SIXTH FRAMEWORK PROGRAMME
PRIORITY 1.1.6.3
GLOBAL CHANGE AND ECOSYSTEMS

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SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT

Annex 1 - "Description of Work"

Project acronym: *WADE*
Project full title: *Floodwater Recharge of Alluvial Aquifers in Dryland Environments*
Contract no.: *GOCE-CT-2003-506680*

Date of preparation of Annex 1: *3rd December, 2003*

Operative commencement date of contract: *1st July, 2004*

1. Project Summary

The WADE project aims to assess long-term (decades to centuries) water resources in selected semiarid to hyperarid ephemeral river basins by determining long-term transmission losses from floods and quantifying floodwater recharge into alluvial aquifers. An innovative approach will be applied based on three principal research themes. 1) Palaeoflood hydrology will be used to determine long-term flood magnitude and frequency in order to quantify the frequency of recharging flood events. 2) Surface and sub-surface hydrology will be monitored in order to quantify transmission losses through the river bed into the alluvial aquifers. The combination of these two methodologies will be able to quantify long-term aquifer recharge through flooding. 3) The final research theme focuses on the socio-economic issues related to the use of alluvial aquifer groundwater within the study catchments. The research will be undertaken in 4 research basins, twinning catchments in Spain and Israel with study catchments in Namibia and South Africa.

2. Project Objectives

The overall scope of the project is to apply newly developed methodologies, technologies, and approaches in order to **assess long-term (decades to centuries) water resources** in selected semiarid to hyperarid ephemeral river basins by **determining long-term magnitude and frequency of floods and quantifying transmission losses and floodwater recharge into alluvial aquifers.** Research experience on integrated water resources management in selected basins of Spain and Israel will be twinned with research initiatives in basins of two selected African countries, namely Namibia and South Africa, that suffer from permanent aridity and water scarcity.

Africa's water resources are considered critical to any sustainable economic development strategy. Namibia and the South Africa region of Namaqualand were selected because those areas are the most arid zones of Southern Africa, facing important water scarcity problems. As a result, planning in these regions requires information on sustainable water resources and therefore there is the need to improve long-term evaluation of groundwater availability. This groundwater recharge assessment can be achieved using technological and methodological developments carried out in Israel and Spain. This approach can solve the question of where to find new water resources and to evaluate these resources with a long-term perspective to meet the increases in demand in southern Africa drylands, such as Windhoek (Namibia's capital city). Here new ideas of extending the Eastern National Water Carrier (ENWC) to the Okavango River to provide water to Windhoek has raised much criticism internationally. Water conservation along with a better estimation of the groundwater resources located at the northern part may help to solve this problem.

A principal source of water in arid environments around the world is related to floods in ephemeral rivers. In drylands, significant floods are caused by intense rainstorms of short duration that may last from minutes to days depending on drainage basin size. Though floodwater itself is not considered a sustainable water resource, floodwater infiltrating alluvial aquifers always represented the backbone of traditional water supply in arid areas. Even with this intensive reliance on these sources, at present, there is no available methodology to quantify a) the processes that control this recharge and b) its long term quantities that in turn affect the sustainability of this water resource. Both natural ecosystems and human societies depend on this scarce water source to maintain life in arid lands. The key objective of this project is to **develop and apply an innovative method of investigating the occurrence of floodwater resources, in time and space, to quantify the sustainable water yield of selected ephemeral streams and to formulate integrated water management strategies for their use.**

In recent years a new methodology to estimate shallow aquifer recharge processes, combining flood and palaeoflood records with data on modern transmission losses, has been developed and applied successfully in the Negev Desert, Israel (Greenbaum et al., 2002), and is now being implemented in arid areas of SE Spain, where economic growth depends upon groundwater supplied to greenhouse agriculture. New monitoring technology, that was developed by Dahan et al (2003), will be applied in the selected study catchments in Spain, Israel, Namibia and S. Africa in order to **monitor the processes that transmit floodwaters into catchment aquifers**. This technology will allow simultaneous monitoring and analysis of all three hydrological domains: (1) the

flood hydrograph as the water source for the vadose zone; (2) the response of the deep vadose cross section to flood events and; (3) the ground water response to both the flood event hydrograph and the variation in the vadose zone moisture profiles.

As these floods are rare in the gauged and historical records, there is limited data on which to base an evaluation of the **long-term frequency of the recharging events**, data that is of crucial importance for integrated water resource management. Therefore, evidence of former floods in the alluvial sediment record and isotopic information on past recharge events and recharge processes in the alluvial groundwater are of paramount importance for the study of water resources in ephemeral stream systems. The methodology of palaeoflood hydrology is able to reconstruct the magnitude and frequency of flooding over timescales ranging from decades to hundreds and thousands of years. Newly developed statistical software enables flood frequency analysis to be carried out on this non-systematic data, thereby quantifying, statistically, return period quantiles for the recharging floods. The state of the art combination of palaeoflood reconstruction techniques, together with isotopic composition and dating of subsurface water and the contemporary monitoring of surface and sub-surface hydrology provide a better scientific and technical understanding of long-term transmission losses into shallow alluvial aquifers and, therefore, improved long-term groundwater recharge estimates. The combination of palaeoflood hydrology and integrated groundwater isotope studies relate past flood records to their real net impact on the groundwater system. Isotopes in groundwater contain information on the net long term average of recharge and processes, reveal the influence and path of evaporation, the age of groundwater components and their turnover time and estimated age. The project partners have access to isotope data in rainfall and isotope data in groundwater from previous studies (Kuells, 2000).

We believe that combining these distinct methodologies together is a new approach that will generate a sound scientific basis for future management of water resources currently used along these streams. In addition to the state of the art technology and scientific methodologies employed in the project, socio-economic and institutional aspects of the management of shallow aquifer water resources in the study catchments will be studied. This research will focus on a historical perspective of water resource use in the study catchments in order to relate to the long-term floodwater recharge data obtained from the palaeoflood and groundwater isotope data. The combination of this socio-historical data with long-term estimates of shallow aquifer recharge will lead to improved, scientifically based and sustainable, integrated water resource management.

During the development and implementation of this methodology and technology in the twinned basins from Europe and Africa, the attainment of the following scientific/technical objectives is foreseen:

- To extend the **record of the magnitude and chronology of large floods** using palaeoflood hydrology in order to obtain improved understanding of the temporal distribution of large floods through time and their magnitude. This will allow for better long-term water management strategies in these catchments and will allow planners to base their decisions on long-term (decades and longer) flooding potential, providing a sustainable approach to a varying water resource on the annual-decadal time scale. The chronology of large floods will also indicate their sensitivity to climatic variability.

This objective will be achieved by Month 32 of the project and relates to the following milestones:
M5 - The identification of palaeoflood sites (**Month 6**).
M12 - Palaeoflood data collection completed (**Month 18**).
M15 - Determining the appropriate hydraulic model to estimate palaeoflood discharge at the study reaches (**Month 24**).

- To directly **quantify the present-day processes of floodwater infiltration, transmission losses and percolation** through the channel bed into shallow aquifers. The methodology we will use is new and was developed by P8 specifically to address this issue. This data will then be used to produce the best estimation of the long-term water loss from the flood into the streambed and, therefore, to quantify actual recharge.

  This objective will be achieved by Month 35 of the project and relates to the following milestones:
  M3 - Compilation of available data on surface and sub-surface hydrology and water balance (**Month 5**).
  M4 - Selection of sites for probe installation (**Month 6**).
  M6 - Installation of the TDR probes at the demonstration site (**Month 6**)
  M10 - Monitoring systems installed and operational in all catchments (**Month 12**)
  M16 - Relationships between floodwater stage, percolation rates and groundwater recharge determined (**Month 24**)

- To establish isotope-based indicator methods **to identify active recharge sections** and, therefore, potential development areas along alluvial aquifers.

  This objective will be achieved by **Month 30** of the project when deliverable D20, groundwater chemical and isotopic composition will be completed.

- **To formulate and quantify a model of groundwater recharge from floodwaters along long reaches of ephemeral rivers in dryland environments.** The model that will be conceptualised and formulated can later be used as a basis for research, planning, and development programs in other arid lands around the world.

  This objective will be achieved between months 18 and 35 of the project and relates to the following milestones:
  M17 - Mass and moisture balance determined for the studied cross-sections (**Month 24**)
  M18 - Choice of the numerical model that best-fits the character of the collected data (**Month 30**).

- **To increase local and national awareness and understanding of the water resource potential of alluvial aquifers in desert areas, both quantitatively and qualitatively.** This will lead to better, scientifically-based and probably cautious water resource development/management in arid lands, allowing optimal exploitation and conservation of both water resources and economic means.
  This objective will be achieved by the end of the project (Month 36) and relates to the following milestone:
  M7 – Maps of water resource use along the study basins (**Month 10**).

- **To enhance cooperation and collaboration among scientists, engineers, risk analysts, policy makers, government/management agencies, local communities and the inhabitants along a river.** Enhancing and improving a sustainable watershed management that supports both water resource management as well as restoration of the watershed ecologic system in arid lands.

  This objective will be achieved by the end of the project (Month 36) and relates to the following milestones:
  M2 - Regular meetings with communities and local partners (**Month 3** and throughout the project).
  M19 - Institutional analysis relevant to the improved sustainability of water supplies (**Month 30**).

In addition, the following specific measurable objectives will be attained:

Related to palaeoflood studies:

1. At each palaeoflood site the following will be achieved: (a) Detailed topographic survey, (b) Stratigraphic analysis of flood deposits; (c) radiocarbon dating & sedimentology of flood deposits. (d) Document historical information on recent floods and identify anecdotal observations about historical floods. (f) Tie palaeoflood sites near gauging stations to the measured record. (**Month 24**)
2. Construct 1D and/or 2D hydraulic models for the studied reaches to calculate flood magnitude associated with the elevation of the flood sediments. Use this field and modelled data to estimate the frequency of recharge floods. (**Month 30**)
3. Establish at-a-site palaeoflood chronology and magnitude. Establish a regional chronology and regional curve of maximum flood peaks. (**Month 32**)

Related to transmission losses and groundwater recharge

1. Installation of three Deep Vadose Zone monitoring systems at selected sites in each study basin (**Month 12**).
2. Monitoring of transmission losses along the studied reaches, quantifying the percolation processes through the unsaturated zone, and monitoring the groundwater recharge of the alluvial aquifers. We see this aspect as a pioneering effort in calibrating true rates of transmission losses (**Month 35**).
3. Construct experimental surface modifications in order to assess the usefulness of such an approach for enhancing groundwater recharge. For example: are

retention dams along ephemeral streams more/less efficient in inducing recharge than leaving the bed undisturbed and allowing recharge along the entire reach. (**Month 36**)

4. Establish the average stable isotope composition and the seasonal isotope time series in alluvial aquifers ($d^{18}O$, $d^{2}H$) and to determine groundwater age and turnover time (^{3}H, CFC). (**Month 30**)
5. Development of hydrologic models for flood routing in ephemeral streams, including data on transmission losses, groundwater recharge estimation, water demand estimation and groundwater response based on long-term recharge from flood waters (**Month 35**).

Related to water management and socio-economic issues

1. Outline priorities (in addition to the basic science) according to which the specific basins and sites will be studied (**Month 12**).
2. Interact with ecologists dealing with riparian vegetation along ephemeral streams in arid areas (**Month 24**).
3. Determine the environmental history of alluvial aquifer utilisation in the African study basins, thus linking the socio-economic history with the geomorphic palaeoflood record (**Month 30**).
4. Assist in the assessment of short- and long-term water resources and development in desert areas that depend on alluvial and other shallow aquifers (**Month 36**).
5. Address problems outlined by local end-user and stakeholders (**Month 36**).

References

Dahan, O. et al (2003): Development of A Flexible TDR Probe for Deep Vadose Zone Monitoring. Accepted for publication in *Vadose Zone Journal.*

Greenbaum, et al (2002): Paleofloods and the estimation of long-term transmission losses and recharge to the lower Nahal Zin alluvial aquifer, Negev Desert, Israel. In: House, P. K. et al (eds.) *Ancient Floods, Modern Hazards: Principles and Applications of Paleoflood Hydrology*, AGU, pp. 311-328.

Kuells, C. (2000) Groundwater of the North-Western Kalahari. Dissertation, Würzburg University.

3 List of Participants

Partic. Role*	Partic. no.	Participant name	Participant short name	Country	Date enter project**	Date exit project**
CO	1	Consejo Superior de Investigaciones Cientificas	CSIC	ES	1	36
CR	2	Hebrew University of Jerusalem	HUJI	IL	1	36
CR	3	HYDROISOTP gmbh	HY	D	1	36
CR	4	Desert Research Foundation of Namibia	DRFN	NA	1	36
CR	5	University of Edinburgh	UEDIN	UK	1	36
CR	6	University of Cape Town	IPC	SA	1	36
CR	7	Institut National de la Recherche Scientifique	INRS	CA	1	36
CR	8	Ben Gurion University	BGU	IL	1	36
CR	9	Ministry of Agriculture, Water & Rural Development, Namibia	MAWRD	NA	1	36
CR	10	Surplus People Project	SPP	SA	1	36
CR	11	Kamiesberg Municipality	KM	SA	1	36
CR	12	Nama Khoi Municipality	NKM	SA	1	36

*CO = Coordinator
CR = Contractor

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4. Relevance to the objectives of the specific programme

1. Specific Programme: Integrating and strengthening the European Research Area
2. Activity: Priority thematic area "Sustainable Development, Global Change and Ecosystems"; Sub-Priority "Global Change and Ecosystems"
3. Call title: Thematic call in the area of "Global Change and Ecosystems"
4. Call identifier: FP6-2002-Global-1
5. Activity Call: SUSTDEV-2002-3.II.3.1.a - Twinning European/third countries river basins.

II. Water cycle, including soil-related aspects
II.3. Integrated management strategies and mitigation technologies
II.3.1) Integrated water management at catchment scale
II.3.1.a) **Twinning European/third countries river basins**.

The main objective of the project is to use newly developed methodologies, technologies, and approaches in evaluating **long-term transmission losses**, **recharge into alluvial aquifers**, **and water resources** in semiarid to hyperarid ephemeral streams of selected semiarid European and arid African countries. It complies with Section ***II.3.***"Integrated management strategies and mitigation technologies", and in particular with the objectives of the point II.3.1.a) **Twinning European/third countries river basins** since:

a) It promotes twinning experiences on integrated water resources management research activities being carried out in Israel and Spain to similar river catchments of selected African countries (Namibia and South Africa);
b) It contributes to the objectives of the EU Water Initiative launched in Johannesburg at the World Summit on Sustainable Development, and to the recently held 3rd World Water Forum (March 16-23, 2003) in Kyoto;
c) It would make a significant contribution to solving some of developing world's most pressing problems, including water scarcity, water conservation, poverty reduction, and sustainability,
d) There is a close involvement of end-users and additional local stakeholders dealing with water scarcity and sustainability in the selected areas.

Throughout the research, that will be conducted within WADE, we will comply with the scientific, technical, wider societal and policy objectives of the Global Change and Ecosystems Sub-Priority in the area II.3. Integrated management strategies and mitigation technologies, by addressing the following points:

1) *Soil & water resources development & conservation*: This research will improve the knowledge on floodwater percolation and ground water recharge in arid lands. The knowledge on the recharge mechanism will allow better understanding of the water resources potential of alluvial aquifers in desert areas, both quantitatively and qualitatively. This knowledge will lead to better *water resource development* in arid lands, allowing optimal exploitation and *conservation* of both water resources and economic means.

2) *Ecosystem processes supporting & enhancing the management*: Throughout this research some aspects of floodwater percolation and groundwater recharge methods in desert areas will be investigated in light of their effect on the natural *ecological system*. The knowledge on the percolation mechanism that will be assessed in this research would help in evaluating long-term open channel recharge therefore *enhancing* a sustainable watershed *management* that *supports* both water resource management as well as *restoration* of the water shed *ecologic systems in* arid lands. These issues are contributions to an improved knowledge on "integrated management strategies and mitigation technologies, and scenarios of water demand and availability" indicated in Section "**II.3.1) Integrated water management".**
3) *Global Change and Water Cycle*. This research will reconstruct long-term records obtained from palaeoflood records (flood records over hundreds and thousands of years) that allow a better "understanding of the mechanisms, and an assessment of, the impact of global change and in particular climate change on the water cycle". This is achieved through the analysis of the impacts of long-term climatic variability and related regional responses of hydrologic system components such as extreme flood frequency and magnitude and groundwater recharge and availability. This project "provides bases for management and technological tools for water systems to mitigate the impacts" of climate change on arid and semiarid areas.

In addition, the project contributes to an improved understanding of **Management of scarce water resources and mitigation techniques** (II.3.3), and particularly to section II.3.3.a, Technologies for monitoring and mitigating the impact of water scarcity (STREP and Coordination Actions), since our project proposes new technologies for monitoring water content on natural groundwater reservoirs, which allows for a better water management and to combat water scarcity in dryland environments.

Lastly, the project aims to develop concepts and tools for facing the complex challenges expressed in the EU Strategy on Sustainable Development and the Johannesburg Summit. WADE will partially contribute to the characterisation of the state of the environment (ecological, social and economic dimensions) addressed on the key action VIII. Crosscutting issue: Sustainable Development concepts and tools, and particularly complies with point VIII.1.a Harmonising and sharing of methods and data (STREP and Co-ordination Actions).

State of the Art

In terms of hydrological monitoring, the current state of the art in Namibia and Namaqualand is for the monitoring of rainfall, river flow and groundwater levels. For example, a description of the monitoring work currently carried out by the DRFN for the Kuiseb River (P4) can be found at:
http://www.dea.met.gov.na/data/publications/Databases/MetaDB/Gobabeb/Kuiseb%20River%20Flow.htm

At best a black box model is used to model transmission losses and alluvial aquifer recharge estimates. Elsewhere, efforts to quantify alluvial aquifer recharge have been made using the following methodologies:

- Infiltration tests.
- Comparison between reach entrance and exit hydrographs.
- Modelling.
- Tracers.

However, the limited gauged transmission losses and recharge data, coupled with short instrumental record lengths of significant recharging floods enabled only minor advances in the estimations of long-term water resources in arid basins.

Recent methodological and technological advances, led by the Ben Gurion University (P8 of the WADE project), have been made in evaluating long-term transmission losses, recharge into alluvial aquifers and water resources in semiarid to hyperarid catchments. In terms of technological developments the key advance has been in the ability to install TDR (Time Domain Reflectometry) sensors at increased depths (>1.5 m). The TDR technique is one of the most common methods for water content measurement in unsaturated soils or sediments. It measures the velocity of propagation of a high-frequency signal transmitted along a metal wave-guide. The velocity of propagation depends on the dielectric coefficient of the material surrounding the wave-guide. Since the dielectric coefficient of water (~80) is significantly higher than most soils (2-7), a measurement of the velocity of propagation is used to estimate the volumetric water content. However, the use of TDR probes for water content measurements is usually limited by the probe installation technique. Installation of standard TDR probes in shallow soil horizons is simple and does not impose technical difficulties. In general, the probes can usually be inserted into the ground from the land surface with only minor disturbance of the natural soil properties. However, the need to insert TDR wave-guides into deep soil horizons or sediments (>1.5 m) can be difficult if natural undisturbed sediment condition is required.

A new methodology for the application of TDR in the deep vadose zone was developed by Ofer Dahan of the Ben Gurion University (Dahan, et al., in preparation; patent pending). The proposed technique allows multi-level installation of TDR probes to any desired depth with minimal disturbance of the sediment column structure, thus allowing continuous, real-time, moisture measurements of the entire vadose zone cross section from the surface to the water table. The technique uses a small diameter (15-20 cm) slanted borehole, drilled at 45°, and flexible TDR wave-guides made of stainless still foil attached to the outer side of a flexible sleeve. The sleeve, made of rubber or thin PVC liner, is inserted into the borehole and then filled with liquid two-component urethane. Prior to curing the urethane generates hydrostatic pressure that attaches

flexible sleeve with its wave-guides to the borehole walls. It is the flexibility of the sleeve and the wave-guides that allow perfect contact of the wave-guides to the borehole walls even though the borehole is likely to be of variable diameter and rough walls. Although some disturbance of the natural sediment properties near the borehole annulus (a couple of centimeters around the borehole) is expected, the sediment profile from that minimal zone to the land surface is likely to be undisturbed. A schematic illustration of the field set-up is presented in Figure 4.1.

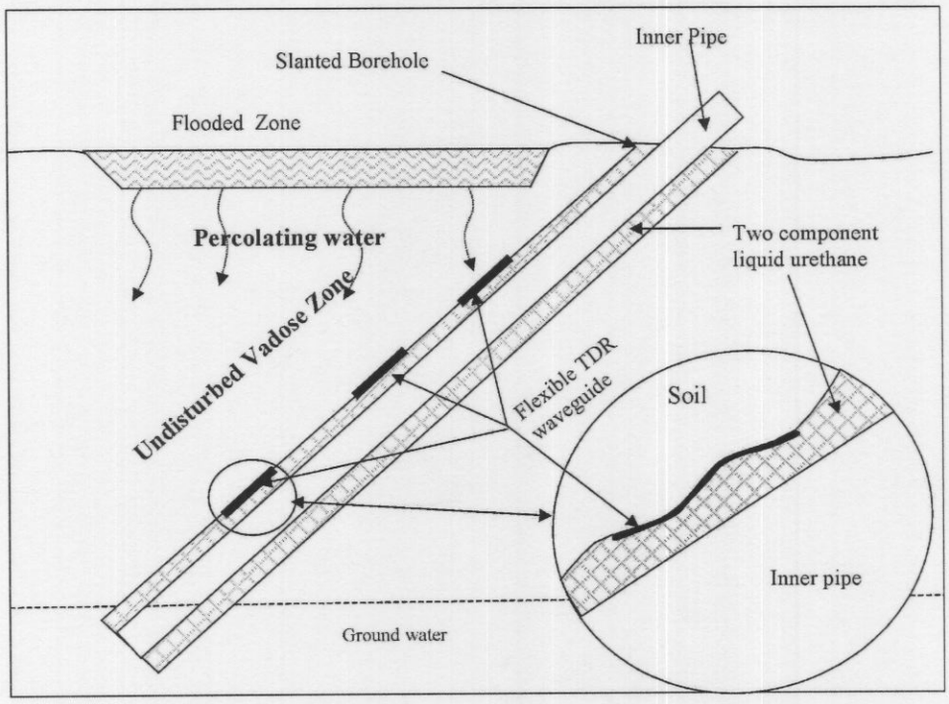

Figure 4.1 Schematic diagram illustrating the method of drilling and the positioning of the TDR probes beneath the river channel and the undisturbed vadose zone

In terms of the state of the art for evaluating long-term recharge, the technological advances for monitoring the recharge process (described above) have successfully been combined with the methodology of palaeoflood hydrology, that can reconstruct long-term flood magnitude and frequency from sedimentary evidence of former floods. The combined methodology has been utilised successfully once before during a study in the Negev Desert, Israel (Greenbaum et al., 2002).

During the WADE project this state-of-the-art technology and methodology will be applied within twinned catchments in Israel, Spain, Namibia and South Africa. It will be the first time that the approach will be used to assess long-term water resources in alluvial aquifers in semi-arid to hyper-arid catchments where water supply is a critical issue. The combination of the technology to monitor contemporary transmission losses and the recharge process will be combined with long-term data on flood frequency (determined by palaeoflood hydrology) and environmental history, including historical socio-economic aspects of alluvial aquifer utilisation in the study basins. This interdisciplinary approach will further develop the state of the art with respect to assessing the long-.term water resource potential of alluvial aquifers.

Other relevant research projects: a) International Projects

Table 4.1 summarises recent multidisciplinary projects that have investigated different aspects of groundwater resources that are considered within the WADE project. A number of the projects have studied the influence of global change on groundwater resources. The GRACE and ECRASE projects have used modelling approaches to forecast the groundwater response to future climate change based on Global Circulation Model (GCM) data. The project most related to WADE was the study of the Grand Erg Orientale Basin in N. Africa where decadal recharge history was determined using stable isotopes. All these projects, however, refer to rock aquifers as distinct from shallow alluvial aquifers that will be the focus of the WADE project.

Project	**Global change**	**Ephemeral rivers**	**Ground-water modelling**	**Ground-water recharge**	**Country/ Region**	**Other information**
Mediterranean desertification & land use impacts MEDALUS II	√			√	Mediterranean	
Groundwater resources & climate change effects GRACE	√		√		UK, Germany, NE Spain	GCM simulations of climate change
Evaluation of the effect of climatic variations on recharge of aquifers in southern European catchments ECRASE	√			√	S. Europe	GCM simulations of climate change
Groundwater Recharge in the Eastern Mediterranean GREM			√	√	Greece, Israel, Jordan, Cyprus	
GRAPES			√		Temperate & semi-arid catchments	
Artificial recharge of groundwater				√	no details on CORDIS	
Recharge characteristics & groundwater quality of the Grand Erg Orientale Basin	√			√	N. Africa	Decadal recharge history stable isotopes
Impact of climatic variability on agro-ecosystems & water resources in drylands (Network)	√				N.Africa, China, Argentina	Climate variability over the last 200-300 years
TEMPQSIM	√	√			Mediterranean	Integrated Water Management
CATCHMOD						Research cluster

Table 4.1 Recent R&D projects that have studied groundwater resources in semi-arid or arid environments and/or the effects of global change on groundwater resources.

In terms of projects including modelling approaches the MEDALUS II project has tested two models, based on channel water flow, sediment transport and sediment yield (MEDRUSH and SHETRAN), within the Guadalentín basin in SE Spain, one of the WADE study basins. Data sets have been assembled from catchment modelling for the Guadalentín, these could have potential use for the WADE consortium.

The TEMPQSIM project aims to increase the efficiency of integrated water management in Mediterranean and semi-arid river catchments and in particular in modelling ephemeral river channels where ongoing dynamic processes during the

period of no surface runoff are generally unconsidered in existing models. Of particular interest to the WADE project is this modelling of ephemeral river channels as it is complementary to the WADE research. WADE will reconstruct the magnitude and frequency of significant recharging flood events and model the transmission losses of flood events into shallow alluvial aquifers. Therefore, knowledge on modelling ephemeral river behaviour would be a valuable asset to the research.

The TEMQSIM project is one of the projects included in the CATCHMOD research cluster set up by the EC to support the implementation of the Water Framework Directive. The main objective of the cluster is the development of harmonised modelling tools for the integrated management of water at the basin or sub-basin scale.

Other relevant research projects: b) National Projects

Namibia

The presence of slackwater flood deposits in Namibian river valleys has been described by Klaus Heine (Heine et al, 1999; Heine and Heine, 2002). These papers describe extremely large flood events that occurred between 19,000 and 23,000 years ago. The research theme is, therefore, focused on Quaternary climatic reconstruction. A short paper available on the internet (http://www.kluft.de/files/p08.pdf) provides some, as yet unpublished, radiocarbon dates indicating the presence of Little Ice Age slackwater flood units, again with a climate change and flood risk interpretation. The state of the art approach of the WADE consortium in terms of palaeoflood hydrology will be to augment the long-term flood record by including more sites of slackwater flood deposits, then define the discharge of these palaeofloods using hydraulic modelling and palaeohydraulic reconstructions i.e. in addition to reconstructing long-term flood frequency, the reconstruction of long term flood discharge series can be attained. The combined use of palaeoflood hydrology with deep groundwater TDR data will enable state of the art assessment of the water recharge potential of flood events.

South Africa

The WADE project will draw on the existing work that has been carried out on groundwater water resources. In particular two recent reports have been published documenting alternative approaches to assessing groundwater resources and water supply within the Namaqualand case study region of the WADE project (Atkinson and Ravenscroft (2002) and Titus et al (2002). The consortium will endeavour to be in contact with these authors in order to draw on their experiences.

References

Atkinson, D & P. Ravenscroft. (2002): Alternative service delivery options for Municipalities in the rural areas: Kamiesberg Local Minicipality Case Study. Water Research Commission, WRC Report No KV137/02, Pretoria.

Heine, K. and Heine, J.T. (2002): A paleohydrologic reinterpretation of the Homeb Silts, Kuiseb River, central Namib Desert (Namibia) and paleoclimatic implications. Catena, 48, 107-130.

Heine, K., Heine, C. and Kühn, T. (2000): Slackwater Deposits der Namib-Wüste (Namibia) und ihr paläoklimatischer Aussagewert. Zbl. Geol. Paläont. Teil I.Stuttgart.

Titus, R. K. Pietersen, M. Williams, S. Adams, Y. Xu, I. Saayman & C. Colvin. (2002): Groundwater assessment and strategies for sustainable resource supply in arid zones The Namaqualand Case Study. Water Research Commission, WRC Report No 721/1/02, Pretoria.

5. Potential impact

Strategic impact

Over 1 billion people, or 18% of the world's population, lack access to safe drinking water and over 2.4 billion people do not have adequate sanitation. Providing access to clean water is crucial to alleviating poverty and improving health conditions in the developing world, where more than 2.2 million people, mostly children, die each year from water-related diseases. Adequate supplies of clean water and sanitation could reduce cases of some diseases by as much as 75%. Dealing effectively with water problems can have other positive side effects. Successful water access encourages improvements in governance, creating cross-border cooperation and regional stability where water shortages are, or could be, a source of local tension or conflict.

In this project we provide the scientific basis to improve the management of water resources within dryland environments. Such basins suffer from a growing lack of water - one of the most limiting factors in the development of arid regions and standard of living within Africa's diverse communities. In arid environments floods generate the water that recharges subsurface aquifers through losses into channel beds. Our research group is committed to identify and realistically evaluate the flood recharge, which is central to the livelihood of the inhabitants of these areas. We believe that the lack of information on the frequency and magnitude of the large storms and floods curtails the realistic approach toward this resource in both large and small drainage basins. This project also complies with the EU water initiative in that it is based on a strategic partnership with specific regions, civil society stakeholders and the private sector. The ideas, methodologies and applications of this project will benefit first and foremost, the local inhabitants and the decision makers working in water and floodplain management. A major effort during the project will be to train hydrologists from the respective countries to deal with the specific problem at a specific basin scale and with at the regional scale including all field, instrumentation, methodologies and modelling involved.

To ensure maximum potential impact beyond the duration of the project, WADE end-users will play a leading role in the project, being involved in the research whilst developing and maintaining close links with the key stakeholders in the study catchments.

WADE will also fit in with new basin management water policy in Namibia in terms of the integrated approach of surface waters and water resources, plus the involvement of stakeholders. In addition the involvement of the MAWRD in the RTD workpackages (namely WP3, WP4 and WP5) will enable capacity building in a country with a marked shortage of trained technical and professional staff in engineering and science (especially in the water sector). This will enable impact beyond the Kuiseb Basin, with Namibia's water sector professionals possessing the expertise and experience to apply new approaches in other basins.

Innovation-related activities

This research approach can be considered highly innovative both in their parts and as a whole. A major **methodological innovation** comes from the combination of palaeoflood records with data on modern transmission losses (estimated by different methods). This approach can be considered as new since it has only been successfully achieved once in Israel (Greenbaum et al., 2001). We believe that new ground will be broken in terms of the data collected, methodologies used, and procedures outlined for the proposed regions and it would be of stimulus for other dry lands. The research will produce a long-term, quantitative, and realistic estimation of the recharge potential of the studied catchments. As water demands increase such a view is crucial to prevent basin or regional water crisis. New capabilities brought into the decision-making process are crucial for future water resource management. Non-realistic views on the water potential of our arid environment can lead to over sensitivity to future changes and to potential catastrophe.

The **technological approach** is also highly innovative. Dahan of the Ben Gurion University (P8 of this project) has developed a new methodology for applying Time Domain Reflectometry (TDR) in the deep vadose zone. This allows multi-level installation of TDR probes in any desired depth with minimal disturbance of the sediments and thus, continuous, real-time, moisture measurements of the entire vadose zone from the surface to the water table. This data on the vadose zone, together with data on groundwater characterisation and groundwater dating, will be processed through the modelling approach that best fits the character of the collected data.

Another major innovation of WADE is its **integrated approach** to address the ground water resource problems from the environmental, social and economic point of view, and twinning European/third countries river basins. Therefore, a concept for the use of this resource needs will be established for the whole basin in an integrated way. All the parties involved, affected and interested will be described and their interrelationship understood. The socio-political interdependencies and mechanisms of control will be studied. This will include gender issues considering the different roles, needs, and experiences of women and men related to water use on the studied communities. For this integrated framework a proposal for water management will be developed.

Exploitation and dissemination plan

The WADE exploitation and dissemination plan includes:

- Web-based Information System for creating awareness of the generated knowledge beyond the Consortium, and in particular communication with stakeholders including among others: users, water managers, decision makers, scientific community (students, scientists and professionals) and the general public.
- Production of a semestral Newsletter, which will include new advances within the different subprojects of WADE.
- Presentations to the general public aiming for dissemination and the creation of public awareness.Media Conference to disseminate advances at National and regional levels.
- Support of technological innovation and software development of new products and processes within WADE. This project will support new patents.
- A final, open meeting will be held to present the results of the WADE project to interested technicians, professionals and scientists. It will be held either in Namibia and/or South Africa.

- Publications, reports and presentations: A major theme of this project is to describe current best practice or usual practice in water management at the study areas. All partners will contribute throughout Europe to the dissemination of information about the project and its results at conferences and seminars.

European added value

The Political Declaration that were adopted in the Johannesburg Summit on water issues, together with the World Water Forum recently held in Kyoto have shaped a global partnership for sustainable development. This partnership includes EU commitments to increased development assistance for developing countries, good governance and a better protection of the environment. These subjects requires the participation of multidisciplinary and international groups working together to improve water resource assessment and management within developing countries. The WADE project will allow research collaboration between individual research institutions, many of which are actively involved on national research programmes as well as on finished and on-going EU funded projects (e.g. SPHERE) resulting in efficient methodological income to this new research. Indeed the close involvement of end-users in the research tasks will help focus the methodological needs as well as data, knowledge and expertise pooled within the Consortium, with the final aim of constructive dissemination of results.

Contribution to policy developments

A key objective of the Council-Commission statement of November 2000 on EC Development Policy was to help focus EC development cooperation on a number of priority areas to help achieve the Millennium Development Goals. Among these Goals, the principal one is to reduce poverty with a view to its eventual eradication. Poverty is defined not simply as the lack of income and financial resources but also as encompassing the notion of vulnerability and such factors as no access to adequate food supplies, education and health, natural resources and drinking water, land, employment and credit facilities, information and political involvement, services and infrastructure. In many developing countries, water is the main limitation to its development and sustainability and, therefore, technical and scientific cooperation will be a valuable way of support the EC Development Policy. In recent years, the EC Development Policy has be shaped by new EU international commitments resulted from the Monterrey, Johannesburg, Doha and Kyoto agendas.

In particular, the Johannesburg Summit (2002) and Kyoto Summit (2003) aimed to mobilise international resources to deal with these and other water-related problems. At these summits, the European Union proposed a series of important sustainable development issues on water, including the development of a new partnership on fresh water and sanitation, involving developing countries, Member States, civil society and the private sector. The overall target of these initiatives comprises the millennium target to halve the proportion of people lacking access to safe drinking water by 2015, together with a complementary target on sanitation. In support of these actions, the European Commission adopted in March 2002 a "Communication on water management in developing countries". This Water Initiative should ensure the health of aquatic ecosystems and balance the water needs of the environment with the water needs for economic development and agricultural purposes. The Communication stresses to apply

an approach based on "Integrated Water Resources Management", in which three critical areas of the EC policy have been identified:

(1) Ensuring a supply to every human being, especially the poorest, of sufficient *drinking water of good quality and an adequate means of waste disposal*, with the general objective of reducing poverty and improving people's health and quality of life;

(2) Sustainable and equitable *transboundary water resources management* taking into account all relevant interests and integrating the competing needs of the various users, in particular those of riparian communities and states sharing the same resource base;

(3) *Cross-sectoral coordination to ensure fair and appropriate distribution of water between users of different kinds,* requires mainstreaming water management principles into related policies : water for food security, for the environment, energy, industry, etc.

The WADE project will contribute to these policies both in points 1 and 3, through the development of methodologies and monitoring systems, generating the scientific bases for a better water management in drylands of the world. Since water is a social, economic and environmental good fundamental to human activity, the effective evaluation and management of the resource is a key aspect of any development policy. In addition, the WADE project provides an integrated view of both surface water and groundwater resources which improves the evaluation and management, as well as the consideration of socio-economic and environmental issues. This innovative technological and scientific approach for evaluating the scarce water resources in drylands will provide the bases for sustainability of the drainage basin in these hyperarid zones. The knowledge generated will provide options and enable choices of sustainable lifestyles and water resources uses as well as promotion of appropriate incentive and regulatory policies by the countries involved in the project.

6. Project Management and exploitation/dissemination plans

6.1 Project Management

For the successful implementation of WADE, the following organisation, management and decision making structure has been established:

Project Coordinator

The coordinator of the project will be the **CSIC**, the Spanish National Research Institute with coordinating and participating experience in many EU projects from previous "Framework" programmes.

The coordinator will assume the responsibility of project management and will be the main interface between the project group and the European Commission. The CSIC will also liase between partners, channel information to the other partners and coordinate project planning, budgeting and reports using information supplied by the partners, as well as informing the EC scientific officer about all scheduled management meetings.

Steering committee

The steering committee will be established to address high level management issues, including scientific and technical matters, financial ownership of results, exploitation planning and control matters. This committee will include a senior manager of each partner and will meet at least twice a year (or more if an urgent issue arises). Decisions will be taken following a vote amongst members of the steering committee. The details of the voting procedures are outlined in the consortium agreement.

The steering committee chairman will be appointed at the first meeting. Throughout the project, the steering committee will also contact other potential end-users to transfer the project's results. This task will be mainly undertaken through the established networks that our end-users have with other administrations and organisations of Africa and the European Union, such as water authorities, NGOs, water managers etc.

The coordinator will collect all the produced data (databases) and software and will build a project WEB page for dissemination purposes including the resulting methodology guide (pdf format) and free software.

WP Leader

The workpackage (WP) leaders (Table B5.1) have been chosen and accepted by partners according to their specific expertise with respect to the aim of each workpackage. The WP leader is involved in the detailed coordination, planning, monitoring and reporting on the WP, and in the collaboration with other WPs. He/She will organise meetings with WP partners. The technical and meeting agendas of the WPs will be communicated to the project coordinator.

Partners

The partners will hold a kick-off meeting within the first month of the project to discuss the project workplan and the detailed responsibilities of the partners through the

different project milestones. One important aspect of the meeting will be to identify skills gaps within the consortium so that applicable training and capacity building can be addressed within the WPs.

Partners are responsible of their scientific and technical tasks, the participation to the Project Meetings and for on time reporting of their progress activities to the WP Leaders. The progress of activities will be reviewed by technical reports delivered to the European Commission on months 6, 12, 18, 24, 30 and 36.

Work Package	WP Leader	Participants
WP1: Management	P1	P2, P3; P5, P8
WP2: Site characterisation	P2	P1, P2, P3, P4, P5, P8, P9, P10
WP3: Reconstructing long-term flood magnitude and frequency	P1	P2, P7, P9
WP4: Monitoring of surface and subsurface water	P8	P1, P2, P3, P4
WP5: Demonstration of TDR probe and the estimation of transmission losses.	P8	P3
WP6: Modelling of transmission losses and groundwater recharge	P3	P2, P8, P9
WP7: Participatory water management: socio-economic & historical perspectives	P5	P4, P6, P9, P10, P11, P12
WP8: Results' dissemination and exploitation	P1	P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12,
WP9: Review and assessment	P1	P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12

Table 6.1 WP leaders and participatory partners

Milestone reviews

At the milestone reviews the progress of the project and the outlook for exploitation of the results will be critically reviewed and compared to the planning and criteria described in this Work-Programme. Depending on the progress and the results achieved, a change in the Work-Programme may be proposed. Alternatively, in case of insufficient technical results or poor outlooks for future exploitation of the results, it can be decided to discontinue the project. For the mid-term and final assessment a special review meeting will be organised with the steering committee and a representative of the European Commission.

Methods for monitoring and reporting progress

Each partner will report every 3 months to the corresponding WP Leader about the progress of the work on the basis of a regularly updated detailed planning. These progress reports will contain a review of :

- Work carried out, results obtained
- Work delayed, reasons and actions to correct the problems
- Work planned for the following period
- Percentage of completion, estimated time of completion.

In addition, once a year Partners will submit the individual cost statements derived from

the project execution, together with the institutional auditing certificate which has been budgeted by each partner under the management activities item.

The WP Leader will then summarise the overall project status and planning and send it to the project coordinator, who will finally prepare the corresponding 6 month management report and annual progress and cost statement reports, taking care of their distribution to the commission in time. A final project report will review the scientific achievements of the project and main deliverables.

In addition an exploitation plan will be defined during the project, complementing the technology implementation plan which will be evolving during the project execution. an exploitation manager will be defined, and depending on the expected results exploitation responsibilities will be described regarding the involved partners.

Of particular importance for the monitoring of the project's progress will be the **mid-term review**. Two independent scientists will be invited to attend the 2nd annual meeting where all partners will present a summary of the work completed with respect to the original project objectives, milestones and deliverables. The progress of WADE in terms of scientific achievements and its potential impact will be reviewed by the independent scientists.

Meetings

Meetings will be held every 6 months (7 in total, including the kick-off meeting) at different places easily accessible to all the partners. In addition, other work meetings may involve some of the partners to transfer information and data generated by the project. Main annual meetings will be held at the African countries coinciding with the field work periods. Meeting organisation will be assigned to either project coordinator or work package leaders. A preliminary programme with possible locations will be generated at the kick off meeting. Meeting organisers will be responsible for its organisation and minutes preparation. Meetings will contemplate technical revisions, including elementary or significant changes in the programme, interpretation of obtained results, further investigations and reporting to the EU. There will be a balanced weighting of all partners. Decisions will be made by bare majority. If fundamental problems occur, the coordinator will have to decide. These periodical meetings will ensure the proceeding of the work. If a partner fails to perform or report his results, he will be demanded by the coordinator to make up for it.

6.2 Plan for using and disseminating knowledge

Plan for the management of knowledge

The communication strategy aims to keep all the partners fully informed about the project status, the planning and all other issues which are important to the partners in order to obtain maximum transparency for all involved and to increase the synergy of the cooperation. Interactive management meetings and technical meetings take an important role in the communication strategy. All information (like minutes of meetings, visit reports, task reports, relevant publications etc.) will be communicated to the main project coordinator, who will decide whether channel this information to the other partners or not, when appropriate. The communication strategy also aims to effectively communicate with parties outside the consortium, such as with other European project consortia, other potential users, etc. The communication strategy -

which includes a planning for publications to be realized, presentations to be given and conferences to be attended on behalf of the consortium - will be a topic at each steering committee meeting. In addition, a project Web site will be implemented for dissemination of results and communication purposes outside the Consortium.

All partners are principal contractors and have access to all reports and results. Changes in working programme and other information concerning the consortium and the project will be communicated to all partners. Each partner will designate a contact person responsible for communication. All partners are equipped with computers, internet access and e-mail accounts. Standard communication will be done by e-mail. In addition, a virtual office (intranet) for written material exchange amongst participants will be installed.

Intellectual Property

Partners will sign a Consortium Agreement previously to the signature of the Project Contract by the Coordinator. This Consortium Agreement will clearly indicate ownership and use of Intellectual Property.

6.3 Raising public participation and awareness

Raiing the awareness of stakeholders is needed to ensure that they recognise the value of water in all its dimension – economic, social, cultural for health and the environment. The WADE project addresses this awareness through the participation of different users and policy makers.

In the Kuiseb Basin in Namibia, the Desert Research Foundation of Namibia (DRFN, P4) and the end-user the Ministry of Agriculture, Water & Rural Development (MAWRD, P9) are key members of the Kuiseb Basin Management Committee (KBMC). As a result, the WADE research will be carried out in conjunction with the KBMC, that includes a wide range of stakeholders including the Walvis Bay Municipality; NamWater (bulk water suppliers); the Department of Rural Water Supply, the Department of Agricultural Extension in the Ministry of Agriculture, Water and Rural Development; commercial and communal farmers; the Ministry of Environment and Tourism, as well as the DRFN and MAWRD. Furthermore a number of Basin Management Committees (BMC's) are currently being established in neighbouring basins with ephemeral river systems and the KBMC will be cooperating closely with them, enabling further impact beyond the study basin.

In Namaqualand (South Africa), three end-users will be working within WADE, namely the Surplus Peoples Project (SPP, P10), the Kamiesberg Municipality (P11) and the Nama Khoi Municipality (P12). Recent re-organisation of local government and water services provision in South Africa (Municipal Systems Act 2000 and Water Services Act 1997) puts the onus on local government as the Water Service Authority (WSA) to create Water Service Providers (WSP), preferably by promoting the development of community leadership and organisational capacity. The South African Ministry of Agriculture, Water & Rural Development' policy emphasises the importance of building municipal capacity, for example through the BOTT (build-operate-train-transfer) and OTT (operate-train-transfer) programmes. WADE is ideally situated to play a key role in supporting such a process at research sites in Namaqualand. Through their involvement in WP7 (Participatory Water Management), the SPP will play a key

role in integrating the research into local (municipal) government initiatives and build institutional capacity at the community level. This fits squarely within the remit and experience of the SPP and will ensure maximum impact of WADE will continue after the project's duration.

Awareness and public participation outside the consortium will be addressed through a number of publication and activities, taking advantage of the active participation of a good representation of stakeholders within the project. Basic information of the project objectives and results will be disseminate through the publication of the Project Flyer, and the development and updating of a Project Web Page. This Web Page will contain an e-Newsletter with the latest results and socio-economic implications. In addition, activities to be promoted include public education campaigns –through the NGO's participating in the project-, through the media, schools, professional associations and political fora. Training and formation activities directed to technical staff from Namibia and South Africa will be also implemented.

7. Workplan – for full duration of the project

7.1 Introduction – general description and milestones

The overall scope of the WADE project is to investigate the critical relations between the floodwater recharge processes of shallow alluvial aquifers. A long-term approach (centuries) will be used to accurately assess the sustainability of floodwaters as a water resource. In order to achieve this ambitious goal, the research is an integrated study that will simultaneously monitor and analyse three hydrological domains, (1) the long-term occurrence of flood events (palaeofloods) and characterisation of the flood hydrograph as the water source for the vadose zone, (2) the deep vadose cross section response to flood events, and (3) the ground water recharge in response to low frequency-high magnitude flood events. The results will then be used to create a model for groundwater recharge from floods in drylands. The model that will be conceptualised and formulated can be later used as a basis for research and development programs in other drylands around world. The WADE project includes a large proportion of the work effort focused on the socio-economic importance of floodwater recharge as a component of basin water resource management and will include local community participation and will address gender and poverty alleviation issues. The two research areas in Africa, selected for twinning, with basins in Spain and Israel, are in Namibia and Namaqualand (South Africa).

The WADE project is an integrated study with the participation of 12 partners representing science and technology developers, SME's, local government and NGO's working in the study areas. The project will last for 36 months, including a total work effort of 411 person months. The implemenation of the WADE project will be carried out within **9 Workpackages**, WP1 being a specific management workpackage aimed at ensuring efficient project management, monitoring the progress of the project in terms of the deliverables obtained in other WP's and completing the periodic progress reports. WP2 is a general workpackage devoted to collecting a range of general scientific and socio-economic data from the study catchments. The remaining workpackages cover the distinct research methodologies employed within the WADE project, managed by experts within the relevant fields. These workpackages include reconstructing long-term flood magnitude and frequency (WP3), the monitoring of surface and subsurface water (WP4), the modelling of transmission losses (WP6) and participatory water management (WP7). In addition a demonstration WP (Demonstration of TDR probe and installation, WP5) will be completed to demonstrate the effective installation and sub-surface monitoring of the TDR probes. Finally, WP8 is dedicated to results' dissemination and exploitation, and WP9 is focused on the Review and assessment of the project results and objectives. All the project milestones from the 9 workpackages are listed in Table 7.1.

Milestone No.	Milestone	Workpackage	Month
1	Kick- off meeting	1	1
2	Regular meetings with communities and local partners	7	3
3	Compilation of available data on surface and subsurface hydrology and water balance	4	5
4	Selection of sites for probe installation and sample collection	2	6
5	Identification of palaeoflood sites and first fieldwork data collection	3	6
6	Installation of the TDR probes at the demonstration site	5	6
7	Maps of water resource use along the study basins	7	10
8	First WADE annual coordination meeting	1	12
9	WADE dissemination plan	8	12
10	Monitoring systems installed and operational in all catchments	4	12
11	Decision to be made on whether to implement the WADE contingency plan	1	18
12	Palaeoflood fieldwork data collection completed	3	18
13	Mid-term project review	9	24
14	Data integration from WP2 (Site characterisation)	2	24
15	The appropriate hydraulic model will be determined for the palaeoflood study sites	3	24
16	Relationships between floodwater stage, percolation rates and groundwater recharge determined	4	24
17	Mass and moisture balance of the studied cross-sections	6	24
18	Choice of the numerical model that best fit the character of the collected data	6	30
19	Institutional analysis relevant to the improved sustainability of water supplies completed	7	30

Table 7.1 The WADE milestones

The WADE case study areas

The project will address the relations between surface water dynamics and recharge of dryland aquifers through a combination of geomorphic assessment of ephemeral channels, continuous monitoring of soil water through the shallow and deep vadose zone, continuous monitoring of the ground water stage and development of conceptual models of the recharge processes. This project will focus on recharge associated with **four** different desert watersheds that represent **four** different land uses and efforts to utilize aquifer recharge.

One of the main objectives of this project is to develop new methodologies and to create substantial improvements in the analysis and capabilities of the existing ones. In order to achieve these specific scientific and technical objectives a case study approach will be carried out. A second major objective of the project is the twinning of European and Third country catchments. The technology to be applied in the methodology, particularly in WP4 and WP5 has been developed in **Israel**, plus the methodology of palaeoflood hydrology (WP3) has been utilised within integrated water management, in terms of flood risk, in both **Spain** and **Israel**. For this reason catchments in Spain and Israel will be twinned with those of the selected Third countries – **Namibia and South Africa**.

In **Spain** research will focus in the semi-arid region of SE Spain, where ongoing research within the Guadalentin River basin is compiling palaeoflood records and past

flood frequencies from gorge reaches. In between the gorge reaches are areas of alluvial terraces containing important aquifers. The importance of these shallow groundwater resources is in the supply of water to the local 'greenhouse' economy and food production. This catchment is ideal for installation of the TDR probes and the long-term quantification of groundwater recharge.

In **Israel**, the developed deep vadose zone and TDR technology has been tested within the Nahal Zin catchment of the Negev Desert, that drains the eastern flanks of the Negev Mountains. The alluvial aquifers within this catchment are within a Pleistocene terrace, up to 20 m thick. Downstream of the alluvial aquifer the river is incised within carbonate rocks and forms a 20 km long gorge, where palaeoflood deposits have been preserved. The largest recorded floods in the catchment have a discharge of around 500 m^3/s.

In **Namibia** the Kuiseb catchment has been chosen for the WADE project, as it already has a hydrological monitoring infrastructure in place, managed by the MAWRD (P9). In additional to the hydrological monitoring, the Kuiseb project also involves community participation that will also be encouraged in WADE, through WP6. The mean annual rainfall in the Kuiseb catchment varies from 300 mm/a in the headwater regions to 50 mm/a in the lower catchment, with the principal rainy season lasting from November to February.

In **South Africa**, research will be carried out in the western province of Namaqualand, where mean annaul rainfall is between 100 and 300 mm/a, with a winter rainy season from June to September. The study will focus in the western draining catchments of the region, south of the Orange River, in particular the Buffels River. The final study reach will be chosen from satellite imagery, maps and air photography. The consortium includes 5 research groups working in Namaqualand, partners P5, P6 and end-users P10, P11 and P12. Their research focuses on environmental history and socio-ecological issues associated with water resources as well as with developmental, management and institutional aspects of water service provision at the local level.

In the described field areas, three approaches will be used in this assessment (all described in more detail below). First, extending the record of the largest floods to several hundreds and even thousands of years, and determining the largest single flood within a specific basin and a region. In addition, the modern flood hydrograph will be monitored and the floodwater will be sampled for its chemical and isotopic compositions. Secondly, the vadose zone of selected sites will be examined using emerging technology that allows for the first time direct and continuous monitoring of the deep vadose zone moisture and temperature profiles under relatively undisturbed condition. Third, shallow ground water will be monitored continuously for its water stage and the groundwater will be sampled for chemical and isotopic composition. The chemical and isotopic composition of water will be compared with the surface and the vadose zone water. Sampling of percolating water will be done through specially designed sampling ports that are prepared specifically for this research. These ports will be installed along with the moisture and temperature sensors. The vadose zone moisture profiles together with the water table fluctuation will be analysed to construct a comprehensive model for floodwater percolation in arid lands. The model results will be examined independently through the chemical and isotopic composition of the water from the flood, vadose zone and ground water. The study results will be used to elucidate potential recharge rates from natural open streams as the main groundwater

recharge of alluvial aquifers in dryland streams. Finally the socio-economic relevance of the data will be assessed through an anthropological study, from a historical perspective, that will include gender and poverty alleviation issues.

The workplan has been divided into a total of 9 Steps, corresponding to the workpackage lists presented in Section 7.6. Step 1 covers management activities whilst the remaining steps describe the scientific/technical issues of the project, with a demonstration activity in Step 5. The general description of the workplan and the timing of the key milestones and deliverables within each step is presented below:

STEP 1: WADE PROJECT MANAGEMENT *(Management Activities)*

Description: The objective of this WP is the definition of the management structure of the project and the efficient running of the project throughout its 3 year duration.

Task 1.1: ***Coordination and management***

Methodology: A steering committee will be established for the project, formed by one representative of each partner and chaired by the co-ordinator. The steering committee will contribute to scientific, technical, financial, planning and control matters arising during the project. The WP's leaders will be responsible for gathering and processing the information generated in each individual Workpackage.

The project administration, edition and preparation of the progress and final reports will be done by the general co-ordinator, together with the economic forms (cost statements). He will also co-ordinate the definition of the Technology Implementation Plan and the Plan for Exploitation of Results. The partners will keep internal communication and will report directly to the WP's leader with regard to their progress throughout the course of the project. Each partner will submit the corresponding WP leader a 3-month progress report describing their progress including possible deviations from the original timetable. This information will further feed intermediate reports. Each Partner will also prepare a concluding report describing their activities and achievements during the course of the project and submit it to the general coordinator, who will edit and include them in the final report to be submitted at the conclusion or the project.

A virtual office will be created for an easier management of the information within the project. It will have restricted access to the consortium participants.

Milestones and Deliverables

The key milestones within this WP are:

Milestone No.	Milestone	Month
1	Kick- off meeting	1
8	First WADE annual coordination meeting	12
11	Decision to be made on whether to implement the WADE contingency plan	18

The main deliverable will be the password protected section of the WADE Web page (D1a) that will enable efficient coordination of information between the partners. This

will be achieved by month 3. The ultimate deliverable, however, will be the successful completion of the project.

STEP 2: SITE CHARACTERISATION *(RTD/Innovation activities)*

Description: Site characterization has two goals: (1) determine general characteristics and dynamics of ephemeral channels and (2) select sites for probe installation and sample collection. Site characterization will integrate information from geomorphic, flood and palaeoflood hydrology, and soil and sediment information combined with previous knowledge on the local groundwater.

Task 2.1: ***Geomorphic setting***

Methodology: Soil and geomorphic variables related to the flow and storage of water along ephemeral channel will be evaluated to determine the best sites for installation of soil probes and sampling and to form a foundation for evaluating monitoring results. Geomorphic variables will include mapping and the distribution of principal ephemeral channel features such as terraces, floodplains at the study sites. All features will be plotted on aerial photographs. This step will provide an assessment of where water is most likely to percolate along channels. Channel morphology will be further characterized using a laser theodolite to measure detailed channel cross sections at several sites along the channel including sites where probes will be installed. This information will help establish maximum floodwater depths.

Task 2.2. ***Sediment characterisation***

Methodology: Sediment will be characterized at each site through surface soil sampling and cross sectional sediment samples collected during drilling. The sediment samples from each site will be analysed for texture, calcium carbonate, and soluble salts. The granulometry, the content of fines (clay and fine silt) will be determined. A photographic documentation of the different surfaces will be made and linked to the description and mapping of cross-sections. Based on this discretisation the different surface types will be characterised and described regarding the hydrological and hydraulic properties. The granulometric survey will be linked to existing soil physical databases in order to derive roughness, infiltration capacity and hydraulic conductivity. The roughness is a major parameter for the hydraulic processes during a flood event, controlling the water level-discharge relationship at a given cross-section. The infiltration capacity will be used to estimate the infiltration during the flood event. The hydraulic conductivity within the alluvium is the major parameter for the lateral and vertical distribution processes of water during and after a flood event. From previous research of the working group, extensive knowledge on database references and own data exist to assist the work of parameter estimation and regionalisation. For the control of parameter estimates infiltration tests will be carried out in selected locations.

Task 2.3. ***Riparian ecosystems:***

Methodology: The riparian ecosystems will be classified and characterised. The distribution of classified riparian plant communities will be mapped along the study reaches using ground mapping with base-maps, photographs and ground truth evaluation. Evapotranspiration is a major loss component of alluvial aquifers. Evaporation losses will be estimated based on existing eco-hydrological studies for the specified classes of riparian vegetation. The total balance of evaporation losses through riparian vegetation can be checked through solute mass balances of halogens if the chemical composition of recharged flood water and of the groundwater affect by

significant losses is known. Therefore hydrochemical profiles along longitudinal transsects of alluvial bodies will be sampled for chloride and the stable isotopes ^{18}O and ^{2}H.

Task 2.4: ***Groundwater characterisation***

Methodology: For the study reaches the ground water systems will be delineated and characterised regarding their physical and hydrochemical properties. At a first stage a delineation of the aquifers will be made. The delineation includes a characterisation of the aquifer type and a conceptual model of the aquifer relationships with adjacent or underlying units. During a second stage the existing information on the physical and chemical properties will be collected. The hydrochemical properties will be characterised based on available hydrochemical data on major ions. Existing isotope studies will be used (German Geologic Survey Kuiseb Isotope Project, personal communication, C. Kuells).

From the groundwater of alluvial bodies samples for the stable isotopes ^{18}O, ^{2}H, ^{3}H will be taken. In the case of absence of tritium as an indicator of young groundwater ^{14}C will be evaluated as additional parameter – in the case of presence of tritium – chloro-fluoro-hydrocarbons (CFC) will be analysed to refine the age estimate of young groundwater. For every alluvial body a longitudinal profile consisting of 5 samples and a cross-section of 5 boreholes will be chosen for sampling. The radioactive isotope analysis of tritium (^{3}H) and inorganic carbon-14 (^{14}C) will provide groundwater ages and direct estimates of the actual impact of recharge.

Estimates of the lateral flow rates and the amount of recent recharge can be made based on appropriate cross-sectional and longitudinal profile sampling. The lateral flow rate perpendicular to an alluvial body in arid environments results in an apparent aging of the groundwater with increasing distance from the linear recharge source. This aging is correlated with the lateral flow rate and the geometry of the flow system.

In addition stable isotope analysis of oxygen-18 and of deuterium will allow to estimate the altitude of recharge due to the well established altitude effect. Rainfall stemming from higher altitudes has a more depleted lighted stable isotopic composition. This effect can be used to estimate the altitude of runoff generation and helps to identify the sources of groundwater.

Task 2.5. ***Aquifer characterisation***

Methodology: The depth and characteristics of the aquifers will be determined by borehole drilling and geophysical survey. Available information from the borehole databases or files of the local water affairs administration will be used (e.g. Ministry of Agriculture, Water & Rural Development, Namibia: Borehole database and 'Airborne geophysical survey of Namibia', data at the Geological Survey of Namibia). The delineated aquifers will be represented in GIS (Geographic Information System) compatible format as polygon maps of the total elevation of the aquifer top and the aquifer base. The aquifer thickness will be derived by discretisation of the aquifer boundaries and mathematical raster rendering processes within a GIS environment. The physical properties of alluvial aquifers – their hydraulic properties, conductivity and effective porosity – are estimated based on a combination of field data and previous sedimentological studies. Available stratigraphic classifications are standardized and linked to databases of granulometric studies and respective hydraulic properties in arid alluvial bodies. The analysis of existing borehole pumping tests will be used to assist the parameter identification.

Task 2.6. ***Socio-economic characterisation***

Methodology: The purpose of this task is to evaluate the socio-economic importance of alluvial aquifers in terms of the available water resources within the study catchments. In arid environments shallow groundwater from alluvial bodies have been the traditional source of water. Spatial and temporal patterns of water consumption will be evaluated for the study catchments based on a socio-anthropological approach and working closely with the WADE end-users.

Milestones and Deliverables

The key milestones from this Step are presented below.

Milestone No.	Milestone	Month
4	Selection of sites for probe installation and sample collection	6
14	Data integration from WP2 (Site characterisation)	24

The main deliverables will be a report on the optimal sites for drilling and the installation of the TDR probes (D3); geomorphologic maps of the study reaches (D5); a report on the socio-economic importance of alluvial aquifers in the study catchments (D6); the characterisation and distribution of riparian ecosystems (D14); surveyed cross-sections of the study reaches (D15).

STEP 3: RECONSTRUCTING LONG-TERM FLOOD MAGNITUDE AND FREQUENCY *(RTD/Innovation activities)*

Description: This WP will focus on reconstructing the magnitude and frequency of individual hydrological events in the past by using methods of palaeoflood hydrology. *Palaeoflood hydrology* is the reconstruction of the magnitude and frequency of large floods using geological evidence, research usually concentrated within the time frame of 0-2000 years (House et al, 2002). Flood reconstruction is based on the erosional and depositional field evidences left by floodwaters, which provide indication of water stage (elevation) at/or close to peak discharge.

Task 3.1: ***Palaeoflood hydrology***

Methodology: Slackwater flood deposits (SWD) are a particularly reliable type of sedimentological evidence used for the reconstruction of palaeoflood magnitude and frequency. They consist of fine-grained sand and silt that settle out of suspension in protected areas of reduced flow velocity and flow separation during large floods (Benito *et al*, 2003). Over the last two decades, analysis of SWDs and paleo-stage indicators (PSI, including high-water marks) in bedrock canyons has become an accepted tool in hydrological research, and the applications, advantages and limitations of the method have been described in an important review publication (House *et al.* 2002). The method has been successfully tested on rivers of various sizes and channel morphologies in a range of environments.

Bedrock canyons are ideal for the accumulation and preservation of SWDs because they confine the high-magnitude flows and create a relatively large rise in flood stage with relatively small increases in discharge. The canyon deposits are sheltered from subsequent erosion in permanent areas of ineffective flow, such as back-flooded tributaries, alcoves, and eddy zones at expansions, contractions or irregularities in the channel margin. Floods that overtop a sequence of SWDs generally lay down successive

layers in a vertical sequence without significant disturbance of underlying sediments. Smaller floods leave lower, inset deposits that are more susceptible to undercutting and erosion by the river. This setting selectively preserves evidence of the largest events over long periods of time; precisely the information that is lacking in the comparatively short-gauged discharge records. Each site preserves records of multiple floods, and the deposits from separate floods can be distinguished in the field using conventional sedimentological and stratigraphic criteria. The method relies heavily on radiocarbon dates on organic materials within or between the flood layers to provide the main basis for determining the ages of individual flood deposits and developing a flood chronology. In ideal depositional settings the upper surfaces of slackwater deposits approximate peak flood stages, as demonstrated through both field observations and flume experiments. The heights of the deposits is then used in conjunction with a hydraulic flow model to reconstruct palaeoflood discharges. Choice of sites in bedrock canyons ensures long-term channel stability such that the palaeoflood deposits maintain a direct relationship to the channel geometry for long periods of time, thus reducing important modelling uncertainties. The project consortium comprises some groups which are among the most experienced scientists in that field.

Task 3.2: ***Historical flood records***

Methodology: Documentary evidence and oral accounts (from questionnaires) will be used to compile flood records over recent decades to centuries. High-water elevations derived from historical evidence will be located in the field. In Namibia, this data will be augmented by early hydrologic data that exists from the 19th Century. This task will be carried out in cooperation with WP6, specifically, task 6.2 concerning the environmental history of the catchments.

Task 3.3: ***Hydraulic modelling of extreme palaeoflood and historical flood events***

Methodology: Flood magnitude, or discharge, associated with these palaeoflood deposits can be determined by the hydraulic modelling of surveyed study reaches. The individual flood units represent the minimum water surface elevation during the flood event. Step backwater modeling, for example the 1-dimensional HEC-RAS model, calculates the water surface profiles associated with specific discharges, so that the surveyed elevations of the slackwater palaeoflood deposits can be used to obtain a discharge estimate. The two principal sources of error are: (a) an underestimate of the palaeodischarge due to the unknown level of the floodwaters above the deposited sediments and (b) changes in the valley cross-section. The first can be approached by the study of the sedimentology of the flood deposits (Benito et al, 2003) that can enable interpretations regarding flow velocities and energy conditions at the site of deposition and, therefore, inferences can be made regarding the level of the water above the deposits. The second error, that of cross-sectional stability, is substantially reduced by conducting palaeoflood studies in bedrock gorge reaches. Bedrock channel geometry is significantly more stable than alluvial floodplain channels, for example, and will not have been substantially altered over the past centuries to millennia. By combining the results from all sites of palaeoflood deposition along the study reach an accurate assessment of palaeoflood magnitude and frequency can be determined and an accurate discharge estimate for the river's largest flood can be obtained.

Task 3.4 ***Flood Frequency Analysis (FFA)***

Description: FFA will be carried out using the discharge estimates of past floods (Task 3.3) and the chronology of flooding derived from Task 3.1 & 3.2). Data will be analysed

using the FRESH software, specifically designed by P7 for FFA using non-systematic flood data. This will provide statistical return period quantiles to quantify the frequency of recharging flood events.

This will be of particular interest in studying the role of global change on flood frequency. For example, the Kuiseb River (Namibia) used to reach the Atlantic 2/3 times each decade up to 1963, but since then there has been a long gap of almost 40 years

Milestones and Deliverables

The key milestones from Step 3 are presented below:

Milestone No.	Milestone	Month
5	Identification of palaeoflood sites and first fieldwork data collection	6
12	Palaeoflood fieldwork data collection completed	18
15	The appropriate hydraulic model will be determined for the palaeoflood study sites	24

The main deliverables will be: a report on palaeoflood site selection (D4); a database collating an inventory of all palaeofloods (D16); discharge estimates of palaeofloods (D20); and return period quantiles of the recharging river flows (D26).

STEP 4: MONITORING OF SURFACE AND SUBSURFACE WATER *(RTD/Innovation activities)*

Description: This workpackage aims the installation of field equipment, monitoring of the transmission losses into shallow alluvial aquifers and estimation of groundwater recharge.

Task 4.1. ***Water surface hydrology***

Methodology: The floodwater stage hydrograph provides important information about the availability of floodwater for percolation in natural stream channels as well as in reservoirs, as it present the upper boundary condition for the percolation process. Therefore, the study sites are located in reaches already equipped with automated, continuously recording, hydrometric stations. We will also monitor flood stages with a pressure transducer installed in a special shelter casing in the stream bed. The data from the pressure transducer will be collected and stored in a data logger for generating the flood hydrograph. The stream cross section at each site and changes in cross section will be surveyed to allow the determination of maximum flood. Following the flood we will determine the thickness of active bed and max cut and fill.

Task 4.2. ***Vadose zone hydrology***

Methodology: Water content is a key parameter needed for vadose zone monitoring. One of the most common methods for measurement of water content in unsaturated soil/sediments is Time Domain Reflectometry (TDR) The use of standard TDR probes for water content measurements is usually limited to shallow (< 2m) depths. Insertion of TDR wave-guides into deeper sediments (>2 m) is difficult when a natural undisturbed condition is required because methods of excavation, such as drilling, by

definition prevent insertion of probes into undisturbed material. A new methodology for the installation of TDR technology into the deep vadose zone (i.e. > 2m) was recently developed (with patent currently pending by Dahan et al.(2002). The technique allows multi-level installation of Flexible TDR Probes in any desired depth with minimal disturbance. This technique allows continuous, real-time, moisture measurements of the entire vadose zone cross section from the surface to the water able.

Description of the new TDR probe design: The technique uses a small diameter (10-20 cm) slanted borehole that is drilled at 45° to the desired (water table or up to 15 m depth). The TDR wave-guides consist of a flexible stainless steel foil attached to the outer side of a flexible sleeve. The sleeve, made of rubber or thin PVC liner, is inserted into the borehole and then filled with liquid two-component urethane. Prior to curing the urethane generates hydrostatic pressure that attaches the flexible sleeve, with its wave-guides, to the borehole walls. It is the flexibility of the sleeve and the wave-guides that allow perfect contact of the wave-guides to the borehole walls even though the borehole is likely to be of variable diameter and rough walls. Although some disturbance of the natural soil properties near the borehole annulus (a couple of centimetres around the borehole) is expected, the soil profile from that minimal zone to the land surface is likely to be undisturbed.

Field installation: The vadose zone moisture profile will be monitored at three different sites along different sections of an open stream channel and at one site under a reservoir. At each site a slanted borehole will be drilled for the installation of the moisture sensors (see Figure 4.1). The boreholes will be drilled, slanted at 45^{0}, to a length of 15 m (~10 m vertical depth), or to the water table. A total of eight flexible TDR probes will be installed, distributed along the length of the borehole at the following distances: 1, 2, 3, 4, 6, 9, 12 and 15m.

Task 4.3. ***Groundwater hydrology***

Methodology: Prior to drilling of the slanted borehole and installation of the TDR probes a vertical borehole will be drilled for a detailed sampling of the sedimentary cross section at each site and for the installation of a piezometer in the upper most groundwater. Each piezometer will be equipped with pressure transducers to monitor the water table response to the land surface flood stage and the vadose zone moisture variation.

Water samples from each flood event and from frequent sampling of the groundwater will be collected for chemical analysis of major and microelements together with oxygen and hydrogen stable isotopes. Geochemical and isotopic analysis of the water samples from all three hydrological domains, which are linked to each other, would allow better evaluation of the percolation processes.

Optional investigation tool: Tracer tests where the percolating water may be marked by chemical tracers may also be performed. The tracer tests can provide unique and important information on flow rate, connectivity and travel time of the percolating water from the surface to the ground water.

Milestones and Deliverables

The key milestones from Step 4 are presented below:

Milestone No.	Milestone	Month
3	Compilation of available data on surface and subsurface hydrology and water balance	5
10	Monitoring systems installed and operational in all catchments	12
16	Relationships between floodwater stage, percolation rates and groundwater recharge determined	24

The major deliverables from Step 4 of WADE will be: a report on the first and second years' monitoring programmes (D7 and D17); results of the groundwater chemical and isotopic composition (D21) and a final database of all surface and subsurface hydrological data (D27).

STEP 5: DEMONSTRATION OF TDR INSTALLATION AND THE MODELLING OF TRANSMISSION LOSSES (*Demonstration activities)*

Description: The demonstration activity envisaged within the WADE project will be within WP4, *Monitoring of surface and subsurface water* and WP5 *Modelling of Transmission Losses*. This relates to deliverable D17 the *demonstration of the TDR probe design and installation technique* that will be completed by partners P8 and P3 (the Ben Gurion University and HYDROISOTOP, respectively). As the monitoring of subsurface water within WP4 requires significant, state of the art technological input, will the drilling and installation of monitoring equipment, including TDR probes, it will be necessary over the duration of the project to demonstrate this technology. The methodology and technology of this approach has been explained in Section 4 above, however, in particular with respect to demonstration activities it is the application of this new methodology to the WADE study sites that will be demonstrated and its ability to accurately monitor sub-surface water flow. Of particular importance is the demonstration of its application to calibrate the modelling of transmission losses (WP5).

Task 5.1. ***Demonstration of the TDR probe installation and monitoring***
Methodology: The TDR probes and monitoring equipment will be installed in the deep vadose zone at the pilot study site to enable the monitoring of sub-surface water. A guide will be written to explain the details of the equipment, its installation and monitoring processes.

Task 5.2. ***Estimation of transmission losses.***
Methodology: Data requirements will be listed and the data gathering process documented within a manual with figures, tables and photographs. This includes the site characterisation, the survey of groundwater data and hydrological data, the sampling and analytical techniques. The available software will be described. The modelling includes the data preparation (pre-processing), the description of the theoretical background of hydraulics and infiltration as well as the adequate choice of the analytical or numerical approach depending on the hydro-geological setting. The process of modelling transmission losses will be explained and made transparent in applied exercises with case study datasets. The important quality control and calibration of the results using isotope data will be demonstrated in different case studies.

Milestones and Deliverables

The key milestones from Step 5 are presented below:

Milestone No.	Milestone	Month
6	Installation of the TDR probes at the demonstration site	6

The main deliverable will be the field demonstration of TDR installation and monitoring of sub-surface waters (Month 18) and the Methodological guide for the TDR installation, monitoring and estimation of transmission losses (Month 36).

STEP 6: MODELLING OF TRANSMISSION LOSSES AND GROUNDWATER RECHARGE *(RTD/Innovation activities)*

Description: Temporal changes in vadose zone moisture profiles will be examined with respect to the surface flood stage hydrograph regime characterized at each site (open stream channel or reservoir), using geomorphic and hydrograph data. The vadose zone moisture profiles will be processed through several independent modelling approaches: (1) mass balance; (2) moisture and temperature profile, and (3) numerical modelling. This Step will begin at Month 18 of the project.

Task 6.1. ***Mass balance.***

Methodology: The moisture profiles will be examined through water mass balance over the entire cross section. Following this approach the moisture profile will be summed to total cross section water storage as a function of time. The water mass balance will ignore the upper section that is affected by evapo-transpiration. Thus any increase in the total water mass will be considered as water that has percolated down from the surface, while any reduction in the total water mass will be considered as the amount of water that left the cross section and recharged the aquifer below. This approach is very simplistic and may be applied only when the surface wetting time cycle is wide enough and the cross section is thick enough to allow significant and observable moisture variation over time. This approach cannot be applied when the percolation flow regime is at or near steady state flow condition, or if the wetting cycle is too short. The advantage of this approach is that it is a direct approach that relies only on measured data and dose not need the estimation of immeasurable parameters that are required for the model solution.

Task 6.2. ***Moisture and temperature profiles***.

Methodology: The second modelling approach uses the combined moisture and temperature profile to evaluate the percolation regime. While the moisture profile will be obtained by the TDR probes the temperature profiles will be obtained by thermocouples that will be installed next to each TDR probe. In this approach the profile thermal fluctuation is a consequence of heat diffusion combined with heat advection. The heat advection, which is the heat transported by the percolating water, is solved through the model.

Task 6.3. ***Numerical Modelling.***

Methodology: The third approach solves numerically the unsaturated zone flow equations (HYDRUS or a compatible modelling approach). Though this is the most comprehensive and common vadose zone modelling approach it is strongly dependent on the need for accurate definition of the medium hydraulic parameters and boundary condition. Unfortunately these parameters and boundary conditions usually need to be estimated with a relatively large degree of uncertainty since they are rarely measured accurately in the field. However, the implementation of this type of model can more

accurately represent the actual flow conditions, as for the first time it is possible to calibrate the models to the entire actual moisture profile of the modeled cross section.
At this stage, before the data has been collected and analysed, no approach appears superior, therefore, all three approaches will be examined for their suitability and the data will be processed through the modelling approach that best fits the character of the collected data.

Milestones and Deliverables

The key milestones from Step 6 are presented below:

Milestone No.	Milestone	Month
17	Mass and moisture balance of the studied cross-sections	24
18	Choice of the numerical model that best fit the character of the collected data	30

The main deliverables will be the mass balance of moisture profiles (D22); moisture and temperature profiles (D23); and the numerical modelling of the unsaturated zone.

STEP 7: PARTICIPATORY WATER MANAGEMENT: SOCIO-ECONOMIC AND HISTORICAL PERSPECTIVE *(RTD/Innovation activities)*

Description This workpackage will evaluate the socio-economic importance of water resources from shallow alluvial aquifers for the population of the study basins and investigate environmental changes within the catchment areas in terms of water management, land use, government policies and climate change. The key issue of the sustainable use of water resources by local communities will be addressed by engaging local stakeholders (local government, water service providers, village water management committees) in both the research and in a developmental process of institutional capacity building around water management.

Task 7.1. ***Community participation***

Methodology: The research methodology will include workshops, interviews with key informants, participant observation and action research techniques in order to assess current water resource management practices and strategies. Associations & partnerships will be established between WADE, local communities and government officials in order to foster a sense of in-country ownership of the research. Participation will take place at various levels:

- Workshops will be held with all stakeholders including local communities, water service providers, local government and where appropriate, government researchers from the Water Research Commission (in South Africa) and the Ministry of Agriculture, Water & Rural Development (in Namibia).
- A number of local research assistants will be given appropriate scientific and technical training from WADE researchers, thereby creating a knowledge bridge between the WADE team and local communities.
- The inclusion of local government officials responsible for water provision and integrated development planning will help forge links with local communities and to identify obstacles to, and solutions for, sustainable water service provision.

- Interaction between WADE end-user partners and local communities will aim to establish development initiatives in order to address problems related to water quantity and quality, managerial capacity and the use of water for improved health, poverty alleviation and food security.
- Project communities will be encouraged to participate in Municipal and District level networks of governance in order to disseminate knowledge gained from participating in the WADE project.

Task 7.2. ***Environmental history***

Methodology: Archival research, recording of oral history and the use of repeat landscape and aerial photographs will form part of an environmental history of the ephemeral rivers of Namibia and Namaqualand.

Research into the history of water use and management, socio-economic change and political transformation during the 20th century will have a strong anthropological perspective in order to build an understanding of dynamic change, rather than a just 'snap-shot' of the present. Without a knowledge of how (and why) the environment has changed, it is difficult to make informed decisions about how to plan for the future. One of the most important aspects of this component of the research is that common misconceptions about environmental change can be rectified by historical evidence. This can be communicated to local communities and stake holders through convincing photographic evidence and the narrative of historical events. Participation in this process by local elders oral histories is likely to embed such knowledge within the wider community.

Task 7.3. ***Gender and poverty alleviation***

Methodology: Interviews, questionnaire by local research assistants and action research within and by community development committees. To be facilitated by local end-users.

Research will focus on gender related water-use and management implications as well as on poverty alleviation among previously disadvantaged populations insofar as access to and management of water affects livelihoods. In some research sites, HIV/AIDS and food security is likely to be a serious social issue. The management of water from alluvial aquifers for use in gardens might be one development priority identified by communities in order to improve community health. WADE end-user partners will play a central role in facilitating this research and in finding means of implementing relevant initiatives.

Task 7.4. ***Integrated water management (IWM)***

Methodology: This task aims to combine the data generated in WP's 2-6 with the socio-anthropological approach of this WP in order to determine strategies for IWM focused on the use of floodwaters as a water resource. A key input will be from WADE end-users as facilitators of research and communication between local communities and the WADE team. In a very important sense, this task represents the goal and final product of the WADE project: to leave real and lasting results in communities in order that people are empowered to effect changes in their own health and livelihoods through an increased awareness of the dynamics of alluvial aquifers. Furthermore, increased skills and organisational capacity, gained as a result of participating in WADE, is likely to have lasting implications for the effective management and control of water resources at the community and local government levels. If successful, WADE will add to the ongoing process of local democratisation which is taking place in both Namibia and South Africa after many decades of governance dominated by apartheid ideology.

Milestones and Deliverables

The key milestones from Step 7 are presented below:

Milestone No.	Milestone	Month
2	Regular meetings with communities and local partners	3
7	Maps of water resource use along the study reaches	10
19	Institutional analysis relevant to the improved sustainability of water supplies completed	30

The main deliverables will be: local community participation in the WADE project (D8); a report on gender and poverty alleviation issues (D18); a report on the environmental history of the study region (D24) and a final report on strategies for an integrated approach to water management focusing on floodwaters as a water resource (D29).

STEP 8 RESULTS' DISSEMINATION *(RTD/Innovation activities)*

Description: The main objectives of this work package are to identify optimal dissemination pathways to ensure that the project data, deliverables and resource management tools are distributed to their maximum potential to end-users and the scientific community.

Task 8.1 Project dissemination: The purpose of this task is to ensure the maximum publicity for the WADE project within the both the scientific and professional community as well as the general public. The main objectives of the project will be presented on a project flyer that will be produced and circulated at the beginning of the project. For on-going dissemination a project web page will be developed by month 3 of the project in order to provide easy access for finding up to date information about the project. An annual newsletter will also be produced and circulated (by email and post) to appropriate researchers and end-users who will be identified during the project (including members of the other EC funded river twinning projects).

Task 8.2 Dissemination of scientific results: This task will encourage dissemination of results from all partners through scientific conferences, oral seminars, articles in peer reviewed journals, technological exhibitions, events promoted by national/local authorities. In addition, an open meeting will take place at Month 36. A results exploitation plan will be defined.

Milestones and Deliverables

The key milestones from Step 8 are presented below:

Milestone No.	Milestone	Month
9	WADE dissemination plan	12

The main deliverables will be: the WADE project flyer (D2); an annual electronic newsletter (D9); the WADE dissemination plan (D10); peer reviewed journal articles

and international conference participation (D11); the results' exploitation plan (D25); a report on the conclusions of an open meeting to be held at the end of the project (D30).

STEP 9 PROJECT REVIEW AND ASSESSMENT *(RTD/Innovation activities)*

Description: The main objectives of this work package the progress of the project and compared to the planning and criteria described in the Work Programme.

Task 9.1 Monitoring and reporting progress:

Each partner will report every 3 months to the corresponding WP Leader about the progress of the work on the basis of a regularly updated detailed planning. These progress reports will contain a review of :

- Work carried out, results obtained
- Work delayed, reasons and actions to correct the problems
- Work planned for the following period
- Percentage of completion, estimated time of completion.

In addition, once a year Partners will submit the individual cost statements derived from the project execution. An institutional auditing certificate will be presented by each partner together with the final cost statement. The WP Leader will then summarise the overall project status and planning and send it to the project coordinator, who will finally prepare the corresponding 6 month management report and annual progress and cost statement reports, taking care of their distribution to the commission in time. A final project report will review the scientific achievements of the project and main deliverables. The project will be reviewed by the final report

Task 9.2 Mid-term review:
Of particular importance for the monitoring of the project's progress will be the mid-term review. Two independent scientists will be invited to attend the 2nd annual meeting where all partners will present a summary of the work completed with respect to the original project objectives, milestones and deliverables. The progress of WADE in terms of scientific achievements and its potential impact will be reviewed by the independent scientists.

Milestones and Deliverables

The key milestones from Step 9 are presented below:

Milestone No.	Milestone	Month
13	Second annual coordination meeting and Mid-term Project Review. Two independent experts will be present at the meeting to provide a report on progress and impact of the project. **Month 24**	12

The main deliverables will be: the Mid-term review (D19), and the report on the conclusions of the project (D32).

Significant risks

Included in the project workplan is the WADE contingency plan to be implemented should there be insufficient rainfall for the hydrological monitoring component of the project. The WADE project has been developed in order to assess the sustainability of floodwater recharge of alluvial aquifers as a water resource in semi-arid and arid basins. The approach that will be applied involves the combination of palaeohydrological techniques to reconstruct long-term flood frequency (WP3) and contemporary monitoring of the surface and subsurface hydrological system (WP4) to quantify floodwater transmission losses and rates of aquifer recharge. The direct measurement of transmission losses in ephemeral streams requires river flow and, therefore, the major potential risk could relate to the unpredictability of dryland rainfall and the failure of the installed monitoring equipment to witness significant flow events.

The first step taken has been to develop a workplan that reduces the risks of missing significant rainfall events. In total 4 river basins are being twinned – the site in SE Spain is semi-arid, however, there is always river flow in the Guadalentin River basin at least once a year. The basins at significant risk are the African basins where the study rivers (the Kuiseb in Namibia and the Buffels in South Africa) flow on average once every 3 years. The project timeplan will ensure that 3 rainy seasons will be included within the 3 year duration of WADE. Furthermore, the Buffels and Kuiseb rivers not affected by the same climate system, with the Kuiseb dominated by a November to February rainy season and the Buffels by winter rainfalls (June to September) increasing the probability of capturing significant rainfall events.

In the worst case scenario of no rainfall events monitored in either of the African basins then:

1) The WADE consortium will ensure that the TDR monitoring system is in place and that the local professionals have the knowledge and expertise to continue monitoring once the three years of the project has finished.

2) In order to monitor the transmission of water in the vadose zone, rainfall simulations will be carried out at one cross-section.

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7.2 Planning and timetable

Month 1: At the beginning of the project a **kick-off meeting** will be held in Madrid to discuss the project plan, including the WADE management structure; the responsibilities of the Partners and to examine with all the participants the sources of data and the advanced methods of data analysis and data integration technology to be applied during the development of the project. Skill gaps within the consortium will be identified in order to focus the training and capacity building that needs to be addressed in each of the WPs.

Month 6: the project Web page will have been developed an the first fieldwork campaigns in Namibia and S. Africa will have been completed and data will have been collected for WP2 *Site characterisation* and the available data on surface and subsurface hydrology (WP4) will have been compiled. The first major milestones will have been completed, the selection of sites for probe installation (WP2) and the identification of palaeoflood sites (WP3). The progress of activities will be reviewed and assessed by the **first technical report**.

Month 12: all the surface and subsurface hydrological monitoring systems (including the TDR probes and piezometers) will have been installed (WP4) and will be operational. Within WP6, local community participation in the data collection will have been sought. The progress of the first year's activities will be reviewed at the first annual coordination meeting and the subsequent **first annual report**. A newsletter will be produced and distributed ti interested parties describing the projects' activities.

Month 18: the second fieldwork campaigns will have been completed, with continued data collection in all WP's. The geomorphological mapping and cross-section surveys will have been completed (WP2). The database of historical flood events will have been developed and all data entered. Within WP6 a report on the socio economic importance of alluvial aquifers in the catchment water resources will have been produced The progress of activities will be reviewed and assessed by the **third technical report**.

Month 24: at the end of the 2nd year of WADE, preliminary data on the palaeoflood chronologies, textural changes and chemical analysis will be available and integrated in the palaeoflood database (WP3). The appropriate hydraulic model for the study reaches will have been determined and preliminary discharge estimates produced (WP3). The different models available for the modelling of transmission losses will have been reviewed (WP5). A report will have been produced on gender and poverty alleviation issues that will be addressed by WADE (WP6) .The **second annual report** will be produced. During this period an independent mid-term review will be carried out in order to assess the progress of the project, including its impact and success in capacity building (WP9).

Month 30: the final results exploitation plan will be formulated (WP1). A conceptual model of transmission losses along the ephemeral rivers will be developed (WP5). Hydraulic modelling and chronologies of palaeoflood sites will be completed

and the record of flood magnitude and frequency will be provided (WP3). Groundwater isotope analysis will be completed (WP4). A report on the environmental history of the catchments will be presented (WP6) along with the **fifth technical report**.

Month 36: the data from the three major components of WADE (palaeoflood hydrology, hydrology & transmission losses & the socio-economic relevance) will be combined to determine strategies for integrated water management incorporating floodwaters as a sustainable water resource (WP6). Dissemination will include an open meeting for interested parties. The project will be reviewed by **the Final Report**.

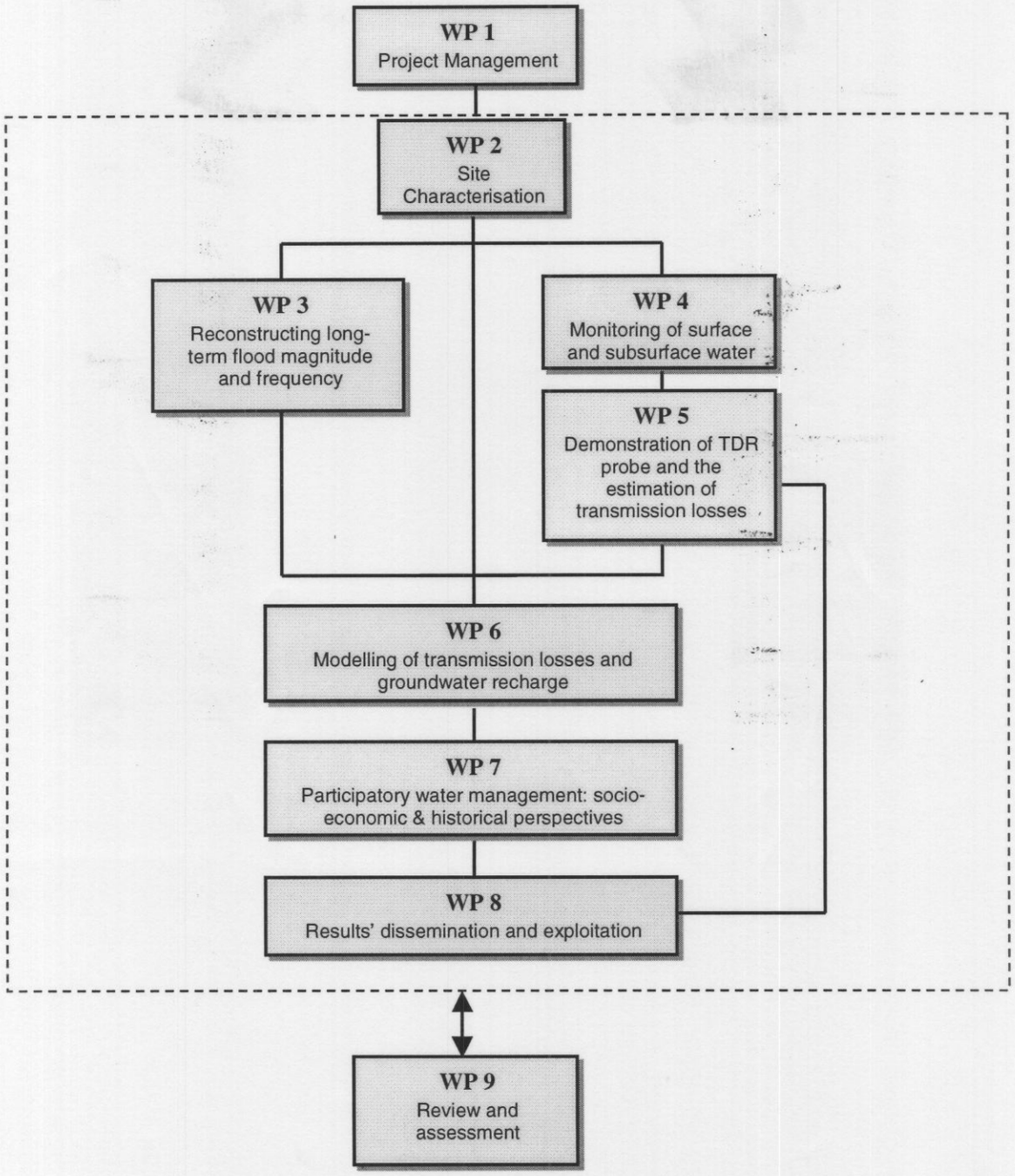
Work Package	Work Package Title	YEAR 1												YEAR 2												YEAR 3											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WP1	**WADE Project Managements**																																				
	Task 1.1 Coordination & management																																				
	Deliverable Nos.			1																																	
WP2	**Site characterisation**																																				
	Task 2.1 Geomorphic setting																																				
	Task 2.2 Soil/sediment analyses																																				
	Task 2.3 Riparian ecosystems																																				
	Task 2.4 Aquifer characterisation																																				
	Task 2.5 Socio-economic characterisation																																				
	Deliverable Nos.						3						5 & 6										13		14&15												
WP3	**Reconstructing long-term flood magnitude & chronology**																																				
	Task 3.1 Palaeoflood hydrology																																				
	Task 3.2 Historical flood records																																				
	Task 3.3 Hydraulic modelling																																				
	Task 3.4 Flood Frequency Analysis																																				
	Deliverable Nos.						4																		16						20		26				
WP4	**Monitoring of surface & subsurface water**																																				
	Task 4.1 Water surface hydrology																																				
	Task 4.2 Vadose zone hydrology																																				
	Task 4.3 Groundwater hydrology																																				
	Deliverable Nos.												7												17						21					27	
WP5	**Demonstration of TDR probe and the estimation of transmission losses**																																				
	Task 5.1 Demonstration of TDR installation																																				
	Task 5.2 Estimation of transmission losses																																				
	Deliverable Nos.																		12																		31
WP6	**Modelling of transmission losses and groundwater recharge**																																				
	Task 6.1 Mass balance																																				
	Task 6.2 Moisture & temperature profiles																																				
	Task 6.3 Numerical modelling																																				
	Deliverable Nos.																														22&23					28	
WP7	**Participatory water management: socio-economic & historical perspectives**																																				
	Task 7.1 Community participation																																				
	Task 7.2 Environmental history																																				
	Task 7.3 Gender & poverty alleviation																																				
	Task 7.4 Integrated water management																																				
	Deliverable Nos.												8												18						24						29
WP8	**Results' Dissemination & Exploitation**																																				
	Task 8.1 Project dissemination																																				
	Task 8.2 Dissemination of scientific results																																				
	Deliverable Nos.			1 & 2								9 &10		11	→										9						25					9&30	
WP9	**Project Review and Assessment**																																				
	Taks 9.1. Monitoring and report progress																																				32
	Task 9.2. Mid-term review																								19												

Table 7.2 Gannt Chart illustrating the WADE project timetable

Other aspects of project planning		YEAR 1												YEAR 2												YEAR 3											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
FIELDWORK	Spain																																				
	Israel																																				
	Namibia																																				
	South Africa																																				
MEETINGS	Coordination meetings																																				
	Open meeting																																				
REPORTS	Progress reports																																				
	Mid-term review																																				
	Final report																																				

Table 7.2 Gannt Chart illustrating the WADE project timetable (continued)

7.3 Graphic presentation of workpackages



Management activities	RTD-Innovation activities	Demonstration activities

7.4 Workpackage lists

Work-package No[1]	Work package title	Lead contractor No[2]	Person-months[3]	Start month[4]	End month[5]	Deliv-erable No[6]
1	WADE project management	P1	20	1	36	D1a
2	Site characterisation	P2	36	1	24	D3, D5, D6, D13, D14, D15
3	Reconstructing long-term flood magnitude and frequency	P1	80	2	32	D4, D16, D20, D26
4	Monitoring of surface and subsurface water	P8	95	2	35	D7, D17, D21, D27
5	Demonstration of TDR and installation	P8	8	6	18	D12, D31
6	Modelling of transmission losses	P3	32	18	35	D22, D23, D28
7	Participatory water management: socio-economic & historical perspectives	P5	92	1	36	D8, D18, D24, D29
8	Results' dissemination	P1	42	1	36	D1b, D2, D9, D10, D11, D25 D30
9	Review and assessment	P1	6	3	36	D19, D32
	TOTAL		411			

[1] Work package number: WP 1 – WP n.
[2] Number of the contractor leading the work in this work package.
[3] The total number of person-months allocated to each work package.
[4] Relative start date for the work in the specific work packages, month 0 marking the start of the project, and all other start dates being relative to this start date.
[5] Relative end date, month 0 marking the start of the project, and all ends dates being relative to this start date.
[6] Deliverable number: Number for the deliverable(s)/result(s) mentioned in the work package: D1 - Dn.

Community
=Minutes of KBMC

7.5 Deliverables list ?

Deliverables list

those person months 4 Lead participant only or any

Del. no.[7]	Deliverable name	WP no.	Lead partici p-ant	Estimate d person-months	Nature[8]	Dissemi nation level [9]	Deliver y date[10] (proj. month)
1	WADE project web page	1 & 8	P1	2	O	PU	3
2	WADE Project Flyer	8	P1	1	O	PU	3
3	Report on the optimal sites for the drilling and installation of instrumentation	2	P8	2	R	RE	6
4	Report on palaeoflood site selection	3	P1	2	R	RE	6
5	Geomorphological maps of the study reaches	2	P2	8	O	PU	12
6	Report on the socio-economic importance of alluvial aquifers in the study catchments	2	P5	8	R	PU	12
7	Report on the Year 1 monitoring of surface & sub-surface waters	4	P8	34	R	PU	12
8	Local community participation in the WADE project	7	P4	14	O	PU	12
9	Annual electronic newsletter	8	P1	3	R	PU	12 (24 & 36)

[7] Deliverable numbers in order of delivery dates: D1 – Dn

8 Please indicate the nature of the deliverable using one of the following codes:

R = Report
P = Prototype
D = Demonstrator
O = Other

[9] Please indicate the dissemination level using one of the following codes:

PU = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).

[10] Month in which the deliverables will be available. Month 1 marking the start of the project, and all delivery dates being relative to this start date.

	newsletter						&36)
10	WADE dissemination plan	8	P1	1	R	RE	12
11	Peer reviewed journal articles and international conference participation	8	All	28	O	PU	13 onwards
12	Demonstration of the TDR installation and monitoring	5	P8	2	O	PU	18
13	Analytical results for collected soil, sediment & groundwater samples	2	P3	5	O	PU	22
14	Characterisation and distribution of riparian ecosystems	2	P6	4	R	PU	24
15	Surveyed cross-sections of the study reaches	2	P2	6	O	PU	24
16	Database collating an inventory of palaeofloods	3	P1	12	O	PU	24
17	Report on the Year 2 monitoring of surface & sub-surface waters	4	P8	34	R	PU	24
18	Report on gender and poverty alleviation issues addressed by WADE	7	P10	9	R	PU	24
19	Mid-term project review	9	P1	2	R	RE	24
20	Discharge estimations associated with the palaeoflood & historical flood data	3	P2	54	O	PU	30
21	Groundwater chemical and isotopic composition	4	P3	16	O	PU	30
22	Mass balance of moisture profiles	6	P8	10	O	PU	30
23	Moisture and temperature profiles	6	P8	10	O	PU	30
24	Report on the environmental history of the study areas & its relationship with socio-economic, political and climate change	7	P5	51	O ?	PU	30

25	Results exploitation plan	8	P1	3	R	RE	30
26	Return period quantiles determined by flood frequency analysis	3	P7	12	O	PU	32
27	Database of surface and subsurface hydrological data	4	P3	11	D	PU	35
28	Numerical modelling of the unsaturated zone	6	P8	12	O	PU	35
29	Report on strategies for an integrated approach to water management focusing on floodwaters as a water resource	7	P9	18	R	PU	36
30	Report on the conclusions of the open meeting	8	P1	1	O	PU	36
31	Methodological guide for the TDR installation, monitoring and estimation of transmission losses	5	P3	6	R	PU	36
32	Report on the project conclusions	9	P1	4	R	PU	36
			TOTAL	388*			

* Person-months were estimated considering both the time require to obtain the knowledge and the final product (deliverable). The rest of the person months up to a total of 411 are allocated on produce interim reports, final reports and meetings.

7.6 Workpackage descriptions

** denotes WP leaders*

WADE Project Management

Work package number	1	**Start date or starting event:**	Month 1
Activity Type	Management Activities		
Participant id	P1*		
Person-months per participant	20		

Objectives

The main objectives are the efficient and effective management of the project, including coordination between all the partners of the project consortium and liaison with the EC.

Description of work

Task 1.1 Co-ordination and management:

An 9 workpackage structure has been established for the WADE project. The coordinator of the project (P1) will assume responsibility for the efficient and effective management of the project using past experience of project coordination. P1 will liase between the WADE partners and the EC and will be responsible for producing the periodic reports on-time. A Management Committee will be established, headed by P1 and comprised of the other WP leaders. The purpose of the committee will be the troubleshooting of any specific problems that should arise and to ensure that data and information is readily exchanged amongst all the project partners, including end-users. Coordination within this committee will predominantly be carried out on-line via email and the password protected project web page.

Deliverables

D1a. WADE project web page. Password protected pages will be used to enable information exchange and co-ordination between the partners**.** This will be ready by **Month 3** but will be continually updated throughout the duration of the project.

Milestones and expected result

M1. Kick- off meeting to discuss the management structures, partners' responsibilities as well as detailed discussion on the coordination and integration tasks. **Month 1**

M8. First WADE annual coordination meeting that will provide a forum for: evaluating & monitoring the progress of the project over the first 12 months; encourage exchange of ideas; and refine project planning. The main expected result will be to focus the workplan for the 2nd year of the project. **Month 12**

M11. Decision to be made on whether to implement the WADE contingency plan, should the two rainy seasons not have produced sufficient hydrological monitoring data at the study sites. **Month 18**

Site characterisation

Work package number	2	**Start date or starting event:**					Month 1			
Activity Type		RTD/Innovation activities								
Participant id		P2*	P1	P3	P4	P5	P6	P8	P9	P10
Person-months per participant		5	5	2	9	1	6	2	2	4

= 36

Objectives

Site characterisation has three principal goals: 1) to determine the general characteristics and dynamics of the selected ephemeral channels; 2) to choose the optimum sites for probe installation and sample collection and 3) identify the role of alluvial aquifers in the socio-economy of the catchments. Site characterisation will integrate information from geomorphic, flood and palaeoflood hydrology, soil and sediment information, knowledge on the local groundwater and its use as a water resource. This WP will be complementary to WP's 3-6 and will aim to pull together the differing research themes developed in the other WP's.

[GIST student with write up from "intern"]

Description of work

Task 2.1. Geomorphic setting: Sedimentologic and geomorphic variables related to the flow and storage of water along ephemeral channels will be evaluated to determine the best sites for installation of soil probes and sampling and to form a foundation for monitoring the results. Geomorphic variables will include mapping of the study reaches, and the distribution of principal ephemeral channel features such as terraces, floodplains and areas along channels where surface water is likely to pond. Detailed channel cross sections will be surveyed. Direct estimates (by topographical and evaporation characteristics) and volumetric simulations of surface transmission losses will be analysed to see the sensitivity for site selection, monitoring and modelling techniques. 2 JIC - Guido

Task 2.2 Sediment characterisation: Sediments will be characterized at each site through the analysis of sediment samples collected during drilling. A granulometric analysis and a photo documentation of distinct types of surfaces will be prepared. Hydraulic (roughness) and hydrologic properties (infiltration capacity) will be estimated based on the granulometric description. 1.5 JIC

Task 2.3. Riparian ecosystems: Evapotranspiration by riparian ecosystems is a major loss component of alluvial aquifers. The riparian ecosystems will be classified and characterised. The distribution of classified riparian plant communities will be mapped along the study reaches using ground mapping with base-maps, photographs and ground truth evaluation. Evaporation losses will be estimated based on existing eco-hydrological studies for the specified classes of riparian vegetation. Claudia Sa. 2.5 AM

Task 2.4. Aquifer characterisation: For the study reaches the ground water systems will be characterised by existing data on their physical and hydrochemical properties in addition to information collected during and after drilling. The depth and characteristics of the water table will be determined by borehole drilling and geophysical survey. The groundwater will be sampled for the stable isotopes ^{18}O and ^{2}H, and for the radioactive isotope ^{3}H, tritium. Water samples containing tritium will be analysed for CFC, groundwater samples without tritium for ^{14}C in order to ascertain and refine the groundwater age. 0.5 JH

Task 2.5. Socio-economic characterisation: The purpose of this task is to evaluate the socio-economic importance of alluvial aquifers in terms of the available water resources within the study catchments. Spatial and temporal patterns of water consumption will be evaluated for the study catchments based on a socio-anthropological approach and working closely with the WADE end-users. Anna 2.5 AM

= 9 months

[April
May
June]

Deliverables

D3. Report on the identification of optimal sites for the drilling and installation of instrumentation **Month 6**

D5. Geomorphologic maps of the study reaches. **Month 12**

D6. Report on the socio-economic importance of alluvial aquifers in the study catchments. **Month 12** UNAM → Field attachment

D13. Analytical results for the collected sediment and groundwater samples. **Month 22**

D14. Characterisation of riparian ecosystems. **Month 24** (Will Jankowitz) – fieldwork / survey cross-section

D15. Surveyed cross sections of the study reaches. **Month 24** [Eike distribution ?]

Milestones and expected result

M4 Selection of sites for probe installation and sample collection **Month 6**

M14 Data integration – understanding the characteristics of the selected sites from an integrated physical, ecological and socio-economic perspective **Month 24**

- Homeb
- Oswaster
- Natab 1 + 2.
- Gobabeb
- Sand river

Reconstructing long-term flood magnitude and frequency

Work package number	3	**Start date or starting event:**			Month 2
Activity Type		RTD/Innovation activities			
Participant id		P1*	P2	P7	P9
Person-months per participant		36	30	12	2

Objectives

The objective of this WP is the reconstruction of long-term flood chronologies, over centuries to millennia, using palaeoflood and historical data, to obtain a long-term frequency of floodwater recharge events. Past flood magnitudes will be determined by hydraulic modelling, with discharge estimated from evidence of water surface elevations, including slackwater flood deposits in the case of palaeofloods and known flood elevations from historical evidence.

Description of work

Task 3.1: Palaeoflood hydrology. Geomorphological evidence of palaeoflood events, such as slackwater flood deposits, will be used to reconstruct long-term (centuries to millennia) flood records. In stable bedrock reaches such deposits provide a minimum water surface elevation of a flood event. Sedimentological analysis of palaeoflood deposits will identify the number of individual flood events represented at a site. The chronology of flood deposition will be determined by radiocarbon dating.

Task 3.2: Historical flood records. Documentary evidence and oral accounts (from questionnaires) will be used to compile flood records over recent decades to centuries. High-water elevations derived from historical evidence will be located in the field. In Namibia, this data will be augmented by early hydrologic data that exists from the 19th Century.

Task 3.3: Hydraulic modelling of palaeoflood and historical flood events. Hydraulic modelling will be used to estimate discharges from water surface elevation data provided by Tasks 3.1 and 3.2. The palaeohydrological reconstruction will be accomplished by computing the water surface profiles for various hypothetical discharges that are routed through the river. By comparing the model-generated profiles to the palaeostage indicators probable palaeodischarges will be specified.

Task 3.4: Flood Frequency Analysis (FFA): FFA will be carried out using the discharge estimates of past floods (Task 3.3) and the chronology of flooding derived from Task 3.1 & 3.2). Data will be analysed using the FRESH software, specifically designed by P7 for FFA using non-systematic flood data. This will provide statistical return period quantiles to quantify the historic frequency of historic floods and the expected frequency of similar future events.

Deliverables

D4 Report on palaeoflood site selection **Month 6**.

D16 Database collating an inventory of palaeoflood and historical flood events **Month 24**.

D20 Discharge estimations associated with the palaeoflood and historical flood data **Month 30**.

D26 Return period quantiles determined by flood frequency analysis **Month 32**.

Milestones and expected result

M5 Identification of palaeoflood sites and first fieldwork data collection. **Month 6**
M12 Palaeoflood fieldwork data collection completed. **Month 18**
M15 The appropriate hydraulic model will be determined for the study sites. **Month 24**

Monitoring of surface and subsurface water

Work package number	4	**Start date or starting event:**			Month 2		
Activity Type		RTD/Innovation activities					
Participant id		P8*	P1	P2	P3	P4	P6	P9
Person-months per participant		45	3	10	18	10	3	6

Objectives

The principal objective of this WP is to monitor transmission losses through the river bed during flood events in order to estimate rates of groundwater recharge. In order to achieve this the status and behaviour of the surface and subsurface hydrological system will be monitored during flood events. One important technological objective will be to install the field equipment as soon as possible to increase the likelihood of recording rare flood events.

Description of work

Task 4.1. Water surface hydrology: The floodwater stage hydrograph provides important information about the availability of floodwater for percolation in natural stream channels as well as in reservoirs, as it represents the upper boundary condition for the percolation process. Therefore, sites will be located in reaches already equipped with an automated, continuously recording, hydrometric station e.g. Kuiseb catchment in Namibia. Flood stage will be monitored with a pressure transducer installed in a special shelter casing in the stream bed. The data from the pressure transducer will be collected and stored in a data logger for generating flood hydrographs. 1.0

Task 4.2. Vadose zone hydrology: Water content is a key parameter needed for vadose zone monitoring. One of the most common methods for measurement of water content in unsaturated soil/sediments is Time Domain Reflectometry (TDR). Insertion of TDR wave-guides into deeper sediments (>2 m) will be done following a new methodology recently developed by P8. The technique allows multi-level installation of Flexible TDR, and continuous, real-time, moisture measurements of the entire vadose zone cross section from the surface to the water table. 4.5 GBB + Grimnelle

Task 4.3. Groundwater hydrology: Piezometers will be installed in the upper most groundwater and detailed sampling of the sedimentary cross section at each site will be carried out. Each piezometer will be equipped with pressure transducers to monitor the water table response to the land surface flood stage and the vadose zone moisture variation. Water samples from each flood event and from frequent sampling of the groundwater will be collected for chemical analysis of major and microelements together with oxygen and hydrogen stable isotopes (^{18}O, ^{2}H, ^{3}H, depending on ^{3}H absence or presence also ^{14}C/CFC). Activated tracer tests, where the percolating water is marked by chemical tracers, will, optionally, be performed. The tracer tests can provide unique and important information on flow rate, connectivity and travel time of the percolating water from the surface to the ground water. Tracers that are activated by flood events and that are not toxic and invisible are used (SF_6). JIC 4.5 = 10

Deliverables

D7 Report on the Year 1 monitoring of surface and sub-surface waters **Month 12**.
D17 Report on the Year 2 monitoring of surface and sub-surface waters **Month 27**.
D21. Groundwater chemical and isotopic composition **Month 30**.
D27. Database of surface and subsurface hydrological data **Month 35**.

Milestones and expected result

M3 Compilation of available data on surface and subsurface hydrology and water balance. **Month 5**
M10 Monitoring systems installed and operational in all catchments **Month 12**
M16 Relationships between floodwater stage, percolation rates and groundwater recharge. **Month 24**

GBB

* Gerald
* Grimnelle (based @ Gobabeb)

Demonstration of TDR probe and the estimation of transmission losses

Work package number	5		**Start date or starting event:**	Month 4
Activity Type		Demonstration activities		
Participant id		P8*	P3	
Person-months per participant		4	4	

Objectives

The monitoring of subsurface water within WP4 requires significant, state of the art technological input, with the drilling and installation of monitoring equipment, including the TDR probes. This WP will aim to demonstrate the successful installation and running of the technology, including its ability to accurately monitor sub-surface water flow.

The estimation of transmission losses based on available field data is a major prerequisite for extending the use of groundwater from alluvial bodies up to the natural limits sustained by the recharge processes. The demonstration activities aim at developing and implementing a routine methodology for the estimation of recharge rates from ephemeral rivers based on economically accessible data. For this purpose the data requirements will be listed and the data gathering process documented within a manual with figures, tables and photographs. This includes the site characterisation, the survey of groundwater data and hydrological data, the sampling and analytical techniques..

Description of work

Task 5.1. Demonstration of the TDR probe installation and monitoring:
The TDR probes and monitoring equipment will be installed at the pilot study sites. This equipment is highly innovative in its use in the deep vadose zone, and for monitoring of sub-surface water. Demonstration activities will be performed for the end-users, and other technical staff from organisations outside the consortium. A guide will be written to explain the details of the equipment, its installation and monitoring processes.

Task 5.2. Estimation of transmission losses. Data requirements will be listed and the data gathering process documented within a manual with figures, tables and photographs. This includes the site characterisation, the survey of groundwater data and hydrological data, the sampling and analytical techniques. The available software will be described. The modelling includes the data preparation (pre-processing), the description of the theoretical background of hydraulics and infiltration as well as the adequate choice of the analytical or numerical approach depending on the hydro-geological setting. The process of modelling transmission losses will be explained and made transparent in applied exercises with case study datasets. The important quality control and calibration of the results using isotope data will be demonstrated in different case studies.

Deliverables

D12. Field demonstration of TDR installation and monitoring of sub-surface waters **Month 18**.

D31. Methodological guide for the TDR installation, monitoring and estimation of transmission losses **Month 36**.

Milestones and expected result

M6. Installation of the TDR probes with expected start of sub-surface water monitoring **Month 6**

Modelling of transmission losses and groundwater recharge

Work package number	6	**Start date or starting event:**			Month 17
Activity Type	RTD/Innovation activities				
Participant id	P3*	P2	P8	P9	
Person-months per participant	15	5	10	2	

Objectives

To model, using several independent approaches, temporal changes in the vadose zone moisture profiles associated with surface flood and palaeoflood stages determined along the ephemeral rivers (using data collected from WP's 3 and 4). At this stage, before the data has been collected and analysed, no approach seems superior to the other, therefore all three approaches available will be examined for their suitability and the data will be processed through the modelling approach that best fits the character of the collected data.

Description of work

Task 6.1. Mass balance: The moisture profiles will be examined through water mass balance over the entire cross section. Following this approach the moisture profile will be summed to total cross section water storage as a function of time. Thus any increase in the total water mass will be considered as water that has percolated down from the surface, while any reduction in the total water mass will be considered as the water amount that left the cross section downwards and recharged the aquifer below. The advantage of this approach is that it is a direct approach that relies only on measured information and dose not require estimates of immeasurable parameters for the model solution.

Task 6.2. Moisture and temperature profiles: The second modelling approach uses the combined moisture and temperature profile to evaluate the percolation regime. While the moisture profile will be obtained by the TDR probes the temperature profiles will be obtained by thermocouples that will be installed next to each TDR probe. The thermal fluctuation in the profile is a consequence of heat diffusion combined with heat advection, the latter, the heat transported by the percolating water, is solved through the model.

Task 6.3. Numerical Modelling.

The third approach solves numerically the unsaturated zone flow equations (using HYDRUS or a compatible modelling approach). Though this is the most comprehensive and common vadose zone modelling approach it is strongly dependent on the need for accurate definition of the medium hydraulic parameters and boundary conditions. Due to the new technology employed in WP4, for the first time it may now be possible to calibrate the models to the entire actual moisture profile of the modelled cross section and so improve representation of the actual flow conditions.

Deliverables

D22. Mass balance of moisture profiles. **Month 30**

D23. Moisture and temperature profiles **Month 30**

D28. Numerical modelling of the unsaturated zone **Month 35**.

Milestones and expected result

M17 Mass and moisture balance of the studied cross-sections **Month 24.**

M18 Choice of the numerical model that best fit the character of the collected data **Month 30.**

Participatory water management: socio-economic & historical perspectives

Work package number	7	**Start date or starting event:**			Month 1		
Activity Type		RTD/Innovation activities					
Participant id		P5*	P4	P6	P9	P10	P11	P12
Person-months per participant		20	26	28	6	10	1	1

Objectives

The principal objectives of this WP will be to evaluate the socio-economic importance of water resources from shallow alluvial aquifers for the population of the study basins and to understand environmental changes within catchment areas in terms of water management, land use, policy, climate change and other determining factors. The impact of current policy options and institutional structures on the sustainability of alluvial aquifer management practices will be determined. Finally strategies for an integrated water management approach, using floodwater as a water resource, will be formulated using the data generated in WP's 2-6. The WP will use socio-anthropological methods and community participation, with the cooperation of, and facilitation by, the WADE end-users.

AM

Description of work

Parallel or together ?

Task 7.1. Community participation: The research will include interviews, participant observation and action research techniques in order to assess current water resource management practices and strategies. Associations & partnerships will be established between WADE, local communities and government officials in order to foster a sense of in-country ownership of the research. 6

Task 7.2. Environmental history: Archival research, recording of oral history and the use of repeat landscape and aerial photos will form part of an environmental history of the ephemeral rivers of Namibia and Namaqualand. Research into the history of water use and management, socio-economic change and political transformation during the 20th century will have a strong anthropological perspective in order to build an understanding of dynamic change, rather than a just 'snap-shot' of the present. 6

Task 7.3. Gender and poverty alleviation: Action research will focus on gender related water-use and management implications as well as on poverty alleviation among previously disadvantaged populations insofar as access to and management of water affects livelihoods. (Walvis Bay) 8

Task 7.4. Integrated water management (IWM): This task aims to combine the data generated in WP's 2-5 with the socio-anthropological approach of this WP in order to determine strategies for IWM focused on the use of floodwaters as a water resource. A key input will be from WADE end-users. 8

Deliverables

D8 Local community participation in the WADE project **Month 12**.
D18 Report on the gender and poverty alleviation issues addressed by WADE **Month 24**.
D24 Report on the environmental history of the study areas and its relationship with socio-economic, political and climate change **Month 30**.
D29 Report on strategies for an integrated approach to water management focusing on floodwaters as a water resource **Month 36**.

Milestones and expected result

M2 Regular meetings with communities and local partners. Participating communities are well informed and motivated to contribute to project and respond to the emerging results as they unfold. **Months 3 – 36**

M7 Maps of water resource use along the study basins. **Month 10**

M19 Institutional analysis relevant to the improved sustainability of water supplies completed. **Month 30**

Results' dissemination and exploitation

Work package number	8			**Start date or starting event:**					Month 1			
Activity Type		RTD/Innovation activities										
Participant id		P1*	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Person-months per participant		10	3	3	6	1	3	2	2	2	4	3	3

Objectives

The main objectives of this work package are to identify optimal dissemination pathways to ensure that the project data, deliverables and resource management tools are distributed to their maximum potential to end-users and the scientific community.

Description of work

Task 8.1 Project dissemination: The purpose of this task is to ensure the maximum publicity for the WADE project within the both the scientific and professional community as well as the general public. The main objectives of the project will be presented on a project flyer that will be produced and circulated at the beginning of the project. For on-going dissemination a project web page will be developed by month 3 of the project in order to provide easy access for finding up to date information about the project. An annual newsletter will also be produced and circulated (by email and post) to appropriate researchers and end-users who will be identified during the project (including members of the other EC funded river twinning projects).

Task 8.2 Dissemination of scientific results: This task will encourage dissemination of results from all partners through scientific conferences, oral seminars, articles in peer reviewed journals, technological exhibitions, events promoted by national/local authorities. In addition, an open meeting will take place at Month 36. In addition a results exploitation plan will be defined.

Deliverables

D1b. WADE project web page. Public access to enable dissemination of information and results **Month 3**.

D2. WADE project flyer **Month 3**.

D9. Annual electronic newsletter to highlight the latest project news and results **Month 12**.

D10. WADE dissemination plan **Month 12**.

D11. Peer reviewed journal articles and international conference participation **Month 13 onwards**.

D25 Results exploitation plan **Month 30**.

D30. Report on the conclusions of the open meeting **Month 36**

Milestones and expected result

M9 WADE dissemination plan that will highlight the optimal pathways for effective dissemination. **Month 12**

Project Review and Assessment

Work package number	9		**Start date or starting event:**				Month 3
Activity Type		RTD/Innovation activities					
Participant id		P1*	P2	P5	P6	P8	
Person-months per participant		3	1	1	1	1	

Objectives

The main objectives of this work package the progress of the project and compared to the planning and criteria described in the Work Programme.

Description of work

Task 9.1 Monitoring and reporting progress:

Each partner will report every 3 months to the corresponding WP Leader about the progress of the work on the basis of a regularly updated detailed planning. These progress reports will contain a review of :

- Work carried out, results obtained
- Work delayed, reasons and actions to correct the problems
- Work planned for the following period
- Percentage of completion, estimated time of completion
- Progress of training and capacity building

In addition, once a year Partners will submit the individual cost statements derived from the project execution. The WP Leader will then summarise the overall project status and planning and send it to the project coordinator, who will finally prepare the corresponding 6 month management report and annual progress and cost statement reports, taking care of their distribution to the commission in time. A final project report will review the scientific achievements of the project and main deliverables. An institutional auditing certificate will be presented by each partner together with the final cost statement.

Task 9.2 Mid-term review:

Of particular importance for the monitoring of the project's progress will be the mid-term review. Two independent scientists will be invited to attend the 2nd annual meeting where all partners will present a summary of the work completed with respect to the original project objectives, milestones and deliverables. The progress of WADE in terms of scientific achievements and its potential impact will be reviewed by the independent scientists. The impact of the training that has taken place within the WPs will be assessed with respect to the capacity and skills gaps identified at the kick-off meeting.

Deliverables

D19. Mid-term project review **Month 24**

D32. Report on the conclusions **Month 36**

Milestones and expected result

M13. Second annual coordination meeting and Mid-term Project Review. Two independent experts will be present at the meeting to provide a report on progress and impact of the project. **Month 24**

8. Project resources and budget overview

The WADE consortium counts on a wide range of expertise and resources necessary to successfully implement the research project. A summary of this expertise and the resources provided by each partner is presented in Table 8.1.

The role and specific skills of the participants

Table 8.1 highlights the principal tasks designated to each partner and the principal areas of expertise that each partner will provide to the WADE consortium. The role of project co-ordinator will be taken on by Dr Gerardo Benito, of the Consejo Superior de Investigaciones Cientificas (CSIC, P1), who already has EU project coordination skills and expertise through the SPHERE and PHEFRA projects. In addition to the WADE coordination the CSIC will lead the palaeoflood research (WP3) in cooperation with Prof Yehouda Enzel of the Hebrew University of Jerusalem (P2), who in addition to his expertise in palaeoflood hydrology, also has vast experience of desert geomorphology and hydrology, specifically in the Negev Desert in Israel. One important task within WP3 is the statistical analysis of the non-stationary palaeoflood data produced by the palaeohydrologists (P1 and P2). This will be carried out by the INRS (P7) led by Prof Taha Ouarda, a leading expert in the statistical analysis of long-term non-stationary flood data, who has developed statistical analysis software within the EU funded SPHERE project.

For the tasks of monitoring surface and subsurface water (WP4) and modelling transmission losses (WP5) the WADE consortium includes two research groups. The Ben Gurion University research group (P8), led by Dr Dahan, recently developed the technology and methodology for monitoring deep vadose zone hydrology (Dahan et al, 2002) that will be employed within this project. A patent for this technology is currently pending. Their role in the project will be to apply this technology and their expertise to the case study catchments, as well as taking on a coordinating role in WP4. HYDROISOTP (P3) are experts in groundwater geochemistry and modelling and have research experience in Namibia so are ideally placed to coordinate WP5, the modelling of transmission losses, and will complement the technological innovation supplied by P8.

In addition to the palaeoflood hydrology and surface and sub-surface hydrology components of the WADE project, the final key research theme is that of the societal importance of water resources derived from aquifers in the study catchments (WP6). This WP will deal with various socio-anthropological issues, ranging from the effects of global change through to the development of integrated water management strategies for using floodwaters as a sustainable water resource. This WP will be coordinated by Dr. Rhode of the Centre of African Studies of the University of Edinburgh (P5), who has experience of working within EU projects within both Namibia and S. Africa. Also actively involved in this WP will be the Desert Research Foundation of Namibia (P4), who currently have community led water resource projects on-going in the Kuiseb catchment in Namibia, and the Institute of Plant Conservation of the University of Cape Town (P6) who will focus on the effects of global change on the environmental history of the catchments. In addition the expertise of the two end-users will be counted on for the development of this WP – the Ministry of Agriculture, Water & Rural Development (WP9) in Namibia and the NGO Surplus People Project (P10) in South Africa, especially in terms of the implications of the results for integrated water resources management.

In addition to the palaeoflood hydrology and surface and sub-surface hydrology components of the WADE project, the final key research theme is that of the societal importance of water resources derived from aquifers in the study catchments. WP6, *Participatory water management: socio-*

economic and historical perspectives, will deal with various socio-anthropological issues, ranging from the effects of global change through to the development of integrated water management strategies for using floodwaters as a sustainable water resource. This WP will be coordinated by Dr. Rhode of the Centre of African Studies of the University of Edinburgh (P5), who has experience of working within EU projects within both Namibia and S. Africa. Also actively involved in this WP will be the Desert Research Foundation of Namibia (P4), who currently have community led water resource projects on-going in the Kuiseb and Hoanib catchments in Namibia, and the Institute of Plant Conservation of the University of Cape Town (P6) who will focus on the effects of global change on the environmental history of the catchments. In addition the expertise of the four end-users will be counted on for the development of this WP – the Ministry of Agriculture, Water & Rural Development (WP9) in Namibia, the NGO Surplus People Project (P10) in South Africa, and two South African municipalities, Kamiesberg (P11) and Nama Khoi (P12), especially in terms of the implications of the results for integrated water resources management.

Partner		Principal WADE tasks	Expertise	Human Resources	Material Resources	International projects
P1	CSIC	Project coordination & management (WP1) Site characterisation (WP2) Palaeoflood Hydrology (WP3)	Coordination of the EU funded SPHERE & PHEFRA projects Palaeoflood hydrology, hydraulic modelling GIS, topography & surveying	Dr Gerardo Benito (Palaeohydrologist) Dr Varyl Thorndycraft (PDRA) 1 x part-time Assistant	Palaeoflood Research Laboratory (sedimentary analyses) Hydraulic models within a GIS environment	SPHERE (Coordinator) (EVG1-CT-1999-00010). PHEFRA (Coordinator) (EVG1-CT-2002-60001)
P2	HUJI	Site characterisation (WP2) Palaeoflood Hydrology (WP3) Monitoring of surface water (WP4)	Palaeoflood hydrology, surficial hydrology, test of methodology in Negev Desert, Israel Arid geomorphology	Prof Yehouda Enzel (Palaeohydrologist) Dr Noam Greenboam (Hydrologist) 1 x PhD Student	Flood Routing Model	SPHERE (EVG1-CT-1999-00010) PHEFRA (EVG1-CT-2002-60001)
P3	HY	Site characterisation (WP2) Monitoring of subsurface water (WP4) Modelling of transmission losses (WP5)	Groundwater hydrology, dating, groundwater geochemistry, isotope methods. Research in Namibia and other arid/semi-arid regions.	Dr Christoph. Kuells (Groundwater hydrologist) 1 x laboratory technician 1 x junior hydrologist	Isotope geochemistry laboratory, MODFLOW, Hydras (groundwater and soil physics software)	ITER (EVK4-CT-2001-30004)
P4	DRFN	Site characterisation (WP2) Participatory water management (WP6)	Desert environmental research Basin management in Namibia	Dr Mary Seeley 1 x PhD student Namibian student interns	Gobabeb Training and Research Centre on ephemeral Kuiseb River	WERRD (ICA4-CT-2001-10040)
P5	UEDIN	Site characterisation (WP2) Participatory water management (WP6)	Socio-anthropology. Environmental history research experience in Namibia and Namaqualand	Dr Rick Rhodes (Socio-anthropologist) 1 x PhD student	Environmental history database of Namibia and South Africa.	INCO-DC: ERBIC 18CT970162 INCO-DEV: ICA4/CP/2000/50006
P6	IPC	Site characterisation (WP2) Participatory water management (WP6)	Ecological conservation, environmental history in Namaqualand	Dr Timm Hoffman (Ecologist) 1 x PhD students	Historical Monitoring of vegetation changes. Historical photographic archive.	INCO-DC: ERBIC 18CT970162 INCO-DEV: ICA4/CP/2000/50006
P7	INRS	Flood frequency analysis (WP1)	Statistics, Flood Frequency Analysis (FFA)	Prof Taha Ouarda (Applied statistician)	FRESH software (for FFA of non-stationary data)	SPHERE (EVG1-CT-1999-00010)
P8	BGU	Site characterisation (WP2) Monitoring of surface and subsurface water (WP4) Modelling of transmission losses (WP5) Participatory water management (WP6)	Groundwater modelling. Development of vadose zone monitoring technology and quantification of transmission loss. Installation of vadose zone monitoring systems	Dr Ofer Dahan (Vadose zone Hydrologist) Dr Alex Yakirevich (sub-surface hydrology modeler) 1 x PhD Student 1 x Technician	Vadose zone monitoring technology (TDR systems) Infiltration model Hydrochemical laboratory	

Table 8.1. The WADE consortium illustrating the critical mass of resources required to effectively and efficiently carry out the project.

P9	MAWRD	Site characterisation (WP2) Participatory water management (WP6)	Namibian governmental department. Integrated Water Resource Management	Mr Guido Langenhove P. Heyns (Director) 1 Hydrologist (MAWRD staff) 1 Technician (MAWRD staff) 1 Support staff (MAWRD staff)	Flood discharge database	
P10	SPP	Site characterisation (WP2) Participatory water management (WP6)	Development facilitation – natural resource management	Harry May (Senior development facilitator). Ronald Newmam Edith Newman	Extensive networks within the Northern Cape government	Zuid-Afrika F05 (58 45)
P11	KM	Participatory water management (WP6)	South African local government department	Mr. F. Roodman (Municipal Manager)	Local information	
P12	NMK	Participatory water management (WP6)	South African local government department	Mr. W. Engelbrecht (Municipal Manager)	Local information.	

Table 8.1. (continued) The WADE consortium illustrating the critical mass of resources required to effectively and efficiently carry out the project.

Complementarity of the resources

The WADE consortium is composed of research institutes, universities, SME's, NGO's and end-users that are well balanced in terms of the types of organisations represented, their geographical locations and their complementary research skills (Table 8.1). The consortium represents 3 organisations from 3 different EU member states; 2 organisations from an associated member state, 6 organisations from 2 countries included for specific measures in support of international cooperation and 1 non-member organisation (from Canada).

The state of the art technology developed for quantifying long term transmission losses and alluvial aquifer recharge from flood events was developed in the Negev Desert by the Ben Gurion University (P8) and the Hebrew University of Jerusalem (P2). The technology is currently being utilised in Spain by the Consejo Superior de Investigaciones Cientificas (P1). P1 and P2 represent the experts in palaeoflood hydrology in the consortium, these two organisations being the leading researchers in European palaeoflood hydrology. The research expertise of the Spanish and Israeli organisations will be applied in Namibian and South African catchments in order to twin African basins with those currently under study in Israel and Spain. The consortium includes a number of organisations with extensive experience of research in both Namibia and S. Africa, including the locally based organisations, the Desert Research Foundation of Namibia (P4) and the University of Cape Town (P6), both specialising in the study of dryland environments from geomorphological, hydrological and ecological points of view. In addition, the German SME, HYDROISOTP (P3), who specialise in groundwater hydrology and geochemistry, have extensive research experience in Namibia. The Centre of African Studies of the University of Edinburgh (P5) have many years of anthroplogical research experience related to environmental issues both in Namibia and Namaqualand, the South African study region. Finally, four-end user organisations are represented, the Water Affairs Department (P9) of the Namibian Government, the Surplus People Project NGO (P10) who work in sustainable development issues in South Africa, and two municipalities Kamiesberg (P11) and Nama Khoi (P12) in South Africa, with responsibilities in water resource supply.

Including SME's in the WADE consortium

The opportunity of including an SME within the WADE consortium has been taken with the involvement of the German consultancy HYDROISOTP (P3). In addition to HYDROISOTP's laboratory facilities, and their experience and knowledge of the analysis of groundwater isotopes, Dr Christop Kuells has extensive field experience in dryland environments and has already specifically worked in Namibia. The local knowledge and specialist expertise of this SME will, therefore, be drawn upon for the WADE project.

Description of Resources

The WADE consortium is confident that it has amalgamated the necessary critical mass of resources, both human and material, in order to successfully achieve the objectives of the project. These resources are summarised in Table 8.1, where the human resources, both permanent staff members and research students to be contracted on the projects, are listed alongside any specific material resources the organisation will input to the project.

In terms of resources for effective project management, the CSIC (P1), in its role as the WADE coordinating institution, can count on a vast experience of managing R&D contracts. The CSIC, the largest public multidisciplinary research organisation in Spain, has considerable experience in managing R&D projects. Within the V Framework Programme, a total of 772 R&D contracts have been managed by the relevant units of the CSIC. In addition to this administrative support the

WADE coordinator, Dr. Benito, has experience of project coordination within the SPHERE and PHEFRA projects (see Table 8.1) of the V Framework Programme.

Type of material resources	Description	Partner	Work Package contribution
Patented technology	TDR systems for monitoring the deep vadose zone	P8	WP4
Laboratory	Palaeoflood Research Lab.	P1	WP3 (&WP2)
	Isotope Geochemistry Lab	P3	WP4
Computer models	Flood Routing Model	P2	WP3
	MODFLOW, Hydras	P3	WP6
	GIS based hydraulic modelling	P1	WP3
Software	FRESH – flood frequency analysis	P7	WP3
Field research site	Kuiseb Water Resource study	P4	WP2, WP4, WP7
	Namaqualand environmental database	P6	WP1, WP7
	Municipal background information	P11, P12	WP1, WP7

Table 8.2 The principal material resources within the WADE consortium

In terms of the human resources mobilised to carry out the WADE research objectives, the consortium is represented by 14 permanent staff, within the 12 partner organisations, who will be actively involved in the WADE project. In addition, one Post-doctoral Research Assistant (PDRA) will be contracted by the coordinating organisation (CSIC, P1) and 5 full time research students will be taken on. The rest of the research time is composed of part-time staff including laboratory technicians and research assistants. Within the Namibian and S. African study areas, community participation will be encouraged within WP6, developing links between the WADE consortium and the local community (P11 and P12).

One of the most important features of the WADE consortium is the critical mass of material resources that the partners will be mobilising for the project. These are summarised in Table 8.2 and include the newly developed technology of P8, for monitoring the deep vadose zone, probably the most important material resource necessary for the project's successful completion. In addition, the consortium provides two analytical laboratories, one operational field research site, various hydrologic models and a newly developed statistical analysis software for the flood frequency analysis of non-systematic data. Other valuable material comprises the field site knowledge on natural resources and socio-economic problems.

8.1 Efforts for the full duration of the project

The following table shows the WADE Project Effort Form by person-months per participant associated with each activity.

STREP Project Effort Form
Full duration of project

Project acronym - **WADE**	CSIC	HUJI	HY	DRFN	UEDIN	IPC	INRS	BGU	MAWRD	SPP	KM	NKM	TOTAL PARTNERS
Research/innovation activities													
WP2 Site characterisation	5	5	2	9	1	6	-	2	2	4	-	-	36
WP3 Reconstructing long term flood magnitude & frequency	36	30	-	-	-	-	12	-	2	-	-	-	80
WP4 Monitoring of surface & sub-surface water	3	10	18	10	-	3	-	45	6	-	-	-	95
WP6 Modelling of transmission losses and groundwater recharge	-	5	15	-	-	-	-	10	2	-	-	-	32
WP7 Participatory water management: socio-economic & historical perspectives	-	-	-	26	20	28	-	-	6	10	1	1	92
WP8 Results' dissemination & exploitation	10	3	3	6	1	3	2	2	2	4	3	3	42
WP9: Review and assessment	2	1			1	1		1					6
Total research/innovation	56	54	38	51	23	41	14	60	20	9	4	4	383
Demonstration activities													
WP5 Demonstration of TDR probe and installation	-	-	4	-	-	-	-	4	-	-	-	-	8
Total demonstration	-	-	4	-	-	-	-	4	-	-	-	-	8
Management activities													
WP1 WADE Project Management	20	-	-	-	-	-	-	-	-	-	-	-	20
Total management	20	-	-	-	-	-	-	-	-	-	-	-	20
TOTAL ACTIVITIES	76	54	42	51	23	41	14	64	20	9	4	4	411

8.2 Overall budget for the full duration of the project

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme for Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.1

Proposal Number[1]	506680	Proposal Acronym[2]	WADE

Financial information – whole duration of the project

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities[41]: RTD[42] or Innovation-related[44] activities (1)	Demonstration activities[43] (2)	Consortium Management activities[45] (3)	Total (4)=(1)+(2)+(3)	Total receipts[41]
P1	CSIC	FC	Eligible costs	*Direct costs (a)*	367865		66854	*434719*	**434700**
				of which subcontracting	*30000*			*30000*	
				Indirect costs (b)	*263534*		*52146*	*315680*	
				Total eligible costs (a)+(b)	*631399*		*119000*	*750399*	
			Requested EC contribution		315700		119000	434700	
P2	HUJI	AC	Eligible costs	*Direct costs (a)*	196863			196863	**230036**
				of which subcontracting	*31000*			*31000*	
				Indirect costs (b)	*33173*			*33173*	
				Total eligible costs (a)+(b)	*230036*			*230036*	
			Requested EC contribution		230036			230036	
P3	HY	FCF	Eligible costs	*Direct costs (a)*	223472	17126		240598	**140126**
				of which subcontracting	*11500*			*11500*	
				Indirect costs (b)	*42394*	*3425*		*45819*	
				Total eligible costs (a)+(b)	*265866*	*20551*		*286417*	
			Requested EC contribution		132933	7193		140126	
P4	DRFN	AC	Eligible costs	*Direct costs (a)*	207925			207925	**124755**
				of which subcontracting	*0*			*0*	
				Indirect costs (b)	*41585*			*41585*	
				Total eligible costs (a)+(b)	*249510*			*249510*	
			Requested EC contribution		124755			124755	
TOTAL[46]			Eligible costs						
			Requested EC contribution						

Please use as many copies of form A3.1 as necessary for the number of participants	***Form A3.1 page***	*1*	***of***	*3*

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme for Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.1

Proposal Number[1]	506680	Proposal Acronym[2]	WADE

Financial information – whole duration of the project

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities[41]: RTD[42] or Innovation-related[44] activities (1)	Demonstration activities[43] (2)	Consortium Management activities[45] (3)	Total (4)=(1)+(2)+(3)	Total receipts[41]
P5	UEDIN	AC	Eligible costs	*Direct costs (a)*	142860			142860	171432
				of which subcontracting					
				Indirect costs (b)	*28572*			*28572*	
				Total eligible costs (a)+(b)	*171432*			*171432*	
			Requested EC contribution		171432			171432	
P6	IPC	AC	Eligible costs	*Direct costs (a)*	156684			156684	182021
				of which subcontracting	*30000*			*30000*	
				Indirect costs (b)	*25337*			*25337*	
				Total eligible costs (a)+(b)	*182021*			*182021*	
			Requested EC contribution		182021			182021	
P7	INRS	AC	Eligible costs	*Direct costs (a)*	225000			225000	0
				of which subcontracting					
				Indirect costs (b)	*45000*			*45000*	
				Total eligible costs (a)+(b)	*270000*			*270000*	
			Requested EC contribution		0			0	
P8	BGU	AC	Eligible costs	*Direct costs (a)*	244992	2620		247612	285090
				of which subcontracting	*50000*			*50000*	
				Indirect costs (b)	*38998*	*524*		*39522*	
				Total eligible costs (a)+(b)	*283990*	*3144*		*287134*	
			Requested EC contribution		283990	1100		285090	
TOTAL[46]			Eligible costs						
			Requested EC contribution						

Please use as many copies of form A3.1 as necessary for the number of participants	***Form A3.1 page***	*2*	***of***	*3*

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme for Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.1

Proposal Number[1]	506680	Proposal Acronym[2]	WADE

Financial information – whole duration of the project

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities[41]: RTD[42] or Innovation-related[44] activities (1)	Demonstration activities[43] (2)	Consortium Management activities[45] (3)	Total (4)=(1)+(2)+(3)	Total receipts[41]
P9	MAWRD	AC	Eligible costs	*Direct costs (a)*	39000			*39000*	**46800**
				of which subcontracting					
				Indirect costs (b)	*7800*			*7800*	
				Total eligible costs (a)+(b)	*46800*			*46800*	
			Requested EC contribution		46800			46800	
P10	SPP	AC	Eligible costs	*Direct costs (a)*	77510			77510	**46506**
				of which subcontracting					
				Indirect costs (b)	*15502*			*15502*	
				Total eligible costs (a)+(b)	*93012*			*93012*	
			Requested EC contribution		46506			46506	
P11	KM	AC	Eligible costs	*Direct costs (a)*	16056			16056	**19267**
				of which subcontracting					
				Indirect costs (b)	*3211*			*3211*	
				Total eligible costs (a)+(b)	*19267*			*19267*	
			Requested EC contribution		19267			19267	
P12	NMK	AC	Eligible costs	*Direct costs (a)*	16056			16056	**19267**
				of which subcontracting					
				Indirect costs (b)	*3211*			*3211*	
				Total eligible costs (a)+(b)	*19267*			*19267*	
			Requested EC contribution		19267			19267	
TOTAL[46]			Eligible costs		2462600	23695	119000	2605295	**1700000**
			Requested EC contribution		1572707	8293	119000	1700000	

Please use as many copies of form A3.1 as necessary for the number of participants	***Form A3.1 page***	*3*	***of***	*3*

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme for Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.2

Proposal Number[1]	506680	Proposal Acronym[2]	WADE

Estimated breakdown of the EC contribution per reporting period

Reporting Periods	Start month	End month	Estimated Grant to the Budget	
			Total	In which first six months
Reporting Period 1	1	12	736246	
Reporting Period 2	13	24	507880	304728
Reporting Period 3	25	36	455874	273524
Reporting Period 4				
Reporting Period 5				
Reporting Period 6				
Reporting Period 7				

8.3 Management level description of resources and budget

The total cost of the project is € 2,605,295 and the requested grant to the European Community amounts to € 1,700,000. Per activities, the EC granted amount was distributed as follows: € 119,000 (7%) for management, € 8293 for demonstration, and € 1,572,707 for RTD/innovation activities.

Management costs cover the management activities described in WP1 and auditing costs. A part-time contract is included in the coordination costs as well as scheduled travelling to the project meetings. Requirement of auditing certificates by the EC is a new item of the 6FP and, therefore, there are not previous reference prices for these certificates. As coordinator I have noted that prices provided by Universities and agencies are highly variable and usually trend to provide a rather high amount. Although in the project proposal the auditing costs were budgeted individually per partner, we opted for budgeting all certificates costs to the Coordinator Management costs. The coordinator (P1) will pay the final auditing costs of the partners upon reception of the invoice. The estimated costs for these certificates are € 13,500 (€1125 per certificate).

Demonstration activities are scheduled within WP5, including demonstration of TDR probe and installation. These will be focussed on of the TDR probe design and installation technique, and on modelling demonstrations, re-evaluation and data analysis with local experts. The demonstration costs are 23,695, although the real cost reaches over 50,000 since a large amount of permanent personnel under AC costs will be used in this activity. The requested amount (35% of total costs) for the demonstration activities amounts to € 8293.

In the RTD/Innovation activities, "Personnel cost" are the main contribution to the project expenditures, accounting for a total amount of € 1,196,555 of which about € 675,000 is requested to the European Community. In Table A.1 (Annex 1) the human resources of each partner are indicated. This includes Post-Doctoral and Pre-doctoral fellowships and part-time contracts to technicians.

The WADE Project is based entirely on hydrological monitoring stations that need to be constructed and installed in four different countries: Israel, Namibia, Spain and South Africa. These monitoring stations include the installation of customized special monitoring equipment for the vadose zone in boreholes that must be drilled specially for this project, and newly drilled boreholes to the groundwater. The vadose zone monitoring equipment is newly developed and there is no alternative shelf product or method. The detailed budget, attached here, contains the list of components of this monitoring system. All items are part of the system, which can only function when all of the listed items are present. The monitoring system comprises the construction and installation of a total of 11 monitoring systems, 3 in each country (in Israel only 2 sets; 11 sets at total). It is recognized that 3 stations for each site is the minimum number of monitoring stations that would allow proper evaluation of the recharge process, while considering the known large field heterogeneity and parameter variability.

Field installation of the TDR probes consumes a total of € 273,000 (€ 230,500 requested to EC), which includes the borehole and installation of three sets of TDR boreholes along one river in each of the 4 countries (in Israel only 2 sets; 11 sets at total). Durable

and consumables required for these installation are €163,000 (€ 135,370 requested to EC), whereas the field borehole reaches € 110,000 (€ 95,000 requested to EC). Vadose and groundwater monitoring equipment, and borehole works (subcontracting) was charged in the budgets of CSIC (P1), DRFN (P4), IPC (P6) and BGU (P8), although the installation will be coordinated by BGU (P6).

Field installation	Price per item	No. of rerquired items	Israel	No. of rerquired items	Namibia	No. of rerquired items	Spain	No. of rerquired items	South Africa
datalogers (3 year depreciation)	1350	2	2700	3	4050	3	4050	3	4050
multiplexer (5 year depreciation)	500	4	1200	6	3000	6	3000	6	3000
1 TDR 100 (5 year depreciation)	4100	2	4920	3	12300	3	12300	3	12300
pressur transducer for groundwater monitorig (5 year depreciation)	750	4	1800	6	4500	6	4500	6	4500
Vadose zone monitoring system (flexible sleeves, TDR probes, thermocouple, and field accessories). (4 IL, 6 Na, 6 ES, 6SA) (Consumable)	1500	22	33000						
Urethane (150 liter per system 10EU liter (Consumable)	1500		6000		9000		9000		9000
Ladoratory material and dispansable sampling supply (Consumable)	5000		5000						
field equipment shelter boxes (consumable)	900	2	1800	3	2700	3	2700	3	2700
			56420		35550		35550		35550
Drilling									
2 slanted boreholes to the vadose zone (15 m each) ~$200/m	5500								
1 vertical boreholes to the water table (25 m' each on average) ~$200/m	4500								
Total drilling		2	20000	3	30000	3	30000	3	30000

Detailed budget of the components required for the field installation of the vadose and ground water monitoring systems.
Note: prices on drilling may vary among countries depending on the labour and drilling equipment costs.

For the modelling of transmission losses, data on the geometry of the alluvium are important parameters. For the geophysical investigation of profiles in Namibia and in South Africa we intend to contract a local company that carries out the resistivity measurements along transsects defined by Hydroisotop GmbH (P3). The company will also carry out the inverse analyses of the soundings and provide depth profiles of the alluvium. Hydroisotop Gmbh (P3) has allocated a sum of 11.500 ,- € for this work. We have proposed to work with the local company BIWAC. This company, to our knowledge, is the only company in Namibia with extensive experience in geophysical resistivity soundings. We are aware of previous activities for the BGR (Bundesanstalt für Geowissenschaften und Rohstoffe) through which BIWAC has experience in the Kuiseb Basin of Namibia. Borehole and geophysics will be subcontracted to local companies. In addition, we have estimated the radiocarbon dating expenses of € 31,000. Radiocarbon analysis will be subcontracting to the Zurich University Irchel.

The consumables expenses are about € 116,000 (€ 90,000 requested to the EC) basically regard to containers, cables and supplies for TDR field installation, photographic processing of historical material, chemical products to perform analysis, bibliographic material, aerial photographs and maps of case study catchments and Internet and database consultations for data compilation.

In the travel and subsistence section, a total of three meetings in Africa (Namibia and South Africa), and 3 meetings in Europe have been considered. In addition, field work was scheduled according to the Work Plan needs. Some of these travels are expensive, but meetings in Africa will be schedule during the field work studies. An average of € 1,500 for overseas flights, € 300 for European flights, and € 500 for Israel-Europe flights were budgeted. The hotel costs and the per diem expenses were budgeted according to the National and/or organisation rules. The travel and subsistence category totals and amount of € 394,000 of which € 345,000 is requested to the EC.

The indirect costs of the project are € 378,000.

	Personnel	Durable	Consum.	Travel	Subcontract	Others	Overheads
Cost (€)	1197	102	121	411	152	17	605
EC cost (€)	675	85	90	345	125	2	378
Budget %	46	4	5	16	6	0	23

Economic resources of the WADE project by category in K euros.

Note: These numbers with the information provided by the partners. In any case, there are approximated and subject to change according to the progress of the project.

9. Gender Issues

Major efforts within this project will be focused to involve women in water resource management, through empowerment of women in local communities. Many countries have recognised the benefits of involving women in all aspects of their water and sanitation programmes. Most government guidelines, project designs and program policies now incorporate a gender dimension: this is regarded as crucial to the sustainability of any program or project. It has been accepted that water development and management policies and programmes that exclude women as actors, and as an interest group, bypass half the population and are lower in efficiency and effectiveness. However, at the implementation level, the promotion of a gender balance is often lacking. This reveals that it is not enough to accord women paper rights through policy, law or institutional reform. Instead, the overall goal of any gender strategy for the water sector should be: to develop a framework which ensures that both women's and men's concerns and experiences are an integral dimension of the design, implementation, monitoring and evaluation of water projects - as well as of legislation, policies and programmes. These issues will be addressed in Task 7.3 that will focus on gender related water-use and management implications.

10. Other Issues

For the objective of improving the potential impact of WADE it is envisaged that the project will contribute to the EU Water Initiative adopted to address the global challenge of the growing scarcity and decreasing quality of water. The WADE project will participate in a research cluster including other river twinning networks and projects of the VI Framework Programme. Currently identified projects in this cluster include WADE, TWINBAS, RIVERTWIN and the network TWIN BASIN XN. These projects will all be included on the mailing list for the annual newsletter reporting on the progress of WADE.

In particular WADE will cooperate with the TWINBAS project that is also working in southern Africa, specifically in the delta region of the Okavango River in Botswana, a region sensitive to interactions between surface and groundwater. The work within these two projects will be coordinated in order to identify and use common approaches. The two projects use different methodologies that could be usefully applied in the other project, such as the TDR technology of WADE and the economic analyses of TWINBAS. It is envisaged that the two projects will meet to discuss the methodology and progress of the projects.

The project shall **coordinate with the EU Working Groups on Africa**, (Water Supply and Sanitation and IWRM).

In addition following the conclusion of the contract the co-ordinator **shall inform our Delegations in Namibia** (http://www.delnam.cec.eu.int/Delegation/main.htm) and in **South Africa** (http://www.eusa.org.za/) on the implementation of the project, its objectives/contents and the local partners involved.

Appendix A - Consortium description

PARTNER 1: Environmental Sciences Centre
Consejo Superior de Investigaciones Científicas (CSIC)

Responsible: Gerardo Benito, WADE Coordinator (benito@ccma.csic.es)

Description of the participating organisation

The CSIC is the largest public multidisciplinary research organisation in Spain and has considerable experience in managing R&D projects. Within the V Framework Programme, a total of 772 R&D contracts have been managed by the relevant units of the CSIC. In addition, 1,615 nationally funded R&D projects were administered during the period 1994-1997 and every year more than 1,500 training grants are dealt with by the CSIC.

Human Resources of Partner 1

Gerardo Benito (born 1961). Ph.D. Geosciences (May, 1989), University of Zaragoza, Spain.

- 1990-92: Research Associate, Department of Geosciences, University of Arizona, Tucson, USA.
- 1992-Present: Full Researcher in the National Research Council (CSIC), Madrid.
- EC projects: has coordinated the EC funded SPHERE and PHEFRA projects.
- EXPERTISE:- Flood hydrology, Fluvial Geomorphology.- Past Global Changes.

Varyl Thorndycraft (born 1972). PhD. Geography (February, 2000), University of Exeter, UK.

- 2000-present: Post-doctoral research assistant at the CSIC, Madrid.
- EC projects: research and administration experience within the SPHERE and PHEFRA projects.
- EXPERTISE: Fluvial Geomorphology; Palaeoflood Hydrology; Alluvial Records of Global.

Additional support will be provided by:

Alfredo Perez Gonzalez (born 1941). Ph.D. Geosciences (1979), Madrid, Spain. Senior Lecturer at the University Complutense of Madrid. EXPERTISE: Fluvial Geomorphology amd stratigraphy.

Alfonso Sopeña, born 1945. Ph.D. Geosciences (1979), Madrid, Spain. Present position: Researcher Professor of the Instituto de Geología Económica (CSIC). EXPERTISE: sedimentology and stratigraphy.

Yolanda Sánchez Moya, born 1962, Ph.D. Geosciences (1991), Madrid, Spain. Senior Lecturer at the University Complutense of Madrid. EXPERTISE: Fluvial Stratigraphy, Sedimentology.

Recent and ongoing European Projects

"*Sustainable use of natural resources in rural systems of eastern Africa drylands (Ethiopia, Kenya, Tanzania), strategies for environmental rehabilitation*". (Programme INCO, of the European Union, ERB3514PL961307).

"Systematic, Palaeoflood and Historical data for the improvEment of flood Risk Estimation" SPHERE (V Framework Programme, EVG1-1999-00039). Coordinated by Gerardo Benito.

"*Palaeoflood and Historical Evidence in Flood Risk Assessment*" *PHEFRA* (V Framework Programme, EVG1-CT-2002-60001). Coordinated by Gerardo Benito.

Selected Publications

Baker, R.V.; **Benito, G**. and Rudoy, A.N. (1993). Palaeohydrology of Late Pleistocene superflooding, Altay Mountains, Siberia. *Science*, 259, 348-350.

Benito, G., Sánchez-Moya, Y & Sopeña, A. (2003). Sedimentology of high stage flood deposits of the Tagus River, Central Spain. *Sedimentary Geology*, 157, 107-132.

Benito, G., Sopeña, A., Sánchez-Moya, Y., Machado, M.J., Perez-Gonzalez, A. (2003): Palaeoflood record of the Tagus River (Central Spain) during the Late Pleistocene and Holocene. *Quaternary Science Reviews* 22, 1737-1756.

Benito, G., Lang, M. Barriendos, M., Llasat, M.C., Francés, F., Ouarda, T., **Thorndycraft, V.R**., Enzel, Y., Bardossy, A., Coeur, D. And Bobeé, B. (in press). Use of systematic palaeoflood and historical data for the improvement of flood risk estimation. Review of scientific methods. *Natural Hazards*.

Machado, M.J., **Pérez-González, A**. and **Benito, G**. (1998). Paleoenvironmental changes during the last 4,000 yr. in the Tigray, Northern Ethiopia. *Quateranary Research, 49*, 312-321.

Thorndycraft, V.R., Hu, Y., Oldfield, F., Crooks, P. Appleby, P. (1998): Individual flood events detected in the recent sediments of the Petit Lac d'Annecy, E France, *The Holocene*, 8, 741-746.

Thorndycraft, V.R., Benito, G., Barriendos, M. and Llasat, M.C. (2003): *Palaeofloods, historical data and climatic variability: applications in flood risk assessment*. CSIC, Madrid. 378pp.

PARTNER 2: Institute of Earth Sciences, Hebrew University of Jerusalem (HUJI)

Responsible: Yehouda Enzel (yenzel@vms.huji.ac.il)

Description of the participating organisation

The Hebrew University of Jerusalem (HUJI) was founded in 1925 and is the oldest research university in Israel. HUJI has a national as well as an international reputation in all aspects of research and especially in the sciences. It has over 1100 permanent academic researchers and approximately 20 tenured researchers in research fields relevant to this study including a leading group in fluvial, flood, hydrological processes, and hydroclimatology in arid environments. Both the Institute of Earth Sciences and the Department of Geography have long-standing, proven research capabilities in water resources, flood and paleoflood hydrology, fluvial geomorphology, flood recharge, ecology of streams, and climatology of floods. The university researchers focus on arid and semiarid environments of the world. Researchers of this institute were first to combine paleoflood/long-term flood frequency with rates of recharge to arid alluvial aquifers to evaluate water resources in such harsh environments. The researchers of HUJI have experience in studying, communicating, and disseminating new ideas, approaches, and results to end users around the world and are considered by water and planning authorities in Israel as consulting experts in the above fields.

Human Resources of Partner 2

Prof. Yehouda Enzel has extensive experience in flood and paleoflood hydrology in Southwestern United States, India, Israel and recently in France. He leads flood research in the Hebrew University and in Israel. He has authored and co-authored over 70 peer-reviewed journal manuscripts in addition to many manuscripts in books, proceedings, etc. His experience include locating suitable sites, determining their stratigraphy, stratigraphic correlations between sites, age dating (^{137}C, ^{14}C, OSL), soil development within sequences, topographic surveying, and modeling aspects needed for constructing basin and regional long-term flood records, upper bounds and flood frequency and the climatic control over flood distribution in time. Has a lot of experience in arid environments, flood research in arid to hyperarid environments and analyses of synoptic and hydroclimatologic causes of floods. He is serving on editorial boards of two international journals and has been a visiting scholar at a number of institutes.

Dr. Noam Greembaum is a member of the Hebrew University flood research team and teaches in Haifa University. He is one of the most experienced paleoflood hydrologists in hyper arid environments. His PhD and post doc research dealt with reconstructing flood records in the hyperarid Negev desert in truly marginal conditions. He led the first ever effort to combine paleoflood record and recharge data in alluvial aquifers. His pioneering results are at the basis of this project.

Recent and ongoing European Projects

"Systematic, Palaeoflood and Historical data for the improvEment of flood Risk Estimation" SPHERE (V Framework Programme, EVG1-1999-00039).

Selected Publications

Enzel, Y., Wells, S.G., and Lancaster, N., eds., 2003, Paleoenvironments and Paleohydrology of the Mojave and Southern Great Basin Deserts, Boulder, Colorado, *Geological Society of America Special Paper* 368, 260 p.

Enzel, Y., 1992, Flood frequency of the Mojave River and the formation of late Holocene playa lakes, southern California. *The Holocene*, v. 2, p. 11-18

Ely, L.L., **Enzel, Y.**, Baker, V.R., and Cayan, D.R., 1993, Atmospheric circulation patterns and extreme paleofloods: A 5000-year record from the southwestern United States, *Science* v.262, p. 410-412.

Enzel, Y., Ely, L.L., House, P.K., Baker, V.R., and Webb., R.H., 1993, Paleoflood evidence for a natural upper bound to flood magnitudes in the Colorado River basin. *Water Res. Research*, v. 29, 2287-22.

Greenbaum, N. Schwartz, U., Schick, A. P., and **Enzel, Y**. 2002, Paleofloods and the estimation of long-term transmission losses and recharge to the lower Nahal Zin alluvial aquifer, Negev Desert, Israel. In: House, et al, eds. *Ancient Floods, Modern Hazards: Principles and Applications of Paleoflood Hydrology*, American Geophysical Union, Water Resources and Application v. 5, p. 311-328

Greenbaum, N., Enzel, Y. and Schick, A. 2002. Magnitude and frequency of palaeofloods and historical floods in the Arava basin, Negev Desert, Israel. Israel Journal of Earth Sciences, v. 50, p 159-186

PARTNER 3: Hydroisotop gmbH (HY), Germany

Responsible: Christoph Kuells (christoph.kuells@hydroweb.de)

Description of the participating organisation

Hydroisotop gmbH is an environmental isotope laboratory. The company has profound experience in the field of measurements and interpretation of isotope data and water quality data. During the last 20 years the company has focused on water research and specialised in the measurement and interpretation of natural isotope data in connection with chemical investigations to determine groundwater ages, to investigate groundwater resources and to define the origin of contaminants and pollution. Employing a total of 19 scientists, engineers and technicians in 2002, the *Hydroisotop gmbH* is a highly specialised company with continuously increasing activities in the following key areas with relevance to WADE:

Groundwater development & isotope investigations: Isotopes reveal the origin of groundwater, the age of groundwater and the flow patterns, the offer direct and effective monitoring of the groundwater system, its stability and its vulnerability towards pollution. *Hydroisotop gmbH* offers a wide range of analytical facilities, has broad experience and offers technical assistance and consulting in well defined and optimized monitoring and sampling strategies and in the interpretation of the water quality data in terms of their relevance for groundwater management.

Water Scarcity Management: Hydroisotop GmbH has worked as consultant in several semi-arid, sub-tropical and tropical countries, assisting in the assessment of water resources and concepts for their development.

Modelling and Data visualiation: Hydroisotop gmbH has developed and applied hydrologic models for groundwater recharge estimation, water demand estimation, groundwater response and has worked on integrated hydrologic decision support systems for regional water quality management.

Human Resources of Partner 3

Dr. Christoph Kuells is a hydrologist, holding a PhD in hydrogeology and has worked in international projects in Brazil (BMBF), Israel (GIF), southern Africa (Groundwater Recharge, German Science Foundation), Cyprus/Greece/Jordan/Israel (EC), Abu Dhabi. He is the national representative for the UNESCO FRIEND initiative on *'Large scale hydrological variations'*. He has worked for *Hydroisotop gmbH* since 2000 as a specialist for isotope investigations and hydrologic modelling. He is an expert in arid zone hydrology through his continuous hydrological work on different aspects of drylands: transmission losses in Israel (Kuells et al., 1994), groundwater recharge in Namibia (Kuells, 2003; Kuells et al. 1999) and water management of drylands in S. America (co-author of Voerkelius et al., 2003).

Dr. André Voropaes is a physicist with a specialisation in isotope analyses, including all the technical aspects of isotope measurements of deuterium, oxygen-18 and nitrate. André Voropaev developed a method to measure stable isotopes on chemical compounds. He is responsible for the measurements and quality control. He will be involved in the interpretation of isotope results from the different test catchments in in mathematical models to estimate residence times from the raw analytical results.

Peter Maier is a qualified laboratory technician at the isotope laboratory, responsible for the measurement of gases in water, tritium and for sampling methods. will be responsible for the preparation of sampling missions and sampling devices.

Recent and ongoing European Projects ITER (EVK4-CT-2001-30004)

Selected Publications

VOERKELIUS, S., **KUELLS, C.**, LÓPEZ GIL, M.M., ALVES SEMRAU, L. (2003): Investigations on Water Management and Water Quality in Picos/PI and Tauá/CE. In: Global Change and Regional Impacts – Water Availability and Vulnerability of Ecosystems and Society in the Semiarid Northeast of Brazil, Springer: 173-184

KUELLS, C. (2000): Groundwater of the North-Western Kalahari, Namibia. Dissert., Univ. Würzburg, also online: http://opus.bibliothek.uni-wuerzburg.de/opus/volltexte/2002/333/

KUELLS C., LEIBUNDGUT C. SCHWARZ U. & SCHICK A. (1994): Channel infiltration study using dye tracers. Application of Tracers in Arid Zone Hydrology. IAHS Publ., 232 (ed. by E. Adar & C. Leibundgut): 429-436

PARTNER 4: Desert Research Foundation of Namibia (DRFN)

Responsible: Mary Seely (mseely@drfn.org.na)

Description of the participating organisation

The Desert Research Foundation of Namibia (DRFN) has its origins in the Desert Ecological Research Unit (DERU) established in 1962 at what is now the Gobabeb Training and Research Centre in the central Namib Desert, Namibia. With a staff of approximately 35 persons, capacity building of young professional staff is a primary focus. The DRFN's overall goal is to contribute to enhancing decision-making at all levels for sustainable development of Namibia. To this end it works with a variety of stakeholders ranging from government institutions and extension services, to the University and Polytechnic of Namibia, to NGOs and CBOs, to commercial and communal farmers managing natural resources. It has a finance and administration department, a communications unit and a training and facilitation unit. The DRFN seconds two staff members to the Gobabeb Training and Research Centre where they serve as technicians for the long-term research programme and other activities based there.

The DRFN organises it programme under three primary areas with a variety of large and small donor-funded projects in each subject area. For example,
Sustainable land management: Namibia's Programme to Combat Desertification (on contract to the Ministry of Environment and Tourism (MET) with funding from GTZ); Desert Margins Programme (GEF: 1 of 7 African countries); Supporting environmental education in Namibia (Danida through Ibis); SADC-DRFN Desertification Interact (GTZ-CCD Project, funding for regional project); four year capacity building process and conference, Desertification 2002, with communities from three SADC countries; coordinator of NGO preparations and participation in Johannesburg Summit.
Sustainable water management: Decision Making in the Kuiseb River Catchment (EU support to National NGOs; basin management in collaboration with Ministry of Agriculture, Water & Rural Development); Water and Environmental Resources in Regional Development (1 of 6 partners in EU project focused on Okavango River); Secretariat of Country Water Partnership (under GWP, Sida); Summer Desertification Project (Sida-funded two-month research training course for tertiary students).
Sustainable energy management: Renewable energy and energy efficiency capacity building (Danida through Ministry of Mines and Energy); wrote proposal for and on Steering Committee for Demonstration at Gobabeb of renewable energy and energy efficiency (Danida through Ministry of Mines and Energy); partner representative of project on biomass energy conservation (GTZ funding) and secretariat of Biomass energy management programme for Ministry of Mines and Energy.

Human Resources of Partner 4

Dr M K Seely, PhD - 1965, U California, Davis. During 35 years of research and training co-supervised over 50 higher degrees in arid zone ecology and environment. Organised and contributed to training programmes for University and Polytechnic of Namibia and international educational groups. Since 1990, overall programme coordination for over 50 projects of DRFN. Overall professional coordination of environmental assessments for Environmental Evaluation Associates of Namibia (Pty) Ltd. Published over 160 papers and organised and/or contributed to over 20 books. Currently: executive director – DRFN.

Recent and ongoing European Projects

WERRD (ICA4-CT-2001-10040)

Selected Publications

Seely M.K. *et al.* 2003. Ephemeral and endoreic river systems: Relevance and management challenges. Pp 187-212. *In*: Turton A *et al.* (eds). Transboundary rivers, sovereignty and development: Hydropolitical drivers in the Okavango River basin. AWIRU & GCI. 369 pp.

PARTNER 5: University of Edinburgh, Centre of African Studies (UEDIN), Scotland, UK

Responsible: Richard F. Rohde, WP6 Leader (rick@rohde.fsbusiness.co.uk)

Description of the participating organisation

The Centre of African Studies, University of Edinburgh currently has 20 doctoral students working on Africa, as well as some 10 doing the masters programmes. We draw on expertise from approximately 100 staff, across the University of Edinburgh, concerned with Africanist research, teaching, policy work and consultancy.

Human Resources of Partner 5

- **Richard F. Rohde** (born 1950).
- 1994 Consultant to the Ministry of Lands, Resettlement and Rehabilitation, Government of Namibia
- Ph.D. Anthrology, (April 1997) University of Edinburgh, Scotland
- 1997-1998 Research Consultant, EU Inception Report for A Regional Assessment of the Situation of the San People in Southern Africa.
- 1999-2000 Research Associate, International Institute for Environment and Development (IIED) Edinburgh.
- 2000 Consultant to Edinburgh Resource Centre Ltd.: Project evaluation for UK Department for International Development (Civil Society).
- 1998 – 2003 Senior Researcher, Programme for Land and Agrarian Studies (PLAAS), School of Government, University of the Western Cape, South Africa.
- EXPERTISE: More than ten years experience of working in Namibia and South Africa, on a range of environmental projects relating to rural livelihoods, land reform and environmental history.

Recent and ongoing European Projects

- "Sustainable use of natural resources in rural systems of eastern Africa drylands (Ethiopia, Kenya, Tanzania), strategies for environmental rehabilitation". (Programme INCO, of the European Union, ERB3514PL961307).
- "Managerial and Policy Options for the Sustainable Development of Communal Rangelands and their Communities in Southern Africa" (MAPOASDA) (INCO-DEV: ICA4/CP/2000/50006)
- "Global Change and subsistence rangelands in Southern Africa" (INCO-DC: ERBIC 18CT970162)

Selected Publications

Rohde, R.F., M.T. Hoffman & N. Allsopp. (2003) Hanging on a wire – a historical and socio-economic study of Paulshoek village in the Leliefontein communal area of Namaqualand. *PLAAS Research Report* No 4. Programme for Land and Agrarian Studies, School of Government, University of the Western Cape.

Rohde, R. F. & T. Hilhorst. (2002) A profile of environmental change in the Lake Manyara Basin, Tanzania. *IIED Issues Paper* No. 109, Dryland Programme, International Institute for Environment and Development, London.

Sullivan, S & **R.F. Rohde** (2002) On non-equilibrium in arid and semi-arid grazing systems. *Journal of Biogeography* 29, 1-26.

Rohde, R.F., T.A Benjaminsen & M.T. Hoffman. (2002) Land reform in Namaqualand: poverty alleviation, stepping stones and 'economic units'. In T. Benjaminsen, B. Cousins & L. Thompson (eds.) *Contested Resources - challenges to the governance of natural resources in Southern Africa.* Cape Town: UWC.

Machado, M.J., A. Perez-Gonzalez, **R.F. Rohde** & A. Benito (2001) Land degradation and historical environmental changes: case studies of northern Ethiopia and northern Tanzania. Proceedings of the VI Reunión Nacional de Geomorfología - *Geomorphology for the Third Millenium and Society.* (Madrid, September 17-20, 2000).

PARTNER 6: University of Cape Town, Institute for Plant Conservation (IPC),

Responsible: Timm Hoffman (thoffman@botzoo.uct.ac.za)

Description of the participating organisation

The Leslie Hill Institute for Plant Conservation (LHIPC) was established in 1993 as a result of a generous endowment to the University of Cape Town made by Mr Leslie Hill. It is closely linked to the University of Cape Town's Botany Department where it is housed. Over the years its staff and students have produced a wide range of high quality research products, contributed significantly to the teaching responsibilities of the university and provided advice and research support to the broader environmental and conservation community. The Mission of the LHIPC is to develop human and institutional capacity through the pursuit of scientific knowledge about the biological functioning of and pressures facing the vegetation of the succulent karoo and fynbos biomes of South Africa so that people are able to make sound management decisions for the sustainable use, conservation and restoration of this unique asset. The vision for the LHIPC is to be a world-class, African-centred research and post-graduate training institute for plant conservation that improves the conservation status of the flora of the succulent karoo and fynbos biomes of South Africa and thereby contributes to the quality of life of the people living there. The focus of the LHIPC is clearly on the winter-rainfall region of South Africa. This broad geographic region contains the fynbos and succulent karoo biomes, two internationally-recognised hotspots of exceptional biological diversity and high levels of endemism. A sound knowledge of current and historical patterns and processes is essential for the prediction of the possible future impact of land use practices and climate change on the region. The core research effort of the institute is contained in five main research programmes: land use and sustainable development, environmental history, disturbance and restoration ecology, people and plants, invasive plant ecology and conservation planning. The activities of the LHIPC are well integrated with those of UCT's Department of Botany and other departments, institutes and organisations active in the field, both locally and internationally.

Further details of the LHIPC may be found at www.uct.ac.za/depts/ipc/

Human Resources of Partner 6

Timm Hoffman I completed my Phd in plant ecology in 1989 and after a post doc in the United States of America and 10 years with the National Botanical Institute I joined the Botany Department at the University of Cape Town as Director of the Leslie Hill Institute for Plant Conservation in 2001. My research interest has focused consistently on the impact of people on South African landscapes, particularly those of the semi-arid Karoo. I have a strong interest in environmental history. I teach several courses at postgraduate level which deal with community based natural resource management issues, particularly in arid lands. My work is concerned ultimately with the development of more sustainable land use practices in Namaqualand.

Recent and ongoing European Projects

INCO-DC :International Cooperation with Developing Countries (1994-1998; 2000-2004), Contract No. ERBIC18CT970162) since 1994. This work involves villagers and farmers from the communal area of Leliefontein in Namaqualand and is focused on the impact that land use practices have on the landscapes of the region.

Selected Publications

Rohde R.F., **Hoffman M.T**. & Allsopp N.A. 2003. Hanging on a wire: A historical and socio-economic study of Paulshoek village in the Communal Area of Leliefontein, Namaqualand. Occasional paper. Programme for Land and Agrarian Studies, University of the Western Cape. (In press).

Riginos C., **Hoffman M.T**. 2003. Changes in population biology of two succulent shrubs along a grazing gradient. Journal of Applied Ecology 40: 615-625.

Hoffman M T & Todd S W 2000. A national review of land degradation in South Africa: the influence of biophysical and socio-economic factors. Journal of Southern African Studies. 26(4): 743-758.

PARTNER 7: Institut National de la Recherche Scientifique (INRS), Canada

Responsible: Taha Ouarda (Taha_Ouarda@inrs-eau.uquebec.ca)

Description of the participanting organisation

INRS-Eau is a component centre of the National Institute for Scientific Research (INRS), a university research institute (part of the University of Quebec). Its primary objectives are to promote the development and expansion of research in the field of water resources and the environment, and to train researchers and experts capable of identifying, analysing, understanding representing and solving the problems posed both nationally and internationally in these fields.

INRS-Eau, a multidisciplinary research centre, conducts many scientific activities aimed at amassing the knowledge and developing the technologies needed to promote the rational and sustainable use of water resources and the environment. Mindful since its inception of the importance of creating and maintaining a critical mass of researchers in specific areas, the Centre has fostered the development of expertise in hydrology (statistical and deterministic), hydrological modelling, environmental chemistry and geochemistry, aquatic ecotoxicology, and wastewater treatment. INRS-Eau has a staff of approximately 125 people, consisting of 22 professors, 8 research officers and professionals, research associates, research assistants and support staff. Students and research trainees round out this team.

Human Resources of Partner 7

Taha B.M.J. Ouarda, Professor. Specialties: Statistical Hydrology, Water Resources Systems Analysis. Eduation: 1991 Doctor of Philosophy in Civil Engineering. Water Resources Systems Analysis Program. Colorado State University, Fort Collins, Colorado, USA 1991 - 1993. Postdoctoral Fellow. *Faculty of Sciences, School of Engineering.* University of Moncton, New-Brunswick, Canada. Reviewer for over 12 international journals. Member of the Technical and organising Committees of several international conferences amd seminars.

Recent and ongoing European Projects

"Systematic, palaeoflood and historical data for the improvement of flood risk estimation (SPHERE)". UE Environment and Climate (DGXII). EVG1-CT-1999-00010).

Selected Publications

Ouarda, T.B.M.J., Rasmussen, P.F., Haché, M., Bobée, B., Bruneau, P. and Fagherazzi, L. (1997). Analyse fréquentielle des apports naturels au lac Kénogami avec de l'information historique. INRS-Eau, rapport de recherche "*confidentiel*" n° R-496, 87 pages.

Ouarda, T.B.M.J., Rasmussen, P.F., Bobée, B. and Bernier, J. (1998). Use of historical information in hydrologic frequency analysis. Water Sciences Journal (in French), 10: 41-49.

Ouarda, T.B.M.J., Van Guelder, P., And Bobée, B. (1999). Classical and Bayesian hydrological frequency analysis with historic information. Canadian Water Resources Journal, (in preparation).

Rasmussen, P.F., Haché, M., **Ouarda, T.B.M.J.**, Bobée, B., Fagherazzi, L., Grygier, J. and Bruneau, P. (1997). Modélisation stochastique des apports journaliers au lac Kénogami. INRS-Eau, rapport de recherche "*confidentiel*" n° R-507, 96 pages.

PARTNER 8: Ben Gurion University (BGU), Israel

Responsible: Ofer Dahan (odahan@bgumail.bgu.ac.il)

Description of the participating organisation

Ben-Gurion University (BGU) is a major center for teaching and research, with over 17,000 students. The University is a world leader in arid zone research, offering its expertise to many developing countries while playing a key role in promoting industry, agriculture and education in the Negev, Israel. BGU has successfully participated in a wide array of both 4th and 5th Framework research projects – including the primary role of Project Coordinator.

Human Resources of Partner 8

Ofer Dahan (born 1961).

- Ph.D. Hydrology (1999), The Hebrew University of Jerusalem, Israel.
- Postdoctoral: Groundwater hydrology (1999-2001), The Desert Research Institute, Reno NV.
- 2001-Present: Lecturer and Research Staff Member, Ben Gurion University, Israel

Recent and Ongoing Projects

- Direct Measurement of Flood Water Percolation in Arid Lands: International Arid Land Consortium, $100,000, 2003.
- Direct Measurement of Flood Water Percolation and Groundwater Recharge of Alluvial Aquifers: Israel Science Foundation, $93,000, 2003.
- Evaluation of groundwater contamination by industrial activities on the coastal aquifer, central Israel. Funding Agency: Israel Water Commissioner.
- Land use impacts on groundwater recharge at the coastal plain of Israel.

Selected Publications

Dahan, O., Nativ, R., Adar, M. E. and Berkowitz, B., 1998: A measurement system to determine water flux and solute transport through fractures in the unsaturated zone. *Ground Water*, 36, no. 3: 444-449.

Dahan, O., Nativ, R. and Adar, M. E., 1999: Water percolation and solute transport through the vadose zone of fractured chalk under desert conditions. *Israel Agresearch,* Vol. 10, No.1-2, pp. 215-229 (In Hebrew with English abstract).

Dahan, O., Nativ, R., Adar, M. E. and Berkowitz, B., 1999: Field observation of flow in a fracture intersecting unsaturated chalk. *Water Resour. Res.*, 35, no.11:3315-3326.

Dahan, O., Nativ, R., Adar, M. E., Berkowitz, B. and Weisbrod, N., 2000: On fracture structure and preferential flow in unsaturated chalk. *Ground Water*, 38, no.3:444-451.

Dahan, O., Nativ, R., Adar, M. E. and Berkowitz, B., 2001: Water flow and solute transport in unsaturated fractured chalk. Flow and Transport Through Unsaturated Fractured Rock – 2nd ed, AGU, Geophysical Monograph Series: 42.

Dahan, O. and Zeev, R., 2001: Analytical procedure for simultaneous use of seven fluorobenzoates in multi-tracer test. *Ground Water*, 39: 366-370

Weisbrod, N., Dahan, O. and Adar, E.A., 2002: Particle transport in unsaturated fractured chalk under arid conditions. *Journal of Contaminant Hydrology*, 56:117-136

Dahan, O., McDonald, E. and Young, M, 2003: Development of A Flexible TDR Probe for Deep Vadose Zone Monitoring. *Vadose Zone Journal, 2:270-275*

PARTNER 9: Ministry of Agriculture, Water & Rural Development (MAWRD), Namibia

Responsible: Guido Langenhove (LangenhoveG@mawrd.gov.na)

Description of the participating organisation

The Namibian Ministry of Agriculture, Water and Rural Development comprises two Departments, Agriculture & Rural Development and Water Affairs. The Ministry of Agriculture, Water & Rural Development has two Directorates, viz. the Rural Water Supply and Resource Management, with five Divisions: Geohydrology, Hydrology, Law Administration, Planning and Water Environment.

The objectives of the Directorate : Resource Management are:

- To assist the Government in the overall management of the national water resources
- To remain the guardian over the water resources of Namibia
- To assume responsibility for an implement measure to ensure the protection and sustainable utilization of the water resources of the country.
- To control water abstraction and decide on the equitable allocation of water resources
- To be responsible for the regulation, planning and control of the water sector.

To fulfil these objectives, its main operations are:

- Collect, process, store, publish and supply water related data and information
- Investigate and assess the water potential of the country on a national and regional scale
- License the utilization of particular water resources and monitor compliance with conditions
- Advise the Minister on technical matters to give effect to the provisions of the Water Act
- Negotiate with neighbouring states to obtain access to shared water resources.

The Directorate: Resource Management has a post structure for 230 staff, of which 44 at professional level, mostly engineers and scientists. Its annual budget is in the order of EUR3,500,000.

Human Resources of Partner 9

Guido Van Langenhove has a degree in Civil Engineering, University of Leuven, Belgium, 1976. He worked there as research engineer, in hydraulics and hydrology, until 1981 when he joined the Department of Water Affairs, Namibia. He is now Head of the Hydrology Division which does hydrological information gathering and investigations.

In his career, Mr Van Langenhove has covered hydrometric monitoring, operational hydrology, computer modeling and water resources studies, including rainfall/runoff modeling, recharge studies, ephemeral water resources, IT management and basin stakeholders interaction. He was active in initiating new hydrometric monitoring techniques, such as electromagnetic sensors, tracers and isotopes for flow gaugings and satellite telemetry. His record contains more than 20 published scientific papers and presentations in the fields of hydraulics, hydrology and water resources.

Klaudia Schachtschneider (M.Sc. Environmental Science, University of Cape Town) has been employed as a Hydrologist in the Water Environment Division, Ministry of Agriculture, Water and Rural Development since February 1999.

Her scope of present duties broadly cover research and co-ordination in the fields of wetland ecology, water demand management and environmental flow requirements in ephemeral systems. Currently Ms Schachtschneider is planning research on subsurface water and riparian tree interactions in the Kuiseb River.

PARTNER 10 : Surplus People Project (SPP), South Africa

Responsible: Harry May (harry@spp.org.za)

Description of the participating organisation

The Surplus People Project (SPP) has been working as an NGO in the land reform sector for 16 years, first as a voluntary organisation and, from 1995, registered as a section 21 not-for-profit company. Our areas of operation are the Northern Cape and Western Cape Provinces, in particular the Namaqualand, Hantam Karoo and West Coast districts respectively. Our principle functions are: information dissemination, facilitating the acquisition, use and management of land for the poor and previously disadvantaged men and women; research; and contribution to land reform and rural development policy.

Human Resources of Partner 10

Harry May (born 1967).

- MA (Geography and Environmental Studies, 1999), University of the Western Cape, South Africa.
- 1994 – date: Started as principal at SPP and is currently the manager for the Namaqualand Program, Northern Cape. Has also been a Director and Deputy director of Surplus People Project.
- 2000-1 Harvard-South African Fellow: Kennedy School of Government (KSG)
- 1993-4 Human Sciences Research Council (HSRC) Progress Internship
- 1996 - International Course on Environmental Management (IHE, Holland)
- EC projects: has coordinated the joint EC/ Broederlijk Delen funded "Facilitation of land reform and community capacity building in the Namaqualand and Hantam-Karoo districts of the Northern Cape (South Africa)"- Zuid-Afrika F05 (58 45).
- EXPERTISE:- Natural resources management, community facilitation and policy studies.

Ronald Newman (born 1970)

- EXPERTISE: Community facilitation and commonage management.

Edith Newman (born 1974)

- National Diploma for Secretarial Office Administration (NDSOAD), 1996. Peninsula Technicon. South Africa.
- EXPERTISE: Administration

Recent and ongoing European Projects (ends in December 2003):

"Facilitation of land reform and community capacity building in the Namaqualand and Hantam-Karoo districts of the Northern Cape (South Africa)" Zuid-Afrika F05 (58 45).

Selected Publications

1) May ,H et al., 1997: 'Consultation report tot the rural areas committee: rural areas act (act 9 of 1987), Nothern Cape Province. Surplus People Project.
2) May H., 1997: Report on the current situation of stock farming in reserves, municipal areas (with commonage land) en areas with communal grazing in Namaqualand. Surplus People Project
3) May H and Pienaar J., 1997: The legal position with regard to dry land plots and related matters in the Act 9 areas of Namaqualand. Surplus People Project.
4) Power S and May H., 1999: 'Report on the 'Saailand' Pilot Study in the Rural Areas of Namaqualand. Surplus People Project.
5) May H., et al., 1999: 'Namaqualand District Planning and Management Project, Final Report'. Surplus People Project.
6) Power S. & May H., 'Northern Cape Department of Agriculture and Surplus People Project Extension Pilot Project (commonage committees)'. Surplus People Project.
7) May H., Hoffman MT and Marinus T., 1996: 'The case for the communally-managed reserves in semi-arid Namaqualand, South Africa. Paper presented at a workshop on Global Change and Subsistence Rangelands in Southern Africa, Gaberone, Botswana.
8) Power S., & May H.,1999: Report on the community facilitation and education project on municipal demarcation in the Act 9 areas of Namaqualand. Surplus People Project.

PARTNER 11: Kamiesberg Municipality (KM), South Africa

Responsible: Mr. F. Roodman (Municipal Manager)

Description of the participanting organisation

The Kamiesberg Municipality (KM), South Africa, is a local administration located in the Namaqua District Municipality. The population of Kamiesgerg is about 10,000 inhabitants, of which 3500 people are leaving in an urban area. The population, comprised of different ethnic groupings, is highly urbanized. Afrikaans is the language of choice. English and Xhosa are spoken to a lesser extent.

Most of the Namaqua District municipalities are authorised to perform the water and sanitation function in this district. The Kamiesberg Municipality supervises planning documents which proposes at a supra communal level the main middle and long-term prospects for the development of urban and rural areas. It allows a more rational management of the regional development and needs tools for a better monitoring of the town and country planning.

Human Resources of Partner 11

Mr. F. Roodmand is the Municipal Manager deals with the supervision on local aspects related to water resource management. Other members of the local management committee will be involved on spreading knowledge generated by the WADE Project at local and district levels.

PARTNER 12: Nama Khoi Municipality (NKM), South Africa

Responsible: Mr W Engelbrecht (Municipal Manager)

Description of the participanting organisation

The Nama Khoi Municipality (NKM), South Africa, is a local administration located in the Namaqua District Municipality. The population of Nama Khoi is about 54,000 inhabitants, of which 10,00 people are leaving in an urban area. The population, comprised of different ethnic groupings, is highly urbanized. Afrikaans is the language of choice. English and Xhosa are spoken to a lesser extent.

Most of the Namaqua District municipalities are authorised to perform the water and sanitation function in this district. The Nama Khoi Municipality supervises planning documents which proposes at a supra communal level the main middle and long-term prospects for the development of urban and rural areas. It allows a more rational management of the regional development and needs tools for a better monitoring of the town and country planning.

Human Resources of Partner 12

Mr. W. Engelbrecht is the Municipal Manager deals with the supervision on local aspects related to water resource management. Other members of the local management committee will be involved on spreading knowledge generated by the WADE Project at local and district levels.

A.2 Sub-contracting

In order to complete the project successfully, sub-contracting must be carried out within three research tasks: *Reconstructing long-term flood magnitude and chronology* (WP3), *Monitoring of surface and subsurface water* (WP4) and *Participatory water management* (WP7).

Within WP3 it is essential that an accurate chronology of past flood events is obtained. The standard technique for dating individual flood units is by radiocarbon dating organic material, such as charcoal, deposited within the flood sediments. Very few research departments have their own radiocarbon laboratories due to the dual expenses of developing such a laboratory and then contracting scientific and technical staff to run the laboratory. It is, therefore, standard practice to sub-contract radiocarbon dating out to well established radiocarbon laboratories, the results obtained from such laboratories being of a very high standard. Prices among European radiocarbon laboratories are similar. The partners 1 and 2 involved in this WP3 are used to work with the University of Zurich, Department of Geography, at a special price for EU-grants.

Within WP4, in order to monitor the sub-surface hydrology drilling must be undertaken. Drilling into alluvial river beds is a profession that does not exist in regular research institutes. To have such professional staff within a research organisation is a) expensive and b) they are never fully occupied. It is, therefore, normal practice in the hydrology community to hire drilling professionals in the field. This also has the advantage that the most appropriate equipment can be chosen. In our case the problem is even greater as the new methodology demands oblique drilling (not a vertical hole) and the resulting drill hole must remain open so that the monitoring instruments can be inserted. Our experience indicates that only very professional drillers can achieve this, therefore we must subcontract such a company.

Sub-contracting is also important in terms of borehole site selection. Within WP2, BIWAC, a Namibian Hydrogeological Expert Company specialised in hydrogeological consulting, will be sub-contracted to supervise this task. A key qualification for this company is their experience in carrying out geophysical investigations for the location of boreholes in the fractured domain and for the estimation of aquifer thickness. The company has introduced the use of geophysical methods for borehole siting. Due to their long experience in the field, including mapping, the company provides excellent expertise on the local geologic conditions. The company respects and applies the principals of equity for its enrolment.

Drilling works will be carried out by different companies in each country. The tender will be performed according to the national regulations in of the countries where the subcontracting will take place. The Contractor shall execute the tasks assigned to him in accordance with the Technical Specifications.

In WP7 for the tasks involving local community participation it is essential that Afrikaans speakers are sub-contracted to be able to successfully implement the research tasks. The work to be carried out in WP7 will be to evaluate the socio-economic importance of water resources from shallow alluvial aquifers for the population of the study basins and investigate environmental changes within the catchment areas in terms of water management, land use, government policies and climate change. The key issue

of the sustainable use of water resources by local communities will be addressed by engaging local stakeholders (local government, water service providers, village water management committees) in both the research and in a developmental process of institutional capacity building around water management. In terms of community participation the methodology will include workshops, interviews with key informants, participant observation and action research techniques in order to assess current water resource management practices and strategies. Associations & partnerships will be established between WADE, local communities and government officials in order to foster a sense of in-country ownership of the research. Participation will take place at various levels. To successfully complete the majority of these tasks, Afrikaans speakers must be sub-contracted. The tender will be done according to the South Africa national legislation.

A.3 Third parties

Nambia and **South Africa** are Third parties in the WADE Project. These countries are included in the list of groups of target countries for specific measures in support of International Cooperation. In particular, South Africa is negociating a specific agreement on Research with the EU (bi-lateral S&T component). In addition, **Canada** participates in this WADE project although his budget will be provided by the Canadian Goverment.

A.4 Funding of Third country participants

In the attached list, there is a summary of the institutions and organisations participating in the WADE project,

List of Third country Participants

Partic. Role*	Partic. no.	Participant name	Participant short name	Country	EC contribution
CR	4	Desert Research Foundation of Namibia	DRFN	NA	198478
CR	6	University of Cape Town	IPC	SA	182021
CR	7	Institut National de la Recherche Scientifique	INRS	CA	0
CR	9	Ministry of Agriculture, Water & Rural Development, Namibia	MAWRD	NA	46800
CR	10	Surplus People Project	SPP	SA	46506
CR	11	Kamiesberg Municipality	KM	SA	19267
CR	12	Nama Khoi Municipality	NKM	SA	19267

*CR = Contractor