

**WORLD METEOROLOGICAL ORGANIZATION**



**RA VI HYDROLOGY FORUM 2012**

**Koblenz, Germany, 8 – 10 May 2012**

**SUMMARY REPORT**

## **BACKGROUND**

Through formal and informal meetings with representatives of National Hydrological Services (NHSs) and other stakeholders in the water domain, the RA VI Working Group on Climate and Hydrology (WG-CH) and the WMO Secretariat have noted the need to discuss strategic and operational aspects of hydrological activities between NHSs and their main partners. Due to the pressures that the community is facing (e.g. new EU legislation, budget reductions, demands for improved services), this need for collaboration and joined planning is growing more and more important. .

RA VI Hydrology Forum is a new concept for regular meetings between the National Hydrological Services and their groups of interest. The first Hydrology Forum took place in Koblenz, Germany from 8 to 10 May 2012. This event was organized by the WMO Secretariat, the RA VI WG-CH, its Task Team Hydrometry, and the German Federal Institute for Hydrology that hosted the meeting.

Since it was decided that the main topic of the first forum's meeting was hydrological networks, the task team on Hydrometry of the RA VI WG-CH also participated to the organization.

The number of participants to the forum was about 60; they represented some 30 National Hydrological Services (out of 50) and several international organizations (See Annex I - List of participants).

The Hydrology Forum 2012 was focused on the design and operation of hydrological monitoring networks. The meeting was structured as follows:

1. NHS statements on the status of their hydrological networks and services (based on a web survey on RA VI hydrological monitoring networks and practices).
2. Stakeholder views of their needs for hydrological data and information.
3. Analyses on NHS strengths and gaps: what joint activities can be promoted by the Hydrology Forum?
4. Terms of Reference for the RA VI Hydrology Forum.

## **PART I: SYNTHESIS OF THE MONITORING SURVEY AND NHS STATEMENTS**

### **Short summary of the survey**

The web-based questionnaire has been elaborated by members of the Task Team on Hydrometry with support of the WMO Secretariat and the Swiss Federal Office of the Environment. Invitation to fill in the questionnaire was sent to all NMHSs in RA VI in March 2012. Questions were related to the objectives, structures, operation and costs of the hydrologic networks. 28 replies were returned (60% response). The main findings were:

- Most of the countries have a national hydrological service. More than half of these services are under the ministry of Environment, some under the Ministry of Agriculture, or are attached to Universities or other institutions or to another institution.
- The main tasks of the hydrological services include monitoring, hydrological forecasting, analyses and expert reports, and national coordination of hydrological activities. Some services have commercial activities.
- The subjects handled are very varied. All the measurement networks are multi objective (in order of importance: flood protection, hydrological forecasting, water scarcity and drought, climate-related issues, water quality, research, hydropower, water supply, design of water works, agriculture, navigation).
- The infrastructure and operating costs are difficult to estimate and half the services did not answer these questions. Given the heterogeneity of the networks, a synthesis is not very

informative. However, the issue of funding is crucial and must be discussed again in a later phase of the forum. A more detailed evaluation will also enable the costs per station to be derived.

- Development of network density has been generally stable, but more than 40% of networks are experiencing reductions of varying magnitude for the last 10 years. This is reflected in the funding trend, which is in decline in half the cases.
- The situation is more serious at the human resource level, with 70% of respondents indicating cuts in personnel over recent years.
- The majority of the networks are continuously optimised, but primarily on the basis of experience and the local conditions, with very little or no basis on statistical or optimisation methods.

## **Synthesis of the statements from NHSs**

All the national representatives present at the forum in May 2012 were asked to name one success factor, one issue that has caused failures and the most important expectation internally and internationally. The most notable and frequently mentioned points are listed below. Comments specific to one service are not referred to at this level.

### ***Successful achievements***

The successes mentioned can be grouped as follows:

#### **1. Improvement of hydrometric networks**

Improvement of measurement networks was mentioned 15 times as the most important success: Modernisation and extension of the hydrological network, renovation of technical equipment, automation of the monitoring network, remote data acquisition networks, multi-parameter monitoring and research stations, installation of mobile stations, network configuration (including regional-national), establishment of an information platform.

#### **2. Services to society**

The opportunity to serve society and national institutions with high quality hydrological products, and working in this way to protect people and property was stated at least 6 times. It was also highlighted that it is rewarding to receive very good feedback from administrations, industry and the public. The fact that the services are secured in a new national water law should also be mentioned (e.g., national adaptation of the Floods Directive).

#### **3. Flood forecasting and warning and other projects**

The receipt of resources for improved flood forecasting systems, services and warnings was mentioned several times. Generally speaking, the successful realisation of projects and guidance was mentioned several times. Preventing damage as a result of good forecasting was mentioned a couple of times.

#### **4. National and international cooperation**

Cooperation, coordination and working with very different partners to reach common goals are among the encouraging activities of the NHSs, at both the national and international level, particularly for transboundary relations and cooperation with EU projects such as EFAS.

## **5. Data management**

Several services also stated recent fruitful developments in relation to data management: real time transmission of measurements, new information systems, information strategy, standardisation of hydrological characteristics, new yearbooks, etc.

## **6. Optimisation**

Another encouraging point concerns savings realised by the installation of automatic field stations and developing related data processing, plus the ability to design clever ways of doing things to save people's time. It was mentioned twice that reorganisation of the service resulted in optimisation of the processes, as well as a clear separation between demand and supply.

## **7. Working atmosphere**

Last but not least, a very good and pleasant working atmosphere has also been emphasized.

### ***Recognised problems***

#### **1. Financial resources**

The reduced budget was identified as a major issue by at least 13 services, with consequences on personnel, projects and equipment. Deterioration of equipment (including vandalism), outdated technologies, incomplete river quality monitoring, and the inability to realise a master plan of hydrological stations were also mentioned. Lack of modern monitoring equipment and forecasting methods, including those relating to flash floods, is also a consequence. Even worse, savings realised by optimising the services have not been reinvested in hydrology.

#### **2. Human resources**

As a consequence of the above-mentioned lack of finances, human resources management was several times mentioned as frustrating. Scientific and technical qualifications of staff should be improved, but there is a lack of training, staff levels are being reduced and young hydrologists are leaving: personnel moral is reduced. The increasing complexity of new equipment is not always matched by the qualification levels of hydrologists.

#### **3. Political context**

Political, structural and management changes and decisions were made without professional argument or basis (mentioned twice). A lack of political awareness for operational activities was also highlighted, as well as the gap between identified social demand and the limited possibility to act. A particular point concerns the European Flood Alert System (EFAS), which apparently does not receive sufficient political support.

#### **4. Research and development**

Generally speaking, there are many administrative reforms to be implemented in parallel which can lead to project delays. Insufficient scientific and research activities were recorded, with implications e.g. in relation to appropriate software for data analysis and calculations, hydrological modeling or measurement technologies for torrents.

## **5. Data management**

In some countries, there are difficulties in relation to internal data exchanges and there is no geodatabase for hydrometeorological data. Furthermore, electronic databases are lacking and there is an urgent need to secure large amounts of hydrological data. A lack of integration of remote sensing information is also mentioned. A deficit in international and regional cooperation, especially for data exchange and sharing, has been identified. In some cases access to the NWP and now-casting products from neighbouring countries is a deficit.

## **6. Communication**

It was recognised that the inability to communicate with the general public with one voice slows down cooperation with different organisations and increases the risk of duplication.

### ***Expectations at national level***

#### **1. Data management**

The greatest expectation, concerns development of optimal data standards and implementation of more efficient data, acquisition, processing and dissemination – including real time distribution and free access to data - with modern data processing tools. In particular, there is the wish to improve mechanisms of data sharing/exchange within the country and between countries. It should be noted that this is especially true for meteorological data, which should be free of charge, of high quality and quickly validated.

#### **2. Flood management**

Creation of new flash flood forecasts, warning systems and capabilities, especially in relation to flash flood guidance, are equally important.

#### **3. Political recognition and organisation at the national level**

At least four NHSs mentioned the desire to draw the State's and government's attention to the national interest represented by strengthening the capacities of the NHS (including the availability of more resources - personal and financial), with a view to forming a unified view regarding the priorities of monitoring programs and meeting the social demand for assessment of water resources and of climate change impacts, river restoration or reconstruction of wetlands.. Implementation of a national water law was also mentioned. . Improving the national cooperation among various entities operating monitoring programmes at various administrative levels is also needed, especially in relation to natural hazards.

#### **4. Improvement of hydrological networks and data management**

At least 4 NHSs specified the need to extend and re-equip the hydrological observation network. Automation of observation networks, combination with remote sensing and improving telecom systems for real-time transmission were also mentioned, as well as the regular calibration of measurement instruments and the follow-on of achievements: database, data control and calculation of rating curves for the whole range of water levels as well as improving the quality of observation and measurements in general, including hydrological models. Budget savings should still permit adequate hydrological ground monitoring systems.

## **5. Research and capacity building**

The need to improve hydrological research was mentioned several times, especially concerning investigation of extreme events, flood vigilance and forecasting and operational systems, plus knowledge of the entire hydrological cycle. Capacity building is also a recurrent demand of the NHSs.

### ***Expectations at international level***

#### **1. Cooperation**

The highest expectation is in relation to institutional cooperation within the RA VI in order to ensure knowledge transfer and training within NHSs, which would lead to better services, higher scientific levels, standardisation of basic hydrological practices, analysis of hydrological processes and development of common methods.

Financial and technical assistance is required for the modernisation of the network and in relation to databases, data sharing and training, modern tools for telecom systems, preparedness against extreme events, flood forecasting and warning, and raising awareness regarding the importance of hydro-meteorological data and information. The possibility of further integration of networks was also presented as a way to explore in order to promote international collaboration and achieve more harmonized monitoring systems. There is a special desire to initiate, under the auspices of the WMO, a large-scale international hydrological project on assessing changes in water resources and the hydrological regime of large rivers in RA VI over the last 25-30 years.

It is expected that cross-border exchanges in particular will be optimised in domains such as hydrological modeling, mapping, information and forecasting, real time and validated data for transnational catchments, including groundwater.

#### **2. Access to data and information and standardisation**

There is a desire to enhance exchanges of observed and forecast data and to provide easy access to the weather forecasts of several European models. Standardised data exchange and improved general hydrological information is required. The possibility of having the hydrological network on Google Earth should be assessed. A simplification and unification of measurement and reporting processes under different legislative requirements is needed.

#### **3. Positioning of the hydrological community**

Several NHSs reported the necessity of better positioning the hydrological community in order to become a strong actor at policy, operational and scientific levels, thanks to networking within the WMO-NMHS family. Establishing an international legal framework for hydrological monitoring and hydrometry could also help.

#### **4. Relations with the EU**

Some NHSs are expecting a realistic assessment from the European Commission regarding the requirements of the WFD implementation process, especially concerning the directive on the assessment and management of flood risks. The Global Framework for Climate Services (GFCS) should be better supported.

## **PART II: NEEDS FOR HYDROLOGICAL DATA AND INFORMATION – STATEMENTS OF PARTNER ORGANIZATIONS**

Some important international organizations were invited to give their views on the need of hydrological data. These actors play an important role in hydrological monitoring network design as key clients of hydrological services.

### **RA VI Working Group on Climate and Hydrology – Expert Group Climate (Anahit Hovsepyan)**

Since the implementation of the new RA VI structure in 2009, the climate and hydrology experts have formed a joint working group that also has separate Expert Groups for the both communities. The work programme of the Expert Group on Climate is composed of five activities: (1) coordination of and support to the implementation of the RA VI network of Regional Climate Centres, (2) guidance and support to the implementation of the Regional Climate Outlook Forum mechanism in RA VI and beyond, (3) coordination of integrated drought management, (4) support to the data rescue efforts, and (5) evaluation of agro-meteorological services identification of new challenges/tasks for agrometeorological services.

A brief description was given on each activity, with short introduction to the concept of RCOFs and Climate Watch System, as well as MEDARE initiative. The Forum had a separate presentation on RAVI Regional Climate Centres Network. Expert Groups on Climate and Hydrology have close collaboration in drought related issues. The other four topics also have close links with hydrology, particularly Climate Watch System could be implemented to issue advisories on the possibility of spring floods. Hydrological data are highly important in many climate related studies and services. New synergy aspects between climate and hydrology will be taken into account in the next work programme (2014 – 2017).

### **European Environment Agency (Beate Werner)**

Historical hydrological data are needed for various EU level uses. River discharge data are especial important, and EEA supports the concept where these data sets could be supplied by GRDC. Discharge data are being used for EU overview assessments; contextualizing of CC adaptation, vulnerability, floods and water scarcity and drought policies; scoping applicability of policies; and piloting possible methodologies. Both daily and monthly observed average river discharge values are used for current applications within EU. EEA would appreciate if the mandate of GRDC could be extended for the sharing of data for research and policy assessments by EU institutions. This could be developed as a specific module under the water information system for Europe (WISE) as a principle exchange platform, however respecting all aspects of WMO resolution 25.

The European Environment Agency (EEA) has been developing water accounts; they are important as basic records and in many applications (e.g. 2012 Blueprint to safeguard UE waters; water stress and vulnerability). EEA has adapted the approach to sub-basin and monthly assessment of water accounts. EEA has also re-analyzed and processes data sets for better consistency, and it aims at linking the water accounts with ecosystem services in a future.

### **Global Runoff Data Centre (<http://grdc.bafg.de> / Ulrich Looser)**

The Global Runoff Data Centre (GRDC) is the world-wide repository for river discharge data and associated metadata. It operates under the auspices of WMO on the advice of an International Steering Committee. GRDC gets financial support from the Federal Republic of Germany and its offices are located at the Federal Institute of Hydrology. GRDC supports many climate related

programmes and projects of the UN and its services are used widely by the international scientific community.

The GRDC aims at increasing volumes of river discharge time series data updates at regular frequencies. Consolidated data requests will include all GRDC requirements and provision of all data will be carried out under WMO Resolution 25 conditions. GRDC is working towards the standardisation of hydrological data to improve data exchange.

### **European Flood Awareness System (Peter Salamon)**

The European Flood Awareness System (EFAS) aims at offering added value for NHSs by its services and operationally targeted research, and developing novel products for European civil protection. The Pan-European concept of EFAS is supporting EU CC strategy and implementation of the Water Framework Directive and other water related directives. Currently the near real time data collection of EFAS includes some 6,000 meteorological stations, but the number of hydrological stations is still small and unevenly distributed.

Collection of hydrological data has faced many problems. Station metadata are often incomplete, and in general, it is difficult to contact data providers. Values of discharge are based on several different ways of producing and using raw data; EFAS has recognized 22 different "methods" for defining river discharge values! Moreover, each data provider has different ways of transmitting data, and this requires specific data parsers. Currently EFAS has some 25 providers of near real-time hydrological data.

### **Commission for the Hydrology of river Rhine (CHR) (Johannes Cullman)**

The Commission for the Hydrology of River Rhine (CHR) is a union of scientific institutes of the Rhine riparian states. It fosters developing joint hydrological research for sustainable development of the Rhine basin.

The CHR was founded in 1970 following advice by UNESCO to promote closer co-operation in international river basins. Since 1975, the work has been continued within the framework of the International Hydrological Programme (IHP) of the UNESCO and the Operational Hydrological Programme (OHP) of the WMO. The member states of the CHR are: Switzerland, Austria, Germany, France, Luxembourg and the Netherlands.

Core tasks of CHR as per its statutes are:

- joint research
- exchange of data, methods and information
- development of standardized procedures
- publications and communication

Solutions for cross-border problems are being sought after through the formulation, management and provision of:

- information systems, e.g. GIS for hydrological practice
- Models, e.g. models for water management, alarm models etc.

The CHR is core funded through membership fees. With this contribution the CHR is able to operate a standing secretariat. This guarantees continuity of the programme and supports communication with all stakeholders.

Further inquiries can be made with the Secretary of CHR, Eric Sprokkereef: via email: [eric.sprokkereef@rws.nl](mailto:eric.sprokkereef@rws.nl)



### **International Sava River Basin Commission ([www.savacommission.org](http://www.savacommission.org) / Dejan Komatina)**

Sava is the largest tributary of Danube; the basin is shared by six countries and its contribution to the Danube river discharge is some 25%. The ISRBC was established in 2005 to coordinate the transboundary cooperation for sustainable development of the region, and the particular objectives of the agreement are to support navigation, water management and management of hazards. The basin is developing a joint flood risk management plan and establishing integrated systems, e.g. for meteorological and hydrological data exchange, and flood forecasting and warning. The ISRBC expert group for meteorological and hydrological issues provides permanent links with the NMHSs of the basin countries.

The ISRBC, in cooperation with the NMHSs, produces hydrological yearbooks of the Sava river basin. The hydro-meteorological data exchange system includes 4 hydrological and 5 meteorological parameters from 41 hydrological and 45 meteorological stations. Different frequency of data provided by national databases is a shortcoming. Hydrologic and hydraulic models have been developed for the basin. A water and climate adaptation plan for the Sava river basin is also being developed. Among planned activities are the establishment of a flood/drought forecasting and warning system, and the development of a hydrological study of the Sava basin.

### **Regional Climate Centres ([rcc.cm@dwd.de](mailto:rcc.cm@dwd.de) / Stefan Rösner)**

Regional Climate Centres are centres of excellence that assist WMO members to deliver better climate services and products. Meteorological and hydrological services in all 50 member countries of RA VI are potential contributors and users of RCC services. RA VI is operating a pilot RCC network that has three components: Climate Data, Climate Monitoring, and Long-range Forecasting. RCC on Climate Data offers various data sets – both station and gridded data. Among the main products of RCC are maps, anomalies, trends, reports, and significant weather event database. RCC on Long-range Forecasting provides seasonal forecast bulletins, and maps and graphs on model performance. RA VI RCC network has started work on hydrological seasonal forecasts.

### **UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE Water)**

UNECE Water was not able to attend the Forum. However, it had delivered a statement on the role of hydrological data and information. The Second Assessment of Transboundary Rivers, Lakes and Groundwaters that has been published by UNECE Water in 2012, is a comprehensive overview of the status of transboundary waters in the pan-European region. The Second Assessment presents a broad analysis of transboundary water resources, pressure factors, quantity and quality status, and transboundary impacts, as well as responses and future trends (including predicted impacts of climate change). The Assessment highlighted a number of issues related to availability of and access to hydrological information in a transboundary context.

Availability of hydrological information consistently at the level of a river basin as the management unit - also a transboundary basin - is necessary for sound management. In most transboundary basins information exchange still very weak and information produced in riparian countries is not harmonized. Harmonization of approaches remains a challenge. Joint monitoring and assessment almost do not exist in many transboundary basins of the region, while such cooperation would foster a common understanding about the water availability and variability, and create a good basis for developing commonly agreed objectives for planning. Cooperation with the WMO and the national hydrometeorological services in the future assessments is very much hoped for.

### **PART III: STRENGTHS, GAPS AND NEW JOINT ACTIVITIES**

Based on the NHS statements and stakeholder addresses, the Forum assessed at general level strengths and gaps in hydrological data production and services. Five working groups identified important strengths and shortcomings that are common in the region. The working groups (that were composed mainly of NHS experts) also proposed regional priority activities that the Hydrology Forum would like to convey to NHSs.

After the group work, the Forum discussed proposed priority issues and decided to develop some selected topics into concrete actions. During the first phase, the following categories of activity were outlined:

- Technical issues
- Standards
- Data sharing and policies
- Networking
- Capacity development
- Institutional issues
- Political backing and visibility.

During the second round, the following concrete activities and their coordinators were selected.  
Group I – support to the RA VI Hydrometry Task Team:

- operational maintenance procedures of networks, synthesis of security regulations (coordinator: Vasko Stojov, Macedonia)
- inventory of monitoring needs; network optimization and strategic planning (Dominique Bérod, Switzerland)
- case studies on network design practices (Elise Trondsen, Norway)
- harmonization of methodologies, quality control and access to data (Harry Dixon, UK)

Group II – other activities:

- positioning of the RA VI hydrological community in respect to decision makers and other expert and science communities (Markku Puupponen, Finland)
- providing an overview on how actual challenges are addressed (Ann Calver, UK)
- identifying national focal points (Tommaso Abrate, WMO Secretariat)
- data needs analysis - synthesis of national and regional requirements (medium term) (Mary-Jeanne Adler, Romania)
- improving formalized data sharing procedures with regard to data centres; simplify data exchange for day to day operational requirements of NHSs (Ulrich Looser, Germany)
- joint resource mobilization for enhancing cooperation in the region (Johannes Cullmann, Germany)

The Forum agreed that the coordinators are free to decide on the organization of their activity. The participants of the Forum and RA VI NHSs are expected to give full support to the coordinators. The coordinators will prepare brief activity plans that will be uploaded on the Hydrology Forum web page.

The duration of the activities is two years, till the tentative date of the 2<sup>nd</sup> Hydrology Forum. WMO Secretariat and RA VI Working Group on Climate and Hydrology will consult the coordinators in more detail about the tasks and their management.

## **PART IV: TERMS OF REFERENCE FOR THE RA VI HYDROLOGY FORUM**

The Forum assessed draft Terms of Reference and proposed several changes to the text. As a result, the following version of was accepted for the final check of the WMO Secretariat:

Terms of Reference for the RA VI Hydrology Forum.

To provide a platform where all the issues and challenges related to the operation of hydrological networks and services can be discussed among interested professionals and other stakeholders, the WG-CH has proposed to set up a Hydrology Forum for members of WMO RA VI, with the following Terms of Reference:

1. To develop a common strategy in RA VI for the sustainability, design and harmonization of regional hydrological monitoring and data networks and other hydrological services.
2. To act as a platform for capacity building, exchanging good practices and technical solutions and promote approaches that will improve the cost-efficiency of hydrological services.
3. To strengthen the networking amongst RA VI NHSs in the field of hydrology including through joint projects and activities.
4. To promote and facilitate the cross-border exchange of hydrological information and practices in the spirit of WMO Res. 25 (Cg-13).
5. To facilitate development of coordinated positions on improving hydrological services in support of social, economic and environmental needs, such as security, health, water management and climate adaptation in complementarity with and support to relevant WMO programmes.
6. To provide advice to the WG-CH in identifying possible contributions of RA VI NMHSs to WMO programs, in particular the Hydrology and Water Resources Programme, and to liaise with the Commission for Hydrology (CHy) with respect to synergies in work programmes.
7. To develop proposals on hydrological contributions to global, regional and national water and climate activities (WMO Integrated Global Observation System (WIGOS), WMO Information System (WIS), Global Framework for Climate Services (GFCS), Regional Climate Centres (RCCs), Regional Climate Outlook Forums (RCOFs), Climate Watches) and provide inputs in the development of the GFCS User Interface concept.
8. To discuss issues and challenges related to the implementation of EU directives and their implications for non EU members.

The RA VI Hydrology Forum is an informal entity, but it will be strongly linked with the work of RA VI WG-CH, as well as the regional operational hydrology on a larger scale. The Hydrology Forum will operate through a series of meetings/events, an e-forum and related consultation between WMO Secretariat, CHy, RA VI WG-CH and NHSs.

Primarily the RA VI Hydrology Forum is targeted to the National Hydrological Services of the region. As the forum aims at improved dialogue within the water and related sectors on national and regional scales, other experts and groups of interest will also be invited, depending on the themes of future events.

Provisionally it is proposed to organize an RA VI Hydrology Forum event at least every two years.

## **CONCLUSIONS**

The creation of the European Hydrology Forum as support for the national services has received a large commitment from the NHS. The first WMO RA VI Hydrology Forum was able to highlight some common problem areas which could be resolved by combining the strengths of the region's NHSs. There is a need to guarantee good hydrological services to the society: data, forecast and other products, and to enhance the national and international cooperation. However, NHSs are confronted to human and financial shortages that handicap the quality of the services and the modernization of the tools

Actual and potential users of hydrological services emphasized the need of historical river discharge data for water policies and the necessity to promote and operate common tools such as GRDC or EFAS. International, and especially cross-border collaboration is absolutely necessary.

Following the discussion of its role and function at the meeting in May 2012, the Hydrology Forum should make an important contribution to achieving this. The outline of the action plan and the subject responsibilities was also discussed. This is a process which has to be firmed up over time and which aims to provide mutual support within the RA VI hydrological community, to develop joint actions and in general to respond to the needs of the WMO. Priority will be dedicated to operational maintenance procedures of networks, inventory of monitoring needs; network optimization, case studies on network design practices and harmonization of methodologies, quality control and access to data. Cooperation and positioning of the RA VI hydrological community in respect to partners will also be addressed.

Based on this, terms of references of the Forum have been defined. Main points include common strategy for hydrological monitoring, building of a platform for capacity building, networking amongst NHSs and cross-border exchanges of information. The Forum should accordingly help to maintain the hydrometric networks and to improve hydrological services.