives making recycled water much cheaper than freshwater and demonstrating benefits in practice. For example reused water tariffs in Cyprus range from 33%-40% of freshwater rates; these ratios appear typical for the EU Mediterranean islands. Cyprus identified the subsidies as a strong incentive to improve acceptability of water reuse. The table below presents a comparison of the selling rates of abstracted freshwater and treated wastewater.

Use	Tertiary Treated Effluent	Fresh not filtered water from government water works
	€/m3	€/m3
For Irrigation divisions for agricultural production	0.05	0.15
For Persons for agricultural production	0.07	0.17
For irrigation of hotels green areas and gardens	0.15	0.34
For pumping from an aquifer recharged by the treated effluent	0.08	n.a

Figure 2 Selling rates of the treated effluent in Cyprus. Source: Cyprus Water Development Department, 2008.

Yearly water needs of irrigation amounts to an average of 178.5 million m^3/year; however, as this demand is rarely satisfied, the actual water consumption in agriculture fluctuates around 150 million m^3/year. Irrigated agriculture accounts for 88% of this amount (or 132 million m^3 of water per year) while accounting for only 28% of the total area under crops. Agricultural sector accounts for around 60% of total Cyprus' water consumption.

The capacity of the new Waste Water Treatment Plans was expected to reach in 2015 up to 65 million m^3 per year and 85 million m^3 for long term (2025).

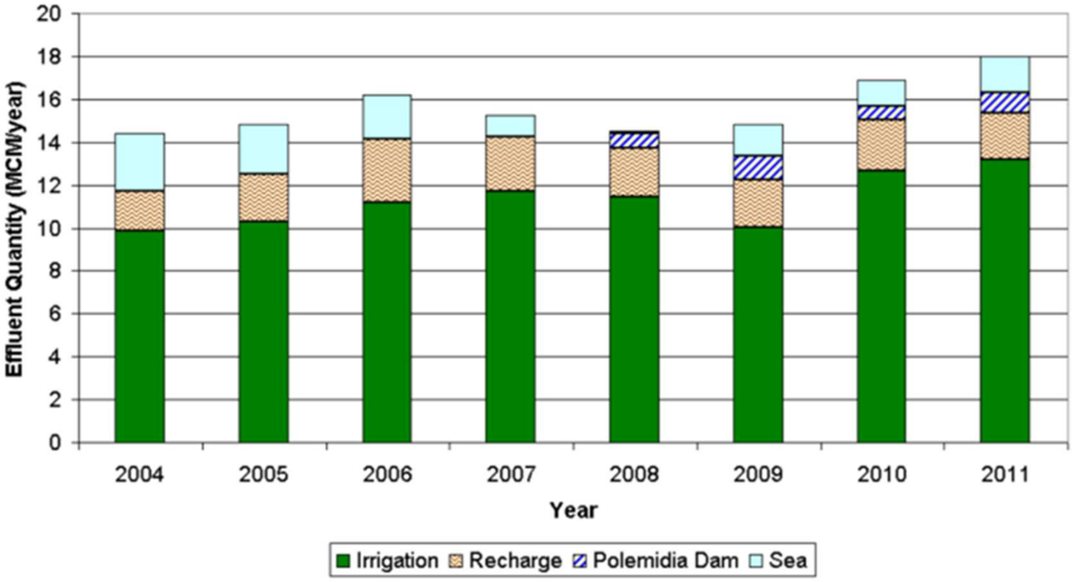

Figure 3 Quantity of the treated effluent used in Cyprus (Mm³/yr), between 2004-11, categorised by use

	2012	2015	2025
Municipal wastewater treatment plants	46 Mm³/yr	51 Mm3/yr	69 Mm³/yr
Rural wastewater treatment plants	13 Mm³/yr	14 Mm3/yr	16 Mm³/yr
Total	59 Mm³/yr	65 Mm3/yr	85 Mm³/yr
Annual water recycling	52 Mm³/yr		

Figure 4 Estimated volumes of treated wastewater. Source: Cyprus Water Development Department.

Desalinated water is an additional resource for public water supply and to support holiday resorts in arid areas. Desalination on a large-scale basis was introduced in 1997 with the operation of the 20,000 m³ per day, reverse osmosis plant at Dhekelia. In 2009, the domestic water demand amounted to 70.3 mm³, of which desalination contributed to 49.4 mm³ per year. Therefore, the desalination plants contributed to 70% of the total domestic water. In 2013, a different picture could be observed, where only 14% of the total domestic water came from desalination. This drop in domestic demand for water from desalination plants was compensated by an increase in the domestic demand of water coming from dams. This increase was a product of the decision to operate desalination plants at their lowest possible production capacity and most of the plants were set in standby mode. These instructions were according to contractual provisions, which allow the Water Development Department to manage the water production taking into account the water reserves.

Artificial aquifer recharge with reused water: A recharge scheme for the Ezousas aquifer in Cyprus, where treated water is mixed with water from the Asprokremmos dam before being recharged in the aquifer through specially constructed shallow ponds. This water, after natural purification, is pumped from the aquifer for irrigation. Pumping is carried out strategically so that retention time in the aquifer is maximised.

Grey water is also used as a means of reducing the consumption of water in households, other living quarters such as hotels and a few types of industry such as laundries. Water, which is used for washing (e.g. washhand basins, baths, showers, washing machines and dishwashers), is collected in a separate system and then filtered.

Cyprus is one of the Member States where water reuse provisions are fully integrated into the legislation on urban wastewater treatment and discharge (State Law N.106 (I)/2002, as amended). Quality criteria for the treated wastewater take the specific conditions of Cyprus into account. In particular, conventional secondary treatment has been preferred to stabilisation ponds in some areas because of the high cost of land (coastal areas) or for protection of environmental and aesthetic amenities for tourism.

Cyprus adopted water quality standards for wastewater reuse in 2005 and is prohibiting the irrigation of treated wastewater for vegetables that are consumed raw (leafy vegetables, bulbs and condyles) and crops for exporting.

The Water Development Department (WDD) is responsible for implementing the Government's water policy, to provide effective protection, rational development and sustainable management of water resources in Cyprus. The Government's water policy focuses on addressing water scarcity and droughts and uncontrolled exploitation. Within the framework of the Government's water policy, other nonconventional water resources, such as recycled water (the use of which releases equal quantities of good quality water), desalination of seawater and brackish groundwater as well as rainwater utilisation are promoted. In addition, the cultivation of a water saving culture is promoted across all citizens.

In general, all treated wastewater produced in Cyprus is reused, primarily for the irrigation of agricultural land, parks, gardens and public greens, where the Code for Good Agricultural Practice (K.D.P.407/2002) is applied. This Code of Practice is intended to ensure further protection of public health and the environment (for each potential use, irrigation methods are indicated). As part of the transposition of the UWWT Directive and the IPPC Directive, Cyprus issued the State Law N.106(I)/2002 (amendments 2002-2009) concerning 'The Control of the Waters Pollution' and the associated regulations K.D.P. 407/2002, 772/2003 254/2003, KDP269/2005. According to this law, the operation of any establishment, which might cause or causes the pollution of the soil and/or the waters, is forbidden, unless it has Wastewater Discharge Permit. Wastewater Discharge Permits are issued by the Minister of Agriculture Natural Resources and Environment for the Sewerage Boards and the Water Development Department. Permits specify the quality objectives and the disposal conditions of the treated wastewater for the agglomerations above 2 000 population equivalents.

Legally-binding numerical limit values are set for a range of parameters. They apply at the WWTP outlet. These values are different depending on the size of the WWTP. In order to comply more efficiently with the guidelines, most of new projects under planning (new wastewater treatment plants as well as extension of existing ones) are beginning to consider advanced technologies such as membrane application, e.g. bioreactor technology (Larnaca, Limassol, and Nicosia) or reverse osmosis. Combined efforts by the Sewage Board and local governments to conduct periodic monitoring of water quality according to the regulation, has led to public acceptance and confidence in the use of reclaimed water.

In conclusion, effluent reuse, water resources management and water conservation are essential for water scarce countries like Cyprus. By the introduction of regulations, controls, and safety measures they are completely safe and reliable sources of water and EU should take advantage of these alternative sources of water following the example of the Cypriot country.

5. TOP-DOWN POLICIES TO FOSTER WATER REUSE – CASE STUDIES OUT OF EUROPE

E. Irvine Ranch Water District (California)

Context: The District is in a semiarid region with an average precipitation of only 304.8 to 330.2 mm of rainfall per year.
Good Practice: Recycling water makes up more than 20 % of total water supply, reducing the need to import additional (expensive) water. The recycled water system also helps to make the District "drought resistant" and reduces the use of potable water for non-potable uses in order to maximize drinking water supplies.
Limits: Main problems encountered are due to water salinity, dimensioning of storage in relationship with seasonal fluctuations and more maintenance of the storage and distribution system required by using recycled water
Lesson to be learnt: Public education and involvement to raise the community awareness about the benefits of water reuse and conservation.

Background

Irvine Ranch Water District (IRWD) was founded in 1961 in the Orange County area of Southern California. This semiarid region receives an average of only 304.8 to 330.2 mm of rainfall per year. At the time the District was formed, the area was primarily agricultural. A majority of the property within the District boundaries was owned by The Irvine Company, which began development of the former ranch as a planned community in the early 1960s.

About 40 percent of IRWD's drinking water is surface water from the Colorado River and Northern California purchased from the Metropolitan Water District of Southern California. The remaining 60 percent is obtained from local groundwater wells. In the early 1960s water reuse for other than agricultural applications was relatively rare, but the Water District's early visionaries realized that water would be a key component to the viability of the new community.

Wastewater came to be viewed as a unique resource rather than something in need of disposal. The Michelson Water Reclamation Plant (WRP) was built and became operational in 1967, supplying the growing community with highly treated recycled water. IRWD merged with the Los Alisos Water District in 2000 and began serving additional customers with recycled water from the Los Alisos WRP.

The main purpose of the water recycling program is to maximize drinking water supplies by reducing the need to use potable water for non-potable uses. Another purpose is to minimize the amount of treated wastewater that must be sent to a regional wastewater agency for disposal through an ocean outfall.

Project Description

Unlike some projects that serve a limited number of customers, IRWD's recycled water distribution system reaches most of its 344.47 km^2 service area, which has a population of 316,000. While some recycled water distribution lines are retrofitted, common practice at IRWD is to install recycled water lines along with domestic water and sewer lines as new housing or commercial developments are built.

Currently, there are over 3,400 m of recycled water connections.

Two facilities, the Michelson and Los Alisos WRPs, treat wastewater to tertiary standards specified in the California Department of Health Services Water Recycling Criteria for high level non-potable uses, such as irrigation of residential property. Recycled water is delivered throughout the community through a dual distribution system that includes more than 480 km of recycled water pipelines, 12 storage reservoirs, and 15 pump stations. Two of the reservoirs are open lakes; the others are pre-stressed concrete or steel tanks. Prior to discharge from the two open reservoirs to the recycled water distribution system, recycled water may receive additional treatment by straining, pressure filtration, and/or disinfection. The recycled water storage capacity currently is 2.5 million m^3.

The primary use of recycled water is landscape irrigation. Eighty percent of all business and public area landscaping in the District is irrigated with recycled water. Landscape irrigation uses include parks, school grounds, golf courses, a cemetery, freeway landscapes, city-maintained streetscapes, common areas managed by homeowner associations, and front and back yards at individual residential dwellings, including large residential estate lots. Recycled water is also used for food crop irrigation, toilet and urinal flushing in 12 dual-plumbed office buildings, and in commercial office cooling towers. Steve Bourke, Landscape Superintendent for the City of Irvine, states that, "We've been using recycled water for more than 30 years with no documented adverse effects. Having recycled water available has been a win-win situation for everybody."

Problems Encountered

The major problems encountered by IRWD are related to salinity, seasonal storage, and increased maintenance.

- Salinity/Water Softeners: IRWD must constantly fight the battle of salinity. With source water (Colorado River) becoming more saline, the District has become increasingly concerned over the addition of more salts into the "closed loop" water reclamation system. Self-regenerating water softeners can add a large amount of salt to the sewer system each year. In addition, regulators attempting to limit nonpoint sources of pollution (i.e., urban runoff) often suggest that the salty runoff be diverted to the sanitary sewer. IRWD recognized the problem due to salinity and enacted rules and regulations in the early 1970s to prohibit the use of self-regenerating water softeners within IRWD boundaries. Exchange tank systems that do not add salt to the sewer system were not prohibited.

  The City of Irvine was incorporated in 1971, and the prohibition on self-regenerating water softeners soon became an ordinance of the city. The salinity problem re-emerged in 1997, when court cases brought by the water softener industry against water agencies elsewhere in California overturned such bans. IRWD continues to work legislatively toward restoring the ability of water recycling agencies to control salinity.

- Seasonal Storage: Southern California receives most of its rainfall during the winter months. Since landscape irrigation is the main use of recycled water, demand fluctuates seasonally. In the winter months, more recycled water is produced than can be used. In the hot summer and fall months, the plant capacity cannot produce sufficient water to meet demand. Balancing the seasonal storage issue through the use of open lakes is an ongoing challenge, and finding land in an urban setting to build more seasonal storage is a difficult task. IRWD currently is able to meet year round demand through the use of its numerous storage reservoirs but continually seeks locations for additional recycled water storage to meet expected future demand.

- Increased Maintenance: Recycled water systems require more maintenance than drinking water systems. This includes more frequent reservoir tank cleaning, increased control valve maintenance, and potential damage to mainline valve body seats from higher chlorine levels. From a regulatory standpoint, leaks or spills of any amount must be reported to the county health department. Also needed is an onsite inspection group to conduct ongoing monitoring to prevent cross connections.

None of the maintenance issues presented by recycled water proved to be major problems, but they did result in equipment and procedural changes to adequately address the maintenance issues. For example, IRWD now specifies a different type of valve seat, which has a higher resistance to chlorine. When dealing with leaks or spills of recycled water, IRWD attempts wherever possible to route the water into a sanitary sewer system instead of the separate storm drain system which flows to the ocean. In other cases, leaked or spilled water is collected and trucked to the sewer system.

Public Outreach

Recycled water generally is very well accepted within the IRWD service area. Because the district has a 35-year track record of successfully and safely providing recycled water to the community, it is not met with resistance by the general public. This is due, in part, to an extensive public education and involvement program via brochures, videos, workshops, tours, and other means that have resulted in community acceptance of water reuse as an environmentally sound method for stretching limited water supplies.

IRWD's public outreach program has included an extensive classroom water education program in local schools for nearly 30 years. The need for water conservation is taught at all grade levels, and the water reuse concept is introduced to students in the fifth grade. In addition, tours of the WRPs and water quality laboratory are regularly held for the general public. IRWD has found that a well-informed public is less apprehensive about water reuse.

Costs and Revenues

IRWD has continued to expand and upgrade its reclaimed water program throughout the years, with most of the capital costs financed via the District's internal funding mechanisms. Infrastructure costs are recovered through a combination of property taxes and connection fees. The annual O&M cost of the recycled water system (including treatment and distribution system maintenance) was about $6.6 million for fiscal year 2002-2003. The base recycled water rate is $0.68/2.8 m^3, which is 90 percent of the base domestic water rate. IRWD uses an ascending block rate structure that severely penalizes excessive water use.

Future Upgrades

The district currently is working on conversion of an existing open reservoir that was formerly used for drinking water storage to provide additional seasonal storage of recycled water. When completed in early 2005, this reservoir will add another 3 million m^3 of recycled water storage to the IRWD system. The District is also in the design phase on the Irvine Desalter Project, which will remove trichloroethylene (TCE) from a plume of pollution migrating from a former military base. Following treatment by reverse osmosis, air stripping with activated carbon filters, and disinfection, the product water will be added to the recycled water system. Beginning in 2006, this project is expected to provide an additional 2.2 million m^3/year of water.

Because the IRWD service area is still being developed, there will be a need for additional recycled water in the future.

F. Montebello Forebay Groundwater

Context: Southern California is an arid region with an average precipitation of only 381 mm per year. Over the years, the increasing demand for water caused the overexploitation of the ground water aquifer.
Good Practice: This is the oldest project doing groundwater recharge with recycled water in California and it is the primary source of replenishment for the Central Basin. Recycling water for groundwater recharge and also for non-potable uses (landscape and agricultural irrigation, industrial process water, recreational impoundments, and wildlife habitat) has helped to reduce the overdraft in the Central Basin.
Lesson to be learnt: The use of recycled water in lieu of imported potable water for groundwater recharge helps in saving money and prevent overdrafting.

Recharge Project Background

Southern California is essentially a desert area with limited water resources and an annual rainfall averaging about 381 mm/year. In the early 1900s, local precipitation and runoff was sufficient to replenish the groundwater supply of the coastal basins, which initially was the primary source of water. By the 1950s, increasing demand for water resulted in severe over drafting of groundwater in the region. Water needs were exacerbated in 1982 by a Supreme Court decision that awarded the State of Arizona surplus Colorado River water, which makes up more than 50 percent of the Metropolitan Water District of Southern California's (MWD) annual withdrawals, raising the possibility of decreased availability of Colorado River water in the future.

The Montebello Forebay Groundwater Recharge Project – the oldest planned indirect potable reuse groundwater recharge project in California – is located in south-eastern Los Angeles County and is the primary source of replenishment for the Central Basin, which is the main groundwater basin underlying the greater Los Angeles metropolitan area. Planned recharge of recycled water occurs in an unconfined (non-pressure zone) region of the Central Basin known as the Montebello Forebay. The Central Basin is an adjudicated basin with 85 groundwater pumpers operating more than 400 active wells. Imported water from the Colorado River and State Water Project purchased from MWD provides 55 percent of the water used within the basin, with groundwater accounting for the remainder.

If recycled water was not used for groundwater recharge of the Central Basin aquifer, the Water Replenishment District of Southern California (WRD) would have to purchase an equivalent amount of imported water from MWD for recharge at a much higher price or restrict pumping of the aquifer to prevent overdrafting, which would shift water demand to surface supplies. Surface deliveries could be augmented by seawater desalination, albeit at a much higher cost than either recycled or imported water.

In addition to groundwater recharge, the County Sanitation Districts of Los Angeles County (CSDLAC) uses recycled water for a variety of nonpotable applications, such as landscape and agricultural irrigation, industrial process water, recreational impoundments, and wildlife habitat.

Project Description

The use of recycled water for groundwater recharge began in 1962. Approximately 14.8 million m^3/year of disinfected activated sludge secondary effluent from the Whittier Narrows Water Reclamation Plant (WRP) was spread in the Montebello Forebay area of the Central Basin, which has an estimated storage capacity of 962 million m^3. The County of Los Angeles provided funding for the plant, the U.S. Army Corps of Engineers provided the site behind the Whittier Narrows dam, and CSDLAC designed, built, and operated the plant.

In 1973, the San Jose Creek WRP was placed in service and also supplied secondary effluent for recharge. The San Jose Creek WRP provides the majority of the recycled water now used for recharge. In addition, effluent Pomona WRP that is not reused for other purposes is discharged into San Jose Creek, a tributary of the San Gabriel River, and ultimately becomes a source of recharge in the Montebello Forebay. During the mid to late 1970s, all three plants were upgraded to provide tertiary treatment via filtration as a public health protection measure to protect people recreating in the receiving waters. The WRPs have since been upgraded to include nitrification/denitrification treatment. Recycled water is used along with storm water runoff and imported surface water (Colorado River and State Water Project water) for recharge.

In 1987, a Los Angeles Regional Water Quality Control Board (RWQCB) order permitted the CSDLAC to increase the annual quantity of recycled water used for replenishment from 40.3 to 61.7 million m^3. In 1991, the water reclamation requirements for the project were revised to allow for a maximum recharge of 74 million m^3 in any year as long as the running 3-year total did not exceed 61.7 million m^3/year or 35 percent recycled water.

The increase in the amount of recycled water used for recharge allowed in 1987 requires also the California Department of Health Services (DHS) and the RWQCB to monitor, not only the effluent from the three WRPs contributing to the recharge project, but also bimonthly sampling of six shallow monitoring wells and semiannual monitoring of 19 production wells. This long-term monitoring program has continued to demonstrate that the introduction of recycled water into the aquifer meets all regulatory requirements and has not adversely impacted groundwater quality.

Project Management

CSDLAC operates the Water Replenishment District and monitors the recycled water quality. The Los Angeles County Department of Public Works (DPW) operates the recharge facilities (river conveyance and spreading basins), and the WRD is responsible for overall management of the groundwater basin – including groundwater monitoring. DPW has constructed two spreading areas designed to increase the percolation capacity. The Rio Hondo Spreading Grounds have 2.3 km^2 of spreading basins available for spreading, and the San Gabriel Coastal Spreading Grounds have 0.52 km^2. Percolation also occurs in 0.54 km^2 of the unlined San Gabriel River channel. The WRPs are located upstream of the spreading grounds, allowing gravity flow and existing waterways to transport the recycled water, thus reducing capital and O&M costs.

Under normal operating conditions, batteries of basins are rotated through a 21-day cycle. The cycle consists of three 7-day periods during which the basins are filled, the flow to the basins is terminated, and the basins are allowed to drain and dry out thoroughly. This wetting and drying operation serves to maintain aerobic conditions in the upper strata of the soil and to control vectors in the basins. The vadose zone under the spreading basins (i.e., the sandy loam soil layer extending from the bottom of the basins to the groundwater table in which additional treatment takes place) is variable depending on location but generally is 305 cm thick or more.

Water Quality/Regulatory Requirements

In California, DHS has the authority to adopt water reuse criteria, which are implemented by the RWQCBs via their permit system. DHS has been developing groundwater recharge regulations for a number of years and, although draft regulations have been released, it is unclear what the final criteria will contain upon adoption. It is clear that recycled water used for groundwater recharge will have to meet drinking water standards, very low nitrogen and total organic carbon (TOC) limits, dilution requirements, and not contain measurable levels of pathogens. Also, monitoring of other constituents, such as xenobiotic compounds (e.g., pharmaceuticals and personal care products), will be required by the regulatory agencies. It is noteworthy that the water quality criteria apply to the water after percolation through the vadose zone.

Recycled water produced by the WRPs complies with the primary drinking water standards, and meets total coliform and turbidity limits. Extensive virus and parasite sampling indicates that the recycled water is essentially free of measurable levels of pathogens.

The ongoing concern over emerging contaminants and associated health concerns requires effluent monitoring and research beyond what has been done in the past. Development of virus and parasite quantitative analytical techniques, microbial viability studies, evaluation of soil aquifer treatment, and surrogates for health significant organic constituents are just some of the research efforts underway at CSDLAC.

Project Benefits

The recharge of more than 1233 million m^3 of recycled water since 1962 has helped to significantly reduce the cumulative overdraft in the Central Basin. The recycled water provides a new water supply roughly equivalent to the demands of 250000 people and reduces wastewater discharges to surface waters. Also, the use of recycled water in lieu of imported water for groundwater recharge saves WRD more than $12 million per year in water purchases.

G.San Antonio Water System

Context: San Antonio in Texas needed to develop new water resources to preserve aquifer yield.	

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Good Practice: Water recycling and conservation program. With the construction of a system to deliver recycled water for non-potable uses, the effective use of existing water supplies increase. Use of recycled water for industrial cooling water, river maintenance, and landscape irrigation at golf courses, schools, commercial sites. Replace aquifer water with recycled water.

Limits: The project seems to focus only on water reuse and not to educate to an efficient use of water resources.

Lesson to be learnt: Water conservation programs for education, plumbing and landscape retrofits, conservation pricing, and leak detection have resulted in a reduction in potable water use.
Water quality deterioration and potential accidents were prevented by introducing safety measures and routines.

Background

For over two centuries, San Antonio, Texas, depended on the Edwards Aquifer for its water supply. In the 1890s, water that used to emerge as natural spring flow began to be withdrawn from municipal and private wells. By the 1920s, streams in the area had little to no flow in them in some years, and by the mid-1950s, springs and streams were almost totally dry. Upper reaches of streams were completely dry, and most stream flows were due solely to effluent discharged from wastewater treatment plants.

Water withdrawals from the Edwards Aquifer were historically based on the right of capture, which allowed any user to withdraw as much water as could be used for beneficial purposes. Demand for water in the 1990s began to surpass the aquifer's safe yield, and legislation was passed to limit aquifer withdrawals to ensure continual springflows. For the first time in its history, San Antonio needed to develop new water resources. In 1993, the San Antonio Water System (SAWS) adopted a Water Conservation and Reuse Plan that solidified the City's commitment to a water recycling program. Water conservation programs for education, plumbing and landscape retrofits, conservation pricing, and leak detection has resulted in a 31 percent reduction in potable water use since 1986. Current water consumption averages 0.55 m^3 per capita per day. About 4 to 6 million dollars is spent annually for conservation programs. Along with conservation, making more effective use of existing supplies became a key concern, and building a system to deliver recycled water for nonpotable uses became a high priority. One stated goal was to maintain adequate flows in the San Antonio River and Salado Creek. Flows in the San Antonio River in the downtown River Walk area had been supplied by wells for decades, and Salado Creek was an impaired stream with high fecal coliform concentrations and low dissolved oxygen levels.

System Development

SAWS owns and operates four major Water Recycling Centers (WRCs) that combined currently produce approximately 439,107 m^3 per day of tertiary-treated wastewater. Although there is no requirement in Texas that effluent derived from groundwater must be returned to water courses, SAWS has agreed to discharge a minimum of 185,485 m^3 per day for downstream surface water rights holders. In addition, SAWS has been providing recycled water to the City's municipally-owned electric generating facility for power plant cooling for more than 30 years from the Dos Rios WRC. The plant discharges treated wastewater to the San Antonio River, from which water is withdrawn to cooling water lakes. In 1995, SAWS embarked on an effort to provide the remaining uncommitted wastewater, 117,347 m^3 per day, to other customers from the Salado Creek and Leon Creek WRCs. Construction of almost 121 km of pipeline began in 1997. The Salado leg began discharging recycled water in 2000, and the Leon leg was brought online in 2002. The Salado Creek

WRC serves the east side of the system and the Leon Creek WRC serves the west side. Interconnections are currently under construction to connect all the facilities. When completed, the Salado Creek WRC will be taken out of service. The City's master plan includes use of recycled water from the Medio Creek WRC on San Antonio's west side. The interconnections will enable recycled water to be delivered to any point in the system from any of the remaining WRCs, thus providing a high degree of reliability and redundancy. Potential recycled water users were asked to sign a request for service document in 1997. The document confirmed the intention by customers to purchase recycled water from SAWS when such water became available. Potential demand exceeded supply as SAWS allocated an average of 117,347 m^3 per day of recycled water to be available and about 158,987 m^3 per day of recycled water was requested by 77 potential customers. More than 70 percent of the total available volume from the Salado Creek and Leon Creek WRCs currently is contractually committed for recycled water applications. About 45 percent of the total available volume, is online. Uses include industrial cooling water, river maintenance, and landscape irrigation at golf courses, schools, commercial sites, etc. Potential customers are subject to onsite water use surveys and checks for proper backflow prevention devices and code compliance by SAWS staff. One requirement is a two-way pressure separation testing followed by a dye test of the system prior to connection. The Texas Commission on Environmental Quality (TCEQ) is the state agency that governs recycled water programs, and its predecessor, the Texas Natural Resource Conservation Commission (TNRCC), was responsible for adopting the State's water reuse criteria. The Texas standards prescribe water quality limits, but do not include specific treatment unit process requirements. SAWS provides "Type I" (i.e., human contact with the water is likely) reclaimed water to its users. When complete, the recycled water system will reduce dependence on the Edwards Aquifer supplies – which are now subject to allocations and cutbacks – by 20 percent, thus reserving groundwater supplies for potable use. The goal is to replace 41.6 million m^3/year of Edwards Aquifer water with recycled water. Other benefits include the following:

- A reliable supply of water to industrial and commercial users;
- Acquisition of additional Edwards Aquifer pumping rights by the city through trading for an equal amount of reclaimed water;
- Improvement and enhancement of environmental conditions in the San Antonio River and Salado Creek;
- An unrestricted water source that can be used in times of drought or curtailment of Edwards Aquifer potable water;
- Reduced fertilizer costs due to the nutrients in reclaimed water; and
- Elimination of the Water Supply Fee or the Edwards Aquifer Authority Fee.

Problems

One problem encountered early was water quality deterioration in the distribution system, primarily due to microbial growth in supply lines and tanks resulting from stagnation during startup with low flows. In response, SAWS developed a database to track chlorine levels throughout the system, initiated a program to eliminate stagnation of water in a storage tank by fluctuating water levels in the tank, and installed gas chlorine injection systems at key locations, thus giving SAWS the ability to maintain a chlorine residual of one mg/L throughout the system. Additionally, the system's storage tanks are periodically drained and cleaned to remove suspended solids that settle in the tanks. During the first few years of operation there were a series of pipeline failures. Most of them were customer related, but failures also occurred on main transmission lines that supplied the Salado Creek Segment (one joint failure) and a portion of the Leon Creek Segment (three joint failures). SAWS was able to maintain service to most of the customers during these incidents by having a potable "backup" supply line – with an air gap – at each major pumping station. A concern was expressed that high total dissolved solids (TDS) levels, particularly chlorides, could adversely affect vegetation. SAWS responded by incorporating TDS assurance levels in the Recycled Water Service Agreement, as well as assured levels of related constituents. A cross connection incident in 2002, where recycled water intended for use at a golf course was introduced into the potable system, was caused by failure to disconnect a potable system valve and pipe that was directly connected to the reclaimed water system. As a result of this incident, SAWS made substantial changes to its procedures to preclude future occurrences. Before allowing a new recycled water service to begin, customer training classes are now conducted with customer workers involved in routine system operation. No system is connected until a 5-step process is completed that ensures complete separation between the recycled and potable systems. After initiation of recycled water service to any new customer, the system is rechecked and tested by SAWS staff.

Stream Augmentation

One of the benefits of the recycled water system has been improved water quality in the San Antonio River and Salado Creek. Extensive laboratory studies in 1996 and 1997 and an extensive San Antonio River sampling program begun in 1997 have confirmed that water quality has improved since discharge of recycled water started. This is evidenced by the return of several pollution intolerant species of fish to the San Antonio River system. Suspended solids levels are generally lower than they were prior to recycled water discharges, while TDS levels have increased. Ammonia nitrogen and phosphorus levels are slightly higher since the addition of recycled water began, but Chlorophyll-a levels are lower due to increased flows. River water at the San Antonio River Walk is clearer, contains less algae, and has fewer odors than before implementation of the recycled water program. The introduction of recycled water to Salado Creek has begun to restore a healthy aquatic ecosystem. With Salado Creek flowing again, San Antonio is planning a linear park which may include hiking and biking trails, parks, shallow pools, and waterfalls. In 2000, voters approved a proposition to generate $20 million for land purchases along Salado and Leon Creeks for floodways, open space, and hike and bike trails. In its initial phase, almost 32 km of Salado Creek is targeted for improvements.

Costs and Fees

The potable water rate is $0.098/100 gallons plus a Water Supply Fee (WSF) and Edwards Aquifer Authority (EAA) fee. In 2003, the WSF was $0.094/0.4 m^3 and the EAA fee was $0.0086/0.4 m^3, resulting in a total cost of $0.20/0.4 m^3, while the recycled water rate was $0.098/0.4 m^3, resulting in a cost savings of 51 percent over the potable water rate. Recycled water rates vary slightly based on season and amount of water used. Customers who trade Edwards Aquifer pumping withdrawal rights in exchange for recycled water pay a rate of $0.025/0.4 m^3; others pay the above stated rates. The total capital cost to date for the recycled water system is $124 million.

H.West Basin Municipal Water District

Context: In Southern California, the major amount of water used is imported and the District was threatened by the prospect of a dwindling supply of imported water caused by environmental concerns and anticipated future allotment cutbacks. In addition, with the occurrence of droughts, the availability of water was not assured.
Good Practice: To reduce the region's dependence on imported water, alternative sources of water supply to the region were searched. The solution was identified in recycling treated municipal wastewater and desalinating seawater.
Lesson to be learnt: The treatment processes have been specifically designed to produce water that meets the specific needs of the end user and the quality requirements.

Background

The West Basin Municipal Water District (WBMWD), formed in 1947, is a public agency that wholesales imported potable water and recycled water to local cities, water companies, private companies, and investor owned utilities. WBMWD's service area encompasses 518 km2 in southwest Los Angeles County, California. WBMWD provides 80% of the potable water used in its service area to more than 850000 people; the remaining 20 percent is local groundwater pumped by retail water agencies.

In the early 1990s, about 80 percent of the water used in southern California was imported. WBMWD purchased State Water Project and Colorado River water from the Metropolitan Water District of Southern California (MWD) for resale to its customers. It was around this time that WBMWD began considering alternative sources of water supply to the region due to the prospect of a dwindling supply of imported water caused by environmental concerns and anticipated future allotment cutbacks. In addition, extended droughts that occur from time-to-time and a lack of emergency storage facilities to assure reliable deliveries during droughts made it more imperative for WBMWD to diversify its water supply portfolio. Recycling treated municipal wastewater and desalinating seawater were identified as the most viable alternatives available to supplement WBMWD's water supplies. WBMWD pursued water recycling as the most economical choice that would also give the District the opportunity to treat wastewater to different levels depending on end use. WBMWD embarked on a large scale conservation and recycling program in the early 1990s to improve water supply reliability and reduce the region's dependence on imported water. Consistent with its mission to "obtain and provide a safe and adequate supplemental supply of high quality water to our member agencies, including the communities, businesses, and residents they serve, in an efficient, effective, and economical manner," plans were underway to establish WBMWD as one of the leaders in water recycling.

The goals of the recycling program are to reduce dependence on imported water by 50%, provide an alternative drought proof local water source, reduce the volume of treated wastewater discharged to Santa Monica Bay by 25%, and prevent further saltwater intrusion of the groundwater basin. In addition to providing recycled water to customers for diverse applications, the overall program includes education, conservation, and resource planning.

Various agreements were necessary to proceed with the proposed project. An agreement was needed with the City of Los Angeles to purchase secondary effluent from the Hyperion Wastewater Treatment Plant (HTP). Another agreement was needed with MWD for their local project rebate of up to $250/ac-ft (i.e., 70,000 ac-ft for 25 years, a financial commitment of over $200 million). Both agreements were approved and construction of the first phase of the project was initiated in 1992 and completed in late 1994. Delivery of recycled water began in 1995.

In 2002, an average of 90,849 m^3 per day of recycled water was used for a variety of applications, including landscape irrigation, industrial cooling and boiler feed water, commercial applications, and groundwater recharge. The treatment processes have been specifically designed to produce water that meets the specific needs of the end user; thus the term "designer water" was coined to describe the five different qualities of recycled water produced at the West Basin Water Recycling Plant (WBWRP).

Project Description

Phase I of the project consisted of a pump station at HTP, a 1.5 m force main, a recycled water treatment plant, and a distribution system. Secondary effluent from HTP is pumped five miles from the 90-mgd (340,687 m^3 per day) pump station to the WBWRP in El Segundo, California, for further treatment prior to reuse.

The WBWRP produces five different qualities of recycled water, all of which meet the treatment and water quality requirements specified in the California Department of Health Services (DHS) Water Recycling Criteria for the different recycled water applications. The quantities of recycled water (2002 annual data converted to daily averages), types of treatment, and uses of the water are as follows:

- 9,463 m^3 per day of disinfected tertiary treated recycled water for irrigation;
- 28,012 m^3 per day of nitrified and disinfected tertiary treated recycled water for industrial cooling makeup water;
- 24,605 m^3 per day of recycled water that has undergone tertiary treatment, lime treatment, reverse osmosis (RO), and disinfection for groundwater recharge;
- 21,955 m^3 per day of recycled water that has undergone microfiltration, RO, and disinfection for low pressure boiler feed water; and
- 9,084 m^3 per day of recycled water that has undergone microfiltration, RO, disinfection, and second pass RO for high pressure boiler feed water.

Tertiary Treatment for Nonpotable Uses: Tertiary treated recycled water is used for industrial cooling water and a variety of irrigation uses. The tertiary treatment train at the WBWRP consists of coagulant addition using ferric chloride, flocculation basins, anthracite mono-media filters, and disinfection using sodium hypochlorite. The finished water is stored in an 18,927 m^3 storage reservoir from which it is pumped to a 121 km long distribution system for industrial and commercial applications and irrigation of parks, golf courses, schoolyards and other landscape areas. Phase I had an initial treatment capacity of 56,781 m^3 per day, which was expanded to 113,562 m^3 per day after completion of the Phase II expansion.

Nitrified Water: A portion of the tertiary treated water receives additional treatment to remove ammonia, which causes corrosion in industrial cooling towers that have copper-based alloys. Nitrification to convert the ammonia to nitrate takes place in biofilters at satellite package plants. Sodium hypochlorite is then added to assure complete destruction of the ammonia and for disinfection purposes.

AWT for Recharge: The West Coast Basin Barrier Project, operated by the Los Angeles County Department of Public Works, was constructed in the 1950s and 1960s to inject imported MWD water into a series of wells along the coast to halt or reduce seawater intrusion into the potable groundwater basins. There are more than 150 injection wells that, in total, inject an average of approximately 24 million m^3/year into the aquifers, although as much as 49 million m^3/year has been injected in some years.

Three parallel treatment trains with a total capacity of 28,390 m^3 per day produce recycled water for the barrier. In Phase I of the project, two identical treatment trains were built to treat a maximum of 18927 m^3 per day of recycled water for recharge. Treatment of HTP secondary effluent by these trains includes decarbonation to remove CO2 and raise the pH, chemical coagulation and clarification using lime to precipitate magnesium and other chemical constituents from the water and provide disinfection, recarbonation to lower the pH, filtration using trimedia filters (anthracite, garnet, and sand), addition of sulfuric acid for pH adjustment and a scale inhibitor to prevent deposition of salts on the RO membranes, RO treatment, decarbonation for pH adjustment, disinfection using sodium hypochlorite, and lime addition to stabilize the water.

During the Phase II expansion, a third treatment train with a capacity of 9,463 m^3 per day was built. In this train, treatment of HTP secondary effluent includes sodium hypochlorite addition, straining, microfiltration, addition of sulfuric acid and a scale inhibitor, RO, decarbonation, disinfection using sodium hypochlorite, and lime addition. The product waters from all three treatment trains are then combined, blended with MWD potable water, and pumped to barrier wells for injection. The recycled water is subjected to extensive monitoring and meets all treatment process and water quality requirements specified by the California DHS in its most recent draft groundwater recharge criteria. The reject water (concentrate) from all RO units is discharged into the HTP's 8 km secondary effluent outfall pipeline for disposal.

RO for Industrial Boiler Feed Water: WBMWD supplies recycled water to a Chevron refinery in El Segundo for both low pressure and high pressure boiler feed water and to an Exxon Mobil refinery for boiler feed water. Because minerals and other constitueproblems in boilers, they must be removed from the water. Therefore, treatment similar to that used for barrier injection (i.e., microfiltration, RO, decarbonation, and disinfection) is used at the WBWRP to produce water for the Chevron refinery and at a satellite treatment plant to produce water for the Exxon Mobil refinery. Because higher quality water is required for high pressure boiler feed, some of the water (after the first pass RO treatment and disinfection) passes through RO a second time (second pass) to remove more dissolved solids from the water. About 21,955 m^3 per day that has received single pass RO treatment is produced for low pressure boiler feed, while an additional 9,084 m^3 per day receives second pass RO treatment for high pressure boiler feed. Product water is pumped to a storage tank at the nearby Chevron refinery in El Segundo. Reject water from the RO processes is discharged to the HTP outfall line. Product water from the satellite MF/RO plant in Torrance is pumped to the Exxon Mobil refinery.

Funding

Funding for Phase I facilities capital construction costs of about $200 million was obtained from WBMWD water revenue bonds, U.S. Bureau of Reclamation grants, and State of California low interest loans. By 2003, total capital costs (including land) expended for all phases of the project were approximately $365 million. The operating cost of the project was $14.8 million for the fiscal year ending 2002.

WBMWD sells imported water to its customers for $510/ac-ft (510$/1233.5 m^3), while the price of recycled water charged to customers varies according to the level of treatment the water receives. Tertiary recycled water is sold for 25 to 40 % less than imported water. Nitrified water is sold for 20 percent less than imported water. AWT recycled water is sold for 10 percent less than imported water. Users of single and double pass RO water for low pressure and high pressure boiler feed are charged a rate equal to, or slightly higher than, imported water.

Public Information Programs

WBMWD has an extensive ongoing public outreach program. A proactive children's education program, called the Planet Protector Explorations, was developed to heighten public awareness in the entire community. The outreach efforts work in tandem with construction, recycled water marketing, conservation, and school education to inform the public. WBMWD's Speakers Bureau targets local cities and civic and environmental groups that are affected by WBMWD's recycling project. These programs have been instrumental in capturing the support and enthusiasm of the residents, educators, students, and businesses and industries.

I. Methods to conserve and reuse water in Chicago (Illinois)

Context: In the city of Chicago the demand for water is expected to increase over the next 20 years, with a projected population increase of 20%. In the same timespan, the city is expecting increased incidence of local flooding each year due to severe storms, but also water level reduction of the lakes.	
Good Practice: Reduce fresh and potable water use and promote water reuse, conservation and recycling.	
Limits: Standards for water reuse systems are not included in the legislation therefore the Committee on Building Standards and Tests is required to evaluate each project independently, which may add cost and time.	
Lesson to be learnt: Potable water use reduction is stressed through policies and projects to ensure the region's ongoing water vitality	

The City of Chicago is located at the junction of the Chicago River and Lake Michigan, as well as at the convergence of the Mississippi River and Great Lakes watersheds. Nearly 95 percent of the nation's fresh water supply is found in the Great Lakes. While the region's fresh water supply may appear endless, there are compelling reasons to initiate comprehensive conservation methods. These efforts are in line with a Supreme Court 1967 ruling that limits Lake water diversion rates to 91 m^3 per second, regardless of the future development or population growth the area has experienced. Policy documents of many major regional planning agencies, such as the Chicago Metropolitan Agency for Planning and the Alliance for the Great Lakes, emphasize potable water use reduction to ensure the region's ongoing water vitality.

Water levels in Lake Michigan have been falling, with only one percent of the water in the Lake renewed each year. Ground water levels have declined between 91 and 244 m in the region, further lowering Lake water levels. At the same time, demand for water is expected to increase over the next 20 years, with a projected population increase of 20% in the Chicago-Milwaukee region. With both increasing demand and decreasing supply, it is critical for the Chicago area to take prudent and sustainable measures to safeguard against a dwindling fresh water supply.

At the same time, the Chicagoland area is experiencing increased incidences of local flooding each year due to severe storms; flooding within the City alone is largely a result of the City's high water table and combined sewer system (a sewer system in which wastewater and storm water are combined and treated in the same way). The combined sewer system occasionally overflows (CSO) during major storm events, causing sewer contents to discharge into a waterbody, such as Lake Michigan or the Chicago River. Prevention of such flooding is important to minimize the cost of damages as well as to protect water quality. These issues can be at least partially ameliorated by reusing water and reducing the load on the municipal sewer infrastructure.

The City of Chicago acknowledged the water reuse need and opportunity several years ago, and nowadays offers several methods to conserve and reuse water. These strategies are outlined to reducing fresh water, or potable water, usage and provide many key benefits.

Chicago's voluntary Meter-Save program

Chicago's Meter-Save program, which installs residential water meters free of charge, is designed to promote water conservation. Any resident current on their water bills who owns a single family home or two-flat qualifies for the program. More than 117000 new meters have been installed since the program began in 2009.

This program is successful because people are seeing considerable savings with completely free installation and a seven-year guarantee that bills will be no higher than they would be without a meter, there is no downside to participating.

Non-metered customers pay a flat fee for water every six months. Metered customers pay only for the water they actually use. This amount tends to be well below the estimate calculated by the non-metered payment formula. The program also offers indoor or outdoor water conservation kits as incentives for signing up.

The Illinois Plumbing Code, the Department of Buildings Green Permit Program and the Committee on Building Standards and Tests

The Illinois Plumbing Code, adopted by the State of Illinois and administered by the Illinois Department of Public Health (IDPH), sets minimum standards that regulate the design and construction of plumbing systems within the State, the City of Chicago, and the County of Cook. The Illinois Plumbing Code and the Chicago Building Code currently do not include standards for water reuse systems, although this may change in the near future given recent activity around Illinois State legislation.

Until these standards are fully established, public health and safety is protected through required review by the State DPH and the City of Chicago through the Department of Buildings Green Permit Program and the Committee on Building Standards and Tests (CST). The Green Permit Program provides incentives to sustainable design and gives the City of Chicago a tool to track sustainable features installed in Chicago. CST's purpose is to "ascertain the suitability of systems of construction not permitted by or varying from, the performance requirements established by the building provisions of this Code but are claimed to be equally as good as or superior to those permitted" under the Chicago Building Code. A growing number of water reuse systems have been approved to date. However, the CST is required to evaluate each project independently, which may add cost and time to the review process, and should be considered in budget and schedule development. State approval is not necessary for rain barrel exterior rainwater harvesting systems for irrigation, as they are not physically tied to the public water system, and therefore are exempt from the State Plumbing Code. However, cisterns, which store larger quantities of water and have greater maintenance requirements, and may have a connection to City water for supplemental supply, are subject to review under State and City code. Both such systems are widely accepted and approved in the City of Chicago, the County of Cook and the State of Illinois.

Rainwater harvesting memorandum

There has been considerable recent activity at the State of Illinois and City of Chicago levels in regulatory guidance for rainwater harvesting systems. Greywater systems have recently been included in this discussion. In January 2010, Illinois Department of Public Health (IDPH) issued a Memorandum to serve as an interim guideline for evaluating rainwater harvest systems to be used for toilet and urinal flushing. The memorandum, reported below, outlines the basic requirements for such systems.

Illinois Department of
PUBLIC HEALTH

Pat Quinn, Governor
Damon T. Arnold, M.D., M.P.H., Director

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MEMORANDUM

To: Regional Plumbing Inspectors
Regional Supervisors

From: Frank Shimkus, Plumbing Program Manager

Date: January 1, 2010

Subject: Guidelines for Evaluating Rainwater Harvesting Systems used to Flush Water Closets and Urinals

Harvested rainwater, used in place of potable water for toilet and urinal flushing, is becoming a popular way to conserve water. Rainwater harvesting systems have been proposed for many new buildings across the state. This is not a new technology. Cisterns holding rainwater have a long history of use in Illinois, but cisterns were primarily used only when an adequate supply of well water was unavailable.

The Illinois Plumbing Code requires all buildings to be provided with a potable water supply (Section 890.1110). Potable water is required for drinking, cooking and washing purposes (Section 895.20). Water closets and urinals are the only plumbing fixtures that do not need potable water to protect public health. All other fixtures and outlets, including sillcocks and yard hydrants, must be supplied with potable water.

The Illinois Plumbing License Law and Code have specific requirements that apply to all rainwater harvesting systems used for flushing water closets and urinals.

1. The installation of the domestic water distribution pump, hydropneumatic storage tanks, treatment equipment and distribution piping is plumbing and must be performed by a registered plumbing contractor.
2. The harvested rainwater distribution system must be sized for the fixtures served (Section 890.1210) and the fixtures must be installed with backflow protection.
3. The harvested rainwater distribution piping must be permanently identified by a distinctive yellow-colored paint (Section 890.1120). As an alternative, the commonly used purple pipe is acceptable. The piping or insulation must be marked "non-potable" at intervals not to exceed ten feet.
4. A supply of potable water must be provided to supplement the harvested rainwater. The potable water must be added to the cistern through a fixed air gap. (Section 890.1130c)
5. The potable water system may not have a physical connection to the non-potable harvested rainwater system. (Section 890.170c2).
6. The water closets and urinals supplied with harvested rainwater must be provided with a permanently affixed wall sign stating "*This fixture is flushed with harvested rainwater. Not safe for drinking.*" or a sign with similar wording.
7. To prevent sewage from backing up into the cistern, the overflow from the cistern may not discharge directly to a sanitary sewer or combined sewer. The overflow may discharge to a storm sewer or open site outlet.

To ensure the proper operation of the flushing mechanisms, the harvested rainwater must be free of sediment and fouling slime. To accomplish this, treatment is needed as listed below:

1. The rainwater collection system must have a means of diverting the initial rainfall to waste, to prevent dirt, leaves and bird droppings from entering the cistern.
2. The water serving the water closets and urinals must be filtered to remove sediment.
3. The water serving the water closets and urinals must be disinfected to destroy fouling organisms.
4. It is recommended that the water serving the water closets and urinals at non-residential installations be dyed blue or green with a food grade vegetable dye.

The Illinois Plumbing Code will be revised to incorporate regulations covering all aspects of rainwater harvesting systems.

City of Chicago ordinance affecting water reuse

The City of Chicago does not have ordinances that specifically address water reuse. As with the state regulations, however, several ordinances can have an effect on water reuse.

For example, Title 11 of the Municipal Code of the City of Chicago addresses Utilities and Environmental Protection. Chapter 8, which deals with Water Supply and Distribution Systems, clearly spells out that the city intends to rely on Lake Michigan as its source for potable water: “No groundwater well, cistern or other groundwater collection device installed after May 14, 1997, may be used to supply any potable water supply system, except at points of withdrawal by the City of Chicago or by a unit of local government pursuant to intergovernmental agreement with the City of Chicago.”

Groundwater recharge with treated wastewater would still be possible but the city would have to be involved if the groundwater were to be used as a source of potable water. Section 11-12-100 addresses efficient water use. The commissioner has the ability to cut-off the water supply and charge the user for the wasted water. Section 11-12-210 describes water meters, which are required for all new buildings and any new services on existing buildings. Metered consumers are charged a uniform rate for water use. Rates per 3.785 m^3 (1000 gal) were $1.25, $1.29, and $1.33 during 2003, 2004, and 2005, respectively. The rates remained at the 2005 level for 2006 and 2007. In the absence of water use meters, rates are based on the dimensions of the building and the number and types of fixtures in the building.

Water Reuse Policy in Chicago

The City of Chicago describes strategies for water resource management in Chicago’s Water Agenda 2003 In that agenda, Mayor Richard M. Daley acknowledges water as a vital resource that should be protected, conserved, and managed wisely. The agenda addresses water conservation, water quality protection, storm water management, and outreach.

Highlights of the program include:

Chicago Parks: The Chicago Park District is taking the following steps to address conservation issues:

- Ensure that there are on/off controls on all new drinking fountains;
- Upgrade 53 swimming pools so they safely re-circulate water;
- Install splash fountains that re-circulate water; and
- Disconnect Park District downspouts from the sewer system so that stormwater can be used for irrigation and groundwater recharge.

Public places: The City is installing water saving plumbing fixtures in City buildings. The City will also:

- Examine the building code for opportunities for more efficient fixtures, such as dual flush toilets and waterless urinals;
- Explore opportunities for grey water systems for flush toilets or to irrigate landscaping around public buildings;
- Reduce the need for landscape watering by planting native species that are drought tolerant.

Industries: The Chicago Department of Environment Industrial Energy Efficiency Program can provide energy-and-process audits for interested large industrial energy users. That program also features interest-free loans that can be used to implement recommendations from the audit. Audits of 12 Chicago businesses have already identified nearly $4.92*10^5$ m^3 /y (130 million gallons per year) in water savings.

Residential use: Most residential water customers pay a flat rate for water use, regardless of the amount of water used. To promote responsible water use, the Department of Water Management is developing a plan to install water meters for all residential water users.

Replacement of water mains: The Department of Water Management instituted a five-year, $620 million capital improvement program, and part of that effort is directed to replacing old leaking water mains. In addition, the Department is helping other municipalities examine their distribution systems for leaks. The improvements in Chicago alone will save an estimated $4.54*10^5$ m 3 /y (120 million gallons) of water each day.

J. More legislative aspect from USA

Context: The more arid areas of the United States are often subjected to drought and the management of water resources is a serious problem due to the scarcity.
Good Practice and Lessons to be learnt: In many U.S. cities rainwater and greywater harvesting legislation has been enhanced in order to promote and legalize their use.

Rainwater harvesting legislation has been advancing steadily across the nation for a number of years, starting with the landmark document adopted by the State of Texas in 2001, "The Texas Manual on Rainwater Harvesting."

While not as common as legislation related to rainwater harvesting systems, several states across the U.S. are in the process of enacting or have already enacted legislation that enables greywater reuse, including Washington, Massachusetts, New York, South Dakota, Montana, Texas, Nevada, Arizona, California, Utah, New Mexico, Georgia, Idaho, Wisconsin, and Florida. Generally speaking, greywater reuse is more broadly permitted for subsurface irrigation than it is for flushing toilets. When greywater is reused for irrigation, purification of the greywater is typically not required, particularly for smaller scale systems. However, greywater reuse for flushing toilets typically must include a purification process such as chlorine or UV treatment.

Much of the efforts to legalize greywater use have been spearheaded in arid areas of the country that are prone to drought; the same is true on the international level where drought and water quality are serious issues. Therefore, a majority of initiatives worldwide related to greywater reuse focus to a greater extent on irrigation issues (for agricultural uses for example).

Arizona

Arizona's Grey Water Law, enacted in 2001, is widely considered to be the trailblazer in the U.S. with regard to greywater legislation. Many other states have modelled their greywater regulations after the Arizona law. It establishes a 3-tier regulatory approach according to the size of the greywater system: 1. Type 1 systems (single-family only) under 400 gallons (1.5 m^3) per day are permitted by right as long as they follow certain design criteria; 2. Type 2 systems (commercial, multi-family, and institutional) utilizing between 400 and 3000 gallons (11 m^3) per day are allowed by general permit; and 3. Type 3 systems over 3000 gallons per day are considered on a case by-case basis. Greywater may be reused for toilet flushing (non-single family homes only) and/or irrigation if it is treated to a minimum quality standard before reuse. Design specifications for the systems are not provided. Arizona offers tax credits for grey-water construction projects and plumbing systems. In 2010, the City of Tucson began requiring all residential new construction to incorporate dual plumbing that will enable the reuse of greywater in the future.

K. India Rainwater harvesting

Context: In India the average annual rainfall oscillates from 300 to 650 mm, but most of the precipitation comes from the southwest monsoon. Therefore there are both dry and wet seasons and regions with different characteristics and annual precipitation levels.
Good Practice: In many cities rainwater harvesting has been made mandatory.
Limits: Difficulties in the regular maintenance of the rain catching systems to ensure quality of harvested rain water.
Lesson to be learnt: Promote rainwater harvesting and reuse through financial support given to people for the construction of rainwater harvesting systems.

Rainwater harvesting has many benefits as:

- Low cost practice;
- Meet household water needs especially during periods of scarcity;
- Increases groundwater availability through recharge mechanisms;
- Reduces stormwater runoff thus preventing flooding and overloading of sewage treatment plants in cities.

In India this practice has been widely adopted between Ministers, Authorities, Agencies and people. In fact many cities adopt laws and policy on rainwater harvesting; in addition financial assistance is given to people who decide to build a rainwater harvesting system. For example, in New Delhi a financial support is given to a maximum of 50% of total cost of the Rain Water Harvesting structure or 100000 rupees (1260 euro), whichever is less.

In the following the rules and laws present in some of the most important city in India:

New Delhi

- The Central Ground Water Authority (CGWA) has directed Group Housing Societies/Institutions/Schools/Hotels/Industrial establishments/Farm Houses in South and South West Districts and group housing societies located outside notified areas of NCT of Delhi where ground water levels are more than 8 meters below the ground surface to adopt Roof Top Rain Water Harvesting systems in their premises.
- Ministry of Urban Development and Poverty Alleviation, Govt. of India has made modifications to the building bye laws that requires Water Harvesting through storing of water runoff including rain water in all new buildings on plots of 100 sq. meters and above will be mandatory.
- Building plans are not sanctioned unless such provision is provided. DDA/MCD representatives undertake a site inspection before issue of Completion Certificate to the building and ensure that the RWH is made as per plan.
- Buildings with plots of 200 sq. meters or above that extract ground water through tube wells, bore wells, etc need to implement Rain water harvesting.
- Financial assistance is given to a maximum of 50% of total cost of the Rain Water Harvesting structure or Rs.100 000 whichever is less.

Bangalore

Every owner or occupier of a building with site area 223 m2 or above or every owner who proposes to construct a building with site area more than 111 m2 shall provide rain water harvesting structures in such a manner as provided in the regulations.

Example of implementation in Bangalore, Residence of A.R. Shivakumar:

The residence of A.R. Shivakumar is located on a ridge in the city of Bangalore and there is no municipality water connection in the site. The only source of water is rainwater supplemented by groundwater which is extracted through one borewell in the premises. About 70% of the rainwater is diverted to the northern side of the house and gets stored in an overhead tank of 4500 litres capacity placed on the ground floor roof. Before passing to the tank, the rainwater passes through a stabilization tank, whereby the silt gets settled. This water is generally used for non-potable purposes like cleaning, washing etc. The overflow of the tank flows to an underground sump of 25000 litres capacity. This is an L shaped tank and is used for drinking and cooking only. About 30% of the rainwater from the roof gets diverted to pop up filters placed on the ground level. The filtered water free of suspended and floating particles gets stored in another sump of 10000 litres capacity. The underground sumps are interconnected. The water from the overhead tank is used during rainy season and that from the underground sumps are used during the non rainy seasons. The rainfall falling on the backside of the building percolates to the ground through four recycled plastic drums with their bottom cut and buried underground. The interconnected drums recharge the groundwater. Care has been taken that not a single drop of water passes out of the premises. The groundwater recharge has improved the groundwater level. Before the implementation of the system, the groundwater level in the surrounding area was 61 m below the ground level but recently groundwater is available at the depth of 9 m bgl.

Gujarat

Under the Gujarat Development Control Regulations, buildings with area between 500 and 1500 sq. meters, the owner or developer shall have to undertake Rainwater Harvesting as per the Authority Specifications. For buildings with area between 1500 to 4000 sq meters, owner/developer has to provide percolation wells with rain water harvesting system at one percolating well for every 4000 sq. meters or part thereof of building unit. The state Roads and Buildings Department has made rainwater harvesting mandatory for all government buildings.

Mumbay

The State Government has made rainwater harvesting mandatory for all buildings that are being constructed on plots that are more than 1,000 sq m in size.

Example of implementation in Mumbay, Raheja, Goregaon(W):

Consultation and implementation work of Rain Water Harvesting was successfully carried by M/s. N.S. & Associates in the fair season of March 2005 prior to 26.7.2005 heavy flooding in Mumbai. The plot is situated at the south west side of Goregaon rail over bridge, off. S.V. Road. The area of the plot is approx. 5093 sq. m having slight slope towards the road side. A building having stilt + 14 stories, club house etc. was proposed and constructed on site. There are 8 flats in each floor i.e. total 110 flats. Storm water drain was constructed having slope from west to east. The catchment of water harvesting system is the surface that directly receives the rainfall and provide water to the system. It is paved area of terrace (800 sq.mt.) podium (1100 sq.mt.) and rest of paved area of the plot. There are two bore wells having yield of 25000 l/day and 45000 L/day. As per soil investigation report, a layer of weathered basalt is observed about 4.5 m below the ground above which lies the hard clayey soil.

Water required for flushing purpose is 27500 l/day (110 flats x 5 person per flat x 50 l = 27500 l). Considering the site condition and flushing requirement, consultant had proposed and implemented 2 units of Rain Water Harvesting system. Rainwater Harvesting System consists of recharging of groundwater through borewells.

Unit I of Rainwater Harvesting System is at backside of main building using terrace and podium water for recharge of the bore well. Recharging of borewell where all the terrace water is diverted. As per planning first the water is passed through filtration tank and then transferred to the borewell through gravitational force. The filter is the combination of graded sand and metal to allow rainwater to percolate and to trap suspended and floating material.

Unit II Rainwater Harvesting System is near main gate, using paved area water for recharging of bore well using settling tank and filtration tank and then transferred for recharging borewell.

Society saves annually 45000 rupees (570 euro).

This design has given extraordinary results during monsoon of 2005 and 2006. During 26.7.2005 floods, entire rain water was recharged in the soil and there was absolutely no flooding in the plot. There was water logging outside building during 26.7.2005 floods but rainwater harvesting system has helped to avoid flooding in the building. Rainwater harvesting has helped in improving the yield of borewells and it has improved the quality of water. The water from rainwater harvesting system is utilized for only secondary purpose i.e flushing, gardening and car washing.

6. BOTTOM-UP POLICIES TO FOSTER WATER REUSE – CASE STUDIES

The following examples are not completely bottom-up policies case studies, because, according to our knowledge, case studies fully compliant do not exist. We classify the following as bottom up cases because of citizens' active participation in the project. The people's role in the two examples is different. In the first one, from Colombia, people are involved in the decision making process through questionnaires consultation, in order to find a solution that better fits with the citizens' needs. In the second example, from the USA, the citizens give the first input in the development of the project, forcing the upper political levels to find a solution to effluent discharges in the lake.

L. Co-design with end-user in Bucaramanga (Colombia)

Context: The average residential water consumption in Bucaramanga is higher than the average value of the country.
Good Practice: Three alternatives for the greywater and rainwater harvesting systems and their subsequent reuse are proposed trying to balance end-user preferences and water availability.
Limits: People acceptability can limit utilisation of alternative water supplies (rainwater and greywater). The reason why average water cosumption is higher in Bucaramanga is not enquired nor questioned. The good practice is proposed for the elites with high consumption and not for the average population.
Lesson to be learnt: Investigation and survey of the consumers opinion on rainwater harvesting and reuse in order to design solutions that better fit their needs.

In this research, the financial feasibility of implementing a system that allows for RWH and GWR to be used in strictly non-drinking water residential uses is evaluated, considering social, technical and building-related conditions linked to acceptability. The research is situated in a typical high water using household in Bucaramanga (Colombia).

Study area

The study system was located in the metropolitan area of Bucaramanga (Colombia) and classified as socioeconomic stratum 6 (strata 1 and 6 represent the lowest and highest socioeconomic levels, respectively). The system is composed by a three storey building, a roof comprising Spanish clay tiles (101 m^2), a patio (18 m^2), a garden (21 m^2) and five bathrooms, across a total built area of 216 m^2. The house was equipped with a hydro-pneumatic pump system located on the third floor (next to a previously used drinking water storage tank) to ensure the pressure for the bathroom located on this floor. The average rainfall in the study area was 1053 mm/year and the temperature was 25°C (IDEAM 2015).

Criteria for alternative RWH and GWR system designs

In addition to standard design criteria, such as the sizing of the tank, features affecting end-user acceptability and water quality should also be considered at the design stage. In this study, the focus was on social acceptability in relation to source water and willingness to undertake maintenance activity and water quality with regard to consideration of including a treatment system.

User acceptability

A questionnaire was developed to determine the types of criteria that may be important to householders in the design of a RWH or GWR system. The questionnaire had 14 questions that explored issues such as (i) average per capita water consumption, (ii) the device users would be willing to connect to an AWSS (auxiliary water supply system), (iii) participants' willingness to undertake operation and maintenance activities of an eventual AWSS and (iv) the range of additional investment that users would be willing to pay for such a system.

From the water service bills provided by the residents who took part in the household survey (35 households), an average water consumption of 203 l per capita per day (lpcd) (±84 lpcd) was estimated. This value was higher than the average value reported for the country, which for high socioeconomic strata (i.e. 5 and 6) is 170 lpcd.

It was identified that 97 and 86% of participants were willing to use AWSS, such as rainwater and greywater, respectively. These results were similar to those obtained for GWR in Brazil and Oman, where 83 and 84%, respectively, expressed this willingness. However, there was greater acceptance for RWH compared with GWR due to hygiene concerns when greywater is used (100% of participants).

Participants expressed greater willingness to use GWR and RWH in areas of the home including toilets, patio, garden, laundry and washing machine, coinciding with the accepted uses in countries such as South Africa, the UK and Oman. Based on these results, it was decided to include these end-uses as those proposed to be connected to the designed AWSS due to the demonstrated acceptability.

Regarding the willingness of users to perform reactive maintenance on the AWSS, 94% of participants indicated that they would be willing to carry out this type of activity once every 2 weeks, 83% once a week, 34% twice a week and only 9% daily. Concerning preventive maintenance, 94% of participants suggested that they would perform this maintenance annually, 83% every 6 months and 37% monthly. Taking into account the availability of householders to perform maintenance tasks is an integral element in designing the system and is of importance as it is one of the factors affecting the acceptance of such systems. In relation to the willingness to pay for implementing RWH and GWR systems in a new household, participants would be willing to increase the initial investment cost compared to that of a conventional household as follows: (a) less than 2300 USD, 94% of participants; (b) between 2300 and 4900 USD, 54%; and (c) more than 4900 USD, 14%. These findings excluded the consideration of some GWR proposals in this study, for instance, prefabricated or proprietary off-the-shelf devices that met drinking water quality standards, whose costs for 2015 were 15,800 USD and which are available from Latin American providers.

Proposed alternatives

Three alternatives (Alt 1, Alt 2 and Alt 3), summarised in Fig. 5, for the GWR and RWH systems were initially proposed trying to balance end-user preferences and water availability. For this, a factor that weights two features was computed: (i) users' preferences concerning end-uses for the alternative sources (rainwater and greywater), captured through the household survey on users' acceptability, and (ii) water demand for each end-use. The weight of the features was defined based on the authors' experience, where the users' acceptability had greater weight (0.8) than end-use water demand (0.2), as it is well documented that acceptability can limit utilisation of alternative water supplies rather than availability. Using results of the potential end-use factor for rainwater (p.eu.f.rw) and greywater (p.eu.f.gw), Alt 1 consisted of harvested rainwater collection, treatment and storage for use in toilets (0.82 p.eu.f.rw), external tap (0.79 p.eu.f.rw) and internal taps (0.78 p.eu.f.rw) (i.e. the three higher p.eu.f.rw). Alt 2 consisted of harvested rainwater for use in washing machines (0.67 p.eu.f.rw), sinks (0.72 p.eu.f.rw), internal taps (0.79 p.eu.f.rw) and external taps (0.78 p.eu.f.rw) and greywater from showers for use in toilets (0.94 p.eu.f.gw) (i.e. the five higher p.eu.f.gw). Alt 3 consisted of harvested rainwater for use in washing machines (0.67 p.eu.f.rw), sinks (0.72 p.eu.f.rw) and internal taps (0.79 p.eu.f.rw) and greywater from showers for use in external taps (0.88 p.eu.f.gw). Since Colombia lacks regulation of AWSS, usage in sinks is considered as a non-drinking water residential use, despite the possibility that water from sink taps may be ingested.

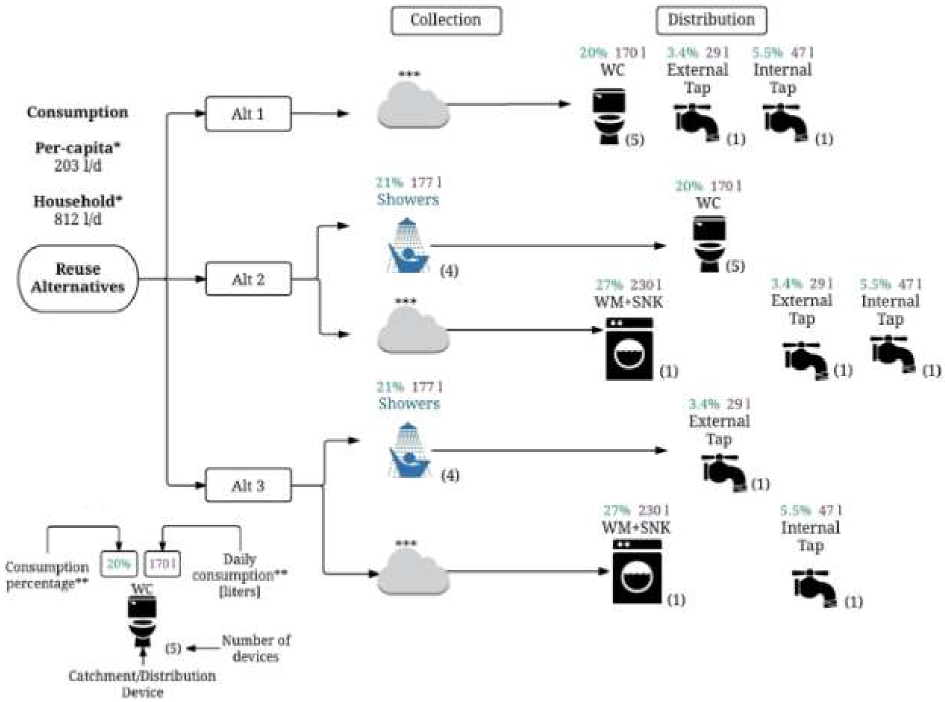

Figure 5 Three proposed alternative rainwater harvesting and greywater systems detailing water sources and potential end-uses

For each of these alternatives an initial analysis of the savings in water and energy demand was made. The alternative that offered greater water savings and lower energy costs was assessed further based on additional criteria such as network configuration.

M. Orange County Water Conserv II Distribution Center

Context: In Florida a group of citizens rose up against the County because the effluent discharges were contributing to degradation of the lake and its fish habitat.
Good Practice: With a cooperative water reuse project by the City, the County, citizens and the agricultural community, the use of reclaimed water started. Construction of the Conserv II Distribution Center in western Orange County to provide reclaimed water, aquifer recharge and guarantee water quality of the lake.
Lesson to be learnt: Citizens can make changes in the water management system.

Background

In 1979, a citizens group filed a lawsuit against Orange County, Florida and the City of Orlando to stop discharge of treated wastewater to Shingle Creek. At that time, effluent from the County's Sand Lake Road Wastewater Treatment Facility (since renamed the South Regional Water Reclamation Facility) and the City's McLeod Road Wastewater Treatment Facility (since renamed the Water Conserv II Water Reclamation Facility) was discharged to the creek, which flows into Lake Tohopekaliga. The citizens group contended that the effluent discharges were contributing to degradation of the lake and its fish habitat. The citizens group won the case, and an injunction was issued against the City and County to cease discharge of effluent into Shingle Creek by March 1988. This occurred at a time when a growing population in the region required expansion of both wastewater treatment plants.

During a lengthy evaluation process nine project alternatives were investigated. These included continued discharge to surface waters with advanced treatment and phosphorus removal, shallow well injection, citrus irrigation, rapid infiltration basins (RIBs) to recharge the Floridan aquifer, deep well disposal, combined citrus irrigation and RIBs, on-lot disposal (with combined citrus irrigation and RIBs), and ocean disposal. The selected alternative was combined citrus irrigation and RIBs, which was determined to be both cost-effective and innovative. Thus began the Water Conserv II project, a cooperative water reuse project by the City and County and the agricultural community.

The project initially encountered strong resistance from area citrus growers and residents. The growers' concerns centered on potential adverse effects of irrigating with reclaimed water, while the residents' concerns focused on health and environmental issues. The citrus growers agreed to accept the reclaimed water after they were provided initial research data on citrus production and fruit quality indicating that irrigation of citrus with the reclaimed water would be beneficial to growing citrus. The City and County also agreed to provide funding for research on the long term effects of irrigation with reclaimed water. As incentives to the growers to participate in the project, reclaimed water would be provided to the growers at no cost for the first 20 years at a pressure suitable for microsprinkler irrigation, and the water would be provided during freezing conditions for frost protection. The residents accepted the project after assurances were provided through an interlocal agreement between the City and County and after the County adopted several resolutions to address the residents' concerns.

Construction of facilities began in 1983, and a contract operator was hired for operation and maintenance of the project. To remain in control of day-to-day activities, the City and County implemented a cost-plus-fixed-fee budget for the contract operator.

Project Goals

Project goals include:

- Elimination of surface water discharges;
- A reliable, cost-effective supply of reclaimed water for agricultural and other customers;
- Conservation of groundwater supplies;
- Groundwater recharge via a system of RIBs;
- Funding for research (through the MidFlorida Citrus Foundation) to develop management practices for the profitable reestablishment of citrus in the Central Florida area and evaluate the economic viability of irrigating non-citrus crops with reclaimed water;
- Evaluation of agricultural crops for economic viability; and
- Evaluation of reclaimed water for golf course irrigation.

Project Description

The project, located in western Orange and southeast Lake Counties, began operation in December 1986, more than 1½ years ahead of the court-mandated deadline. The City's and County's water reclamation facilities both provide advanced wastewater treatment (i.e., secondary treatment followed by filtration and high level disinfection). They produce a total of approximately 158,987 m^3 per day of reclaimed water which meets all of the Florida Department of Environmental Protection's (DEP) requirements for public access reuse, such as irrigation of citrus, open access areas, and residential lawns. About 132,489 m^3 per day of the reclaimed water produced is sent to Conserv II, and the remainder is beneficially used in the City's and County's individual reclaimed water systems serving urban areas.

Reclaimed water is pumped from the water reclamation facilities to the Conserv II Distribution Center in western Orange County. The water is then distributed to customers or to the RIBs through a network of distribution pipes ranging from 15 to 137 cm in diameter. The entire process is monitored and carefully controlled by supervisory control and data acquisition (SCADA) computers located at the Distribution Center. Orange County and the City of Orlando own 21 km2 for existing and planned RIB expansions. There currently are seven RIB sites that collectively contain 65 RIBs having from one to five cells. The RIBs, which provide aquifer storage capacity and wet weather storage for excess flows during rainy periods, were selected based on percolation capacity. The current total capacity of the RIB system is 83,279 m^3 per day. Agricultural and commercial customers use 60 percent of the reclaimed water, with the remaining 40 percent going to the RIBs. Operation of the RIBs is controlled through a computerized management system known as the Groundwater Operational Control System, which provides the ability to forecast the impact on the groundwater system of loading an individual or groups of RIBs at prescribed rates and duration.

Rapid Infiltration Basins

Reclaimed water is served to 87 customers for agricultural and landscape (e.g., golf courses, residential property, a browse farm for Walt Disney World's Animal Kingdom, and other landscape areas) irrigation, soil compaction at landfills, soil cement production, and washdown water at an animal shelter. The agricultural customers include more than 17 km2 of citrus, eight tree farms, four fruit and vegetable growers, and nine indoor foliage and landscape nurseries.

The system was originally designed to serve 48 to 60 km2 of citrus groves, but devastating freezes in the 1980s put several citrus growers out of business and forced others to move their operations to potentially warmer climates in south Florida. The availability of reclaimed water for freeze protection in the late 1980s helped in the survival of many groves. However, more than 11 times the average daily flow rate for irrigation is needed for freeze protection. Supplementary flow is primarily provided by 25 wells connected to the distribution system that produce a total of about 302,832 m^3 per day. In addition, there is a total of 143,845 m^3 of storage capacity at the reclamation facilities and Distribution Center. The demand for water during freeze conditions is a major factor in not pursuing additional agricultural customers that require water for freeze protection.

Project Funding and Costs

Conserv II capital costs expended as of 2003 total $277.7 million, and the current annual operating cost of the distribution system is approximately $4.8 million. Operating costs are split between Orange County (60 percent) and the City of Orlando (40 percent) based on flow contributed. Project costs do not include capital and operating costs for the Water Conserv II Water Reclamation Facility and South Regional Water Reclamation Facility. The U.S. Environmental Protection Agency originally provided grant funding of about $100 million for the project; the remaining costs have been borne by the County and the City.

Project Benefits Realized

Environmental benefits associated with the project include: elimination of discharge to environmentally sensitive surface waters; reduction of demand on the Floridan aquifer by eliminating the need for well water for irrigation; replenishment of the Floridan aquifer with reclaimed water via RIBs; and establishment of a preserve within the RIBs for endangered and threatened species of plants and animals.

Water Conserv II has provided the following benefits to citrus growers: a dependable long term source of irrigation water that is not subject to water restrictions during droughts; elimination of installation, operation, and maintenance costs associated with well or surface water pumping systems; enhanced freeze protection capabilities; increased crop yields; and better tree growth. As one of the growers states: "We have three-year-old trees that are almost six feet tall. We have been able to produce bigger trees with more fruit because we have increased our growing capacity."

7. FORMER EUROPEAN PROJECTS ON WATER REUSE

N.RusaLCA (Slovenia, 2013-2017)

Context: Life RusaLCA - Nanoremediation of water from small waste water treatment plants and reuse of water for local needs. In order to preserve drinking water resources, in Slovenia the legislation required that the drainage systems in inhabited areas had to be adequately build by the end of 2017. Instead, the owners of building located in areas without any requirement and outside settlements had to arrange for the cleaning of communal wastewater by the end of 2018. This need arises from climate change which caused frequent droughts and scarcity of water. In response to this problem, a sustainable use of water should be adopted which include: reduction in water need, use of renewable resources and efficient use of them.

Good Practice: For small settlements and municipalities, a sustainable option is the construction of small-scale wastewater treatment plants of the kind that treats water as a renewable resource. The water originating from these biologically-based treatment plants is not released into surface water channels, but it is additionally cleaned by means of an innovative technology which makes use of nanoparticles of zero-valent iron and then returned to be reused. Water will satisfy the requirements for drinking water but it will be used for households and for common purposes as: watering of gardens and similar areas, washing of cars, needs of fire-fighters, etc.

The project also establishes a protocol about the use of solid waste obtained from small-scale wastewater treatment plants, and from nano-remediation tanks, in different types of composites for use in the construction industry, as well as in environmental improvement projects. The recycled solid waste will be used for humus composites, whereas settled material from nano-remediation tanks will be used in concretes.

Lesson to be learnt: This new approach will save drinking water from natural sources, and make the management of existing resources easier. It is estimated that in this way the consumption of drinking water from natural sources will decrease by about 30%. In the case of small settlements, this approach will also reduce the cost of municipal services, and increase the economic efficiency of households and local communities.

It is a zero waste solution, since both the sludge from the purification process and the sediment from the remediation process are recycled, and then used in the civil engineering industry. This contributes to the conservation of natural resources due to the recycling of waste.

The dissemination of the acquired knowledge and good practice to both the professional and the local public was proved to be a key element for the success of the project. The operational pilot wastewater management system located in the municipality of Šentrupert with zero waste should be taken as example to be reproduced in other geographical areas with similar characteristics.

O. AQUOR (Italy, 2011-2015)

Context: LIFE+AQUOR - Implementation of a water saving and artificial recharging participated strategy for the quantitative groundwater layer rebalance of the upper Vicenza's plain (Italy). In the study area, the upper Vicenza’s plain, the groundwater resources are overexploited so they are gradually decreasing (about -3.5 cm per year). The aim is to restore the groundwater balance and to ensure the sustainable use of this resource by current and future generations by increasing the hydro-geological recharge rate of aquifer. The changes in the average rainfall per year due to climate change, the increase of population, human and industrial activities, the rain system of irrigation and the transformation of river bed into artificial are the main causes of the lowering level of the groundwater resources.

Good Practice: The project wants to act on different aspects:

- development of a GIS information system that allows to identify rechargeable areas (suitability to the permeation, closeness to irrigation ditches, availability of areas, lack of naturalistic emergencies); in addition it can be used as technical tool to plan and schedule activities to safeguard groundwater resources;
- campaigns to raise awareness on water conservation and saving, involving different users' contexts (rural, urban), levels (public, private) and sectors (civil, manufacturing, services);
- realization, in upper Vicenza's plain, of demonstrative activities to raise the hydro-geological recharge rate of aquifers through the increase of infiltration into the soil (7 demonstration sites have been built; 11 groundwater recharge system have been operating since autumn 2013 as infiltration wells in Preganze, infiltration trench in Sarcedo and sub-surface infiltration area in Rosà)
- ex-ante and in-itinere monitoring (to study the self-depuration capacity of the sub-soils neighbouring the recharge areas) in support of optimization of project's actions, the examination of the expected outcomes and the planning of future measures;
- development of a participated decision process and set up of an action plan for the governance of groundwater resources: groundwater contract;
- non-stop information about the project and dissemination of the outcomes (events, technical and publicity documents, website, newsletter).

Lesson to be learnt: Active involvement of stakeholders and consolidation of a shared commitment to the quantitative protection of the upper Vicenza's plain that brings to the development of an integrated and participated governance of groundwater resources at a local scale. In particular, the set up of the action plans for the governance of the groundwater resources aims at representing a good practice for the dissemination of the initiative and a solid contribution for the safeguard of the groundwater resources.

Technical and economic feasibility and the environmental sustainability of the solutions proposed for the recharge of the groundwater layers.

8. CONCLUSIONS

Europe has still much progress to do in terms of developing and adopting smart governance solutions applicable in urban circular water management. There are some directives created in order to preserve the water resources, protect the environment and human health and regulate the water cycle but no legislative and financial support is present at the European or National level for the most part of the European countries.

Another important aspect that should be underlined is the need to give a common and shared definition of “smart governance” solutions, applicable in circular water management and water reuse. In the CWC project, a useful common task could be to define “smart governance” in this context; in particular, inserting and explaining it in the online handbook would be very useful.

Many obstacles (conceptual, financial and legislative) should be overcome at European level, but the good practices shown in this document, can give many inspirations, including: the development of low water consumption technology, awareness programs aimed at water use efficiency and conservation, implementation of low-cost tariffs for reclaimed water, capturing water (e.g. greywater or rainwater) and then treating and distributing it for non-potable water uses in households.

The final purpose is to encourage European countries to develop policy and governance on circular water management and water reuse across Europe.

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