

## 3.2 River Basins

For every cross-section of a river we can determine a catchment area. This zone is separated from adjacent areas by watersheds. The entire catchment area of a single river is called a river basin.

We distinguish between above-ground and subterranean catchment areas. The watersheds of the above-ground catchment areas are determined by orographic features, while subterranean catchment areas are established by hydrogeological circumstances. In topographically structured terrain both watersheds usually coincide. Exceptions arise in karst terrain, for example, where the hydraulic conditions in the underlying rock, which is interspersed with cavities, make it difficult to distinguish between the various zones. It is also difficult to locate watersheds conclusively in wet areas (moors and swamps) and in plain areas, where the catchment areas can also change with the water level of the river.

During the course of geological periods, watersheds undergo a change. A well-known instance of this is river breaching whereby erosion causes a river to break through the existing watershed and increase its catchment area by subsuming the breached water.



Fig. 1 Major river basins of Europe

Most Central European streams and rivers flow into the North and Baltic Seas, thus following the general downward incline from the Alps to the outlying seas towards the north. Only the Danube runs towards the southeast into the Black Sea. The main watershed in Europe, between the Mediterranean and the North and Baltic Seas, crosses South Germany as the dividing line between the Danube area and the Rhine and Elbe catchment areas. There are a number of water channels that conduct water across the catchment areas through shipping canals or long-distance water pipelines.

### Map Structures

Map 3.2 represents the above-ground river basins with a surface of over 500 km<sup>2</sup>. The river basins have been classified according to the order number of the rivers by variously emphasizing the symbols for the watersheds. According to the conventional approach to river categorisation, the main river is Class 1; those tributaries that drain directly into it are Class 2, while those which drain into the latter are Class 3, etc. Here the river basins have been classified by analogy, whereby the 6 river systems of Germany and the coastal areas of the North and Baltic Seas have been put into Class 1.

A river is divided into sections (upper, middle, and lower course) according to morphological and hydrological aspects. For the river systems represented, the catchment areas of those sections have been given distinct colours.

#### The Danube 817,000 km<sup>2</sup>

With a length of 2,857 km and a long-standing average discharge of approx. 6,500 m<sup>3</sup>/s, the Danube is the second largest river of Europe after the Volga. Its source rivers, the Breg and Brigach, rise in the southern Schwarzwald (Black Forest). From the unification of the small source rivers in Donaueschingen until Ulm, the Danube is regarded as a low mountain river. As the tributaries from the northeast Alps flow in from its right, the Danube below Ulm metamorphoses into a river with alpine regime, and leaves the Federal Republic of Germany at Passau after flowing through the country for 625 km. The largest tributary of the Danube in the northern Alpine foothills is the Inn River, 515 km long. At their junction near Passau, the Inn carries more water than the Danube itself.

The upper Danube region extends from its sources in the Black Forest to the Porta Hungarica, east of Vienna.

#### The Rhine 185,300 km<sup>2</sup>

Lake Toma, in the northern high cirque of Piz Badus (2,928 m) in Switzerland is regarded as the source of the Vorderrhein (front Rhine). The Hinterrhein (rear Rhine) rises from the Paradies Glacier at the Maschhorn (Adula Range) in the Rhine Forest area. The source rivers join in Reichenau, near Chur. The alpine Rhine, or the course until Bodensee (Lake Constance), is a high mountain river. Below Lake Constance, from Stein am Rhein, the river flows west as the Hochrhein (High Rhine) over a distance of 142 km until Basel. From the mouth of the Aare on, the discharge rate of the Rhine is affected by numerous glacier and high-mountain streams, whose unbridled drainage "patterns" compensate for three alpine fringe lakes.

After Basel, the Oberrhein (Upper Rhine) flows through the approx. 300 km long and, on average, 35 km wide Upper Rhine graben, or rift. With the exception of the Neckar area, only relatively minor catchment areas follow; however, they have high runoff levels due to the high precipitation and the relief. In Mainz the tributary with the largest surface, the Main, joins the Rhine after a distance of 524 km. Until Bingen only small secondary rivers flow into the Rhine.

The section of the Rhine that extends from Bingen to south of Cologne is called the Mittelrhein (Middle Rhine). The largest tributaries along this stretch are the Nahe, Moselle, Lahn, and Sieg Rivers, and of these the Moselle, which is 545 km long and rises on the western slope of the Vosges, represents the main one.

South of Cologne the Middle Rhine discharges into the Niederrheinische Bucht (Lower Rhine Bight). At the western Lower Rhine the watershed of the Maas is close to the Rhine. Since the water level of the Maas is lower than that of the Rhine, subterranean drainage towards the Maas is easy.

Immediately after the German/Dutch border, the Rhine Delta begins, the area where the Rhine and the Maas dovetail; that is why the catchment area of the Maas might also be regarded as belonging to the Rhine.

The IJssel and its main tributary the Vechte, both of which are typical lowland rivers, could also be included in the Rhine area, since Rhine water flows into the IJssel Lake via the Pannerdensch Canal. Both rivers drain the western part of the Münsterland, a region that is characterised by sandy and marshy landscapes, high ground-water levels, and leisurely-flowing rivers with numerous forks. Because of the slight incline this region is only inadequately drained by the unhurried flow of the Vechte, Dinkel, Berkel, and other tributaries of the IJssel system. In the natural state of these waters the watersheds in this landscape are variable depending on the water levels of the rivers.

#### The Ems 15,600 km<sup>2</sup>

The Ems, a lowland river of some 370 km in length, rises from the Senne at the southern foot of the Teutoburger Wald, in a spreading, sandy region. Until the tide mark at Papenburg, the Ems flows mainly through geest landscapes of the northern Münsterland and the Lower Saxon Emsland. The watersheds of the tributaries on its right bank have been artificially fixed in a number of areas, e.g. in the Massholt Depression of the Emsland moors. The section of the river as far as Bentlage corresponds to the upper course, from Bentlage to Meppen is the middle course, and the stretch from Meppen to Emden is viewed as the lower course of the Ems. The most important German tributaries of the Ems are the Hase, which joins the Ems at Meppen, and the tidal river Eda, at Leer. The Hase bifurcates some 10 km after its source. This is where the Else rises; its catchment area drains the Weser region, though. The Aa of Westerwold, the largest Dutch river in the catchment area of the Ems, flows into the southern tip of Dollart Bay.

#### The Weser 46,300 km<sup>2</sup>

The Weser springs from the junction of its source rivers the Werra and Fulda near Münster. Until the mouth of the river at the North Sea it covers a distance of 432 km; from the Werra Springs at the Thüringer Wald (Thuringian Forest) to the river mouth the distance is 725 km. Below the Porta Westfalica the Weser is a plains river. There is little landscape and hydrographic change along its course to the mouth of the Aller, 128 km away. The river basin barely grows, first meandering through geest landscapes before being deviated into the ice marginal valley (Urstromtal) of the Aller below Verden, which causes a sudden rise in the discharge rate.

The basin of the Aller is more strongly developed on the right bank than on the left, as with the other north German rivers, which has its geomorphological foundation in the inclusion of the Aller Urstromtal in the river basin of the Weser. The Aller itself, which rises at the rim of the Magdeburger Börde (Magdeburg ledge), is also a lowland river; however, its drainage dynamics are influenced by mountain springs of the Harz Range. The nontidal section of the Weser ends at Bremen; the Lower Weser that follows is subject to the tides of the North Sea.

#### The Elbe 148,270 km<sup>2</sup>

The River Elbe rises in the Czech Republic, on the southern slope of the Riesengebirge crest, at 1383 m above sea level, and flows through the basin of northeast Bohemia in a wide bend. There it receives its greatest tributary, the Moldau ( $A_{Eo} = 28,090 \text{ km}^2$ ), which carries a greater volume of water at this point than the Elbe. The Elbe reaches the German/Czech border above Pirna. From the national border to the mouth of the Elster, the Elbe first flows through the Elbsandsteingebirge (Elb Sandstone range). Upon quitting the widening valley of the Dresden Basin, the Upper Elbe reaches the north German lowlands at Castle Hirschstein, 96 km into its course. From there to the Geesthacht Weir, below Lauenburg, the river – now called the Middle Elbe – is a plains river. In the area of the Breslau-Magdeburg Urstromtal the Mulde and Saale Rivers flow into the Middle Elbe; both tributaries can transport high runoff levels during floods.

In the Glogau-Baruth Urstromtal, the Havel river ( $A_{Eo} = 24,096 \text{ km}^2$ ) flows into the Elbe as the second largest tributary. It rises from the Havel spring lakes near Dambeck in Mecklenburg-Vorpommern (Mecklenburg Western Pomerania), flows through numerous lakes in the Havel region via the Gnevsdorf draining ditch with a very balanced water flow and then into the Elbe.

The part of the river from the Geesthacht Weir to the location where the Elbe flows into the North Sea near Cuxhaven-Kugelbake (Elbe-km 727) is called the Lower Elbe (Tidal Elbe).

#### The Odra 118,860 km<sup>2</sup>

The source of the Odra lies in the Odra Range, in the Czech part of the Eastern Sudeten Mountains near Olomouc, at 634 m above sea level. Its principal tributary is the Warthe, flowing in from Poland. With 5,587 km<sup>2</sup> the German segment of the Odra catchment area, which amounts to 118,860 km<sup>2</sup>, is a relatively small one. The main tributaries within this area are the Lausitzer or Eastern Neisse and the Hohensaaten-Friedrichstal Waterway.

Over a continuous length of 376 km the Lausitzer Neisse, Odra, and West Odra constitute the national border between the Polish Republic and the Federal Republic of Germany. The Odra flows completely back onto Polish territory slightly above Stettin.

The drainage patterns of the Odra result from climatological and hydrographical conditions on Polish and Czech territory. German tributaries have only minor influence on the Odra's drainage patterns. Flooding is determined exclusively by precipitation events in the Polish and Czech mountain regions.

Table 1 Characteristic values of the river basins

river basins and coastal regions	catchment area surface total [km <sup>2</sup> ] <sup>a</sup>	catchment area German segment [km <sup>2</sup> ] <sup>a</sup>	river length total [km]	mean annual discharge 1961-1990 [m <sup>3</sup> /s] at gauging station
Danube	817 000	59 630	2 857	1 426 Achleiten
Rhine	185 300	104 660	1 320	2 382 Rees
Ems	15 600	13 200	370	82 Versen
Weser	46 300	46 300	432	332 Intschede
Elbe	148 270	96 930	1 091	877 Cuxhaven
Odra	118 860	5 590	850	558 Hohensaaten Finow
North Sea		6 540		77
Baltic Sea		22 280		158

<sup>a</sup> rounded values, coastal regions with islands (preliminary values)

### Practical Information

To derive the catchment areas represented, the watersheds were calculated automatically based on a digital drainage network (map scale 1 : 500,000) and a digital elevation model with a grid size of 1 x 1 km, using the algorithms contained in the GIS Software ARC/INFO. Subsequently the borders were adjusted manually while taking analogue maps into account.

National hydrographic descriptions of river basins and catchment areas can be found in the text book section of the Hydrological Atlas of 1978 (KELLER 1979). Catchment areas and surface indications, for foreign river courses too, can be found in the hydrological monographs for the Rhine (KHR/CHR, 1978) and the Danube (Regional Co-operation of the Danube Countries, 1986). Hydrographic descriptions and map representations of selected catchment areas, to a scale of 1 : 500,000, are contained in the Deutsches Gewässerkundliches Jahrbuch (DGJ, German Hydrological Yearbook) series in accordance with the regional classification of those publications. Information concerning place names, place codes, and the surface areas of all the catchment areas defined the Federal Republic of Germany can be found in the surface register of the Federal States.