Postgraduate education in hydrology

by

P. Kovar and W.H. Gilbrich

A state-of-the-art report

International Hydrological Programme
United Nations Educational, Scientific and Cultural Organization

UNESCO
Paris, 1995
INTERNATIONAL HYDROLOGICAL PROGRAMME

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IHP-IV Project E-3.1

UNESCO, Paris, 1995

SC.95/WS.7
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Abstract

The report describes the aims and objectives of postgraduate education in hydrology and water resources.

It analyses the development of postgraduate education over the past thirty years and the relationship between undergraduate university education and postgraduate training, followed by an evaluation of the present situation.

Postgraduate education is in rapid development and the report tries to develop ideas concerning future trends with regard to both the contents and forms of postgraduate education. The report also deals with course evaluations and with the value of postgraduate training such as expressed in the diploma that may be obtained.

In order to assist planners and organizers of courses an attempt has been made to discuss the problems encountered with the manpower market.
Preface

Although the total amount of water on Earth is generally assumed to have remained virtually constant during recorded history, periods of flood and drought have challenged the intellect of man to have the capacity to control the water resources available to him. Currently, the rapid growth of population, together with the extension of irrigated agriculture and industrial development, are stressing the quantity and quality aspects of the natural system. Because of the increasing problems, man has begun to realize that he can no longer follow a “use and discard” philosophy -- either with water resources or any other natural resource. As a result, the need for a consistent policy of rational management of water resources has become evident.

Rational water management, however, should be founded upon a thorough understanding of water availability and movement. Thus, as a contribution to the solution of the world’s water problems, UNESCO, in 1965, began the first worldwide programme of studies of the hydrological cycle -- the International Hydrological Decade (IHD). The research programme was complemented by a major effort in the field of hydrological education and training. The activities undertaken during the Decade proved to be of great interest and value to Member States. By the end of that period a majority of UNESCO’s Member States had formed IHD National Committees to carry out the relevant national activities and to participate in regional and international co-operation within the IHD programme. The knowledge of the world’s water resources as an independent professional option and facilities for the training of hydrologists had been developed.

Conscious of the need to expand upon the efforts initiated during the International Hydrological Decade, and, following the recommendations of Member States, UNESCO, in 1975, launched a new long-term intergovernmental programme, the International Hydrological Programme (IHP), to follow the Decade.

Although the IHP is basically a scientific and educational programme, UNESCO has been aware from the beginning of a need to direct its activities toward the practical solutions of the world’s very real water resources problems. Accordingly, and in line with the recommendations of the 1977 United Nations Water Conference, the objectives of the International Hydrological Programme have been gradually expanded in order to cover not only hydrological processes considered in interrelationship with the environment and human activities, but also the scientific aspects of multi-purpose utilization and conservation of water resources to meet the needs of economic and social development. Thus, while maintaining IHP’s scientific concept, the objectives have shifted perceptibly towards a multi-disciplinary approach to the assessment, planning, and rational management of water resources.

As part of UNESCO’s contribution to the objectives of the IHP, two publication series are issued: Studies and Reports in Hydrology and Technical Papers in Hydrology. In addition to these publications, and in order to expedite exchange of information, some works are issued in the form of Technical Documents.
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INTRODUCTION

At the beginning of the sixties, the United Nations World Plan of Action for the Application of Science and Technology to Development emphasized the urgent need for scientific manpower. A contribution towards the training of such manpower is UNESCO’s general programme of postgraduate courses, initiated in 1962, which received wide support from Member States.

In the field of hydrology, UNESCO based its programme on recommendations of the Intergovernmental Meeting of Experts in Hydrology, Paris, April 1964, to inquire into the needs and existing facilities for training hydrologists in Member States, and to identify the extent to which each country could render assistance to other countries.

At its first session in 1965, the Coordinating Council of the International Hydrological Decade invited (Resolution I-62) Member States to indicate the kinds of training assistance that they could supply, and in particular the number of fellowships they were willing to reserve for hydrology students primarily from developing countries.

UNESCO then sponsored a number of existing postgraduate courses and, in view of the increasing needs for training activities, encouraged a number of new courses to be established under UNESCO’s sponsorship. In order to better appreciate the current situation, it is worthwhile to briefly review the history of these hydrology postgraduate courses.

In 1957, the Netherlands Government established an international postgraduate course in Hydraulic Engineering in Delft which functions under the auspices of The Netherlands Universities Foundation for International Cooperation (NUFFIC). Starting in 1963, UNESCO regularly concluded special contracts, allocating funds for the training of students from developing countries through participation in the course on hydraulic engineering. From 1966/67 onwards, this course offered a special option in hydrology. A separate hydrology course was started in 1966/67 and has been held annually since then having a duration of eleven months since 1973, the regular courses held in Delft have included hydraulic engineering, sanitary engineering, environmental science and technology, inland water transportation and hydrology.

In 1966, four new hydrology courses were established, each of six months’ duration. Budapest offered a course on hydrological methods for developing water resources management, Madrid on general and applied hydrology (in Spanish), Padova on general hydrology (with courses in either English or French) and Prague on hydrological data for water resources planning (in English). These international courses formed the nucleus of the UNESCO-sponsored postgraduate hydrological courses.

The first extension took place in 1972. With a view to strengthening training activities in developing areas and to transferring educational activities to such areas, UNESCO initiated the opening of an international postgraduate course at the University of Roorkee, India, on surface and sub-surface hydrology. This course has a duration of eleven months.

The above listed long- and medium-term courses cover general hydrology and subsurface hydrology and can be classified as postgraduate hydrological training which supplements basic studies such as civil engineering, etc. However, the need for more specialized courses
and for short-term refresher courses became apparent. Such specialized courses were held in Austria, Israel and Sweden. Short-term courses and summer schools were organized in the Netherlands, USA and USSR, and are briefly described below. At the time, these courses were innovations and have partially evolved into permanent UNESCO-sponsored courses.

In 1967 and 1970, the University of Stockholm organized three-week training courses on glacier mass budget, heat budget and runoff studies in glacial regions in Tarfala.

In 1969, the University of Graz, Austria, began to organize biannually one-month course on ground water tracing techniques.

In 1969, the Directorate of the International Courses in Hydraulic and Sanitary Engineering in Delft, the Netherlands, organized a one-month summer school for hydrology professors. Also in 1969 a series of summer schools were initiated in the United States of America as well as in the USSR (Moscow Lomonosov University) with subjects and themes changing annually. Three months’ courses on water resources management, with special emphasis on ground water exploration, were held in Haifa and Jerusalem, Israel from 1970 to 1973.

Of the twenty one courses started up only two have been discontinued by the end of the 1980’s. The list of current courses shows a much improved topical and geographical coverage since the end of the last decade. One problem emerges as being more and more important. For much of the decade, UNESCO was able to cover a large part of the costs of the courses as far as the travel of students from developing countries was concerned. At the end of the reporting period, UNESCO’s contribution had been considerably reduced, partially due to the increased number of courses, but also due to the increasing budgetary constraints on the Organization. Subsequently, the host countries had to increase their share of costs and it became evident that developing countries were not in a position to start new courses unless they had long-term commitments of assistance from industrialized countries.

The average number of participants was between fifteen and fifty per course; since some of the courses have been held only biannually, the total average number of postgraduate trainees can be estimated at about 400 per year.

During the third phase of the IHP, further courses were established or already existing ones were incorporated into the network. However, a number of problems continued to remain unresolved. Apart from the problems of UNESCO funding referred to above, without long-term commitments from industrialized countries, some courses in poorer countries will find it increasingly difficult to maintain a reasonable output or even to survive. Another serious problem is that of coordination. For financial reasons, no meeting of course directors could be held.

Although all courses award a diploma or degree at the end of the course, or at least a certificate of attendance, many of these documents lack world-wide acknowledgement as a career aid. As a positive development, UNESCO has noted the increasing interest of non-governmental organizations in hydrological education as well as the growing number of bilateral arrangements for such education between industrialized and developing countries. It is now being recognized that training and education is a particularly efficient form of development aid and the transfer of knowledge and technology has become an integral part of many aid schemes.
From this historical introduction [GILBRICH, 1992], it can be concluded that the UNESCO-sponsored postgraduate courses in hydrology were established some twenty-five years ago and that the network of courses has since expanded considerably. Despite such progress, however, the above mentioned deficiencies remain, including a lack of coherence and other such problems with the programme which the 1990 Session of the Intergovernmental Council of IHP-UNESCO took into consideration (ANNEX 1). Nevertheless, the general trends in the development of postgraduate training in hydrology were approved with regard to the main aims and the corresponding activities, as listed below.

Besides promoting programmes for the training of hydrology technicians, improving hydrology courses at university level and providing guidance for continuing education for the education of general public, for students and for planners and decision makers, the fourth phase of the IHP (1990 - 1995) made particular provisions for postgraduate education in hydrology. IHP Project E-3.1 has the following aims:

- To improve the system of UNESCO-sponsored postgraduate hydrology courses, on the basis of an evaluation report prepared during the third phase of IHP.
- To share experiences and improve cooperation among existing UNESCO-sponsored courses.
- To create better information networks on new developments in hydrological education and training.
- To include environmental aspects in existing teaching programmes.
- To assist in making cooperative arrangements including the exchange of teachers.
- To assist in the modification of curricula and in the establishment of new courses.
- To enable greater participation of developing countries in holding courses.
- To adapt the courses to the needs of the year 2000.
- To organize a Workshop of directors of the UNESCO-sponsored postgraduate hydrology courses.

Objectives of this Report

The above aims which offer some opportunities for communication between the courses in order to improve the current situation, are now to be implemented. To this end, it was considered beneficial to convene a Workshop in which course directors and professors could participate, along with a number of other high level hydrologists, so as to have sitting together trainers and users of the courses, i.e. those engaged in research, administration and consulting. The main objective of this report, is to assess the current situation of the existing UNESCO-sponsored postgraduate courses and to gather ideas on how to make these courses more effective.

The first step, in November 1990, was the development of a tentative agenda for the 1994 Workshop. The main task of the preliminary work was an evaluation of the present system of courses with suggestions to increase its effectiveness. To prepare such an evaluation, all the
National Committees for IHP, as well as the directors of some postgraduate UNESCO-sponsored courses, were invited by the UNESCO Secretariat for their philosophy and comments on the following points:

- Current and future structures of postgraduate hydrology courses, definition of the term “postgraduate”, appropriate levels of instruction, appropriate languages of instruction, special forms of education required.
- Manpower market analysis
  - subjects desired by students
  - expectations of students
  - expectations of employers (knowledge, degree, skills, etc.)
  - need for qualified personnel
- Curricula and syllabi development for the year 2000
  (new subjects, deepening of existing ones, optional subjects elimination or amalgamation of subjects)
- Requirements for diploma and their international recognition
- Guidelines for the organization of courses:
  - short-term (less than 3 months)
  - medium-term (less than 6 months)
  - long-term (over 1 academic year)
  - optimal set-up of a course for diploma/degree recognition
- Methodologies for course evaluation

There were only few detailed replies. Some were incomplete but others contained interesting general ideas which could be used as a starting point for the authors to prepare this Report. There were some valuable suggestions and/or comments in the material of respondents regarding the individual tasks listed above. These ideas were utilized when compiling the first version of the Report, later to become the Key Paper of the Workshop on Postgraduate Hydrology Education. P. Kovar (Czech Republic) volunteered as Rapporteur. That version was discussed during the Rapporteur’s mission in June 1991 with the course directors or teachers J. E. Nash and K. M. O’Connor (both Galway), W. A. Segeren and M. Shahin (both Delft), A. Van der Beken (Brussels), A. Musy and D. Devred (both Lausanne) and later with H. Zojer (Graz) and P. Efremov (Moscow). Due to lack of funds, there was no follow-up working group recruited and the subsequent exchange of material and discussions took place mostly by correspondence. The report is a joint effort of Prof. P. Kovar (Czech Republic) and W. H. Gilbrich from UNESCO. The authors are much indebted to Dr. K. O’Connor (Ireland) for his review.

The main aim of these discussions was to find a way to improve the existing system of UNESCO-sponsored courses. In these discussions, it was pointed out that this can be done mainly by implementing the following tasks:

- to improve the cooperation among the existing courses by creating a better information network on new developments in hydrological training and education
- to up-date and to modernize the course curricula and syllabi
to promote deeper specialization of some of the UNESCO-sponsored courses

to develop better criteria for the selection of candidates for postgraduate courses

to introduce more environmentally-oriented subjects into the course programmes

The general strategy for the development of postgraduate training is a complex problem, the solution for which is not unique. During the last decade, the development of education and training at various levels in the field of hydrology was based on manpower needs data collected in the second half of ‘70s, with some predictions for the year 2000 [AYIBOTELE et al., 1988 from FAO and WMO sources]. It is now necessary to update these data for future developments of the postgraduate system of courses.

The formulation of a new course structure can hardly be done without detailed knowledge of manpower needs and the facilities for meeting them in individual countries, of the extent of water-related problems in various geographical locations and of new trends in the development of hydrology (both the scientific and technological aspects), etc. UNESCO and other international organizations (WMO, FAO, IAHS, and others) should cooperate in exchanging new information about these areas.

In spite of the fact that there are quite a number of UNESCO courses currently in operation, the need for hydrological education has not decreased. It has, in fact, risen because of the further growth of water consumption and of the development of water economy in the world, particularly in developing countries. Therefore, to better satisfy the needs of postgraduate hydrological education in a more efficient and a more comprehensive way, the exchange of experience between the directorates of courses from different countries and regions and also the coordination of the activities of these courses are essential.

It is evident that because of the different economic, social and political conditions in various regions of the world, different tasks and problems arise when courses are organized, regardless whether sponsored by UNESCO or not. Nevertheless, a number of universal problems exists, common to all regions and all nations. These need urgent consideration and coordination. Thus, the Workshop held in Prague (Czech Republic) from 29 to 31 August 1994 within the framework of the project IHP-IV E-3.1 on Postgraduate Education in Hydrology, was considered to be very important and timely and the Workshop lead to an improved version of the Key paper refered to above what now is presented in form of this state-of-the-art report.
1. ASSESSMENT OF THE PRESENT STATUS OF POSTGRADUATE EDUCATION

1.1 University study as a prerequisite for postgraduate studies

The development of scientific hydrology has undoubtedly had repercussions on university study programmes, and thus the scientific progress is one factor influencing a university curriculum. The other is the requirement of the potential employer. Therefore, an undergraduate university programme, in contrast to Ph.D. studies, always will be a balanced compromise between scientific and practice-oriented aspects, supplemented by management and working skills, reporting techniques and awareness of socio-economic and ethical problems. It should not be overlooked that the majority of such students are educated for technical and administrative jobs. A good university programme will find a sound balance between theoretical instruction and field/laboratory work, thus establishing academic understanding and the necessary contact with practical problems.

In general, university education in hydrology has not been directed towards highly specialized undergraduate study. Depending on the aim of the study programme and on the intensity of hydrological instruction, the following breakdown of study periods can be observed, as illustrated in Fig. 1. The numbers of years indicated in Fig. 1 refers only to the university education and one has to add some twelve or more years of primary and secondary education to arrive at the total time spent by the trainee prior to graduation.

<table>
<thead>
<tr>
<th>Study period</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>c</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>Basic studies</td>
</tr>
<tr>
<td>General studies with specialization</td>
</tr>
<tr>
<td>Specialized studies</td>
</tr>
<tr>
<td>Postgraduate studies</td>
</tr>
</tbody>
</table>

0 2 3 4-5 and more years

Undergraduate level

<table>
<thead>
<tr>
<th>D.E.U.G.</th>
<th>B. SC.</th>
<th>M. SC.</th>
<th>Postgraduate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vordiplom</td>
<td>Licence</td>
<td>Maitrise</td>
<td>Diploma, event. Ph. D., Doctorate</td>
</tr>
</tbody>
</table>

Figure 1: Educational Career

The concept presented in Fig. 1 has been proposed by the working group of the UNESCO Project E-2.1 “University Education in Hydrology” and it considers the following options:

1. Studying the basic courses, possibly with one or two optional advanced courses, in a programme leading to a degree in engineering, geography, etc. (Study periods A and B).
2. Taking hydrology as a major option in an undergraduate or in a postgraduate programme of studies. (Study periods A, B, and C).

3. Participation in a postgraduate training as a professional hydrologist. (Study period D).

It is evident that the configuration in Fig. 1 can serve only for a general approach as there are considerable variations all over the world. These variations grow in number because of different understanding of the term “postgraduate” as will be discussed later. The level at which hydrology is taught and the aims of this teaching are very varied. The extent of this variety basically depends on the system of education prevalent in the country of location. There are three main educational activities in hydrology available at the university level:

(a) Hydrology as an auxiliary subject in such fields as civil, sanitary, water resources, environmental, agricultural and forest engineering, geology, geography and geophysics.

(b) Hydrology as a major option in undergraduate or postgraduate curricula.

(c) Fully-fledged studies in hydrology as a complete denominated undergraduate programme.

It is generally felt that the rare fully-fledged programmes should be actively promoted and introduced in more countries, as professional hydrologists will be needed even more in the future. According to the scheme in Fig. 1, combinations A and B treat hydrology as an auxiliary subject and this option will be referred to in the Table 1 as “Stream I”. If study period C is included, hydrology becomes the essential or dominating subject, referred to as “Stream II”. This special case of “Stream II”, comprising a complete undergraduate study programme in hydrology, can be considered as a fully-fledged programme of study. Table 1 illustrates, in terms explained above, the scheme of education in hydrology at university level. In ANNEX II, the list of subjects for hydrology-related study programmes is given. This list has been recently compiled by the working group of the UNESCO Project E-2. 1“University Education in Hydrology” [MANIAK, 1993].

The success of postgraduate study is strongly affected by the participants’ initial knowledge gained at the undergraduate university level. The educational systems at the many universities that provide education and training in hydrology and water resources are extremely diverse, depending mostly on the discipline (civil engineering, agricultural engineering or forestry, geography, geology, etc.). Only a few universities provide the opportunity for complete undergraduate training as a professional hydrologist (fully-fledged study). Hence, the exit level of the university degree programme is the entry level of the postgraduate course and thus dictates the efficiency of postgraduate education.

From consideration of the curricula of a number of universities and other institutes or centres for the teaching of hydrology, it appears that the level of diversity corresponds to the basic goal- to educate a generalist with a broad problem-oriented approach and background.

The extent of a “general knowledge” in hydrology is still debatable, but the curriculum should enable the development of a high degree of professional adaptability. The demand for a broad spectrum of knowledge precludes specialization if study time cannot be extended. The requirement for specialist knowledge can appear either a short or a long time after graduation.
Such a situation is usual in any professional career enhancement structure but in hydrology and in other water-related disciplines it arises very frequently. Therefore, the continuing education system, in relevant forms and reflecting specific requirements, is often necessary after graduation.

Table 1: Streams of Education in Hydrology at University Level

<table>
<thead>
<tr>
<th>No.</th>
<th>Discipline</th>
<th>Stream I Courses in hydrology used as auxiliary subject</th>
<th>Stream H Hydrology as essential or dominating subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Civil engineering</td>
<td>11 a) Coastal engineering</td>
<td>12 a) Hydrology, Water resources engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Construction &amp; Transportation engineering</td>
<td>b) environmental engineering &amp; Pollution control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Sanitary engineering</td>
<td>c) Urban hydrology &amp; sanitary engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>d) Hydraulic structures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>e) Irrigation &amp; Drainage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>f) Waste Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>g) Water resources management</td>
</tr>
<tr>
<td>2</td>
<td>Geography</td>
<td>21 Physical geography</td>
<td>22 Hydrogeography, Applied Geography</td>
</tr>
<tr>
<td>3</td>
<td>Geology</td>
<td>31 General geology</td>
<td>32 Applied geology, Hydrogeology</td>
</tr>
<tr>
<td>4</td>
<td>Agriculture and forestry</td>
<td>41 Agricultural engineering, Forest engineering</td>
<td>42 a) Land and water engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b) Agriculture Environmental engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c) agrohydrology</td>
</tr>
<tr>
<td>5</td>
<td>Biology</td>
<td>51 Ecology</td>
<td>52 Hydrobiology</td>
</tr>
<tr>
<td>6</td>
<td>Chemistry</td>
<td>61 General chemistry</td>
<td>62 Hydrochemistry</td>
</tr>
<tr>
<td>7</td>
<td>Physics/Meteorology</td>
<td>71 Meteorology</td>
<td>72 Hydrometeorology</td>
</tr>
<tr>
<td>8</td>
<td>Hydrology</td>
<td>81 not applicable</td>
<td>82 Hydrology (fully-fledged undergraduate programme)</td>
</tr>
</tbody>
</table>
1.2 Structure of courses

The structure of the course strictly depends on:

● the aim of the course and corresponding curricula
● the course duration
● the general or special character of a course
● the target group

Curricula, structure and duration are three interrelated characteristics. Obviously, a broader scope of hydrology needs a longer course duration. This is frequently the case in a postgraduate hydrology study when integrated programmes of a longer duration are required.

The previously published UNESCO evaluation Report [AYIBOTELE et al., 1988] lists three categories of hydrology courses:

less than or equal to

Short-term courses .................................................. 3 months

Medium-term courses ............................................. 6 months

Long-term courses .................................................. 1 academic year or more

Furthermore, 15-18 month courses are usually organized for the M. SC. degree and 36 month courses for the Ph.D. degree. However, such study programmes are not considered as postgraduate courses within the terminology of this Report.

The above categories of duration of courses are valid for instruction at the training institution (generally university) by physical presence of the student in the classroom. Especially in case of courses for practitioners of field engineers working fully in their job, open university courses (correspondence courses) are offered as an alternative to courses requiring physical presence. They have the advantage of much lower costs (no accommodation), of not interrupting the daily work and also that the social environment of the trainee is not disturbed. Serious training takes place while the daily work continues and since the training is considered by the trainee as a valuable input to improving the professional performance the trainee invests a high energy for obtaining a good examination result. The training by correspondence is described elsewhere [VAN DER BEKEN, 1993].

To define the basic terminology of postgraduate study, its purpose, scope and the level, one has to start by considering the levels of qualifications of a university education. Graduation is the prerequisite and the entry level for postgraduate study. This fact is clear but looking again at Fig. 1, misunderstandings can arise because some graduates are at the Bachelor’s (B. SC.) level only (just having passed study periods A and B or other special arrangement in curricula) while others are already at the Master’s (M. SC.) level, which in many universities is the normal or indeed the only university-exit level and thus the entry level for future postgraduate study is somewhat blurred. This is the first discrepancy which could influence the appropriate level of postgraduate study. In the case of candidates having achieved the B. SC. degree and those who achieved the M. SC. level coming together on one and the same course, the diploma awarded to both of them after successful participation has practically the same recognition value, irrespective of the individual abilities, potential and level of understanding of the individual.
participants. This is a wide-spread practice which, although not unfair, makes the courses less attractive to M, SC. level participants and also less efficient in that the courses are not tailored to match the different levels qualification of the participants.

The authors of the present Report, in agreement with the working group members of the UNESCO Project E-2. 1 “University Education in Hydrology”, recommend use of the term “professional hydrologist” for those who have obtained a degree of M. SC. in hydrology, hydrogeology, etc., either by graduating from a complete undergraduate hydrology studies or from along-term postgraduate course in hydrology. In all other cases, where the primary degree is that of a civil or agricultural engineer, geologist, geographer, etc., the authors recommend use of the terms “hydrologist” or “practicing hydrologist”. This distinction does not express the difference in qualification in hydrology but rather the difference in the certificate. For example, a civil engineering graduate may take a six months postgraduate courses in hydrology as a basic training to enable him/her to practice as a “hydrologist”. Practical jobs in hydrology and a duration of hydrological practice which should make people familiar with various techniques and technologies, methods of handling data, computations, etc. are usually required between graduation and the undertaking of postgraduate study.

In the usual organization of postgraduate courses, only long-term courses cover all general hydrology subjects, and a deeper specialization comes later. Some people consider such courses as “postgraduate” however, the authors of this report, in conformity with IHP - IV Project D -4.1, consider this type of training as continuing education and this idea will be explained bellow in the paper. Experience has shown [CSVH-UNESCO, 1981] that in short and medium courses, it is not practicable to tackle extensively a general programme in hydrology, and therefore these courses often focus on selected areas such as:

- Hydrological data collection and processing
- Environmental aspects of hydrology
- Surface hydrology operation
- Groundwater flow and groundwater recovery
- Agrohydrology or forest hydrology
- Use of tracers in hydrology etc. or focused on particular geographical regions:
  - Arid zones
  - Tropical rain forest
  - Mountainous regions
  - Coastal areas and islands
  - Deltaic areas etc.

Other short courses can be demand-oriented to particular special topics, and they should be organized with a flexible orientation reflecting the actual needs of the participants. These short courses can either be topically or regionally focused.

Some examples of short UNESCO-sponsored regionally and of topically oriented courses can be listed as follows:
Regionally - oriented courses:

CAIRO (Egypt) - Environmental hydrology for arid and semi-arid zones (2 months)
MONTPELIER (France) - Hydrology of fractured rocks (2 weeks)
CRICA (Caribbean) - Island hydrology (4 weeks)

Topically - oriented courses:

ANKARA (Turkey) - Sediment technology (4 weeks)
BARCELONA (Spain) - Groundwater hydrology (6 months)
GRAZ (Austria) - Groundwater tracing techniques (5 weeks)
LISBON (Portugal) - Operational hydrology (2 months)
MOSCOW (Russia) - Annually changing specialized topics (2 months)
PRAGUE (Czechia) - Hydrological data for water resources planning (6 months)

In the integrated postgraduate programmes, a student follows a more or less fixed curriculum for periods of between six months and two years. These programmes are directed, as much as possible, towards providing education in the wide spectrum of hydrology and equipping students to handle hydrological problems either with limited or no guidance. A number of such programmes has been developed as UNESCO-sponsored and other international postgraduate courses. Universities in some countries also organize multidisciplinary postgraduate hydrology courses leading to a Master’s degree. This approach considers the teaching of some selected subjects for various hydrology-oriented disciplines, such as soil science, geology, water resources, land conservation, etc. Listed below are examples of such long-term UNESCO-sponsored courses:

BRUSSELS (Belgium) - Hydrology and hydrogeology (1 or 2 years)
DAR-ES-SALAAM (Tanzania) - Water resources engineering (18 months)
DELFT (Netherlands) - Hydrology with specialization in: Surface runoff, Groundwater, Water resources management (all 11 or 18 months)
GALWAY (Ireland) - Hydrology (15 months)
LAHORE (Pakistan) - Water resources management (1 to 2 years)
LAUSANNE (Switzerland) - Hydrology (15 months)
NEUCHATEL (Switzerland) - Hydrogeology (15 months)
MADRAS (India) - Hydrology and water resources engineering (1 year)
MONASH (Australia) - Hydrology and water sciences (1 year)
NEWCASTLE-UPON-TYNE (United Kingdom) - Hydrology and water resources (1 year)
OUAGADOUGOU (Burkina Faso) - Sanitary engineering (11 months)
ROORKEE (India) - Hydrology (and several additional options), (1 year).

1.3 Analysis of the level of instruction

The level of instruction has been analyzed for many UNESCO courses [CHANDRA, MOSTERTMAN, 1983], [AYIBOTELE et al, 1988]. In general, the level of instruction may
be low, intermediate or advanced, depending on:

- Scientific or engineering orientation of the course.
- Duration of the course. In short courses, if the initial level of knowledge of participants varies greatly, the effectiveness of lecturing is decreased. In longer courses, such differences can be more easily balanced.
- Teaching/learning level of the course, i.e. the professional/academic level of the teaching staff, the initial level of participants’ knowledge and their motivation to study.
- Forms of education with respect to:
  - Nature of instruction
    - lectures
    - seminars
    - individual reading
    - field/laboratory work
    - group projects
    - individual projects of research design or analysis
  - Development of professional contact
    - via visiting professors/lecturers
    - via site visits
    - via study tours
    - via attendance at national or regional meetings or conferences of professional institutions or organizations
- Laboratory and computer facilities, including books and lecture notes.
- Balance among various forms of instruction: lectures, exercises (seminars), field and laboratory work, individual projects, group work, etc.
- Possible twinning arrangement between educational institution and participant’s country.
- Proficiency of teaching staff and of participants in the language of instruction.

Concerning the ideas of respondents on the level of instruction in postgraduate courses, these can be briefly summarized as follows:

The level of instruction should be aimed at producing students who, having acquired the theoretical background, the skills and experience in hydrological techniques are able to use straight-forward data processing methods and have the ability to both understand and to penetratingly question the accuracy and adequacy of the data they are expected to use. One facet of this process is for students to have a natural understanding of the size of the numbers they are given to use so that they can quickly detect when they are dealing with something that is an extraordinary hydrological event or simply erroneous.

This objective looks obvious but, to judge from the experiences of many working group
members in teaching hydrological models and also in teaching data processing techniques, hydroinformatics, etc., it cannot be overemphasised. These subjects should be tackled keeping in mind the broader aspects of the logical interactions within hydrological processes, the need to balance numerical accuracy and data measurement accuracy and the need to recognize when a computed result has the wrong scale of magnitude or is physically realistic.

During the past 25 years, the network of the UNESCO-sponsored courses has grown to 32. The list of these (including the long-term courses) is given in each IHP Information issued quarterly by UNESCO. In the third phase of IHP (1984-89), a working group chaired by Mr. Ayibotele (Ghana) compiled the report “Evaluation of the UNESCO-sponsored postgraduate courses in hydrology and water resources” published by UNESCO [AYIBOTELE et al., 1988]. This included the basic statistical data on geographical locations, language, subjects, level, duration, research training, type of institution, character and admission requirements. A brief outline of these data is presented below:

Geographical location: Out of the 32 courses considered 17 are located in Europe, 4 in Asia, 3 in Africa, 2 each in Australia and Central America, 1 in North America, 2 in South America and 1 in the Arab States.

Language: 21 of the courses are offered in English, 3 in French, 5 in Spanish, 1 in Russian and 2 in Portuguese.

Main subjects: 18 of the courses offer general hydrology and water resources courses, 4 are directed towards groundwater and 3 towards surface water, 1 deals with sediment transport and others with different topics.

Level: The majority of 18 of them award a certificate, 8 a diploma, 6 an M. SC.

Duration: 6 of the courses are up to 1 month, 4 are between, 1-3 months, 6 are between 4-6 months, 9 are between 7-12 months, and 5 are between 1-2 years. The duration of 5 of them varies.

Research: 7 of them indicate that they offer opportunities for research.

Type of institution: The majority of the courses (24) are hosted by universities, while 8 are hosted by non-university institutions.

Character: 26 of the courses are academic in character, while 6 are operational.

Admission requirements: The majority (22) of the courses require a university degree. From these, 11 also require some years of work experience.

General observation: The bulk of the courses follow a classical pattern by emphasizing water quantity aspects. Components of water quality, ecology, water biology, mapping and reporting are either missing or are marginal. This observation will again be discussed in chapter 2.

1.4 Language of instruction

The dominant language of instruction of UNESCO-sponsored courses is English. Far fewer courses are held in the other official languages of the UN system. English is exclusively the language used in the long-term courses. Outside the system of UNESCO sponsored
courses, many courses are also offered in other languages. Some of these, such as in Germany, France and in Japan, are also open to foreign students.

Obviously there are no language problems if both students and lecturers are fluent in the chosen language of instruction. If not, some questions arise:

a) Is it necessary to organize a language course for some students, possibly before the start of the hydrology courses?

b) Is it necessary to provide additional support to some course lecturers where the language of instruction is not the native (or first) language of these lecturers?

These questions can significantly influence the organization of a course. Apart from funding’ considerations, a decision to organize new courses firstly depends on manpower needs, secondly on the target group of participants and thus on the major languages used in the regions concerned. Manpower surveys should be prepared carefully before establishing the programme and before determining the course language. A primary objective for any new course must be to satisfy as large a target group as possible and to ascertain the long-term viability of the course. The language of the course, therefore, is crucial.

1.5 Special forms of postgraduate education

Apart from the traditional duration categories of short-, medium-, and long-term postgraduate courses, other special forms of education programmes have also been successfully implemented.

**Summer courses**

Some short postgraduate courses are organized as summer courses or as summer schools (e.g. the Moscow postgraduate course). Summer schools are usually organized for the training of teachers or instructors who want to update their knowledge and become better qualified. Such instructors, who have had the necessary scientific and engineering training and sufficient practical experience, can be trained within a considerably short period of one to three months in specialized courses or “summer schools” for professional hydrologists.

**Twinning arrangement**

Twinning arrangements are usually conducted between an institution in a donor country and one in a recipient country. Such an arrangement can encompass a variety of activities, including the exchange of staff, fellowships, cooperative research and material assistance. These arrangements should be based, as much as possible, on a project approach. One of the most frequent forms of twinning arrangements is a short course organized in the participants’ country by visiting teaching staff from the donor country.

Traditional roving seminars have been conducted over the last two decades, mainly in Africa and in South-East Asia (Indonesia) primarily for training purposes. Positive experience [in AYIBOTELE et al., 1988, the contribution of L. J. Mostertman] has also been gained from training the teaching staff in the receiving country, where other participants (mostly technicians) can be trained by trainers in their own language. From the point of view of economics, such seminars are less costly than sending participants for training overseas. On the other hand, short
courses run in a donor country usually have a much higher number of qualified teachers, better technical facilities available and a different living environment experience, factors which can hardly be overlooked. Perhaps inspired by IHD/IHP, but outside of the UN system, many other organizations and countries have created cooperative arrangements between courses.

In the second half of the eighties, the first inter-university projects sponsored by the European Union have been launched. These projects, as good examples of twinning arrangements between EU countries, are running very successfully, under the project names of ERASMUS and COMETT. Since 1990, some recent twinning activities have also been contracted between universities in Western and Eastern Europe, within the Joint European Projects TEMPUS. This concept of creating international partnerships or “intellectual alliances” between involved counterparts has been emphasized as an appropriate and effective means for technology transfer by the participants of the International Symposium on Hydrology and Water Resources Education and Training held in 1991 in Chihuahua, Mexico [NUCKOLS, 1992].

Individual research study programmes

The highest level of formal postgraduate education is undoubtedly the doctorate study programme. The demand for Ph.D. level hydrological scientists to fill teaching and/or research positions is relatively small. This demand has been met by those universities and institutions which support departmental programmes that provide an adequate coverage of the broad hydrological field and a deeper concentration on a part of that field. Such programmes have thus tended to create an elite of academically excellent graduates.

The qualitative level of the Ph.D. programmes corresponds to the developments in hydrological science. Universities should consider the establishment of the institutional mechanisms and academic offerings necessary for the support of multidisciplinary Ph.D. programmes in hydrological science. These would differ according to local programmes and could vary from separate departments of hydrological science, where such exist, to “ad hoc” programmes assembled from across the institution to address different hydrological topics. The exchange of Ph.D. students among universities within a well developed “sandwich programme” has been found to be beneficial to both sides.

1.6 Evaluation of the present situation

This chapter does not lay any claims to evaluating exhaustively the present complex situation. A more detailed evaluation has been made by the Workshop of the UNESCO-sponsored postgraduate course directors and the findings of the workshop have confirmed the statement of this Report. A list of the existing UNESCO-sponsored courses in hydrology can be found in the ANNEX V.

Firstly, the current budget situation of UNESCO makes it almost impossible to launch new courses unless other financial sources can be found. Therefore, the existing courses and the new ones organized by Member States and regional institutes must be managed as effectively as possible to maximize the benefit, particularly with a view to not lessening the impact on developing countries.
Secondly, the development of education and training in the UNESCO postgraduate hydrology courses has to be based on the data of manpower needs for various regions of the world. The National IHP Committees should be asked to collect these data as a necessary prerequisite for further development of water sciences education. Due to the increased needs for manpower, the existing courses should continue, with a tendency to more specialization. At the normal postgraduate level, it is no longer possible to teach all the general water-related subjects within one course, and therefore further specialization is needed.

Thirdly, high priority should be given to strengthening and developing the existing educational infrastructure within developing countries. This is of particular relevance to technician training, where practical exercises in the field play an important part. In order to provide training economically to a large number of hydrologists, the concept of twinning arrangements, by way of international partnerships, should be promoted.

Fourthly, among the great number of publications in the water sciences, only a few take account the special problems of developing countries. It would be very useful to increase the efforts of such journals to covering the hydrological regimes in developing regions. Furthermore, introducing advanced learning technologies, such as computer assisted learning, use of remote sensing technologies, etc., into the educational process makes learning more efficient and meets with the present pedagogical trends.

Finally, the different backgrounds in knowledge and skills of participants, particularly from developing countries, is a well known problem. Many of them are deficient in applied mathematics, statistics, fluid mechanics, use of computers, and other subjects important to understanding advanced hydrology. The problem could be somewhat alleviated if the course management could get more detailed information about the nominees in advance. The entry level of the course should be specified as clearly as possible in a relevant information booklet. While in the case of long-term courses, the problems of different initial levels of knowledge can be overcome through tutorials, in the case of short courses this problem usually persists as time does not allow for correction of such deficiencies. Instruction in the course language, prior to the start of the course session is desirable, but difficult for the course management to provide. International training probably has to live with this problem.

One of the most difficult problems is the situation when both groups of candidates with B. SC. and M. SC. apply for participation in one course, unless an integrated dual system of courses (as given in Galway, Ireland) can be provided. This problem should be weighted carefully, particularly in distinguishing the level of diploma to be awarded (see Chapter 3).

As mentioned several times, the term “postgraduate” is ambiguous and within different educational systems has different meanings, functions and results. A short course following a B. SC. graduation cannot be compared with a (French) D.E.A. or with a course leading to an M. SC. degree or even a doctorate. The problem becomes even more complicated since “undergraduate”, “graduate” and “postgraduate” have different meaning indifferent countries. Hence, already from the linguistic viewpoint a solution on a world-wide basis is unlikely.
In conclusion, the authors recommend that the following problems in particular remain under discussion:

- How to evaluate the existing information exchange system among courses and to explore the possibilities for improving and expanding cooperation.
- To look critically at the degree of communication between the course management and the respective IHP Committee when the latter is nominating a participant.
- Similarly, to establish if there is any feedback between the course management and/or the IHP Committee when evaluating a course.
- A better specification of the entry level of the course, distinguishing clearly between candidates at the B. SC. and M. SC. levels.
- A more unambiguous definition of the term “postgraduate”, in the context of hydrology courses.
2. FUTURE TRENDS FOR POSTGRADUATE HYDROLOGY EDUCATION AND TRAINING

The general policy for the development of postgraduate training has to be derived from the development of hydrology itself and from manpower needs with respect to the extent of water-related problems in various geographical locations. To successfully implement the main task of the formation of the Hydrologist for the year 2000, the exchange of knowledge, technology, and information on education and training must be more intensive than it has been in the past. Universities, laboratories, and institutions, including UNESCO and other international organizations (WMO, FAO, IAHS, etc.), should better organize the sharing of these activities, using more advanced information systems, and thus interact more efficiently.

2.1 The changing features of hydrology

Development in the field of hydrology during the last decade has been governed by the rapidly increasing interference of man in the hydrological cycle. The effects of human activities, such as changes in land use, large scale deforestation, urbanization, surface- and groundwater development, irrigation and other reclamation practices on the hydrological regime, can hardly be predicted using only traditional concepts describing rainfall-runoff processes. This development has been enhanced by the introduction of more and more physically based models which better simulate the hydrological processes and which provide a more in-depth look at the interactive hydraulic, chemical, and biological features of a problem. While problems of water quantity grow and thus gain importance in teaching programmes, the environmental problems related to water are moving to the forefront. Water quality in general, water chemistry, water biology, ecology, socio-economic aspects are demanding more and more space in modern teaching programmes and even way attain primary importance. The use of more powerful computers and facilities for sharing information in world networks facilitates finding solutions to such problems. The increasing demand for good quality water will hopefully increase the importance of the quality of the environment and also confirm the need for more fundamental research in decision theory using many recently developed tools, such as Geographical Information System (GIS), remote sensing techniques, database management systems, etc.

2.2 Requirements for the future development of postgraduate education

It maybe that the great influence of technology on hydrology and the lack of understanding of hydrology as a geoscience have recently given rise to discussion on the scientific content of the present hydrological research. Avery interesting formulation of the educational requirements for hydrologists, has been published by the team of authors of the Report IAHS/UNESCO [NASH et al., 1990]. They put emphasis on the training of applied hydrology:

“The Panel of IAHS/UNESCO agrees, but believes it is important to stress the directions in which the training of applied hydrology should evolve:

a) An effort should be made to increase the hydrological content of bachelor degree courses, thus increasing motivation and providing appropriate background for subsequent postgraduate training in applied hydrology and related research.
b) Present postgraduate courses should be examined critically with a view to providing an increased content of basic science, and a greater variety of hydrological sub fields. A conscious effort should be made to introduce experimental and observational content into the courses and to eliminate any naive dependence on analysis.

c) Efforts should be made to ensure that the developments in hydrological science achieved in geoscience departments are made readily available to the applied hydrologists, typically in engineering departments. Close contact should be established by joint appointments, visiting lectures and possibly by geoscience departments offering some courses specifically for engineering hydrologists."

Hydrological scientists should strive to understand more thoroughly the natural complexity of hydrological processes through careful hydrological observation, process study and physically-based modelling. This may also be the answer to the question of which facet of hydrology should be emphasized - the scientific or the technological one. The scientific character of hydrology has to be dominant but the technological side should be implemented to its practical application, mainly in engineering hydrology.

In addition, apart from the pure geoscience orientation of hydrology, the second major trend in hydrological education cannot be underestimated. This is the trend giving priority to the engineering aspects, recognizing that hydrology is a “demand-driven” science. Owing to the fact that most hydrologists started off as civil engineers, the engineering aspects should be given in a proper balance with the geoscience ones in such a way as to be able to solve all needed tasks of engineering hydrology on a high scientific level. Engineering hydrology still plays the prevailing role, the highest proportion of jobs being requested from this field and therefore it would be impractical to ignore it.

The discussion within the hydrological community on the topic of which trend in hydrology education should be the prevailing one has been reflected also in this Report. Some respondents of the E-3.1 Project on Postgraduate Education in Hydrology agree with the IAHS/UNESCO Panel conclusions about the lack of a natural science background in hydrology while others would disagree with the view that the perceived lack of progress in research is a result of poor quality of hydrological training in postgraduate hydrology courses. This view would only be correct in the case of sciences such as physics, or chemistry, or biology. These disciplines are basic sciences in the sense that all physicists are trained to be physicists, and researchers in physics are generally trained physicists. Therefore, if their training is poor, the quality of their research will also be poor.

However, in the case of hydrology, not all research hydrologists are trained exclusively as hydrologists. Their specialized training is in one of many other disciplines, mainly engineering, statistics, geology, meteorology, etc. and very rarely physics. Therefore, they are “secondary” hydrologists in this sense, and their commitment to the development of the actual science (as distinct from the practice) of hydrology is perhaps less than the commitment of a physicist to the science of physics. This situation cannot be rectified by changing the syllabi in the postgraduate hydrology courses. These courses are “professionally oriented” and differ from the traditional postgraduate courses in other scientific disciplines. They were created to satisfy the demand for “applied hydrologists”, and that demand still seems to exist particularly
in developing countries. Therefore, the main trends in the development of the postgraduate hydrology courses are unlikely to change substantially in the future. It lies in the nature of scientific development that some universities or research institutions become centres of excellence of hydrological research, particularly those which adopt a multi-disciplinary approach. Their advances set the pace for other universities, world-wide.

Once the general level of hydrological research has improved, the level of teaching hydrology would automatically be raised. It would be a serious mistake if the responsibility of improving the quality of research was entrusted solely to the directorates of a few postgraduate courses, since they do not generally have the resources to take on that kind of responsibility, and neither is it their primary task. The current demand for postgraduate education varies, and also in future will vary, from short-term specific problem-oriented courses to the Ph.D. level hydrological courses/scientific training. The latter includes such subjects as advanced mathematics, stochastic processes, aqueous geochemistry, plant physiology, radiation physics and geophysical fluid dynamics.

In parallel with the effort to introduce hydrology as a geoscience, the conventional methods of education and training professional hydrologists will continue by means of postgraduate courses designed for “topping up” existing training, usually in an appropriate branch of engineering, or for converting a science graduate. The main advantage of this trend lies in the fact that students taking such courses will, in most cases, have reached a mature decision to pursue a career in hydrology and often will already be employed in that area.

2.3 Structure and duration of courses

Basic deliberations on the structure, duration, entry level, target group and the character of the postgraduate courses have been mentioned in Chapter 1.2, which describes the existing situation. Here, only some notes and comments will be considered that could be relevant to possible future trends in postgraduate hydrology education. Despite the classical division of three categories of postgraduate courses (short-, middle-, and long-term), generally there are only two basic types of postgraduate programmes in hydrology:

a) programmes of short duration (up to 6 months) on specialized topics leading to increase competence in special subjects or to widening the participant’s knowledge and improving the skills.

b) Integrated postgraduate programmes of long duration, leading to a postgraduate degree or diploma as professional hydrologist, and often serving as the initial step towards a doctorate programme.

Upon examining the analysis of the 32 UNESCO sponsored courses (Chapter 1.2), it is remarkable that relatively few courses have a duration beyond 12 months. Short courses have the following advantages:

- Short leave of absence for participants from their duty,
- Relatively lower cost for running a course,
- Choice of training for specific topics.

The expected achievements in the majority of short courses are: first, a basic training in
hydrological observation, analyses and data processing; and second, the acquisition of new techniques and knowledge of hydrological methods. Short courses also concentrate on specialized subjects.

Since short courses, not only to financial reasons, are believed to play an important role in future, some salient features shall be described here:

- Entry requirements: In order not to lose time for the adaptation of the participants the entry conditions must be clearly described in the application form (type, time and place of graduation (s), publications, professional experience, expectation to the course).

- Course content: New research activities. new research findings. The participant should be taught on the selection of the most proper method for solving a problem or on the combination of several methods. Socio-economic aspects should be included.

- Determination of teaching methods: Distinction between educational and professional aspects (scientific versus practical problems), establishment of teams or working groups for the solution of specific problems establishment of demonstration access for performing field and laboratory experiments.

- Specific course parameters: Regional topics, feed-back by participants, eventually for selected students subsequent on-the-job training. Development of the ability that the student transmits his knowledge and skills to other persons in his home service (multiplier effect: the trainee becomes a teacher at home).

Postgraduate programmes of long duration normally lead to a postgraduate degree or diploma as a professional hydrologist, and often reach the starting level of a doctorate programme. The advantages of such a long-term course are evident. However, one of disadvantages is the difficulty of obtaining a commitment to study over a sufficiently long period of time, particularly involving mature participants with family responsibilities having to travel abroad for the course. Another disadvantage is that universities often consider postgraduate study only for potential Ph. D. students recruited from the best of the graduates. Postgraduate courses thus tend to become academically biased, paying attention only to academically exceptional graduates, rather than providing a spectrum of personnel with practical and theoretical skills that a stable professional community needs. To overcome this difficulty, universities should be encouraged to recognize such continuing education (or “topping up”) courses for what they are and to distinguish between these and higher level specialist courses, usually academically excellent, which they could continue to provide for academically distinguished graduates.

There is an increasing demand for the joining of the M. SC. and later Ph.D. programmes in hydrology and water resources. After one academic year of attendance at many UNESCO-sponsored long term postgraduate courses, it is possible to continue education with additional M. SC. programmes for those who began as B. SC. participants. These courses provide well-qualified alumni with a M. SC. degree, who are prepared to be leaders in their own national training centres. For the recipient countries, it is an important step in the direction of becoming self-reliant and in providing motivation for improving their own educational structures. Good examples of such structured postgraduate education, offering a postgraduate diploma after one
academic year, then M. SC. (and later Ph. D., resp. for outstanding students), are provided by the UNESCO courses in Brussels, Delft, Galway, Lahore, Lausanne, Neuchatel and others.

However, this is not a challenge to transform all short-term courses into long duration ones. Short-duration courses are complementary to long duration courses and will remain necessary. The main factors retarding advanced studies are:

- availability of fellowships (usually less than demanded)
- inaccessibility to data presumably available at the participants home countries
- inaccessibility to laboratories and experimental stations
- insufficient extent of cooperation among universities and research institutes.

The present practice of sending fresh M. SC. or even B. SC. graduates with insufficient background to postgraduate courses, with the well-known disadvantages, could be largely avoided and postgraduate courses in future could be designed for and directed towards their real aim, namely, to provide very advanced training after graduation, i.e. to deepen hydrological knowledge beyond the level of an undergraduate education in hydrology.

2.4 Suggestions for curricula and syllabi in the perspective of the year 2000

The present situation concerning the education of hydrologists can be evaluated from several angles. One of them is the critical view of the IAHS/UNESCO Panel [NASH et al., 1990]. The basic discrepancy that - “the majority of hydrologists are not trained as scientists but as technologists” - has been discussed in that report and strength has been given to the need to train scientific hydrologists. The other orientation, giving priority only to engineering aspects in hydrology, is another extreme. The authors anticipate that the trend of development has to be in coincidence with needs of all branches of hydrology and therefore it should, in general, vary between these both of these extremes always recognizing that the character of the course must be predetermined by needs.

The fact that hydrologists are mostly recruited from engineering areas and therefore are not thoroughly educated in the hydrological sciences should not be underestimated. Hydrological sciences need to understand natural phenomena through hydrological observations, detailed study of hydrological processes and physically - based modelling. This is the way to give hydrology the status of a real natural science with its basic principles. Postgraduate education has to take this into consideration. Therefore, the question of differentiating between courses clearly oriented to hydrological sciences or engineering/operational hydrology should be raised. Hydrology sometimes is not perceived as an independent scientific discipline. However, it is more and more being recognized as such and therefore it should be taught as such and not merely as an application of another discipline. Consequently, applied hydrology has to be taught with a distinction between scientific and technological methods. Technological or operational methods having an empirical background have to be explained within their application limits, in terms of the physical representativeness. Revision of curricula and syllabi should be a continuous process reflecting progress made in research as well as in technology. Truly significant developments should certainly find their way into the classroom.

The UNESCO-IHP working group, in the framework of IHP-III Project, from 1986 to
1988, has proposed a model curriculum for postgraduate courses. This model curriculum has been compiled under the chairmanship of U. Maniak [in AYIBOTELE et al., 1988] and it contains a list of subjects which should be compulsory for all courses of six months duration. The general curriculum consists of four sections:

A. Subjects to be taught at the undergraduate level
B. Basic subjects
C. Hydrological subjects
D. Subjects of hydrology of specific regions, different land use and water resources engineering aspects.

Blocks B, C, and D together require a minimum of 550 hours. All subjects listed also contain a brief syllabus including the extent of lecturing in hours. The model curriculum is flexible enough to allow changes to bring it up-to-date.

The starting point for compiling a new curriculum can be found in the list of subjects for undergraduate study programmes where hydrology is a dominating subject. The list has been compiled by the UNESCO working group of the Project E-2.1 IHP-IV “University Education in Hydrology” and it is attached in ANNEX III. Syllabi corresponding to these curricula have been published in the Report of the E-2.1 IHP-IV UNESCO Project [MANIAK, 1993].

Within E-3. 1 Project the following suggestions have been discussed for the development of existing curricula and syllabi. These suggestions mostly reflect long-term courses, but some of these ideas can also be utilized for short ones:

- Increase coverage of basic hydrological sciences, including meteorology, soil science, physical hydrology, hydrochemistry, etc. On the other hand, basic chapters from mathematics, statistics, computer informatics, ...etc., can be dropped from the curriculum if the course participants have a good command of such material before beginning the course. Updating the course curriculum in the undergraduate study programme should be seen in the context of the development in the teaching of hydrology at various universities. Then the repercussion of undergraduate study on postgraduate programmes can be expected.

- Deepening of the understanding of the hydrological cycle, inter-action of atmosphere/vegetation/land surface/soil/groundwater is necessary. Also the role of factors affecting evapotranspiration should be highlighted. Mathematical modelling of hydrological processes based on the physical background will then have a new scope.

- Widen the scope to include more environmental topics and principles of environmental impact assessment. Space should be made for introducing such subjects as applied ecology, microbiology, land and water conservation, water quality, impact of man activities, etc. It would be very beneficial to provide at least some exposure to environmental awareness through case studies. Also water quality features, including transport of ions in soil and in water, different behaviour of pollutants and their transformation will find more space in new curricula.

- Subjects including applications of remote sensing in hydrology, GIS, and those
including field measurement have proven to be most valuable. Good training in hydrometry, meteorological and soil measurements should provide the necessary background for increased skills in the physically-based modelling of hydrological processes as a consequence of land use changes.

The recent American Society of Civil Engineers analysis [ASCE, 1990] has highlighted that use of personal computers is the most common technological tool. The use of PCs has enhanced hydrological modelling, data processing, real time river flow forecasting, statistical analysis, etc. As for other new technology areas, the ASCE respondents point also to the trends distributed between the two functional areas of toxic/hazardous wastes and hydrogeology/hydraulic processes. Next in order, they refer also to the data collection mechanism of remote sensing, use of GIS, and the three analysis techniques of risk assessment, expert systems, and systems engineering as areas of growing importance.

Based on long-term observation, some general hydrology postgraduate course directors claim that four hours (1 hour = 45 rein) can be regarded as an upper limit for lectures and exercise sessions each work day. This corresponds to about 20 hours per workweek. As such, introducing new subjects into the existing course curriculum requires an increase in the duration of the course and/or elimination of one or more of the existing subjects (e.g. fluid mechanics). In Delft, for example, after 25 years of experience in running general courses in hydrology, the course will shortly be given a new structure, in which the number of contact hours has been reduced from 780 to 680. Roughly half of these hours comprises the first term, and this is common to all course participants. In the second term, which consists of the second half of the contact hours (360), the course is divided into three branches, namely: surface water hydrology, groundwater hydrology and water resources planning and management. This restructuring will help increase the extent of the diversity of the course material and the depth or specialization in a less broad area of hydrology. It is hoped that this plan will make the course training more useful and attractive to the future applicants. To ensure having a reasonable number of participants (10 or more) per branch, there is a strong need to allocate more places in the future.

It is proposed that the introduction of new trends stressing the physical and chemical aspects of natural hydrological processes should be introduced in programmes of postgraduate study, particularly in Ph.D. programmes, through selected dissertation topics. Due to the interdisciplinary character of hydrology, the authors of the IAHS/UNESCO report [NASH et al., 1990] “propose that hydrological studies should be undertaken mainly in university departments of geoscience and the advances which should flow from this association with the study of other aspects of geoscience should be made available to departments (typically engineering departments) dealing with the education of applied hydrology.

2.5 Conclusions

The present systems of UNESCO-sponsored courses are difficult to compare in terms of subjects to be taught, duration spent on the curricula or specialization aspects of the courses. However, there is a need to establish a somewhat better information system among the courses. A mobility programme for students and for teachers of UNESCO-sponsored courses would be a good means of exchanging information. For European courses, this can be done through the
programmes of the European Union (TEMPUS, ERASMUS, COMETT). There is still a big need for a similar exchange programme between developing and developed countries. A prerequisite for future cooperation is through exchange of information on the courses, which can be arranged according to ANNEX III [VAN DER BEKEN, 1989].

In conclusion, there are still other suggestions for future trends in postgraduate education and training in hydrology:

- Application of remote sensing and Geographical Information System.
- Using more computer-assisted lecturing and learning.
- Introducing more environmentally-oriented problems, including land degradation, erosion and consequences of improper land use.
- Study of the impact of global/climate changes on hydrological and water resources systems and how these could be mitigated.

However, there are also other problems still to be addressed. One of them is a need for the compilation of model curricula and syllabi for medium- and long-term courses. This idea automatically evokes the following questions. Is there a danger of imposing a uniform “politically correct” curriculum which lacks recognition of the local strengths, specializations and priorities of the various regions and of the need to maintain and encourage diversity and originality? Is it possible to prepare general material reflecting all facets of postgraduate hydrology education? If so, which subjects should be promoted and which omitted? How can an exchange of some well-developed teaching software be organized?
3. CRITERIA FOR RECOGNITION AS A POSTGRADUATE COURSE

Section 1.6 of this paper already introduced to the linguistic problem even within English-speaking countries concerning the term postgraduate. Educational systems other than the English-speaking ones add to the problem and comparisons are somehow arbitrary. It is apparent that the differences in educational systems are conditioned by the history of countries and that the IHP and its educational component has to live with these differences and that all attempts for standardization will find their limits in the national educational systems. Hence, considerations within the IHP can only envisage slight modifications and improvements but they will fail to change the general educational set-up in the world. Traditions and funding problems oppose major changes. Therefore, this report does not lay claims to assess exhaustively the situation but it rather tries to facilitate understanding and a certain harmonization.

"Postgraduate" literally means a course taken after "graduation". To understand the term "postgraduate", in the context of hydrological education, and to specify its meaning, one should look again at Fig. 1: "Educational career", where after the minimum duration of three years of university study for the degree of "Bachelor", B. SC. is written down. In general, this lowest academic degree can be achieved after basic studies and general studies with some "rough" specialization. However, there are many countries (mainly in Central Europe) where the B. SC. degree does not exist and where the undergraduate studies end with a diploma after about five years and this is largely at the level of the "Masters" i.e. the M. SC. degree. In the case of the 5-year diploma programme, the term postgraduate is clear as it means all educational activities after having reached the Diploma/M. Sc. degree level. Nevertheless, in other countries, having the B. SC. system, (after the break-point on Fig. 1 at the end of Block B), this is the end of studies for the bulk of students. For such B. SC. holders, a continuation of the studies, if desired at all, could consist of:

First, a "Master's" study programme, i.e. an, M. SC. for those who continue in a specialized study, often at a different university than that which awarded the B.Sc., for at least 15 months, or more commonly, for two years of intensive studies, or

Second, simply a postgraduate programme of study for those who have finished the university study, eventually worked for some period, and then returned to study to the university or to some other institution that provides a postgraduate education often without distinguishing between B. SC. or M. SC. level of the participants.

The minimum length of M.Sc. study after the B. SC. level can range between 15 months (Lausanne, Galway), or more frequently 18 months (Delft, Brussels); at least 6 months of that time should be spent on active research analysis or project work.

From the above, one may conclude

● that a general postgraduate hydrology course for B. SC. graduates is considered by many people as an alternative to formal M. SC. studies (Block C). If the course duration is shorter than indicated in Block C, the level achieved will certainly be less than that of an M. SC. degree and perhaps not deserve the pretentious title "postgraduate";

● that a course accepting both B. SC. and M. SC. holders cannot satisfy both groups: one
group is being either over-qualified or under-qualified;

- that only B.Sc. and M. Sc. constitute world-wide acknowledged terms and degrees and that “postgraduate” simply means studies after graduation (whichever primary degree has been obtained).

- that as long as postgraduate studies are not standardized in terms of level, duration, content and output, a world-wide accepted diploma cannot be expected. It is a general experience of the organizers of the shorter UNESCO-sponsored courses that participants from developing countries are frustrated since the certificate they get, has practically no legal value. Experience shows that the certificate of these courses even within the country of the course enjoys only limited recognition.

This is the core of the problem which has been discussed during the Workshop because the equivalence of these certificates with other diplomas achieved at the end of complete (5 year) undergraduate study programmes is disputable. At the universities where no B. Sc. exists, this problem does not arise at all. In addition, postgraduate courses shorter than 15 months can hardly provide postgraduate degrees when participants start on the B. Sc. level.

In those countries which recognize the term B. Sc. degree only as an interim step in a 5-year diploma programme, the term “postgraduate” is either applied to all courses organized after M. Sc. (including correspondence courses) or more frequently to Ph.D. programmes. Thus, the term “postgraduate” represents abroad scale of meanings which are mostly based on the accreditation of the respective country. The respondents express these differing interpretations of the term “postgraduate”. For the sake of clarity, the present Report proposes the following definitions:

- The difference between B. Sc. and M. Sc. levels is simply the M. Sc. study.

- After M. Sc. study, the term “postgraduate” can only be used either for further specialized study or for Ph.D. programmes.

- Finally, those who are at the B. Sc. level cannot apply for postgraduate study but only for M. Sc. or for any specialized programmes which however could not be considered as postgraduate study.

The highest level of formal education is that of the “Doctorate” or Ph.D. degree. The M. Sc. level is often of prerequisite condition for admission to Ph.D. studies. The Ph.D. programme is an informal one; Ph.D. students do not work in classes, they work individually and almost independently. This is still “education”, but more oriented to a “self-learning” and eventually a group training.

Although the problem of the term “postgraduate studies” is not specific to hydrology, the Prague Workshop nevertheless thought about a classification for use, at least, within the framework of the UNESCO-sponsored hydrology courses. The following classification is proposed:

- **Specialization courses**
  for holders of a B. Sc.: These courses often have a duration of six months and cover more
or less all hydrological subjects at an introductory level. They would also be attended by those M. SC. holders who so far have not yet studied hydrology.

- **M. SC. courses**
  which constitutes Block C between B. SC. and M. SC.

- **Postgraduate courses**
  of high level, after graduation with sufficient basic knowledge in hydrology (Block D).

- **Continuing education courses**
  which cover only selected subjects and have a duration of generally much less than six months. They are open to all participants having the prerequisites for the continuing educational programmes in the respective course topics at the given course level. It is not the intention, in this Report, to go into details concerning continuing education, despite the great importance of this form of training. The reader is referred to Van der Beken: Continuing Education in Hydrology, UNESCO Project E-4.1 [VAN DER BEKEN, 1993].
4. MANPOWER MARKET ANALYSIS

The purpose of this paper is certainly not to present a profound discussion of all problems related to the manpower market and to its analysis. Such a discussion would require many statistical data from many countries to show the situation in the field of the job market in hydrology and water resources. Such data are not available to the extent required. Nevertheless, some experiences from individual courses and mainly from UNESCO have been considered in the following discussion. Manpower market, in a context of international training activities, is discussed herein with regard to:

- Expectations of the course participants
- Expectations of the employers
- Job market analysis

4.1 Expectations of the course participants

A wide range of subjects is desired by students, according to responses that have been obtained, and this coincides with the statistical data in the UNESCO Report [AYIBOTELE et al., 1988]. This situation can be illustrated by the response of the Dar-es-Salaam course:

“The subjects desired by our course applicants would be so diverse that they cannot be accommodated in anyone postgraduate course. Each student who comes to study in our course has his/her own idea of what a course in water resources/hydrology should comprise. These ideas are often based on the individual’s own interest, or his/her background education, the present employment or the prospect of a future employment. If the question is prompted by the assumption that the choice of the subjects desired by students would reflect the requirements of their employers, we would be very concerned, because of serious doubt concerning the validity of this assumption”.

Obviously, the lists of subjects desired by applicants differ significantly, depending on their country’s specific problems and on their professional orientation.

In the experience of the Prague course (6 months course on “Hydrological Data for Water Resources Planning”), participants appreciate the environmental aspect of hydrology and water resources. Today’s problems require a highlighting of the influence of human activity on hydrological processes. In particular, monitoring, modelling and the prediction of environmental impacts on water balance and extreme events in hydrology (minimum and maximum), consequences of deforestation (as an impact of acid rain), surface mining, deterioration of physical properties of soil, air pollution, erosion problems, impact of climate changes on water resources, etc. are currently the most serious problems for participants from Central and Eastern Europe. (And, one must assume, for those from developed countries, too).

The UNESCO/UNEP booklet on basic curricula in environmental engineering is helpful [UNESCO/UNEP, 1988]. Due to the rapid developments in this field, the up-dated version of this publication will be certainly appreciated. According to the materials received from the IHE Delft Development Plan 1990-94, their Environmental Engineering courses there are, to a large degree, to be expanded and consolidated.

According to the experience from Galway, some students from less developed countries
are inclined to take only courses which are directly relevant to their most recent area of employment, on the grounds that transfer to other areas of employment is unlikely owing to the structure of their employing organization.

In this case, it could be recommended:

a) that younger students should be encouraged to take a wide range of options and
b) that older (more experienced) students should be allowed a more narrow field of specialization.

A comprehensive assessment of the ability of courses to meet participant’s aspirations has been published by the working group of IHP-III [AYIBOTELE et al., 1988] with these general conclusions:

1. The courses, though good in themselves, were too short and needed to have more time spent on certain subjects.
2. Some new subjects reflecting new scientific and technological development in hydrology should have been included.
3. The course was an incentive for further studies.
4. Some wanted more subjects taught, and some will continue further with their studies. The lack of resources and the infrastructure in their home countries prevent them from putting their knowledge into practice.

To express precisely a “general” students’ expectation is not feasible. However, in our experience, the bulk of students wishes that the education should help them in their professional job.

As most of them are working in the field of engineering hydrology, they simply wish to be educated in the new trends of engineering hydrology. Therefore, this expectation is obviously in contrast with the type of education suggested by the [IAHS/UNESCO booklet [NASH et al., 1990].

According to the survey undertaken by UNESCO in the 1980’s, the expectations of participants roughly coincided with their evaluation by employers 3 years after completion of the courses. The courses have contributed to the promotion of a majority (55%) of the participants. 45 % rate the course as having a good to excellent impact on their performance, though their high performance may also be due to the fact that the majority (55 %) have had other training since returning from the UNESCO-sponsored courses.

A student’s expectation largely depends on information made available to the participant before the commencement of the course, i.e. on the accuracy and adequacy of the course publicity material. Students should be clear beforehand on the type of award available (certificate of attendance, diploma, degree) and when it will be available, i.e. what is the time lag between completion of all aspects of the course and the issuing of the award. A special information handbook with the clear description of the course programme should be available to the participants before they depart from their home country.
The manpower market analysis should also include for each course:

- the number of applicants
- the number of places
- the number of and source of fellowships
- completion/achievement rates
- time taken (within target time or not)

It is important to have some ideas of students’ motivation to undergo postgraduate education which costs time and money. First of all, their motivation is often created by realizing the necessity to improve their knowledge for a professional career. There again, many of them require more engineering than scientific aspects in hydrology. One more motivation aspect for students coming from overseas is that a stay in the country of the course helps them enhance their common living horizons which is also important.

The authors suppose that a participant who has finished a postgraduate course should subsequently be able to supervise a small team of technicians and to write consistent and well-argued reports on the analysis of the problems they are asked to investigate.

4.2 Expectations of the employers

In principle, all employers appreciate better qualified personnel. The working group received consistent answers from the several employers. They contained more or less general requirements for the synthesis of quantitative understanding of hydrological processes with a sound knowledge of field practice. They put in the first place an understanding of the hydrological cycle and the ability to adapt to whichever environment they find themselves working in.

From an economic point of view, much of the effort put into the educational programmes of courses is wasted if students who have finished a course start jobs which are not adequate to their knowledge and to their professional level. This is not an exceptional case, and it cannot be completely eliminated because a country’s personnel policy is entirely the responsibility of the respective government. Before supporting the nomination of the candidate for the course selection, it would be worthwhile if the National Committees for IHP could always consult on this matter with the candidate’s employer.

In conclusion, employers very often require postgraduate knowledge and skills particularly in:

- Field studies and experiments, observations, and laboratory work.
- Communication, i.e. technical writing (clarity of thought, report organization, using PCs, grammar and syntax, etc.), and formal oral presentation.
- Organizational management, i.e. project management, project planning, leadership and motivation, and ethics.
In addition, the employers expect:

- The ability to contribute to the conversion of knowledge from research to practice.
- Ingenuity in problem solving
- Motivation and appropriate background for continuing education, subsequent training, and involvement in professional associations.

Thinking in general terms of the manpower market analysis question, all the course organizers realize that they suffer from the lack of data on this topic. Then the following questions arise: How much do we know about the real needs of countries? How can we explain the scant interest of developing countries to provide fellowships to their participants? How can we help a successful participant in getting a relevant job after the course? There are many other such questions in this field. Their analysis is, however, necessary and urgent. Such an analysis has to take into account also the “brain drain” phenomenon considering for instance, that during the last 30 years about 40,000 Ph.D.’s (from all scientific sectors) have left Africa. Unfortunately, such a quantified analysis is missing and the way of getting basic manpower data from individual countries is completely beyond the competence of the authors. What is given below are some deliberations only concerning the main principles of this problem.

4.3 Job market analysis

As mentioned above, the discussion here cannot cover all problems related to the manpower market and to its analysis. However, a few viewpoints need to be considered in order to better understand international postgraduate training activities.

The first item is the job market itself. An employer will try to fill the jobs with the most qualified personnel so that a postgraduate is likely to push aside ordinary graduates, even if the job requirements would not necessarily call for a postgraduate. Hence, at a time of manpower excess a young person will try to obtain the highest possible qualification. Nevertheless, for organizing such high and costly training, it would be important to know how many postgraduates are working in positions requiring such training and also how many have found a job outside hydrology utilizing their academic degree only as an entry requirement for another type of work.

The second item is the cost of training. If all costs (teaching personnel, general staff, buildings, teaching aids, travel and living costs for the student, etc.) will be added up, the costs per student are prohibitive.

The other extreme is free-of-charge training, and as a consequence, a theoretically endless demand for training. Even persons having no aspirations within the study subject might choose it because it is free of charge as long as other study subjects are charged for. Applied to the international courses in hydrology, the number of fellowships granted determines the number of trainees from developing countries. It must be clearly spelled out that the number of requests for fellowships is not identical to the number of jobs to be filled but simply reflects a desire to take advantage of cheap training, in the hope that a suitable job will be found later.

Another aggravating factor is the behaviour of the employer, regardless whether private or public. The employer requires a defined level of knowledge and skills from the candidate but leaves it to individuals to obtain it. This attitude explains why the bulk of developing
countries does not supply fellowships despite the need for trained personnel. They leave to the trainee the burden to obtain higher training (and a fellowship). It is suggested that governments make provisions for fellowships based on their national needs rather than rely entirely on international aid programmes to supply such fellowships. The UNESCO-sponsored courses clearly show the vulnerability of such reliance. The UN system undoubtedly has not been created to serve as a universal fund for fellowships.

A proper balance between available jobs and students can only be reached under artificially regulated market conditions, as was the case earlier in the socialist countries. In any free or semi-free market there should be constraints on the costs since otherwise the number of students will greatly exceed the number of jobs. There are alarming examples of academic over-production which leads not only to frustration for young people but also to unjustified costs on the public purse.

Numerous attempts have been made to conduct manpower surveys in order to make it possible to reasonably determine the appropriate number of students. Almost none of these surveys have yielded the expected results. To influence the number of students through study fees maybe possible at national level (although often politically impracticable), but the method fails at the international level. When governments are willing and capable to finance, at least partially, postgraduate studies abroad, then they would be interested in knowing their actual needs and help course organizers and sponsors to arrive at realistic figures.

The present system of no contribution by the benefiting governments leads to curious consequences:

- in developing countries, the number of fellowships dictates the number of postgraduates irrespective of real needs;
- governments cannot influence their own supply of postgraduates and can only rely on the unpredictable behaviour of donors;
- at a time of economic restrictions, the number of fellowships will drop. This may lead developing countries to understaff their hydrological offices;
- course organizers find it difficult to convince the donor agencies of the need for international postgraduate training due to the lack of government commitment on the part of developing countries;
- if financially committed, the developing countries would exercise the highest care in selecting the best candidates and press on course organizers to deliver the highest quality training in accordance with their needs.

It would be added that commitment on the side of recipient countries would stabilize the finances of the courses and reduce their dependence on sponsoring agencies.
4.4 Conclusions

From above, the following conclusions can be drawn:

● The number of available and appropriate jobs for postgraduates will hardly ever be known to course organizers and donor agencies, except in the case of small countries.

● Where available in excess, postgraduates are likely to replace less qualified personnel even where the lesser qualified would suffice.

● Fully-paid studies are prohibitive, hence subventions and/or fellowships are needed. The slogan “free education for all” certainly has its limits in higher and highest education.

● Developing countries should not entirely rely on foreign aid and should finance at least a part of the costs related to their own nationals.

● At present, the number of international fellowships is not linked to real needs but to the attitude of donors. Their number could be either too high or too low. Partial financing by the recipient countries would lead to more realistic figures.

● Subventions from international organizations and from countries hosting international courses distort the market analysis. On the other hand, it is obvious that very poor countries will not be able to contribute substantially.

● It would be interesting to know how many of the postgraduates are working in the position corresponding to their (high) training and whether this is in the field of hydrology.
5. METHODOLOGIES OF COURSE EVALUATION

Some methodological views on course evaluation have been presented in the relevant UNESCO Reports [AYIBOTELE et al., 1988] and [DOCKRELL, 1990]. Not only for the evaluation itself, but rather for the feedback analysis, which is frequently carried out by a course management and which provides the basis for a course improvement, many questionnaires have been already disseminated. These forms have been addressed to a great number of participants and to their employers, and then statistically analyzed. The assessment by participants regarding the ability of the courses to meet their aspirations is a useful measure of participants’ satisfaction. A second such measure is the evaluation of employers of former participants (alumni) some time after they finish the course. Apart from these main measures, some others still remain, such as the course accreditation and assessment by the supervising authority. One more form of evaluation, which cannot be overlooked, as it provides course teachers with information on how the study matter has been understood and so immediately gives a measure of the course efficiency, is the system of continuous evaluation of participants during a course.

When evaluating a course, it should be clearly stated who evaluates whom, how and for which purpose and what will be done with the evaluation results. The purposes of evaluation may be split up into those related to “efficiency” and those related to effectiveness”. Training efficiency has been traditionally measured by some assessment of the systematic development of the individuals knowledge and skill. Quality aspect of organizing the programme are included in such efficiency evaluation. Training effectiveness has to do with the performance of a task or job in an adequate way and with personal fulfillment. Training effectiveness depends therefore on the identification of training needs, definition of training objectives and selection of the trainees. The programme may be very efficient in doing what it sets out to do, but it cannot be effective if the wrong people are attending. Therefore, the course evaluation procedures should consist, in broad terms, as follows:

● Evaluation of the course by a supervisory board
● Evaluation of participants by course management
● Evaluation of the course by participants
● Evaluation of the course by the employers of participants

5.1 Evaluation of the courses by a supervisory board

The government of the country where a course is organized (usually through the Ministry of Education) often supports a course by providing financial contributions to keep it running. Consequently, this authority obviously needs, apart from the internal self-evaluation report prepared by the course management, to carry out its own independent evaluation. This is usually done through its accreditation committee or by the university administration or by an external auditor. Such an evaluation is undoubtedly a very important procedure for course organizers because its conclusions might significantly affect the level of funding.

The evaluation concerns mainly the curriculum and syllabi of a course. In addition, it also should cover quality of teaching, the level of teaching aids and of other facilities, proportions of time allocated between lectures, exercises, laboratory and field work, etc. This kind of evaluation is entirely the responsibility of respective government. However, it would seem to
be worthwhile at this stage of evaluation to coordinate it with UNESCO or at least to provide the Secretariat of IHP with a copy of the final assessment report. The individual courses within the present system of courses sponsored by UNESCO are difficult to compare in terms of subjects to be taught, duration spent on the subjects or other aspects. Nevertheless, there is a need to bring about some order in the system and in its efficiency evaluation. In order to identify some objective criteria for the evaluation of all the courses, the set of questions in at least two following areas are proposed:

a. Teaching/learning area

- Do the curricula and syllabi of the course correspond to recent research trends in water science?
- Is the course curriculum such as to enhance the participant’s knowledge and skill in hydrology?
- Are all members of the teaching staff at the required academic/professional level?
  Are all members of the teaching staff proficient in the language of the course?
- Is there an adequate proportion of time between lectures, exercises, and other practical forms of the teaching/learning process?
- Are there enough high quality teaching materials, aids, and other facilities for participants?
- Is the proportion of participants with satisfactory results adequate for the course level?
- Is the examination level appropriate to the syllabus offered?

b. Organizational area

- Are there clear and objective criteria for selection of candidates for their enrolment?
  Which criteria are used for this?
- What is the percentage of funding of the following individual items in a course budget?
  - Fellowship and health insurance
  - Travel cost of participants
  - Accommodation costs
  - Individual tuition expenses
  - Rent for premises and facilities (if any)
  - Honoraria for lecturers
  - Cost for printing and updating of lecture notes
  - Cost of field work and study trips
  - Laboratory material, course library costs
  - Administration, etc.
  - Marketing and recruitment costs
5.2 Evaluation of participants by course management

The authors wish to emphasize that the current system of examinations, though unpopular, is considered as the essential part of an educational process and also as the clearest evaluation criterion. Such a system may consist of:

- Written and/or oral examinations
- Evaluation of individual project report
- Defence of thesis or of closing paper
- Practical field and year’s work by continuous assessment

In many UNESCO-sponsored postgraduate courses, the participant goes through the prescribed set of written examinations (tests). The series of lectures on a particular subject is usually completed at the end of term and then the teacher prepares and supervises the examination task either as open or as closed book type. These examinations give an overview on the extent to which the individual student has grasped the study material. Before the end of each term (or at the end of a course), each student goes through oral examinations where he/she proves before a faculty committee not only his/her knowledge but also the ability to make a formal oral presentation of the thesis or other individual project. The committee assesses his/her knowledge including the communication skills.

The grading system in many postgraduate courses corresponds to that used for undergraduate programmes, or at least in conformity with the grading system of similar courses offered by that university or institution. Nevertheless, some of the respondents propose to apply to the UNESCO courses one unified system additional to the standard system used by the respective institution.

5.3 Evaluation of the courses by participants

Apart from the assessment of the numbers of postgraduates turned out, an investigation was made to determine the extent to which the present system of UNESCO-sponsored courses meets the aspirations of participants. Questionnaires were used for this purpose. The responses were first published in the UNESCO Report [AYIBOTELE et al., 1988]. Further information has been received from the courses in Delft, Graz, Brussels, and Prague. The impact of the courses was generally positive. The main benefits drawn from the courses can be listed as follows:

- Knowledge and skill extension in general
- Enhancement of specialized knowledge
- Getting the broad context of hydrology and related subjects
- Promotion in one’s professional career
- Better willingness to shoulder responsibility
- Ability to use computers and advanced technology
- Incentives for further study
On the other hand, the most frequently repeated weak-points of some postgraduate courses were that:

- Courses are too short and some subjects are either missing or they should have a greater extent in hours (e.g. environmental disciplines)
- Practical exercises, laboratory and field training should be extended.

In order to have a reliable and comparative base for the assessment of the effectiveness of the courses, the authors propose an “Evaluation questionnaire”, to be dispatched to the participants after finishing the course. An example of such a questionnaire is attached in ANNEX IV.

5.4 Evaluation of the courses by employers

From the scant information available the expectations of participants are almost in coincidence with the evaluation by their employers. In general, this largely depends on information made available before a course starts and on the identification of suitable participants. Clear information is necessary for the participant’s employer who needs to make a personal policy and training programme. In this aspect, the following questions should be answered:

- Is there in agreement by the employer to give leave of absence to the participants and to utilize the new knowledge gained by the participants on the course?
- Are students who fail to meet prescribed course objectives recorded as such or is this fact softened/covered up in subsequent communications with employers?
- Is there publicity material about the course which is targeted specifically at managers and employers, distinct from that intended for participants?
- Is there a feedback mechanism or an opportunity for managers and employers to make recommendations about course content or duration?

The authors consider that a participant who has finished a postgraduate course should subsequently be able to supervise a small team of technicians and to write consistent and well argued reports on the analysis of the problems he/she is asked to investigate.

Much of the effort put into the educational programmes of courses is wasted if students who have finished the course then start a job beneath their professional level.

The authors have not made any special investigation in the area of postgraduate employment. Nevertheless, there are some published data on this [AYIBOTELE et al., 1988], [ASCE, 1990], [DOCKRELL, 1990]. The most important benefits, when postgraduates are evaluated by their employers, are usually the following:

- Increased knowledge and skills in hydrology
- Capacity to take responsibility for more advanced work
- Capacity to tackle problems
- Ability to use all range of available facilities
- Better communication skills
5.5 Conclusions

The self-evaluation of an individual course made on the national level can hardly provide an adequate basis for comparison among such international courses. It would probably be more meaningful to evaluate it on the international level, accredited by UNESCO. The lecture notes, the teaching aids, perhaps also laboratory and computational facilities, and the quality of examinations in testing the extent to which the participants are familiar with the study matter, can be the subject of such an international evaluation. The target evaluation level for a quality assessment has yet to be determined because the UNESCO-sponsored courses have grown independently and have developed in the absence of a coordinating mechanism. It is proposed that such a quality assessment initially stands as self-assessment but subsequently a coordinated procedure should be developed, executed or at least arranged for by UNESCO.

A well-defined accreditation system should then be developed in order to make the network of courses more efficient and effective. Such a system should involve a team of qualified evaluators or a group nominated by agreement between two (or more) UNESCO-sponsored courses. This team appointed by UNESCO would also nominate a group of examiners who could standardize examination questions, grading, and the granting of diplomas and certificates. If a course meets with defined minimum standards, it could be accredited as a UNESCO-sponsored course.
6. TYPES OF DIPLOMAS AND THEIR RECOGNITION

As a general rule, short-and medium-term courses lead to certificates, while long-term courses either lead to a diploma or to an academic degree. These certificates and diplomas are presently not comparable because of the lack of uniformity, but the academic degrees of M.Sc. and Ph.D. are well recognized internationally and the courses which provide these degrees have to be accredited by the national educational authority (usually by the Ministry of Education). Therefore, the procedure for getting an academic degree is clear enough and thus it is omitted in the discussion here.

The degree status clearly is a university function and this should remain so. Universities are autonomous bodies with the respective government. Another point for international courses is the endorsement by an international body which could be a NGO (Non-Governmental Organisation) like IAHS, IAH, IWRA... or a UN Agency like UNESCO, WMO... However, any accreditation as a professional hydrologist would require a world-wide accepted definition of “a hydrologist”.

Certificates, on the other hand, should be awarded to all successful participants in the short- and medium-duration courses. Certificates of attendance will be awarded in the long-term courses to those who did not do well enough to merit a diploma. For these certificates, no common criteria have been developed and are not likely to be developed. Such criteria are usually based on the academic traditions of the awarding institutions. Each certificate should clearly show the subjects taught in the course and possibly also the extent in hours.

For many participants, the question of which form of document they receive upon successful completion of their studies, whether certificate or diploma, is very important because of their future professional career and possibilities of promotion. The authors propose that the certificates and diplomas provided by the UNESCO-sponsored courses be valid in the member-countries of UNESCO and be recognized by local employers.

The problem, as seen by the Prague Workshop, is that the bulk of UNESCO-sponsored courses is considered to be of an ad-hoc character. Where they are institutionalized in a university, the university is not likely to accept suggestions from UNESCO with regard to degree or diploma.

The problem of accreditation of diplomas or degrees of UNESCO-sponsored courses might be softened if a cooperation network would be established to set standards for programmes and examination. Such network could also act as a fund-raising base to negotiate with international agencies and national donors.

The Workshop when discussing the value and validity of diploma from UNESCO-sponsored courses was concerned about the course continuity and that the system of courses now is at random. It was brought out that long-term commitments from donors and from UNESCO were required to institutionalize the course system on a solid ground and that only such which ground could serve as a base to solve the problem of accreditation of diploma. Government commitments are indispensable. In this connection, the Workshop recommended that the IHP National Committees take a strong role in the selection of course applicants and in promoting the acknowledgement of the awarded diploma within their respective country.
Any UNESCO - endorsed diploma depends on the availability of a more or less standardized course programme. For this purpose the Workshop considered the compilation of consolidated course material in form of lecture notes derived from those now in use in the existing courses. On the other hand, the Workshop also realized that each existing course hat its own character, its own priorities and that standardization was opposed to the individual character of each course. Standardized lecture notes would have to compete with the lecture notes each course has developed in conformity with its own needs and course character. The acceptance of standardized material appeared questionable to the Workshop. Hence, the question of comparable diploma probably will remain pending for the foreseeable future.
REFERENCES


IHE Delft: Programme of activities for the new hydrology section. Delft, the Netherlands. 1990.


**ANNEX I**

<table>
<thead>
<tr>
<th>Project E - 3 - 1</th>
<th>POSTGRADUATE TRAINING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OBJECTIVES</strong></td>
<td></td>
</tr>
<tr>
<td>Improvement of the system of postgraduate courses in hydrology and water resources through better topical, geographical and language distribution</td>
<td>To improve the system of UNESCO-sponsored postgraduate hydrology courses, on the basis of an evaluation report prepared during the third phase of IHP</td>
</tr>
<tr>
<td></td>
<td>To exchange experiences and improve cooperating among existing courses</td>
</tr>
<tr>
<td></td>
<td>To include environmental aspects into existing teaching program</td>
</tr>
<tr>
<td></td>
<td>To assist in making cooperative arrangements</td>
</tr>
<tr>
<td><strong>PRODUCTS</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuation and, if possible, expansion of the existing system of UNESCO-sponsored postgraduate courses</td>
</tr>
<tr>
<td></td>
<td>Better topical, geographic and language coverage</td>
</tr>
<tr>
<td></td>
<td>Transfer of know-how, cooperative agreements</td>
</tr>
<tr>
<td><strong>ACTIVITIES</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To assist in the modification of curricula and in the establishment of new courses</td>
</tr>
<tr>
<td></td>
<td>To include environmental aspect into existing teaching programmes</td>
</tr>
<tr>
<td></td>
<td>Conference of directors of the UNESCO-sponsored postgraduate hydrology courses</td>
</tr>
<tr>
<td></td>
<td>To assist in arranging for meetings between interested course directors</td>
</tr>
<tr>
<td><strong>METHOD OF IMPLEMENTATION</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consultancies to advise on curricula modifications and the establishment of new courses</td>
</tr>
<tr>
<td></td>
<td>Input by IHP/NCs</td>
</tr>
<tr>
<td></td>
<td>International symposium on Education and training in Water Resources (see E-2-1, E-4-1)</td>
</tr>
<tr>
<td></td>
<td>Information and contacts through IHP and WMO Secretariats</td>
</tr>
<tr>
<td></td>
<td>Mutual agreements between courses,</td>
</tr>
</tbody>
</table>
## ANNEX II

### Table 2: List subjects for hydrology - related study programmes
(where hydrology is a dominant topic)

<table>
<thead>
<tr>
<th>Number</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Water balance and hydrological processes</td>
</tr>
<tr>
<td>02</td>
<td>Open channel hydraulics and channel processes</td>
</tr>
<tr>
<td>03</td>
<td>Meteorology and climatology</td>
</tr>
<tr>
<td>04</td>
<td>Hydrological measurement and data processing</td>
</tr>
<tr>
<td>05</td>
<td>Hydrological statistics, time series and frequency analysis</td>
</tr>
<tr>
<td>06</td>
<td>Hydrochemistry and hydrophysics</td>
</tr>
<tr>
<td>07</td>
<td>Hydrogeology</td>
</tr>
<tr>
<td>08</td>
<td>Soil sciences</td>
</tr>
<tr>
<td>09</td>
<td>Regional hydrology and hydrology of specific areas</td>
</tr>
<tr>
<td>10</td>
<td>Fundamentals in water resources</td>
</tr>
<tr>
<td>11</td>
<td>Principles of water engineering</td>
</tr>
<tr>
<td>12</td>
<td>Fluid mechanics and hydrodynamics</td>
</tr>
<tr>
<td>13</td>
<td>Hydrological data assimilation and Information Systems</td>
</tr>
<tr>
<td>14</td>
<td>Hydrological modelling</td>
</tr>
<tr>
<td>15</td>
<td>Applied systems analysis</td>
</tr>
<tr>
<td>16</td>
<td>Reservoir sizing and operation</td>
</tr>
<tr>
<td>17</td>
<td>Hydraulic engineering</td>
</tr>
<tr>
<td>18</td>
<td>Microbiology</td>
</tr>
<tr>
<td>19</td>
<td>Limnology</td>
</tr>
<tr>
<td>20</td>
<td>Ground water dynamics</td>
</tr>
<tr>
<td>21</td>
<td>Tracer hydrology</td>
</tr>
<tr>
<td>22</td>
<td>Water supply</td>
</tr>
<tr>
<td>23</td>
<td>Urban hydrology and principles of storm drainage and sewage network</td>
</tr>
<tr>
<td>24</td>
<td>Sewage treatment and disposal</td>
</tr>
<tr>
<td>25</td>
<td>Agricultural and forest hydrology</td>
</tr>
<tr>
<td>26</td>
<td>Solid matter transport, soil conservation and erosion control</td>
</tr>
<tr>
<td>27</td>
<td>Water resources management</td>
</tr>
<tr>
<td>28</td>
<td>Control and protection of water resources</td>
</tr>
<tr>
<td>29</td>
<td>Integrated planning and Master plans</td>
</tr>
<tr>
<td>30</td>
<td>Legal and environmental aspects of water resources</td>
</tr>
</tbody>
</table>
EXAMPLE OF PREREQUISITE
INFORMATION FOR INTERUNIVERSITY COOPERATION

(VAN DER BEKEN, 1989)

1. Course general information (name, address, language, level, duration and frequency, type of institution, research training and Ph. D.-programme, admission requirements and beginning of programme.
2. Curricula and syllabi, including prerequisites or corequisites for each course and the level of content.
3. Lecture notes and other written course material.
4. Audio-visual course material like transparencies, slides films, videotapes.
5. Computer aided learning (CAL) or multimedia systems.
7. Students: number, general background, origin, fellowships, aspirations.
8. Academic staff: number, degree, origin., affiliation, specialization, funding.
9. Non-academic staff: number, affiliation, tasks, finding.
10. Time structure: semesters, holiday breaks, examination periods, thesis preparation, etc.
11. Credit system: grading system, examination procedures, grades, etc.
ANNEX IV

EVALUATION QUESTIONNAIRE
(Model proposal)

Evaluation of the course by participants
(Section 1 should be filled before the course, other sections after)

SECTION 1: Profile of respondent

1.1 What was your previous education?
   a. University you have attended?
   b. Area in which you have specialized (civil engineering, agriculture
      engineering, forestry, geology, geography, chemistry, biology, etc.)?
   c. Grade you have obtained (B.Sc., M.Sc., Ph. D., or others)?

1.2 What is your employment record after university graduation and how do the working
   requirements fit to your university knowledge?

1.3 In which professional areas do you need further education and training?

1.4 How were you informed about the course and was the information sufficient?

SECTION 2: Teaching philosophy

2.1 Indicate (in percentages) your assessment of the emphasis placed in the course curricula
   a. Facts and principles
   b. Critical thinking, analysis, problem solving

2.2 In carrying out reports in the course, indicate the importance of the following topics
   as essential, important, and unimportant:
   a. Clarity of thought
   b. Report organization and its form
   c. Use of visual aids
   d. Grammar and syntax

2.3 In solving practical hydrological problems, do you prefer using the existing software
   or rather develop your own programmes?

2.4 Were the methods used in the Course programme
   a. Modern?
   b. Conventional?
   c. Obsolete?

SECTION 3: Course programme evaluation

3.1 List subjects in the course and put the assessment as follows (the table will be helpful):
a. How did you find the content of the session
   - very useful
   - useful
   - not very useful
b. Was the time devoted to the topic
   - insufficient
   - sufficient
   - too much

3.2 Did you find the activity below as “not very useful”, “useful”, “very useful” in:
a. Training in the use of computer
b. Laboratory training
c. Field training
d. Study tours
e. Training in the language of the course

3.3 Was the time allocated to the individual forms of education
   - insufficient
   - sufficient
   - too much

3.4 Was the material presented to you in lectures, exercises, and seminars relevant to the problems to be solved
   - irrelevant
   - relevant
   - very relevant

3.5 On the whole, given the range of courses covered, did you find the length of the programme
   - too short
   - short
   - adequate
   - too long
What would be the best length:

3.6 List subject matter, skill, or techniques that you feel should have increased emphasis

3.7 List new technology areas that you feel should be introduced into water-oriented education

3.8 Give your general comments on the programme:

<table>
<thead>
<tr>
<th>Teaching aspects</th>
<th>Organizational aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>- very good</td>
<td>- well organized</td>
</tr>
<tr>
<td>- good</td>
<td>- fairly organized</td>
</tr>
<tr>
<td>- satisfactory</td>
<td>- poor organization</td>
</tr>
<tr>
<td>- unsatisfactory</td>
<td>- many weak-points</td>
</tr>
</tbody>
</table>
SECTION 4: General evaluation

4.1 How did you find relations between participants and
good average bad
- teaching staff
- other participants
- non-teaching staff

4.2 How did you find the arrangements with respect to:
good average bad
- organization
- time schedules
- room space
- service of secretariat
- library
- language use.
Please, comment:

4.3 How did you find the housing accommodation:
- good
- adequate
- unsatisfactory
Would you prefer to be housed in a University hostel?

4.4 Do you wish to keep in touch with the Course by
- newsletter, publications ?
- information about programmes ?
- personal contacts ?

4.5 Please, suggest ways and means for future cooperation between the Course and your
institution:
- research cooperation
- conferences or workshops
- contact alumni-new students
- through National Committee for IHP


**ANNEX V**

**LIST OF UNESCO-SPONSORED POSTGRADUATE COURSES**

**IN HYDROLOGY AND WATER RESOURCES**

The list below contains the UNESCO-sponsored postgraduate hydrology courses. The Division of Water Sciences supports a number of these courses financially and candidates may apply directly to the course organizer to request a fellowship or travel support. There are no other funds at UNESCO for individual hydrology fellowships except within the framework of UNESCO’s Participation Programme for which requests can only be submitted by the National Commission for UNESCO of the trainee’s country.

<table>
<thead>
<tr>
<th>Place</th>
<th>Subject of course</th>
<th>Duration</th>
<th>Frequency</th>
<th>L</th>
<th>Deadline</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADELAIDE (Australia)</td>
<td>Master programme in hydrology and water resources</td>
<td>1 year</td>
<td>annually begins in February</td>
<td>E</td>
<td>Inquire</td>
<td>Program Administrator Joint Universities’ Masters Program in Hydrology and Water Resources School of Earth Sciences Flinders University of South Australia GPO Box 2100 ADELAIDE, South Australia 5001</td>
</tr>
<tr>
<td>ANKARA (Turkey)</td>
<td>Sediment technology</td>
<td>4 weeks</td>
<td>annually begins mid-June</td>
<td>E</td>
<td>10 April</td>
<td>Dr Ergun Demiroz DSI Teknik Arastirma ve Kalite Kontrol Daiser Baskanligi 06100 ANKARA</td>
</tr>
<tr>
<td>ARGENTINE: Buenos Aires, Santa Fé, Mendoza, San Juan</td>
<td>General hydrology with emphasis on the environment</td>
<td>6 months</td>
<td>Inquire</td>
<td>S</td>
<td>Inquire</td>
<td>Director del Curso Comité Nacional para el Programa Hidrológico Internacional Av. 9 de Julio 1925- 15° Piso 1332 BUENOS AIRES</td>
</tr>
<tr>
<td>BARCELONA (Spain)</td>
<td>Groundwater hydrology</td>
<td>6 months</td>
<td>annually, begins in January</td>
<td>$</td>
<td>30 Sept.</td>
<td>Curso Internacional de Hidrología Subterránea Calle Beethoven 15, 3° 08021 BARCELONA</td>
</tr>
<tr>
<td>BELGIUM (Brussels / Leuven)</td>
<td>Water resources engineering</td>
<td>2 years</td>
<td>annually, begins mid-September</td>
<td>E</td>
<td>As soon as possible</td>
<td>Interuniversity Programme in Water Resources Engineering Prof. A. Van der Beken Vrije Universiteit Brussel Laboratory of Hydrology Pleinlaan, 2 B-1050 BRUSSELS or Institute for Land and Water Management Katholieke Universiteit Leuven Vital Decosterstraat 102 3000 LEUVEN</td>
</tr>
</tbody>
</table>

*E = English, F = French, P = Portuguese, R = Russian, S = Spanish*
<table>
<thead>
<tr>
<th>Location</th>
<th>Subject</th>
<th>Duration</th>
<th>Special Announcements</th>
<th>Mode</th>
<th>Inquirer Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIRMINGHAM</td>
<td>Water resources engineering in developing countries</td>
<td>9 months</td>
<td>special announcements</td>
<td>E</td>
<td>The Graduate School Secretary School of Civil Engineering University of Birmingham P.O. Box 563 BIRMINGHAM B15 2TT</td>
</tr>
<tr>
<td>BUDAPEST</td>
<td>Hydrology</td>
<td>6 months</td>
<td>annually, from January</td>
<td>E</td>
<td>Dr. G. Kienitz Research Centre for Water Resources Development (VITUKI) International Postgraduate Course in Hydrology, P.O. Box 27 H-1453 BUDAPEST '92</td>
</tr>
<tr>
<td>CAIRO</td>
<td>Environmental hydrology for arid and semi-arid zones</td>
<td>2 months</td>
<td>annually, May-June</td>
<td>E</td>
<td>Prof. Dr. Mostafa M. Soliman Course Manager International Course on Hydrology for Arid and Semi-arid Regions P.O. Box 5218 Heliopolis-West, CAIRO</td>
</tr>
<tr>
<td>CRICA</td>
<td>Changing subjects (for subject and date inquire with organizer)</td>
<td>several courses per year in cliff countries</td>
<td>annually</td>
<td>S</td>
<td>Ing. Juan Luis Guzmán Coordinator General del CRICA Esc. Regional de Ingen. Sanitaria Univ. de San Carlos de Guatemala Ciudad Universitaria, Zona 12 GUATEMALA</td>
</tr>
<tr>
<td>DAR-ES-SALAAM</td>
<td>Water resources engineering</td>
<td>18 months</td>
<td>annually, begins in October</td>
<td>E</td>
<td>Mr. F.W. Mtalo Disciplinary Area Coordinator for Water Resources Engineering P.O. Box 35131 DAR-ES-SALAAM</td>
</tr>
<tr>
<td>DELFT</td>
<td>Hydrology, with specialization in: - surface water - groundwater - water resources management</td>
<td>11 or 18 months</td>
<td>annually starting in October</td>
<td>E</td>
<td>IHE Westvest 7 P.O. Box 3015 2601 DA DELFT</td>
</tr>
<tr>
<td>GALWAY</td>
<td>Hydrology</td>
<td>1 year</td>
<td>annually, begins in October</td>
<td>E</td>
<td>Dr. K.M. O’Connor Department of Engineering Hydrology University College Galway GALWAY</td>
</tr>
<tr>
<td>GRAZ</td>
<td>Groundwater tracing techniques</td>
<td>5 weeks</td>
<td>1995, 1997, etc. begins in August</td>
<td>E</td>
<td>Dr. H. Zojer Postgraduate Training Course on Groundwater Tracing Techniques Institute for Geothermics and Hydrogeology Elisabethstrasse 16/II A-8010 GRAZ</td>
</tr>
<tr>
<td>GUATEMALA</td>
<td>Hydraulic resources</td>
<td>1 week</td>
<td>annually, begins end September</td>
<td>$</td>
<td>Ing. Arturo Pares S., Director Escuela Regional de Ingeniería Sanitaria y Recursos Hidráulicos Facultad de Ingeniería Ciudad Universitaria, Zona 12 GUATEMALA CITY</td>
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</table>

*E = English, F = French, P = Portuguese, R = Russian, S = Spanish*
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<thead>
<tr>
<th>Location</th>
<th>Program Description</th>
<th>Duration</th>
<th>Start Date</th>
<th>Language</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>KENSINGTON</td>
<td>Hydrology, covering principles, practice and applications of surface and ground water hydrology</td>
<td>3 months annually</td>
<td>December</td>
<td>E</td>
<td>Course Director Graduate Course in Hydrology School of Civil Engineering The University of New South Wales P.O. Box 1 KENSINGTON New South Wales 2033</td>
</tr>
<tr>
<td>LAHORE</td>
<td>Water resources management. Various options: - post-graduate - M. Sc. - M. Phil</td>
<td>12 mo. 16-1/2 mo. 2 years annually</td>
<td>September</td>
<td>E</td>
<td>30 June The Director Centre of Excellence in Water Resources Engineering University of Engineering and Technology LAHORE 31</td>
</tr>
<tr>
<td>LAUSANNE</td>
<td>Hydrology</td>
<td>15 months annually, begins in October</td>
<td>May</td>
<td>F</td>
<td>Cycle postgraduate inter-universitaire en hydrologie et hydrogéologie EPFL-IAE CH-1015 LAUSANNE</td>
</tr>
<tr>
<td>NEUCHATEL</td>
<td>Hydrogeology</td>
<td>15 months annually, begins in October</td>
<td>May</td>
<td>F</td>
<td>Cycle postgraduate inter-universitaire en hydrologie et hydrogéologie CHYN 11, rue Emile-Argand CH-2007 NEUCHATEL</td>
</tr>
<tr>
<td>LISBON</td>
<td>Operational hydrology</td>
<td>2 months annually</td>
<td>September</td>
<td>P</td>
<td>Curso Internacional de Hidrologia Operativa Direcção-Geral dos Recursos Naturais Av. Almirante Gago Coutinho, 30 1000 LISBOA</td>
</tr>
<tr>
<td>MADRAS</td>
<td>Hydrology and water resources engineering</td>
<td>1 year annually</td>
<td>May</td>
<td>E</td>
<td>Centre for Water Resources College of Engineering Anna University 600025 MADRAS</td>
</tr>
<tr>
<td>MADRID</td>
<td>General and applied hydrology</td>
<td>6 months annually</td>
<td>June</td>
<td>S</td>
<td>Centro de Estudios y Experimentación de Obras Públicas Alfonso XII, Num. 3 MADRID 28014</td>
</tr>
<tr>
<td>MONASH</td>
<td>Hydrology and water sciences</td>
<td>1 year annually</td>
<td>December</td>
<td>E</td>
<td>Course Director Dept. of Civil Engineering Monash University Clayton 3168 VICTORIA</td>
</tr>
<tr>
<td>MONTPELIER</td>
<td>Hydrogeology of fissured rocks</td>
<td>2 weeks</td>
<td>September</td>
<td>F</td>
<td>Inquire CREUFOP (J.C. Legars) 99, Avenue d’Occitanie 34096 MONTPELIER Cedex 5</td>
</tr>
<tr>
<td>MOSCOW</td>
<td>1995: Scientific and engineering limnology</td>
<td>2 months annually</td>
<td>June</td>
<td>E</td>
<td>28 Febr. International Higher Hydrological Course Geography Department Moscow State University Lenin Hills MOSCOW 119899</td>
</tr>
</tbody>
</table>

*E = English, F = French, P = Portuguese, R = Russian, S = Spanish*
<table>
<thead>
<tr>
<th>Location</th>
<th>Course</th>
<th>Duration</th>
<th>Start/End</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAIROBI (Kenya)</td>
<td>Hydrology</td>
<td>9 months</td>
<td>annually begins</td>
<td>The Principal, Institute for Meteorological Training &amp; Research</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>September</td>
<td>Dagoretti Corner</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15 July</td>
<td>Ngong Road</td>
</tr>
<tr>
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<td></td>
<td>P.O. Box 30259</td>
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<td></td>
<td></td>
<td></td>
<td>NAIROBI</td>
</tr>
<tr>
<td>NANJING (China)</td>
<td>Hydrology (advanced)</td>
<td>2 months</td>
<td>Special</td>
<td>International Activities Office</td>
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<tr>
<td></td>
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<td></td>
<td>announce-ments</td>
<td>East China Technical University</td>
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<td></td>
<td>of Water Resources</td>
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<td></td>
<td></td>
<td>1. Xikang Road</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>NANJING 210024</td>
</tr>
<tr>
<td>NEWCASTLE-UPON-TINE</td>
<td>(a) Hydrology</td>
<td>1 year</td>
<td>annually begins</td>
<td>The Registrar</td>
</tr>
<tr>
<td>(United Kingdom)</td>
<td>(b) Water resources</td>
<td></td>
<td>October</td>
<td>Department of Civil Engineering</td>
</tr>
<tr>
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*E = English, F = French, P = Portuguese, R = Russian, S = Spanish*
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