Summary of methods, rules and criteria to be incorporated into the DSS

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TRANSITIONS TO THE URBAN WATER SERVICES OF TOMORROW

Summary of methods, rules and criteria to be incorporated into the DSS

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FINAL VERSION FOR DISTRIBUTION

November 2013

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 265122.

EXECUTIVE SUMMARY

An impact assessment methodology for evaluating the qualitative impact of urban water technologies and methods on objectives and criteria of the TRUST sustainability dimensions (social, environment, economic, governance issues and assets [1]) is described in this report. The relevance of selected technologies and methods is assessed in terms of being enablers or barriers for the realisation of the TRUST sustainability objectives.

In general, the assessed technologies and methods focus on improved planning and more sustainable operation of urban water cycle services. The main focus on methods (e.g. operational options) and technologies (incl. new technologies, tools, equipment) investigated in TRUST (WA 4) lies on optimising processes, improving process control and best operation practices within the perspectives of sustainability and life cycle assessment. This summary of methods, rules and criteria for decision making includes the use of resources in the fields as follows:

- Enhanced water treatment processes (WP41)
- Urban water use management (WP42)
- Wastewater and storm water management in urban water systems (WP43)
- Enhanced utilisation of alternative water sources in urban water systems (WP44)
- Water-energy nexus in urban water systems (WP45)
- Enhanced technologies for infrastructure asset management (WP46)

The report is mainly addressed towards the scientific community as well as the scientists involved in TRUST. The framework for impact assessment on TRUST objectives can be used for individual and case-specific evaluations.

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1. INTRODUCTION & CONTEXT

The qualitative impact assessment provides an overview about the targeted sustainability objectives to be improved by selected technical intervention options available. Trust provides innovative instruments to assists in different stages of decision making processes at different institutional levels. The trust roadmap guideline provides a description of how transition planning efforts in Urban Water Cycle Systems (UWCS) can be organised and offers templates to support the working process. The roadmap guideline illustrates diverse aspects in water supply and waste water management in terms of sustainability with its five TRUST sustainability dimensions: social, environment, economic, governance and assets. The trust self-assessment tool [1] creates an initial interest on the matter by means of a rough estimation of the areas in need of further attention. Together with the latter, the rough impact assessment assists in directing the users to the appropriate TRUST tools to improve and reach the 2040 target.

This report provides a list of urban water technologies and methods as well as the impact assessment method of the (expected) qualitative impact on sustainability criteria. The qualitative impact assessment provides an overview about the targeted sustainability objectives to be improved by selected technical intervention options available. The aim is to provide a generic exemplary impact assessment for evaluating the expected potential of interventions to improve the UWCS sustainability in order to assist in individual case-specific evaluations. It thus encourages a definition of intervention strategies by selecting different methods, tools and criteria with regard to the impact on the future UWCS sustainability and to assess the impact case-specifically for a given city. The impact assessment is suitable to assist in the back casting step of the road mapping approach. The case-specific impact assessment results in a comparative ranking of assessed intervention options (techniques, methods or political instruments etc.). This is suitable for the prioritisation of intervention options with the aim of targeted improvement of sustainability criteria. This is relevant for the TRUST Decision Support System (DSS), developed in WA 54 which assists in different stages of the decision making process including problem definition, structuring and analysis of activities as well as indicating possible solutions [2]. The impact assessment data can be used in the problem definition module of the DSS. This module incorporates a pre-defined list of technical intervention options allowing the user to specify individual technical intervention strategies. Thus, the impact assessment encourages a definition of intervention strategies by selecting different methods, tools and criteria with regard to the impact on the future UWCS sustainability to be quantitatively analysed in the DSS [2].

1.1. Assessed technologies and methods

The over-all objective of TRUST is to support a transition towards sustainability for urban water cycle services. In this context, sustainability means exercise of good service for customers with a balanced use of water, materials including chemicals and energy with a minimum discharge of pollutants and gases into the environment as well as financial resources. The aim of the related TRUST work area 4 (WA 4) is to fulfil this objective for water, wastewater and storm water systems by means of technologies and methods. The investigated drinking water and waste water service specific intervention options cover conceptual studies, modelling and simulation tools as well as experimental investigations in pilot scale on treatment and monitoring technologies. Different intervention options are applied in several pilot cities depending on their specific needs. The types of intervention options for UWCS improvement investigated in WA 4 are summarised in Table 1.

Table 1: Overview of assessed groups of intervention options

TECHNOLOGICAL DOMAINS	TECHNOLOGY / METHOD	TYPES OF INTERVENTION OPTIONS
Enhanced water treatment (WP 41)	Natural organic material fractionation	technology option
	Full-scale coagulation optimisation	management option
	Water treatment optimisation	management option
	Life cycle assessment	management option
Urban Water Demand Management (UWDM) (WP 42)	Integrated planning of water demand, energy consumption and wastewater production	management option
	Water losses management	management option
	Metering and tariff structures	management option
	Use of household fittings and appliances	technology option
	Soft UWDM technologies	management option
	Use of grey water recycling/rainwater harvesting systems	technology option
Wastewater and storm water management in urban water systems (WP 43)	Integrated planning of wastewater and storm water systems	management option
	Performance assessment and enhanced wastewater treatment	management option
Alternative Water Sources (WP 44)	Use of treated wastewater	technology option
	Desalination	technology option
Strengthening the water-energy nexus in urban water systems (water-energy connection) (WP 45)	Integrated planning of water and energy	management option
	Enhanced energy efficiency technologies/equipment	technology option
	Energy recovery technologies	technology option
Enhanced technologies for infrastructure asset management (WP 46)	Integrated IAM planning	management option
	Enhanced technologies to support data collection and information management	management option
	Enhanced rehabilitation technologies	technology option

Enhanced water treatment (WP 41)

The optimisation of existing water supply systems towards more sustainable and resource-effective operation procedures is the main focus of WP41 as existing systems will still be in operation for decades. The selection of the investigated technologies and tools is based on the needs of TRUST pilot cities and utilities involved in the project. Basically, WP 41 builds on the technologies and roadmap principles developed within the recent EU project TECHNAU and aims at application, extension and optimisation of the TECHNAU outcomes. The objective is to generate applicable results to be implemented in the TRUST pilot cities to enable the desired transitions to urban water systems of tomorrow being also relevant for other European areas and world-wide.

In general, the technologies and tools support the optimisation of water treatment performance (e.g. full-scale coagulation treatment optimization procedures) and the adaptation of treatment processes to changes in raw water quality and variability (e.g. process control options). Changes in the raw water quality affect water treatment and distribution, e.g. increasing demand for treatment chemicals (coagulants, flocculants, filter aids, ozone, etc.), increased use of filter backwash water, increased activated carbon regeneration frequencies, increased sludge production, increased energy demand, etc. The identification of site-specific best available technologies and the best operation practices through full-scale optimisation procedures is essential in order to meet future safety and sustainability needs, starting with the assessment of the current operation performance including advanced water quality surveys and analyses (NOM fractionation [3], BDOC analyses [3], use of chemicals and energy). The treatment performance current status mapping supports the identification of needed additional or alternative treatment processes. The Life Cycle Assessment software tool is based on data on use of resources and current operation performance and indicates the environmental impacts of factors such as coagulant type selection, coagulant processing/manufacturing, transport distance, resources use/coagulant doses, energy use, sludge handling and others [4]. The assessed methods and technologies are summarised in Table 2.

Table 2: Assessed WP 41 - intervention options

TYPES OF INTERVENTION OPTIONS	METHODS AND TECHNOLOGIES FOR UWCS IMPROVEMENT WP 41
Enhanced water treatment	NOM fractionation/Rapid NOM fractionation
	BDOC analyses (6 columns-in-series)
	Full-scale coagulation treatment optimization procedures/roadmap
	Water treatment optimization – incl. mapping of optimization benefits - with respect to: safety/water quality, sustainability /use of resources use,) and distribution/biostability
	Life Cycle Assessment (LCA) - as a tool for assessing environmental impacts of coagulant type selection, coagulant processing/manufacturing, transport distance, resources use/coagulant doses, energy use, sludge handling, etc.

Urban Water Demand Management (WP 42)

Water Demand Management (WDM) aims at controlling the demand by acting at the customer side and at the utility side. The sustainable reduction of water demand conserves the resource and enables economic as well as environmental efficiency. The reduction of drinking water consumption by customers may be achieved by incentivising the domestic and non-domestic sector to save water (e.g., efficient household fittings and appliances) or use alternative sources (e.g. grey water recycling systems, rainwater harvesting systems). Water metering and innovative tariff structures can change the domestic and non-domestic water use behaviour as well as soft technologies e.g. education and media campaigns. As regards water utilities, conventional water losses management, including water balancing, pressure management, use of leakage detection devices and correlators to localise leakages, priority (water loss) based maintenance repairs, is an important tool within the WDM [5].Also the innovative water losses management method, the TRUST tool Pump and Valve Logic Optimal Scheduling (PaVLOS) for the hydraulic optimisation of water networks aiming at leakage reduction and energy optimisation. It consisting a leakage quantification model and a hydraulic model (based on EPANET hydraulic simulation engine), as well as an optimal leakage reduction function (optimising the pressure, valve setting and costs for electrical power as well [6]. The assessed methods and technologies are summarised in Table 3.

Table 3: Assessed WP 42 intervention options

TYPES OF INTERVENTION OPTIONS	METHODS AND TECHNOLOGIES FOR UWCS IMPROVEMENT WP 42
Integrated planning of water demand, energy consumption and wastewater production	Impact assessment tool for different combinations of WDM interventions with respect to their cost, water-related energy use and impact on supply/demand balance of water distribution systems
Water losses management	Conventional water losses management methods: e.g. water balancing, pressure management, use of leakage detection devices and correlators to localise leakages, priority (water loss) based maintenance repairs
	Innovative: Software based water losses management. Pump and Valve Logic Optimal Scheduling (PaVLOS) software: Tool for the hydraulic optimisation of water networks aiming at leakage reduction and energy optimisation
Metering and tariff structures	Introducing tariff models and metering systems/optimisation of metering policy: e.g. implementation of water meters and tariff models with the objective of socially accepted cost recovery (e.g. fix revenues cover fix costs).
Use of household fittings and appliances	Implementation of efficient household micro-component appliances and fittings – WCs, baths, showers, washbasin taps, kitchen sink taps, dishwashers, washing machines, outdoor taps
Soft UWDM technologies	Education / media campaigns with the aim of optimising the cusomter's behaviour regarding water demand
User grey water/rainwater harvesting systems	Implementation of alternative/new water systems – grey water recycling systems (GWR), rainwater harvesting (RWH) systems, sustainable urban drainage systems (SuDS) at the household level

Wastewater and storm water systems management (WP43)

WP 43 tools support more sustainable waste- and storm water management by evaluating the potential of methods and technologies with regard to energy use, flood protection and discharge of pollutants into the water cycle. A set of selected technologies and tools are chosen within TRUST to be investigated and implemented in TRUST pilot cities.

The current operation performance of waste water treatment plants by the PASTool – determining the operation performance of conventional and enhanced waste water treatment systems [7][8][9]. This enables the identification of the needed additional or alternative system components, especially in order to adapt these systems to future needs. Some software tools support storm water master planning by calculating different elements e.g. impervious and permeable surfaces, dry weather flow, sub-catchments, pollution load modelling, flood routing, river ecology and flood risk management. The STORM model (www.sieker.de) indicates the potential for implementing sustainable urban drainage systems (SUDS), e.g. disconnection of storm water from the sewer system. The aim of SUDS is the retention of storm water. Possible intervention options cover e.g. bioretention cells, land use prepared for storage and flood-paths, adjustment of area use for infiltration, gully filters (e.g. INNOOLET® –www.sieker.de) or innovative infiltration devices (e.g. INNODRAIN® –www.sieker.de). The INFOWORK model predicts the frequency and intensity of combined sewer overflow. Further options are inflow quality and quantity-depending flexible operation of treatment plants and new treatment technologies (e.g. biological wastewater treatment) and detention options for storm water in decentralized basins [10]. The assessed tools are summarized in Table 4.

Table 4: Assessed WP 43 – intervention options

TYPES OF INTERVENTION OPTIONS	METHODS AND TECHNOLOGIES FOR UWCS IMPROVEMENT WP 43
Integrated planning of wastewater and storm water systems	STORM model: Creation of disconnection potential maps for SUDS (sustainable urban drainage systems)
	INFOWORK model for prediction CSO (combined sewer overflow) frequency and intensity
Performance assessment and enhanced wastewater treatment	PASTool (set of indicators especially developed to determine the performance of water and wastewater treatment plants)

Alternative Water Sources (WP 44)

The incorporation of alternative water sources in enhanced urban water systems by reclamation and reuse of wastewater/storm water or utilisation of other marginal water sources such as brackish groundwater by desalination is focussed by WP44.

Table 5: Assessed WP 44 - intervention options

TYPES OF INTERVENTION OPTIONS	METHODS AND TECHNOLOGIES FOR UWCS IMPROVEMENT WP 44
Use of treated wastewater	Decentralised wastewater/storm water treatment systems
	Modelling different reuse roadmaps
	Ceramic membranes to reclaim water for urban multi-purposes
Desalination	Sea water desalination
	Brackish water desalination
	Plant Audit as tool to assess performance (desalination: energy optimization and brine handling)

Strengthening the water-energy nexus in urban water systems (WP 45)

The objective of WP45 is achieving energy self-sufficiency of water utilities by developing innovative technology and management options in order to reduce the carbon footprint of the water sector. The water-energy nexus is explored by identifying and investigating opportunities for reducing energy consumption on the one hand and for increasing energy production on the other throughout the urban water cycle. Selected water-energy intervention options are applied in different TRUST pilot cities: Improving energy efficiency in water supply, wastewater treatment technologies with a reduced carbon footprint, heat and power generation from wastewater, heat and cold recovery combined with underground thermal energy storage and micro-generation in water systems [11]. The assessed water saving technologies, water production technologies and tools are summarised in Table 6.

Table 6: Assessed WP 45 – intervention options

TYPES OF INTERVENTIONS OPTIONS	METHODS AND TECHNOLOGIES FOR UWCS IMPROVEMENT WP 45
Integrated planning of water and energy	Integrated pressure and energy management in water distribution
	Energy efficiency audits
Enhanced energy efficiency technologies/equipment	Wastewater treatment with P-recovery (as struphite)
	Energy production from waste water (retention of organic matter and biogas production)
	Enhanced sludge digestion
Energy recovery technologies	Heat recovery from wastewater effluent
	Heat and cold recovery from (waste)water (sewer system), in particular combined with aquifer thermal energy storage
	Micro hydro-generation

Enhanced technologies for infrastructure asset management (WP 46)

The objective of WP 46 is to implement new and enhanced maintenance and rehabilitation technologies for drinking water, wastewater, and storm water networks. The AWARE-P integrated asset management approach and software supports the development of sustainable rehabilitation concepts. Innovative localisation, visualisation and inspection techniques support ground work interventions by improving the access to information and enhancing data collection and data quality. The assessed methods and technologies are summarised in Table 7.

Table 7: Assessed WP 46 - intervention options

TYPES OF INTERVENTION OPTIONS	METHODS AND TECHNOLOGIES FOR UWCS IMPROVEMENT WP 46
Integrated asset management planning	AWARE-P infrastructure asset management approach and software
Enhanced technologies to support data collection and information management	Mobile software to support asset assessment and repair
	Non-destructive inspection for enhanced assessment condition of water pipelines (here pipe scanner BIT)[1]
Enhanced rehabilitation technologies	Pipe, sewer and storage tank rehabilitation technologies

[1] The application of the pipe scanning method for the enhanced condition assessment of pipes is restricted to grey cast iron pipes with diameters of up to DN 300 (effective 2013). However, in urban water networks, cast iron can be regarded as one of the main pipe materials.

1.2. UWCS Sustainability dimensions, objectives and criteria

The impact assessment of methods and technologies on the UWCS sustainability dimensions is based on the pre-defined TRUST set of criteria grouped to objectives within the five dimensions of social, environmental, economic, governance and assets sustainability [1] (Table 8).

Table 8: Objectives and criteria of the UWCS sustainability dimensions

DIMENSION	OBJECTIVES	ASSESSMENT CRITERIA
Social	S1) Access to urban water services S2) Effectively satisfy the current users' needs and expectations S3) Acceptance and awareness of UWCS	S11) Service coverage S21) Quality of service S22) Safety and health S31) Affordability
Environment	En1) Efficient use of water, energy and materials En2) Minimisation of other environmental impacts	En11) Efficiency in the use of water (including final uses) En12) Efficiency in the use of energy En13) Efficiency in the use of materials En21) Environmental efficiency (resource exploitation and life cycle emissions to water, air and soil)
Economic	Ec1) Ensure economic sustainability of the UWCS	Ec11) Cost recovery and reinvestment in UWCS (incl. cost financing) Ec12) Economic efficiency Ec13) Leverage (degree of indebtedness) Ec14) Willingness to pay
Governance	G1) Public participation G2) Transparency and accountability G3) Clearness, steadiness and measurability of the UWCS policies G4) Alignment of city, corporate and water resources planning	G11) Participation initiatives G21) Availability of information and public disclosure G22) Availability of mechanisms of accountability G31) Clearness, steadiness, ambitiousness and measurability of policies G41) Degree of alignment of city, corporate and water resources planning
Assets	A1) Infrastructure reliability, adequacy and resilience A2) Human capital A3) Information and knowledge management	A11) Adequacy of the rehabilitation rate A12) Reliability and failures A13) Adequate infrastructural capacity A14) Adaptability to changes (e.g. climate change Adaptation) A21) Adequacy of training, capacity building and knowledge transfer A31) Quality of the information and of the knowledge management system

2. IMPACT ASSESSMENT

The implementation of methods and technologies in the planning, operation and maintenance of water, wastewater and storm water systems supports the transition towards sustainable urban water cycle services.

The trust approach on assessing the sustainability of UWCS is defined in [1]. Based on the trust definition of sustainability, the generic impact assessment lists the potential of improving metrics associated to the sustainability dimensions, objectives and criteria without regard on the individual urban structure or individual sustainability objectives of a city. The qualitative impact assessment is not representing absolute and quantitative impacts on the UWCS performance.

The aim is to provide a generic exemplary impact assessment for evaluating the expected potential of interventions to improve the UWCS sustainability in order to assist in individual case-specific evaluations.

The impact assessment in this report provides a generic evaluation which represents the view of the scientific community of TRUST WA 4 (including the work package leaders, associates and the work area deputy leader). The impact assessment method includes a central organisation and the independent and transparent evaluation based on common assessment criteria. The assessment is performed on the basis of a set of impact indicators as defined in Table 9. The weighting factor decision is based on the collaborative evaluation by the experts. To clarify the generic impact assessment methodology, the justification of the impact assessment of two interventions is exemplary shown in chapter 2.2.

Due to the generic character, the assessment should be universally applicable, but, of course, may vary in individual cases. A comparative ranking of technologies based on the generic evaluation (not case-specific) is not recommended, due to possible misguiding effects. However, a comparative ranking can be useful in order to examine which sustainability dimension or criteria are more strongly influenced by intervention options (cf. Chapter 2.3 and Table 20).

It must be noted that a case-specific impact assessment may result in different results, due to different relative importance under different city contexts. Additionally, it serves the one who cannot estimate the impact of urban water technologies and methods.

The impact assessment method handles a wide range of different intervention options including both, generic methods and specific technologies. Regarding intervention options being a tool (desktop method or software), the impact assessment evaluates the advanced indication of hot-spots for improvement, and incorporates the implementation of the steps for improvement in particular into the evaluation (e.g. the software based identification for pipe renewal and the implementation of e.g. maintenance (hard technologies) is incorporated into the impact assessment). Hence, desktop methods, including broadly oriented tools such as software based water losses management or asset management are much more open-ended (if the recommended action is implemented) than specific hard technologies and thus might have broader impacts than specific, limited in scope, and technology orientated hard technologies. In order to clarify the impact assessment methodology, the justification of the impact assessment of a generic method (integrated asset management approach and software: AWARE-P) and a specific method (conventional water losses management) is shown in chapter 2.2.

The complete impact assessment is listed in chapter 2.1.

Table 9: Impact assessment metrics used for the assessment of the qualitative impact intervention options on the sustainability dimensions

TYPE OF IMPACT		SYMBOL	DEFINITION
enablers	enables improvement of sustainability criteria	+++	very high impact on the realisation of objectives
		++	high impact on the realisation of objectives
		+	low impact on the realisation of objectives
no impact	no impact	o	no effects and consequences
barriers	hinders improvement of sustainability criteria	-	slightly hindering realisation of objectives
		--	strongly hindering realisation of objectives
		---	very strongly hindering realisation of objectives
	unknown	?	Impact is not assessable

2.1. Results

Methods and technologies in the field of enhanced water treatment (WP 41)

Table 10: Qualitative impact of WP 41 intervention options on the TRUST sustainability dimensions

DIMENSION	SOCIAL					ENVIRONMENT				ECONOMIC				GOVERNANCE					ASSETS					
Objective	S1	S2		S3		En1			En2	Ec1				G1	G2		G3	G4	A1				A2	A3
Criteria	S11	S21	S22	S31	S32	En11	En12	En13	En21	Ec11	Ec12	Ec13	Ec14	G11	G21	G22	G31	G41	A11	A12	A13	A14	A21	A22
NOM fractionation/Rapid NOM fractionation	0	+	+	0	0	0	0	++	++	++	++	0	+	0	+	0	0	0	0	0	0	+	0	+
BDOC analyses	0	+	++	0	++	0	0	++	++	++	++	0	0	0	+	0	0	0	0	0	0	0	0	++
Full-scale coagulation treatment optimization procedures/Roadmap	0	+	+	0	0	+	++	+++	++	0	+	0	0	0	0	0	0	0	0	0	+	++	0	+
Water treatment optimization	0	++	++	0	+	++	++	+++	++	0	+	0	0	0	+	0	0	0	0	0	++	++	0	+
LCA	0	0	0	0	+	++	++	+++	++	0	0	0	0	0	+	0	0	0	0	0	0	++	0	+

Table 11: Qualitative impact of WP 42 intervention options on the TRUST sustainability dimensions

DIMENSION	SOCIAL					ENVIRONMENT				ECONOMIC				GOVERNANCE					ASSETS					
Objective	S1	S2		S3		En1			En2	Ec1				G1	G2		G3	G4	A1				A2	A3
Criteria	S11	S21	S22	S31	S32	En11	En12	En13	En21	Ec11	Ec12	Ec13	Ec14	G11	G21	G22	G31	G41	A11	A12	A13	A14	A21	A22
Water losses management	0	0	+	0	+++	+++	+++	+	+	+++	+++	0	0	0	+	0	0	+	++	+	+	0	0	+
Efficient household micro-component appliances and fittings	0	0	0	0	0	+++	++	0	+++	0	0	0	0	++	+	0	0	+	0	0	0	0	0	0
Alternative /new water systems	0	0	0	0	0	++	0	0	++	0	+	0	+	+	+	0	0	+	0	0	+	0	0	0
Metering and tariff structures	0	0	0	+	?	++	0	0	0	++	+	+	?	+	+	0	0	0	0	0	0	0	0	++
Soft technologies – e.g. education / media campaigns	0	0	0	0	+	++	0	0	+	0	+	0	+	++	+	0	0	0	0	0	0	0	0	0
Impact assessment tool for UWDM options	0	++	+	0	0	++	+++	++	+++	++	+	++	++	0	0	0	0	+	0	0	+	0	0	+++
PaVLOS stand-alone software	0	+	0	0	0	+++	+++	0	+++	++	+++	0	0	0	0	0	0	+	+	+	+	0	0	+

Table 12: Qualitative impact of WP 43 intervention options on the TRUST sustainability dimensions

DIMENSION	SOCIAL					ENVIRONMENT				ECONOMIC				GOVERNANCE					ASSETS					
Objective	S1	S2		S3		En1			En2	Ec1				G1	G2		G3	G4	A1				A2	A3
Criteria	S11	S21	S22	S31	S32	En11	En12	En13	En21	Ec11	Ec12	Ec13	Ec14	G11	G21	G22	G31	G41	A11	A12	A13	A14	A21	A22
STORM model	0	++	0	0	0	0	+	+	+	++	++	0	0	+	0	0	0	+	0	+	+	+	0	++ +
INFOWORK model	0	++	+	0	+	0	0	0	0	+	0	0	0	0	0	0	0	+	0	0	+	+	0	++
PASTool performance of water and wastewater treatment plants)	0	++	++	0	0	+	++	0	+	0	0	0	0	0	0	0	0	0	0	0	++	+	0	++ +

Methods and technologies in the field of alternative water sources (WP 44)

Table 13: Qualitative impact of WP 44intervention options on the TRUST sustainability dimensions

DIMENSION	SOCIAL					ENVIRONMENT				ECONOMIC				GOVERNANCE					ASSETS					
Objective	S1	S2		S3		En1			En2	Ec1				G1	G2		G3	G4	A1				A2	A3
Criteria	S11	S21	S22	S31	S32	En11	En12	En13	En21	Ec11	Ec12	Ec13	Ec14	G11	G21	G22	G31	G41	A11	A12	A13	A14	A21	A22
Use of treated wastewater	0	+	0	+	0	++	+	0	+	++	0	0	0	+	0	0	0	+	0	0	+	0	0	0
Modelling different reuse roadmaps	0	+	0	0	+	++	0	0	+	0	0	0	0	+	0	0	0	+	0	0	+	0	0	0
Ceramic membranes to reclaim water for urban multi-purposes	0	+	+	0	0	+++	+	+	+	0	0	0	0	+	0	0	0	0	0	0	0	0	0	0
Sea water desalination	0	+	0	0	0	0	0	0	--	-	0	0	0	0	0	0	0	+	0	0	+	0	0	0
brackish water desalination	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	0	0	0
Plant Audit as tool to assess desalination performance	0	0	0	0	0	+	++	+	+	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0

Table 14: Qualitative impact of WP 45 intervention options on the TRUST sustainability dimensions

DIMENSION	SOCIAL					ENVIRONMENT				ECONOMIC				GOVERNANCE					ASSETS					
Objective	S1	S2		S3		En1			En2	Ec1				G1	G2		G3	G4	A1				A2	A3
Criteria	S11	S21	S22	S31	S32	En11	En12	En13	En21	Ec11	Ec12	Ec13	Ec14	G11	G21	G22	G31	G41	A11	A12	A13	A14	A21	A22
Integrated pressure and energy management in water distribution	0	++	+	0	0	0	+++	+	+	0	+	0	0	0	0	0	0	+	0	0	+	++	0	+
Wastewater treatment with P-recovery (as struphite)	0	0	0	0	++	0	0	+++	++	+	+	0	0	0	0	0	0	0	0	0	0	0	0	0
Wastewater treatment with AB-system (Dynafil)	0	0	0	0	0	0	+	0	++	0	+	0	0	0	0	0	0	0	0	0	+	+	0	0
Enhanced sludge digestion	0	0	0	0	0	0	++	+	++	0	+	0	0	0	0	0	0	0	0	0	++	0	0	+
Heat recovery from wastewater effluent	0	0	0	0	+++	0	+++	0	+	0	+	0	0	++	0	0	0	+	0	0	0	0	0	0
Heat and cold recovery from (waste)water (sewer system	0	0	0	0	+++	0	+++	0	+	0	+	0	0	++	0	0	0	+	0	0	0	+	0	0
Micro hydro-generation	0	0	0	0	+++	0	++	0	++	0	+	0	0	+	0	0	0	+	0	0	0	+	0	+

Methods and technologies in the field of enhanced technologies for infrastructure asset management (WP 46)

Table 15: Qualitative impact of WP 46 intervention options on the TRUST sustainability dimensions

DIMENSION	SOCIAL					ENVIRONMENT				ECONOMIC				GOVERNANCE					ASSETS					
Objective	S1	S2		S3		En1			En2	Ec1				G1	G2		G3	G4	A1				A2	A3
Criteria	S11	S21	S22	S31	S32	En11	En12	En13	En21	Ec11	Ec12	Ec13	Ec14	G11	G21	G22	G31	G41	A11	A12	A13	A14	A21	A22
AWARE-P infrastructure asset management approach and software	0	+++	++	+	0	++	++	+	++	+++	+++	+++	++	++	++	+++	++	+++	+++	++	++	+++	+	+++
Mobile software to support asset assessment and repair	0	+	0	0	0	0	0	+	0	0	+	0	0	0	+	+	0	0	+	+	0	0	0	+++
Pipe scanning method for enhanced assessment condition of water pipelines (here pipe scanner BIT)	0	+	0	0	0	+	0	+++	0	+++	+	0	0	0	0	0	0	0	+++	+++	0	0	0	++
Pipe, sewer and storage tank rehabilitation technologies	0	++	++	0	0	+	+	+++	++	+	++	0	+	0	0	0	0	0	+	+	+	0	0	0

2.2. Justification of the impact assessment

The impact assessment method handles generic methods and specific technologies. In order to clarify the impact assessment methodology, the justification of the generic evaluation performed by the trust experts, both a generic method (integrated asset management approach and software: AWARE-P) and a specific method (conventional water losses management) is shown in the following tables.

Water losses management

Conventional water losses management appertains to the group 'urban water demand management'. In this report, the reduction of real losses by water losses management is evaluated. Real losses (leakage) consist of the volume lost through all leaks, bursts, on mains, and of leaks and overflows of service reservoirs. Real losses also include leakage of service connections up to the point of customer metering [6]. Water losses management contains water balancing, pressure management, use of leakage detection and localisation devices, and priority based maintenance repairs.

Table 16: Comments on the impact assessment of the implementation of water losses management on the sustainability criteria

DIMENSION	OBJECTIVE	CRITERION	CRITERION NAME	IMPACT	COMMENT
SOCIAL	S1	S11)	Service Coverage	0	Water balancing and pressure management do not effect e.g. percentage of households being supplied
	S2	S21)	Service Quality	0	Water balancing and pressure management do not effect e.g. service interruptions
		S22	Safety and Health	+	In case of high water losses, as a secondary effect, a pressure management can reduce intrusion of contaminants through leaks.
	S3	S31)	Affordability	0	Water losses management is supposed not to influence water charges/prices
		S32)	Acceptance	+++	Water losses management will be well accepted, especially in water scarcity regions
ENVIRON MENT	En1	En11)	Efficiency in the use of water	+++	Water loss reduction activities reduce real losses and thus positively influences the efficiency in the use of water
		En12)	Efficiency in the use of energy	+++	As a secondary effect, the efficiency in the use of energy for water distribution is improved
		En13)	Efficiency in the use of materials	+	In case of high water losses, the reduction of water losses leads to decreasing use of chemical (less water to be treated, smaller pipe diameters etc.)

	En2	En21)	Environmental efficiency	+	The potential environmental impacts related to water loss reduction are rather covered by energy efficiency and water use efficiency. However, a secondary effect through reduction of energy and materials might be identifiable
ECONOMIC	Ec1	Ec11)	Cost recovery and reinvestment	+++	Reinvestment rates will rise due to earlier infrastructure renewals
		Ec12)	Economic efficiency	+++	The reduction of water losses increases the volume of sold water. The efficiency of the use of energy for treatment and distribution is improved resulting in optimised energy costs
		Ec13)	Leverage (degree of indebtedness)	0	Impacts on the dept service coverage ratio are not directly assessable
		Ec14)	Willingness to pay	0	Impacts on e.g. billing complaints are not assessable
GOVERNANCE[2]	G1	G11)	Participation initiatives	0	Water losses management is not supposed to be encouraging for public participation initiatives.
	G2	G21)	Availability of information and public disclosure	+	As a secondary effect, the availability of information on real and apparent water losses is given through water losses management. Anyhow, the method does not influence if the information will be published.
		G22)	Availability of mechanisms of accountability	0	Technologies and management options don't effect mechanisms of accountability such as transparency e.g. citizen's access to information. In general, the accountability of governments to public bodies is not effected.
	G3	G31)	Clearness, steadiness and measurability of policies	0	Impacts on e.g. billing complaints are not assessable.
	G4	G41)	Degree of alignment of city... planning	+	As a secondary effect and in case of high leakage reduction rates, the alignment of corporate and water resources planning might be improved.
ASSETS	A1	A11)	Adequacy of the rehabilitation rate	++	The rehabilitation rate directly depends on the failure rate and the water losses rate.
		A12)	Reliability and failures	+	The infrastructure leakage index will be improved as well as the mains rehabilitation rate and, due to pressure management, failure rates might decrease.
		A13)	Adequacy of infrastructural capacity	+	Water losses management might provide reliable data concerning water balance and hydraulic conditions. These data are required for assessing the infrastructural capacity building the base for improving A13.
		A14)	Adaptability to changes	0	Water losses management uses the flexibility (alternative operation) of water networks, however, the flexibility and the adaptability won't be improved.
	A2	A21)	Adequacy of training [...]	0	Water losses management has no influence on e.g. training and capacity-building activities in utilities.
	A3	A31)	Quality of information [...]	+	Water losses management improves the collection of information and delivers methods for data analysis and evaluation.

[2] In general, administration acts cannot be affected by urban water technologies and management options. Hence, the potential of intervention options for providing information that might be relevant for participation initiatives, public disclosure and for city, corporate and water resources planning is assessed.

AWARE-P approach and software

AWARE-P appertains to the group 'Enhanced technologies for infrastructure asset management'. It consists of a broadly applicable tool box including a data manager, which allows for an easy data import, export and editing; a 3D network visualizer that can read and use existing GIS information, an water distribution hydraulic model, a failure analysis and forecast tool, a tool for assessing component importance of pressurized networks, a risk assessment tool that combines failure probability and component importance, a performance indicators tool, which offers the main PI libraries within the sector (e.g. the IWA PI libraries), a tool that assesses the net present value (NPV), the payback period and the internal rate of return (IRR) of a financial project, a tool that assesses the infrastructure value index (IVI) of a given infrastructure, and a tool – the most integrative one - that allows to compare multiple intervention alternatives, in a long term perspective, taking based on the objectives, assessment criteria and assessment metrics and targets defined by the users. It thus has the potential to improve a wide range of sustainability criteria.

Table 17: Comments on the impact assessment of the implementation of AWARE-P on the sustainability criteria

DIMENSION	OBJECTIVE	CRITERION	CRITERION NAME	IMPACT	COMMENT
SOCIAL	S1	S11)	Service Coverage	0	Being directed to the service provided and to the management of the infrastructures supporting it, does not have a direct impact on the non-served population.
	S2	S21)	Service Quality	+++	It is oriented by the service objectives established. Contains tools to assess the quality of service (PI and PX tools) and to compare the best intervention options that better serve the users (PLAN).
		S22	Safety and Health	++	If safety and health objectives, assessment criteria and metrics are taken on board, the use of AWARE-P will allows to take them into account in the decisions.
	S3	S31)	Affordability	+	AWARE-P may have a marginal impact on this criterion because it allows to compare and rank alternative interventions based on this criteria.
		S32)	Acceptance	0	Although AWARE-P can accommodate this criterion, and acceptance metrics can be defined, the current version of the existing PI libraries and the other existing tools do not specifically cover this aspect.
ENVIRONMENT	En1	En11)	Efficiency in the use of water	++	AWARE-P PI tool contains several indicators related to the efficiency in the use of water. The network analysis and PLAN can be used to prioritise intervention options that contribute to a better efficiency.

		En12)	Efficiency in the use of energy	++	AWARE-P PI tool contains several indicators related to the efficiency in the use of energy. The network analysis and PLAN can be used to prioritise intervention options that contribute to a better efficiency.
		En13)	Efficiency in the use of materials	+	Although this aspect is not so well covered by the existing PI libraries, the users can easily include metrics that quantify this criterion and compare intervention solutions using them.
	En2	En21)	Environmental efficiency	++	AWARE-P PI tool contains several indicators relevant to assess environmental efficiency. If the appropriate metrics are chosen, PLAN allows to rank the best intervention alternatives from this point of view.
ECONOMIC	Ec1	Ec11)	Cost recovery and reinvestment	+++	AWARE-P contains tools to assess the economic efficiency (PI tool and IVI) and the long term financial performance of investments (Financial project). PLAN tool allows to rank and select intervention options taking into account economic and financial metrics in parallel with service performance and risk metrics.
		Ec12)	Economic efficiency	+++	Cf. Ec11)
		Ec13)	Leverage (degree of indebtedness)	+++	AWARE is basically a planning tool, promoting a balance between performance (efficiency and effectiveness), risk and costs in the short, medium and long term. Increasing levels of indebtedness are mostly a consequence of unbalances between revenues, costs, and effectiveness of the investments in terms of the quality of the service. A sound planning is a key pillar of leverage.
		Ec14)	Willingness to pay	++	AWARE-P is easily usable as a communication tool with non-technical people (e.g., elected politicians and population at broad). It is therefore an adequate means to explain the relationships between certain levels of costs and the corresponding quality of service, contributing to a better acceptance of change and willingness to pay.
GOVERNANCE	G1	G11)	Participation initiatives	++	Being an effective means of communication. AWARE-P can be a facilitator in participation initiatives.
	G2	G21)	Availability of information and public disclosure	++	AWARE-P provides transparency and accountability to the entire decision process when comparing and choosing alternatives. The results of several of its tools are appropriate to make information available to public. PLAN and PI tool are at the top of them.
		G22)	Availability of mechanisms of accountability	+++	The AWARE-P provides transparency and accountability to the whole decision-making process. The objectives, assessment criteria, metrics, targets and weights of each metric are documented. The options analysed are ranked. The user is free to make decisions not consistent with the proposed ranking, but it is required to record the decision and its justification.
	G3	G31)	Clearness, steadiness and measurability of policies	++	Cf G22)

	G4	G41)	Degree of alignment of city... planning	+++	Key aspects of Aware are to provide a common communication means among stakeholders (via the 3D Cube of AWARE-P Plan) and to promote the use of the same (or at least, aligned and consistent) objectives, assessment criteria and metrics across all decision levels, inside the organisation and between the organization and other city stakeholders, particularly city planners.
ASSETS	A1	A11)	Adequacy of the rehabilitation rate	+++	The rehabilitation performance indicators of the PI tool, the IVI. The Fail and Financial Project provide the means to assess and analyse the adequacy of the rehabilitation rate. Plan assists selecting the best rehabilitation options.
		A12)	Reliability and failures	++	The AWARE-P FAIL tool allows to analyse failure records and forecast failure probability of pipes and sewers.
		A13)	Adequacy of infrastructural capacity	++	Among the multiple AWARE-P tools that may be used to assess the adequacy of the infrastructure to the service objectives, the water network simulator is particularly suitable.
		A14)	Adaptability to changes	+++	By the use of objective oriented standardised metrics, very different intervention options can be analysed, assessed and ranked for multiple scenarios (e.g. of climate change) within the AWARE-P environment. This allows the user to consider several transition paths and assess how effective, flexible and resilient they may be for the multiple likely scenarios.
	A2	A21)	Adequacy of training [...]	+	AWARE is adequate for training and may contribute for training efficiency and adequacy, but does not affect directly the actual adequacy of training in the organisations
	A3	A31)	Quality of information [...]	+++	AWARE-P provides a data management environment where most types of information may coexist (e.g. GIS shape files, text files, AWARE tool specific files, support documentation, etc.). This is an enabler for an effective information management. The PI tool requires an accurate definition of the performance indicators selected, and recommends the specification of quality assessment criteria. The whole AWARE-P approach allows to identify the key information needed to support the decisions to be made, and leverages the users to improve the quality control of these data items.

2.3. Impact evaluation of interventions options

The generic evaluation provides an overview for stakeholders involved in the planning, operation and maintenance of UWCS and also at the administrative level e.g. the city planning level, and serves as basis for discussion regarding the implementation of urban water methods and technologies as well as performing a case-specific evaluation.

The common assessment criteria and the scoring system assist experts who assess the qualitative impact of individual technologies/methods case-specifically for a given city. Then, the application of a case-specific weighting adjustment is recommended. It is highly recommended to integrate the scientific community into these case-specific evaluations. The generic evaluation serves as template, thus an intervention option may be scored low for improvement of UWCS performance (e.g. desalination of sea water, because of hindering environmental efficiency), but scoring can be higher if case-specific regional pressures or development needs are involved into the assessment (e.g. sea water as the only available alternative water source near the city).

Generic evaluation

The ranking system is based on the highest potential for improving metrics associated to different sustainability dimensions, objectives and criteria without regard on the individual urban structure or individual sustainability objectives of a city. The comparative ranking can be useful in order to examine which sustainability dimension are more strongly influenced by the intervention options covered within WA 4.

Table 18: Ranking system and scoring of assessed impacts

SYMBOL	SCORE
+++	3
++	2
+	1
o	0
-	-1
--	-2
---	-3
?	-

The rank for improvement at the level of sustainability dimensions is calculated by summation of all criteria scores associated to the dimension as shown in the following example (Table 19). In this example, the environmental dimension is expected to be most strongly influenced by the evaluated technique.

Table 19: Impact ranking system: Exemplary calculation of scores for a single technology

DIMENSION	SOCIAL					ENVIRONMENT				ECONOMIC			
Objective	S1	S2		S3		En1		En2		Ec1			
Criteria	S11	S21	S22	S31	S32	En11	En12	En13	En21	Ec1	Ec2	Ec3	Ec3
Impact	0	0	+	0	+++	+++	+++	+	+	+++	+++	0	0
Score	0	0	1	0	3	3	3	1	1	3	3	0	0
Total score dimension	4					8				6			
Rank	3					1				2			

The generic impact assessment evaluates the degree of influence of WA 4 intervention options (urban water technologies and methods) on the sustainability dimensions. The ranking in order of the scoring for positive influence the five sustainability dimensions indicates that the metrics associated to the environmental dimension are influenced most strongly (Table 20). This outlines the targeted effects of the technologies and methods developed or examined within WA 4. Regarding the technical orientation of the assessed WA4 intervention options, it was expected that the social and governance aspects are scored lower than environmental, economic and assets dimensions.

Table 20: Ranking of sustainability dimensions in order of the positive influence (improvement) by intervention options covered within WA 4

RANK	SUSTAINABILITY DIMENSION
1	ENVIRONMENT
2	ECONOMIC
3	ASSETS
4	SOCIAL
5	GOVERNANCE

Additionally, the ranking the level of the criteria is regarded and shown in Table 21.

Table 21: Ranking of sustainability criteria in order of the scoring for positive influence (improvement) by intervention options covered within WA 4

RANKING	SUSTAINABILITY CRITERIA
1	En12) Efficiency in the use of energy
1	En21) Environmental efficiency
2	En11) Efficiency in the use of water (incl. final uses)
3	A31) Quality of information
4	Ec12) Economic efficiency
5	En13) Efficiency in the use of materials
6	S21) Quality of service
7	Ec11) Cost recovery and reinvestment
8	A13) Adequacy of infrastructural capacity
9	S32) Acceptance
10	G41) Degree of alignment of city, corporate and water resources planning
11	A14) Adaptability to changes
12	S22) Safety and health
12	G11) Participation initiatives
13	G21) Availability of information and public disclosure
14	A11) Adequacy of the rehabilitation rate
15	A12) Reliability and failures
16	Ec14) Willingness to pay
17	G22) Availability of mechanisms of accountability
18	S31) Affordability
18	Ec13) Leverage (degree of indebtedness)
19	G31) Clearness, steadiness and measurability of policies
20	A21) Adequacy of training...
21	S11) Service coverage

Exemplary case-specific evaluation

A comparative ranking of methods and technologies based on a case-specific evaluation is a useful initial method in order to plan decisions regarding setting focusses of improvements.

A hypothetical case of a high developed but aged urban water cycle system was regarded exemplary in order to provide the ranking of intervention options based on the potential for improvement of the environmental sustainability dimension (Table 22).

Table 22: Ranking of intervention options based on the potential for improvement of the environmental sustainability dimension

RANK	INTERVENTION OPTIONS FOR IMPROVEMENT OF THE ENVIRONMENT DIMENSION[3]		
1	Impact assessment tool for WDM interventions		
2	Water treatment optimization	LCA	PaVLOS
3	Full-scale coagulation treatment optimization procedures	Efficient household micro-component appliances and fittings	
4	AWARE-P	Pipe, sewer and storage tank rehabilitation technologies	
5	Water losses management	Ceramic membranes to reclaim water for urban multi-purposes	

The best ranked intervention option is the TRUST tool, assessing the impact of different combinations of WDM interventions with respect to their cost, water-related energy use and impact on supply/demand balance of water distribution systems. It appertains to the group 'Urban water demand management (UWDM)'.

This case-specific evaluation and listing of intervention options with regard of improvement of dimensions, objectives or criteria is suitable for linkage to the TRUST Self-Assessment-Tool developed in WA 3 [1]. If the sustainability assessment indicates poor scores for a dimension, objective or criterion, the suitable WA4 intervention options can be listed to be analysed in the DSS.

[3] The impact assessment method is an MS Excel® based tool which allows individual case-specific evaluations. The scoring system automatically evaluates the impacts and provides ranking lists. The prioritisation of intervention options is available for every sustainability dimension, objective and criteria. In this document Table 46 shows exemplarily the prioritsation for improvement of the environmental sustainability.

3. CONCLUSION

The provided generic exemplary impact assessment for evaluating the expected potential of interventions to improve the UWCS sustainability assists in individual case-specific evaluations. The impact assessment method including the MS Excel® based tool which was developed within Task 52.1, consists a scoring system providing a ranking list of evaluated intervention options. In this report, urban water technologies and methods are evaluated. However, the method is applicable for the impact assessment of other intervention options, such as political instruments (e.g. administrative reorganisation, incentives, public participation initiatives, integrated planning). Further, tools being available in the future (to be developed in the trust project) can be included into the impact assessment system and individually evaluated. The resulting comparative ranking of assessed intervention options (techniques, methods or political instruments etc.) based on case-specific evaluations is suitable for the prioritisation of intervention options with the aim of targeted improvement of sustainability criteria. The case-specific ranking is suitable for linkage to the TRUST Self-Assessment-Tool developed in WA 3 [1].

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5. ANNEX

AWARE-P / TRUST software platform

Software overview

The AWARE-P IAM planning software offers a non-intrusive, web-based, collaborative integration environment for all data and processes that may be relevant to the IAM decision-making process, including maps, GIS layers (shapefiles) and geographical data; inventory records; work orders, maintenance, inspections/CCTV records; network models, performance indicators, asset valuation records, among others.

The software provides an organized framework for evaluating and comparing planning alternatives or competing IAM solutions, through selected performance, risk and cost metrics. It comprises a portfolio of system metrics and network analysis tools that may equally be used individually for diagnosis and sensitivity gain.

From a technology viewpoint, the software is deployed as a web-based application that may be run from public or private servers, as well as on an individual machine as a stand-alone deployment. It materializes as an integrated and expandable suite of plug-in tools made available on the Baseform™ development platform (baseform.org), taking advantage of its user management, common data integration services, GIS information management and advanced 2D/3D visualization capabilities (Figure 1). It is open-source, Java-based and runs on all operating systems that support Java, such as Windows, Mac OS X or Linux, as well as on mobile systems such as iOS or Android.

AWARE-P has the capability to bring to a single environment a large variety of IAM-decision making data, and take advantage of them around two main usage modes:

1. as a portfolio of assessment-oriented models and analysis tools, used individually or in combination for diagnosis and sensitivity gain to a system; or
2. following the AWARE-P IAM planning procedure, oriented to the definition of a planning framework (time horizon, metrics, alternatives) and to feeding the PLAN tool with metrics issued from the tools available or sourced externally.

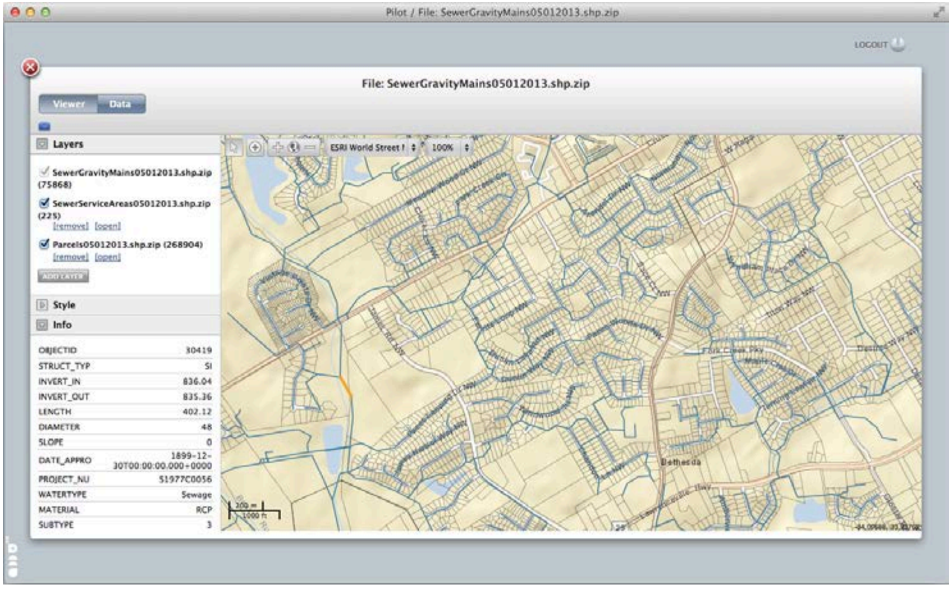

Figure 1. The GIS viewer and geographical data browser

The PLAN decision-making environment

PLAN embodies the central planning framework, where planning alternatives or competing solutions are measured up and compared through selected performance, risk and cost metrics, through interactive numerical 2D/3D graphical information display.

The tool is based on the three main axes that characterize the assessment and comparison exercise: a set of alternatives, a set of standardized metrics and a given time frame. The latter comprehends a number of user-specified time steps and may include both a planning horizon (i.e., the time frame of the intervention) and an analysis horizon (a longer time frame for impact assessment).

The metrics selected by the user, which may come from the performance, risk and cost assessment tools present in the AWARE-P portfolio or from external evaluations as selected by the user, are standardized as numerical indices and then categorized as color-coded levels, with an emphasis on coherent definition by the user of the target category values.

The NETWORKS network-level integrated environment

NETWORKS is the second integration environment present in the software, and operates at the network level (Figure 1). A physical description of the infrastructure is provided along with 2D and 3D visualization, based on either a network model or layered geodatabase (GIS) maps. The NETWORKS environment allows the expression of component-based analysis results such as failure analysis, component importance, performance indices or hydraulic simulation to be concurrently expressed on the same 2D/3D visualization.

The portfolio of analysis tools

The software makes available a coherent set of user-configurable assessment algorithms or models related to performance, cost and risk, which are used to evaluate user-defined alternative system configurations or planning solutions, following the AWARE-P methodology. Based on given planning objectives and measuring criteria, the user selects a set of metrics from the software's available metrics portfolio and proceeds to evaluate each planning alternative at the selected time frames within the planning and analysis horizons, feeding a 3-dimensional space of planning results.

The software's tools are also ready to be used in stand-alone, direct assessment mode for the fastest possible path to results (or in the context of general-purpose sensitivity gain and system diagnosis). Examples of such uses may be a PI calculation (AWARE-P includes a full-fledged performance indicators tool with the most up-to-date PI libraries), an analysis of failures rates (Poisson and LEYP models are available), or an investigation of network component importance (as a measure of consequence of failure). The tools have been specifically developed to make the available methods and analysis algorithms accessible for effective industry usage, striving to retain a maximum of simplicity in delivering useable results.

The tools plug into the integrated environment, with the current range comprising:

PI – Performance Indicators, quantitative assessment of the efficiency or effectiveness of a system through the calculation of performance indicators based on state-of-the-art, standardized PI libraries as well as user-developed or customized ones.

PX – Performance Indices, technical performance metrics based on the values of certain features or state variables of water supply and waste/stormwater networks. The indices measure performance concepts related to level-of-service, network effectiveness and efficiency.

FAIL – using models such as Poisson and LEYP, prediction of future pipe or sewer failures for a given network, e.g. in the context of estimating risk or cost metrics, based on an organized failure history in the form of work orders and pipe data.

CIMP – calculates a reduced-service component importance metric for each individual pipe in a water supply network, based on the impact of its failure on effective consumption. The metric is computed based on the network's hydraulic model, using full simulation capabilities.

UNMET – calculates a service interruption risk metric expressed as the expected volume of unmet demand (reduced service) in a water supply system over one year, given the expected number of outages for each pipe, the average downtime per pipe outage, and the importance of each pipe.

IVI – Infrastructure Value Index, representing the ageing degree of an infrastructure, calculated through the ratio between the current value and the replacement value of the infrastructure.

FIN – Financial project planning tool with the capability to project investments, costs and revenues over a user-defined period of time and calculate NPV and IRR.

EPANETJAVA – an efficient, Java-implemented EPANET simulation engine and natively integrated MSX library, for full-range water supply network simulation, available in the NETWORKS environment and taking advantage of its 2D / 3D network and results visualization.

The tools marked with an asterisk are currently only for water supply networks at the current the initial portfolio of AWARE-P. The remaining tools are equally applicable to water supply and wastewater/storm water infrastructures.

Summary of methods, rules and criteria to be incorporated into the DSS
D 52.1

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 265122.