Sustainable Hydro Assessment and Groundwater Recharge Projects (SHARP)

<u>SHARP MANUAL</u>

Good Practices and Adaptations

Editors:

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WATERPOOL Competence Network GmbH

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1 Introduction

1.1 Scope and aims of SHARP

The overall objective of SHARP is to save and protect existing water resources for future generations. To achieve that goal project partners from seven different European countries exchange and develop promising and innovative technologies in the frame of sustainable groundwater management and risk prevention of water supplies which will improve future decisions and actions at the local/regional level. This scope of SHARP supports the conservation, improvement and sustainable availability of groundwater resources – essential for human beings, animals and plants.

The SHARP project deals in general with innovative tools, methodologies and technologies to enhance the quantity and quality of existing groundwater resources, to protect and save them for future use. Therefore SHARP helps to solve the existing conflict on groundwater reserves between drinking water supply and the water supply for irrigation or industrial use. In that context, all project partners share their knowledge in the area of general groundwater management and transfer their experiences. The close cooperation between project partners coming from European regions with different climate, geological and geographical conditions assures the development of new approaches and innovative solutions of the common problems.

The wide topic of general groundwater management tools is completed by six specified areas of work that represent the key contents of SHARP. These areas include:

- artificial groundwater recharge technologies,
- groundwater monitoring systems,
- strategic use of groundwater resources,
- techniques to save water quality and quantity,
- drinking water safety plans including risk management tools and
- water balance models.

The mutual exchange of know-how will be supported by project partners (PPs) discussing, evaluating and elaborating the individual conditions for the implementation and improvement of groundwater management technologies within their own regions and by study visits where project partners get practically informed on site about realised pilot projects in groundwater management practices.

Moreover, project partners will develop technology transformation, based on the identification and analysis of good practices, and its necessary adjustment considering diverse conditions. Thus, the planned SHARP results comprise the exchange of innovative technologies and improvement of policy making concerning groundwater management aspects to preserve and improve water quality and quantity.

Tab. 1: The following entities are SHARP project partners (PPs).

PPs	Name	Abbr.
LP	WATERPOOL Competence Network GmbH, Graz, AT	WP
PP 2	Region of Western Macedonia, Kozani, GR	RWM
PP 3	Region of North Aegean, Mytilene, GR	RNA
PP 4	Regional Agency for Rural Development of Friuli Venezia Giulia, Gorizia, IT	ERSA
PP 5	Local Councils' Association, Balzan, MT	LCA
PP 6	Institute of Meteorology and Water Management, Wroclaw, PL	IMGW
PP 7	International Resources and Recycling Institute, Edinburgh, GB	IRRI
PP 8	Saxon State Office for the Environment, Agriculture and Geology, Dresden, DE	LfULG
PP 9	Holding Graz GmbH – Services, Graz, AT	HG

1.2 Methodological approach in SHARP

In following paragraphs an overview of the methodological approach of SHARP is given. SHARP runs throughout the INTERREG IVC program as a Regional Initiative Project under the priority 2 "Environment and risk prevention". SHARP project duration is from January 2010 until the end of December 2012.

Seven main actions are done within SHARP to ensure the attainment of goals:

1. Well experienced and less experienced European partner regions with different climate, geological and geographical conditions are brought together in SHARP. Their specific knowledge supports European groundwater-resources-management actions based on innovative technologies applied in different European regions.

2. During the 1st transnational seminar project partners present their specific experiences in the frame of the issues tackled (based on specific regional conditions) and the demand for problem solving methodologies on groundwater-resources management for drinking water, irrigation and industrial use. During the 2nd transnational seminar project partners collect, discuss and assess existing pilot projects, practical experiences, methods and techniques in the frame of the identified demands within the SHARP partnership. The 3rd transnational seminar systematically aggregates and process selected good practices and techniques as well as prepares/develops relevant innovative methods and techniques to ensure the sustainable use of groundwater reserves considering different regional and national premises.
3. The innovative realised pilot projects on sustainable groundwater management and monitoring of groundwater resources are examined via study visits (show-how to know-how). The theoretical elaborations during the transnational seminars are demonstrated on site (concrete implementation) and discussed in situ.
4. Finally the gained and aggregated know-how and experience are presented to a wider audience in the course of two SHARP International Conferences and published in this SHARP Manual.
5. To support the generation and expansion of SHARP know-how, all information is administered in the SHARP Knowledge Management System (KMS) and its results are published on the SHARP website. Interim results on methods, examples, techniques etc. are published in specific newsletters.
6. The necessary intensive communication between project partners as well as the dissemination of outputs/results are supported by direct partner meetings (seminars, study visits, conferences), by VoIP conferences and by the communication tool of the KMS (knowledge management system within the website of SHARP).
7. To ensure a sound project monitoring and controlling, four Steering Group Meetings take place.

The INTERREG IVC program divides each project in different Components in which working topics are defined. C1 stands for Component 1 “management and coordination”, C2 for Component 2 “Communication and dissemination” and C3 for Component 3 “Exchange of experiences dedicated to identification of analyses and good practices”. C3 comprises the exchange of experience between project partners (e.g. project partners’ presentation of specific know-how expert discussion on the application of innovative technologies in different project partners’ regions, existing studies, selected good practices, interim and final reports, recommendations etc.). While C1 is dedicated to management and coordination activities in order to monitor the project's overall performance, C2 covers the communication and dissemination (internal and external) of outputs generated in C3.

1.3 SHARP key contents

Several key contents build the core of SHARP. Concerning to the planned goals of the project following activities are handled throughout the project implementation:

- The exchange of experience is carried out in three transnational SHARP-Seminars, where the partner's staffs – experts and responsible persons –present, declare, discuss and disseminate existing experiences on the one hand and define current and expected future problems/demands on groundwater resource management on the other hand. Each partner sends staff members to the seminars to support the exchange of experience in face to face sessions.
- A total of two Study Visits of already implemented innovative pilot-projects take place.
- The SHARP know-how pool (gathered and generated specific SHARP know-how) is presented by the project partners in two International Conferences.
- The exchange of experience is additionally supported by the SHARP Virtual Information Centre (VIC) consisting of the SHARP Website and Knowledge Management System. A SHARP DVD about the highlights of the SHARP events is published. 17 good practices are identified, adapted and distributed through the SHARP Manual and two International Conferences. To disseminate and communicate SHARP`s results/outputs to a wider selected audience, a total of five SHARP press conferences are hold (including press releases and SHARP Newsletters distribution).
- Steering Group Meetings in order to monitor the general progress and activity and financial related performance of the operation are hold and specific reports are produced.

Regarding to these key contents SHARP leads to below mentioned results:

1. Experts with increased capacity on groundwater management concerning different climate, geographical and geological areas.
2. 17 successfully transferred good practices which will lead to direct improvements of regional/local policies and strategies concerning groundwater resources.
3. More sensitivity/awareness on climate change related problems created.
4. 15 improvements/adaptations of existing technologies due to enlarged know-how.

5. Installation of a sustainable groundwater expert net within different European areas.
6. Direct contacts with key players (administrative decision makers at local/regional/national/European level, water suppliers, media).
7. Direct know-how enlargement on groundwater management systems due to SHARP Study Visits, links to existing water networks and water suppliers to ensure a systematic dissemination between European experts.

2 Partner competences and needs

2.1 Project partner description, competences and needs

To facilitate an effective work flow, each project partner first describes his present know-how (competences, expertise) and already implemented procedures or technologies as well as his current and/or likely future problems and demands (e.g. needs for know-how, innovative tools) within the SHARP key contents. Every project partner contributes accordingly to the overall achievement of the project goals.

15 examples of existing good practices on groundwater management were planned throughout the proposal of the project, due to the importance of several topics 17 are defined and selected from the project partners' competence and needs. In this process, also less experienced project partners try to come up with an example from their region or area of activities. On the other hand, also the more experienced project partners think about possible applications of upgraded good practices of groundwater management within their environment.

2.1.1 WATERPOOL Competence Network GmbH

WATERPOOL Competence Network GmbH was established in December 2003 and today this Competence Network is one of Central Europe's competence centres in water management for artificial groundwater enrichment, valley and basin systems, sustained water supply in mountain areas, water and health, water in underground mining and power station construction, net product chain management of water resource utilisation of groundwater for agriculture and industry. The Competence Network's staff consists of highly experienced experts and scientists in the fields tackled by the SHARP co-operation.

WATERPOOL is highly interested in the expertise within the SHARP partnership as well as in the analysis of existing innovative technologies and strategies in view of an application in different geographical and geological European areas. Furthermore WATERPOOL is interested in receiving feedback on currently applied technologies in saving, storing, improving and enriching groundwater reservoirs.

Acting as an advisor on European, national and regional level, WATERPOOL Competence Network GmbH is highly interested in innovative groundwater management technology and its practical realisation potential aiming at the sustainment of essential groundwater resources for future generations.

2.1.2 Region of Western Macedonia

Specific problems:

- Water pollution from agricultural activities (eutrophication of lakes).
- Pollution created by lignite exploitation.
- Sarigkiol aquifer is pumped to ensure drainage in the open pit.

Competences/Experiences:

- Production of GIS-based vulnerability maps to support the spatial development planning process.
- Integrated water resource management in agriculture based on the optimization of water consumptions and cutback of groundwater pollution.

2.1.3 Region of North Aegean

Due to the climate change, the islands of the Region of North Aegean are facing serious water shortages, especially during the spring and summer months. The SHARP project provides the needed robust know-how for managing effectively underground water reservoirs and facing the high demand for drinking water during high-tourism season. Various studies conducted by IGME have indicated that the drinking water reservoirs of Lesbos, Samos, and Chios have been depleted and are at great risk. The protection of underground water resources is supported by both regions and national strategic plans. SHARP will assist regional experts in determining water demand and supply patterns in order to plan water management more effectively.

Main problems of the Region are:

- Water scarcity.
- Aquifer salinization.

Competences:

- Web GIS based decision making tools.
- Environmental education and awareness tools.

Needs:

- Knowhow on Aquifer recharge techniques.
- Water balance models for monitoring and management of groundwater.

2.1.4 Regional Agency for Rural Development of Friuli Venezia Giulia

- Needs and demands on groundwater management aspects refer to present water demand for different uses.
- Activities focus on agricultural use of water
  - Crop response to different irrigation patterns.
  - Water deficit estimation in agriculture; optimization of water use.
  - Water balance models development.
  - Regional code of good agricultural practice (soil attenuation capacity map).
- Future problems will concern the need of a better allocation and use of water resource for drinking, agricultural and industrial use
  - An overall regional plan for water utilization should be done.
  - Some changes in water utilization in agriculture are desirable.
  - Using simulation models could help to draw different scenarios and choose best practices for local situation.

2.1.5 Local Councils' Association

The project is highly relevant to the Maltese localities in the outer management system and there is a high level of interest at all levels of local and specialized organizations to be able to develop pilot projects based on best practices from neighbouring countries. Malta suffers of a shortage of water and such shortage led to the damaging of water tables. There is a need to recharge these water tables and the Association will prepare a series of best practices that will be then followed by the national government.

The Local Councils’ Association will develop:

- Best practices;
- Make expert work on the projects;
- Publicity.

2.1.6 Institute of Meteorology and Water Management

- Optimization of post-mining reclamation plans to stabilize groundwater resources and water balance have been done to meet both the environmental needs and the users of ground- and surface water supplies.
  - Identification and verification of the surface and groundwater users' needs.
  - Analysis of long-term variation of groundwater levels.
  - Groundwater modelling (to examine variants and show impacts).
- Demands:
  - Monitoring of the stabilization and reconstruction of groundwater resources.
  - Decision Support System in the groundwater resources management.

2.1.7 International Resources and Recycling Institute

- Purpose-designed geological software GSI3D which uses a digital terrain model, digital records of geological surface outcrops and downhole coded borehole data.
- BGS's in-house family of groundwater modelling codes, ZOOM (including ZOODRM distributed recharge model and ZOOMQ3D saturated groundwater flow model).

2.1.8 Saxon State Office for the Environment, Agriculture and Geology

- Focus on quantitative and qualitative aspects of groundwater management
  - Questions about quality control and transferability of water balance models.
  - Groundwater monitoring networks for mining are operated and evaluated in a long-term German-Polish co-operation.
  - LandCaRe-DSS investigates effects of regional climate change projections and weather extremes on agriculture, water supply and material fluxes.
- Interest in transnational know-how exchange on the evaluation of groundwater stocks with water balance models and groundwater monitoring systems.

2.1.9 Holding Graz GmbH – Services

Holding Graz is well experienced in the operation, maintenance and monitoring of groundwater resources for more than 40 years. Within the Competence Network of Styria, several specific studies were carried out in this field. It is the Holding Graz which tests and implements innovative groundwater technologies, developed by JOANNEUM RESEARCH Forschungsgesellschaft mbH.

Holding Graz is highly interested in projects able to enhance in-house expert knowledge as a basis for future knowledge transfer. Furthermore the Holding Graz is a highly renowned expert in the field of hydrology, geology, the determination of groundwater reserves and public drinking water management. It has great expertise in monitoring (measuring the quality indicators, evaluation and classification of the groundwater body) as well as in the sustainable protection of water reserves and in the innovative technique of artificial groundwater enrichment. Holding Graz has practical experience in monitoring the water protection and in risk prevention concepts.

Holding Graz is interested in the exchange of experience, gaining feedback on the currently applied technologies in order to carry out possible improvements and to anticipate aspects of climate change.

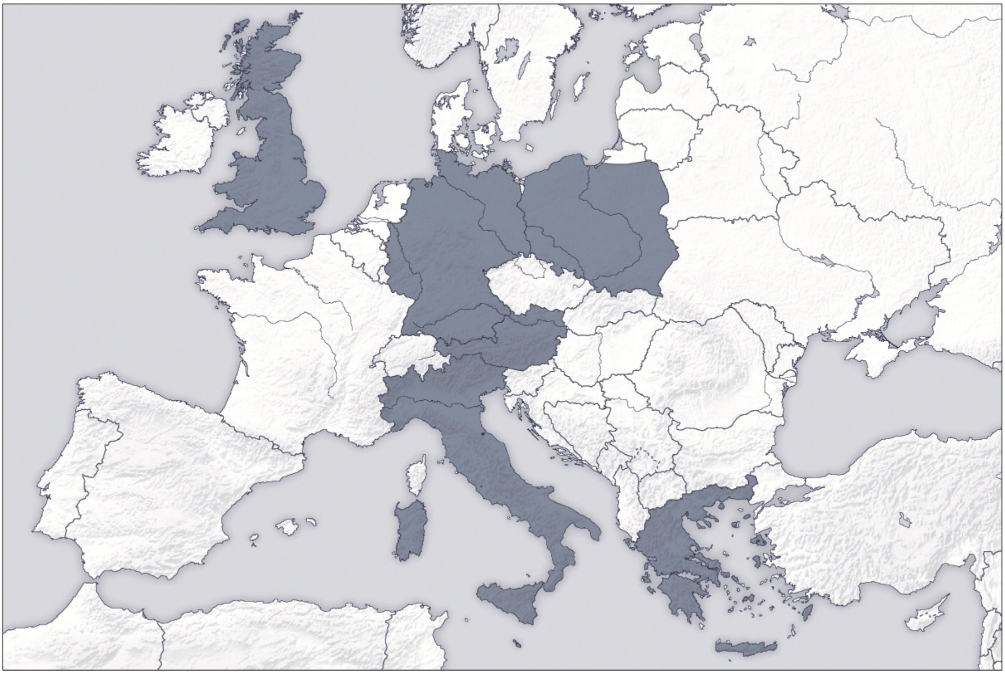

Fig. 1: SHARP – Participating countries.

2.2 List of existing good practices

Based on all project partners' competences and needs the following list of existing good practices was adopted containing 17 examples (see Tab. 2). The dissemination of good practices/innovative technologies among the partnership is one main goal of the project.

Tab. 2: List of existing good practices of SHARP project partners (PPs).

No.	Title	PP
1	GIS vulnerability maps	RWM
2	Tools for water management plans	RWM
3	Binomial fee estimation for a rational use of water in agriculture	ERSA
4	Web tool to disseminate agricultural best practices codes	ERSA
5	Water Framework Directive Guidelines	ERSA
6	Vulnerability maps	ERSA
7	Aquifer recharge project	LCA
8	Systematic monitoring of groundwater and surface water (mining closure)	IMGW
9	Quantifying groundwater/surface water interaction	IMGW
10	Urban groundwater monitoring using 3D geological information to inform hydrogeological understanding	IRRI
11	Development of a groundwater monitoring database and data capture templates for optimisation of data quality and transfer	IRRI
12	Digital water book	LfULG
13	KliWES	LfULG
14	Stormwater management – Sustainable precipitation management concepts to save water quality and quantity	LfULG
15	Artificial groundwater recharge @ Friesach	HG
16	Artificial groundwater recharge @ Andritz	HG
17	Aegean water resources digital repository	RNA

2.3 List of discussion of good practices to be adapted

In a second step 15 additional examples of good groundwater management practices (including tools and methodologies considering their practicability) to be adapted and potentially transferred into different SHARP (or similar) regions in the frame of the SHARP key contents are mutually selected by the project partners. Tab. 3 summarizes the elaborated topics; the underlined project partner is responsible to coordinate the activities in this area with the other project partners contributing.

Tab. 3: List of good practices to be adapted.

No.	Title	Project partners (PPs)
1	Effects on groundwater by mining	LfULG, IRRI, RWM, RNA
2	Application of water balance models with respect to climate change	LfULG, RWM, RNA
3	Online monitoring and DSS	HG, RNA, WP
4	Geothermal use of groundwater	LfULG, HG, RWM
5	SuDS and Groundwater	IRRI, LfULG
6	How to engage with key stakeholders	IRRI, all PPs
7	Drinking water safety plans	HG, IRRI, LfULG, RNA, WP
8	Transboundary issues	IMGW, RWM, LfULG
9	Use of DSS for strategies of groundwater resources management	IMGW, ERSA
10	Groundwater modelling development and verification	IMGW, ERSA, IRRI, LfULG
11	Development of groundwater monitoring for anthropogenic transformed areas	IMGW, IRRI, HG
12	Raising awareness on different levels	RNA, WP, all PPs
13	Techniques to save water quantity	LCA, LfULG, RNA
14	Water allocation and efficient water use in agriculture	LCA, ERSA
15	Optimization of water use in agriculture using IT	RWM, ERSA

3 Description of existing good practices (GP) – short version

3.1 Overview of good Practices identified by SHARP Project Partners

1. GIS vulnerability maps
2. Tools for water management plans
3. Binomial fee estimation for a rational use of water in agriculture
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11. Development of a groundwater monitoring database and data capture templates for optimisation of data quality and transfer
12. Digital water book
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14. Stormwater management – Sustainable precipitation management concepts to save water quality and quantity
15. Artificial groundwater recharge @ Friesach
16. Artificial groundwater recharge @ Andritz
17. Aegean water resources digital repository

3.1.1 GP 1: GIS vulnerability maps

P. BARTZOPOULOU, E. KOSMIDIS & P. PEKAKIS

Vulnerability maps inform about the need of groundwater protection and pollution prevention. The maps help to determine which areas may have groundwater vulnerability problems and what types of site-specific data or studies may be needed. GIS-based vulnerability maps support the spatial development planning process. The spatial integration of the vulnerability maps in the decision support system enables the regional authorities to design optimal spatial development policies.

Description

The practice on GIS vulnerability maps took place in the frame of the INTERREG III B ARCHIMED project "WATER-MAP-Development and utilization of vulnerability maps for the monitoring and management of groundwater resources in the Archimed area". GIS vulnerability maps were developed using the DRASTIC method and data from hydrochemical analyses (NO_3) of groundwater samples.

Vulnerability maps inform about the need of groundwater protection and pollution prevention. The maps help to determine areas that may have groundwater vulnerability problems and what types of site-specific data or studies may be needed. Hazard assessment is used to define potential hazards caused by human activities and can potentially have an impact on groundwater. Risk assessment is defined as a combination of hazard and vulnerability. Overlaying vulnerability maps, with maps showing the location of pollution sources or polluting land use activities, produces pollution risk maps.

The implementation of GIS vulnerability maps is not a high-financial demanding procedure and their use can contribute to a better understanding for all policy makers of the hazards caused by human activities that potentially could have an impact on groundwater. It should be pointed out that, the vulnerability methods must not replace field studies. The maps could be used as a general guide both for technicians and administrators.

Evidence of success

Benefits of the development and application of a methodology for creating GIS vulnerability maps were:

- Better overview of the water protection needs.
- Development of a Decision Support System (DSS) with information on land uses, populations etc. depending on vulnerability maps.
- Determination of water vulnerability caused by agricultural activities in Region of Western Macedonia is currently working on water and nitrogen management in agriculture in order to assess water and nitrogen losses due to percolation and run-off.

Location of the practice

Greece, Voreia Ellada, Dytiki Makedonia

3.1.2 GP 2: Tools for water management plans

P. PEKAKIS

Region of Western Macedonia's existing and transferable good practice/tool for water management is considered a Decision Support System (DSS) that was pilot implemented in order to support the spatial development planning process. The system aims to facilitate and optimize the decision making process relating to the problems of land use, water management and environmental protection.

Description

The development of tools for Water Management Plans (Model/Decision Support System – DSS) to support the spatial development planning process took place in the frame of the INTERREG III B ARCHIMED project "WATER-MAP-Development and utilization of vulnerability maps for the monitoring and management of groundwater resources in the Archimed area". The model is based on vulnerability maps and facilitates and optimizes the decision making process relating to the problems of land use, water management and environmental protection. The spatial integration of the vulnerability maps in the DSS enables the regional authorities to design optimal spatial development policies.

The DSS is based on a Multicriteria Mathematical Programming model and can achieve the optimum production plan in the area combining different criteria to a utility function under a set of constraints concerning different categories of land, labour, available capital etc.

The model is further used to simulate different scenarios and policies due to changes on different social, economic and environmental parameters (e.g. different levels of chemicals or water consumption per crop). In this way alternative production plans and agricultural land uses as well as the economic, social and environmental impact of different policies can be studied.

Evidence of success

The application of the Model/DSS:

- Optimizes the production plan of an agricultural region taking in account the available resources, the environmental parameters and the vulnerability map of the region.
- Facilitates the decision making process relating to problems of land use/water management/environmental protection.
- Enables regional authorities to design optimal spatial development policies and helps to develop strategies for optimal development of agricultural regions and groundwater protection from agricultural land uses
- Promotes sustainable planning processes and environmental protection of agricultural regions.

Location of the practice

Greece, Voreia Ellada, Dytiki Makedonia

3.1.3 GP 3: Binomial fee estimation for a rational use of water in agriculture

C. SCOGNAMIGLIO, S. VENERUS, S. BARBIERI & V. VOLPE

This practice is meant to provide a reference scheme to be used by the regional land reclamation and irrigation management consortia so as to show and explore the convenience and suitability of a binomial fee aimed to advantage the farmers who adopt a "on demand" water withdrawal strategy.

Description

A simple PC based tool is being developed to simulate different binomial fees schemes to be applied for the use of water in agriculture. The "binomial fee" can be split in two different components: one refers to a fixed quota of management costs, the other one to the cost of water used by the farmers for irrigation purposes. The "binomial fee" conversely to a "flat fee" is aimed at rewarding the farmers who save water resources by intervening with irrigation only when this is normally necessary for the crops, then avoiding waste of water. The wise water management pattern which comes along with the application of a "binomial fee" has also a positive impact on the overall material balance, for instance it saves energy demand currently used to keep in pressure the water flowing in the irrigation net system. Implementation of this simple PC tool for dissemination purposes of a wise water management is being supported by the SHARP budget of the ERSA (PP 4).

Farmers and Land reclamation and irrigation management consortia are the main stakeholders as they can benefit from a tool which put in evidence the convenience of a wise water management in terms of water savings and energy savings.

Evidence of success

This practice can be regarded as a good practice because it shows possible solutions and interventions to be put into action to save water and optimize the use of water resources for agricultural purposes. Benefits arising from the application of the binomial fee should be highlighted and shown to the SHARP project partners in the framework of best practices exchange and adaptations.

Location of the practice

Italy, Friuli-Venezia Giulia

3.1.4 GP 4: Web tool to disseminate agricultural best practices codes

V. VOLPE, S. BARBIERI & S. VENERUS

This tool is aimed to disseminate best practices to the farmers with special emphasis on the reduction of nitrates of agricultural sources as well as sustainable farming.

Description

The web tool has been projected to comprise three different sections: a) self-evaluation tool which enables the users (farmers, technicians, advisory services) to evaluate the sustainability degree of the farm under test, on the basis of farming and breeding techniques applied with respect to a given set of sustainability reference standards; b) estimation of N and P balances at the barn level, vessel capacity for storing the animal effluents, simulation of the animal effluents utilisation in the farm used agricultural area; c) evaluation of farm economic sustainability and profitability.

The web tool has already been developed by ERSA for its advisory purposes and is currently under test for improvements and enhancements. The tool resides on the web and then can be easily reached by all possible stakeholders. It is meant to transfer knowledge and disseminate information on specific and complex topics such as sustainable farming and implementation of the regional action plan concerning the EEC Directive 676/91.

Evidence of success

This practice can be regarded as a good practice because contributes to increase farmers' awareness on the farm sustainability issues and reduction of impact on ground waters from N of agricultural sources.

Location of the practice

Italy, Friuli-Venezia Giulia

3.1.5 GP 5: Water Framework Directive Guidelines

C. Scognamiglio, S. Venerus, S. Barbieri & V. Volpe

This practice is meant to take into consideration the indications provided by the EU Directive no. 2000/60/EC (Water Framework Directive, WFD) in order to assess the economic value of the water distributed. For the implementation of the economic elements the analysis will follow the proposal of the WATECO (WATer Framework Directive & ECOnomics). Consistently with the Water Framework Directive rationale, this approach will contribute to the information of the public and of the interested parties. The different elements of the economic analysis could represent further guidelines to be integrated in the local policy decision.

Description

The economic analysis is being mainly based on the suggestions given by the WATERCO, however having regard of the complexity of the said methodology and to the specific interest in applying the same principles but at a different scale level of investigation (i.e. local area vs. river basin) some flexibility, assumptions and simplification are introduced so as to make clearer the role and the impact of the different water users for the concerned area/s. Key elements of this analysis are: i) current water uses and users, ii) water supply and demand, iii) economic importance of water uses, iv) cost for water uses, v) identify possible measures to rationalize water distribution, vi) features of existing water use programs at regional and local level, vii) possible programs and measures to be implemented by the decision makers.

Farmers, water users in general and policy decision makers could benefit of this economic analysis. Information and knowledge dissemination could be regarded as success factors in this process.

Evidence of success

Information gained through this economic analysis could be used by the decision makers and policy makers to support future measures and programs to be adopted at local or regional level or to increase awareness on the economic cost of water under an environmental perspective.

Location of the practice

Italy, Friuli-Venezia Giulia

3.1.6 GP 6: Vulnerability maps

S. Barbieri, V. Volpe & S. Venerus

This tool is aimed to create GIS-based vulnerability maps to support the process of identification of vulnerable zones concerning the pollution caused by nitrates from agricultural sources.

Description

In order to identify the most vulnerable areas to agricultural-born nitrates, two parametric methods and a GIS are used. On one hand, ERSA developed a parametric system to estimate soil attenuation capacity, choosing five features that mainly affect water quality flowing through the soil: available water capacity (AWC), cat ion exchange capacity (CEC), soil depth, permeability and physiography. Each selected parameter is ranked using range values and stated types to get five classes of attenuation capacity. Soil attenuation capacity maps were obtained for large areas of the region; these maps will cover the whole plain and hills sector of the region as soon as updated soil data will be available. On the other hand soil data were used together with climate and hydrogeological data following a parametric method (SINTACS) as well as implementing GIS tools in order to evaluate intrinsic vulnerability and, taking into account nitrogen agricultural loads, integrated vulnerability.

Vulnerability GIS-based maps can be used both to locate most vulnerable areas for agricultural-born nitrates, where action programs are to be adopted to reduce nitrogen load, and to state suitable agro-environmental measures in the framework of the Rural Development Program. The tool is used by technicians and policy makers of regional government.

Evidence of success

This practice can be regarded as a good practice because it can be useful to figure out water protection measures and identify the areas showing the most relevant impact in terms of groundwater resources due to pollution of N from agricultural source. These should be the areas where regional action plans should considered and undertaken so as to preserve groundwater quality.

Location of the practice

Italy, Friuli-Venezia Giulia

3.1.7 GP 7: Aquifer recharge project

M. SCHEMBRI

Artificial recharge of the Mean Sea Level Aquifer with polished TSE (Treated Sewage Effluents).

Description

Since the 1950s, saving water through managed artificial recharge has been practiced. Indeed, some 75 small dams have been built across the main valley lines of the island to retain storm water with a total design capacity of around 150,000 cubic meters. These dams serve a double-purpose mainly to store water for agricultural irrigation and to enhance the recharge of the underlying aquifers.

A pilot Artificial Recharge Project of the Mean Sea Level Aquifer with polished TSE is underway in Malta. This pilot project is to test the qualitative and quantitative impacts of a direct artificial recharge to the Mean Sea Level system. The TSE polishing includes further purification by ultra-filtration and reverse osmosis.

This project involves the following objectives and practices: setting up of a polishing plant for the further treatment of sewage effluent from a nearby Wastewater Treatment Plant; detailed analytical testing of the polished effluent for indicators of emerging pollutants; Continuous monitoring in the immediate area of the recharge well for groundwater level and conductivity.

The Pilot project is being implemented under the MEDIWAT Project (Mediterranean Network for the Implementation of Innovative Best Practices for Managing Water Scarcity and is part-financed by the European Union under the MED-Programme). The main stakeholder concerned is the Water Services Corporation.

Evidence of success

This practice is considered to be good due to three main reasons. Firstly, a detailed characterization of highly polished effluent with regards to the presence of unconventional pollutants will be obtained; secondly, the reaction time of the aquifer system to a direct artificial recharge will be known; and finally the potential qualitative and quantitative benefits of recharging the aquifers with high water quality will be provided. The project is in its early stages and up till now no results have been issued as yet. Therefore, impacts which the project might have not yet been identified.

Location of the practice

Malta, Zejtun

3.1.8 GP 8: Systematic monitoring of groundwater and surface water (mining closure)

M. Adynkiewicz-Piragas, J. Kryza, I. Lejcuś & I. Zdralewicz

Presented systematic monitoring is helpful in Polish-German bilateral activities, especially supports the decision making process relating to the problem of water management within transboundary river basin.

Description

The monitoring is conducted in a cross-border area under strong anthropogenic pressure. Described methodology and its use allows the rational management of water resources and provides comprehensive as well as systematic information on the quantity and chemistry of water and allows diagnosis of water resources and development for forecasts of the direction and rate of change in the environment. The basis of monitoring concept was elaborated jointly by Polish and German specialists and researchers. Results of the monitoring are presented at meetings on different levels: e.g. meetings of experts performing the analysis of results received during monitoring, working groups (operating for the German-Polish Border Water Commission), which include, among others decision makers and spatial planners from the municipalities and regions. Results of the monitoring are also presented during the meeting of heads of working groups with the Government Plenipotentiary for cooperation on boundary waters. In this way, we contribute to the creation of government policy on boundary waters, and further arrangements associated with water management executed in the transboundary area.

The presented methodology is not complicated and not financial-demanding, provided there is a monitoring network. Monitoring methodology is applicable to other border areas, but requires modifications to local hydrological and hydrogeological conditions, and taking into account the existing problems in the field of water resources.

Evidence of success

The development and implementation of a methodology of systematic monitoring of surface- and groundwater:

- providing of information that may be helpful in achieving environmental objectives within the meaning of the Water Framework Directive – good quality and quantity of water resources;
- are necessary to the decision making process relating to the problem of water management within transboundary river basin;
- allow to carry on a bilateral agreement on the rational use of water resources by users from both countries;
- allow control of water resources users to not deterioration of water state;
- permit formation of foreign policy in the field of water management on transboundary waters.

Location of the practice

Poland, Poludniowo-Zachodni, Wroclaw

3.1.9 GP 9: Quantifying groundwater/surface water interaction

M. ADYNKIEWICZ-PIRAGAS, J. KRYZA, I. LEJCUŚ & I. ZDRALEWICZ

Support of methodology for assessment of water conditions within river basin.

Description

Presented good practice presents the methodology of quantitative evaluation of the interaction between surface water and groundwater.

The purpose of the methodology is the development of a comprehensive approach to understand the water system and the type and strength of connections between surface water and groundwater, due to the fact that the Water Framework Directive introduces the obligation of assessment of the connections between surface water and groundwater. This parameter is part of river hydromorphological assessment, which affects the evaluation of ecological status of surface waters.

Presented methods were used to evaluation water condition and interaction between surface water and groundwater in numerous reports, grants and assessments carried by the IMGW-PIB for various institutions, e.g. Ministry of Environment, Regional and National Water Boards, public companies and offices, private companies/investors etc. The method is simple to apply and less costly, assuming the availability of measured data. Presented good practice is versatile and easy to transfer to other areas.

Evidence of success

The development and implementation of a methodology of quantifying groundwater/ surface water interaction are:

- necessary to fulfil the recommendations of the Water Framework Directive;
- used to determine the type and intensity of assessment of anthropogenic impacts on aquatic and water-dependent ecosystems;
- needed for the location of groundwater intakes used for water supply of people and industry;

- for the need to develop comprehensive water balance areas for efficient water management;
- necessary for the development of management plans for water management;
- for better understanding the relationship between surface- and groundwater;
- used to prepare many reports and assessment for various institutions: e.g. ministries, offices, private companies.

Location of the practice

Poland, Poludniowo-Zachodni, Wroclaw

3.1.10 GP 10: Urban groundwater monitoring using 3D geological information to inform hydrogeological understanding

R. Turner

Groundwater monitoring to improve understanding of urban groundwater systems and support environmental sustainability and economic development.

Description

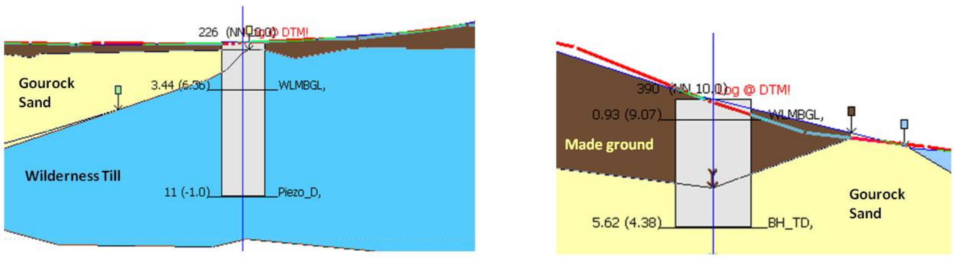
For the first time in Earth’s history, more than half of the human population now live in cities. With continually increasing urban population size and density, coupled with the as yet unknown impacts of predicted climate change, urban groundwater is becoming an increasingly important water resource. In any city, groundwater is a potential resource for abstraction for potable or industrial supply; and a potential energy resource via ground source heating and/or cooling schemes as part of efforts to reduce urban carbon footprints. Groundwater also critically provides baseflow to rivers to maintain flow rates sufficient for the good health of aquatic ecosystems. In cities with industrial heritage, groundwater is also likely to face risk from contaminated land, and to provide a mechanism for the transport of these contaminants to final surface water receptors. In many cities, groundwater is the receptor for storm water runoff via Sustainable Drainage Schemes (SuDS) which are increasingly being introduced in an attempt to mitigate urban flooding and reduce the pressure on piped drainage networks.

However, the effects of each of these processes upon the groundwater system need to be understood in detail if we hope to properly manage the quality and quantity of this resource to keep it fit for its myriad uses in a 21st century city. The basis to understanding groundwater systems is the availability of sufficient suitable information on key hydrogeological parameters, including the temporal and spatial distribution of groundwater levels and groundwater chemistry. This information can only be collected through effective groundwater monitoring.

This report describes work being carried out by the British Geological Survey to investigate and trial groundwater monitoring strategies in a case study city: Glasgow, UK. Glasgow has a complex geology with a repetitive sequence of faulted Carboniferous sedimentary bedrock overlain by an intricate pattern of Quaternary deposits associated with periods of glaciation. As such, 3D geological models have proved very helpful in attempting to visualise and understand the relationship between the various deposits and the likely behaviour of groundwater within them. In addition, groundwater data in Glasgow is relatively sparse and good quality historical records of groundwater levels and quality are largely not available. Much of the groundwater level data lacks important metadata such as datum elevation and the depth the screen was installed, which makes valid interpretation of the data difficult. By using the 3D geological model to validate the groundwater level data we were able to develop confidence in the quality of our data points and select only the most reliable for use in a pilot monitoring network.

Nature of the practice – Methodology

The objective was to use 3D geological models as a means to validate and assign confidence to the available groundwater data and to aid in its subsequent interpretation to begin to understand the behaviour of the system.



a) The borehole lies primarily within one unit. There is a high confidence that borehole 226 is sampling the Wilderness Till.

b) The borehole intersects more than one unit. There is a low confidence that borehole 390 is sampling the Gourock Sand.

Fig. 2: Incorporation of borehole log data into GSI3D for validation of monitored geological unit.

The 3D geological framework model was used to provide a hydrogeological context to the groundwater data. By using the geological model in conjunction with borehole log records and groundwater level data, it is possible to determine which hydrogeological unit each borehole is most likely to be sampling. For each borehole, the total depth, depth and length of screen, and a representative average groundwater level, were imported into the 3D geological framework model. In some instances, borehole logs were absent, in which case the 3D model was also used as a proxy to determine the hydrogeological unit being sampled.

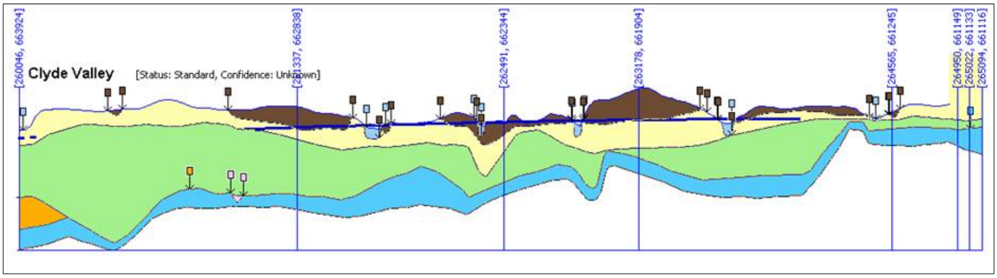


Fig. 3: Cross section along the valley of the Clyde with the contoured water table within the Gourock Sand Formation shown in blue.

At some borehole locations there were contradictions between the geology recorded in the logs and the geology expected by the model. To reflect this uncertainty, confidence criteria were applied to the defined hydrogeological unit for each monitoring borehole. Low confidence was applied if the borehole intersected more than one geological unit in the geological model, and the borehole could not be validated against any lithological record from a borehole log, or if the borehole record and the GSI3D model contradicted each other. Medium confidence was attributed to boreholes where there was reasonable certainty in the hydrogeological unit being sampled, but which could not be verified by a lithological description. Finally high confidence was assigned to boreholes that showed good agreement between the GSI3D model and the borehole log and for those that intersected just one geological unit. In this way the 3D geological model was used to validate the data acquired from the borehole logs and to develop a picture of which horizons each borehole was monitoring.

By using the 3D model to confirm with acceptable certainty which unit each borehole was sampling, it was possible to create subsets of the data comprised of boreholes monitoring the same geological unit. Boreholes were identified as monitoring seven different geological units, including artificial (or made) ground; five distinct Quaternary (superficial deposit) units; and bedrock, although the largest subsets of boreholes are monitoring made ground and the Gourock Sand Formation, a natural deposit of Quaternary age.

Using these subsets, groundwater level contours based on an average groundwater level for each borehole were created to investigate the prevailing groundwater flow direction and to help infer the degree of connection between adjacent hydrogeological units.

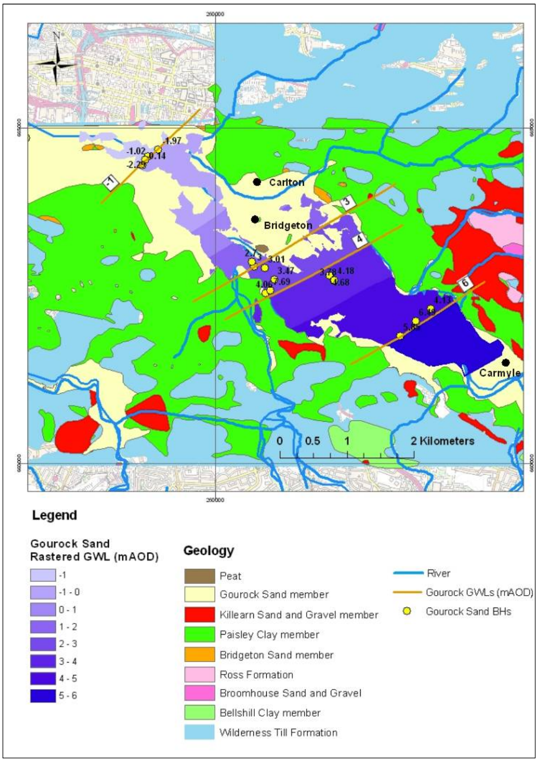


Fig. 4: Groundwater contours for the Gourock Sand Member as an interpolated raster surface and as contour lines.

However, even for the Gourock Sand Formation, for which there are most monitoring points, the available groundwater level data (from 20 boreholes) proved insufficient to produce detailed groundwater contours. Instead, the groundwater level data were employed to create simple hand drawn groundwater contours that delineate the approximate groundwater head gradient through the study area. These contours were converted into a 2D raster surface and imported into the 3D geological model. In the model the groundwater level contours can be viewed in cross-section and indicate good agreement between the groundwater level contours and the level of the River Clyde, which implies that there is hydraulic connection between groundwater in the Gourock Sand Formation and the river in this area. The 3D geological model shows that the geometry and thickness of the Gourock Sand Member is such that there is likely to be a relatively constant thickness along much of its length, permitting groundwater flow throughout the study area. However, in some locations, the geological model indicates that the Gourock Sand Member thins to about 1 metre thickness, indicating that groundwater flow in this area is likely to be different, and potentially highlighting the need for monitoring in this area.

Future

Use of the 3D geological framework model has facilitated the development of hydrogeological knowledge within a study area in Glasgow. Understanding gleaned from the interpretation of the available groundwater level data within the 3D context provided by the geological model has resulted in the identification of one particular geological unit (the Gourock Sand Member) as being a potentially locally significant hydrogeological unit, and its selection as a major focus of the future development of the groundwater monitoring network. In the same way, other geological units have been identified as a secondary focus for monitoring.

The 3D geological framework model has proved a powerful tool to aid hydrogeological understanding in this complex urban area. Its value in informing the refinement of conceptual groundwater understanding and future monitoring network design is in the ease of use of the model for providing context to groundwater monitoring data; and in the enhanced interpretation that is possible by visualising detailed geological understanding in three dimensions.

Such 3D geological models are a relatively new tool and as yet are only available for limited areas, and at present are time-intensive and therefore costly to develop. This is likely to curtail the widespread application of this methodology in the near future. However, the development of 3D geological tools is fast becoming the norm in many parts of Europe, including other areas of the UK and the Netherlands, and where such models do exist, the cost savings of using them to inform hydrogeological understanding could be considerable.

The content of this document is based upon the work detailed in the following BGS internal reports:
Bonsor HC, Ó Dochartaigh BÉ: Groundwater monitoring in urban areas – a pilot investigation in Glasgow, UK.

Bonsor HC, Bricker SH, Ó Dochartaigh BÉ, Lawrie KIG: Groundwater monitoring in urban areas: pilot investigation in Glasgow, UK, 2010-11.

Location of the practice

United Kingdom, Scotland, Glasgow

3.1.11 GP 11: Development of a groundwater monitoring database and data capture templates for optimisation of data quality and transfer

R. TURNER

A new dedicated database to store, manage and allow easy retrieval of groundwater monitoring data from an urban setting.

Drivers for improving hydrogeological understanding in urban areas

The need to develop detailed understanding of urban hydrogeology is becoming ever more important, and is driven by two main pressures. The first is a desire to manage the groundwater resource in order to maintain its many uses within the urban environment – such as abstraction for industrial or potable use; as an energy resource through ground source heating or cooling; in providing essential baseflow to urban waterways; and as a receptor for storm water drainage through Sustainable Drainage Systems (SuDS). Urban groundwater systems are likely to be significantly disturbed by historic, current and future anthropogenic activities, and the effects of these need to be understood if the entire resource is to be maintained in a sustainable way. The second driver is legislative, and relates to the Water Framework Directive's (WFD) requirement to establish the effective, long term monitoring of water bodies within all European member states The WFD demands that all member states have a national groundwater monitoring scheme in place to ascertain the baseline status of groundwater resources and the potential for potable supply.

Developing groundwater monitoring in Glasgow

In Glasgow, as in most other cities, there is not enough hydrogeological information to allow the development of a good understanding of the groundwater system. Before the start of this project in 2008, the British Geological survey held only 119 records of groundwater level within the entire Glasgow urban area, and many of these were one off measurements from boreholes drilled decades before. The data were often of poor quality with little or no information regarding borehole construction, surface elevation or the stratigraphic horizon being monitored.

However, other groundwater data did exist from sites within the Glasgow area, with Glasgow City Council increasing its volume of held data from 2000 onwards. In particular, recent (post 2004) redevelopment works at major regeneration sites in the city (such as the Clyde Gateway, Shawfield, the Commonwealth Games village and the extension of the M74 motorway), all provided sources of continuing groundwater monitoring. This monitoring information was being collected by consultants and provided to Glasgow City Council (GCC), but GCC did not have the resources to manage it effectively, so that the data was stored haphazardly, in different formats, and it was difficult, time consuming and costly to extract and make available.

BGS carried out a two-stage programme to improve the efficiency and effectiveness of managing current and future groundwater monitoring data. A dedicated database was designed to store and allow easy retrieval of monitoring data; and a set of data entry templates was designed to ensure the collection of high quality, relevant data.

Database

A bespoke database was designed by data management and groundwater specialists at BGS. The database structure was designed in Microsoft Access, but was designed so that in future it can be incorporated into corporate BGS Oracle databases. Its structure allows both time series data and single one-off monitoring data to be stored for each monitoring point (borehole), alongside key metadata or index information (geology and borehole construction details). This data can then be easily spatially interrogated within GIS software and compared or potentially merged with other existing BGS datasets characterising, for example, chemistry and borehole log data. The usability of Microsoft Access employed here as the front-end user-interface allows key stakeholders to gain access to the relevant data quickly and easily.

Fig. 5 demonstrates the logical structure of the design of the monitoring database. It is a database that holds the groundwater monitoring data in array lists, which enables effective data searches and is more flexible than if the data were held in a table format. The database was populated initially with monitoring data from the four major regeneration sites in Glasgow mentioned above, for which recent (post 2004) data are available. While populating the database a number of issues relating to data quality, availability and consistency became obvious.

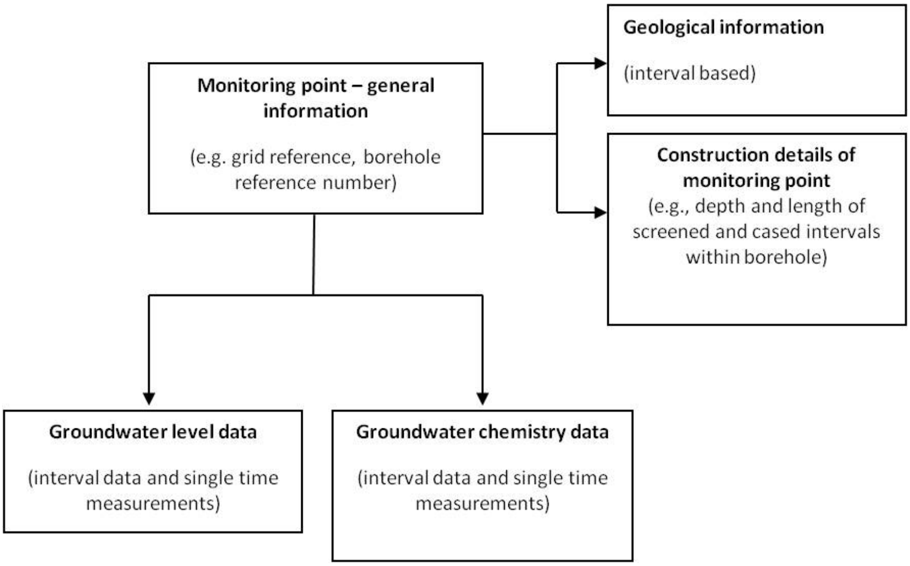


Fig. 5: Conceptual structure of the ORACLE database containing Glasgow's groundwater monitoring data. (The boxes represent entities).

In particular, data from each site were collected by different consultancies and the format of data records was not consistent between different companies and even varied over time within the records provided by a single company as different staff or reporting formats were employed. This is largely as a result of there being no obligation or guidelines detailing the protocols for recording and presenting hydrogeologically relevant data. As a result, bespoke operations and queries had to be developed in order to transfer data obtained from different organisations into a single coherent database. Funds existed during this project to facilitate this time intensive data transfer as a one off trial, but it was clear that this process would need to be increasingly automated if the upkeep, and therefore the integrity of the monitoring database and the value of the information it stored, was to be maintained, and if future data sharing initiatives were to be possible.

A second issue was the recognition that essential borehole index data are typically not reported to GCC with ongoing monitoring data. At present much of the borehole index information is provided separate to ongoing groundwater monitoring data, within the main body text of a consultancy report. Extracting this information from the reports and matching with the correct boreholes for which monitoring data are reported requires a considerable amount of additional work and creates additional risk of error.

Data Templates

In light of these issues, data capture templates were created for use by any contractors providing groundwater data to Glasgow City Council. The templates were designed by BGS in partnership with GCC and with input from the major consultancies working in the city, in order to ensure take-up of the template. These templates ensure that standardised data and the minimum required index data from each groundwater monitoring borehole are recorded. Ensuring that borehole index information is present alongside the monitoring data will be a tremendous advantage in terms of ease of analysis and data value in the future.

As important as ensuring that all necessary data (e.g. index data) are included is ensuring a consistent format for data entry. The data capture templates were designed in Microsoft Excel, which is widely used in the industry and is acceptable to consultants working to collect and record data. The templates provide a separate field for the capture of each relevant hydrogeological data type, which is always in the same location in the template. When data are read from the templates into the database, these unique but consistent field structures allow the production of automated look up routines to read from the digital input data files and then populate the database with the new data. The automation of this data update process will both lead to quicker – and therefore cheaper – data transfer, and will reduce errors in data transmission due to human error and therefore increase the value of the data.

To date, the data capture templates have been developed in draft and positive feedback has been obtained from consultancy firms working on some of the major regeneration sites in Glasgow. Full trials of the templates will start from autumn 2011, with consultancies on some of the major regeneration sites in Glasgow using them to record monitoring data. The transfer of these data from the templates to the BGS database will then be tested and refined. The templates have already received approval from the Glasgow City Council department working directly with groundwater data, and are currently awaiting official sign off at senior level. Once that happens, the templates will become the means of recording and transferring groundwater monitoring data for the whole of Glasgow.

Future Plans

Assuming the successful uptake and implementation of these templates, it is envisioned that the same protocol could be expanded to include information on engineering, geotechnical and geophysical data. All such data could be stored in the same database, increasing its value still more.

The development of the data capture templates is a valuable best practice which will prove hugely beneficial within the Glasgow urban area, and would also be a distinct advantage if rolled out to consultancy and government institutions nationwide. The implications for the rapid transfer and update of data between all institutions involved in groundwater management and research are profound, but will require significant cooperation between organisations.

The content of this document is based upon the work detailed in the following BGS internal reports:
Bonsor HC, Ó Dochartaigh BÉ: Groundwater monitoring in urban areas – a pilot investigation in Glasgow, UK.

Bonsor HC, Bricker SH, Ó Dochartaigh BÉ, Lawrie KIG: Groundwater monitoring in urban areas: pilot investigation in Glasgow, UK, 2010-11.

Location of the practice

United Kingdom, Scotland, Glasgow

3.1.12 GP 12: Digital water book

C. Glöckner & C. Niemand

The Digital Water Book is a web-based information system for existing water management uses and facilities as well as water protection areas and defined flood zones.

Description

A good practice of the Saxon State Office for Environment, Agriculture and Geology (LfULG) is the Digital Water Book (www.wasserbuch.sachsen.de). The Digital Water Book is based on the water books of the Saxon main catchment areas. These water books contain the existing water rights associated with the water bodies in Saxony. The linkage of this information to aerial images gives a good and quick overview of the local conditions. Since this is a free web tool, qualified water management information is generally accessible for governmental institutions as well as for citizens and non-governmental organisations. All persons or parties interested can obtain online information e.g. on water rights, surface waters, groundwater, drinking water protection areas and flood zones. This general transparency in water management measures is the basis for the sustainable management of both groundwater and surface water resources.

The Digital Water Book is a dynamically growing system. It is constantly possible to make new entries or record modifications. Internet provides easy access for the interested public. So the general public is enabled to use the information recorded in the Water Books and gain an understanding of legally required water management measures. The method of making water law-related data publicly available is well transferable. However, the method can be rather complex and requires a high input for setting up such a web-based system and for digitising the analog data (depending on the degree of digitisation of the existing water rights and geodata basis). Especially in the 21st century, with the Internet having emerged as one of the most important media, this tool should be used to make specialist data publicly available. This approach is highly recommendable, because surface waters as well as groundwater are very important public goods. Their use and protection are of general public interest.

Evidence of success

The Digital Water Book has proven successful not only in Saxony, but also in other German states. A Digital Water Book is also maintained in Rhineland-Palatinate. There are Digital Water Books also in Austria (Salzburg, Carinthia and Styria).

The advantage of this type of information system is to have a geographic overview of water rights. So it is possible to get an idea of how strong the human impact is in certain areas, where protection areas are located and where additional groundwater protection is required. Since the Digital Water Book allows direct inquiries, it reduces the amount of administrative work otherwise required for answering requests for information addressed to the competent authorities.

Location of the practice

Germany, Sachsen, Dresden

3.1.13 GP 13: KliWES

C. GLÖCKNER, C. NIEMAND & K. LÜNICH

KliWES – Assessment of the impact of the climate changes predicted for Saxony on the water and material balances in the catchment areas of Saxon water bodies – Water Balance Section.

Description

The KliWES project is a good practice introduced by the Saxon State Office for Environment, Agriculture and Geology (LfULG). It covers the assessment of the impact of the climate changes predicted for Saxony on the water and material balances in the catchment areas of Saxon water bodies. KliWES stands for "Abschätzung der für Sachsen prognostizierten Klimaveränderungen auf den Wasser- und Stoffhaushalt in den Einzugsgebieten der sächsischen Gewässer". Especially today where the predicted climate change calls for urgent adjustments to its impacts on a worldwide scale and poses new challenges on the management and prognostics of water resources, KliWES is a good example for how to tackle this issue. The KliWES project started in 2008 as a follow-on project of the well-proven KliWEP (2007) project, which already focused on the impact assessment of the climate changes predicted for Saxony specifically for the water and material balances in the catchment area of the Parthe River.

The Saxon State Office for Environment, Agriculture and Geology (LfULG) worked closely together with the Technical University of Dresden to jointly develop the methodology and procedure for the assessment and evaluation of the impacts of the climate change on the water balance in the catchment basins of Saxony. So KliWES is an enhancement of the KliWEP project, which was limited to the study of a single catchment area. KliWES is based on a scientifically founded method or combination of several appropriate methods for the calculation of "complete" water balances (based on mean and/or day values) for any of the areas in Saxony, while offering the possibility to run and evaluate scenarios. The results can be used to classify Saxon catchment areas by their water balance's sensitivity to the climate change. In a second step, the results can be used to give region-specific management recommendations to ensure sustainable management of the surface and ground water re-sources.

Evidence of success

The KliWES project results will enable decision makers to identify the areas in greatest need of adjustment strategies for water resources, agriculture and forestry. The results and recommendations from the KliWES project are available to engineering bureaus, industrials, administrations, institutional users, researchers and scientists, politicians and accountants as well as to national/international bodies and citizens in Saxony. The methodology makes it possible to calculate the actual status as well as climate and land use scenarios. The user is given the possibility to make direct calculations of the effects e.g. of land use changes on the water balance. So a final assessment can be made as to the impact of the climate change on the water balance in the contemplated region under different land use scenarios.

Location of the practice

Germany, Sachsen, Dresden

3.1.14 GP 14: Stormwater management – Sustainable precipitation management concepts to save water quality and quantity

C. NIEMAND & C. GLÖCKNER

Stormwater management in settlement areas as a contribution to sustainable groundwater management.

Description

As a basic condition for sustainable groundwater management, it is necessary to ensure that the groundwater body retains its major characteristics and can be regenerated in a natural way. In urbanised areas, the natural water balance is disturbed by a high percentage of impervious surfaces. They reduce infiltration and groundwater recharge, thereby leading to a lower groundwater table – and thus causing a change in major groundwater characteristics. The conventional urban drainage solution is based on the principle of discharging the stormwater immediately, and to the largest possible extent, as sewage into the public sewer system. This concept is associated with quality problems in the water bodies due to stormwater inflows from the separate storm sewer or due to overflows from the combined sewer system. During the past few decades, this approach caused high investments into and operating costs of stormwater treatment facilities and overflow tanks, with a major part of the facilities being used during rare (heavy rainfalls) events only. Appropriate measures (green roof, stormwater infiltration and rainwater harvesting) and their combination can help restore the natural water balance quite closely. So it is possible to properly use the retention and cleaning capacities of the soil and to reduce runoff peaks. Methods for decentralised stormwater management are to be recommended and can be transferred to other regions or countries. When using groundwater as one of our most important drinking water resources, it is necessary to do everything to provide compensation for the deficit thus created. Such compensation can be achieved e.g. by the judicious and effective use of decentralised stormwater management methods as presented in this paper. This is the only way to guarantee for sustainable groundwater management.

Evidence of success

In Germany, methods and measures for decentralised stormwater management are considered to be a good practice for sustainable groundwater management. The basic idea is that water as a vital resource should be carefully handled and spared in terms of sustainable resource management. Especially at the present time where the projected climate change is expected to increase the frequency of extreme meteorological events like large storms or drought periods, it is desirable to counteract the negative impacts. One of the major challenges in this context is to lessen the impacts on the natural water balance. The decentralised stormwater management is both, an economically and ecologically appropriate alternative.

Location of the practice

Germany, Sachsen, Dresden

3.1.15 GP 15: Artificial ground water recharge @ Friesach

H. SCHMÖLZER & F. GUNDACKER

Use of artificial groundwater recharge to sustain the good quality drinking water supply of the second largest city in Austria.

Description

Being Austria’s fourth largest water supply company the Holding Graz Services has ensured the successful water supply of the Styrian capital for many decades. The city of Graz with approximately 250,000 inhabitants is Austria’s second largest city. The average daily water demand of the area amounts to about 50,000 m³. Approximately 30 % of the total demand is covered by the bulk water supply from the "Zentral Wasser Versorgung Hochschwab Süd". The waterworks Friesach, which covers the additional 40 % of the water demand, operates by means of artificial groundwater recharge plants where horizontal filter wells serve as drawing shafts. In Graz groundwater management and artificial groundwater recharge have a long tradition. The first groundwater recharge system operated in the 1920s. In the 1980s the artificial groundwater plants in Friesach were commissioned. The groundwater recharge systems serve to increase the productivity of the aquifer and to reduce the share of the infiltration from the river Mur. Protection areas have been identified to ensure that the water quality of the aquifer stays at optimal levels. The protection areas are divided into zones indicating various restrictions for usage and planning. Two respective streams serve as the source for the water recharge plants.

The method of artificial groundwater recharge is an effective tool for the artificial regulation of the groundwater level. It can also be applied for increasing the pumping rate of wells and makes it possible to use the natural storage capacity for water in the underground. This technique is simple and can be applied at many other places.

Evidence of success

The practice can be considered as good example for sustainable use and also reuse of scarce resources. Since artificial recharge is a low cost technique it can be easily transferred to regions where water resources are less abundant. However, the raw water quality, which can be improved during the subsurface passage, is the key of success of artificial groundwater recharge. The value of it can be expressed in the cost that arise if water supply would have to covered by different means, e.g. by seawater desalination. Furthermore, artificial groundwater recharge might serve other purposes like storing stormwater runoff, thus replacing costly surface reservoirs, or avoiding mixture of good quality groundwater with polluted groundwater parts.

Location of the practice

Austria, South-Austria, Graz

3.1.16 GP 16: Artificial ground water recharge @ Andritz

H. SCHMÖLZER & F. GUNDACKER

Use of artificial groundwater recharge to sustain the good quality drinking water supply of the second largest city in Austria.

Description

Based on the results of pilot plants, comprehensive research activities regarding the aquifer system and monitoring of the raw water quality, the recharge system functions as depicted in the following scheme:

Raw water → sedimentation tank → horizontal gravel filter → infiltration plants → underground passage → horizontal filter well → water supply network, customers

The quality of the surface water is measured by means of a turbidity meter and if the turbidity of the water exceeds a defined level, water withdrawal is automatically stopped. After passing through intake- and sedimentation tanks, the water enters a horizontal gravel filter system and the infiltration plants. Different infiltration systems are utilized. The sand filter and lawn basins operate intermittently. Each of the various artificial ground water recharge systems displays specific advantages and disadvantages in terms of operation as well as maintenance which have to be taken into account before selecting an infiltration plant.

The method of artificial groundwater recharge is an effective tool for the artificial regulation of the groundwater level. It can also be applied for increasing the pumping rate of wells and makes it possible to use the natural storage capacity for water in the underground. This technique is simple and can be applied at many other places.

Evidence of success

The practice can be considered as good example for sustainable use and also reuse of scarce resources. Since artificial recharge is a low cost technique it can be easily transferred to regions where water resources are less abundant. However, the raw water quality, which can be improved during the subsurface passage, is the key of success of artificial groundwater recharge. The value of it can be expressed in the cost that arise if water supply would have to covered by different means, e.g. by seawater desalination. Furthermore, artificial groundwater recharge might serve other purposes like storing stormwater runoff, thus replacing costly surface reservoirs, or avoiding mixture of good quality groundwater with polluted groundwater parts.

Location of the practice

Austria, South-Austria, Graz

3.1.17 GP 17: Aegean Water Resources Digital Repository

V. ROZAKIS & V. KOPSACHILIS

The purpose of Aegean Water Resources Digital Repository (AWRDR) was to improve public authority's accessibility to a wide variety of reliable spatial and non-spatial data, together with the associated information (metadata), at different scale and from multidisciplinary sources, organized and documented in a standard and consistent way. Reliable and accessible data can provide a safe ground for better water resource management, by assisting decision makers to promote multidisciplinary approaches in vulnerable areas protection and by creating better linkages to water, climate and other data.

Description

The public authorities related to water resource management decided to develop a digital repository accessible from the web, to store and share their available data. Public authorities (local and regional) carried out the project in two stages to ensure the repository's efficiency and effectiveness. In the beginning, data and metadata related to water protection were collected and recorded. Secondly, using the proper tools and methods a web-based digital repository was built to facilitate the exchange of water resources data through the internet.

By improving the remote access to reliable data, through the internet, local and regional authorities have a powerful tool to design master plans and perform easier remote checks regarding the quality and the quantity of the available water resources.

Evidence of success

The Aegean Water Resource Digital Repository succeed to give solution to the fragmentation problem that the insular Aegean Region faces and to improve the access to reliable water resource data towards the water management authorities. Through the AWRDR local and regional authorities saved time, data quality was improved (through the participatory method) and better master plans and controls were made by the policy and decision makers.

In present time AWRDR is used only by the public sector. However, there are efforts to open the AWRDR and its available data to private sector, NGOs, Universities and Research Centres as their contribution to control and monitoring water resource is undoubtedly useful.

Location of the practice

Greece, Voreio Aigaio, Mytilene

4 Description of good practices to be adapted (GPA) – short version

4.1 Overview of SHARP's good practices to be adapted

1. Effects on groundwater by mining
2. Application of water balance models with respect to climate change
3. Online monitoring and DSS
4. Geothermal use of groundwater
5. SuDS and Groundwater
6. How to engage with key stakeholders
7. Drinking water safety plans
8. Transboundary issues
9. Use of DSS for strategies of groundwater resources management
10. Groundwater modelling development and verification
11. Development of groundwater monitoring for anthropogenic transformed areas
12. Raising awareness on different levels
13. Techniques to save water quantity
14. Water allocation and efficient water use in agriculture
15. Optimization of water use in agriculture using IT

4.1.1 GPA 1: Effects on groundwater by mining

C. Niemand, C. Glöckner, C. Fritze, D. Kouras, R. Turner, D. Alvanos & D. Tsimplinas

Involved Project Partners

<u>Saxon State Office for the Environment, Agriculture and Geology (LfULG)</u>
International Resources and Recycling Institute (IRRI)
Region of Western Macedonia (RWM)
Region of North Aegean (RNA)

Concise description of the adapted good practice

Effects on groundwater by mining occur in many of the Sharp Project countries and were focused within the project. The LfULG took the role as lead or responsible partner of this adaptation topic because of its experience. Especially Saxony in the eastern part of

Germany, beside the well-known Ruhr area, has a long mining and therefore a long contamination by mining history and now a nearly 20 year's re-cultivation experience. Therefore the LfULG is the main donator, but also got a lot of information from the corresponding partners (Scotland, Greece and Poland). Within discussions the present approach was critically analysed.

Opencast lignite mining goes along with groundwater quantity and quality problems during active mining and after mining. To ensure and enable active opencast mining usually the existing groundwater has to extract – for the whole period (decades!) of active mining. After the active mining the opencast will still exist and has to be fulfilled even by soils or water. The groundwater rising will suddenly appear when the groundwater pumps will stopped. But this causes a lot of problems. The flooding has to be supported in the context of stability of the surrounding and to shorten the flooding period with additional water if needed, for example.

One of the main quality problems is acid mine drainage (AMD). Acid mine drainage forms metal-rich (e.g. iron) water from the chemical reaction between water and rocks containing sulphur-bearing minerals. The runoff formed is usually acidic and frequently comes from areas where ore- or coal mining activities have exposed rocks containing pyrite, a sulphur-bearing mineral.

In Scotland, the most significant problem after the closure of a mine is also (AMD). For this reason, we decided to focus on methods to clean such acid mine water.

Unfortunately there is no universal remedy; it is much more a matter of finding a good solution for the present situation and circumstances. So we decided that our good practice is a collection of treatment methods that can be used or further researched/extended.

But all these methods have the same goal: to neutralize the water and remove metals from the waters to prevent that other waters come in contact with the contaminated mine waters (fresh groundwater, surface water).

A detailed description of the methods, the treatment goals, and the range of application, the stage of development and the contact to the experienced experts can be found in the annex "Long version of good practices to be adapted reports".

Description of adaption process

Because the Scottish partner is very interested in the cleaning acidified mine water, we visited 2011 the mine water treatment plant in Schleenhain, Germany.

Additionally, internal experts of the LfULG were invited to support the adaptation process. These experts work on the Project VODAMIN. This is a project that searches solutions for the purification of contaminated mine water. The results of VODAMIN are also included in SHARP. So there is possibility to exchange experiences of current methods to clean mining waters. During the SHARP meetings the Greek partners have also expressed their interest in this topic and the presented treatment methods and all project partners visited the mining area of Ptolomeida, Greece. Additional this topic is important for PP 6 (IMGW); during the study visit 2011 all project partners also saw the mine Turow and the mine water treatment plant.

Easily transferable methods (without adaptation) are the mine water treatment facilities, the presented “In Lake” method to neutralize the lake water and oxidative water treatment.

All other presented methods (passive/active techniques; geotechnical, chemical, physical, biological, microbial processes) are actually not state of technology and are at different stages of research. Depending on the actual stages the following steps have to be taken or fulfilled to successfully adapt the methods for the use in rehabilitation:

- Basic research.
- Applied research.
- Laboratory / Pilot plant test.
- Pilot test at the site.

Within the cooperation it was figured out, that project partners are now in different situations or stages of active as well as after mining activities and also political strategies make it difficult to bring the presented techniques into work in another project partner work within this three years of SHARP project duration. But within the SHARP project the main steps were taken, contacts were made and we provide a common basis for future work.

For further information please see detailed description in annex “Long version of good practices to be adapted reports”.

Literature

Reinigungsverfahren von Grundwasser und Oberflächengewässern, Endbericht Februar 2012, LfULG (Auftraggeber), DGFZ (Auftragnehmer).

4.1.2 GPA 2: Application of water balance models with respect to climate change

C. NIEMAND, C. GLÖCKNER & V. ROZAKIS

Involved Project Partners

Saxon State Office for the Environment, Agriculture and Geology (LfULG)
Region of North Aegean (RNA)
Region of Western Macedonia (RWM)

Concise description of the adapted good practice

Especially today where the predicted climate change calls for urgent adjustments to its impacts on a worldwide scale and poses new challenges on the management and prognostics of water resources, the following method is a good example for how to tackle this issue.

Particularly in times of climate change, it is important to know the distribution of water resources. For this reason the KliWES Project (Assessment of the impact of the climate changes predicted for Saxony on the water and material balances in the catchment areas of Saxon water bodies – Water Balance Section) were developed (see description GP 13 on page 44 of this Manual).

The technique based on a scientifically founded method or combination of several appropriate methods for the calculation of "complete" water balances (based on mean and/or day values) for any of the areas in Saxony, while offering the possibility to run and evaluate scenarios. The results can be used to classify catchment areas by their water balance's sensitivity to the climate change. In a second step, the results can be used to give region-specific management recommendations to ensure sustainable management of the surface and groundwater resources. The results will enable decision-makers to identify the areas in greatest need of adjustment strategies for water resources, agriculture and forestry. The results and recommendations are intended for a broad target group, namely engineering bureaus, industrials, administrations, institutional users, researchers and scientists, politicians and accountants, as well as to national/international bodies and citizens.

Resulting of projects such as KliWES the LfULG has much experience in the modelling of the water balance.

Characteristics of the good practice

In the following the procedure for modelling of water balance is explained step by step (for more detailed information see extended version – annex "Long version of good practices to be adapted reports").

A. Specification of input data and derivation of hydrological relevant system characteristics → Analysis and preparation of data bases;
B. Selection of suitable modelling approaches (soil water balance, groundwater etc.);
C. Modelling of the actual state of water and of future water balance considering the climate change to develop strategies for protecting natural water resources.

Description of adaption process

As described in the good practice KliWES, for the needs and demands of the Greek project partners, the first steps for modelling of the water balance in a Greek basin are presented in this paper.

To adapt the topic Water Balance Models to the Greek needs, a questionnaire was sent to RNA (PP 3). Within the 4th SHARP Seminar in Kozani in Greece in 2012 the Greek project partner (PP 2 and PP 3) expressed their interest in this topic. Therefore the further information about the KliWES Project and also the questionnaire was additional sent to them.

Steps for Adaptation

The approach of KliWES can be generally taken:

A. Specification of input data and derivation of hydrological relevant system characteristics → Analysis and preparation of data bases;
B. Selection of suitable modelling approaches;
C. Modelling of the actual state of water and of future water balance considering the climate change to development of strategies for protecting natural water resources.

But in some catchment areas, it isn't easy. The problem in the special case of the identified catchment area of Chios Island is that it is located directly on the coast and in a karst area with a lot of quantity and quality water problems (see extended version – annex "Long version of good practices to be adapted reports"). In KliWES there is no experience with catchment areas near the coastal region. Additionally it is complicated by the fact that it is a karstic region.

For this reason, experience from further projects could be used to support the Greek partners in the determination of the water balance and necessary management strategies.

In a subproject of the IWAS (http://www.iwas-initiative.de/), which is concerned with the water supply of a coastal basin (Oman), there are also problems related to groundwater salinization. It searches for methods, how the country will be irrigated, without negative impacts on water quality and quantity. With the help of models different scenarios can be calculated. In the report of IWAS with the title "Towards an integrated arid zone water management using simulation-based optimization" is written following:

"For ensuring both optimal sustainable water resources management and long-term planning in a changing arid environment, we propose an integrated Assessment-, Prognoses-, Planning- and Management tool (APPM). The new APPM integrates the complex interactions of the strongly nonlinear meteorological, hydrological and agricultural phenomena, considering the socio-economic aspects. It aims at achieving best possible solutions for water allocation, groundwater storage and withdrawals including saline water management together with a substantial increase of the water use efficiency employing novel optimisation strategies for irrigation control and scheduling. To obtain a robust and fast operation of the water management system, it unites process modelling with artificial intelligence tools and evolutionary optimization techniques for managing both water quality and quantity."

An initial discussion with the experts found that in regions such as Chios, an intensive monitoring of the aquifer is particularly important, especially in relation to the withdrawal quantities. These are very simple and can be measured with a relatively high reliability, which ultimately contributes to a more accurate and reliable determination of the water balance and the future helps to make the right management decisions.

At the moment, only those articles can be exchanged and contacts of IWAS Project can be provided. However, in a further collaboration after SHARP a detailed procedure could to be developed with the help of the project IWAS.

<u>Literature</u>

Good practice KliWES.

Towards an integrated arid zone water management using simulation-based optimization, Jens Grundmann, Niels Schütze, Gerd H. Schmitz, Saif Al-Shaqsi; Received: 31 January 2011/Accepted: 15 July 2011; Springer-Verlag 2011.

4.1.3 GPA 3: Online monitoring and DSS

H. KUPFERSBERGER, H. SCHMÖLZER, F. GUNDACKER, G. PROBST & S. SCHAFRANEK

Involved Project Partners

<u>Holding Graz GmbH – Services (HG)</u>
Region of Northern Aegean (RNA)
WATERPOOL Competence Network GmbH (WP)

Concise description of the adapted good practice

The continuous monitoring of water quality, and in particular within the current project of groundwater quality, is an essential task in (ground)water management. This task was typically dealt with by manually taking water samples for later analysis in the lab. This procedure is labour intensive, prone to errors with respect to appropriately taking and storing the water sample and leads only to snapshots of groundwater quality conditions (e.g. only two measurements per year) where it is completely unclear what impact of land use is actually observed. During the last decade various probes were developed beyond the prototype stage that applies different physical measuring principles (e.g. spectrometry) to infer water quality parameters.

A significant advantage of using probes to survey groundwater quality is the option of remote data transfer. Thus, the user can continuously follow the development of the parameter of interest, recognize failure of the system and initiate prompt correction and in the case of exceeding set thresholds (e.g. decisive events) organize for respective action (e.g. manual verification samples). As compared to the lab, typically, the water quality parameter is not measured directly by the probe but some surrogate value (e.g. absorbance of light at a certain wave length) is obtained that needs to be transformed to the desired water quality parameter (e.g. total organic carbon). Hence, to get useful results, a relationship between the two values has to be established. If the complete light spectrum is being recorded by a probe (maybe subdivided into different ranges of interest) multiple water quality parameters can be observed at the same time.

Space requirements of an online probe system depend on the overall probe dimensions and a potential controller unit. Moreover, sufficient space has to be considered for maintenance and manipulation tasks. All important data and meta-data collected by a probe should be accessible on the spot and by remote devices; if a transformer is in use, also raw data should be stored.

Consistent findings from experiences of several users reveal that sensors require only low maintenance efforts leading to low service costs, show a high life span and additionally provide high reliability and accessibility of data. For pH, turbidity, conductivity and oxygen probes it is being recommended to have a yearly technical inspection and recalibration done from the manufacturer. Optical probes should be cleaned weekly (by regular stuff) and being checked for recalibration and maintenance on a quarterly basis (by manufacturer).

Description of adaption process

In 2010 and 2011 the runoff hydro power plant Gössendorf at the river Mur was built next to the water work Feldkirchen. The Mur water level was raised up to 6 meters close to the barrage. To avoid major water seepage through the reservoir dams sheet piles were integrated that reach to the aquitard. Thus, the natural interaction between the two water bodies is interrupted. To compensate for this impact a controllable artificial groundwater drainage system for active groundwater management by 5 adjustable gates was built. The water level in the drainage system is controlled by 5 adjustable gates. If the gates are lowered the original discharge from the aquifer into the river Mur (in this case into the drainage system) can be simulated.

Moreover, also river bank filtration into the aquifer can be imitated by the drainage system. For this purpose a shaft was built at the beginning of the drainage system. The inflowing water into this shaft comes from an upstream urban area and thus may induce water quality risks. To control the quality of the inflowing water a probe for online monitoring is installed. If the water quality is sufficient, the inflowing water is forwarded to the groundwater drainage system and recharges the local groundwater. If not, the water is forwarded to a tight bypass pipe and diverted past the power house into the river Mur.

A s::can probe is installed in the shaft for analysing (temperature, conductivity, oxygen, nitrate and organic substances like TOC) of the inlet water coming from a sampling chamber. A central control system receives the data from the probe and operates the system (in this case slides for drainage system or bypass pipe) fully automated. On the circuit diagram the operating state of the system can be completely observed. All these measures were primarily implemented to simulate the groundwater situation in the water work Feldkirchen without the runoff river power plant Gössendorf. Secondary, it offers the possibility to provide active groundwater management since the groundwater level in the aquifer can be controlled.

In principle it has to be decided if several probes shall be ordered from the same manufacturer or if for each parameter the best ranked probes from different manufacturers should be installed. In the first case a central control unit can be installed which leads to the advantage that all data can be retrieved at one spot. In the case of maintenance or failure contact to only one company is necessary (and not several individual arrangements), which might be beneficial for small water suppliers. However, the performance of the entire probe system relies on this single provider.

4.1.4 GPA 4: Geothermal use of groundwater

C. Glöckner, C. Niemand, F. Gundacker & H. Schmölzer

Involved Project Partners

<u>Saxon State Office for the Environment, Agriculture and Geology (LfULG)</u>
Holding Graz GmbH – Services (HG)
Region of Western Macedonia (RWM)

Concise description of the adapted good practice

Because geothermal energy becomes more and more important, LfULG (PP 8) decided together with HG (PP 9) to exchange experiences about this topic. Using groundwater as energy resource or indirect influence to the groundwater by using the soils and rocks potential of geothermal energy seems to be a “green”, regenerative and sustainable energy resource. But this does not mean that it can be used everywhere and every time without regarding the risks and efficiency. The condition has to be well explored, calculated or well approximated and possible problems and risk have to be considered before using this energy. Especially the risk for the groundwater due to contamination that may occur, quantity and quality changes of the groundwater have to be taken into consideration and need further research.

Geothermal use of groundwater is an important and interesting issue within the SHARP project that was first figured out at the 2nd SHARP Seminar in Udine (Italy) in 2011 by Holding Graz (PP 9) and the LfULG (PP 8). For this, the current state of knowledge of both countries has been compiled to identify deficits and good practices that can be adapted or directly transferred. Within the 4th SHARP Seminar in Kozani (Greece) in 2012 the Greek partner RWM (PP 2) expressed their strong interest in this topic. Therefore also PP 2 had been involved to the working group and the additional exchanged knowledge (risk of use of geothermal energy) and the selected good practice (capacity maps) were chosen for their interests and conditions.

Before focusing on the selected good practice for transfer and the adaptation process, it is necessary to keep in mind the following potential risks and damages by using geothermal energy (for detailed examples see annex "Long version of Good Practices to be adapted reports").

Hydrogeological (hydraulic, hydro-chemical)

- **Geological** (corrosion, flowage, mineral processes and swelling, gas emission)
- **Geotechnical** (anthropogenic)
- **Technical** (anthropogenic)

The selected good practice that was chosen by RWM (PP 2) from the knowledge and experience of the donor partners (PP 9 and PP 8) is the method to develop capacity maps of geothermal energy (from PP 8).

An interactive map (http://www.umwelt.sachsen.de/umwelt/geologie/26631.htm), which is available on the web, represents the geothermal extraction rate so that statements to the geothermal potential are possible.

The capacity map is important to support planning of geothermal project in the near surface underground. The interactive map makes it possible to identify the geothermal available specific extraction rates [W/m] for different depths. In Greece, there are high potentials for the use of geothermal energy. To enable citizens to make it easier to use geothermal energy, the proposed map could be helpful. Thus, the potential builder can inform in advance if a geothermal system at a specific location is reasonable.

Description of adaption process

As already mentioned in introduction, the knowledge and experience were exchanged with PP 9. The experience and report of both partner shows that PP 9 and PP 8 are at the same knowledge and administrative stage for approval of geothermal use of groundwater and so both are donators. The work and the report were presented at the 4th SHARP seminar in Kozani. Due to this presentation and discussions around this meeting and at the 1st International Conference the Greek partner (PP 2) expressed their strong interest in this topic. They were interested in the report written by PP 9 and PP 8, but also asked to focus the subtopic capacity maps and risk of use of geothermal energy. For this reason in the adaptation process, the needs of the Greek partner have been considered.

Therefore a guideline for capacity maps – methodical process to develop a geothermal capacity map (see annex “Long version of good practices to be adapted reports”) was produced for PP 2.

The main obstacle in process of transfer is the shortage of time and resources. Taken into consideration that this is a very technical and time consuming purpose, it will take some time to put this good practice into service in the Region of Western Macedonia. However, PP 2 will do their best to transfer the information and knowledge of the methodology for the creation of capacity maps and to apply later on. All partners consider the continuation of the cooperation through a project dedicated to geothermal energy and water right proceedings this time.

4.1.5 GPA 5: SuDS and Groundwater

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Concise description of the adapted good practice

Introduction

Surface runoff in the urban environment is caused by precipitation falling upon impermeable surfaces such as roads and rooftops, and traditionally the general practice of urban water management was to transfer this water as quickly as possible from the point of origin to a local water course. Whilst this is an effective strategy at source it can cause fluvial flooding further downstream along with other negative impacts such as increased river channel/bank erosion, increased pollutant loads reaching water courses and resultant decrease in urban river biodiversity. In addition, the increased stress upon often aging piped sewer networks leads to leakage of these same polluted waters within the subsurface and subsequent contamination of groundwater.

Attempts to mitigate these flooding and water quality issues now focus mainly around the implementation of Sustainable Drainage Systems or SuDS (the equivalent of Best Management Practices in Europe). The rationale for these systems is the use of infiltration and retention structures that act to delay and reduce runoff volumes and associated contaminant concentrations that would cause a risk to the urban water environment. Experience in this field amounts to only 10 – 15 years and so European nations employ different strategies to regulate, encourage and install the various SuDS they employ. This report aims to contrast the UK experience to European examples, especially Germany where knowledge is advanced, in order to summarise general advice and guidance emerging with regard to SuDS and groundwater protection.

Legislation

In Germany the Federal Environment Agency funded a study to set up emission requirements for storm water discharges. These requirements dictate that discharge into receiving waters is to be limited by quantity as well as by solids load. Groundwaters have to be protected according to the soil conservation act (Grottker, 2003). On the Federal State level, some states demand that storm water infiltration is used as an important source control measure in new built properties and has to be preferred in comparison to conventional drainage systems. In North Rhine-Westphalia infiltration SuDS have to be considered retroactively in already existing drainage master plans (Ristenpart, 2003).

Funding programmes have also been set up for some technical measures in Germany. For instance storm water management measures (infiltration SuDS) are funded by some German states, municipalities or water associations. Funding ranges from 5 – 20 Euros per square meter of runoff producing area that is disconnected from the sewer system. North Rhine-Westphalia also funds the construction of wetlands to a significant degree. Emschergenossenschaft, like many other water associations charge a fee for connection to their trunk sewer network, which can be avoided by infiltrating or discharging the runoff water directly into the local river, provided the quality is satisfactory (Jefferies et al., 2008).

In this way, incentives are provided for disconnecting runoff producing areas from the piped sewer network.

SuDS are a very popular topic in urban drainage in Germany. Beginning with the first exemplary projects in the late 1980's, which already included investigations of impacts on groundwater quality, SuDS are now widely used in drainage planning. This approach is now being pursued in other European countries such as France, Switzerland and the UK.

In the UK, the use of SuDS as an alternative to these traditional water management techniques has been promoted by Policy Planning Statement25 (HMSO, 2010b) since its publication in 2001. However it wasn't until the exceptional rainfall events of 2007, during which 48000 homes were flooded, that changes to legislation were considered. Following this, DEFRA launched the Government's 'Future Water' strategy for England and Wales in 2008 which called for sustainable management of surface water, which included facilitating water re-use, storage and infiltration into the ground to decrease the reliance upon traditional drainage systems. To facilitate this change, the strategy advocated a shift in policy to withdraw the automatic right for developers to connect to the drainage system (Dearden, 2010).

In 2011 DEFRA published National Standards which provide guidance on the suitability of sustainable drainage techniques for particular site conditions and/or development types. The National Standards contain a drainage hierarchy that states the types of drainage techniques that must be considered in order of priority, namely that the installation of infiltration SuDS should be prioritised, followed by those that discharge to a water courses and finally, by those that discharge to the sewer network. This effectively requires that every new development considers infiltration to the ground before other SuDS techniques (Dearden, 2010). In Scotland the sustainable drainage legislation requires that new developments should pass their drainage water through sustainable drainage systems, where surface water is released to the water environment (with exception for single dwellings and discharges to coastal waters).

Legislation is similar between Germany and the UK, in that the switch in emphasis from pipe based sewers to infiltration systems is now enshrined in law, but there are some important differences. UK legislation only applies to new developments (or redevelopments of brown field sites) whereas German law, at least in a few federal states, demands the retroactive consideration of SuDS to already existing drainage solutions.

Description of adaption process – Examples of success

SuDS ponds are an important type of sustainable drainage solution in the UK, particularly in Scotland where they have been constructed since the mid 1980's, due to the widespread occurrence of low permeability soils that limit the rate of infiltration and the wet climate. SuDS ponds are primarily designed to attenuate runoff, and an example discussed by McLean (1998) demonstrates the success of these structures in fulfilling this role within an urban drainage context. However, evidence also exists to show ponds can improve runoff water quality both in terms of heavy metal concentrations and microbiological content, as described in measurements taken from sites in and around Dunfermline (Heal, 2004).

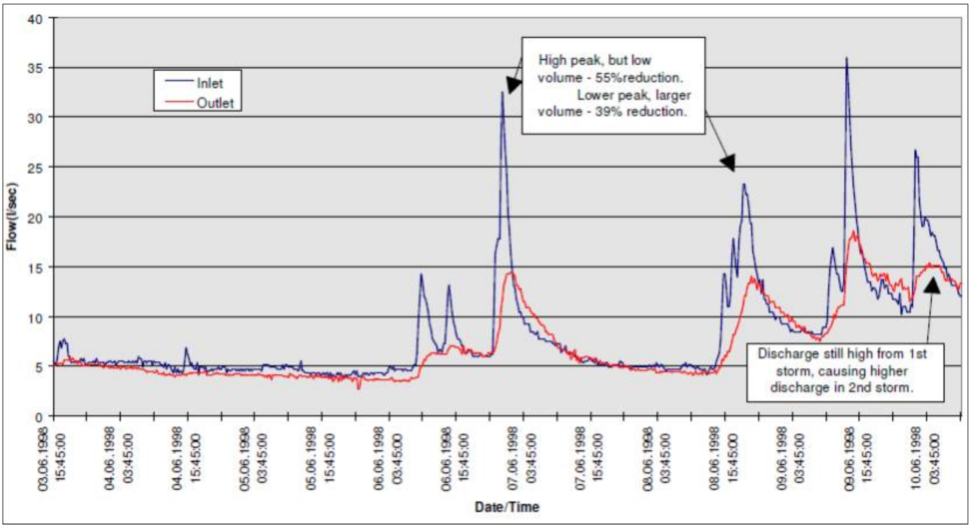

Fig. 6: Flow attenuation during a storm event at Claylands Pond, Edinburgh (after McLean, 1998).

Ellis ,(2006) provided a summary of studies into European infiltration performance and highlighted the work by Wild et al. (2002) who assessed the performance of highway filter drains in Edinburgh and reported ranges in mean runoff values of 42%, and although pollutant removal rates were highly variable, solids were reduced by 75%; and a study by Newman et al. (2002) into the removal of grease and oil by a porous paving system and found effective hydrocarbon degradation (up to 90%) over a 4 year operational period.

A German example by Dierkes et al. (1999) examined the distribution and fate of highway pollutants on adjacent verges and embankments. They found the highest concentrations were located within the uppermost 5cm of soil and within 2m of the highway. Mineral hydrocarbons were noted to have degraded but Poly-aromatic hydrocarbons accumulated within the upper 10cm of soil. Their recommendations were for the removal of the upper soil layer as hazardous waste.

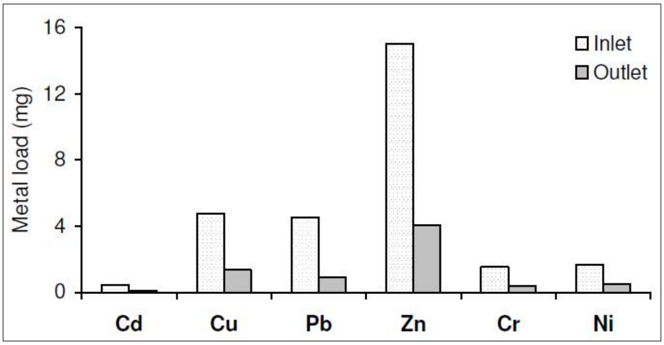

Fig. 7: Heavy metal loads at the inlet and outlet of Stenton Pond, near Dunfermline (Heal, 2004).

Examples of failure

However, a body of evidence exists for examples of failed SuDS schemes, and infiltration SuDS that have not functioned as intended by design. In a study by Schluter and Jefferies (2005) where they assessed the performance of SuDS systems at 43 sites in Eastern Scotland, they found that almost 50% of the systems were unsatisfactory, and over half of these were rated as having failed. Reasons for this poor performance were found to be partial or complete blockages caused by poor or absent maintenance and construction runoff. Also highlighted was the presence of high level bypass or overflow mechanisms.

Swan (2010) describes a water company opting for a conventional in-sewer option to rectify flooding problems within a catchment which will be sited immediately adjacent to a redevelopment site that will include a runoff solution involving sub-surface storage; a potential inefficient use of resources and a missed opportunity to implement a single infiltration-based system to serve both purposes within the catchment.

Recommendations

One of the key lessons emerging from the experiences of practitioners in the UK, Germany and other European countries, is that maintenance of SuDS is a key aspect of their continued efficiency that is currently being overlooked. Some differences exist between Germany and UK in terms of the types of SuDS used and the legislation enacted in order to protect groundwater, but both are now striving for development along very similar lines.

Namely, the promotion of the importance of SuDS maintenance to ensure maximum operational efficiency; the advocacy of more long term study into the performance of SuDS structures in order to fully understand the performance and maintenance requirements of these systems; and perhaps most importantly, the need to move toward a more holistic, integrated approach to the planning, development, and implementation of urban drainage solutions in order to mitigate the negative impacts urban runoff can have on the water environment.

4.1.6 GPA 6: How to engage with key stakeholders

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with participation of all project partners

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Region of Western Macedonia (RWM)
Region of North Aegean (RNA)
Regional Agency for Rural Development of Friuli Venezia Giulia (ERSA)
Local Councils' Association (LCA)
Institute of Meteorology and Water Management (IMGW)
Saxon State Office for the Environment, Agriculture and Geology (LfULG)
Holding Graz GmbH – Services (HG)

Concise description of the adapted good practice

The most important characteristics of engaging with key stakeholders are good communication skills and clear information. This adapted good practice is relevant to International Resources and Recycling Institute, as its expertise lies in strong project management, dissemination of project results, and project communications. International Resources and Recycling Institute is partner in many strategic level European Projects, and has extensive experience of engaging with a variety of stakeholders at different levels. Learning how to successfully engage with key stakeholders will equip project partners with the skills to forge links and develop relationships with key regional, national and transnational stakeholders, allowing the SHARP project to have a tangible effect on groundwater management in their region.

Description of adaption process

The SHARP project has identified three main groups which partners should strive to engage, and work with in their respective regions:

1. Policy-makers (national/regional).
2. Transnational/European policy makers.
3. Urban development and spatial planners.

In order to engage with policymakers on groundwater related issues, IRRI propose that all partners take the following **7 steps**:

1. Check the regulatory planning and policy frameworks relating to SHARP in your region and report briefly on the existing situation including barriers and issues.
2. Identify the key decision-makers in forming planning and policy frameworks in the region.
3. Make contact with the relevant personnel and introduce the SHARP partnership.
4. Explore decision-maker and planner's views on current planning and policy frameworks and the anticipated changes in the near future.
5. Understand mechanisms for change and how change happens.
6. Explain how national Government decisions relate to transnational programmes such as SHARP, and how the initiatives considered in SHARP should be reflected in any changes in national policy. National Governments invest taxpayer's money in both. In other words, national decision-making and transnational ideas must be coordinated. Otherwise the tax-payers money is wasted because the value of the taxpayer's investment in EU programmes is ignored.
7. Ask to be included in all future policy discussions concerning change in planning and policy regulations.

Whilst engagement with key stakeholders is important, it may not always be easy, and there are common obstacles that partners may encounter when approaching stakeholders. There are ways around these obstacles however, and it's important to be persistent in these situations.

<u>Partners may find that stakeholders are difficult to get in contact with or unavailable.</u>

These are busy people, consequently it is important to make contact as soon as possible. Persevere and attempt to be flexible in finding a time to meet. Meeting face to face is the best option, however if this is not possible contact via telephone or Skype may be a practical alternative.

Partners may find that stakeholders are unaware or uninterested in issues relating to groundwater.

This is your opportunity to inform and hopefully inspire people in a position of power into action. Try to be positive and engaging. Inviting stakeholders to regional events you are hosting is a good way of introducing them to the project.

Partners may find that stakeholders do not understand groundwater issues.

It is unlikely that the stakeholders you make contact with will be water experts. As a result they may have little or no understanding of issues relating to groundwater. Use clear, concise language which involves the stakeholder in the process, and where possible, use real life examples or diagrams to help clarify what you are trying to say.

Partners may find that little comes of their conversation with stakeholders.

Follow up on any actions set out during your meetings. Provide the stakeholder with further information on what you have discussed, this will provide a more detailed understanding of the issues and will also act as a prompt.

Remember, groundwater policy and planning exists and requires regulation and implementation. If it is not actively on the policy agenda in your region, it should be. Water is the single most important issue among the modern world's resource challenges. There MUST be people in your region concerned with policy and planning regarding groundwater.

4.1.7 GPA 7: Drinking water safety plans

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Concise description of the adapted good practice

Drinking Water Safety Plans are a means for reducing the risk of contamination in water supplies.

Drinking water is our most important necessity. Therefore high standards are made on water supply services regarding hygiene, security and protection of resources. Drinking water is vital for all humans, thus it has to be available in the highest quality and adequate quantity. A secure and reliable supply of drinking water is an essential basis for health, prosperity and a well performing economy.

The operator is in charge for a correct operation of a water supply installation and for hygienic drinking water. The operator of a drinking-water facility has to assure through his quality assurance actions, that the water quality meets the legal requirements for drinking water at all times.

The high quality of drinking water only can be ensured by preventive quality assurance and permanent quality control. Influence coefficients and changes of the physical / chemical/ microbiological condition as well as of technical relevant parameters have to be detected early and – if necessary – avoided.

Many principles and concepts of the HACCP – method (Hazardous Analysis and Critical Control Point), which is implemented in the rest of the food industry, are suitable tool for the implementation of a product- and process-orientated quality-management-system, with which regularly all processes of a water supply service can be checked and improved. Hazard-identification and risk evaluation are the first steps necessary for a management system.

Due to these facts, the Austrian Association for Gas and Water (OVGW) has developed the Guideline W88 for the implementation of water safety plans in drinking water facilities in 2008, following the recommendations of the WHO. The guideline defines the terms hazard identification and risk evaluation, which mark the starting point for setting up a system management. If required, this guideline can be extended to an all-embracing management system for the whole utility. This guideline particularly applies to small drinking water facilities.

The DWSP approach is relevant to all bodies responsible for extracting water or delivering water supplies to consumers or industries because there still remains the potential for waterborne illness across Europe. Although in Europe there has long been final water and consumer tap testing, this does not verify water safety at all times for every risk. Therefore a comprehensive risk assessment and risk management approach is the most effective means of monitoring drinking water. The plans aim to address the previously identified imbalance in legislation and policies which only focused on Water Treatment Works (WTW) with very little intervention at the raw water catchments.

Scotland has been developing the concept of DWSPs since 2003 when the Water Environment and Water Services Act were introduced. This helped to implement the Water Framework Directive and developed the basis for developing DWSPs. Since the Guideline W88 has been published, a few ambitious water suppliers in Austria have successfully implemented DWSP's.

Clearly Scotland has seen considerable success in gaining acceptance of the DWSP process and has overcome the potential difficulties such as:

- Gaining Scottish Water approval for the resource implications for developing DWSPs (staff time and costs).
- Gaining support of the associated bodies and in particular developing the Memorandum of Understanding between DWQR, SEPA and SW.
- Reviewing the results of the trial projects in Scotland, notably at Papa Westray, Scottish Water have stated that there is considerable benefit in the "use of a generic WSP for small supplies that covers particular types of treatment as long as differences in hazards in the catchment and other specific differences can be taken into account".
- DWSPs are likely to highlight the issue of de-manning and provide a means of assessing when manpower has reached critical levels for assuring safe supplies. They will however, provide a means of knowledge capture that will aid flexibility and will potentially provide savings by preventing the need for constant reaction to problems after they have occurred. Scotland has now developed considerable experience in this area.

Description of adaption process

Given that the initial stimulus for DWSPs comes from the WHO and there is potential for Europe wide legislation to introduce DWSPs as a possible part of a revised EU Drinking Water Directive, there should be positive reception in all EU countries.

The first step to transfer may be for each partner to contact the national, regional or local water body responsible for providing water.

Second, the water provider should contact of the responsible drinking water regulators.

Third, the partner should organize a workshop involving the national stakeholders to outline the work that has been undertaken relating to DWSPs.

Finally the partner will use the SHARP project to advise their relevant national, regional and/or local bodies of the benefits of DWSPs and how it can be introduced in their own area by way of trial.

The acceptance of the new approaches of quality and risk management by drinking water providers can be raised by supporting them with useful and handsome instructions like the OVGW Guideline W88. With clear work instruction in eight steps – illustrated with examples and supplemented with sample forms – this guideline is a reference for setting up a system for self-checking.

The implementation of water safety plan starts in the first two steps with an inventory of technical, organizational and personal conditions of the water supply. Within the following four steps that range from detecting potential risks to setting up measures for risk control the potential risks should be evaluated (risk assessment) and controlled. The basis is formed by the HACCP method. According to the HACCP method measures are determined for all relevant parts of a water supply those locations or processes, which assume greater risks to drinking water quality. In some cases it will be possible to eliminate individual hazards with one-off measures. Where this is not possible, the risk can be reduced by other preventive measures, e.g. with maintenance and repair or with continuous monitoring of critical points. Therefore the remaining hazards are controlled. Two further steps ensure that the QMS is practiced, documented and periodically adjusted or improved, in everyday life.

Especially for Karstic regions like the Region of North Aegean special measures have to be taken to save on hand the water quantity and quality and, on the other hand, to establish monitoring processes for the resource's protection. Latest discussions, also in Brussels, are attempting a new approach for source protection. Based on vulnerability and hazards analyses, combined with modelling systems, risk assessment is taken for identifying sources' hazards. This ensures the creation of protection zones which ensure the maximum protection of the resource. The elaborated GPA Drinking Water Safety Plans allows an easy implementation of measures, which have to be taken, to protect those vulnerable sources.

Tab. 4 shows the individual steps (OVGW Guideline W88).

Tab. 4: Procedure for the implementation of a QM system in a water supply.

Step	Content	
1	Organization of water supply company description of duties and expertise of employees.	System structure
2	Creating or updating the inventory of the entire water supply system.	
3	Looking for possible hazards of water supply evaluate and list the critical points.	Appraisal , Risk Assessment
4	Implementation of one-off measures to eliminate or reduce hazards.	
5	Creating or updating instructions for maintenance.	
6	Create instructions for control of critical issues.	
7	Follow instructions in everyday life and monitor and evaluate results.	Practice system
8	Preparing annual assessment on water, facilities, processes and proposals and implementation of the organization and improvement.	

4.1.8 GPA 8: Transboundary issues

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Concise description of the adapted good practice

Institute of Meteorology and Water Management National Research Institute Wrocław Branch (PP 6) is actively involved in bilateral cooperation on boundary waters with Germany and the Czech Republic and International Commission for the Protection of the Odra River.

Due to involvement of IMGW-PIB in the activities related to cooperation on boundary waters, the adaptation "Transboundary Issue" was proposed with the aim to develop recommendations and guidelines for solving cross-border problems and to create a common model of cooperation in cross-border areas. Adaptation has been developed jointly with LfULG (PP 8) and RWM (PP 2). IMGW-PIB prepared a working structure for adaptation.

Main most important characteristics of transboundary issues are:

- Common approach and Joint Management Plans;
- Identifying common objectives, principles and definitions;
- Common management tools and measure programs;
- Calculation of the water balance of the whole transboundary basin;
- Inventory of current and future water needs in the transboundary basin;
- Ensuring cooperation between countries with the necessary institutional and legal arrangements;
- Recording of the current state of the environment;
- Development and adaptation of a management model to manage the quantity and quality of water resources taking under consideration the cooperation principles of all countries involved.
- Promotion of economic and environmental cooperation in the region.

Relevance to the donor partner

Transboundary Issue is most relevant for all partners but especially for PP 6 and PP 8.

Both partners are mostly involved in the work on several international and transboundary commissions. PP 6 and PP 8 have worked together on bilateral cooperation on the Odra basin since many years. At present, the cooperation in the scope of water management on the boundary waters with the Federal Republic of Germany is based on work plans and schedules of their realization, which are prepared annually. The realization of these tasks is managed bilaterally by the Committees supervised by the Ministers.

Existing know-how of adaptation was elaborate according to the following points:

1. Identification of legal basis and existing cooperation principles in project partners' countries.
2. Description and analysis of the scope of cooperation in project partners' countries.
3. Characteristics of the main problems and benefits of border cooperation in water management.
4. Description and characteristics of the problems during implementation the Water Framework Directive.

5. Examples of the jointly developed projects concerning the issues of groundwater management on transboundary water.
6. Collection and summary of cross-border problems.
7. Develop of recommendations, guidelines and a common model for cooperation on transboundary waters.

IMGW-PIB and LfULG presented several examples of schemes of good cooperation at levels of international and bilateral commissions. These schemes have been basis for PP 6 to elaboration common model of cooperation. Large experience of PP 6 in international cooperation led to the development of guidelines for good cooperation on transboundary waters.

The benefit of this adaptation is common model of cooperation, recommendations and guidelines for solving of transboundary problems. This model and the experience of PP 6 and PP 8 on the transboundary cooperation can be useful for PP 2 and all partners for good cooperation and solving transboundary problems.

Proposal of guidelines for good cooperation on the transboundary waters:

1. Establishing cooperation on transboundary waters with the relevant institutions, experts etc.
2. Exchange of information on: the quantitative and qualitative water resources state, planned investments in the border area and discussion about conflicts and problems.
3. Developing and signing of a joint agreement on the management of transboundary water resources.
4. The creation of the committee which will be responsible for the implementation of the statements contained in the agreement.
5. Appointment of members of committee, permanent and temporary working groups and external experts.
6. Establishing rules for cooperation.
7. Establishing a schedule of meetings of committee, working groups and expert groups.
8. Preparing reports on the progress of the committee and working groups operations.

Main benefits of the transboundary cooperation are:

- Economic growth. Reconcile the demands of different sectors for socio-economic development;

- Environmental protection across ecosystems can be regarded as a whole and not partially;
- More effective flood-drought management,
- Achievement of ecological stability of transboundary water resources;
- Facilitating more effective research in the field of biodiversity values, nature conservation and economic prosperity;
- Bringing economic benefits to local economy.

Description of adaption process

Steps for a potentially successful implementation:

1. Establishing a legal basis for cooperation in cross-border regions and the signing of a cooperation agreement.
2. The creation of appropriate structures and institutions at regional, national and cross-border levels determining the sustainable development and management of transboundary waters.
3. Intensification of cooperation between countries through meetings and exchange of experience.
4. The creation of a joint integrated management of transboundary basins in accordance with the requirements of the WFD – international committees.
5. The exchange of information and joint monitoring and evaluation of water resources in the cross-border area.
6. Local community participation.

PP 8 (LfULG) is also actively involved in bilateral cooperation on transboundary waters with Poland and Czech Republic. LfULG presented schemes for these international commissions.

PP 2 (RWM) – in this region main transboundary water resources are Lake Prespa and aquifers. The Prespa Lake is a natural area of international importance with geomorphological, ecological, biodiversity and cultural significance. Greece has signed an agreement (but not yet ratified) with Georgia, FYROM and Albania, covering issues related to sustainable management of transboundary waters, and monitoring of water pollution. Greece and Albania have also signed an agreement on the Establishment of a Greek-Albanian Commission on Transboundary Freshwater Issues. PP 2 collected and summarized cross-border problems.

Main problems on the implementation of transboundary issues:

- Different laws, policies and protected area systems and powers of management authorities;
- Different political and administrative structure;
- Different stages of economic development and policy;
- Difficult terrain, inaccessibility and lack of transport;
- National, political or cultural differences – misunderstanding;
- Language barriers;
- Different know-how, technology and technical standards;
- Different funding regulations.

Experience has shown that in the development of cooperation, it is usually positive to adopt a step-by-step approach. This approach contributes to the establishment of mutual confidence. If cooperation seems a better alternative than non-co-operation, transboundary water management will progress. Traditionally, transboundary water resources management in Europe is started with the development and implementation of international “agreements”.

4.1.9 GPA 9: Use of DSS for strategies of groundwater resources management

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Concise description of the adapted good practice

Improvement of techniques that are used to sustainable management and protection of groundwater resources is one of the main objectives of the SHARP project. Currently, one of the most advanced techniques for water resource management is decision support systems. Earlier, the interest of specialists was directed for the exploration and documentation of groundwater resources, but now attitude is changing and the main emphasis is turned to the resources management to protect the quality and quantity. For this purpose, the water management systems are created, that include a wide variety of issues and processes, involving many techniques used in hydrogeology.

The primary objective of the informatics system, which is a decision support system, is to provide information that is necessary to decide on a specific management level. DSS allows the user, by changing the parameters, to study the impact of decisions on the conditions of the modelled object (system) to choose the most optimal action scenario. The main aim of works done within the SHARP project was the good practice transfer by providing a common model of creation of DSS and guideline which could be adopted by ERSA (PP 4) and other partners institutions and regions.

IMGW-PIB deals with many aspects of water resources management. Methodology has also been developed to create decision support systems for water resources management, delivered in the form of a manual, entitled "Decision support systems in water management", [Gromiec et all, 2006].

Both partners have experience in the field of decision support systems.

The example of DSS carried out in the IMGW-PIB concerned a closed and reclaimed municipal landfill, where a network of measurement-observational points was established. System allows a combined use of visualization tools with database files and is a useful tool for project management of environmental protection of groundwater.

Presented by Italian Partner a simple DSS is a web-based tool aimed to disseminate codes of good agriculture practices to the farmers, with special emphasis on the reduction of nitrates of agricultural sources as well as on sustainable farming.

Providing a common model of creation of DSS and guidelines include the steps of the DSS creating, which could be adopted in PP 4 and other partners institutions and regions. The use of DSS enables more effective management of groundwater resources, which will allow a faster achievement of environmental objectives and possible benefits in economic terms. Using the tool “Decision Support System” by facilitating decision-making process in the management of groundwater resources allows a better protection of groundwater, both in terms of quantity and quality.

Description of adaption process

To potentially successful transfer of the selected approach, we have to follow the guidelines elaborated during SHARP Project realization. The elaboration procedure to create and implement a decision support system for groundwater management shall include the following stages: data collection process, selection of tools that will be useful to achieve the objective, analysis, evaluation of results, decision concerning the management of groundwater resources.

Partner 4 (ERSA) added to the jointly developed guidelines and scheme aspects, in which IMGW (PP 6) is not involved, namely risk analyses and hazard indexes in order to asses potential pollution of the groundwater resources. PP 4 also paid an attention for interesting issues such as vulnerability maps, urbanization and mitigation measures, degree of water abstraction, possible intervention to restore the primitive conditions of groundwater bodies to counteract pollution events.

Obstacles in the transfer of the described methodology may be:

- a significant technological advancement of decision support systems, which require the use of very sophisticated tools, which involves the participation of highly qualified staff;
- high costs of applying the DSS – the use of complicated tools require buying of expensive commercial software or ordering of execution software, specifically tailored to the requirements of developed DSS;
- different know-how;
- too high expectations of end users to the results obtained by the use of DSS;
- lack of or difficulty in obtaining data, maps and other input elements to DSS;
- significant labour consumption applied solutions.

The easiest way is to simplify the implemented model, which both reduce the costs, labour consumption and the number of input data that will be needed for the planned solution implementation.

A thorough market survey should be carried out with respect to price and possibilities of software available in the market. And then choose a cheaper solution, with the same technological capabilities or use free software such as the use of GRASS GIS instead of commercial software, such as ArcGIS and MapInfo.

4.1.10 GPA 10: Groundwater modelling development and verification

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Concise description of the adapted good practice

Numerical modelling in water management in all EU countries allows the understanding and schematization of processes occurring in ground and water environment. It allows exploring the effects of human impact on the environment.

Modelling requires an understanding of the processes and phenomena occurring in the system, and the proper approach by merging the knowledge of hydrodynamics and the possibility of computing software. Regardless of the type of tools to schematization water circulation conditions used by specialists in different EU countries, numerical models are developed mainly in order to: characterize the groundwater circulation conditions, evaluate the amount of water resources, assess the anthropogenic impact on groundwater (e.g. mining), predict the drainage, designation of protective zones for water intakes and contaminant migration.

The use of modelling tools is the final stage of simulation studies. In the first place, it is important to develop a conceptual model, the choice of computational procedure depending on the complexity of the task and the detailed diagnosis of the actual geological and hydrogeological conditions of the analysed area.

For the purpose of adaptation implementing, the knowledge concerned the hydrogeology modelling was gathered among the project partners, and on its basis a procedure for the development and verification of hydrogeological models was jointly elaborated.

In Poland, the first simulations were performed on the basis of physical models that allowed recognizing the relationship between parameters of filtration by restoring the system characteristics in laboratory conditions, while maintaining the scale.

In Poland, MODFLOW program is used in 80% of cases in using methods for the numerical modelling of the hydrogeological processes. Less commonly used are programs such as FEFLOW, Groundwater Vistas, MT3D, GMS and FLOWPATH. Locally original numerical solutions are applied, however usually limited to individual projects.

In IMGW performed numerous works related to the modelling of the water cycle, water resource management and quality of water resources. Some of these elaborations concerned the groundwater modelling.

All partners more or less do the work associated with the hydrogeological modelling. Details relating to the used solutions are available by the project partners. The general outline of the used methods is contained in elaborated adaptation.

In Saxony, in addition to commercial software, original programs are widely used. Models can be divided into those that represent the unsaturated zone and those that represent the saturated zone (groundwater).

Many modelling codes are implemented in the UK and vary depending on the topic of investigation, and the experience and financial resources of the individual/organization conducting the work. Finite difference models such as MODFLOW are used widely amongst groundwater practitioners, but increasingly newer finite element codes such as FEFLOW are becoming available.

As for the state of the art in the Region Friuli Venezia Giula, at the moment an overall mathematical conceptual model has not been developed yet for the territory. In 2011 a comprehensive and quantitative balance of the groundwater resources of Friuli Venezia Giulia has been published. Other modelling applications available in Italy are dealing with irrigation and related topics.

Transfer by providing a guideline discussing purpose of constructing numerical models, what types of models exist and where sources of information for modelling can be found.

Following this guideline provides the basis for creating a tool for useful prognoses of measures to protect groundwater resources.

The benefits of implementing adaptation “Development and verification of groundwater modelling” are to:

- enable the performance of rational water management based on modelling results;
- enable a diagnosis of the state of the aquatic environment;
- determine the scale of the anthropogenic impact;
- allows defining groundwater resources.

The main benefit of the developed adaptation is establishing and development four steps of procedure concerned the development and verification of the models and the preparation of the scheme transferable to the other countries/areas.

Description of adaption process

To the potentially successful implementation the procedure of the construction of numerical models and performing simulations and further verification was created, which should be divided into four stages:

1. Understanding the real system.
2. Schematization of aquifer system.
3. Tool selection and model construction.
4. Application of the model.

<u>Experience with other models</u>. Contribution of each of the co-partners may be their previous experience in the use of numerical models.

<u>Experience of cooperation with decision-making bodies</u>. Contribution of each of the co-partners may be their previous experience with the transmission of the results of numerical modelling for the government entities involved in water management.

The main problems related to the implementation of adaptation in the form of the development and verification of groundwater modelling are:

- financial aspects (cost of software and work of someone with experience in modelling groundwater);
- time-consuming process of data collection and preliminary work;
- participation of experts in the interpretation of results.

To reduce the costs of modelling works a simplifying of the model structure is needed: increasing generalization of the model, reducing the number of layers of the model (if possible). Simplifying the modelling assumptions can lead to the possibility to select less complicated, less expensive software. Using less complicated software may entail further benefits associated with easier building of model structure and less time-consuming and also can result in not having to hire external experts to solve problems related to modelling work.

4.1.11 GPA 11: Development of groundwater monitoring for anthropogenic transformed areas

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Concise description of the adapted good practice

Legal requirement for EU member states recommended having monitoring networks to assess the quality and quantitative status of groundwater bodies. Many large industrial sites require monitoring schemes to be developed and maintained as part of the risk and environmental assessments. These monitoring schemes are designed to find an occurrence of contaminants leaching from these locations and to provide early warning of failures which can be remediated. Monitoring networks will be needed to detect the effects of climate changes such as long term changes to groundwater levels caused by sea level rise and salt water intrusion or changes in recharge rates and distribution as a result of changing rainfall patterns.

This monitoring provides data and information processed for the assessment not only for the status of water but also can be the basis for making decisions regarding water management. The monitoring could be important for water and environment protection, including aquatic and water-dependent ecosystems. Monitoring of groundwater is therefore an important element for achieving the main objectives of the Water Framework Directive, by influence of analysis of monitoring results on the economy and protection of water resources, determination of groundwater resources changes.

Implementation of adaptation in form of Development of the groundwater monitoring network in the anthropogenic transformed areas by IMGW-PIB (PP 6) was carried out for various government institutions.

PP 6's experience over several decades has been gained through realization of the many research and engineering reports, assessments and elaborations. E.g. "Impact assessment of the Berzdorf mine reclamation on the water balance in the valley of the Lusatian Neisse", "Preliminary study on the impact of the planned expansion of Jänschwalde Nord mine on water resources", "The report – monitoring of Lusatian Neisse", "Groundwater monitoring in the impact area of German opencast mines located along Lusatian Neisse for the Polish-German bilateral commission for cooperation on boundary waters".

Existing know-how

Examples of the implementation of adaptation: Development of the groundwater monitoring network in the anthropogenic transformed areas using the results obtained from the functioning of the groundwater monitoring network in the UK and Austria.

Cardiff is the UK's best example of a monitoring network. It was designed specifically to monitor for a potential increase in groundwater levels as a result of the construction of the Cardiff Bay tidal Barrage London. Though the network now contains hundreds of monitoring sites, only 58 contain records that extend back more than 10 years, and along with the Cardiff Barrage network, indicate the lack of long term systematic monitoring data within in the UK. Both of these networks were designed primarily to prevent damage to structures from increases in groundwater level.

The Scottish Environmental Protection Agency (SEPA) has maintained Scotland's national groundwater monitoring network since 2000.

Glasgow: A monitoring network has been created in Glasgow from a subset of boreholes sunk as part of numerous regeneration schemes in the East end of the city. Though they weren't drilled purposely for the network, the quality of construction of those selected is such that accurate and useful data can be gained from these monitoring points.

Monitoring of the impact of the runoff power plant Gössendorf on the Mur aquifer (Graz-Austria). In case of the Graz Holding (PP 9) the anthropogenically transformed area is linked to the building of a runoff hydro power plant at the river Mur south of the city of Graz.

Benefit (added value) of adaptation

IMGW developed an organizational scheme of setting up a groundwater monitoring system for anthropogenically transformed areas.

Other Partners or the institution from their regions will take advantage by comparing their current monitoring system to the suggested scheme potentially finding aspects that have not been considered in their system so far.

The main benefits of implementing adaptation are:

- enabling the conducting of rational water management based on information about variability of the formation of water levels in the system anthropogenically disturbed,
- informing crisis management, national water management boards and international committees about extreme phenomena concerning groundwater,
- enabling a diagnosis of the water area environment and develop forecasts for direction and rate of hydrogeological conditions changes,
- conducting a comprehensive monitoring of the aquatic environment (including the observation of groundwater) in the anthropogenically transformed area is also important because of the environmental and socioeconomic aspects,
- observation of the impact of mine or other huge water users drainage systems and therefore the observation of depression cones development,
- performance (based on data of surface and groundwater monitoring) hydrodynamic model for the area transformed by human activities,
- determination the disposable resources and principles of their allocation.

Discussed implementation of adaptation in the form of Expansion of the groundwater monitoring in the anthropogenically transformed areas is specified organizational pattern (based on good practice – Systematic monitoring of surface and groundwater in the mining areas previously presented to the SHARP partners), which can be used in the countries of SHARP project partners. Future users will receive detailed description of the method. Developed concept monitoring concerned the minor modifications, which take into account the environmental conditions of land (the hydrogeology, land use, hydrography etc.), can be used to create a monitoring system to other anthropogenically transformed areas.

Description of adaption process

For the potentially successful transfer of this adaptation are necessary:

- the assessment and analysis of the potential threat of groundwater in anthropogenically transformed areas,
- evaluation of needs and benefits of groundwater monitoring networks user,

- analysis of the proposal of the monitoring network extension,
- acquiring information about the specifics of the area and existing anthropogenic impacts,
- identify of stages, scope and extensive zones of groundwater monitoring network,
- implementation of works related to the development of monitoring networks including: the location of observation points, establishing ownership of land, preparation of technical design, construction observation points,
- verification of extended groundwater monitoring network.

The project partners have presented examples of existing groundwater monitoring network in the anthropogenic transformed areas. IRRI (PP 7) has presented information on the monitoring of the Cardiff dam, London and a network of groundwater quality monitoring carried out by SEPA. Partner PP 7 could present the development of enlargement of monitoring network in anthropogenically transformed areas, especially in the area of open pit mines. However, HG (PP 9) has presented monitoring of the impact of the runoff power plant Gössendorf on the Mur aquifer. PP 9 realizes numerous observations of groundwater used for drinking purposes. PP 9 can also use the presented approach for further work related to the following observation of groundwater particularly in anthropogenically transformed areas in Austria.

The main problems related to the implementation of adaptation are:

- financial aspects (significant costs associated with establishing and functioning of the monitoring network),
- the availability of locations for monitoring points in a selected area,
- time-consuming process of data collection. Before starting the monitoring network or before expanding it, it is necessary to detailed analysis of all available archival data in a wide range (geological structure, geological cross sections, hydrogeological structure, hydrography, natural values of the area, meteorological conditions, user review of both surface water and groundwater, land use etc.),
- number of monitoring points. Monitoring points that should be evenly spaced and should be representative,
- participation of experts in interpretation of results. The dynamics of groundwater is estimated based on measurements and interpretation of water level fluctuations in monitoring points. Reliable expertise (analysis) are particularly important, especially with the current approach of the governments of all countries of the European Union

aimed at sustainable management of natural resources, and thus with an emphasis on protecting the quality and quantity of natural resources for future generations,

- vandalism.

4.1.12 GPA 12: Raising awareness on different levels

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with participation of all project partners

Involved Project Partners

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WATERPOOL Competence Network GmbH (WP)
Region of Western Macedonia (RWM)
Regional Agency for Rural Development of Friuli Venezia Giulia (ERSA)
Local Councils' Association (LCA)
Institute of Meteorology and Water Management (IMGW)
International Resources and Recycling Institute (IRRI)
Saxon State Office for the Environment, Agriculture and Geology (LfULG)
Holding Graz GmbH – Services (HG)

Concise description of the adapted good practice

Using Environmental Education and strategic participation as well as implementation as a tool to raise awareness at several levels.

The purpose of Environmental education is that individuals and social groups understand the relationship between humans and the natural environment, be aware of the problems associated with it and be activated with special programs. Based on these basic measures to raise awareness one step further is to provide and implement existing know-how to/at key players and stakeholders level.

The most important characteristic of the good practice adaption is its ability to produce solid results without complex or expensive technical solutions. By implementing community awareness campaigns we can reduce water consumption, over usage, unsuccessful agricultural techniques and irreversible damage to aquifers before even design or pay for necessary infrastructure. Speeches, presentations, publications, information days and workshops allow reaching also specialists and decision makers on the water factor.

The main focus lies in elaborating solutions on how different levels can be addressed by different measures. Based on the activities within the partnership to main methods are presented throughout this good practice.

Region of North Aegean

The Region of North Aegean has the privilege to host the first Environmental Science Department (University of Aegean) in Greece thus it's been a testing field for Environmental education and awareness projects since 1990. Regional authorities of every level (municipalities, prefecture and region) have implemented awareness campaigns as a tool to deal with the most serious environmental problems in the North Aegean, water scarcity and solid waste management.

The most important topic in the Region regarding natural resources is water scarcity. In lack of any other possible solution to increase water quantities for human consumption, the only choice was to decrease the demand. Along with technical solutions (repair and replacement of irrigation and consumption pipelines, precision measurements etc.) many awareness campaigns took place in order to promote water management in houses, agriculture and small businesses.

International Resources and Recycling Institute

IRRI contributes to the idea of awareness by creating and delivering practical solutions to resource deprivation that benefit both the human population and the environment.

Their experience through the "Resource for Life"-project is a valuable advisor especially when your target group are children. The concept of water footprinting is introduced through the water module. Children learn about how water is incorporated in all aspects of daily life, and learn how to use local water sources efficiently.

WATERPOOL Competence Network GmbH

WATERPOOL's activities within this topic are to provide the project partners access to relevant boards on European level and implement activities by collaborating with these boards.

WATERPOOL is a research oriented organization enabling a close co-operation between research and economy and acts as a platform for bundling national and international competence in water management. Acting as an advisor on European, national and regional level, WATERPOOL is most interested in innovative groundwater management technologies for sustaining essential groundwater resources.

Raising awareness by Environmental Education

By using the Environmental education techniques, we can design awareness campaign projects to suit our needs for water resources management. The adaptation offers the designing tools for every level of stakeholders or decision makers in order to proceed with the necessary steps of implementing the campaign.

The main objectives of Environmental Education, as applied to water management issues, are the following:

1. AWARNESS: Obtaining the necessary information about water resources and its problems and sensitization.
2. KNOWLEDGE: Understanding the problems and human-environment interaction through experience.
3. ATTITUDES: shaping values and development of interest in the environment and willingness to participate actively in the improvement and protection of water resources.
4. SKILLS: Acquiring the necessary skills for identifying and solving environmental problems like sustainable water management.
5. PARTICIPATION: Action and active participation in solving environmental problems.

The achievement of the objectives of environmental education is implemented through relevant projects. Such a model of design and implementation should include the following stages:

1. Formulation of the problem:
   Holistic analysis of the issue. Solid data and
   brief and concise wording.
2. Key Objectives:
   Identify desired results.
   Long-term results.
3. Joint Analysis: Definition – Population Division.
4. Objectives: Specific measurable results.
5. Development of Message/Options Media/Common Eligibility:
   Message configuration and exploration of available options.

6. Selection and Facility Design: The most effective means.
7. Schedule: Proper monitoring of project development.
8. Formative Assessment: Correction of erroneous assumptions during design.
9. Final Evaluation: Determination of objectives implementation.
10. Budget: Cost/benefit analysis and total budget.

The implementation of this type of project is highly valued because of its flexibility. The guidelines are easily used by a variety of stakeholders and decision makers, in order to raise awareness on a community level, despite differences in the formulation of the problem. The stages are always the same and this adds to the guide's transferability between regions and/or partners. It also creates a common "language" between different stakeholders, for example public services like education authority and water resources authority, in order to design a project for specific results.

Raising awareness on European levels

Based on the activities of SHARP, WATERPOOL tries to implement elaborated topics in future decision processes of the European Commission by providing relevant information and outcomes to key players/stakeholders. Several main challenges were identified.

Challenges for water management:

- The world population will increase between 2000 and 2050 by 47% from 6.1 billion in the year 2000. This will result in a need for more water for drinking and food production. Furthermore an impact on water infrastructure will reach remarkable dimensions.
- Climatic change will increase disequilibria of ecosystems; floods and droughts will occur with higher frequency.
- The change to a bio-based economy will effect on groundwater storage because of altered infiltration conditions.
- Land use changes are usually associated with higher need for water for the agriculture and in many cases with a decrease of natural groundwater recharge.

Description of adaption process

Environmental Education

The adaption process is characterized as very easy. The methodology is based on common environmental education principles, widely accepted academically, and found in international literature. The guidelines are easily adaptable to different variations of water management problems with only minor changes between regions.

The receiving partner has only to adapt the guide line to his specific needs. The points that must be adapted accordingly are:

1. Formulation of the problem: Different region means different problems
2. Joint Analysis, Definition – Population Division: The population awareness level between regions or countries is not the same. Special care must be taken in order to identify cultural differences.
3. Development of Message/Options Media/Common Eligibility: The means are different even between regions. The selection of the most powerful dissemination channel is of key importance for the adaption process.

European levels

A clear labelling of water withdrawal regarding the quality demands of end users is essential. One has to distinguish between water for drinking and for different uses in industry, agriculture, tourism and energy generation. The latter includes water power and geothermal use.

Main future topics, which are also identified within the project SHARP, will be:

- groundwater,
- climatic change,
- managed groundwater recharge,
- transboundary water management,
- extreme hydrological events,
- specific water treatment.

Within SHARP project partners developed several adaption processes on these topics, which are brought to a wider community. Based on further activities and the outcomes of SHARP, relevant results should be implemented in several actions of the WssTP (Water supply and sanitation Technology Platform). To raise also more awareness, status quos' and initiatives throughout SHARP are presented consequently in the MSMG (Member State and Mirror Group) and are going to be implemented in different initiatives of the WssTP and MSMG (i.e. Managed Aquifer Recharge).

I.e.: WATERPOOL acts as a cutting point between European instruments and the SHARP partnership. This should ensure a sustainable and fruitful exchange of know-how and also the raising of awareness of current ongoing activities on project partner's level.

Actions should follow this scheme:

1. Defining and elaboration of topics within the partnership and vice versa also within the strategic levels;
2. Presentation of work's status and implementation of topics in several initiatives on European level;
3. Returning of given input into the thematic partnership;
4. Setting up of activities, both on an European and on the partners level, for ensuring the awareness of needs;
5. Implementation of initiatives by projects using existing and amending know-how.

4.1.13 GPA 13: Techniques to save water quantity

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Region of North Aegean (RNA)

Concise description of the adapted good practice

Engaging in several techniques to save water quantity is vital to the success of the SHARP project. The countries involved in this adaptation are Malta and Germany. Both countries have different amounts of water resources available. Hence, Germany is known to be rich in water resources although certain regions have limited volumes of water supply. On the other hand, Malta is a country poorly endowed with freshwater resources and with no surface waters, thus it's a challenge to meet a high and rapidly increasing demand for water while protecting and conserving the available resource.

To satisfy the demand for water, in Saxony Germany, drinking water reservoirs, water reservoir used by industries and dams had been set up. The techniques of artificial groundwater recharge (mostly bank filtration) were used to save water quantity at the local level. Regulations and laws protect the water resource in terms of its quantity and quality. Monitoring of the available water resources is also important to ensure that water consumption does not exceed the water resources. In this case the actual strategies and systems have to be modified.

Appropriate measures such as green roofs, stormwater infiltration and rainwater harvesting and their combination can help to restore the natural water balance quite closely. When using groundwater as one of our most important drinking water resources, it is necessary to do everything to provide compensation for the deficit thus created. Other techniques include borehole metering, increase in water tariffs, public awareness and infrastructural techniques such as dams and reservoirs.

Description of adaption process

The steps needed to successfully implement this adaption are:

- Making people aware that water is a precious resource and needs to be conserved. Such awareness is to be projected through education and political campaigns.
- Boreholes should be metered and a tariff should be placed on the water pumped from boreholes. Water tariffs should increase but to a reasonable price.
- Water saving methods within households should be adopted in order to conserve water.
- Rainwater management is an effective possibility to save drinking water and to reduce the dependence on the water distribution and wastewater systems. In the private household rainwater can be used for irrigation and toilet flushing. In the industrial and agricultural sectors water conserving operations and the development of water conserving technologies are required. It is also important to maintain the distribution system to prevent any leakages and therefore loss of water.
- Current local policies and legislations should be amended and updated where necessary to ensure the sustainability of water.
- Better water management infrastructure techniques to be used during the dry months to harness stormwater runoff.

The main obstacles in using techniques to save water quantity are the following:

- Lack of public awareness in using techniques to save water quantity.
- Limited water management infrastructure to save water quantity.
- Stakeholders’ consumption patterns may be difficult to change.
- All techniques and systems are more or less expensive.

4.1.14 GPA 14: Water allocation and efficient water use in agriculture

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Concise description of the adapted good practice

The efficient use of water for agriculture use is vital to the success of the SHARP project. The agricultural sector has been blamed to be the greatest user of water with one of the lowest water use efficiency and lowest output per unit of water used when compared to all other sectors. Meeting the high and rapid increase in the demand for water, while protecting and conserving the resource and the environment is a major challenge. Both Friuli Venezia Giulia in Italy and Malta suffer from a high demand from the agricultural sector to be met by groundwater alone. Therefore, other efficient water use sources must be brought into play, such as treated effluent, rainwater harvesting and improving irrigation techniques.

Artificial irrigation is an important aspect of Maltese agriculture while the sprinkler irrigation system is the most widely used system in the region of Fruili Venezia Giulia. The conversion from surface irrigation systems to sprinkler irrigation systems lies in its efficiency as the latter only makes use of 0.9 l/(s*ha) compared to the 2.2 l/(s*ha) used by the former system.

With a given amount of water available for the irrigation purposes, two different strategies can be considered to enhance efficiency of water agriculture use: (i) investments in the irrigation systems applied, as it is the case of the conversion from the “surface” irrigation system to the “sprinkler” irrigation system, or (ii) act on the pricing scheme for water so as to promote a wise behaviour in terms of water abstraction by the farmers, e.g. the introduction of the “binomial fee”.

The application of a binomial fee is also consistent with the guidelines of the Water Framework Directive, WFD (2000/60/EC) which provides some suggestions on the pricing of the water, which should be related directly to the volume of water consumed by the final user; this pricing criterion, in fact, should promote an efficient use of the water resources.

Striving to ensure sustainability of water resources and use in the agricultural sector within the EU is one of the main aims of the SHARP Project. Given that the agricultural sector is one of the main users of groundwater, efficiency of use is paramount. This can be achieved through the involvement of non-conventional sources such as treated effluent and rainwater harvesting, thus preventing sole reliance on groundwater abstraction.

Description of adaption process

The steps required for a potentially successful implemented adaptation are:

- The applied irrigation techniques should be improved and changed where the irrigation system is changed from the surface technique to the sprinkler technique in order to achieve significant water savings.
- Efficient irrigation methods should be promoted together with the maximization of crop yield efficiency through the use of smart irrigation systems. Furthermore, supply augmentation measures involving aquifer recharge with excess treated effluent and rainwater runoff should be promoted.
- Local stakeholders in the region should be encouraged to implement efficient water use techniques in agriculture by means of rain harvesting through dams and reservoirs; fine tube irrigation systems and also by natural spring water harvesting.
- Increase awareness in the rationalization of water use in agriculture which could contribute to water savings that can be realized in favour of the overall system, i.e. further agricultural land that could be served by irrigation, larger amounts of water that could be used for other purposes such as civil and industry and, on the other hand, also lead to a lower water withdrawal from the system.
- Current local policies and legislations should be revised and amended where necessary to ensure the sustainability of water use.

This point is concerned with the evaluation on the difficulties/opportunities encountered when it comes to transfer techniques to other regions. Practices carried out in different areas cannot be simply exported in other regions, in fact the systems that have been developed in certain territories are able to match the needs and the requirements of that individual area and there is no guarantee that they could work also in other regions having different rules, different organization, different land use or different crops cultivations.

Nevertheless, the water availability and the peak demand of water during the crops growing season make the question of water allocation for agriculture very urgent and even in regions having high precipitation patterns, droughts or scarcity of water for the crops can occur. The need to share good practices and innovation is then apparent.

The main obstacles in maximizing water use efficiency in the agriculture sector include:

- The type of irrigation system adopted. This can be solved by adopting the surface irrigation systems and extraordinary irrigation pattern.
- The lack of information available on water use efficiency. This can be solved by informing the stakeholders through clear and simple language using local case-studies.
- Stakeholders including farmers are not aware and/or interested in issues relating to water use efficiency. This can be approached by inviting stakeholders to events and information meetings to increase their awareness and interests and to introduce new efficient methods that lead to efficient use of water.
- Difficult to implement water use efficiency measures and enforce these in local context. This can be solved by training specialists in the subject in order to have enough resources to carryout inspections and spot checks to monitor the activities and implementation measures being adopted by farmers/landusers.
- Lack of collaboration amongst local authorities and farmers can be solved through face to face meetings with both parties concerned so as to express their views and challenges encountered.

4.1.15 GPA 15: Optimization of water use in agriculture using IT

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Concise description of the adapted good practice

The ICTs and their potential

General speaking the specific interest for the Information and Communication Technologies (**ICTs**) arises from their potential to integrate and manage data and information obtained from different sources which can also be located far away from the site where the “kernel of the system” (**KNS**) resides. The kernel of the system consists mainly of the "expert system" (**ES**) which is specifically designed to process and analyse the input data. The ES has a specific ability in processing all the information gathered according to a specific knowledge domain and then provide solutions and feedback outputs to the concerned system.

Different examples for ICTs can be recalled. Some of them assure data process and analysis, dissemination of knowledge and information through informatics applications. Other more complex ICTs examples can couple informatics and domain technology. ICTs in water management in agriculture could make use of both these approaches.

Web technology is showing new opportunities for the community of users; it is also increasing its popularity for a number of reasons (cheap to produce, no proprietary software to be installed very basic computer skills needed, content easily updated and disseminated).

Besides, a new category of applications called RIA (Rich Internet Applications) or web 2.0 applications can be installed not only on personal computers but also on other types of devices, such as tablets (iPAD) and Smart Phones.

Wireless communication reduces costs and avoids cut-offs of command lines by routine activity in the farm. In due time, wireless communication has become highly reliable with the introduction of cell phones, ISM, GSM and Wi-Fi technologies, SMS bi-directional delivery, as well as the use of satellite communications and Internet networks for remote control and data transfer.

Informatics and technology – ICT applications for irrigation water management

As for the coupling of informatics and domain technology, an ICT application can be seen as a "neural network" which collects data from the "input layer" (source of data), processes them according to a "knowledge function", which is part of the ES, and consequently yields solutions from the "output layer" which represents the feedback of the system itself aimed at improving the management of the resources under control.

Here some examples of application of ICTs dealing with water management in agriculture are described:

- **Water resources management with farm flow meters**: remote control of the individual flow meters and regulation of the timing of the irrigation interventions can also integrate meteorological data in order to prevent excessive water uptake.

- **Water management in green-houses**: for such a closed system, the application of the ICTs can be focused on even more precise tasks. Irrigation in the greenhouses can be managed directly by the ES; moreover the nutrient concentration in the solution used for fertilization can also be directly supervised by the ES.
- **Central management of water resources**: the system is represented by the whole irrigation network which can be managed by the organisation in charge of the regulation of water supply in a given irrigation district. The goal is to optimize the water flow; therefore the system should be able to supply a scheduled amount of water to the network by checking the inflow rate and the outflow rate at the fields.
- **Integrated management of water resources**: similar to the previous one. In this case the ES should be able to integrate a wider set of data; most of them are concerned with spatial components (e.g. GIS). Additional information come from on-field installed probes or meteorological station devoted to estimate the water balance of specific area-cultivation subsystem. After data processing, the information can be translated directly into operational commands to water pumps, valves and peripheral units so as to improve efficiency of the system.
- **Modelling and data process and analysis**: ICTs are very useful to store data and numerical inputs in databases and geo-databases (spatial components). Integration with meteorological data and soil features is of crucial importance. Usual outputs are represented by calculations of: water balance components, water losses, runoff, deep percolation, evaporation or network losses. When coupled with economic assessment objectives the system can provide information on the profitability of the irrigation intervention.
- **Decision Support System in water management in agriculture**: data on water use in agriculture can be integrated with further environmental, economic and hydrological data; the SW can be shaped as a modelling tool coupled with GIS tools and provide long-term simulations on the global water balance in agriculture and thus be used as a Decision Support System (DSS). The DSS can be used as a “what if tool” showing mid-term and long-term effects of decisions and behaviours of the actors playing their role.

Who can advantage from the ICTs technology

ICT tools usually can be accessed on the web by many different users (farmers, advisory services technicians, policy makers). Information and suggestions can be addressed to the farmers by using different technologies such as SMS alerts and email alerts carrying direct indications on the irrigation intervention to be effected.

Technicians from the farmers associations or from advisory services are usually much more skilled and familiar with these applications and thus could assist farmers in advantaging of these ICTs tools, showing the effects and benefits gained by means of graphs, scenarios comparison, economic predictions provided as outputs by the ES.

For public Institutions, policy makers' and decision makers' use of DSS can be of great importance for exploring different options and elaboration of water management plans.

Description of adaption process

When it comes to transferring ICT tools in areas different from those where the applications were originally intended or developed, some questions arise.

The system under evaluation has its own peculiarities and sometimes these are specifically related to the local situations where the ES was originally developed. It should be reminded that a model or a DSS applied to water management describes a specific system that considers different water use, water availability, water management and crops system. It is obvious that the specific options underpinning a model cannot be directly transferred to a different situation. It is necessary to conceptualize the new system and most of the times collect new data to parameterize the equations of the model supervising the ES.

The most interesting point is not the model or the ICT tool itself, rather the idea and the rationale behind the application that can be adapted and adjusted to other situations taking advantage of the experience already carried out.

5 Communication and dissemination

The SHARP project group has established a communication and dissemination plan which covers all project related communication and dissemination activities. It ensures an efficient internal and external communication and the best spreading of results to a wider selected audience. This favours the transfer, replication and implementation of the SHARP results by other bodies responsible for environmental and water policies (imitation processes), to raise an environmental culture at EU/national/regional and local level as well as raise awareness of the importance on groundwater resources management.

The SHARP dissemination and communication plan is based on following main categories:

- Newsletters,
- Articles,
- Publications,
- Progress Reports,
- SHARP DVD,
- SHARP Manual.

On the part of the Lead partner a Communication Manager was nominated who has the overall responsibility for the elaboration and implementation of the SHARP Communication and Dissemination Plan in collaboration with representatives of each project partner. SHARP implements a SHARP Virtual Information Centre (SHARP VIC) comprising a state-of-the-art website and a web-based Knowledge Management System (KMS) including a document and contact management system in order to store the gathered information (e.g. good practices and adaptations, SHARP results and reports, available studies concerning the groundwater management, articles, contact information, networks on water management) in a structured as well as categorised way.

The communication and dissemination activities are strongly linked to other project relevant activities, as on the one hand all organisational, administrative and management related information are constantly available for project partner s and on the other hand, the systematically collected and processed SHARP know-how: identified good practices, experiences, elaborated results, reports etc. which are constantly available for project partners and disseminated to target groups. The main target groups addressed by these activities are project partners and their staff (internal SHARP communication).

Furthermore SHARP addresses primarily local, regional and national decision makers responsible for environmental policy and water management, scientific institutions as well as experts with a focus on water management and groundwater recharge as well as (inter)national/regional specialised, scientific and general media (external communication).

Successful interregional cooperation: Events organised by the project to exchange experiences:

- April 2010: Kick-Off-Meeting, Steering Group Meeting and Study visit in Graz (AT);
- October 2010: Steering Group Meeting, Seminar and Workshop in Edinburgh (UK);
- April 2011: Steering Group Meeting, Seminar, Workshop & Excursion in Udine (IT)
- October 2011: Steering Group Meeting, Seminar, Workshop & Study visit in Wroclaw (PL) and Dresden (GE);
- May 2012: Steering Group Meeting, Seminar, Workshop, 1st SHARP International Conference and Excursion in Kozani (GR);
- October 2012: Steering Group Meeting, Seminar, 2nd International Conference and Excursion in Graz (AT);
- Several events of project partners.

The internal SHARP communication is realised via project meetings and the SHARP VIC communication tool. The external SHARP communication reaches its target groups via participation of relevant decision makers in regional SHARP meetings, via defined open access for stakeholders to the SHARP VIC as well as the distribution of newsletters brochures and press releases for a wider audience.

Furthermore the SHARP VIC is connected with existing water networks and experts. Seminars, Study Visits, Excursions, International Conferences and Press Conferences take place in the South, North, East and West of Europe in order to disseminate elaborated outputs/results directly to a wider audience and to inform citizens and relevant experts about modern groundwater management and its importance for the human beings as well as the economy.

5.1 Outputs and results

Several outputs and results are planned within the project SHARP. All activities should help to strengthen the partnership for enhancing the existing know-how, to spread the output and results to a wider audience and to open new activity fields for the project partners with relevant players. Below all outputs and results of the project are shown:

- SHARP Website and Knowledge Management System to show the results and activities of the project. Also a Virtual Information Centre was launched, with an internal and external section.
- SHARP DVD about the highlights of the SHARP events.
- Start-Up, Progress and Final Reports for monitoring of the project on-going.
- Several newsletters, press releases and releases in other media, in which all relevant activities within the project are brought to a wider audience.
- Interregional events, study visits, excursions, Steering group meetings and two International Conferences.
- Several publications of the project partners concerning SHARP activities and emerged actions born from the project.
- Brochure on project SHARP in several languages.
- SHARP Manual with concrete description of good practices and good practices to be adapted.
- Staff experts in the partnership with increased capacity on groundwater management concerning different climate as well as geographical and geological areas.
- New projects among the partnership resulting from the exchange of experience.
- 17 existing good practices with description of project partner's existing know-how.
- 15 successfully transferred good practices which will lead to direct improvements of regional/local policies and strategies concerning groundwater resources.
- First improvements/adaptations of existing technologies due to enlarged know-how.

5.2 Dissemination activities

One main point for implementing all project activities and bringing them to a wider audience are actions in the field of dissemination. Enclosed all relevant publications, newsletters, press releases, leaflets folders and the manual are shortly described to show how the partnership tries to reach relevant players.

Newsletter

- 1st SHARP Newsletter, June 2010 (EN, GR, PL),
- 2nd SHARP Newsletter, December 2010 (EN, GR, PL),
- 3rd SHARP Newsletter, June 2011 (EN, GR),
- 4th SHARP Newsletter, December 2011 (EN, PL, GR),
- 5th SHARP Newsletter, June 2012 (EN),
- 6th SHARP Newsletter, December 2012 (EN).

Press Releases

- Projekt SHARP – "Sustainable Hydro Assessment and Groundwater Recharge Projects",
- Europe's Major Water Challenges Being Addressed in Scotland,
- Press release on Partner Meeting and Study visit in Udine,
- 1st Press release on Partner Meeting and Study visit in Wrozlaw and Dresden,
- 2nd Press release on Partner Meeting and Study visit in Wrozlaw and Dresden,
- Press release on Partner Meeting and Study visit in Kozani,
- Projekt SHARP – "Künstliche Grundwasseranreicherung als Schlüsseltechnologie für eine gesicherte Trinkwasserversorgung".

Brochures

- Official brochure on SHARP project (EN, DE, GR, IT, PL, MT – WATERPOOL Competence Network GmbH with participation of all project partners);
- Brochure on SHARP project in Polish, June 2010 (Institute of Meteorology and Water Management);
- Leaflet on SHARP project in Polish, Dec 2010 (Institute of Meteorology and Water Management);
- Brochure on SHARP project in German and English, June 2011 (Saxon State Office for the Environment, Agriculture and Geology);
- Brochure on SHARP project in Greek, December 2012 (Region of Western Macedonia).

Articles and publications

- aqua press international: K-net Wasser: Die „Karten" sind neu gemischt, February 2010;
- Austrian Press Association: Grazer Netzwerk steuert europäisches Wasser-Projekt, April 2010;
- Kleine Zeitung: Grundwassermanagement: Grazer Netzwerk steuert europäisches Projekt, April 2010;
- Funding 4y EU, issue 30: Sustainable Hydro Assessment and Groundwater Recharge Projects – SHARP, April 2010;
- Newsletter Local Councils' Association: Sustainable Hydro Assessment and Groundwater Recharge Projects – SHARP, April 2010;
- Business Lounge (Die Presse): Forschungsobjekt Grundwasser, May 2010;

- Newsletter JOANNEUM RESEARCH (17): „SHARP“ Sustainable Hydro Assessment and Groundwater Recharge Projects, June 2010;
- Newsletter JOANNEUM RESEARCH (18): SHARP – Sustainable Hydro Assessment and Groundwater Recharge Projects, Successful launch of transnational cooperation, October 2010;
- Schriftenreihe Freistaat Sachsen, Heft 28/2010: Grundwasser – Altlasten aktuell: Landesamt für Umwelt, Landwirtschaft und Geologie, December 2010;
- Scientific journal „Problemy Ekologii Krajobrazu”: Abstract on SHARP topics and existing good practices, December 2010;
- Information leaflet INTERREG IVC Info Point East in German: SHARP – Sustainable Hydro Assessment and Groundwater Recharge Projects, December 2010;
- Meusac news: Local councils in water conservation, February 2011;
- The Parliament Magazine: WATERPOOL – Saving and Protecting Resources for Future Generations, March 2011;
- Information on SHARP within brochure INTERREG IVC North Area Perspective "Better policies through Interregional Cooperation", March 2011
- Messagero Veneto: Irrigazione in FvG: da rivedere il sistema troppi gli sprechi, April 2011;
- Sustainable Hydro Assessment and Groundwater Recharge Projects – Project Assumptions and Initial Results, May 2011;
- Nauka Przyroda Technologie: ZRÓWNOWAŻONE ZARZĄDZANIE ZASOBAMI WODNYMI I PRAKTYKI ODNAWIANIA ZASOBÓW WÓD PODZIEMNYCH – ZAŁOŻENIA I WSTĘPNE WYNIKI PROJEKTU SHARP, May 2011;
- Via Airportjournal Graz: Forschung für die Wasserzukunft, June 2011;
- Görlitzer Sächischen Zeitung: Wasser-Experten machen Station am See, October 2011;
- Magazine „KWB Turow“ No. 7: Project SHARP, November 2011;
- Maxitis-Grevena: Partner Meeting/Study visit in Wrozlaw (PL) and Dresden (DE), October 2011;
- Proini newspaper part 1: Partner Meeting/Study visit in Wrozlaw (PL) and Dresden (DE), October 2011;
- Proini newspaper part 2: Partner Meeting/Study visit in Wrozlaw (PL) and Dresden (DE), October 2011;
- Proinos Logos newspaper: 1st International Conference and 5th SHARP Partners Meeting in Kozani (GR), May 2012;

- Grammi newspaper: 1st International Conference and 5th SHARP Partners Meeting in Kozani (GR), May 2012;
- Ptolemaios newspaper: 1st International Conference and 5th SHARP Partners Meeting in Kozani (GR), May 2012.
- SHARP Manual (WATERPOOL Competence Network GmbH with participation of all project partners), November 2012;

Posters

- Examples of good practice in the management of groundwater resources (Institute of Meteorology and Water Management),
- Poster presentation within 2nd International Conference in Graz:
    - SHARP: Sustainable Hydro Assessment & Groundwater Recharge Projects (WATERPOOL Competence Network GmbH),
    - Tools for Water Management Plans (Region of Western Macedonia),
    - Good practise and Adaption in the Aegean (Region of North Aegean),
    - Water and agriculture: supply patterns, irrigation systems and ICT, Water allocation optimization and higher efficiency (Regional Agency for Rural Development of Friuli Venezia Giulia),
    - Aquifer Recharge Project (Local Councils' Association),
    - Activities taken by the IMGW-PIB in the SHARP project (Institute of Meteorology and Water Management),
    - Urban groundwater monitoring using 3D geological information to inform hydrogeological understanding (British Geological Survey and International Resources and Recycling Institute),
    - Exchanged Experiences (Saxon State Office for the Environment, Agriculture and Geology),
    - Artificial ground water recharge (Holding Graz GmbH – Services).

Others

- SHARP video on SHARP event in Kozani (GR),
- SHARP Website and Knowledge Management System,
- SHARP DVD,
- 8 Dissemination events and participation in 17 other events for presenting the project activities of SHARP,
- Links to water platforms and suppliers,
- Joint partner statement of SHARP Project Partners.

6 Discussion and conclusion

6.1 Discussion of project results

The overall objective of SHARP is to save and protect existing water resources for future generations. This scope of SHARP will support the conservation, improvement and sustainable availability of groundwater resources – essential for human beings, animals and plants. To achieve that goal project partners from seven different European countries exchanged and developed promising and innovative technologies in the frame of sustainable groundwater management and risk prevention of water supplies which will improve future decisions and actions at the local/regional level.

The SHARP project deals in general with innovative tools, methodologies and technologies to enhance the quantity and quality of existing groundwater resources and to protect and save them for future use. Therefore SHARP will help to solve the existing conflict on groundwater reserves between drinking water supply and the water supply for irrigation or industrial use. In that context, all project partners share their knowledge in the area of general groundwater management and transfer their experiences. The close cooperation between project partners coming from European regions with different climate as well as geological and geographical conditions assures the development of new approaches and innovative solutions of the common problems.

The mutual exchange of know-how was supported by project partners discussing, evaluating and elaborating the individual conditions for the implementation and improvement of groundwater management technologies within their own regions and by study visits, where project partners got practically informed on site about realised pilot projects in groundwater management practices.

Moreover, project partners developed technology transformation, based on the identification and analysis of good practices, and its necessary adjustment considering diverse conditions. Thus, the SHARP results comprise the exchange of innovative technologies and improvement of policy making concerning groundwater management aspects to preserve and improve water quality and quantity.

Generalization of project results – discussion of means of know-how transfer

At the heart of the SHARP project was the idea to make the best use of existing knowledge and experience including technology (e.g. SuDS, online monitoring probes) and procedures (e.g. drinking water safety plans, groundwater modelling development and verification) as well as to investigate the transferability of it to different partner or similar regions instead of duplicating knowledge.

The partners defined the topics for adaption during discussion due to their own competences and needs in the framework of the key contents. Basically, the know-how transfer was developed in a unidirectional way from a donor to a receiving partner; however, within some topics the participating partners worked more or less on the level so that they could mutually learn from the different perspectives and foci and increase their respective skills.

The identified topics for transfer of existing good practices are not strictly limited to technical areas but also embrace socioeconomic aspects (e.g. binomial fee estimation for a rational use of water in agriculture) and awareness rising (e.g. how to engage with key stakeholders, raising awareness on a community level). Within the first part of the SHARP project 17 existing good practices were defined to illustrate the competences of the partners. The topics can be classified into four main areas: artificial recharge, general planning tools, monitoring and modelling. As a result of the joint partner discussion of good practices to be transferred the following categories turn out: monitoring, groundwater and mining, water use in agriculture and application of models. Thus, a focus shift from artificial recharge to water use in agriculture and groundwater and mining can be observed.

The know-how transfer between partners typically consisted of passing on a methodology. Depending on the particular issue the number of involved partners ranges from two to all SHARP partners. Specific aspects include:

- adaption of new procedures, simply, what was not known before by a receiving partner but already applied by a donor partner (e.g. successful project);
    - adaption of an integrated approach where so far only aspect have been considered in part (e.g. partners can now make well informed decisions on their options for online groundwater monitoring of their regional aquifers)
    - provision of guidelines for stepwise implementation (e.g. groundwater model development and verification; geothermal capacity maps);
- common implementation of same standard (new for at least one partner)
    - implementation at both sides of the state border, not only at the side where the project is being carried out but also at the side, which may be affected by the project as well

- sometimes data need first to be collect before a specific model approach can be run (data not deemed important so far); otherwise the basis for transfer of good practice (and useful implementation) to receiving partner is missing and needs to be build first;
- partners also joined their different detailed stepwise approaches as they are using the same methodology (e.g. use of DSS for strategies of groundwater resources management);
- in some examples also recommendations to overcome obstacles in the early implementation (e.g. transboundary issues) and for continued success (e.g. SuDS) have been given.

Overall, the SHARP partners worked together on a wide variety of different topics that match the defined key contents very well and are all related to save and protect existing water resources for future generations. Not only the receiving partners benefitted from the knowledge transfer but also the donor partners since they expanded the range of possible application of their know-how and methodologies. In this respect, existing know-how has been used in a very efficient manner on water resources management topics at a European scale.

Annexes

Long version of good practices reports

Long version of good practices to be adapted reports

The long versions of good practices reports and good practices to be adapted reports can be found on the enclosed CD.