<u>Transferability report</u>

INTEGRATED WASTEWATER PURIFICATION MANAGEMENT (IWPM)

October 2011

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ACRONYMS AND ABBREVIATIONS

B/C	Benefit to Cost Ratio
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DCF	Discounted Cash Flow
ENPV	Economic Net Present Value
ERR	Economic Rate of Return
EU	European Union
FBR	Floating Biodisc Reactor
FFH	Flora, Fauna and Habitat
FNPV	Financial Net Present Value
IEE	Intelligent Energy – Europe
INASEP	L'Intercommunale Namuroise de Services Publics
IPA	Instrument for Pre-Accession Assistance
IRBM	Integrated River Basin Management
IWPM	Integrated Wastewater Purification Management
LIFE	L'Instrument Financier pour L'Environnement
MSBR	Multi-functional Sequencing Batch Reactor
P.E.	Population Equivalent
UV	Ultraviolet
UWWTD	Urban Waste Water Treatment Directive
WVW	Wasserverband Wittlage
WWTP	Wastewater Treatment Plant(s)

EXECUTIVE SUMMARY

This report presents the final results of the Transferability Studies conducted within the Integrated Wastewater Purification Management (IWPM) project. IWPM interconnects Wastewater Treatment Plants (WWTP) and sewer networks to better steer and control the equalisation of inflow peaks and optimal distribution of nutrients.

Since 01.10.2006, the IWPM project has improved wastewater management in Germany by increasing the quality of effluent and reducing costs, thus contributing to the implementation of EU environmental policy and legislation. The two WWTP selected for IWPM were often overloaded (Bad Essen) or under-loaded (Ostercappeln) due to changes in industrial activity. Consequently, treatment was sub-optimal and nutrients discharge from both plants exceeded the future targets for the very sensitive water catchment area --EU-registered "Duemmer Lake" bio-reservation. The conventional solution --extend and upgrade WWTP-- would have been very costly as it is in many other regions. IWPM addresses these environmental and cost problems, triggered by changes in socio-economic and industrial activities, especially for small and medium-sized settlements and WWTP in environmentally valuable areas.

To investigate the replication potential of the innovative IWPM system, we have initially focussed on the New Member States and Candidate Countries, and conducted “Transferability Studies” for Bulgaria, Romania, Turkey and Croatia. **The results of the screening studies under Task G3 (Sector Analysis) have shown a low replication potential of IWPM in these four countries today.** In the future, however, if changes in local socio-economic and industrial activities overload/under-load WWTP like in Bad-Essen, IWPM might be a better option than conventional solutions (i.e., upgrade and extend existing WWTP).

As we could not find any potential cases for immediate IWPM replication in these four countries, we **shifted our scope of investigation to old EU Member States**, in particular the convergence regions of EU15, after the Project Steering Committee’s and the European Commission’s approval. We have subsequently identified and investigated two potential cases for replication --Namur, Belgium and Chiclana, Spain. The Chiclana case has a **high potential for replication** as it meets the baseline requirements for IWPM implementation, and the municipal company “Chiclana Natural” is very interested in finding alternative solutions to the overload/under-load problems for their two WWTP. We further investigated Chiclana and discussed with Chiclana Natural how to implement IWPM in their municipality. We have carried out two missions to Chiclana and Chiclana Natural has visited the IWPM pilot system in Germany to discuss with the IWPM project team the technical details and next steps for implementing IWPM in Chiclana. This report presents the results of this in-depth transferability study.

IWPM PROJECT

TRANSFERABILITY STUDIES

INTRODUCTION

This report presents the results of the Transferability Studies conducted under the Integrated Wastewater Purification Management (IWPM) project. IWPM inter-connects Wastewater Treatment Plants (WWTP) and sewer networks to better steer and control the equalisation of inflow peaks and optimal distribution of nutrients. Such integration could allow using unused plant capacities with significant financial benefits. Since 01.10.2006, the IWPM project has improved wastewater management in Germany, increasing effluent quality and reducing costs, thus contributing to the implementation of EU environmental policy and legislation.

To investigate the replication potential of the innovative IWPM system, we have initially conducted three tasks in four New Member States and Candidate Countries --Bulgaria, Romania, Turkey and Croatia:

- B.4 Analysis of the requirements for IWPM application
- G.3 Sector Analysis
- H.3 Transferability Studies

As part of Task B.4, we have prepared a checklist of the requirements, conditions and constraints to apply IWPM in the selected countries and assessed the administrative, technical, spatial and economic framework conditions by conducting surveys with the relevant administrations in each country. Under Task G.3, we have conducted short screening studies in Romania, Bulgaria, Croatia and Turkey to identify the locations and capacities of the existing, under construction and planned WWTP, and check if there are any two WWTP close to each other. We have conducted desk studies, liaised with relevant national authorities such as the Ministries, and organised short missions to the target countries to meet the administrations in charge of environmental investments and operations. The results of the screening studies under Task G3 (Sector Analysis) show a low replication potential of IWPM in these four countries today. We have, therefore, shifted our scope of investigation to old EU Member States, in particular the convergence regions of EU15, and identified and investigated two potential cases for replication: Namur, Belgium and Chiclana, Spain.

We have investigated in-depth the Chiclana case and we present the Transferability study in the following six sections:

1. Background;
2. Objective;
3. Methodology;
4. Findings;
5. Task H.3 Transferability Studies of the IWPM-system in Chiclana; and
6. Conclusions.

1. BACKGROUND

1.1 Project concept and objectives

THE IWPM SYSTEM

The IWPM System improves wastewater treatment with an “intelligent” pipe (biologically activated and remote controlled) that connects two closely located (ca. 15-20 km) wastewater treatment plants (WWTP), one of which is overloaded and the other under-loaded. IWPM integrates the technical capacities of the two WWTP and enhances wastewater treatment by equalising inflow peaks and fully using plant capacities at all times.

Since 01.10.2006, the Integrated Wastewater Purification Management (IWPM) project has demonstrated how an innovative IWPM System can improve wastewater management in Germany. It has increased the quality of effluent and reduced costs, thus contributing to the implementation of EU environmental policy and legislation, in particular the Directives for Urban Waste Water Treatment (UWWTD)[1], Integrated River Basin Management[2] (IRBM --EU-Directive 2000/60/EC) and Flora, Fauna and Habitat (FFH)[3].

The public water and wastewater association Wasserverband Wittlage (WVW) serves the project area, which is part of the catchment basin of the Duemmer Lake, a highly sensitive ecosystem of European importance (Natura 2000 and bird protection zone). In this area, tourism is of social and economic importance, as well as agriculture and industry --some food factories are among the largest in Europe.

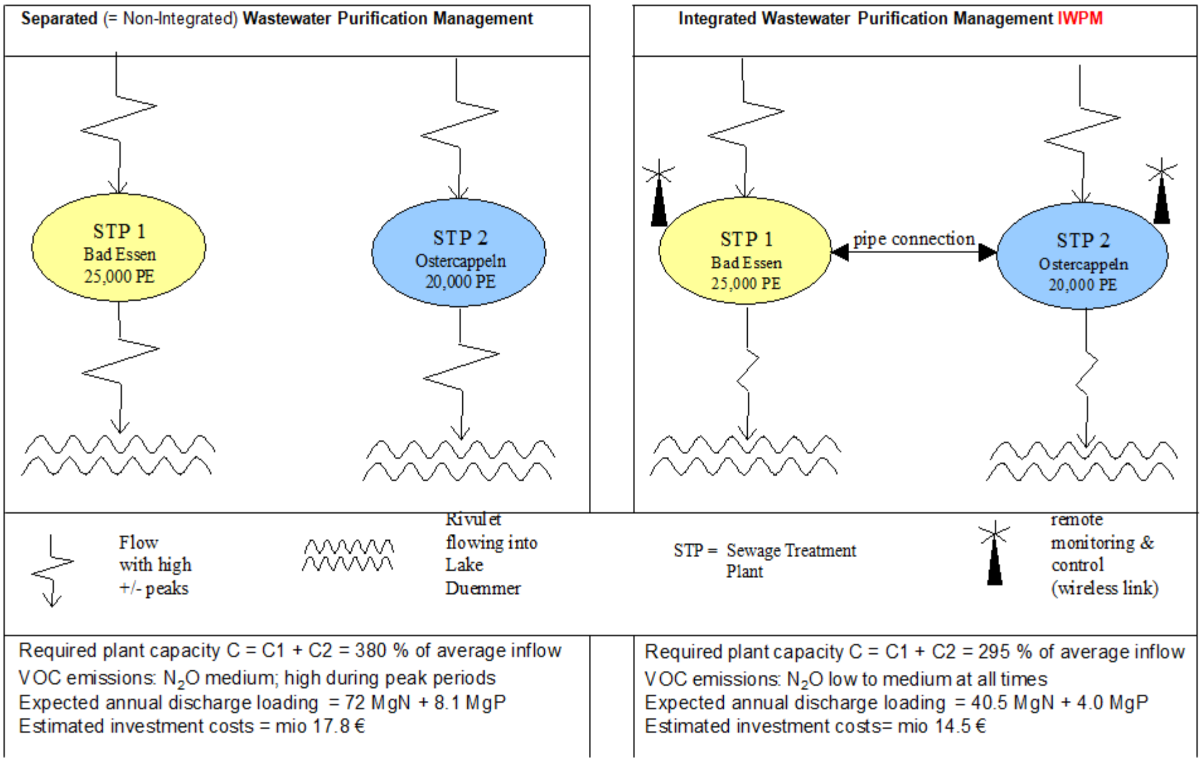
To protect the Duemmer Lake, WVW has to meet stringent technical standards to comply with the EU environmental policy and legislation. In recent years, WVW has made large investments to collect wastewater and upgrade its WWTP. Although the plants meet current EU-effluent standards --maximum concentrations of organic substances and nutrients (e.g., COD, N, P), this is not enough since the Duemmer Lake suffers from eutrophication. The total annual loading of nutrients must be reduced further, not only the maximum concentrations.

Equalising and distributing better the wastewater load to the WWTP could decrease significantly its wastewater discharge to the environment. This led to the idea of an Integrated Wastewater Purification Management - IWPM, inter-connecting WWTP and sewer networks to better steer and control the equalisation of inflow peaks and optimal distribution of nutrients (see FIGURE 1). Such integration allows using unused plant capacity with significant financial benefits.

Advanced monitoring technologies (remote control, automatic analyses of nutrients, etc.) and affordable civil construction techniques ("light" piping) and electronic pump equipment (allowing two-way-flows in pressurised sewer pipes, from A to B or B to A, depending on demand) have opened the door for IWPM (which might not have been technologically reasonable and economically feasible in the past).

[1]Council Directive of 21 May 1991 concerning urban waste water treatment (91/271/EEC)
[2]Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy
[3]Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

FIGURE 1. SEPARATED VERSUS INTEGRATED WASTEWATER PURIFICATION MANAGEMENT



The two WWTP selected for IWPM were often overloaded (WWTP1, Bad Essen) or under-loaded (WWTP2, Ostercappeln) and suffered from peaks in nutrient loading (N, P) and biological unbalance (C:N:P-ratio) due to changes in industrial wastewater flows in both towns. In Bad Essen, the food factory producing sauces (e.g., ketchup, mayonnaise, etc.) doubled its production, which increased wastewater flow. In Ostercappeln, another food factory producing waffles moved out to another location due to expansion plans, which reduced wastewater flow significantly. Consequently, treatment was sub-optimal and nutrients discharge from both plants exceeded the future targets for the very sensitive water catchment area --EU-registered "Duemmer Lake" bio-reservation. Extending WWTP1 and upgrading WWTP2 (conventional solution) would have been very costly as in many other regions. The IWPM project addresses these environmental and cost problems, triggered by changes in socio-economic and industrial activities, especially for small and medium-sized settlements and WWTP in environmentally valuable areas.

According to WVW's cost benefit analysis, IWPM was about €6.6 million less than conventional upgrade and extension of the WWTP. IWPM expects to reduce the nutrient load discharge to the catchment area of Duemmer Lake so that the area fully comply with the Urban Waste Water Treatment Directive: (72 - 40.5) / 72 = 44% for N and (8.1 - 4.0) / 4.0 = 51% for P.

1.2 Status of implementation of Urban Waste Water Treatment Directive

The 5th Commission Summary on the Implementation of the Urban Waste Water Treatment Directive[4] concludes that considerable progress has been achieved in implementing the Directive; however, key challenges remain to align wastewater

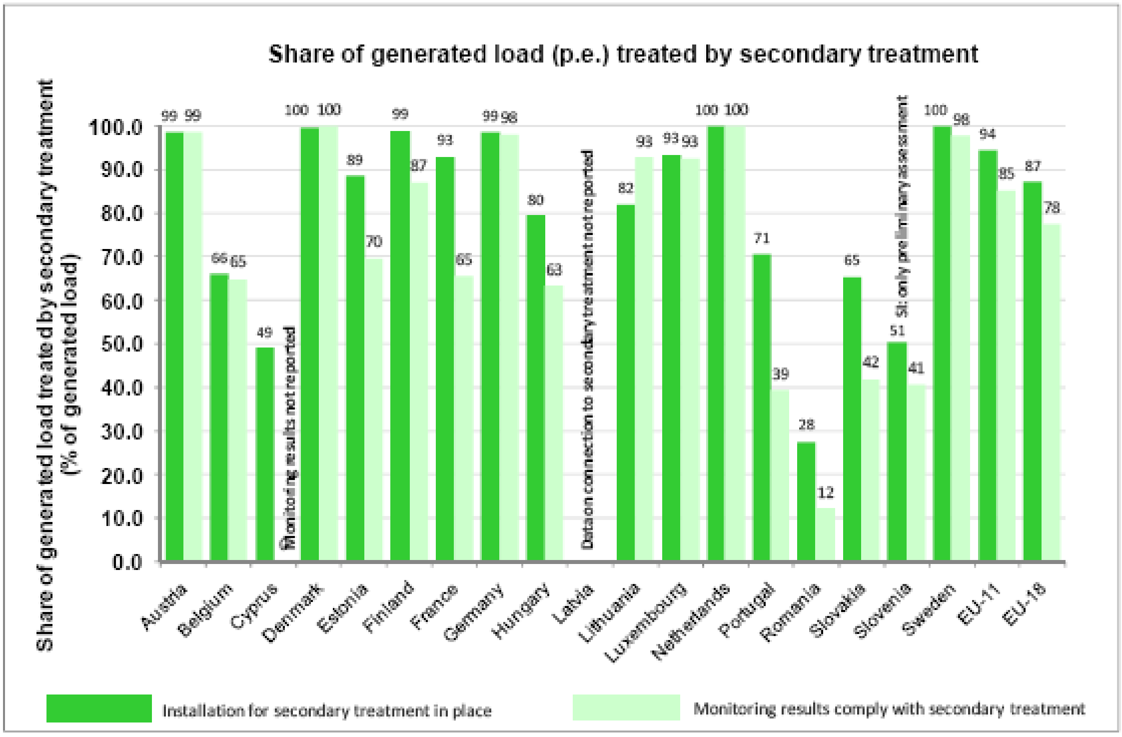
[4] Commission Staff Working Document SEC (2009) 1114 final, 3.8.2009.

treatment in the entire EU with the provisions of the Directive and the "good status" environmental objective under the Water Framework Directive:

- Secondary treatment needs to improve in some EU-15 Member States. While some EU-12 Member States are progressing well towards full implementation, others are still at an early stage of implementation and greater efforts are needed.
- Compliance rates for more stringent treatment are very low in some EU-15 countries and overall greater efforts in implementation are needed. This is especially true for sensitive areas under Article 5 (2,3).
- While implementation in big cities is generally high, greater efforts are needed to ensure implementation of the Directive, especially in the six big cities[5], which had no wastewater treatment and the four big cities[6], which had only primary treatment in 2005.

According to the same report, secondary treatment is in place for more than 98% of the pollution load in Austria, Denmark, Finland, Germany, Netherlands and Sweden, but not in Belgium, France and Portugal. In the EU-12, Estonia, Hungary and Lithuania already have secondary treatment for more than 80% of their pollution load. Romania, Cyprus and Slovenia have secondary treatment for only 28%, 49% and 51% of their pollution load, respectively (see FIGURE 2).

FIGURE 2. SHARE OF LOAD TREATED BY SECONDARY TREATMENT



5 In 2005, six big cities in Portugal and Romania with a combined total load of 4.2 million P.E. had no wastewater treatment: Barreiro/Moita and Costa do Estoril (PT), Bucharest, Braila, Craiova, and Galati (RO).

6 Another four big cities with a total load of 1 million P.E. had only primary treatment: Fréjus (FR), Kaunas (LT), Matosinhos (PT), and Ploiesti (RO).

Several EU Member States still have some way to go in completing their sewage systems and WWTP. Many existing WWTP do not perform satisfactorily, primarily because they are either too small or too large. As explained earlier, IWPM can solve these problems by equalising the loads entering the plants and thereby stabilising the process.

1.3 Project status and achievements

The seven following steps were successfully completed:

1. Detail investment design;
2. Public permission for construction;
3. Public tender and contracting for infrastructure and equipment;
4. Supervision of works;
5. Stepwise optimisation;
6. Fine-tuning; and
7. Testing campaigns.

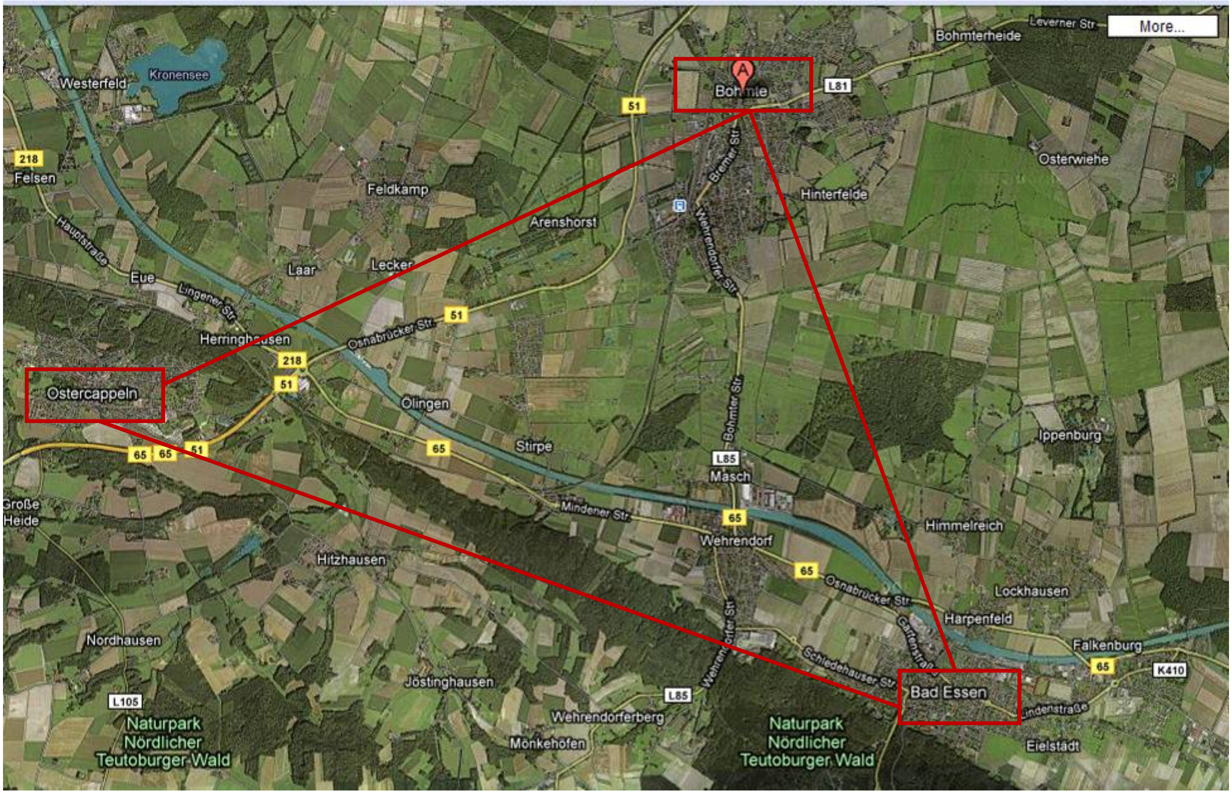
The project has also tested and tuned in the IWPM components and biological processes (in particular the sludge use and disposal). The Multi-functional Sequencing Batch Reactor (MSBR) removed BOD and N at a rate 35% higher than expected. Therefore, sludge treatment could be optimised, as the sludge merely had to be stripped and fed back to the MSBR, instead of being treated with a Floating Biodisc Reactor (FBR).

At the beginning of the project, its design was limited to the Bad Essen and Ostercappeln WWTP. Its first results showed that there was still unused capacity in the IWPM system. Therefore, the project connected the city of Bohmte to the system (See Figure 3). The city of Bohmte, 1.5 km away from the two WWTP, is building a new industrial area and needed to increase its plant capacity.

The project is at the end of Phases II and III, which include the stepwise optimisation and fine-tuning of the project. The project team has recently completed testing campaigns 3 and 4. Testing campaign 3 gathered data between 01.01.2011 and 12.04.2011 in the Bad Essen WWTP to identify and analyse the maximum capacity of the WWTP, based on the supply volume (Q), chemical oxygen demand (COD), Nitrogen and Phosphorous. Testing campaign 3 shows that the Bad Essen WWTP is not facing a hydraulic overload. The WWTP can clean wastewater with a COD load of 4,560 kg/day and a total Nitrogen load of 261.8 kg/day for 23,000 Population Equivalent (P.E.).

Testing campaign 4 analysed the biological activity in the pressurised pipes in three parts. Part 1 analysed data collected between 12.05.2009 and 20.05.2010 on the effluent and inflow of the Bad Essen WWTP. Data included values for COD, ammonium, nitrate and nitrite, and orthophosphate. Digestion of COD and NH_4-N in the pressurised pipes was confirmed. As the other parameters vary depending on the inflow and effluent-concentration, Part 1 concluded that further biological processes, such as denitrification, take place in the pressurised pipes.

FIGURE 3. EXPANDED IWPM SYSTEM INCLUDING THE TOWN OF BOHMTE



Parts 2 and 3 of Testing campaign 4 analysed sewage water and a sewage-sludge-mix separately. Sewage water from the Bad Essen WWTP was pumped from the MSBR through the pressurised pipe 1 to the Ostercappeln WWTP. After disconnecting it from the system, it flowed back to the Ostercappeln MSBR through pressurised pipe 2. The sewage-sludge-mix underwent the same procedure. Digestion and biological activity in the pressurised pipe were observed for COD, NH_4-N and NH_3-N. As PO_4-P increased, it can be assumed that there is phosphate elimination besides digestion of COD, nitrification, and denitrification. The results of Parts 2 and 3 confirmed the results of Part 1.

2. OBJECTIVE

The objective of the Transferability Studies is to investigate the replication potential of the innovative IWPM system. Implementing an IWPM system requires the following key conditions:

- Overload in one WWTP;
- Unused capacity in another WWTP; and
- Short distance between the WWTP.

In addition to these baseline conditions, there are other aspects to consider for replicating IWPM in other regions/countries: administrative issues (e.g., division of responsibilities among local/regional administrations) and cost-benefit analysis, in particular identifying the feasible pipe length based on local costs.

Initially, the target countries of the Transferability Studies were New Member States and Candidate Countries, and STELLA conducted its investigation in Bulgaria, Romania, Turkey, and Croatia.

Romania and Bulgaria are the newest EU Member States –they joined in January 2007. With the help of Cohesion and Structural Funds, they are currently building new WWTP everywhere in the country after conducting detailed Feasibility Studies, which provide detailed data on the pollution loads currently generated in the country. Therefore, situations of overload or unused capacity are very unlikely at this point. This is also the case for Croatia and Turkey, which benefit from pre-accession funds that have allowed them to build new WWTP.

In a few years, however, various economic changes such as the ones that happened in Bad-Essen could favour the implementation of an IWPM system –plant shutdowns reducing the activity in one area and resulting in unused WWTP capacity and plant openings increasing the activity in another area and overloading WWTP capacity.

Since the results of the screening studies have shown that there were no potential cases for immediate IWPM replication in these four countries, we shifted our scope of investigation to old EU Member States, in particular the convergence regions of EU15. We subsequently identified and investigated two potential cases for replication in Namur, Belgium, and Chiclana, Spain.

Although the case in Namur was potentially suitable for IWPM replication, we could not investigate it further as there was little interest due to lack of resources on their side. However, we have investigated further Chiclana and conducted a detailed Transferability study.

3. METHODOLOGY

To assess the replication potential (transferability) of the IWPM system in the target countries, STELLA conducted three tasks:

- **B.4 Analysis of the requirements for IWPM application:** prepare a checklist of the requirements, conditions and constraints to apply IWPM in the selected countries.
- **G.3 Sector Analysis:** carry out short screening studies indicating the expected investments for WWTP, the number and size of plants, plus major locations, as far as available. Based on the results of the screening, the Steering Committee asked STELLA to conduct an in-depth case study in Chiclana de la Frontera, Spain.
- **H.3 Transferability Studies:** deliver the final study analysing and evaluating the potential for IWPM transfer and reproduction in Chiclana.

4. FINDINGS

4.1 Task B.4: Analysis of requirements for IWPM application

STELLA prepared a checklist of the requirements, conditions and constraints (see **Fehler! Verweisquelle konnte nicht gefunden werden.**) to apply IWPM in other countries. Using this checklist, we surveyed the relevant institutional bodies in Romania, Bulgaria, Croatia and Turkey. We have also conducted this survey with Chiclana Natural (see Annex A). The outcome of this task (B4) serves as input for Tasks G3 (Sector Analysis) and H3 (Transferability Studies).

TABLE 1. CHECKLIST OF REQUIREMENTS, CONDITIONS AND CONSTRAINTS FOR IWPM APPLICATION

Administrative
▪ What are the authorities in charge of wastewater treatment? (Ministry, regional and local authorities) ▪ What are the local or regional authorities in charge of national, regional and local roads, railroads, navigable water, etc.? ▪ Which permits are required and who can deliver them? ▪ What kind of tenders are required for this kind of construction? ▪ What are the authorities in charge of spatial planning (cadastre)? ▪ What compensation and what agreements can/have to be signed between the water association and the land owners?
Technical
▪ What is the percentage of wastewater treated? ▪ What are the most usual types of treatment employed? ▪ What are the percentages of each type of WWTP? ▪ How many WWTP have yet to be built? ▪ How many WWTP have been built and are operating? ▪ How many WWTP encounter load problems (underload or overload)? ▪ What are the distances (max – average – min) between the existing plants? ▪ How many WWTP have been built or have yet to be built in tourist areas? ▪ Are there enough human resources to manage such pipes?
Spatial
▪ Is the topography adapted to such a construction? ▪ Is the soil (geology – hydrology – etc) adapted to such a construction? ▪ What is the climate (freezing depth) in the area? ▪ What is the land use on the course of the pipe? (Private properties, gardens, forests, water entities, roads, railroads, agricultural lands, protected areas – Natura 2000, etc.) ▪ Are there any underground constructions on the course of the pipe (other pipes (gas, oil, etc.), optical fibres, electrical lines, etc.)?
Economic
▪ Who will provide the funds? ▪ Is there enough money for such constructions? ▪ Who will design the pipes and the upgrade?

4.2 Task G.3: Sector analysis

4.2.1 Romania, Bulgaria, Croatia, and Turkey

We have conducted short screening studies in Romania, Bulgaria, Croatia and Turkey to identify the locations and capacities of the existing, under construction and planned WWTP, and check if there are any two WWTP close to each other. To do so, we have conducted desk studies, liaised with relevant national authorities such as the Ministries, and organised short missions to the target countries to meet the administrations in charge of environmental investments and operations.

EU Member States and Candidate Countries have similar mechanisms for programming and implementing environmental investment projects. As mentioned above, Romania and Bulgaria benefit from Structural Funds, while Turkey and Croatia receive funds through the Instrument for Pre-Accession Assistance (IPA). Under both programmes, the beneficiary countries allocate budget for environmental infrastructure projects. To identify the WWTP that are planned or under construction, we have collected and analysed the Environment Operational Programmes, as well as the master plans and project applications submitted by the Managing Authorities to the European Commission. We have also conducted interviews with the administrations in charge of environmental investments and operations. The findings of this investigation are presented per country below.

Romania

The total budget of the Sectoral Operational Programme – Environment (SOP ENV) for 2007-2013 is about €5.6 billion and the EU contribution amounts to €4.5 billion (see Table 2). The Managing Authority for the SOP ENV is Romania's Ministry of Environment and Sustainable Development (MESD). We have met with MESD to gather information and data required for the Transferability Studies. MESD gave an overview of the current investment situation in WWTP in Romania and the Cohesion Fund projects in the pipeline.

The SOP ENV strategy for 2007-2013 focuses on investments and collective services, which are required to increase long-term competitiveness, job creation and sustainable development. Establishing effective water and environmental infrastructure will create new jobs (construction, services, SMEs, etc.) and reduce workforce migration by allowing the population to develop businesses or attract investors with local competitive advantages (less expensive resources, valuable natural areas, etc.).

The SOP ENV has six priority axes[7]. Priority axis 1 "Extension and modernization of water and wastewater systems" addresses one of the main weaknesses of the water and wastewater systems reflecting a low rate of connection of the communities to basic water and wastewater infrastructure (52%), poor quality of drinking water and lack of sewerage collection and treatment facilities in some areas. It also addresses the issue of limited efficiency of public water services mainly due to a large number of small operators, many of them dealing with other activities (public transport, urban heating, local electricity, etc.) and due to long-term under-investments, poor management, lack of long-term development strategies and business plans, etc.

WWTP are planned and constructed under Priority axis 1. We have analysed the Cohesion Fund Application Forms for WWTP construction in 10 of Romania's 42 counties. Each county includes on average 4-5 agglomerations and plans to build a WWTP in each agglomeration in most cases. The Application Forms include detailed project maps. Using these maps and Google Earth[8], we have mapped 45 WWTP (see overview in

[7] Regional Policy Inforegio – Romania, Operational Programme "Environment".
[8] http://earth.google.com/

Figure 4).

These WWTP are currently under construction and should be operational in 2013. In each county, we have measured the distances between all WWTP to identify plants close to each other that could be subject to further investigation for IWPM replication. We have identified six cases of WWTP located within 15-20 km of each other in six different counties (see Table 3. CAPACITIES OF WWTP UNDER CONSTRUCTION IN 10 COUNTIES).

TABLE 2. ROMANIA – SOP ENV (2007-2013) FINANCIAL AND TECHNICAL INFORMATION

Financial and Technical information

Title : Operational Programme 'Environment'

Intervention Type : Operational Program

CCI no : 2007RO161PO004

Number of decision : C/2007/3467

Final approval date : 2007-07-12

Breakdown of finances by priority axis

Priority Axis	EU Contribution	National Public Contribution	Total Public Contribution
Extension and modernization of water and wastewater systems	2 776 532 160	489 976 263	3 266 508 423
Development of integrated waste management systems and rehabilitation of historically contaminated sites	934 223 079	233 555 770	1 167 778 849
Reduction of pollution and mitigation of climate change by restructuring and renovating urban heating systems towards energy efficiency targets in the identified local environmental hotspots	229 268 644	229 268 644	458 537 288
Implementation of adequate management systems for nature protection	171 988 693	42 997 174	214 985 867
Implementation of adequate infrastructure of natural risk prevention in most vulnerable areas	270 017 139	59 128 815	329 145 954
Technical Assistance	130 440 423	43 480 141	173 920 564
Total	4 512 470 138	1 098 406 807	5 610 876 945

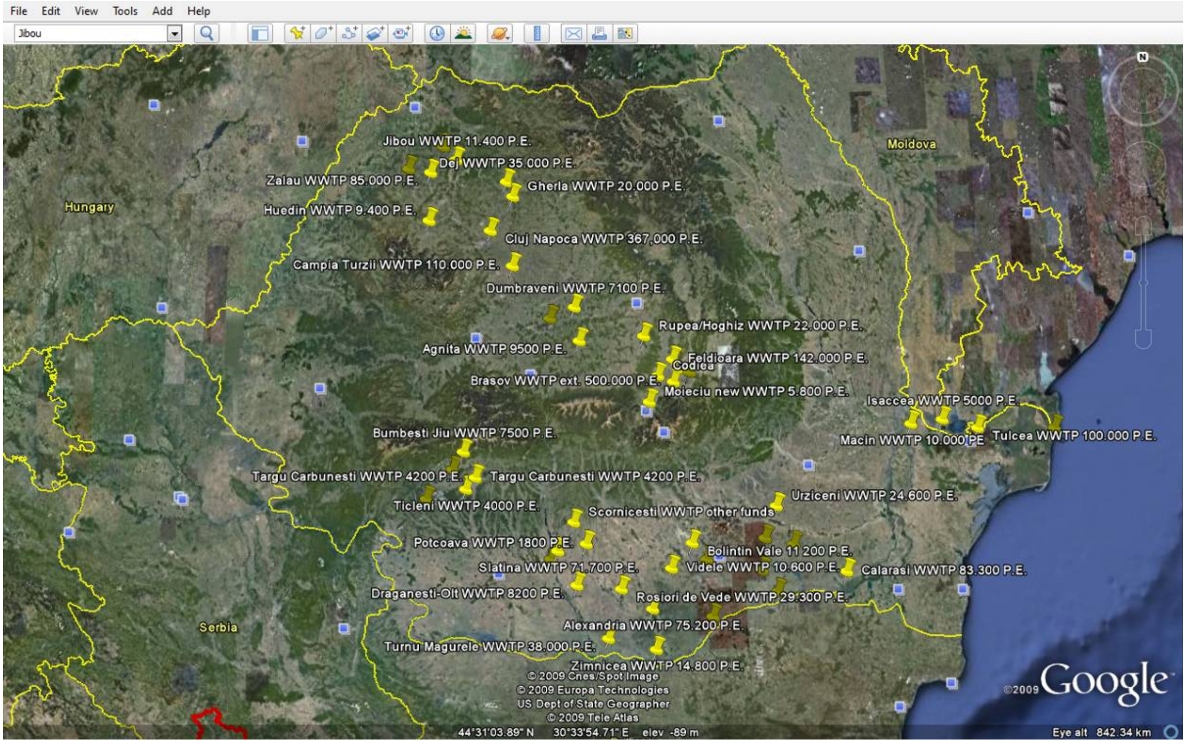
Six cases in six counties of Romania

Below are more details on the six WWTP located within 15-20 km of each other; the information is from the Cohesion Fund Applications of each County.

Priority Axis 1 (PA1) “Extension and modernization of water and wastewater systems” of SOP Environment sets as objectives the following elements:

- Provide adequate water and sewerage services, at accessible tariffs;
- Provide adequate drinking water quality in all urban agglomerations;
- Improve the quality of watercourses;
- Improve the level of WWTP sludge management; and
- Create innovative and efficient water management structures.

FIGURE 4. OVERVIEW OF WWTP UNDER CONSTRUCTION IN 10 COUNTIES



The overall objective is to improve the water infrastructure to benefit the environment and human life in order to meet the water compliance obligations in the Accession Treaty and the objectives of the SOP Environment and PA1. The water supply and wastewater treatment projects will help Romania ensure compliance with the EU environmental legislation within the transition periods agreed between Romania and the EU in the environment field, and facilitate economic development by providing infrastructure and creating sustainable employment. In each county, different options are analysed for each investment component, and finally the most cost-effective option is selected for implementation.

1. Brasov – Feldioara WWTP

Brasov County is in the central part of Romania and has a total population of 589,028 --74% urban and 26% rural, according to the data of the 2002 census. The two WWTP (Brasov and Feldioara) are in the Brasov Agglomeration. In 2036, the population of the Brasov Agglomeration is expected to decrease from 382,315 to 323,510, based on the estimated future growth of the population by the National Statistics Institute. The growth rates used for the forecast are -6.63‰ for urban areas and +4.41‰ for rural areas.

Problems:

- The existing wastewater system serves 323,771 of the 409,915 citizens representing 79% of the total population defined for wastewater in the Brasov Agglomeration.
- The WWTP of Brasov Municipality is inadequate; treated wastewater does not comply with the provisions of the UWWTD and Romanian regulations.

There is no wastewater treatment in some localities of the Brasov Agglomeration.

TABLE 3. CAPACITIES OF WWTP UNDER CONSTRUCTION IN 10 COUNTIES

County	Agglomeration/WWTP	Capacity (P.E.)	Short distance (ca. 15-20 km)
Brasov	Brasov	500,000	Brasov – Feldioara
	Feldioara	142,000	
	Prejmer	28,600	
	Rupea	22,000	
	Moieciu	5,800	
Calarasi	Calarasi	83,300	Budesti – Oltenita
	Oltenita	28,800	
	Budesti	5,000	
	Lehliu Gara	6,100	
	Fundulea	6,600	
Cluj-Salaj	Cluj Napoca	367,000	Dej – Gherla
	Dej	35,000	
	Gherla	20,000	
	Zalau	85,000	
	Simleu Silvaniei	13,200	
	Huedin	9,400	
	Cehu Silvaniei	5,400	
	Jibou	11,400	
Giurgiu	Giurgiu (to be checked)	65,000	Bolintin Vale – Mihailesti
	Bolintin Vale	11,200	
	Mihailesti	6,800	
Gorj	Targu Jiu	107,000	Targu Carbunesti – Ticleni
	Bumbesti Jiu	7,500	
	Targu Carbunesti	4,200	
	Ticleni	4,000	
	Motru (other funds)	NA	
Olt	Scronicesti (other funds)	NA	NA
	Slatina	71,700	
	Potcoava	1,800	
	Piatra Olt	1,500	
	Draganesti Olt	8,200	
Sibiu	Medias	74,000	Medias – Dumbraveni
	Agnita	9,500	
	Dumbraveni	7,100	
Tulcea	Tulcea	100,000	NA
	Sulina	5,000	
	Isaccea	5,000	
	Macin	10,000	
Turda-Cluj	Campia Turzii	110,000	NA
Teleorman	Rosiori de Vede	29,300	NA
	Alexandria	75,200	
	Turnu Magurele	38,000	
	Zimnicea	14,800	
	Videle	10,600	

Solutions:

- Rehabilitate and extend the Brasov WWTP to ensure N, P removal: the plant includes mechanical pre-treatment, primary sedimentation, biological treatment using step feed Bio-NP and final sedimentation. Sludge treatment includes thickening, digestion and dewatering. Capacity: 500,000 P.E.
- Build a new Feldioara WWTP to ensure N, P removal: the plant includes mechanical pre-treatment, primary sedimentation, biological treatment using step feed Bio-NP and final sedimentation. Sludge treatment includes thickening, digestion and dewatering. Capacity: 142,000 P.E.

2. Budesti – Oltenita WWTP

Calarasi County is in the South-East part of Romania and has a total population of 324,617 --120,207 is urban-- according to the 2002 census. In 2006, the total population was 308,000; according to the National Institute of Statistics, the decrease in population is expected to continue. The population of Oltenita Town is expected to decrease from 26,230 in 2006 to 19,920 in 2036, based on the estimated growth rate for urban areas (-9,16‰). Similarly, the population of Budesti Town is expected to decrease from 9,351 in 2006 to 7,076 in 2036.

Problems:

- Insufficient coverage of residential areas;
- No wastewater service in Budesti leading to pollution of the Danube River, soil and ground water;
- Considerable length of sewerage network over 30 years old in Oltenita;
- Equipment in wastewater pumping stations and WWTP with long service life and with high energy consumption due to low efficiency;
- Frequent blockages and collapses of sewers; and
- WWTP effluent non-compliant with EU and national requirements.

Solutions:

- Rehabilitate and extend the water supply and sewerage systems in the Oltenita agglomeration: build a new compact WWTP including dewatering and sludge storage. Capacity: 28,800 P.E.
- Rehabilitate and extend the water supply and sewerage systems in the Budesti agglomeration: build a new compact WWTP including dewatering and sludge storage. Capacity: 5,000 P.E.

3. Dej – Gherla WWTP

Cluj and Salaj Counties are in the North-West part of Romania and have a total population of about 520,000. The Dej and Gherla agglomerations are in Cluj County and have 38,437 and 23,028 inhabitants, respectively. A lack of long-term development programmes and under-investment have caused poor efficiency and sustainability of the water and wastewater infrastructure. Thus, the standards of service in the agglomerations in the Cluj and Salaj Counties differ significantly from each other. The total target population of about 520,000 in 2006 is expected to decrease to 489,302 in 2013, of which 96% are expected to benefit from the proposed improvements of water supply and 79% are expected to benefit from improved drainage and treatment.

Problems:

- The Dej agglomeration currently has only one mechanical treatment stage with screens, grit chamber, degreasing and primary clarifiers, which are all undersized and damaged beyond repair --both civil structure and electro-mechanical equipment. Sludge is not treated and pumped to the neighbouring biological WWTP. BOD removal is ca 50% while removal of COD and SS is even lower.
- The existing WWTP in the Gherla agglomeration was built 30 years ago. The overall BOD removal is around 50% (usual value for mechanical treatment only) with COD and SS removal rates being even lower. All electro-mechanical equipment is either not working or in bad condition, worn out and unsafe to operate.

Solutions:

- Build a new WWTP in the Dej agglomeration, which will include mechanical treatment, as well as secondary and tertiary treatment. Sludge treatment will consist of thickeners, a dewatering unit, a digester and a storage tank as well as a gas holder and CHP for gas utilisation. Capacity: 35,000 P.E.
- Build a new WWTP in Gherla consisting of a mechanical stage, and secondary and tertiary treatment stages. Sludge treatment will consist of two new aerated sludge storage tanks and two new sludge composting beds. Capacity: 20,000 P.E.

4. Bolintin Vale – Mihailesti WWTP

Giurgiu County is in the southern part of the Romanian Plain and has a population of 297,859 --88,537 (29.7%) in urban areas and 209,322 (70.3%) in rural areas-- according to the 2002 census. In Bolintin Vale, the population is expected to decrease from 11,702 in 2002 to 9,383 in 2026, and in Mihailesti from 7,490 to 6,006.

Problems:

- In Bolintin Vale, the existing WWTP is out of order.
- In Mihailesti, the existing wastewater system serves only 769 of the 7,490 inhabitants --10.3% of the population served by the existing centralized water supply system.

Solutions:

- Build a new WWTP in Bolintin Vale with mechanical and biological treatment with nitrification, denitrification and chemical phosphorus removal; sludge stabilization and dewatering. Capacity: two identical lines of 6,100 P.E. each (11,200 P.E. in total) with a treatment capacity of 1,100 m^3/day on each line.
- Build a new WWTP in Mihailesti with mechanical treatment and biological treatment with nitrification, denitrification and chemical phosphorus removal; sludge stabilization and dewatering. Capacity: two identical lines of 3,400 PE each, each line with a treatment capacity of 600 m^3/day.

5. Targu Carbunesti – Ticleni

Gorj County is in the southwestern part of Romania with a population of 385,000 and a total area of 5,602 km^2. The total population in the water supply area is about 144,000, expected to decrease to 133,400 in 2026.

Problems:

- The fraction of wastewater reaching the WWTP is not treated properly, thus causing continuous pollution. This is particularly problematic because a number of dams force the water to stagnate, which contributes to increasing the rivers' vulnerability to eutrophication.
- Only the agglomerations of Targu Jiu, Motru and Targu Carbunesti have WWTP with limited performance in the mechanical treatment stage.
- The Targu Carbunesti WWTP is currently operated in "flow-through" regime and discharges all of its wastewater straight into the Gilort River without any treatment.
- In Ticleni, only limited quantities are presently collected and discharged without any treatment.

Solutions:

- Rehabilitate the Targu Carbunesti WWTP with Rotary Biological Contactors (RBC) to provide secondary treatment and sludge treatment. Capacity: 4,200 P.E.
- Build a new WWTP in Ticleni with RBC to provide mechanical and secondary treatment, and sludge treatment. Capacity: 4,000 P.E.

6. Medias – Dumbraveni

Sibiu County is in the central part of Romania and has a population of 420,000 over a total area of 5,432 km^2. The population in the water supply area is about 75,000.

Problems:

- Only the agglomeration of Medias has a WWTP with limited performance in the mechanical treatment stage.
- The primary sludge generated in the mechanical stage of Medias reaches the sludge drying beds without prior stabilization.
- Many direct discharges negatively affect the Tarnava Mare River. The fraction of wastewater reaching the WWTP is not treated properly, thus causing continuous pollution.
- Dumbraveni collects wastewater, which is released without any treatment into the environment.

Solutions:

- In Medias, build a new WWTP to comply with tertiary treatment requirements in 2011. Capacity: 74,000 P.E.
- In Dumbraveni, build a new WWTP with mechanical and secondary treatment with rotary biological contractors. Capacity: 7,100 P.E.

Conclusions on the six cases in six counties of Romania

The six cases above meet the “short-distance” condition for IWPM replication. Therefore, these WWTP could potentially benefit from IWPM in the future if, at some point, the respective communities experience any socio-economic changes such as an increase/decrease in local industrial activity or local population, etc. that may change wastewater flows.

In each of the six cases, the two WWTP are in one single agglomeration. This is positive from an administrative point of view, since the division of responsibilities among different agglomerations often hampers the decision-making process and the implementation of alternative (non-conventional) solutions such as IWPM.

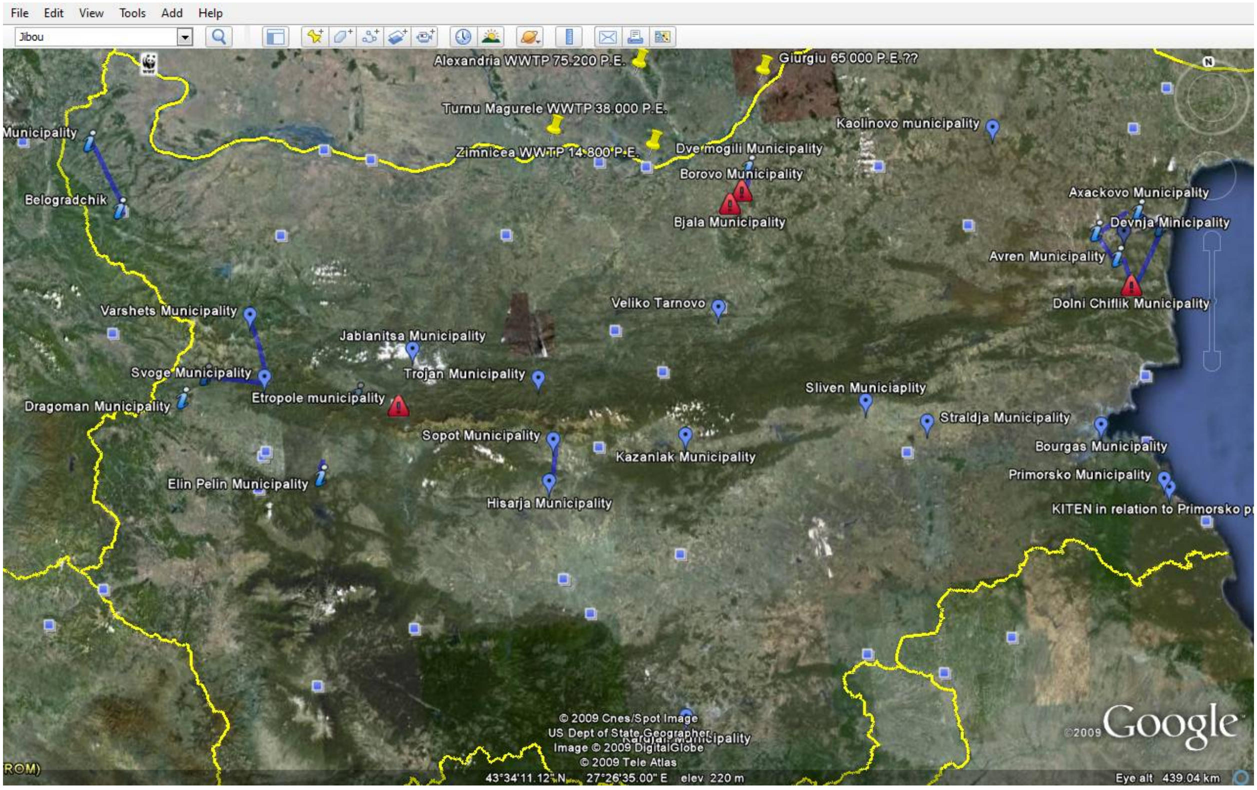
The entire territory of Romania is classified as sensitive according to the Urban Wastewater Treatment Directive. Therefore, all WWTP with a connected P.E. > 10,000 must have tertiary treatment (i.e., nutrient (N, P) removal). Plants with a connected P.E. < 10,000 must have secondary treatment (i.e., biological stage for removing organic compounds). Among the six cases we have identified, some of the WWTP are designed for secondary and others for tertiary treatment depending on the projected agglomeration sizes. IWPM may be especially useful in agglomerations where WWTP currently have a population below 10,000 P.E. and secondary treatment, but may exceed 10,000 P.E. in the future due to socio-economic changes, which will bring them under the legal obligation to implement tertiary treatment. This could happen, for instance, in Medias – Dumbraveni, where the Medias WWTP will have a capacity of 74,000 P.E. and tertiary treatment while the Dumbraveni WWTP will have a capacity of 7,100 P.E. and secondary treatment. If, in the future, wastewater inflow into the Dumbraveni WWTP exceeds 10,000 P.E., and if there is enough extra capacity in the Medias WWTP, it might be possible to use IWPM to transfer the surplus from Dumbraveni to Medias.

Bulgaria

We have investigated the WWTP infrastructure in Bulgaria and mapped some of the WWTP under construction (See Figure 5). The situation in Bulgaria in terms of environmental infrastructure investments and WWTP construction is similar to Romania.

The Bulgarian authorities informed us that the IWPM concept could be particularly useful in touristic regions, where seasonal peaks occur in wastewater flows and in areas that are ecologically sensitive. However we were unable to identify a case for IWPM implementation in Bulgaria that would fulfil IWPM replication conditions.

FIGURE 5. OVERVIEW OF WWTP UNDER CONSTRUCTION IN BULGARIA



Turkey

As mentioned previously, Candidate Countries like EU Member States also benefit from EU funds (i.e., pre-accession assistance) and implement projects in all socio-economic sectors. A notable part of EU pre-accession assistance to Candidate Countries is for environmental infrastructure investments including WWTP. Therefore, both Turkey and Croatia are building several WWTP and have several others in the pipeline.

WASTEWATER PROJECTS IN TURKEY (2007-2009)

In Turkey, Priority 1 in the Environment Operational Programme (EOP) for 2007-2009 is "Improved water supply, sewerage and wastewater treatment services". Within this framework, the Ministry of Environment and Forestry has established a list of priority projects; accordingly, 12 wastewater projects are now planned for implementation during 2007-2009 in various locations for a total cost of €236,750,000. There are similar programming mechanisms in the other countries of this study (i.e. Croatia, Romania and Bulgaria).

Since Turkey is planning and building their WWTP according to EU and international standards and based on detailed feasibility studies and socio-economic projections, we were unable to identify a case for IWPM implementation today that would fulfil IWPM replication conditions.

Croatia

Croatian Waters (national water management agency) coordinates an EC LIFE TCY project, the CROWATER project ("*Strengthening of public-private partnership in order to improve wastewater management in Croatia*", LIFE 05 TCY/CRO/000108), with which IWPM could create a strong synergy. One of the goals of the CROWATER project is to *create a new approach and methodology for successful management of existing and future WWTP*. IWPM could be useful in this respect.

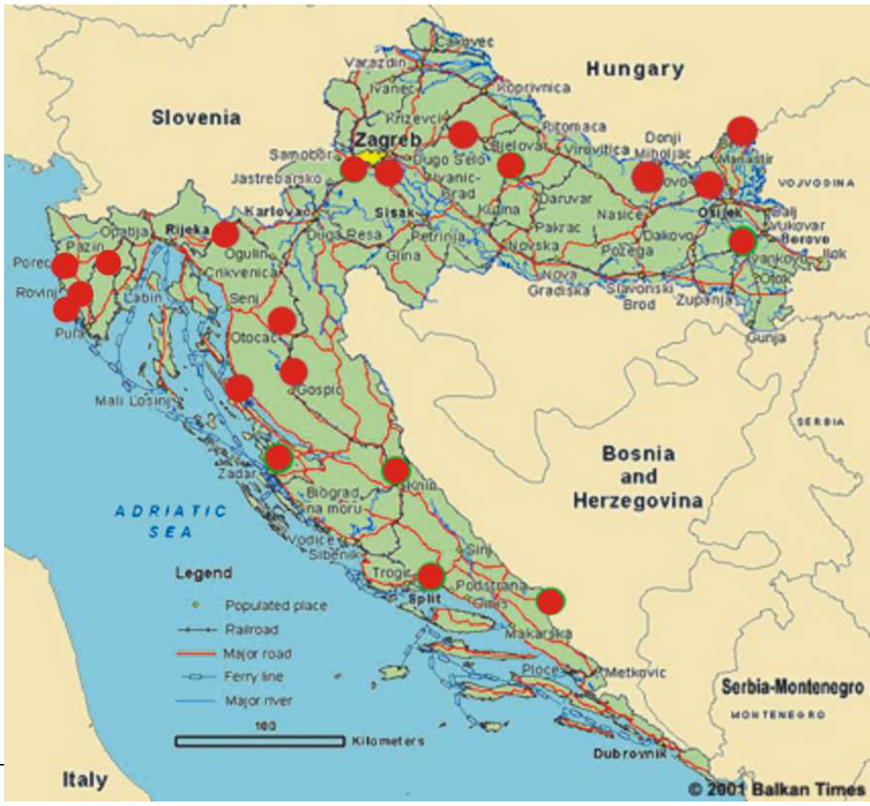
After conducting on-site sampling and analysis to assess the technical conditions of 19 WWTP (see
Figure 6), CROWATER provided recommendations on Best Available Techniques (BAT) and other relevant information on how to comply with forthcoming EU regulations. The project also trained plant manager and operators.

Several structural changes occurred in the industrial sector during the project; for example:

- **Murari Pazin** closed cattle production and its WWTP.
- **Belišće** was in a transition process preparing the company for public offering.
- **Mirna** Fish reduced its production significantly, due to a reduction in the sales of canned fish, which led to a high reduction in wastewater flow.

FIGURE 6. LOCATIONS OF WWTP VISITED IN THE CROWATER PROJECT

1. Delnice
2. Otočac
3. Gospić
4. Novalja
5. Agrolaguna
6. Murari Pazin
7. Valalta
8. Beli Manastir
9. Donji Miholjac
10. Mirna Rovinj
11. Belišće
12. Velika Gorica
13. Durnevac
14. Kvasac
15. Bjelovar
16. Zadar
17. Split
18. Imota
19. Div



We have investigated the Velika Gorica WWTP, one of the seven WWTP for which CROWATER provided recommendations. The WWTP started operating in 1973 as a two-stage (mechanical and biological) plant that discharges treated wastewater into the Želin open channel. Sludge is currently disposed of at the nearby field for open dehydratation. Despite a capacity increase from 12,000 P.E. to 35,000-40,000 P.E, it is currently overloaded with a load of 50,000 P.E., which prevents it from meeting effluent standards. The city of Velika Gorica has significantly increased industrial production, which disturbs the biological processes during wastewater treatment. Thus, the Želin channel and Novo Čiće Lake receive only partially treated wastewater.

CROWATER recommended rebuilding each part of the Velika Gorica WWTP, starting with the mechanical stage, and later the biological treatment stage. However, we were unable to identify another WWTP nearby and with extra capacity to accommodate the surplus from Velika Goica.

Results for Bulgaria, Croatia, Romania and Turkey

The results of the screening studies under Task G3 (Sector Analysis) show a low replication potential of IWPM in these four target countries today. The four countries are planning and building their WWTP according to EU and international standards and based on detailed feasibility studies and socio-economic projections. Therefore, we were unavailable to identify a case for IWPM implementation in these countries. In the future, however, if changes in local socio-economic and industrial activities overload/under-load WWTP like in Bad-Essen, IWPM might be a feasible option against conventional solutions (i.e., upgrade and extend existing WWTP).

We therefore shifted our scope of investigation to old EU Member States, in particular the convergence regions of EU15, and identified and investigated two potential cases for replication in Namur, Belgium, and Chiclana, Spain.

4.2.2 Belgium

We identified a potential case for IWPM replication in the province of Namur, Belgium. INASEP[9], an association in charge of water services of the 38 municipalities of Namur, manages two WWTP that could replicate IWPM. The Kraft WWTP in Namur has a capacity of 55,000 P.E. and is overloaded (hydraulically) while the WWTP of the village of Rhisnes with a capacity of 3,500 P.E. is under-loaded (biologically). The two plants are located 3.2 km. from each other taking into account roads and train lines.

Although this case is potentially suitable for IWPM replication, INASEP has shown little interest in pursuing a further investigation due to lack of resources on their side. If this situation changes in the future, IWPM might be a better option than conventional solutions (i.e., upgrade and extend existing WWTP).

[9] L'Intercommunale Namuroise de Services Publics (INASEP) http://www.inasep.be/

4.2.3 Spain

Many regions in Spain are still classified as convergence regions. We have reviewed Spain's compliance with the Urban Waste Water Treatment Directive (UWWTD), in particular **Andalucia** (a convergence region). According to the Spanish Ministry of Environment's Water Quality National Plan for 2007-2013[10], by 31.12.2005:

- Out of 74 agglomerations with more than 15,000 P.E. which were not in compliance with UWWTD, 22 were in Andalucía;
- Out of 74 agglomerations with more than 15,000 P.E. which were under construction, 20 were in Andalucía;
- Out of 138 agglomerations with more than 10,000 P.E. in sensitive areas, 14% were not in compliance and 4% were under construction;
- Out of 19 agglomerations with more than 10,000 P.E. in sensitive areas which did not comply with UWWTD, two were in Andalucía;
- Out of five agglomerations with more than 10,000 P.E. in sensitive areas that were under construction, two were in Andalucía.

FIGURE 7. AGGLOMERATIONS OF MORE THAN 10,000 P.E. IN SENSITIVE AREAS IN SPAIN AS OF 31.12.2005 shows the agglomerations of more than 10,000 P.E. affecting sensitive areas (in compliance, no compliance, and in construction) in Spain.

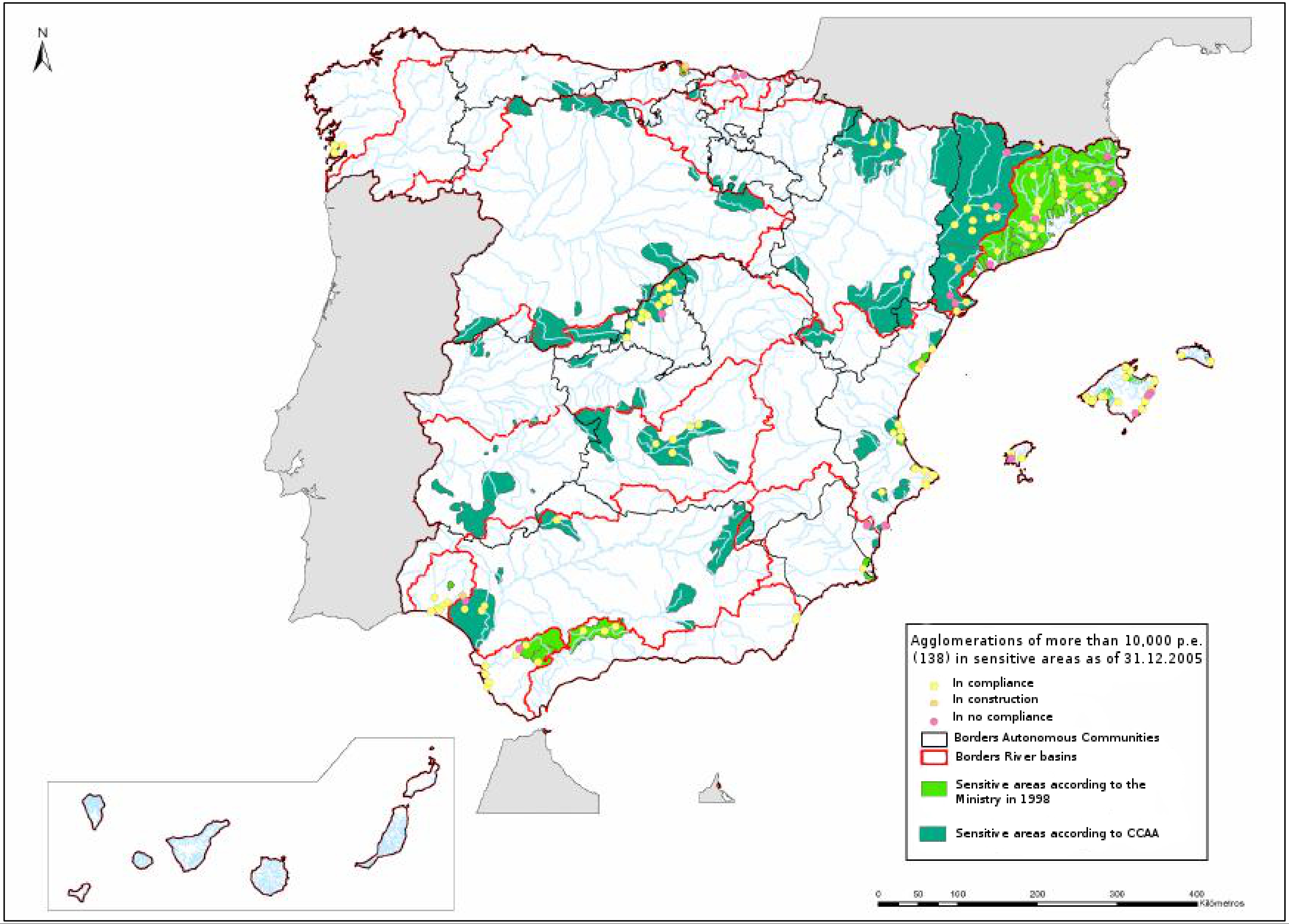
To identify a potential case for IWPM replication, we have interviewed the Infrastructure department of Andalucia's Water Agency[11] and their external Water technical department at the Centre for New Water Technologies Foundation in Seville. They have shown a high interest in IWPM and we have identified a **potential case for replication in the Municipality of Chiclana de la Frontera**. However, the authorities have also mentioned that IWPM may not have a very high replication potential in the entire Andalucia due to a number of challenges:

- Topography;
- Towns are small and scattered around the region;
- Difficulties for two municipalities to work together; and
- High maintenance costs of the IWPM-System for the municipalities.

Nevertheless, after identifying Chiclana de la Frontera as a potential case for IWPM replication, we concentrated our investigation in this town.

[10] Spanish Ministry of Environment. El Plan Nacional de Calidad de las Aguas: Saneamiento y Depuracion 2007-2013.
[11] Agencia Andaluza del Agua. Consejería de Medio Ambiente. Junta de Andalucía.

FIGURE 7. AGGLOMERATIONS OF MORE THAN 10,000 P.E. IN SENSITIVE AREAS IN SPAIN AS OF 31.12.2005



4.3 Task H.3 Transferability Studies of the IWPM-system in Chiclana

The potential for transferring the IWPM system in Chiclana de la Frontera is excellent.

4.3.1 Location

Chiclana de la Frontera is a town and municipality in Andalucia, in the province of Cádiz, with a population of 77.293[12] inhabitants in 2009. In the past ten years, it has become an important tourism area, like many coastal areas in Spain.

The Bahía de Cádiz Natural Park (surface area of about 100 km^2) spans across the municipalities of Cadiz, Chiclana de La Frontera, Puerto de Santa Maria, Puerto Real, and San Fernando. It consists of marshland, beaches, reed and sand dunes as well as many types of shrubs and bushes, and ocean pines. The park belongs to the **Natura 2000 network of sites** targeted by the Birds and Habitats directives. The Spanish government has designated the area as a sensitive area under the UWWTD.

4.3.2 Technical issues

Currently, the municipality of Chiclana manages two WWPT, administered by Chiclana Natural and operated by Aqualia; El Torno and La Barrosa jointly treat a total of 25,000 m^3/day and meet the baseline conditions for IWPM application, as they experience seasonal peaks of wastewater. La Barrosa is overloaded in the summer while El Torno has a slightly unused capacity. In addition, La Barrosa cannot be upgraded/expanded due to spatial restrictions while El Torno is in an area with less spatial restrictions. They are close to each other (≈ 6 km).

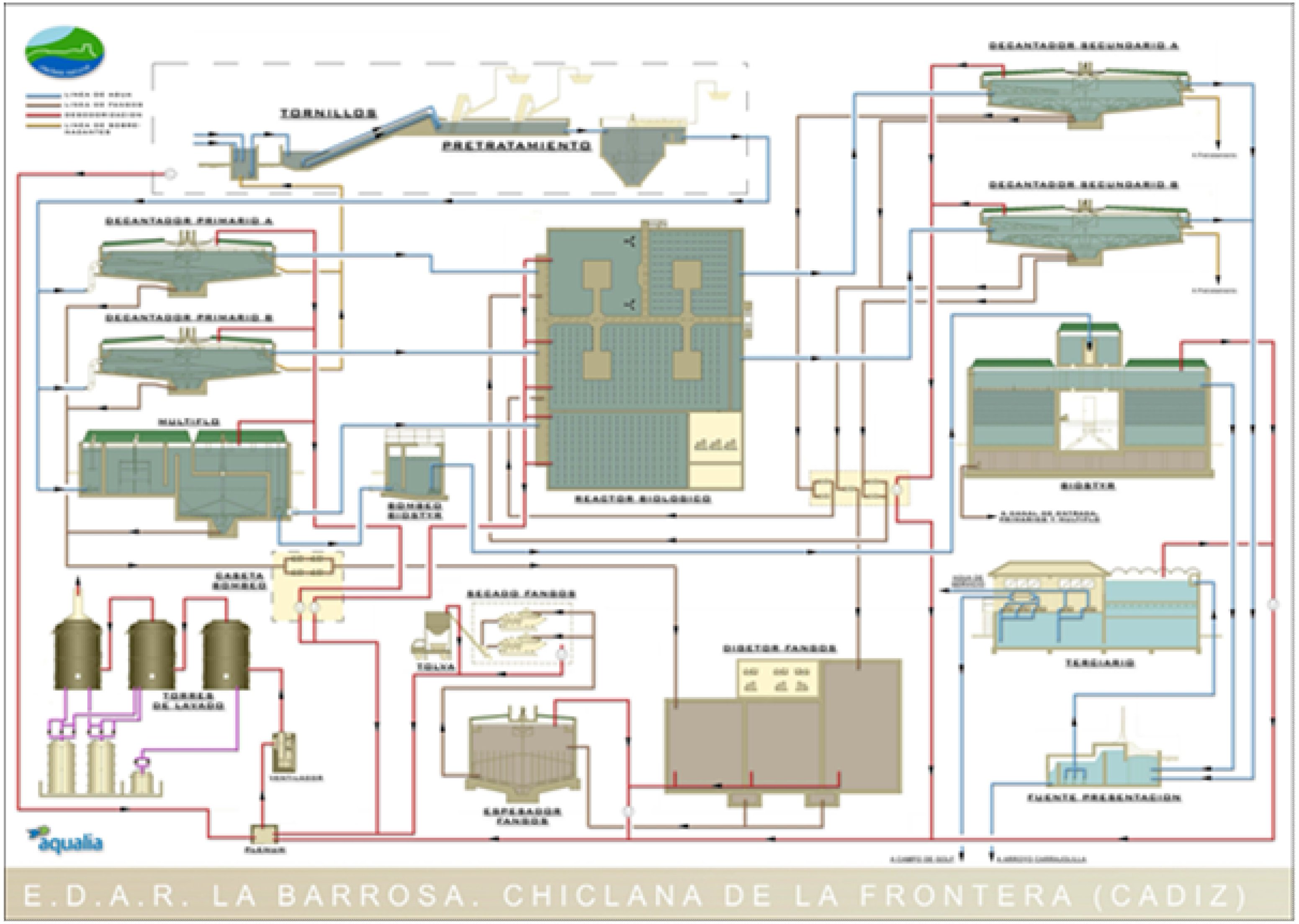
WWTP Overload/Unused capacity

La Barrosa WWTP was designed in 1991 and is in the coastal town of La Barrosa; it collects wastewater from the coastal area of Chiclana and discharges the treated wastewater in the Carrajolilla stream. It serves a population of 30,000 inhabitants and was designed to treat 9,000 m^3/day of wastewater, however it was later expanded and can currently treat a maximum of 14,000 m^3/day of wastewater. La Barrosa WWTP has a seasonal character; its summer inflow is sometimes two to three times higher than its winter inflow. La Barrosa's summer inflow is around 12,000 m^3/day, while, in the winter, La Barrosa inflow is only 6,000 m^3/day, less than half of its design inflow on average.

La Barrosa has two lines of secondary treatment; one is activated sludge and the other uses MULTIFLO™ lamella settlers and Biofilter designed by Veolia (Biostyr™). La Barrosa requires additional biological treatment to meet the N and P requirements of the UWWTD, and if possible biogas production. The plant produces an average 8.9 tonnes of sludge per day. Since La Barrosa is close to residential houses, it must prevent bad odours, and the tanks are mostly covered. FIGURE 8. LA BARROSA WWTP DIAGRAM shows the diagram of La Barrosa WWTP.

[12]Source: Instituto Nacional de Estadística www.ine.es

FIGURE 8. LA BARROSA WWTP DIAGRAM



El Torno WWTP was designed in 1986 (upgraded in 1996) and is in the industrial area of El Torno; it collects wastewater from the rest of Chiclana and discharges the treated wastewater in the Iro river. It serves a population of 40,000 inhabitants.

El Torno WWTP has a more stable and constant flow, treating an average 11,500 m^3/day and a maximum 14,000 m^3/day in the winter. There is a 10% flow reduction in the summer; the maximum design inflow is reached in the winter. This installation operates with conventional activated sludge and sludge treatment by aerobic stabilization with liquid oxygen. FIGURE 9. EL TORNO WWTP DIAGRAM shows the diagram of El Torno WWTP.

Both plants (La Barrosa and El Torno) also have tertiary treatment (UV disinfection).

TABLE 4. DESIGN FLOWS FOR LA BARROSA AND EL TORNO WWTP shows the design flows for both WWTP, while FIGURE 10. DAILY FLOWS FOR LA BARROSA WWTP IN JANUARY AND AUGUST 2009 AND JANUARY AND AUGUST 2011FIGURE 11. DAILY FLOWS FOR EL TORNO WWTP IN JANUARY AND AUGUST 2009 AND compare the daily flows (average, maximum and minimum) for each WWTP in 2009 and 2011. These tables show that:

- The average daily flows of La Barrosa more than doubled between January and August (in 2009 and 2011);
- The average daily flows of El Torno are more constant between the months of January and August (in 2009 and 2011), although there is a decrease in August (in 2009 and 2011);
- Overall the daily flows of La Barrosa and El Torno WWTP have increased between 2009 and 2011 in August;
- Both WWTP have exceeded or been very close to exceeding their wastewater treatment capacity at some point (August 2009 for La Barrosa WWTP and January 2009 and January 2011 for El Torno).

TABLE 4. DESIGN FLOWS FOR LA BARROSA AND EL TORNO WWTP

FLOW (m^3/d)	**DESIGN**	
	TORNO WWTP	**BARROSA WWTP**
Average daily flow	11,472 m^3/d	14,000 m^3/d
Average flow rate	478 m^3/h	545 m^3/h

Moreover both WWTP meet the requirements of the UWWTD, except for Total Nitrogen (see TABLE 5. AVERAGE DISCHARGE OF EL TORNO WWTPTABLE 6. AVERAGE DISCHARGE OF LA BARROSA WWTP).

FIGURE 9. EL TORNO WWTP DIAGRAM

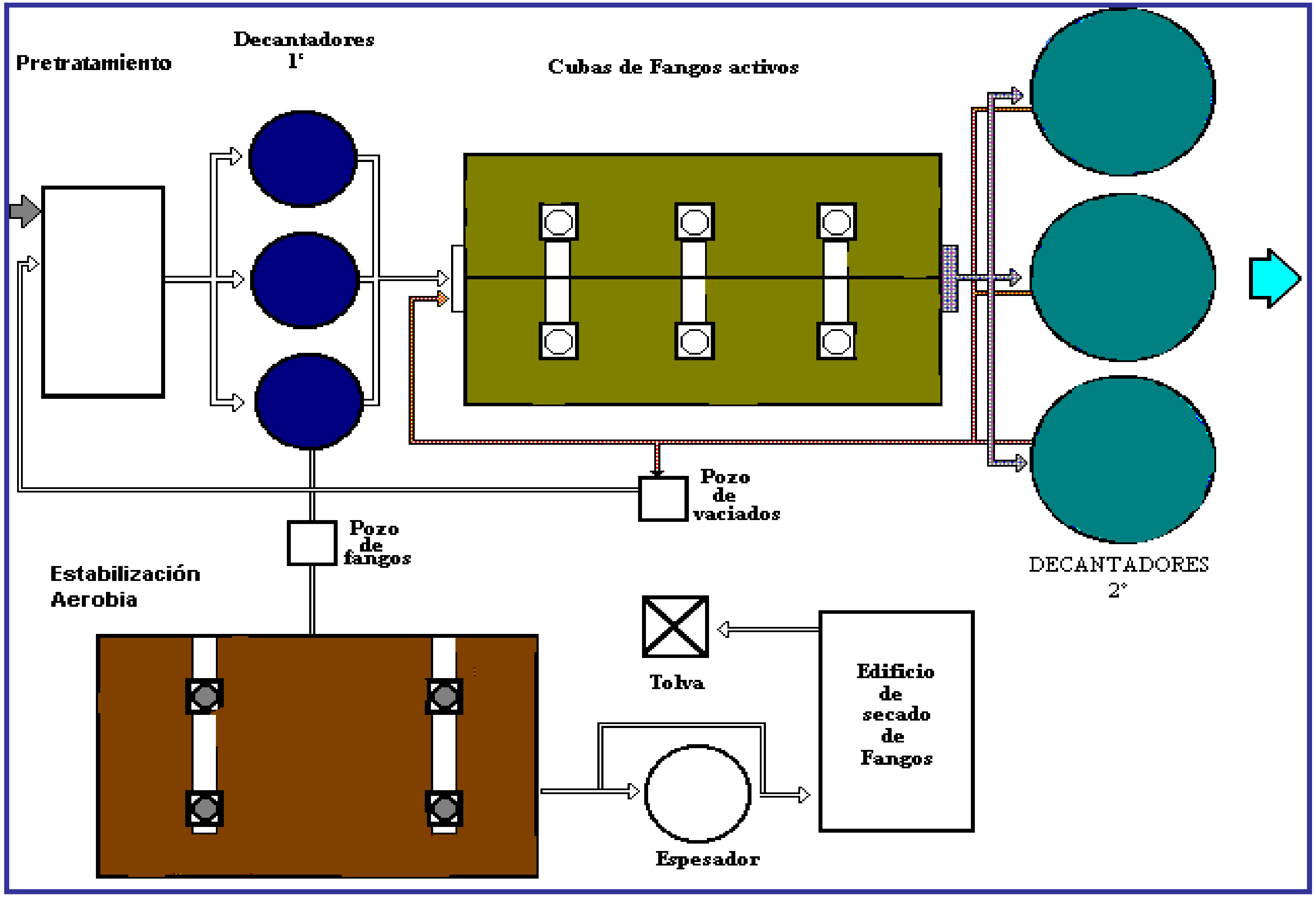
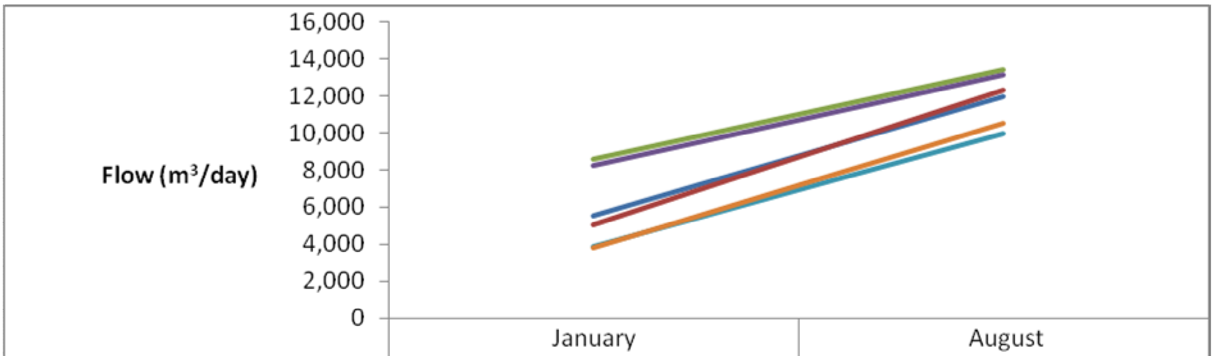
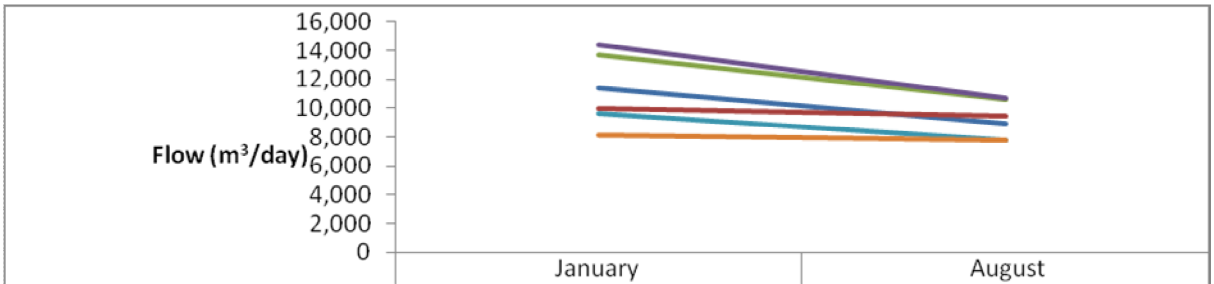


FIGURE 10. DAILY FLOWS FOR LA BARROSA WWTP IN JANUARY AND AUGUST 2009 AND JANUARY AND AUGUST 2011



	January	August
Average daily flow 2009	5,520	11,949
Average daily flow 2011	5,067	12,310
Maximum daily flow 2009	8,578	13,454
Maximum daily flow 2011	8,255	13,170
Minimum daily flow 2009	3,857	9,965
Minimum daily flow 2011	3,829	10,514

FIGURE 11. DAILY FLOWS FOR EL TORNO WWTP IN JANUARY AND AUGUST 2009 AND JANUARY AND AUGUST 2011



	January	August
Average daily flow 2009	11,368	8,919
Average daily flow 2011	9,958	9,491
Maximum daily flow 2009	13,695	10,568
Maximum daily flow 2011	14,386	10,688
Minimum daily flow 2009	9,647	7,815
Minimum daily flow 2011	8,097	7,786

TABLE 5. AVERAGE DISCHARGE OF EL TORNO WWTP

PARAMETERS	FLOW	EFFLUENT	REDUCTION (%)	REQUIREMENTS[13]	MIN. REDUCTION (%)[14]
COD (mg/l)	840	82	90	125	75
BOD (mg/l)	399	11	97	25	70-90
Total suspended solids (mg/l)	358	22	93	35	90
Total P (mg/l P)	8,7	2,0	75	2,0	80
Total N (mg/l N)	62,1	31,6	48	15	70-80

[13] Council Directive of 21 May 1991 concerning urban waste water treatment (91/271/EEC).
[14] *Ibid.*

TABLE 6. AVERAGE DISCHARGE OF LA BARROSA WWTP

PARAMETERS	FLOW	EFFLUENT	REDUCTION (%)	REQUIREMENTS[15]	MIN. REDUCTION (%)[16]
COD (mg/l)	769	73	91	125	75
BOD (mg/l)	360	11	97	25	70-90
Total suspended solids (mg/l)	254	12	95	35	90
Total P (mg/l P)	6,9	2	69	2,0	80
Total N (mg/l N)	51,7	26,4	48	15	70-80

On the other hand, Andalucia is an arid region; demand for water in this area is high and has increased in the last decades, especially in the summer, due to the hotels, summer houses and golf courses. Therefore, Chiclana Natural needs to upgrade La Barrosa WWTP to treat 40,000 m^3/day. Moreover, to meet the N and P requirements of the UWWTD, the plant requires additional biological treatment, and if possible, biogas production; however available space is limited. Chiclana Natural is also planning to connect all illegal settlements of the municipality to the sewage network, which will further increase the sewage load by 50%, according to their estimates.

Short distance between the WWTP

The distance between the two WWTP is 5.8 km (see FIGURE 12. DISTANCE OF 5.8 KM BETWEEN LA BARROSA AND EL TORNO) and they are both at a similar altitude. The distance between the two WWTP taking into account topographic or infrastructural barriers and following a road is around 9 km. These conditions make IWPM implementation feasible.

FIGURE 12. DISTANCE OF 5.8 KM BETWEEN LA BARROSA AND EL TORNO

[15] *ibid.*
[16] *ibid.*

Reuse of water

The municipality of Chiclana is also a pioneer in Spain in the use of treated wastewater. The highest demand for treated wastewater is from the golf courses, which are closer to La Barrosa WWTP. Currently, La Barrosa discharges its effluent in the Carrajolilla creek and has pipes to transfer part of the effluent to five golf courses. Some of these golf courses have subterranean wellheads for water supply when the WWTP does not provide enough treated wastewater, usually in the summer when the aquifers are at their lowest levels. There is therefore a risk that salt-water may intrude into the freshwater aquifers and contaminate the freshwater supplies because these wellheads are on the coast.

El Torno supplies treated wastewater to public green areas and a cemetery. The potential use of this treated wastewater is high, given the existence of potential arable land in the area; however, out of a water volume of 3,800,000 m^3/year, only 1,600,000 m^3/year is used. The rest (57.89% of the total) is discharged to the Iro river, a tributary of Caño de Sancti Petri.

4.3.3 Administrative issues

Chiclana presents good conditions for IWPM application. Chiclana Natural S.A. [17], founded in 1987, is a public company owned by Chiclana de la Frontera municipality. Since its foundation, Chiclana Natural (formerly Aguas de Chiclana) has been responsible for the municipality's water supply; now it is also responsible for its sewage network and wastewater treatment. In 2001, Chiclana Natural became also responsible for waste management in the municipality.

Spain's Ministry of Environment, Rural and Marine Environment is responsible for transposing the EU environmental directives, including water, as well as plan the investments in the sector to comply with the legislation. However, the Government of each Autonomous Community, through the Water Agency, enacts decrees on

[17] www.chiclananatural.com

wastewater treatment regulations for urban areas in the Community's jurisdiction. In addition, the Water Agency, in close cooperation with the municipalities, is in charge of planning and managing wastewater infrastructure. However, wastewater collection and treatment is the responsibility of municipalities.

In consequence, the Government of Andalucia (Junta de Andalucia), through the Andalucia Water Agency (Agencia Andaluza del Agua) is responsible for planning the wastewater infrastructure for Andalucia, including the town of Chiclana[18]. However, the WWTP of Chiclana are owned and managed by the municipality through Chiclana Natural. Chiclana Natural has sub-contracted Aqualia to operate the municipality's WWTP.

The municipality of Chiclana de la Frontera was a pioneer on meeting the legal requirements of the UWWTD. The municipality of Chiclana was the first municipality in the Cadiz Province to start treating wastewater, following the construction of the El Torno WWTP in 1986. Subsequently it financed, using the municipality funds, the construction of a second WWTP to meet the needs of the coastal area. Moreover, Chiclana Natural has been a pioneer in Spain in the reuse of treated wastewater for the irrigation of golf courses since 1996.

Given that the discharge area of the WWTPs was declared a sensitive area, and the continuous urban development and pollution growth in the region, Chiclana Natural had to upgrade Chiclana's wastewater infrastructure a few times in the last years. The Government of Andalucía funded the enlargement of the El Torno WWTP while Chiclana Natural funded the upgrade of the La Barrosa WWTP. However, Chiclana de la Frontera is still growing and its wastewater infrastructure needs to follow this growth to keep the town as a touristic destination without hindering the environment and in particular water quality.

According to Spanish law[19] and EU legislation[20], Chiclana Natural has to launch a public procurement procedure for commissioning public works contracts, including sewage network and wastewater infrastructure design and construction.

4.3.4 Interest in IWPM replication

Chiclana Natural is highly interested in IWPM. In 2009, Chiclana Natural already envisaged connecting the two WWTP with a 600 mm pipe to share only the treated wastewater, use it mainly in La Barrosa and therefore meet the high water demand (treated wastewater) of the golf courses. An outsource study on the subject concluded that the best alternative would be to lay a pipe through the municipality's own land and following one of the main roads between the two plants. This alternative provided the greatest overall technical and economic benefits and had the lowest environmental impact. The total cost of this alternative was €5.3 million.

[18] Ley 9/2010, de 30 de julio, de Aguas para Andalucía (http://noticias.juridicas.com/base_datos/CCAA/an-l9-2010.t1.html).

[19] Ley 13/2003, de 23 de mayo, reguladora del contrato de concesión de obras públicas (http://noticias.juridicas.com/base_datos/Admin/l13-2003.html#da11).

[20] Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0018:En:HTML).

However, this pipe would only help the municipality respond to the demand for treated wastewater in La Barrosa, but would not improve either the quality of the effluent to comply with EU legislation, or increase the capacity of the plants to cope with the seasonal changes in inflows and future inflow increases. Therefore, Chiclana Natural is interested in finding an alternative and combined solution for the high demand for treated wastewater, the overload/unused capacity of the plants, and lack of space to expand and meet the current and future demands and EU legal requirements.

STELLA conducted a first mission to Chiclana in October 2010 to visit the municipality's WWTP, study the baseline conditions for IWPM application, and assess the interest of Chiclana Natural. Annex A presents the result of this mission and the Checklist of Requirements for IWPM replication.

After this meeting, Chiclana Natural representatives showed high interest to visit Bad Essen to discuss the technical details of the IWPM system. STELLA and Wasserverband Wittlage (WVW) organised a one-day visit (15.02.2011) to the Bad Essen and Ostercappeln WWTP and the pumping station between these two plants. The main goal of this visit was to show the IWPM-System to Chiclana Natural. Two Chiclana Natural representatives, Mr. Gallo Fernández, Managing Director of Chiclana Natural and Mr. Barragan, Water treatment and Water quality Technician, went on the visit and co-financed their travel costs (50%). In particular, they discussed the challenges of IWPM application and monitoring with the IWPM implementing agency (WVW). See Figure FIGURE 13. VISIT TO THE BAD ESSEN AND OSTERCAPPELN WWTP. FEBRUARY 2011 for pictures of the visit.

FIGURE 13. VISIT TO THE BAD ESSEN AND OSTERCAPPELN WWTP. FEBRUARY 2011

During this meeting, it became evident that a visit of Chiclana's two WWTP would be helpful to discuss in-depth the possibility of IWPM application. In addition, Chiclana Natural wanted to discuss with IWPM partners the possibility of expanding the IWPM concept to encompass other up-to-date technologies for wastewater treatment and solve other problems in Chiclana.

As a result, Chiclana Natural organised a one and half day visit (01-02.06.2011) to their office in Chiclana and to La Barrosa and El Torno WWTP (see FIGURE 14. IWPM PARTNERS' VISIT TO CHICLANA WWTP. JUNE 2011). During this meeting, Chiclana Natural presented

FIGURE 14. IWPM PARTNERS' VISIT TO CHICLANA WWTP. JUNE 2011

their idea for IWPM implementation and the potential layout/route for constructing the pipe and connecting the plants. Chiclana Natural explained that the initial idea was to connect the two WWTP with a pipe, but after learning of IWPM, the idea now is to use a triple pipe with the following objectives:

- Pump wastewater from La Barrosa to El Torno;
- Pump the treated wastewater to be reused in La Barrosa for irrigating the golf courses; and
- Pump sludge from La Barrosa to El Torno and treat the sludge from the two WWTP in El Torno.

Besides the interesting perspectives of IWPM replication in Chiclana, the visit of IWPM partners prompted interest by the public and the media. The visit was featured in two newspapers, “Información”[21] and “Diario de Cádiz”[22]. Both articles highlighted the usefulness of the IWPM system and its application to Chiclana, where a triple pipe could help Chiclana Natural achieve the three objectives above, which no other system has been able to do so far. It also emphasised the innovative character of the system.

4.3.5 Triple pipe IWPM system cost

Chiclana Natural has estimated the cost of constructing a triple pipe following the IWPM system (see TABLE 7. ESTIMATED COST FOR THE TRIPLE PIPE (CHICLANA NATURAL’S CALCULATIONS)). The cost does not include the monitoring and control system required for controlling the different flows in the pipes, but it includes the materials and engineering and supervision works for constructing the triple pipe.

TABLE 7. ESTIMATED COST FOR THE TRIPLE PIPE (CHICLANA NATURAL’S CALCULATIONS)

Activity/Material	Unit	Amount	Cost per unit (€)	Cost (€)
Trench excavation	m^3	46,580.00	6.50	302,770.00
Sand filling	m^3	4,110.00	11.50	47,265.00
Selected filling	m^3	20,550.00	6.30	129,465.00
Trench filling	m^3	21,920.00	2.60	56,992.00
Pipe polythene □ 180	m	6,850.00	16.50	113,025.00
Pipe polythene □ 560	m	6,850.00	138.51	948,793.50
Pipe polythene □ 450	m	6,850.00	89.30	611,705.00
Valves	unit	15.00	25,850.00	387,750.00
Pump 1 (300 m^3/day)	unit	2.00	8,977.42	17,954.84
Pump 2 (7,500 m^3/day)	unit	2.00	110,945.76	221,891.52
Pump 3 (3,575 m^3/day)	unit	2.00	76,668.43	153,336.86
Works barrels	unit	2.00	65,200.00	130,400.00
Metal works	unit	2.00	52,500.00	105,000.00
Repaving roads	m^2	30,825.00	29.10	897,007.50

[21] http://www.andaluciainformacion.es/portada/?a=179325&i=43 article in Spanish.
[22] http://www.diariodecadiz.es/article/provincia/981503/proyecto/innovador/plantea/la/conexion/las/dos/depuradoras.html article in Spanish.

Paving roads	m^2	47,950.00	2.75	131,862.50
Affected services	unit	1.00	1,860,000.00	1,860,000.00
Waste disposal	unit	1.00	183,620.00	183,620.00
Safety and health (1%)	unit	1.00	64,000.00	64,000.00
			Budget (gross estimate) (€)	6,362,838.72
			Overheads (19%) (€)	1,208,939.36
			Taxes (18%) (€)	1,362,920.05
			Total (€)	8,934,698.13

4.3.6 Future perspectives of IWPM application

Chiclana Natural would like to implement IWPM between the two plants and to advance new technologies for wastewater treatment and reuse of treated wastewater.

ALL-GASS, an FP7 funded project, will use El Torno WWTP as a pilot to demonstrate the sustainable production of biofuel through the low-cost cultivation of microalgae and reuse of nutrients. Sustainable microalgae cultivation will use the nutrients in wastewater from El Torno. The project will also inject the CO_2 emissions from sludge incineration into the algae ponds. The complete process, including wastewater treatment, microalgae cultivation, biomass extraction, extraction of oil and other valuable materials, and biofuel production and use, will be done in an area of 10 ha.

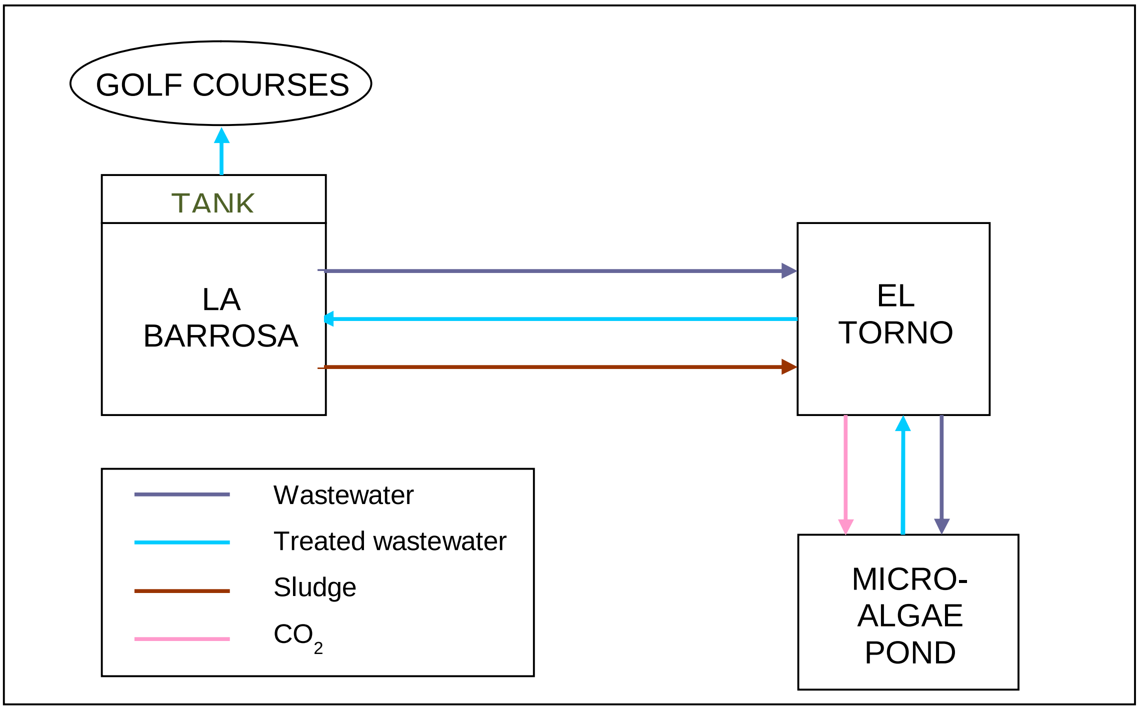
The main goal of this project is to merge two disjointed areas of research on microalgae in an innovative way. The first area is energy production from microalgae, in particular sea algae, with a high investment cost or a low energy balance production. The second area has focused on wastewater treatment through microalgae, using conventional lagoons with low performance and high land uptake since the lagoons were not properly designed and/or did not have injection of CO_2 or aeration systems.

The project will investigate the conditions to:

- Decrease the levels of organic matter and nutrients in wastewater to meet the discharge levels;
- Produce biogas for cars;
- Produce oil to make biodiesel; and
- Produce other valuable products for the aquaculture, health, nutrition, or cosmetic industry.

The project will expand El Torno WWTP by constructing a new wastewater treatment line with a capacity of 5,000 m^3/day. Likewise, the project has investigated the different sources of biomass for producing the CO_2 necessary for cultivating microalgae.

IWPM could play an essential role in the future of the two plants of Chiclana. With a 9 km triple pipe connecting the two plants, the plants will able to share the sewage, in particular when La Barrosa reaches its maximum capacity. Therefore, La Barrosa would profit from El Torno's expansion. Likewise the extra 5,000 m^3/day of wastewater treated through microalgae cultivation could be reused in La Barrosa for golf courses irrigation. In addition, sludge from La Barrosa could be pumped to and treated in El Torno. The CO_2 from gasification will be used to grow the microalgae. This will have two benefits: (i) there will be enough biomass to produce the necessary CO_2, and (ii) avoid the transport of the sludge by trucks from one plant to the other, thus decreasing noise and CO_2 emissions in the residential area.



Such an installation requires the following infrastructure (see FIGURE 15. IWPM CONCEPT ADAPTED TO CHICLANA'S CONTEXT):

- **Triple pipe and pumping stations**: the system connecting both WWTP should be able to send wastewater and sludge from La Barrosa to El Torno, and treated wastewater from El Torno to La Barrosa. The triple pipe follows the IWPM concept.

- **Tank to store treated wastewater at La Barrosa WWTP**: for the correct management and use of treated wastewater, La Barrosa WWTP needs a storage and regulatory system.

- **Tertiary treatment at WWTP El Torno**: development of an adequate tertiary treatment for the effluent from the cultivation of the microalgae.

FIGURE 15. IWPM CONCEPT ADAPTED TO CHICLANA'S CONTEXT

There would be several benefits of installing a triple pipe. Chiclana Natural could use both WWTP as if it were only one. Moreover, the sludge could be pumped by pipe from La Barrosa to El Torno rather than by truck (La Barrosa is a residential area) to be treated at El Torno. In addition, as tourism continues to develop in Chiclana, and illegal settlements are progressively connected to the sewage network, demand for wastewater treatment will increase greatly. Once the sludge treatment line in la Barrosa is eliminated, the space could be used to expand La Barrosa to meet this future demand. In fact, El Torno could treat La Barrosa's wastewater while La Barrosa is upgraded, without having to shut down any of the two WWTP.

4.3.7 Cost-benefit analysis

Before conducting the Chiclana project's financial and economic analysis (and calculation of Benefit/Cost ratio), we wanted to make sure that the triple pipe following the IWPM system was the best option; therefore, we assessed the competing option of expanding La Barrosa. The investment cost of the expansion option (€22 million) is more than twice as high as the investment cost for the triple pipe (€8.9 million as shown in Table 7). In addition, the triple pipe will allow pumping instead of transporting the sludge by truck, which will result in net savings of €60,000/year. Clearly, the triple pipe option is much less expensive to implement than the expansion option.

Financial analysis

The purpose of the financial analysis is to assess the financial performance of the proposed project over the period under consideration, with the view to establish the extent of financial self-sufficiency and long term sustainability of the proposed project. The analysis is typically made up of a series of tables that collect the financial flows of the project, broken down as total investment, operating costs and revenues, sources of financing and cash flow analysis for financial sustainability.

As this project falls within the boundaries of an existing infrastructure, the recommended methodology is the discounted cash flow analysis (DCF), which uses an incremental method that compares a scenario with the project with an alternative scenario without project. The result of this process above is the "incremental" impact of the proposed projects in term of a financial cash-flows statement for all years of operation. We have assumed a period of 30 years, which is typical for such wastewater treatment infrastructure.

We have also assumed that the operation and maintenance costs would be the same with and without project, except for the net savings resulting from pumping instead of transporting the sludge by truck (€60,000/year).

The Financial Net Present Value (FNPV) of the project is negative (-€7.98 million), which was expected because the savings in sludge treatment are not high enough to offset the initial investment in the triple pipe. In pure financial terms, the only way to have a positive FNPV would be to increase the tariffs or use a grant to pay for the investment.

Economic analysis

The purpose of the economic analysis is to assess the project's contribution to society. The project's benefits should exceed the project's costs and, more specifically, the present value of the project's economic benefits should exceed the present value of the project's economic costs. In practical terms, this means that the project must have a positive Economic Net Present Value (ENPV), a Benefit/Cost

(B/C) ratio greater than 1, or a project Economic Rate of Return (ERR) exceeding the discount rate used for calculating the ENPV (i.e. 5.5%).

However, project economic (as opposed to financial) costs are measured in terms of their ‘resource’ or ‘opportunity’ costs; that is, the benefit which has to be foregone (the opportunity lost) by society in using scarce economic resources in the project rather than in some alternative use. Such project benefits can be measured in terms of the amounts that people benefiting from the project are ready to paid for (willingness-to-pay terms) or, alternatively, in costs avoided as a result of implementing the project, as well as in term of external benefits that result from the implementation of the project and that are not captured by the financial analysis.

One of the main benefits of constructing the triple pipe in Chiclana following the IWPM system is the improved quality of bathing and other surface waters, which translates into an improvement in the overall conditions of water bodies in the project area as a result of better wastewater treatment. This benefit refers to the use value of an improvement in the quality of water bodies in the Chiclana region. This is linked to the benefits accruing to people undertaking water related recreational activities.

According to JASPERS’ Guidelines for Cost Benefit Analysis of Water and Wastewater projects supported by the Cohesion Fund and the European Regional Development Fund in 2007-2013, the benefit for Romania was an average of €20.4/person/year in 2008. If we update the figure for 2011 (factor of 1.12) and extrapolate to Spain using the GDP differential (factor of 2.51), the benefit for Spain becomes €57.3/person/year in 2011. This benefit has to be calculated for the whole population living in the concerned area, i.e., the 70,000 people served by La Barrosa and El Torno. However, given that the two plants already exist and that the water quality is relatively good, we can assume that only a quarter of the benefit (€14/person/year) would result from the construction of the triple pipe; therefore, the total benefit would be €980,000/year. Given the fact that the local communities are likely to be the first ones ready to pay for improved water bodies condition in their surrounding, the value above is considered realistic.

The project’s ENPV is €6.2 million, its B/C ratio 1.7, and its ERR 11%. All of these indicators show that the triple pipe project in Chiclana is worth implementing -- positive ENPV, B/C ratio greater than 1, and ERR greater than 5.5%. A positive net present value means that the investment will yield positive economic return, i.e., the project’s contribution to society is positive and it is worth going forward with its implementation.

5. CONCLUSIONS

On the basis of the screening and in-depth studies as well as our missions to Spain and Germany, we conclude that Chiclana is a **high-potential opportunity for IWPM replication** as it meets the baseline requirements for IWPM implementation and the municipal company Chiclana Natural has shown great interest in applying IWPM because it would resolve the overload/under-load problems of its two WWTP as well as other current and future problems, such as the demand for treated wastewater.

IWPM could contribute to building a system more efficient in terms of land, energy, and water to treat wastewater from Chiclana. IWPM would avoid taking more land to expand or upgrade WWTP. The system would decrease the CO_2 emissions generated by the treatment of sludge by using the CO_2 to grow microalgae and by avoiding sludge transportation by trucks from one plant to another. It would also use the sludge to produce electricity. The treated water would avoid using fertilizers and any other source of water that could be used for other purposes. The Cost Benefit Analysis proves that Chiclana's triple pipe would make a positive contribution to society and that it is worth going forward with its implementation.

We hope that IWPM will be implemented in other countries in Europe, and in Chiclana in the near future, since it is a flexible and cost-efficient system contributing to solving under-load/overload problems in WWTP and to improving resource efficiency. The Europe 2020 Strategy[23] supports the shift towards a resource-efficient, low-carbon economy to achieve sustainable growth; IWPM can contribute to achieving the targets set in this strategy and move Europe towards a sustainable development path.

[23] http://ec.europa.eu/europe2020/index_en.htm

ANNEX A

CHECKLIST OF REQUIREMENTS, CONDITIONS AND CONSTRAINTS – CHICLANA DE LA FRONTERA, SPAIN

Information on country, region or area	Chiclana de la Frontera, Spain
Administrative issues	
Ministry in charge of WW treatment	Ministry of Environment and Rural and Marine Environment.
Other Ministries or authorities that could be involved in such projects	▪ Ministry of Interior; ▪ Ministry of Health, Social Affairs and Equality; ▪ Meteorological Service Agency; ▪ National Service of Cadastre; and ▪ Ministry of Economy and Finance.
Regional/Local authorities that could also be involved (spatial occupation authorities included)	▪ Andalusian Government (Andalusian Water Agency).
Permits needed?	Yes, construction permit.
Delivering permit authorities?	NA
Types of tenders?	Project and construction.
Compensation (tables)?	Depends on various factors.
Technical issues	
Percentage of wastewater treated?	El Torno has a capacity of 11,000 m^3 and la Barrosa of 13,500 m^3. La Barrosa should be expanded to treat a wastewater volume of around 35,000-40,000 m^3.
What are the most usual types of treatment used?	Mechanical treatment and activated sludge.
What are the percentages of each type of WWTP?	NA
How many WWTP have yet to be built?	None. La Barrosa needs to be expanded/upgraded.
How many WWTP have been built and are operating?	Two.

Information on country, region or area	Chiclana de la Frontera, Spain
How many WWTP encounter load problems (underload, overload)?	La Barrosa: overload during the summer. El Torno: decreases its load 10% during summer.
What are the distances (max – average – min) between the existing plants?	Minimum: 8 km. Maximum: 12 km. Average: 10 km.
How many WWTP have been built or have yet to be built in tourist areas?	La Barrosa needs an expansion.
Are there enough human resources to manage such pipes?	Yes.
Spatial issues	
Is the topography adapted to such a construction?	Yes.
Is the soil (geology – hydrology – etc) adapted to such a construction?	Yes.
What is the climate (freezing depth) in the area?	NA
What is the land use on the course of the pipe (private properties, gardens, forests, water entities, roads, railroads, agricultural land, protected areas – Natura 2000, etc.)?	Mostly roads, a few private properties and parts of a protected area (the Natural Park Bahía de Cadiz).
Are there any interfering underground constructions on the course of the pipe (other pipes (gas, oil, etc.), optical fibres, electrical lines, etc.)?	Only water and electricity pipes.
Economic issues	
Who will provide the funds?	Financing will depend on the final costs. Part of the costs could be financed by Chiclana Natural Water Agency, but they will need co-financing.
Is there enough money available for such constructions?	Depends on the final costs.
Who will design the pipes and upgrade?	A contractor to be selected through public tendering.