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To CONACyT and DAAD.

To my Supervisory Committee.

To my parents.

To my “flohlich”.

To God.

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List of Abbreviations

BMP	Best Management Practices
CBA	Cost Benefit Analysis
CIS	Common Implementation Strategy
DPSIR	Driving Forces, Pressures, States, Impacts and Responses
EQS	Environmental Quality Status
EU	European Union
GIS	Geographic Information Systems
MCDA	Multi-criteria Decision Analysis
NPS	Non Point Source
UNFCCC	United Nations Framework Convention on Climate Change
UKTAG	United Kingdom Technical Advisory Group
WFD	Water Framework Directive
WMP	Watershed Master Plan

Executive Summary

A watershed is an important unit for development, which is not only environmental but also social and economical. Due to this, the main task is managing the watershed the most efficiently as possible. Thus, the watershed management is a process of creating and implementing plans, programmes and projects regarding to watersheds. Within this process, the development of a master plan is one of the most important steps and the main focus of this work.

The Watershed Master Plan (WMP) is a process of developing a plan that includes structured sets of actions and priority measures to control the environmental degradation processes and the use of natural resources for productive purposes. Its goal will be to achieve forms of sustainable development in the medium and long term.

In general terms, the processes which affect a watershed usually are: river flow regime, erosion, sedimentation, water quality degradation, ecology modifications and human impacts.

In addition, the main content of a WMP should include a description of the current and desired conditions, environmental objectives, program of measures and a cost analysis. The current condition of the watershed is obtained through an environmental status classification of the following quality elements:

- Hydro geomorphological quality elements such as hydrological regime and river continuity,
- Physico-chemical quality elements such as pollutants, pH values, dissolved oxygen and nutrients,
- Biological quality elements such as macrophytes, phytobenthos, invertebrate fauna and fish fauna.

After obtaining a diagnose of the watershed and its environmental quality status, it is possible to determine the main measures and an action plan to be implemented. First, the environmental objectives have to be established. These objectives are:

- Prevention of water bodies deterioration,
- Enhancement and restoration of all protected areas,
- Protection of threatened and endangered species,
- Estimation of current and future pollutants sources and loads.

Then, in order to achieve all objectives, priority measures have to be determined. These measures are:

- Structural measures such as source control measures, new regional facilities, stream erosion and velocity controls,
- Non-structural measures such as land use controls, public education programmes and municipal measures,
- Quantitative measures such as GIS databases.

And finally, a cost analysis has to be done for making a priority classification to the measures, which will be implemented within the WMP. This analysis could be, whether a cost-benefit analysis, a multi-criteria decision analysis or optimization analysis. Any of them would help all stakeholders to improve the decision making process.

KEY WORDS: Watershed, watershed master plan, quality elements, environmental quality status, priority measures.

Resumen Ejecutivo

Una cuenca es una unidad importante de desarrollo, no solo ambiental sino también de desarrollo económico y social. Debido a esto, debe ser manejada de la forma más eficiente posible y esta es la principal tarea del manejo de cuencas. Así, el manejo de cuencas es el proceso de crear e implementar planes, programas y proyectos referentes a cuencas. Dentro de este proceso, el desarrollo del plan maestro de manejo de cuencas (PMMC) es uno de los pasos más importantes y el principal enfoque de este trabajo.

El PMMC es el proceso de desarrollar un plan que incluya un conjunto de acciones y medidas prioritarias para controlar los procesos de degradación ambiental y el uso productivo de los recursos naturales. Su meta será alcanzar formas de desarrollo sustentable tanto a mediano como a largo plazo.
En términos generales, los procesos que afectan el funcionamiento de una cuenca usualmente son: variantes del régimen del flujo en ríos, erosión, sedimentación, degradación de la calidad de agua, modificaciones ecológicas e impactos antropogénicos.

Asimismo, el contenido principal de un PMMC debe incluir una descripción de las condiciones actuales y las condiciones deseables de la cuenca, los objetivos ambientales, el programa de medidas y un análisis de costos. La condición actual de la cuenca es obtenida a través de una clasificación del estado ambiental de los siguientes elementos de calidad:

- Elementos de calidad hidrogeomorfológica como régimen hidrológico y continuidad de los ríos,
- Elementos de calidad fisicoquímica como contaminantes, pH, oxígeno disuelto y nutrientes,

- Elementos de calidad biológica como macrofitos, fitobentos, fauna invertebrada y peces en general.

Después de haber realizado el diagnóstico de la cuenca y haber obtenido el estado de calidad ambiental, es posible determinar las medidas principales y el plan de acción a ser implementado. En primer lugar, deben ser establecidos los objetivos ambientales, los cuales son: prevenir el deterioro de los cuerpos de agua tanto superficiales como subterráneos, mejorar y restaurar todas las áreas protegidas, proteger las especies amenazadas y en peligro de extinción y estimar las actuales/futuras fuentes y cargas de contaminantes.

Seguidamente, para alcanzar dichos objetivos, deben ser determinadas las medidas prioritarias que serán implementadas. Estas medidas son las siguientes:

- Medidas estructurales como medidas de control, erosión por corriente y control de velocidad,
- Medidas no estructurales como control del uso de tierra, programas de educación pública y medidas municipales,
- Medidas cuantitativas como bases de datos obtenidas a partir de procesamiento en software de sistemas de información geográfica.

Y finalmente, para priorizar las medidas a ser implementadas dentro del PMMC, debe ser realizado un análisis de costos, ya sea un análisis de costo-beneficio, un análisis de decisión multi-criterio o un análisis de optimización. Cualquiera de ellos ayudará a todas las partes interesadas a mejorar el proceso de toma de decisiones.

PALABRAS CLAVE: Cuenca, plan maestro de manejo de cuencas, elementos de calidad, estado de calidad del medio ambiente, medidas prioritarias.

Zusammenfassung

Ein Flussgebiet ist ein wichtiger Baustein für die Entwicklung der Umwelt, für die Wirtschaft und die soziale Entwicklung. Aus diesem Grund ist eine höchst effiziente Verwaltung des Flussgebietes die Hauptaufgabe. Folglich ist die Verwaltung des Flussgebietes ein Prozess der Erstellung und Umsetzung von Plänen, Programmen und Projekten in Bezug auf Flussgebiete. Innerhalb dieses Prozesses ist die Entwicklung eines Masterplans einer der wichtigsten Schritte und der Schwerpunkt dieser Arbeit.

Der Masterplan des Flussgebiets (MdF) ist ein Prozess der Entwicklung eines Plans welcher die strukturierten Aktionen und wichtigen Maßnahmen umfasst um die Umweltzerstörungen und die Nutzung der natürlichen Ressourcen für produktive Zwecke zu kontrollieren. Sein Ziel wird es sein Formen der nachhaltigen Entwicklung auf mittel- und langfristige Sicht zu erreichen. Allgemein aufgeführt sind die Prozesse welche ein Flussgebiet in der Regel beeinflussen: Flussregimes, Erosion, Sedimentation, Qualitätsminderung des Wassers, Veränderungen der Ökologie und menschliche Einflüsse.

Darüber hinaus sollten die wichtigsten Inhalte eines MdF aus einer Beschreibung der aktuellen und gewünschten Bedingungen, den ökologischen Zielen, einem Maßnahmenprogramm und einer Kostenanalyse bestehen. Der aktuelle Zustand des Flussgebiets wird durch eine Einstufung der folgenden Qualitätskomponenten der Umwelt erreicht:

- Hydro morphologische Qualitätskomponenten wie hydrologische Regime und Durchgängigkeit des Flusses,

- Die physikalisch-chemischen Qualitätskomponenten wie Schadstoffe, pH-Wert, gelöster Sauerstoff und Nährstoffe,
- Biologische Qualitätskomponenten wie Makrophyten, Phytobenthos, wirbellose Fauna und Fischbestand.

Nach Erhalt einer Diagnose des Flussgebiets und des Qualitätsstatus der Umwelt ist es möglich, die wichtigsten Maßnahmen und einen Aktionsplan zur Umsetzung zu bestimmen. Zuerst müssen die Umweltziele festgelegt werden. Diese Ziele sind:

- Verhinderung von Gewässerverschlechterung,
- Erweiterung und Sanierung aller Schutzgebiete,
- Schutz von bedrohten und gefährdeten Arten,
- Einschätzung der aktuellen und zukünftigen Schadstoffquellen und -belastung.

Danach müssen vorrangige Maßnahmen ermittelt werden um alle Ziele zu erreichen. Diese Maßnahmen sind:

- Strukturelle Maßnahmen wie Maßnahmen an der Quelle, neue regionale Einrichtungen, Stromerosion und Geschwindigkeitskontrolle,
- Nicht-strukturelle Maßnahmen wie Kontrolle der Landnutzung, der öffentlichen Bildungsprogramme und der kommunalen Maßnahmen,
- Quantitative Maßnahmen wie GIS-Datenbanken.

Letztendlich hat eine Kostenanalyse zu erfolgen welche zur Herstellung einer Einstufung der Prioritätsmaßnahmen dient, die innerhalb des MdF umgesetzt werden kann. Diese Analyse könnte entweder eine Kosten-Nutzen-Analyse, eine Multi-Criteria-Decision-Analyse oder eine Optimierungsanalyse sein.

Jede von ihnen würde allen Beteiligten helfen die Entscheidungsfindung zu verbessern.

SCHLÜSSELWÖRTER: Flussgebiet, der Masterplan des Flussgebiets, Qualitätskomponenten, Qualitätstatus der Umwelt, wichtige Maßnahmen.

1 Introduction

The present master thesis presents a research which will be about prioritization measures within the watershed management master plan. Section 2 presents the justification of my master thesis. Section 3 offers the general objective and specific objectives proposed. Section 4 details the methodology which will be use in order to achieve my objectives. Section 5 provides a basic conceptual framework about watersheds, watershed management and watershed master plan, with the aim of having an outlook for understanding what it is described later on. Section 6 includes information about river basin management, basically the river basin management process and the main processes which watershed face on. Also describes the watershed assessments, which are the necessary elements that have to be analyzed to obtain an assessment of a watershed, besides the river basin management objectives and the plan of measures. Section 7 makes a summary of the river basin measures and which are the measures that are usually included in a watershed master plan. Section 8 is about measures prioritization and decision making process. Within this category are the cost-benefit analysis, the multi-criteria decision analysis and the optimization. Section 9 presents the conclusion of this work and section 10 supplies the references used in the elaboration of this document.

2 Justification

Watersheds are the physic units in which take place all natural processes, and are also natural and logical units for environmental, agricultural and socio-economic developing (USAID, 1999), due to this importance, watersheds must be taken in consideration within those units. For this reason, watershed master plans have to consider all issues whose impacts influence those developments.

Generally, watershed master plans describe the necessary measures, but not whether they are the most efficient and how they interact and influence each other. For instance, it has been given the case of affecting one measure by implementing another and this situation is trying to be avoided for a good watershed management.

Due to the mentioned above, the main purpose of the present master thesis is the compilation of priority measures with decision making instruments which would provide substantial support and improvements to the watershed master plan and by consequence improvements to the watershed management.

3 Objectives

3.1 General Objective

Compilation of the priority measures for watershed master plans with the correspondent decision making instruments.

3.2 Specific Objectives

- Make a literature review about watershed management.
- Identify the watershed management process.
- Investigate about the development of a watershed master plan.
- Identify the quality elements in a watershed which must be analyzed with the aim of finding the current conditions of the watershed and thus the areas with main problems.
- Describe the structural, non-structural and quantitative measures within the watershed master plan.
- Analyze the relevance of implementing those measures and how they intervene in the decision making process.

4 Methodology

Due to the fact that this is a methodological work, the method to be used consists in literature review, analysis and classification of the information in order to make a compilation of the main and necessary measures within the watershed master plan. This is with the purpose of collecting the priority data for having a better understanding regarding the functioning of a watershed master plan. In addition, this would help to develop a tool which provides a better clarity and efficiency of the watershed master plan.

It is intended also to make an overview of the main processes which affect a watershed and to see what measures have been used so far and how those measures have been whether successful or not in mitigating or solving the problems. Moreover, to describe which elements need to be analyzed to find the actual state of a watershed and the content of a master plan.

5 Conceptual Framework

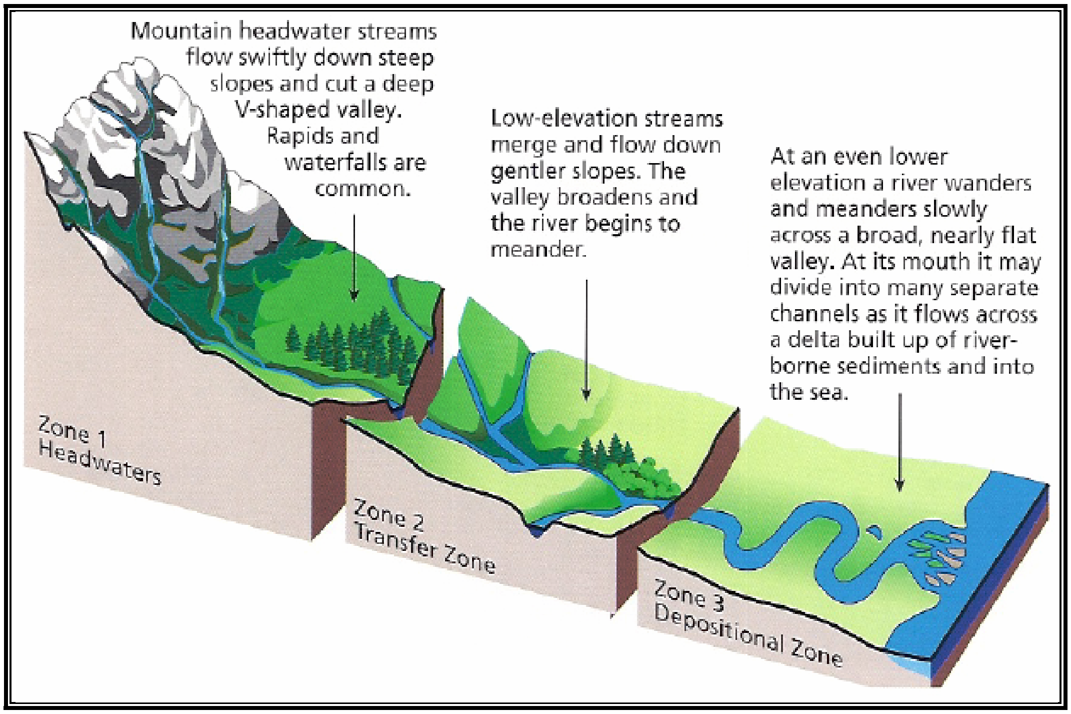
5.1 Watershed

The term watershed can be described as the geographic area of land that drains water down slope to a defined destination along a stream, which usually is a river basin (USDA, 2001). The water moves through a network of drainage pathways, not only on the surface but also underground. These drainages become gradually larger as the water moves downstream. A watershed is also considered as a biological, physical, economic and social system too.

The boundary of a watershed is defined by topography, which means the highest elevations surrounding the watercourse. A larger watershed might be formed by small watersheds; this means that every stream, tributary, or river has an associated watershed. By using topographic maps is easy to delineate a watershed. However each one is formed by three main areas (Jain, 2004), as shows Figure 1:

- Catchment area or recharge zone (headwaters)
- Command area or transition zone (transfer zone)
- Delta area or discharge zone (depositional zone)

Figure 1: Zones in a Watershed

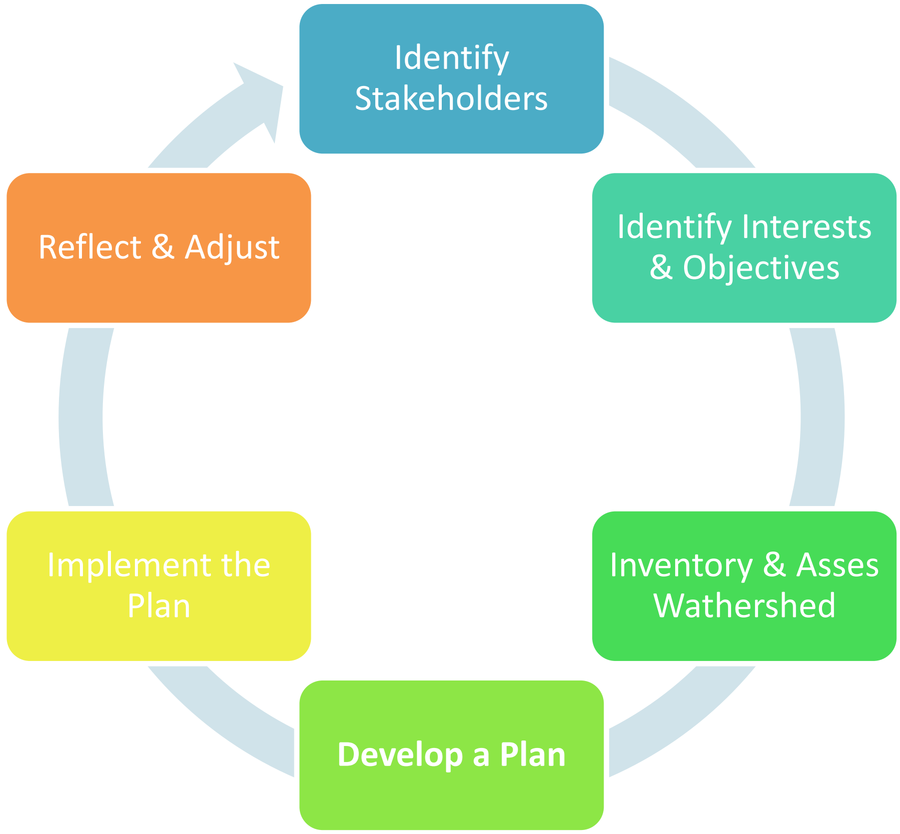


Source: Miller, 1990. Wadsworth Publishing Co.

5.2 Watershed Management

The watershed management is the process (Figure 2) of creating and implementing plans, programmes, and projects regarding to the watersheds. The watershed managements aims to sustain and enhance watershed functions that provide the goods, services and values desired by the community affected by conditions within a watershed boundary (Eliot, 2008). The watershed management compares the current conditions with the desired conditions, due to this the watershed master plan charts a path for closing this gap between actual and desired watershed conditions (Bowker, 2008).

Figure 2: Watershed Management Process



Source: Adapted from: (Bowker, 2008)

The fundamental steps from watershed analysis are the following:

a) Identify issues, describe desired conditions, and formulate key questions.
b) Identify key processes, functions, and conditions.
c) Stratify the watershed.
d) Assemble analytic information needed to address the key questions.
e) Describe past and current conditions.
f) Describe condition trends and predict effects of future land management.
g) Integrate, interpret, and present findings.
h) Manage, monitor, and revise information.

Meanwhile the basic products expected from watershed management are the following:

a. A description of the watershed including its natural and cultural features.
b. A description of the beneficial uses and values associated with the watershed.
c. When supporting data allow, statements about compliance with water quality standards.
d. A description of the distribution, type, and relative importance of environmental process.
e. A description of the watershed's present condition relative to its associated values and uses.
f. A map of interim conservation areas.

As mentioned before, the watershed management process usually starts defining the stake holders, the objectives and interests in order to make an inventory and assessment of the watershed applying the principles of management at watershed scale (Table 1) before develop a master plan.

Table 1: Principles for Management at the Watershed Scale

Use an ecological approach that would recover and maintain the biological diversity, ecological function, and defining characteristics of natural ecosystems.
Recognize that humans are part of ecosystems-they shape and are shaped by the natural systems: the sustainability of ecological and societal systems are mutually dependent.
Adopt a management approach that recognizes ecosystems and institutions are characteristically heterogeneous in time and space.
Integrate sustained economic and community activity into the management of ecosystems.
Develop a shared vision of desired human and environmental conditions.
Provide for ecosystem governance at appropriate ecological and institutional scales.
Use adaptive management as the mechanism for achieving both desired outcomes and new understandings regarding ecosystem conditions.
Integrate the best science available into the decision-making process, while continuing scientific research to reduce uncertainties.
Implement ecosystem management principles through coordinated government and non-government plans and activities.

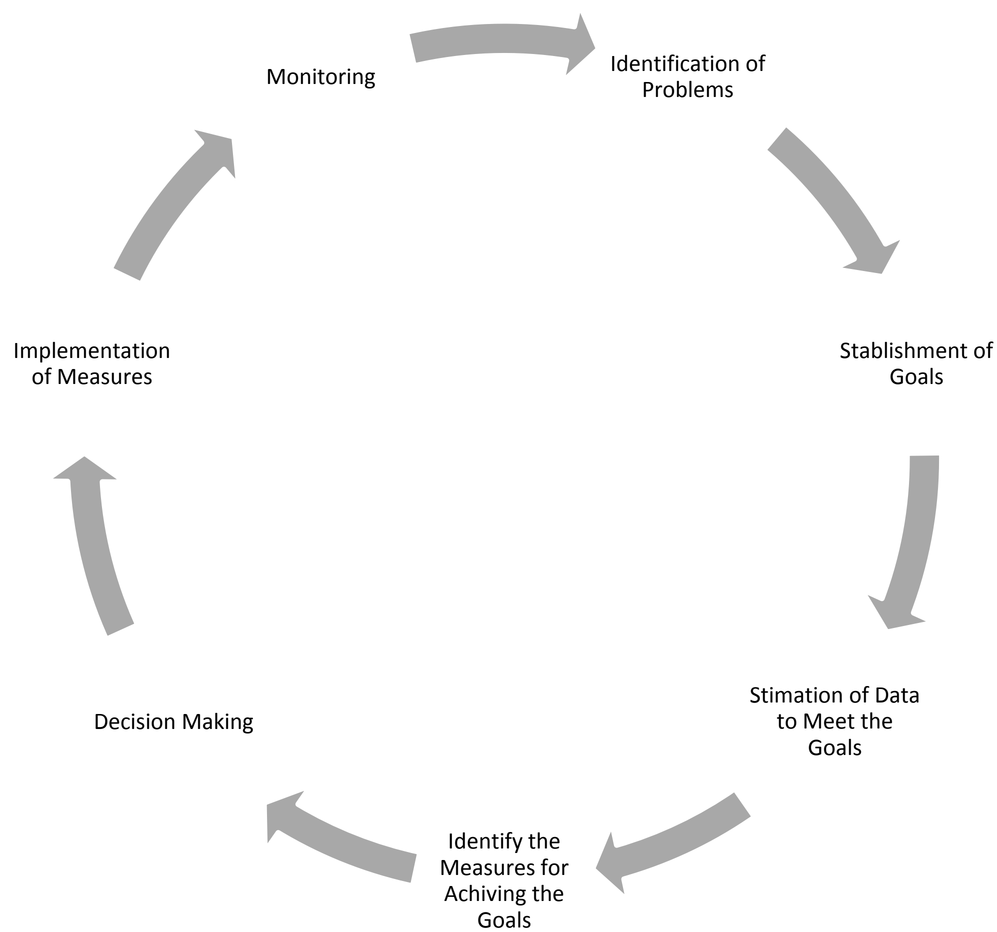
Source: Adapted from the US MAB, 1994. **(Naiman, et al., 1997)**

5.3 Watershed Master Plan

Within the watershed management there is the watershed master plan, which is a process of developing a plan that includes structured sets of actions and priority measures to control the environmental degradation processes and the use of natural resources for productive purposes and its goal will be achieve forms of social, economic and environmentally sustainable development in the medium and long term (Morales Mendoza, 2003).

Also is a tool for managing existing and future watershed conditions, including land use planning and potential impacts on surface water quality (McCarthy, 2010). For instance, the process of developing a watershed master plan (Figure 3) can be described in general terms as following: first it must be identified the existing problems, then it has to be established quality goals for estimating the data and information to meet quality goals or reference values, and finally it has to be identified the actions needed to achieve the goals. Watershed management plans prioritize recommended actions based on cost/benefit analysis, and set an implementation timeline (McCarthy, 2010).

Figure 3: Watershed Management Master Plan Process



Among others, the master plan:

- Specifies the management objectives.
- Establishes the set of measures necessary to achieve its objectives, and how success will be measured.
- Describes potential sources of funding that may be available to carry out components of the plan.
- Should not be confused with the actions required to implement it.

Moreover, the content of the river basin watershed master plan are shown in the following table, according to the WFD. And for more details about elements that shall be cover within the river basin management plan see attachment 1.

Table 2: Contents of the River Basin Management Plan

□ General description of the characteristics of the river basin district, including a map showing the location and boundaries of surface water bodies and groundwater bodies and a map showing the different surface water body types within the river basin.
□ Summary of significant pressures and impact of human activity on the status of surface water and groundwater, including estimations of point source pollution, diffuse source pollution (including a summary of land-use) and pressures on the quantitative status of water including abstractions, and an analysis of other impacts of human activity on the status of water.
□ Map identifying protected areas.
□ Map or the monitoring network.
□ Presentation in map of the results of the monitoring programmes showing the ecological and chemical status of surface water, the chemical and quantitative status of groundwater and the status of protected areas.
□ List of the environmental objectives established for surface waters, ground waters and protected areas, including where use has been made of the derogations.
□ Summary of the economic analysis of water use.
□ Summary of the program or programmes of measures.

Register of any more detailed programmes and management plans and a summary of their contents.
Summary or the public information and consultation measures taken, their results and the changes to the plan as a consequence.
List of competent authorities.
Contact points and procedures for obtaining background documentation and information, including actual monitoring data.

Source: (European Commission, 2003)

Watershed management plans are used by municipal governments, conservation districts, local watershed groups, and other interested stakeholders, to plan for future land use and develop zoning ordinances in a way that is protective of water quality.

Additional potential uses of the watershed management plan are (McCarthy, 2010):

- Documenting existing water quality characteristics to serve as a baseline for future comparison.
- Predicting water quality responses to land use changes and development activities over time.
- Quantifying environmental impact from land uses changes, land development, or similar activities.
- Establishing a monitoring program to determine trends in water quality over time.
- Assessing watershed response to management activities.
- Establishing watershed restoration design and monitoring activities.
- Design of best management practices.
- Development of land use regulations.
- Regulatory permitting decisions

- Building local capacity for watershed protection and management.

For instance, the attachment 2 gives a brief overview of key elements for watershed master plan. Which after its development, should be implemented and then has to be checked how those measures are working and see whether the watershed functioning is the most efficient or not in order to make reflects and necessary adjustments.

6 River Basin Management

6.1 River Basin Management Process

A well-crafted and implemented watershed management master plan is arguably the best and most comprehensive tool to protect watersheds, especially urban streams and riparian corridors from the cumulative impacts of new land development and existing urbanization (Harness, 2005). A master plan should have measures and actions to combat the main processes which affect a watershed, which might be the following:

6.1.1 River flow regime

This can be decreased by dry weather or increased by storms. In the first case, base flow is minimal during extended periods of dry season. Urbanization within the watershed resulted in the loss of wetlands and surface depression storage that formerly acts as watershed sponges. Urbanization also results in a loss of connectivity between stream channels and their adjacent floodplains. In the second case, base flow increases due to storms resulting in larger run-off volumes and peak flows during these events. Floods are another consequence of storms as well.

6.1.2 Erosion

Urbanization within watersheds degrades the natural morphology of streams. In the same way increased storm runoff volumes and flow velocities impact stream channels, make them deeper and separate natural connections between channels and their respective flood plains.

Meanwhile increased urban runoff and associated erosion result in the loss of natural channel meanders, increase of channel slopes and stream velocities.

6.1.3 Sedimentation

This is the main source of water quality degradation. Soil, sand and other solids flow into rivers and lakes when it rains. Sediment harms fish and bottom dwelling organisms besides reducing water clarity.

6.1.4 Water quality

Urbanization within watersheds has introduced water quality constituents that may affect in-stream water quality. For instance, heavy metals, deicing salts, and other water quality constituents are washed into streams and nutrients are washed from lawns in the urbanized portions of the watershed, in this zone floatable material from littering and animal wastes are problems as well. Water quality is affected too by municipal and domestic wastewater. In addition nitrogen and phosphorous from fertilizers contribute to high levels of nutrients which result in algal blooms and this reduces the amount of dissolved oxygen for aquatic fauna.

6.1.5 Ecology

Watershed vegetation presents impacts on the biodiversity of plan species, for instance invasion of exotic species, lack of wetland and streamside vegetation.

6.1.6 Human impacts

Human impacts are one of the most important pressures within a watershed, for instance one of them is urbanization processes. Urbanization within watersheds can significantly stress and limit available aquatic and riparian habitat. Some impacts which have been identified from urbanization are changes on stream quantity and quality and mowing stream channel banks.

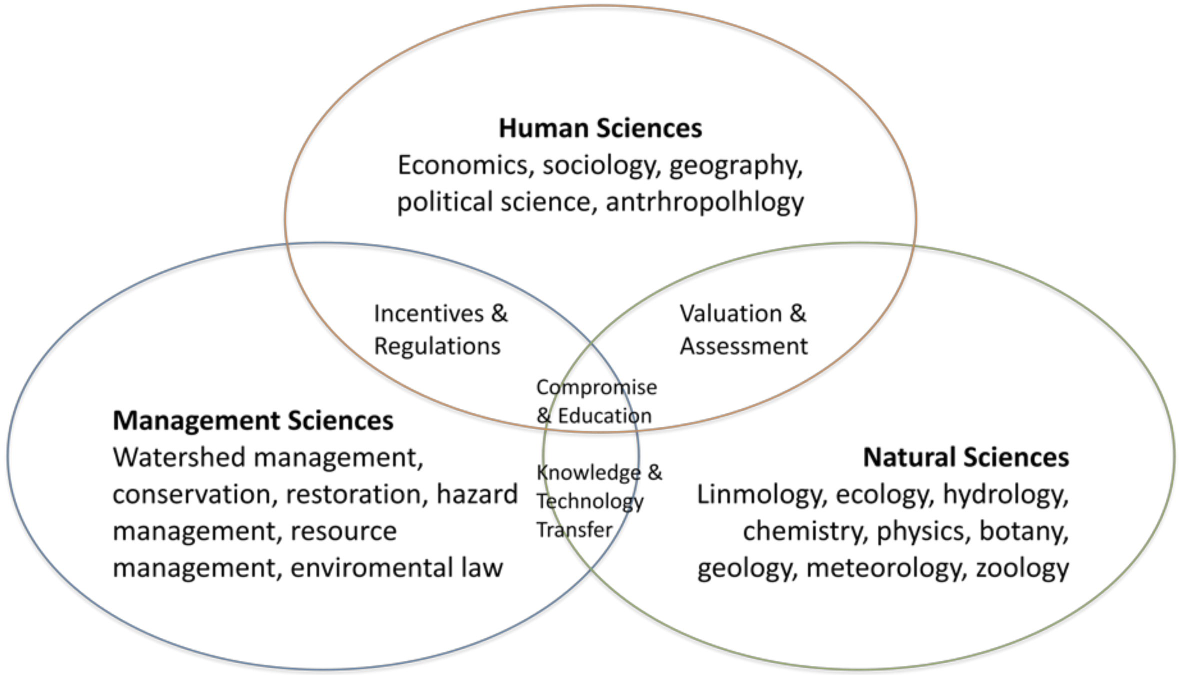
6.2 Watershed Assessment

It is important to establish a reference that characterizes the relatively unimpaired conditions of a watershed. The reference conditions provide a basis for making comparisons between the currents conditions and the desired conditions. Because of that effective management recognizes the mutually dependent interaction of various basic elements of a watershed system (Eliot, 2008); some examples of them are the following:

- Hydrology: precipitation and flow
- Biology: flora, fauna, ecosystems
- Geology: landforms, soils, sedimentation, topography
- Sociology: culture, economics, history

Those are some few examples of the elements within each category. But Figure 4 shows the interaction between not only human and natural sciences but also management sciences. We can more sciences that the mentioned before, since nowadays all of them are important if we want to have a correct management of the watershed.

Figure 4: Interface between Human, Management and Natural Sciences



Source: (Naiman, et al., 1997)

An assessment of a watershed includes a series of studies and monitoring of quality elements which are important agents within the watershed and factors of which the functioning of the watershed depend on. If it is intended to make an assessment of a watershed, the following quality elements should be checked in order to make an analysis of the current conditions (Harness, 2005) and establish an ecological status:

- Hydro-morphological quality elements
- Physico-chemical quality elements
- Biological quality elements

6.2.1 Hydro-geomorphological quality elements

Hydrological regime and river continuity are examples of hydrological quality elements.

The goal of developing an assessment in morphological quality elements is to obtain a coherent process-based, dynamic picture of how everything is connected, how processes create and modify morphology within the watershed and understand apparent trends (Eliot, 2008). For instance, sinuosity, migration rate, number of channels and floodplain drainage density are examples of this category.

Table 3: Hydrological and Tidal Regime

Rivers	Lakes	Transitional waters	Coastal waters
Quantity and dynamics of water flow	Quantity and dynamics of water flow	Freshwater flow	Direction and speed of dominant currents
Connection to groundwater	Residence time		
	Connection to groundwater		

Table 4: Morphological Conditions

Rivers	Lakes	Transitional waters	Coastal waters
River continuity	Lake depth variation	Depth variation	Depth variation
River depth and width variation	Quantity, structure and substrate of lake bed	Quantity, structure and substrate of the estuarine bed	Quantity, structure and substrate of the coastal bed
Structure and substrate of river bed	Structure of lake shore	Structure of the inter tidal zone	Structure of the inter-tidal zone
Structure of the riparian zone		Wave exposure	Direction of dominant currents
			Wave exposure

6.2.1.1 The Geomorphologic Characteristics of a Watershed

For the study and identification of geomorphologic parameters is needed cartographic information on topography, land use and permeability of the region under study. The plans for these analyses are used in scales from 1:25.000 to 1:100.000 for watersheds of a size greater than 100 km2, depending on the objectives of study and the size of the basin in question.

Starting a geomorphologic study should begin with the location of the points where the rivers gauging stations are, in order to have a complete study of the coexisting variables in the basin: both the excitation and physical system and the responses of the watershed system.

The main geomorphologic features of a watershed are the following:
Area, length of the basin and its perimeter, the average slope, basin hypsometric curve, histogram of altimeter frequency, altitude and average elevation, branching ratio, channel drainage density, average profile slope of the main channel and coefficient of forest coverage.

- <u>Area:</u> The watershed area is probably the most important geomorphologic characteristic for the design. Is defined as the horizontal projection of the entire drainage runoff system area, directly or indirectly addressed towards a natural riverbed.

  Its importance lies in the following reasons:

  a) Is a value that is used for many calculations in several hydrology models.

b) For the same hydrologic region or similar regions, the larger area the higher average flows.

c) Under the same hydrological conditions, watersheds with bigger areas produce hydrographs with variations in time smoother and flatter. However, in larger watersheds the hydrographs present a peak when rainfall is intense and close, upstream of the gauging station.

d) The watershed area is related inversely with the relationship between extreme flows, both minimum and maximum.

In hydrology, the calculation of the areas can be made using the planimeter. Nonetheless, nowadays it is calculated using specials softwares. The basin boundary can be delimited by longitude and latitude of the points along itself, assuming that the line which attaches them is a straight line.

- <u>Length of the basin:</u> can be defined as the horizontal distance of the main river between a point downstream (gauging station) and one water point upstream where the general trend of the main river cut the outline of basin.

- <u>Perimeter of the basin:</u> is an important parameter since in connection with the area can tell us something about the shape of the basin.

- <u>Width:</u> is defined as the ratio between the area and the length of the basin.

Regarding the geomorphologic aspects, generally a watershed is formed by sub-watersheds or areas in which precipitation can be measured. Geology and land use are very important when torrential rain or flash floods are coming since they produce large amounts of earth flows which are formed with a heterogeneous mix of sediments of different sizes which have high amounts of vegetation and saturated fine material and they progressively gain volume and velocity and spreading it along the river channels. One of the principal changes produced in the channels of the river, in the tributaries and in the course of the main channel is the removal of high amounts of coarse sediment previously accumulated like rain deposits (González, et al., 2004). This provokes the exposition of the river bank and sometimes more depth and enlargements in the river.

A combination of many geomorphologic aspects of the watershed favor to the generation of flash flood, for instance:

- A small watershed has the probability of a simple meteorological event produces rain simultaneously in all sectors and generates run off in the tributaries. In bigger watersheds there is barely the chance of recollecting rain simultaneously in all sector, this condition delays the run-off in time and generates separated hydrogram maps.
- Reduced concentration time, is also related with the area and its slope. In small watersheds the interval between precipitation and maximum discharge is short. Hydrogram maps and precipitation maps are synchronic; in those watersheds still rain when the maximum discharge occurs. It has to be taken into account that discharge has to be calculated using the period of return of the event.
- Form of the watershed, since circular watersheds are prone to generated flash flood in comparison with larger watersheds. The

cause is because the run-off flow lines follow a short path and they are more synchronic in circular-form watershed. The circularity is an morphometric indicator, which can be defined with the following equation (Chorley, et al., 1984):

$$\mathrm{Rc} = \frac{\mathrm{P}}{2\sqrt{(\pi \mathrm{A})}}$$

In which P is the drainage perimeter with the perimeter of a circle. Values between 1.0 and 1.25 are common in circular-form watersheds and those are the most prone to develop flash floods.

- Watersheds located in mountains have higher gradients not only in longitudinal profiles but also in slopes. This gradient has an effect of reducing the run-off concentration time and increases its velocity.
- An incipient geomorphologic development also favors to flash floods since it’s characterized by very rough hills, straight segments of the river and predominant erosion above sedimentation (González, 1982)
- A highly developed drainage net reduces the concentration time and can be expressed such as (Chorley, et al., 1984):

$$D = \frac{\mathrm{L_t}}{\mathrm{A}}$$

In which Lt is the total length of the channel system in the watershed and A is the total area of the watershed. The D values change in function of geology and precipitation.

- Capacity for transporting coarse material is a consequence of hydraulic force, of which depends the water flow.
- The amount of precipitation is bigger and shows high intensity and duration in watersheds located in humid and semi-humid climates (Vásquez, 1994).
- In addition the factors above, also the saturated soil contributes to run-off and the slope losses its stability and the collapses, since the saturated soil has high porous pressure and they are overloaded.

Besides the geomorphologic aspects, the following aspects contribute to generate flash floods as well:

- Melting of snow caused by a temperature rise.
- Human activities, for instance, urbanization.

In order to calculate the magnitude and frequency of floods, the classic hydrologic methods must be completed with paleo-hydrologycal records based in geomorphologic, chrono-statigraphy and sedimental techniques (González, et al., 2004). These studies can provide objective information about chronology and magnitude of previous floods without records and also they can help to develop a map of hazards and a land use plan in mountainous watersheds.

Among the classic methods to obtain the discharge are the following:

- Empiric Equations: these equations are valid to give a first reference value or order of magnitude. These equations are based in experimentation and the discharge is in function of the surface. For instance:

    - $Q = 17 \cdot \frac{2}{3} S$ (Gómez Quijado) for surfaces in which S < 2000 Km^2
    - $Q = Q_1(1 + 0.8 \cdot \log T)$ (Fuller) in which Q_1 is the average of the daily discharge every year and *T* is the return period.
    - $Q = 21 \cdot 0.6 \cdot S$ (Zapata)

- Statistical Methods: these methods are based in big series of annual discharge which allow obtaining the maximum discharge. For instance:

    - Compilation of information
    - Analysis of information
    - Statistical extrapolation
    - Contrast of results

  It is recommendable to use a sample of minimum of 40 up to 50 years of data in order to have a consistent study. If only are available a series of 30 up to 40 years of data, it is recommendable support the analysis with another method which works with similar watersheds or a method which studies the discharge from the precipitation. And in short series with only 10 up to 20 years of data should be used hydrograms.

- Rational Method: is used in small watersheds with surface between 2.5 ~ 3 Km^2 or a watershed with concentration time of 1 hour. In order to determinate the maximum discharge when the concentration time it's bigger or at least equal than the raining time, it can be used the next equation:

    - $Q = \frac{(C \cdot I \cdot A)}{3.6}$ In which C is the run-off coefficient, I is the rainfall intensity and A is the area of the watershed.
      The rainfall intensity can be obtained using the following equation: $I = \frac{a \cdot T \cdot n}{(t+b)m}$; in which a, b, n and m are parameters

which depend of the meteorological conditions of the zone, T is the return period and t is the rainfall time.

The rainfall coefficient depends of the daily precipitation and the discharge threshold. Table 5 shows the values for this coefficient depending of different the land uses.

Table 5: Coefficient C Values depending of the Land Use

Land Use	C	Land Use	C
Business:		***Lawns:***	
Downtown areas	0.70 - 0.95	Sandy soil, flat, 2%	0.05 - 0.10
Neighborhood areas	0.50 - 0.70	Sandy soil, avg., 2-7%	0.10 - 0.15
		Sandy soil, steep, 7%	0.15 - 0.20
		Heavy soil, flat, 2%	0.13 - 0.17
		Heavy soil, avg., 2-7%	0.18 - 0.22
		Heavy soil, steep, 7%	0.25 - 0.35
Residential:		***Agricultural land:***	
Single-family areas	0.30 - 0.50	*Bare packed soil*	
Multi units, detached	0.40 - 0.60	Smooth	0.30 - 0.60
Multi units, attached	0.60 - 0.75	Rough	0.20 - 0.50
Suburban	0.25 - 0.40	*Cultivated rows*	
		Heavy soil, no crop	0.30 - 0.60
		Heavy soil, with crop	0.20 - 0.50
		Sandy soil, no crop	0.20 - 0.40
		Sandy soil, with crop	0.10 - 0.25
		Pasture	
		Heavy soil	0.15 - 0.45
		Sandy soil	0.05 - 0.25
		Woodlands	0.05 - 0.25
Industrial:		***Streets:***	
Light areas	0.50 - 0.80	Asphaltic	0.70 - 0.95
Heavy areas	0.60 - 0.90	Concrete	0.80 - 0.95
		Brick	0.70 - 0.85
Parks, cemeteries	0.10 - 0.25	Unimproved areas	0.10 - 0.30
Playgrounds	0.20 - 0.35	Drives and walks	0.75 - 0.85
Railroad yard areas	0.20 - 0.40	Roofs	0.75 - 0.95

Source: http://water.me.vccs.edu/courses/CIV246/table2.htm

- Hydrograms: the unitary hydrogram can be used in medium watersheds with surface between 300 ~ 400 Km^2. The synthetic or artificial hydrogram consists in determinate the main characteristics of a hydrogram by using empirical equations when doesn't exist real data.

6.2.2 Physico-chemical quality elements

In order to obtain an ecological status of the water bodies in a watershed, it is recommendable to identify the main pollutants. For instance, fertilizers, pesticides and by-products are the most common pollutants of water bodies in a watershed besides heavy metals. Not only those agents must be checked, but also physic-chemical parameters such as PH, dissolved oxygen and nutrients, since they are required to support a functioning ecosystem.

According to the UKTAG there are boundary values corresponding to high, good, moderate, poor and bad status for a number of supporting elements. In classification, however, supporting elements can only influence status down to moderate, while only a biological element can determine poor or bad status. The quality elements that have been used in producing the draft classifications are shown in the following table:

Table 6: Physico-Chemical Quality Elements

Rivers	Lakes	Transitional and coastal waters
Soluble reactive phosphorus (unfiltered orthophosphate)	Total phosphorus	Dissolved inorganic nitrogen
Dissolved oxygen	Dissolved oxygen	Dissolved oxygen
pH	pH	pH
Ammonia (total as N)	Ammonia (total as N) Acid neutralizing capacity	
Specific pollutants	Specific pollutants	Specific pollutants

Moreover, in the Attachment 3 are shown with more details the specific pollutants which be analyzed in water bodies according the WFD.

6.2.3 Biological quality elements

Bio-assessment is useful for detecting aquatic life impairments and identifying the agents and possible mitigation strategies (EPA, 2005). Aquatic life includes among others: phytoplankton, macrophytes and phytobenthos as a single quality element but in practice, macrophytes and phytobenthos (diatoms), benthic invertebrate fauna and fish fauna.

Table 7: River Biological Quality Elements

Quality element	Description
Macrophytes and phytobenthos - diatoms	Algae such as microscopic diatoms found on rocks and plants
Macrophytes and phytobenthos - macrophytes	Water plants visible to the naked eye, growing in the river or on the banks of the river
Macro invertebrates	Insects, worms, mollusks, crustacean etc living on the river bed
Fish	Including eel and lamprey

Table 8: Lake Biological Quality Elements

Quality element	Description
Phytoplankton	Free-floating microscopic plants
Macrophytes and phytobenthos - diatoms	Algae such as microscopic diatoms found on rocks and plants
Macrophytes and phytobenthos - macrophytes	Water plants visible to the naked eye, growing in or around the lake
Macro invertebrates	Insects, worms, mollusks, crustacean etc. living on the lake shore or bed.

Table 9: Transitional and Coastal Water Biological Quality Elements

Quality element	Description
Phytoplankton	Free-floating microscopic plants
Macro algae	Seaweeds visible to the naked eye
Angiosperms	Sea grasses and salt marsh plants
Benthic invertebrates	Worms, mollusks and crustacean, etc living in or on the bed of the estuary or sea
Fish (transitional only)	Fish which spend all or part of their life in transitional waters

Each quality element can be under pressures of the environment, but each element is capable of responding those pressures. The following table shows the most sensitive quality elements under pressures acting on a water body and which are used for classifying them. This is commonly also risk-base monitoring. For more details regarding pressures on quality elements and drivers see Attachment 4.

Table 10: Pressures indicated by Quality Elements

Quality element	Pressures indicated
Rivers	
Macrophytes and phytobenthos - diatoms	Primarily nutrient enrichment
Macrophytes and phytobenthos - macrophytes	Sensitive to nutrient enrichment and morphological alterations
Macro-invertebrates	Sensitive to organic enrichment, pollution by toxic chemicals, acidification, abstraction of water
Fish	Sensitive to all pressures, but primarily sensitive to abstraction of water and morphological alterations
Lakes	
Phytoplankton	Nutrient enrichment
Macrophytes and phytobenthos - diatoms	Nutrient enrichment
Macrophytes and phytobenthos - macrophytes	Nutrient enrichment
Macro-invertebrates	The Chironomid Pupal Exuviae Technique (CPET) tool is sensitive to nutrient enrichment, Clear Lake Acidification Macro invertebrate Metric (CLAMM) and Humid Lake Acidification Macro invertebrate Metric (HLAMM) are sensitive to acidification
Transitional and coastal waters	
Phytoplankton	Nutrient enrichment
Macro algae	Nutrient enrichment
Angiosperms (sea grasses)	Nutrient enrichment
Benthic invertebrates	Respond equally to organic pollution and toxic chemicals
Fish (transitional only)	Organic enrichment, habitat destruction

6.2.4 Ecological Status

A classification is necessary since can provide information about the quality of the environment, in which conditions prevail it, which are the improvements that can be done and so on. Also helps to improve master plans, shows trends and provides support in the monitoring of actions to be taken. It is important point out that classification is based in data monitoring.

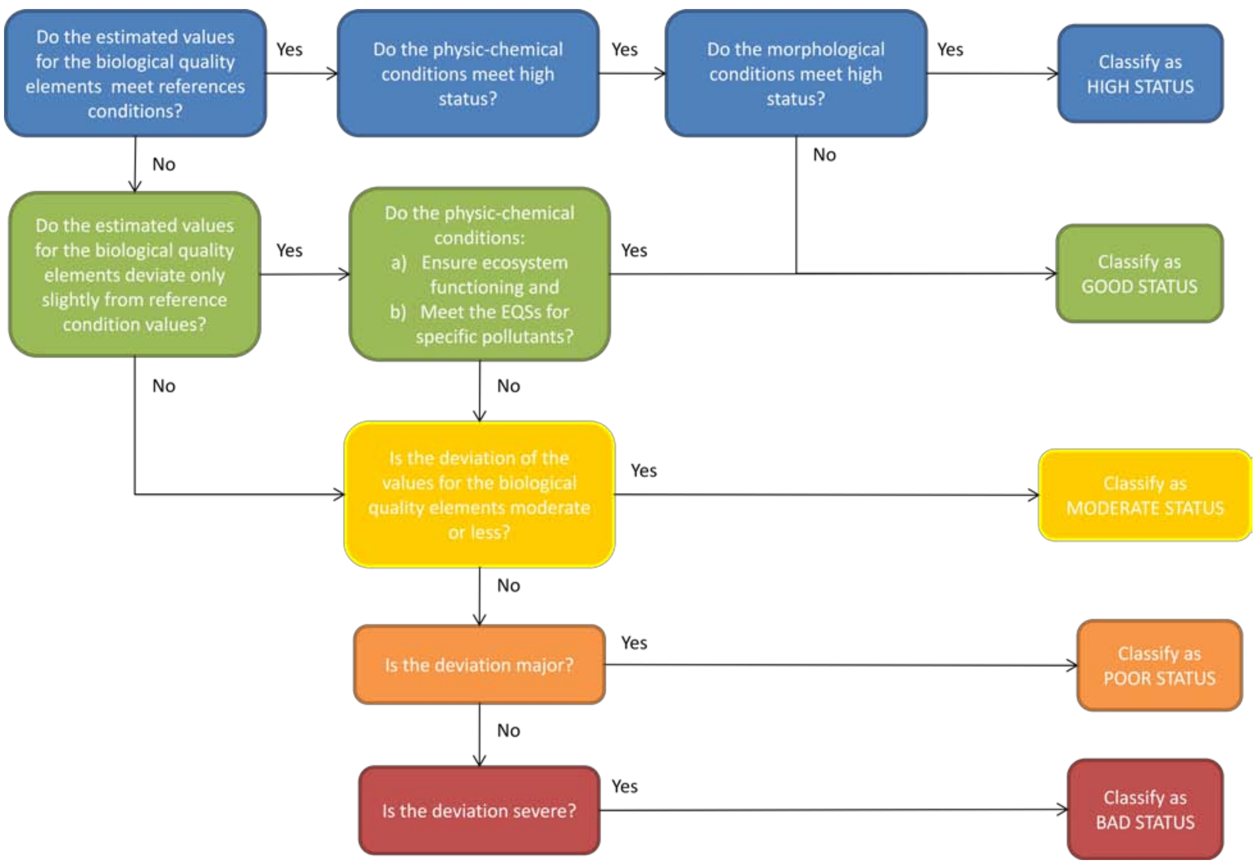
According to the WFD, The ecological status of the water bodies can be reached by analyzing the quality elements described previously. Depending of the state achieved, the classification could be:

- High status
- Good status
- Moderate status
- Poor status
- Bad status

The high status is achieved when the three quality elements meet all the reference conditions, which mean when the morphological, physic-chemical and biological quality elements are within the references parameters. The good status is reached when the biological quality elements deviate only slightly from the reference conditions and the other quality elements meet those conditions or when the morphological quality elements are not within the references but the other quality elements are within the parameters. When the deviation is moderate can be classify as moderate status and depending of the deviation also can be poor status but if is major bad status when the deviation is severe or barely the requirements' values are meet. This deviation must be expressed as an ecological quality ratio (EQR) which ranges from zero at the bad end to one at the high status end. According to the WFD, the ecological status is determined by the worst scoring component. In the case of the European Union, under the Article 4 of the Directive, by 2015 all groundwater, surface and coastal water have to achieve the good status or the good ecological potential (UFZ, et al., 2008).

This classification is shown in the next tree-decision diagram.

Figure 5: Tree-Decision Diagram for Water Bodies Classification Status

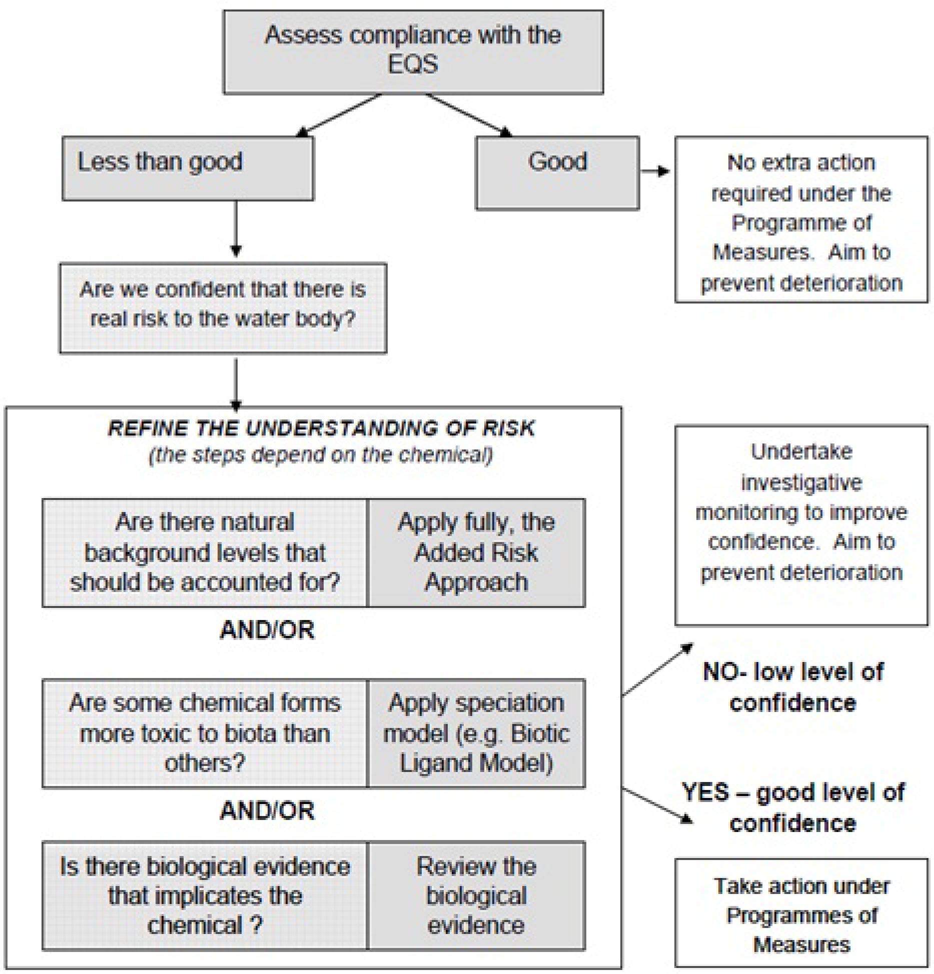


Source: European and UKTAG Guidance, 2011.

In some cases, in the classification of quality components there is not sufficient information or no measurements available in the water body, that is why that similar bodies can be analyzed for finding a classification according to expert assessment (Ministerium für Umwelt und Naturschutz, 2009).

After diagnose of the watershed and the EQS of the water bodies obtained, it is possible to determine the main measures and action plan to be implemented. In the Figure 6 is presented a decision diagram in which is determined the need of actions under the program of measures. Those actions depend on the previously analyzed quality elements.

Figure 6: Determining the need for action under the Program of Measures



Source: (UKTAG, 2008)

6.3 River Basin Management Objectives

In order to achieve the management goals there has to been a mutual agreement from all stakeholders, experts and managers. All of them are assembled with the purpose of sharing information. Their input is to establish the focus, scope and complexity of the river basin management process (EPA, 2008). Even though sometimes it's especially complex because a watershed typically overlaps multiple jurisdictions that are managed by organizations with different goals and responsibilities and inhabited by numerous stakeholders with varied interests (EPA, 2008).

The objectives of the river basin management process are to gain a better understanding of the most important environmental changes resulting from human activities and the effects associated as a result. For this reason, some of the main objectives to aim are the following:

a) Collect and verify existing water quality data. For instance: stream gage data, historical flood records, aerial photo coverage's, pollutants records, existing species and habitats and so on (McCarthy, 2010).
b) Establish water quality goals.
c) Protect threatened and endangered species.
d) Ensure the continued existence of native habitats in the watershed (EPA, 2008).
e) Estimate current and future pollutants sources and loadings. This can be done by using specific models and/or equations such as the Spreadsheet Tool for Estimating Pollutants Loads and/or Dillon-Rigler and Vollenweider Trophic Status Model (McCarthy, 2010).
f) Estimate pollution limits and/or reductions needed.
g) Estimate actions to achieve all above.

h) But it is important also try to minimize costs.

All objectives above should be explicit and quantifiable since as long the goals become more refined, usually they tend to be more expensive and this situation it is intended to be avoided. For more references, in the attachment 5 are shown the environmental objectives of a river basin management plan for the program of measures according to the legislative text of the WFD.

Although reaching an agreement from all management objectives is difficult and delays the start of the implementation of measures, it is vital for obtaining a most efficient analysis of the current situation and for consequence a better and detailed analysis of the needs to be fulfilled and an implementation of the most relevant management options.

In order to verify the implementation of these actions there has to be an adequate monitoring process for observing the effectiveness of the implementation efforts over time (McCarthy, 2010). The frequency of the monitoring depends of the element to be monitored and the goals which are intended to be achieved. Likewise, the method used for monitoring should be the national or international standards in order to obtain qualitative and comparable results. For monitoring the quality elements described previously, the next table shows the frequency of each one according to the WFD.

Table 11: Frequency of Monitoring of the Quality Elements in a Watershed

Quality element	Rivers	Lakes	Transitional	Coastal
Biological				
Phytoplankton	6 months	6 months	6 months	6 months
Other aquatic flora	3 years	3 years	3 years	3 years
Macro invertebrates	3 years	3 years	3 years	3 years
Fish	3 years	3 years	3 years	
Hydromorphological				
Continuity	6 years			
Hydrology	continuous	1 month		
Morphology	6 years	6 years	6 years	6 years
Physico-chemical				
Thermal conditions	3 months	3 months	3 months	3 months
Oxygenation	3 months	3 months	3 months	3 months
Salinity	3 months	3 months	3 months	
Nutrient status	3 months	3 months	3 months	3 months
Acidification status	3 months	3 months		
Other pollutants	3 months	3 months	3 months	3 months
Priority substances	1 month	1 month	1 month	1 month

Source: (Water Framework Directive, 2000)

Thus, the established indicators will help to evaluate the achievement of the objectives and the progress being made toward attaining them. The intention of verification is with the aim of determining if the river basin management objectives in the watershed master plan are working toward their accomplishment.

6.4 Plan of Measures

Before the plan of measures there is the problem formulation phase, in which must be determined the current condition of the watershed and the desired condition is planted as well. After this step continues the establishment of the action or set of actions will be taken in order to achieve the desired conditions in a watershed.

Thus, the plan of measures is a plan which contains all objectives of the analysis phase and actions or measures to be implemented in order to attain the desired conditions in a watershed. The plan should describe possible results and uncertainties and how this information will be communicated (EPA, 2008).

Those measures could be classified according the type of action which is required, for instance, if the measures are for prevention, mitigation or correction. Usually those measures are the most common measures included in a watershed master plan. The degree of detail will depend of the stakeholder's needs.

It is important also to have a model of Driving forces, Pressures, States, Impacts and Responses (DPSIR) as it shows figure 7. In which the driving forces are represented by the economic and political sector who are usually the stakeholders in the watershed management master plan, also Planification and development sectors are important agents of development and land use is a driving force since it is one of the most important activities to manage within a watershed basin.

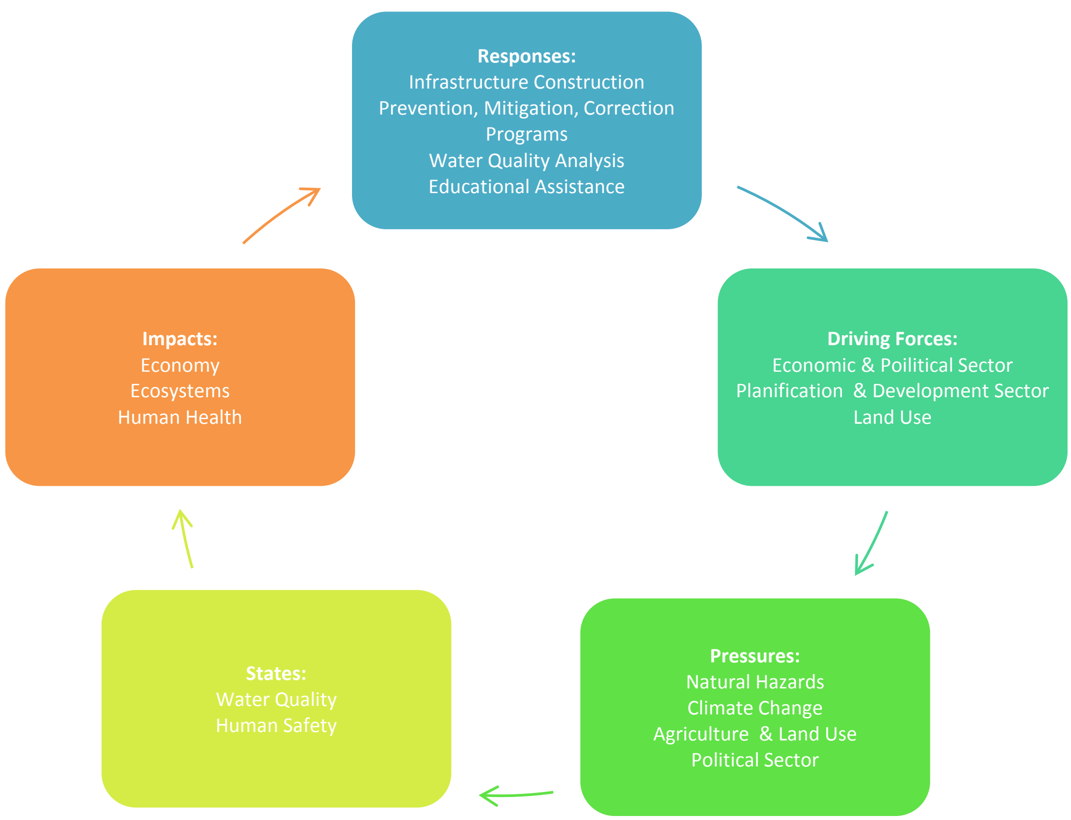
The pressures are natural hazards and climate change related to the environment; however agriculture, land use and the political sector are common pressures which affect the functioning of a watershed.

The states which are supposed to be reached are a water quality of all water bodies and by consequence human safety.

The impacts of any alteration in normal the watershed functioning are reflected in the economy, ecosystems and human health.

And the main responses created in order to front those problems are infrastructure construction, prevention, mitigation, correction programmes, water quality analysis and/or educational assistance among others.

Figure 7: Model DPSIR for a Plan of Measures



The management plans in accordance with WFD shall contain a description of the status quo of the surface water and groundwater on the basis of WFD-compliant monitoring outcomes. They include a list of management objectives and a summary of action programmes that are established to achieve the management objectives.

7 River Basin Measures

The impacts of development within a watershed have altered natural drainage patterns, natural rainfall-runoff-storage relationships and added pollutants to storm water runoff and watershed streams. Due to these circumstances are needed measures that can deal with those problems. For instance, alternatives directed toward restoring a watershed can include the enhancement and expansion of existing wetlands, the creation of additional water storage capacity, and the restoration of more natural flow conditions and habitat. Moreover, the watershed restoration can include the modification and stabilization of the stream channel, the creation of acceptable water quality, and reintroducing hydrologic variability (Harness, 2005). These measures will provide benefits to the ecosystem and the surrounding communities in an aesthetically and ecologically improved natural area.

For those reasons watershed management must provide workable management options which include actions that intervene in the current system and produce results towards a specific target. These options include structural measures which are measures that use technology or structures to change the existing conditions, the non-structural measures which are measures that rely on changes in human behavior and quantitative measures which are measures based in monitoring and then processed in special software. Usually structural measures are easy to implement and more expensive in comparison with non-structural measures.

In order to improve the watershed conditions, the main measures to be considered in a management master plan are those mentioned before: structural measures, non-structural measures and quantitative measures. Each one will be more detailed in the next pages.

7.1 Structural Measures

The alternative structural measures typically require complex engineering analyses and constructions to be implemented. Besides, many structural tools are also available to address environmental degradation in urban watershed areas. Among the alternative structural measures, it can be mentioned the following (Harness, 2005):

7.1.1 Source Control Measures

A wide-range of structural source control measures are available to address problems related to urban runoff. Whenever possible, priority should be given to source control alternatives. Source control measures are generally but not always less expensive than the regional facilities. For example, alternative structural control measures can be applied in the following areas:

- Contour Terracing
  The main objective is to facilitate the proper drainage of the excess water in areas where agriculture is practiced in steep slopes (Singh, et al., 2003). This will reduce the runoff and in consequence soil erosion.

- Contour Embankment
  This action is adopted as soil conservation measure since there are areas where it is necessary to retain the water for the growth of vegetation for natural soil banks (Singh, et al., 2003).

- Gully Plugging

  Due to gully erosion in areas with steep slope, minimal vegetation cover and high runoff velocity, check dams can be constructed in order to minimize this situation (Singh, et al., 2003). Those dams can be constructed from rocks available in situ.

- Reconfigure paved surfaces

  This is with the aim of decreasing the percentage of impervious area. This includes reducing paved surfaces in residential lots, parking, street and sidewalks.

- Porous pavements

  The objective of using porous pavements is to promote infiltration. This is an alternative to use in order to gain infiltration and improve the water quality.

- Roof-top gardens

  The construction of roof-top gardens over public and private buildings would contribute to reduce urban run-off, which affects groundwater and can produced flood in urban areas.

- Use of constructed tanks or cisterns for irrigation

  The capture of runoff in tanks or cisterns would reduce the consumption of water in the households, would provide water supply with high quality, will reduce the urban run-off and will reduce the need of pumping groundwater besides that will creates awareness in the population.

Those are some measures that can be help to improve infiltration and reduce run-off.

7.1.2 New Regional Facilities

A number of systems are available whereby storm water runoff is collected, temporarily stored, and percolated through the soil. These systems include wet or dry ponds, detention basins, dry wells, infiltration basins, and constructed wetlands. These facilities are typically designed to fit aesthetically into the open space landscaping of new development sites. Often, these facilities are fragmented in that individual basins are sited within individual development plans, but regional basins can be constructed to provide storm water management for an entire sub-watershed area. The selection of these structural alternatives is dependent upon the desired level of particulate and dissolved pollutant removal, groundwater recharge, and storm water runoff flow control.

7.1.3 Stream Erosion and Velocity Controls

In stream restoration projects, alternative materials such as logs, root wads, and rock are used to control erosion, stabilize slopes, control stream gradients, create flow diversity, and provide aquatic habitat. They are used in areas for treating invert, toe, top of bank, and full bank erosion situations. Alternative remediation techniques include the use of: root wads, log rock and cross vanes, step-pools, boulder bank stabilization, and rock grade control structures, among others.

7.2 Non-structural Measures

The non-structural measures are source control measures that can be implemented within a watershed to address the wide variety of problems typically related to urban runoff. For instance, applying land use controls, public education programmes, and non-structural municipal measures can have a significant impact on improving water quality and overall watershed protection (UNESCO, 2001). In addition, these measures also consider another such as laws, regulations, zoning, economic instruments, flood forecasting systems, etc.

7.2.1 Land Use Controls

Impervious cover directly influences urban streams by dramatically increasing surface runoff during storm events. The conversion of farmland, forests, and meadows to rooftops, roads, parking lots, and driveways creates a layer of impervious surface in the urban landscape. Since impervious cover has such a strong influence on watershed quality, a watershed management master plan should critically analyze the degree and location of future development and redevelopment that is expected to occur within a watershed.

The basic goal is to apply land use planning techniques to redirect development, preserve sensitive areas, and maintain or reduce the impervious cover within a given sub watershed. This goal can be addressed by applying some of the following land use controls:

- Direct Regulatory Approaches for New Development
  New developments mean that are needed regulatory approaches for instance, to regulate and control pollutant discharges in water bodies using zoning, erosion and sedimentation control and grading and filling ordinances.

- Indirect Regulatory Approaches for New Development
  In this approach can be included the use of steep slopes, impervious surfaces, wetland and floodplain disturbance and tree and vegetation removal.

- Regulatory Approaches for Restorative Redevelopment
  Restoring and revitalizing urban watersheds includes measures such as remove storm water from sewers and recharge groundwater, reduce pollutants in streams, reduce the area of impervious zones within the watershed and restoring natural processes. Regulatory land use approaches can be used as well.

- Land Acquisition to Maintain Open Areas and Buffer Zones
  Open areas and buffer zones are important since they are the zones that serve to limit the entrance of pollutants, sediments and nutrients into the stream.

- Runoff Control Programmes for Industrial and Commercial Sites
  Industrial and commercial activities have the potential of contaminate streams within the watershed. Some facilities like employee training, spill prevention, eliminating non-

storm water discharge, methods of handling wastes and customer awareness are some of many measures than can be implemented.

- Improvements to Current Site Plan Review Process

7.2.2 Public Education Programmes

Watershed education is an important watershed management element. Some education programmes in recent years have influenced watershed behaviors. For example, subjects about public outreach, source control, watershed awareness, pollution prevention, citizen involvement, and stewardship have been developed. For some watersheds, the following problems concerning to water quality problems are result from contamination of runoff by among others, trash, petroleum, lawn care chemicals, products from automobiles and pet wastes. The following items can be taken account for developing educational programmes, since they are the principal causes of contamination in water streams.

- Littering

  Littering is and has been a persistent problem within the watershed. Education is the key for changing attitudes and behavior with regards to littering, with this program, citizens become directly involved in litter prevention.

- Illegal Dumping

Eliminating illegal dumping aims to prevent flooding; this is caused for blockages in the drainage channels.

- Landscaping and Lawn Care

  When there is a high density of residential homes with lawns and landscapes adjacent to water bodies within a watershed can be a problem. That is why educational programmes concerning to impacts of using fertilizers, pesticides and herbicides should be a priority in this category.

- Tree Plantation

  This task could be also an education program and would bring important results if would be implemented since elementary school, taking a control of the tree planted along a period of time, for instance high school.

- Animal Waste Collection

  The greatest impact of animal waste is the bacterial fecal which contaminates water bodies and not only produces risk for other animals but also for humans and result in the spread of diseases.

- Car Washing

  This common routine impacts water quality within the watershed, some actions to prevent it would be outreach on management practices to reduce discharges to storm rains.

7.2.3 Municipal Measures

Municipal coordination and enforcement are other alternatives for successful watershed management and protection. Municipalities have many tools at their disposal to address environmental degradation in urban areas. In order to manage and control the problems related to urban runoff, among others municipal management programmes should be considered in the following areas:

- Storm Inlet Maintenance

  Inlets are the input when raining, due to this fact inlets tends to get clogged for all material which is dragged for water, also can become a source of pollutants by acting like a filter.

- Check Dams

  Small dams must be checked from time to time, most important in the rainy season since they tend to be obstructed with small shrubs, plants and/or garbage.

- Street Sweeping

  It is used to remove sediment build up, debris, litter and other pollutants from curb gutters, roads, parking lots that are potential source of pollution impacting urban waterways.

- Bridge and Roadway Maintenance

  Pollutants like heavy metals, hydrocarbons, sediment and debris is accumulated daily in roads and bridges, condition which may impact water sources and affect its quality.

- Household Hazardous Waste Collection

  These are waste which are produced in households and are hazardous in nature, for instance, used motor oil, batteries, oil-based paint, paint thinners, oven cleaner, muriatic acid, peroxides, pesticides and so on.

- Pet Waste Laws

  Ordinances regarding pet wastes are based mainly in educational approaches, since the owners of animal must be aware of the impacts of animal waste in water bodies.

- Pest Control

  The main objective of pest control is to regulate the use in public land of fertilizers, pesticides and herbicides. The major use of pesticides in urban areas is for killing insects, but this can be regulated in public areas such parks by municipality control and schools support.

- Grass Plantation

  Grass is planted to restore and stabilize the slopes with different techniques depending upon the steepness of the slope (Singh, et al., 2003).

- Trees and Shrub Plantation

  This activity is locally available and nowadays it has had a fast growing. Also important species of plants and shrubs must be planted in degraded zones (Singh, et al., 2003). Meanwhile tree planting reduced erosion and became more attractive the landscape.

- Pasture Development

  The degraded grassland or pastureland and patches of the watershed must be included for the development of the new and healthy pastures depending upon the geomorphologic conditions (Singh, et al., 2003).

- Vegetation Controls

  Vegetative wastes come from moving, cutting and trimming. The aim of this measure will be avoid the rest come into water bodies.

7.3 Quantitative measures

Nowadays with the availability of quantitative tools it can be improved the ability to address watershed management issues. But those tools can be used at the same time with other tools; otherwise the current or future problems will not be solved.

Quantitative measures for instance, are applicable when digital data are available. For example, information about the total area and proportion of the watershed occupied by each cover type can be identified and its area and perimeter recorded (Naiman, et al., 1997). In addition, data such as inventory of vegetation and land cover can be tabulated and then represented in maps, that means that all information which can be processed in software in order to have databases for instance, GIS software, are relevant information that provides support to implement quantitative measures. It is important also recognize the metrics to be monitoring and to be aware of the assumptions and constraints that are implicit in the metrics as well.

7.4 Catalog of Measures

In a watershed master plan all the desired and needed conditions are presented in form of a catalog. The catalog is a basis for recording structured and requested information accordingly. Usually it is not complete for all implications that means, for this reason can be add information to the description of individual situations or items can be overwritten. For instance, the catalog has identified four types of conditions:

- Uses

  Basically water uses or other uses, which by measures could improve and/or could affect significantly the water status and contribute to pollution of the water, for example settlements, agriculture, among others.

- Restrictions

  Are conditions that have the ability to conduct actions limiting conflict, but are not a priority of water use for instance transport infrastructure or archaeological monuments to the potential floodplain.

- Potentials

  Are conditions that contribute to maintain and improve the water status, for example all the synergies such as nature conservation projects or projects´ construction in waters nearby.

- Stresses

  Are direct and indirect water uses which have a proven or preliminary negative impact on monitoring the achievement of "good status" of the watershed.

The more important of classifying the conditions in various categories such as mentioned before, is that the framework for the action plan with time extensions and management objectives will be recognized for all the different units, for instance water bodies group, planning units, etc.

Once the framework is assigned in the catalog of measures, it can be assessed the significance of the relevant conditions within the watershed for each level. Based in this assessment at each level, more detailed management steps could appear. To ensure the efficient acquisition of the conditions, it may be helpful to find the number of conditions necessary for testing a collection of data. In order to optimize the scope of testing, the first thing to do is the framework as a checklist.

In general, the process in each level is competence of the local district governments and usually starts with an agreed timetable of activities. As far the specific guidance is given, the instructions for completing them in appropriate time should be given as well. After this step, third parties could take part into.

According to the WFD, among others the following measures should be considered within the catalog of measures (Ministerium für Umwelt und Naturschutz, 2009). It is important to point out that these measures are focus mainly in water quality. For instance;

Measures / point source / surface water:

- Communities/households
- Local government
- Heat stress
- Mining
- Other point sources
- Mixing and precipitation
- Industry/trade
- Industrial sector

Measures / point sources / groundwater

- Waste
- Mining
- Industry / trade
- Other point sources

Measures / diffuse sources / surface

- Agriculture
- Abandoned sites
- Built-up areas
- Mining
- Soil acidification
- Other diffuse sources
- Accidental entries

Measures / diffuse sources / groundwater

- Built-up areas
- Agriculture
- Mining
- Other diffuse sources

Measures / hydro morphology / surface water

- Morphology
- Water Resources
- Patency
- Other changes

Measures / water withdrawals / surface water

- Fisheries
- Industrial sector
- Agriculture
- Other water withdrawal
- Water supply

Measures / water withdrawals / groundwater

- Mining
- Industrial sector
- Agriculture
- Other water withdrawal
- Water supply

Measures / other / surface water

- Fisheries

- Introduced species
- Other anthropogenic pressures
- Land drainage
- Recreational activities

Measures / other / groundwater

- Other anthropogenic pressures

8 Measures Prioritization – Decision Making

The final determination of which measures could be prioritized will help to improve the decision making process. In this step of determination, it can be defined which measures would be taken both in spatial and temporal forms.
By prioritizing the actions is determined implicitly the state that needs to be achieved (UFZ, et al., 2007). Depending of the prioritized measures, it can be used different models of cost analysis, for instance the cost benefit analysis, the multi criteria decision analysis and the optimization. Those will be briefly described up to next.

8.1 Cost Benefit Analysis (CBA)

The CBA is the standard method for economic evaluation of projects and economic policies. Based on the neoclassical welfare economics, the CBA tries to collect welfare effects of monetary measures and to obtain in this way a statement about whether the total social welfare is improved by the policy intervention or deteriorated. Accordingly, one measure is welfare enhancing when the positive welfare effects or benefits are exceed. This is equivalent to the condition that the benefit-cost ratio (achievable benefits per unit cost) is greater than 1 (UFZ, et al., 2008).

Thus, the measures prioritization using the CBA is a complex process. During this process each measure has to be examined in order to have an order of priorities. Furthermore, a combination of cost-effective measures would be taken and tested. For more reference, in the CIS Guidance documents of the European Commission are detailed proposals for the overall process of establishing the program of measures.

For instance, in the context of the WFD it can be done a management table (Figure 8) in which be detailed the cost for a specific measure. This schematic form would help to facilitate the comparison of the criteria themselves (UFZ, et al., 2007).

Figure 8: Cost Fact Sheet Table

Name of the criterion	
Definition	
Character of the criterion	
Spatial reference plane	
Costs	
Comment/Review	
Overall Rating	

In which:

- Name of the criterion: can be the name used to describe the criterion.
- Definition: describes the criterion shortly.
- Character of the criterion: it is assigned to show in which area the measure will be applied.

Also this sheet can be complemented with the following additional information (UFZ, et al., 2007):

- Spatial reference plane: describes the object to be studied, for example, a water body.
- Costs: indicates the economic criterion, economic or budgetary cost effective considered.

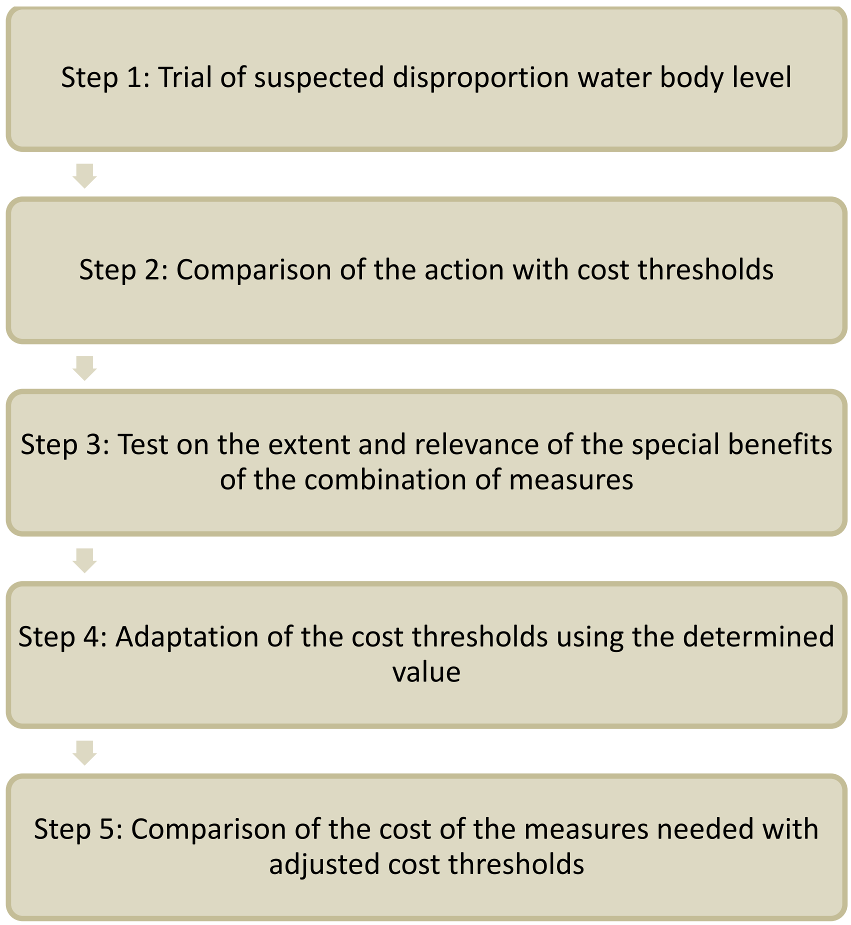
- Comment/Review: here is an assessment of the suitability of the criterion; its advantages and disadvantages, considerations about limitations in its implementation and/or possible variants.
- Overall Rating: gives an overall assessment of the criterion, besides it can be used a classification of three categories, for instance: "suitable", "partially suitable" and "non suitable".

It is important to point out that each criterion must be analyzed and considered individually.

Moreover, the CBA described that if the costs of those selected for the achievement of objectives are the best combination of measures to attain a goal, then there is disproportionality, that means that costs are considered as disproportionate if they exceed the monetized benefits of achieving good status in a water body or, possibly, if costs exceed benefits by a certain safety margin. Even though the WFD itself does not provide any guidance on this, but leaves it to the Member States to substantiate the concept and some explanatory guidance has been developed by the CIS. Ultimately, the judgment on the disproportionality of costs will be a political decision. (Görlach, et al., 2007).

On the basis that the CBA method assesses the proportionality or disproportionality and compares other combinations of measures sets, the Figure 9 shows a flow chart of the decision making process, which is divided into five steps, in order to test the disproportionate cost of a combination of measures. The test ends when the suspicion of disproportionality is refuted (UFZ, et al., 2008).

Figure 9: Test for Disproportionate Costs



Source: (UFZ, et al., 2008)

8.2 Multi Criteria Decision Analysis (MCDA)

One of the well-known approaches used very commonly to address risk in watersheds, specifically regarding floods is the multi-criteria decision analysis approach.
MCDA is both an approach and a set of techniques, with the goal of providing an overall ordering of options, from the most preferred to the least preferred option. (DCLG, 2009).

MCDA is a way of looking at complex problems that are characterized by any mixture of monetary and non-monetary objectives, of breaking the problem into more manageable pieces to allow data and judgments to be brought to bear on the pieces, measuring the extent to which options achieve objectives, of weighting the objectives and then of reassembling the pieces to present a coherent overall picture to decision makers. The MCDA often is based on the quantitative analysis (through scoring, ranking and weighting) of a wide range of qualitative impact categories and criteria (UNFCCC). Different environmental and social indicators may be developed side by side with economic costs and benefits, which must be analyzed in order to give a prioritization of the chosen option since usually the best option is the most expensive, that is why it is recommendable to put them in a balance to find the best option with the more benefits and lower cost.

The purpose is to serve as an aid to thinking and decision making, but not to take the decision, especially when environmental and social impacts cannot have monetary values assigned. For instance, there is a tool by GIS' software which use the MCDA for different scenarios and helps the decision making process.

According to the UNFCCC the steps of the MCDA are the following:

1. Establish the decision context.
   1.1 Establish aims of the MCDA, and identify decision makers and other key players.
   1.2 Design the socio-technical system for conducting the MCDA.
   1.3 Consider the context of the appraisal.
2. Identify the options to be appraised.
3. Identify objectives and criteria.
   3.1 Identify criteria for assessing the consequences of each option.
   3.2 Organize the criteria by clustering them under high-level and lower-level objectives in a hierarchy.
4. Scoring. Assess the expected performance of each option against the criteria. Then assess the value associated with the consequences of each option for each criterion.
   4.1 Describe the consequences of the options.
   4.2 Score the options on the criteria.
   4.3 Check the consistency of the scores on each criterion.
5. Weighting. Assign weights for each of the criterion to reflect their relative importance to the decision.
6. Combine the weights and scores for each option to derive an overall value.
   6.1 Calculate overall weighted scores at each level in the hierarchy.
   6.2 Calculate overall weighted scores.
7. Examine the results.
8. Sensitivity analysis.
   8.1 Conduct a sensitivity analysis: do other preferences or weights affect the overall ordering of the options?

8.2 Look at the advantage and disadvantages of selected options, and compare pairs of options.

8.3 Create possible new options that might be better than those originally considered.

8.4 Repeat the above steps until a ‘requisite’ model is obtained.

8.3 Optimization

The optimization method is oriented towards creating alternatives based on selecting values for decision variables that provide the best value of an objective function, subject to a set of mathematical constraints (equations or limits that need to be satisfied in order for a particular alternative to be feasible) (Mirchi, et al., 2009). Some advantages of optimization models are that they can help to screen a large number of potential alternatives, generate new alternatives that otherwise may have been overlooked, provide an intuitive means of trade-off analysis and provide support in the decision making process.

Also, optimization results need to be interpreted carefully, as the “optimal” outcomes may be overly optimistic and not achievable in practice. For instance, optimization is very suitable for development efforts, but it is not that much in computational efficiency and transparency and acceptability from the stakeholders.

9 Conclusion

Within the watershed management process the elaboration of the master plan is one of the most important steps. That plan will include the program or set of actions and/or priority measures which are proposed for all stakeholders in order to achieve the goals; those are the improvement of the process of the watershed itself by eliminating, reducing or mitigating current problems and also satisfying the actual needs at the lower cost.

The development of a watershed master plan has to take into account all elements which interact within the watershed; hydro morphological, physic-chemical and biological quality elements, each one is analyzed in order to find the actual condition of the basin. For obtaining this status there are specific classification systems, one of them is the classification created for the Water Framework Directive. Even though this classification is only adopted for some European members, the several guidance documents which WFD provides, give relevant information and support to address issues related to watershed management. In this work, most of the reference was taken from the WFD guidelines due to the veracity of the data. However, each country can adopt the best international standards, whose requirements are the most adequate for every specific condition within their watershed basins.

Between the described processes which affect the functioning of a watershed, the human impacts are probably the most important since their effects are the major modifiers of the ecological status in the basin. For achieving the high status, the physico-chemical quality element hast to be the most analyzed and monitored one, due to the specific pollutants which contaminate not only superficial water but also ground water. The WFD specified that at least in a period of three months they should be monitored but this lapse of time could vary depending of the pollution conditions, but certainly the pshyco-chemical quality elements have to be monitored with more frequency than the hydro morphological and biological quality elements.

The main objective of a master plan should be to attain the environmental quality status. To achieve this is essential to develop a set of priority measures to address all issues within a watershed; among them, structural, non-structural and quantitative measures without forgetting the decision making measures which involve cost analysis. Although these measures are nor the only ones which can be used, there are also other measures which can be surge at the same time of implementing the previously established. This will depend of all stakeholders and the level of detail that is desired to fulfill the goals. For instance, the cost benefit analysis is very helpful to make a comparison between the cost and the benefits of applying certain measure. Nevertheless, in every master plan all costs resolutions are a political decision, for that reason is relevant to take that into account and include it on the driving forces and pressures of a master plan as well. This plan could also be checked, readjusted and improve in a period of six years as WFD propose, but it could be revised more frequently, that means for example that –in countries from America, where presidential periods last four years- this early revision would be a plus in the development of a watershed master plan, but always its period of implementation should be greater than that time in order to see the results.

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Attachments

Attachment 1: River Basin Management Plans

Source: (Water Framework Directive, 2000)

A. River basin management plans shall cover the following elements:

1. A general description of the characteristics of the river basin district required under Article 5 and Annex II.

This shall include:

1.1. For surface waters:

- Mapping of the location and boundaries of water bodies,
- Mapping of the eco regions and surface water body types within the river basin,
- Identification of reference conditions for the surface water body types;

1.2. For ground waters:

- Mapping of the location and boundaries of groundwater bodies;

2. A summary of significant pressures and impact of human activity on the status of surface water and groundwater, including:

- Estimation of point source pollution,
- Estimation of diffuse source pollution, including a summary of land use,
- Estimation of pressures on the quantitative status of water including abstractions,
- Analysis of other impacts of human activity on the status of water;

3. Identification and mapping of protected areas as required by Article 6 and Annex IV;

4. A map of the monitoring networks established for the purposes of Article 8 and Annex V, and a presentation in map form of the results of the monitoring programmes carried out under those provisions for the status of:
4.1. Surface water (ecological and chemical);
4.2. Groundwater (chemical and quantitative);
4.3. Protected areas;

5. A list of the environmental objectives established under Article 4 for surface waters, ground waters and protected areas, including in particular identification of instances where use has been made of Article 4(4), (5), (6) and (7), and the associated information required under that Article;

6. A summary of the economic analysis of water use as required by Article 5 and Annex III;

7. A summary of the program or programmes of measures adopted under Article 11, including the ways in which the objectives established under Article 4 are thereby to be achieved;
7.1. A summary of the measures required to implement Community legislation for the protection of water;
7.2. A report on the practical steps and measures taken to apply the principle of recovery of the costs of water use in accordance with Article 9;
7.3. A summary of the measures taken to meet the requirements of Article 7;
7.4. A summary of the controls on abstraction and impoundment of water, including reference to the registers and identifications of the cases where exemptions have been made under Article 11(3) (e);
7.5. A summary of the controls adopted for point source discharges and other activities with an impact on the status of water in accordance with the provisions of Article 11(3)(g) and 11(3)(i);

7.6. An identification of the cases where direct discharges to groundwater have been authorized in accordance with the provisions of Article 11(3) (j);

7.7. A summary of the measures taken in accordance with Article 16 on priority substances;

7.8. A summary of the measures taken to prevent or reduce the impact of accidental pollution incidents;

7.9. A summary of the measures taken under Article 11(5) for bodies of water which are unlikely to achieve the objectives set out under Article 4;

7.10. Details of the supplementary measures identified as necessary in order to meet the environmental objectives established;

7.11. Details of the measures taken to avoid increase in pollution of marine waters in accordance with Article 11(6);

8. A register of any more detailed programmes and management plans for the river basin district dealing with particular sub-basins, sectors, issues or water types, together with a summary of their contents;

9. A summary of the public information and consultation measures taken, their results and the changes to the plan made as a consequence;

10. A list of competent authorities in accordance with Annex I;

11. The contact points and procedures for obtaining the background documentation and information referred to in Article 14(1), and in particular details of the control measures adopted in accordance with Article 11(3)(g) and 11(3)(i) and of the actual monitoring data gathered in accordance with Article 8 and Annex V.

B. The first update of the river basin management plan and all subsequent updates shall also include:

1. A summary of any changes or updates since the publication of the previous version of the river basin management plan, including a summary of the reviews to be carried out under Article 4(4), (5), (6) and (7);

2. An assessment of the progress made towards the achievement of the environmental objectives, including presentation of the monitoring results for the period of the previous plan in map form, and an explanation for any environmental objectives which have not been reached;

3. A summary of, and an explanation for, any measures foreseen in the earlier version of the river basin management plan which have not been undertaken;

4. A summary of any additional interim measures adopted under Article 11(5) since the publication of the previous version of the river basin management plan.

Attachment 2: EPA Key Elements for Watershed Management Plans

a) Identify pollution causes and sources: An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X number of storm drains that need retrofits; Y miles of gravel roads that need drainage BMPs; or Z linear miles of eroded stream bank needing remediation).

b) Estimate pollution reductions needed: An estimate of the load reductions expected for the management measures described under (c). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for storm drain retrofits, gravel road BMPs or eroded stream banks). First quantify the pollutant loads for the watershed. Based on these pollutant loads, determine the reductions needed to meet water quality standards (or other goals).

c) Actions needed to reduce pollution: A description of the NPS management measures that will need to be implemented to achieve the load reduction or habitat restoration scope estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d) Costs and authority: An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. Describe the types and sources of match that will be used to implement the project, keeping in mind that at least 40% of the project cost must be provided in non-federal match.

e) Outreach and education: An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing NPS management measures.

f) Schedule: A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.

g) Milestones: A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

h) Success indicators and evaluation: A set of criteria that can be used to determine whether loading reductions or habitat restoration is being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised.

i) Monitoring plan: A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Attachment 3: Specific Pollutants and Substances which Standards are proposed under the WFD

Source: (UKTAG, 2008)

Table 1 (Part A): Proposals for standards

Water	Exposure	Compliance Statistic	**Our proposal** (*no change from existing standard)	*Existing standard*
PART A: Specific Pollutants for which new standards are proposed under WFD				
2,4-D (µg/l)				
Fresh and salt	Long-term	Annual mean	**0.3**	*40 (acid)* *1 (ester)*
	Short-term	95-percentile	**1.3**	*200 (acid)* *10 (ester)*
Total Ammonia (mg/l)(7)				
Fresh	Long-term 90%ile	Lowland High alkalinity	**0.6***	*0.6*
		Upland low alkalinity	**0.3**	*0.6*
Chromium(VI) (µg/l dissolved) …(2)				
Fresh	Long-term	Annual mean	**3.4**	*5–50 (1)*
	Short-term	95-percentile	Not available	-
Salt	Long-term	Annual mean	**0.6**	*15*
	Short-term	95-percentile	**32**	-
Chromium(III) (µg/l dissolved) …(2)				
Fresh	Long-term	Annual mean	**4.7**	-
	Short-term	95-percentile	**32**	-
Cypermethrin (ng/l)				
Fresh	Long-term	Annual mean	**0.1**	*0.2*
	Short-term	95-percentile	**0.4**	*2.0*
Salt	Long-term	Annual mean	**0.1**	*0.2*
	Short-term	95-percentile	**0.41**	*2.0*
Diazinon (µg/l) …(3)				
Fresh	Long-term	Annual mean	**0.01**	*0.03*
	Short-term	95-percentile	**0.02**	*0.1*
Salt	Long-term	Annual mean	**0.01**	*0.03*
	Short-term	95-percentile	**0.1***	***0.1***
Dimethoate (µg/l)…(4)				
Fresh	Long-term	Annual mean	**0.48**	*1.0*
	Short-term	95-percentile	**4.0**	-
Salt	Long-term	Annual mean	**0.48**	-
	Short-term	95-percentile	**4.0**	-
Linuron (µg/l)				
Fresh	Long-term	Annual mean	**0.5**	
	Short-term	95-percentile	**0.9**	*20*

Water	Exposure	Compliance Statistic	**Our proposal** (*no change from existing standard)	*Existing standard*
Salt	Long-term	Annual mean	**0.5**	*2*
	Short-term	95-percentile	**0.9**	-
Mecoprop (µg/l)				
Fresh	Long-term	Annual mean	**18**	*20*
	Short-term	95-percentile	**187**	*200*
Salt	Long-term	Annual mean	**18**	*20*
	Short-term	95-percentile	**187**	*200*
Phenol (µg/l)				
Fresh and Salt	Long-term	Annual mean	**7.7**	*30*
	Short-term	95-percentile	**46**	*300*
Toluene (µg/l) (3)				
Fresh	Long-term	Annual mean	**50***	***50***
	Short-term	95-percentile	**380**	*500*
Salt	Long-term	Annual mean	**40***	***40***
	Short-term	95-percentile	**370**	*400*

Table 1 (Part B): Proposals for standards (continued)

Water	Exposure	Compliance Statistic	**Our proposal** (*no change from existing standard)	*Existing standard*
PART B: Specific Pollutants - Reviewed substances for which existing standards are proposed for use				
2,4-dichlorophenol (µg/l)				
Fresh	Long-term	Annual mean	20*	*20*
Salt	Long-term	Annual mean	20*	*20*
Ammonia (un-ionized) (µg/l)(8)				
Salt	Long-term	Annual mean	21*	*21*
Arsenic (µg/l dissolved)				
Fresh	Long-term	Annual mean	50*	*50*
	Short-term	95-percentile	-	-
Salt	Long-term	Annual mean	25*	*25*
	Short-term	95-percentile	**-**	-
Chlorine (µg/l)				
Fresh	Long-term	Annual mean	2* (Total Available Chlorine)	2 (Total Available Chlorine)
	Short-term	95-percentile	5* (Total Available Chlorine)	5 (Total Available Chlorine)
Salt	Short-term	95-percentile	2* (Total Residual Oxidant)	10 (Total Residual Oxidant)

Water	Exposure	Compliance Statistic	**Our proposal** (*no change from existing standard)	*Existing standard*
Copper (μg/l dissolved)(1)				
Fresh	Long-term	Annual mean	1-28 *(1)	1-28 (1)
Salt	Long-term	Annual mean	5*	*5*
Cyanide ("Free" i.e. μg/l of HCN/l)				
Fresh and Salt	Long-term	Annual mean	1*	*1*
	Short-term	95-percentile	5*	*5*
Iron (mg/l dissolved) (5)				
Fresh	Long-term	Annual mean	1*	*1*
Salt	Long-term	Annual mean	1*	*1*
Permethrin (μg/l)(6)				
	Long-term	95-percentile	0.01*	*0.01*
Zinc (μg/l) (1)				
Fresh	Long-term	Annual mean	8–125***** (1)	8–125 (1)
Salt	Long-term	Annual mean	40*	*40*

Table 1 (Part C): Proposals for standards (continued)

Water	Exposure	Compliance Statistic	**Our proposal** (*no change from existing standard)	*Existing standard*
PART C: Substances for which existing standards are proposed without further review. These are not Specific Pollutants				
Bentazone (μg/l)				
Fresh	Long-term	Annual mean	500*	500
Salt	Long-term	Annual mean	500*	500
Biphenyl (μg/l)				
Fresh	Long-term	Annual mean	25*	25
Salt	Long-term	Annual mean	25*	25
4-Chloro-3-methylphenol (μg/l)				
Fresh	Long-term	Annual mean	40*	40
Salt	Long-term	Annual mean	40*	40
Chloronitrotoluenes (total) (μg/l)				
Fresh	Long-term	Annual mean	10*	10
Salt	Long-term	Annual mean	10*	10
2-Chlorophenol (μg/l)				
Fresh	Long-term	Annual mean	50*	50
Salt	Long-term	Annual mean	50*	50
Dichlorvos (μg/l)				
Fresh	Long-term	Annual mean	0.001*	0.001
Salt	Long-term	Annual mean	0.04*	0.04
	Short-term	95-percentile	0.6*	0.6
Fenitrothion (μg/l)				

Water	Exposure	Compliance Statistic	**Our proposal** (*no change from existing standard)	*Existing standard*
Fresh	Long-term	Annual mean	0.01*	0.01
Salt	Long-term	Annual mean	0.01*	0.01
Malathion (µg/l)				
Fresh	Long-term	Annual mean	0.01*	0.01
Salt	Long-term	Annual mean	0.02*	0.02
1,1,1-Trichloroethane (µg/l)				
Fresh	Long-term	Annual mean	100*	100
Salt	Long-term	Annual mean	100*	100
1,1,2-Trichloroethane (µg/l)				
Fresh	Long-term	Annual mean	400*	400
Salt	Long-term	Annual mean	300*	300
Triphenyltin (total) (µg/l)				
Fresh	Short-term	95-percentile	0.02*	0.02
Salt	Short-term	95-percentile	0.008*	0.008
Xylene (total) (µg/l)				
Fresh	Long-term	Annual mean	30*	30
Salt	Long-term	Annual mean	30*	30

Environmental Quality Standards will apply to all designated water bodies, but in keeping with existing provisions under the Dangerous Substances Directive and the EU proposal for a Priority Substances Daughter Directive the UKTAG recommends the designation of mixing zones adjacent to points of discharge. In such mixing zones, which must be restricted to the proximity of the point of discharge, concentrations of pollutants may exceed the relevant standard provided that they do not affect the compliance of the rest of the body with those standards. The EU may develop additional guidance on mixing zones.

Unless specified otherwise all the above standards are expressed in terms of concentrations from unfiltered samples. This could overestimate the level of risk because not all of the substance may be in a form that can be taken up by biota. The approach is consistent with that adopted for standards proposed under Annex X of the Water Framework Directive, and with that used already for standards for the Dangerous Substances Directive.

(1) For zinc and copper, the existing standard depends on the hardness of the water. The existing statutory zinc standard is expressed as total metal.

(2) For chromium we propose a Total Risk Approach as natural background levels are not significant.

(3) The UK must continue to comply with the standards set under the Dangerous Substances Directive until its repeal in 2013. Where the work of the UKTAG has derived a more stringent standard than the existing standard under the Dangerous Substances Directive, the new standard will be applied. In the case of the long term standards for toluene, and the short-term standards for diazinon in saltwater, the UKTAG has derived less stringent standards than those in place under the Dangerous Substances Directive. However, the standards under the Dangerous Substances Directive must be applied until 2013, at which point the UKTAG recommends that these standards for toluene and diazinon should be relaxed, where there is scientific evidence that the appropriate level of environmental protection is maintained.

(4) For dimethoate, the UKTAG recommends the adoption of the new standard derived using the European Union's Technical Guidance Document. The UKTAG will look to gain more data to enable a reduced Assessment Factor, to support the second cycle of River Basin Plans.

(5) The current standard of 1 mg/l dissolved iron applies only to England and Wales.

(6) Expressed as a 95-percentile in the original report.

(7) In Fresh waters UKTAG recommends the adoption of the total ammonia standard from the UK Environmental Standards and Conditions (Phase 1) report dated August 2006. UKTAG believes that this approach will provide an effective level of protection for both total and unionized ammonia in freshwaters.

(8) In salt waters UKTAG recommends the continued adoption of the current unionized ammonia standard.

Attachment 4: Quality Elements Sensitive to Pressures

Source: (UKTAG, 2005)

Table 4. Quality elements sensitive to the pressures affecting rivers

SOURCE PRESSURE	CATEGORY OF EFFECT	EXPOSURE PRESSURE	MACROPHYTE	PHYTOBENTHOS	MACRO-INVERTEBRATES	FISH	MORPHOLOGY	HYDROLOGY	GENERAL PHYSICOCHEMICAL	SPECIFIC POLLUTANTS	PRIORITY SUBSTANCES	PRIORITY HAZARDOUS SUBSTANCES
NUTRIENT ENRICHMENT	Primary effect on biology	Change in nutrient concentration in defined water body. Enhanced biomass, changes to other primary producers	X	X				X	Nutrient suite			
ORGANIC ENRICHMENT	Primary effect on biology	Increased organic enrichment; change in biological community structure			X			X	Organic suite			
ANNEX 8 AND ANNEX 10 POLLUTANTS	Primary effects on sediment and water quality	Increased concentrations of contaminants (water column and sediments)			X			X	General suite	X	X	X
HYDROLOGICAL	Primary effect on biology	Changed water levels from abstraction; altered flow regime impacting biology	X	X	X	X	X	X	General suite			
MORPHOLOGICAL	Primary effect on biology	Riparian and channel modification, altered sediment characteristics (e.g. size), smothering and damage to river bed	X		X	X	X	X				
ACIDIFICATION	Primary effect on biology	Change in ANC & Ph; change in biological community & toxicity synergies		X	X	X			Acidification suite			

Table 5. Quality elements sensitive to the pressures affecting lakes

SOURCE PRESSURE	CATEGORY OF EFFECT	EXPOSURE PRESSURE	PHYTOPLANKTON	MACROPHYTE	PHYTOBENTHOS	MACRO-INVERTEBRATES	FISH	MORPHOLOGY	HYDROLOGY	GENERAL PHYSICOCHEMICAL	SPECIFIC POLLUTANTS	PRIORITY SUBSTANCES	PRIORITY HAZARDOUS SUBSTANCES
NUTRIENT & ORGANIC ENRICHMENT	Primary effect on biology	Change in nutrient concentration in defined water body. Enhanced biomass, changes to other primary producers	X	X	X				X	Nutrient suite			
ANNEX 8 AND ANNEX 10 POLLUTANTS	Primary effects on sediment and water quality	Increased concentrations of contaminants (water column and sediments)				X			X	General suite			
HYDROLOGICAL	Primary effect on biology	Changed water levels from abstraction; altered flow regime impacting biology; concentration of nutrients	X	X		X		X	X				
MORPHOLOGICAL	Primary effect on biology	Shoreline and channel modification, altered sediment characteristics (e.g. size), smothering and damage to river bed		X		X		X	X				
ACIDIFICATION	Primary effect on biology	Change in ANC & Ph; change in biological community & toxicity synergies			X	X	X		X	Acidification suite			

Table 6. Quality elements sensitive to the pressures affecting transitional and coastal waters

SOURCE PRESSURE	CATEGORY OF EFFECT	EXPOSURE PRESSURE	PHYTOPLANKTON	MACROALGAE	ANGIOSPERMS	BENTHIC-INVERTEBRATES	FISH (Transitional only)	MORPHOLOGY	HYDROLOGY	GENERAL PHYSICOCHEMICAL	SPECIFIC POLLUTANTS	PRIORITY SUBSTANCES	PRIORITY HAZARDOUS SUBSTANCES
NUTRIENT ENRICHMENT	Primary effect on water quality	Change in nutrient concentration in defined water body [DIN], [DIP], N:P, N:Si (current and changes over time)	X	X	X					X			
ORGANIC ENRICHMENT	Primary effect on sediment quality	Increased deposition of organic carbon to seabed				X				X			
	Primary effect on water quality	Increased organic enrichment of water column				X				X			
	Secondary effects on water quality	Reduced oxygen availability (reduced dissolved oxygen in water column, and anaerobic sediments)				X	X			X			
POINT HAZARDOUS SUBSTANCES	Primary effect on sediment and water quality	Increased concentrations of contaminants (water column and sediments)				X	X				X	X	X
INDUSTRIAL ABSTRACTION	Primary effect on biology	Entrainment of fish and invertebrates					X		X				
	Primary effect on water quality	Altered temperature regime of water column (mean seasonal temp, spatial temp pattern, degrees above surrounding water)					X			X			
	Secondary effects on water quality	Reduced oxygen availability (reduced dissolved oxygen in water column, and anaerobic sediments)					X			X			
CATCHMENT ABSTRACTION	Primary effect on hydrology	Altered salinity regime of estuary (salinity of water body)				X			X	X			

SOURCE PRESSURE	CATEGORY OF EFFECT	EXPOSURE PRESSURE	PHYTOPLANKTON	MACROALGAE	ANGIOSPERMS	BENTHIC-INVERTEBRATES	FISH (Transitional only)	MORPHOLOGY	HYDROLOGY	GENERAL PHYSICOCHEMICAL	SPECIFIC POLLUTANTS	PRIORITY SUBSTANCES	PRIORITY HAZARDOUS SUBSTANCES
	Primary effect on hydrology	Reduced flushing leading to reduced oxygen availability				X	X			X			
MORPHOLOGICAL (INCLUDING: SHORELINE REINFORCEMENT, BARRAGES, WEIRS, SLUICES, LAND RECLAIMATION, DREDGING AND DREDGED MATERIAL DISPOSAL, AGGREGATE EXTRACTION)	Primary effect on morphology	Removal of intertidal or sub tidal area (area lost), Increased availability of hard substrata (area added), altered sediment characteristics (e.g. size), smothering and damage to seabed structures (e.g. increased sedimentation)		X	X	X	X	X	X	X			
	Secondary effects on hydrology	Barrier to movement of mobile fauna, reduced flushing, altered tidal range, decreased / increased saline intrusion	X	X	X	X	X		X	X			
	Secondary effects on water quality	Reduced oxygen availability (reduced dissolved oxygen in water column, and anaerobic sediments), increased turbidity, change in nutrient concentrations	X	X	X	X	X			X			
COMMERCIAL FISHING	Primary effect on morphology	Altered distribution of sediment & seabed topography			X	X		X					
	Primary effect on biology	Damage to sensitive habitats			X	X		X					
	Primary effect on biology	Removal of target and non-target species				X	X						
AQUACULTURE	Primary effect on sediment quality	Increased deposition of organic carbon to seabed				X				X			
	Primary effect on water quality	Increased organic enrichment of water column	X							X			
	Primary effect on sediment and water quality	Increased concentrations of contaminants (water column and sediments)				X	X				X	X	X
	Secondary effects	Reduced oxygen availability				X				X			

SOURCE PRESSURE	CATEGORY OF EFFECT	EXPOSURE PRESSURE	PHYTOPLANKTON	MACROALGAE	ANGIOSPERMS	BENTHIC-INVERTEBRATES	FISH (Transitional only)	MORPHOLOGY	HYDROLOGY	GENERAL PHYSICOCHEMICAL	SPECIFIC POLLUTANTS	PRIORITY SUBSTANCES	PRIORITY HAZARDOUS SUBSTANCES
	on water quality	(reduced dissolved oxygen and anaerobic sediments)											
	Secondary effects on water quality	Reduced carbon availability (shellfish farming)	X			X	X						
ALIEN SPECIES	Primary effect on biology	Invasion and / or replacement of native fauna	?X	?X	?X	?X	?X						
	Secondary effects on Morphology	Altered sediment / substrata characteristics (specific species)			X	X		X	X				

In addition, there are also drivers for monitoring these quality elements according to the WFD. Which are presented in the next table.

Appendix 1. Overlapping drivers for monitoring concurrent with the Water Framework Directive

Drivers	Start	End	Data Collected
EU Directives			
Urban Waste Water Treatment Directive (91/271/EEC)	1991	Ongoing	Chemistry, microbiology, biology
Bathing Waters Directive (76/160/EEC)	1975	Ongoing	Chemistry microbiology, water resources for abnormal weather
Dangerous Substances Directive (76/464/EEC)	1976	2003	Chemistry
Dangerous Substances (List 1) Daughter Directives	1976	tbc	Chemistry
Freshwater Fish Directive (78/659/EEC)	1978	2013	Chemistry, microbiology, biology
Groundwater Directive (80/68/EEC)	1979	2013	Chemistry
Nitrates Directive (91/676/EEC)	1991	Ongoing	Chemistry, biology
Shellfish Waters Directive (79/440/EEC)	1979	2013	Chemistry, microbiology
Surface Waters for Drinking Directive (75/440/EEC)	1975	2007	Chemistry, microbiology
Drinking Water Directive (98/;83/EEC)	1998	Ongoing	Chemistry, microbiology
Exchange of Information Directive (77/795/EEC)	1977	Ongoing	Report chemistry and biology
Environmental Impact Assessment (85/337/EEC)	1985	Ongoing	May inform investigative monitoring
Strategic Environmental Assessment (2001/42/EEC)	2001	Ongoing	May inform investigative monitoring
Habitats Directive (92/43/EEC)	1992	Ongoing	Chemistry and biology as appropriate
Birds Directive (79/409/EEC)	1979	Ongoing	Chemistry and biology as appropriate
Integrated Pollution Prevention and Control (IPPC) (96/61/EEC)	1999	Ongoing	Chemistry
Other legislation and drivers			
Control of Pollution Act (COPA) 1974	1974	2005	Chemistry, water resources for Q95 flows, Microbiology
Pollution Prevention and Control (PPC) Act 1999	1999	tbc	Chemistry, water resources for ground water level
Water Resources Act, 1991 (E+W)	1991	Ongoing	Chemistry, water resources

Drivers	Start	End	Data Collected
Countryside and Rights of Way Act Nature Conservation Act [Scotland]	2000 2004	tbc	tbc – Biodiversity information
Electricity Act 1989	1989	Ongoing	Water resources
Water Fittings (Water Supply) Regulations 1999 [England and Wales] Water Act [Scotland] 1980	1999 1980	tbc	Water resources
Radioactive Substances Act (RSA)	1993	Ongoing	tbc
Water Environment and Water Services Act (WEWS)	2006	Ongoing	Chemistry, water resources, biology, habitat
WEWS regulations	2005	Ongoing	Chemistry, water resources, biology, habitat
Environment Act 1995	1995	tbc	All
OSPAR – including North Sea Conventions	1998		Chemistry, water resources for loadings, discharges
Harmonized Monitoring Scheme			Chemistry, water resources National Marine Monitoring Plans Biology, chemistry Acid Waters Biology, chemistry
Environmental Change Network (ECN)			Chemistry, biology, water resources
Natural Heritage (Scotland) Act	1991		Water resources

Attachment 5: Environmental Objectives

Source: (Water Framework Directive, 2000)

1. In making operational the programmes of measures specified in the river basin management plans:

(a) For surface waters

(i) Member States shall implement the necessary measures to prevent deterioration of the status of all bodies of surface water, subject to the application of paragraphs 6 and 7 and without prejudice to paragraph 8;

(ii) Member States shall protect, enhance and restore all bodies of surface water, subject to the application of subparagraph (iii) for artificial and heavily modified bodies of water, with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of this Directive, in accordance with the provisions in Annex V, subject to the application of extensions determined in accordance with paragraph 4 and to the application of paragraphs 5, 6 and 7 without prejudice to paragraph 8;

(iii) Member States shall protect and enhance all artificial and heavily modified bodies of water, with the aim of achieving good ecological potential and good surface water chemical status at the latest 15 years from the date of entry into force of this Directive, in accordance with the provisions in Annex V, subject to the application of extensions determined in accordance with paragraph 4 and to the application of paragraphs 5, 6 and 7 without prejudice to paragraph 8;

(iv) Member States shall implement the necessary measures in accordance with Article 16(1) and (8), with the aim of progressively reducing pollution from priority substances and ceasing or phasing out emissions, discharges and losses of priority hazardous substances without prejudice to the relevant international agreements referred to in Article 1 for the parties concerned;

(b) For groundwater

(i) Member States shall implement the measures necessary to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater, subject to the application of paragraphs 6 and 7 and without prejudice to paragraph 8 of this Article and subject to the application of Article 11(3)(j);

(ii) Member States shall protect, enhance and restore all bodies of groundwater, ensure a balance between abstraction and recharge of groundwater, with the aim of achieving good groundwater status at the latest 15 years after the date of entry into force of this Directive, in accordance with the provisions in Annex V, subject to the application of extensions determined in accordance with paragraph 4 and to the application of paragraphs 5, 6 and 7 without prejudice to paragraph 8 of this Article and subject to the application of Article 11(3)(j);

(iii) Member States shall implement the measures necessary to reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order progressively to reduce pollution of groundwater.

Measures to achieve trend reversal shall be implemented in accordance with paragraphs 2, 4 and 5 of Article 17, taking into account the applicable standards set out in relevant Community legislation, subject to the application of paragraphs 6 and 7 and without prejudice to paragraph 8;

(c) For protected areas

Member States shall achieve compliance with any standards and objectives at the latest 15 years after the date of entry into force of this Directive, unless otherwise specified in the Community legislation under which the individual protected areas have been established.

2. Where more than one of the objectives under paragraph 1 relates to a given body of water, the most stringent shall apply.

3. Member States may designate a body of surface water as artificial or heavily modified, when:

(a) The changes to the hydro morphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects on:

(i) The wider environment;
(ii) Navigation, including port facilities, or recreation;
(iii) Activities for the purposes of which water is stored, such as drinking-water supply, power generation or irrigation;
(iv) Water regulation, flood protection, land drainage, or
(v) Other equally important sustainable human development activities;

(b) The beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option.

Such designation and the reasons for it shall be specifically mentioned in the river basin management plans required under Article 13 and reviewed every six years.

4. The deadlines established under paragraph 1 may be extended for the purposes of phased achievement of the objectives for bodies of water, provided that no further deterioration occurs in the status of the affected body of water when all of the following conditions are met:

(a) Member States determine that all necessary improvements in the status of bodies of water cannot reasonably be achieved within the timescales set out in that paragraph for at least one of the following reasons:

(i) The scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility;
(ii) Completing the improvements within the timescale would be disproportionately expensive;
(iii) Natural conditions do not allow timely improvement in the status of the body of water.

(b) Extension of the deadline, and the reasons for it, are specifically set out and explained in the river basin management plan required under Article 13.

(c) Extensions shall be limited to a maximum of two further updates of the river basin management plan except in cases where the natural conditions are such that the objectives cannot be achieved within this period.

(d) A summary of the measures required under Article 11 which are envisaged as necessary to bring the bodies of water progressively to the required status by the extended deadline, the reasons for any significant delay in making these measures operational, and the expected timetable for their implementation are set out in the river basin management plan. A review of the implementation of these measures and a summary of any additional measures shall be included in updates of the river basin management plan.

5. Member States may aim to achieve less stringent environmental objectives than those required under paragraph 1 for specific bodies of water when they are so affected by human activity, as determined in accordance with Article 5(1), or their natural condition is such that the achievement of these objectives would be infeasible or disproportionately expensive, and all the following conditions are met:

(a) The environmental and socioeconomic needs served by such human activity cannot be achieved by other means, which are a significantly better environmental option not entailing disproportionate costs;

(b) Member States ensure, for surface water, the highest ecological and chemical status possible is achieved, given impacts that could not reasonably have been avoided due to the nature of the human activity or pollution, for groundwater, the least possible changes to good groundwater status, given impacts that could not reasonably have been avoided due to the nature of the human activity or pollution;

(c) No further deterioration occurs in the status of the affected body of water;

(d) The establishment of less stringent environmental objectives, and the reasons for it, are specifically mentioned in the river basin management plan required under Article 13 and those objectives are reviewed every six years.

6. Temporary deterioration in the status of bodies of water shall not be in breach of the requirements of this Directive if this is the result of circumstances of natural cause or force majeure which are exceptional or could not reasonably have been foreseen, in particular extreme floods and prolonged droughts, or the result of circumstances due to accidents which could not reasonably have been foreseen, when all of the following conditions have been met:

(a) all practicable steps are taken to prevent further deterioration in status and in order not to compromise the achievement of the objectives of this Directive in other bodies of water not affected by those circumstances;

(b) The conditions under which circumstances that are exceptional or that could not reasonably have been foreseen may be declared, including the adoption of the appropriate indicators, are stated in the river basin management plan;

(c) The measures to be taken under such exceptional circumstances are included in the program of measures and will not compromise the recovery of the quality of the body of water once the circumstances are over;

(d) the effects of the circumstances that are exceptional or that could not reasonably have been foreseen are reviewed annually and, subject to the reasons set out in paragraph 4(a), all practicable measures are taken with the aim of restoring the body of water to its status prior to the effects of those circumstances as soon as reasonably practicable, and (e) a summary of the effects of the circumstances and of such measures taken or to be taken in accordance with paragraphs (a) and (d) are included in the next update of the river basin management plan.

7. Member States will not be in breach of this Directive when:

- Failure to achieve good groundwater status, good ecological status or, where relevant, good ecological potential or to prevent deterioration in the status of a body of surface water or groundwater is the result of new modifications to the physical characteristics of a surface water body or alterations to the level of bodies of groundwater, or.
- Failure to prevent deterioration from high status to good status of a body of surface water is the result of new sustainable human development activities and all the following conditions are met:

(a) All practicable steps are taken to mitigate the adverse impact on the status of the body of water;

(b) The reasons for those modifications or alterations are specifically set out and explained in the river basin management plan required under Article 13 and the objectives are reviewed every six years;

(c) the reasons for those modifications or alterations are of overriding public interest and/or the benefits to the environment and to society of achieving the objectives set out in paragraph 1 are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development, and

(d) The beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

8. When applying paragraphs 3, 4, 5, 6 and 7, a Member State shall ensure that the application does not permanently exclude or compromise the achievement of the objectives of this Directive in other bodies of water within the same river basin district and is consistent with the implementation of other Community environmental legislation.

9. Steps must be taken to ensure that the application of the new provisions, including the application of paragraphs 3, 4, 5, 6 and 7, guarantees at least the same level of protection as the existing Community legislation.