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ASSESSMENT OF ANTHROPOGENIC IMPACTS ON WATER BODIES IN AGRICULTURAL CATCHMENT

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Contents

1. INTRODUCTION

The most important European Union's tool in the field of water management is the Directive 2000/60/EC of the European Parliament and of the Council, commonly called the Water Framework Directive (WFD). The Directive entered into force on 22 December 2000. The WFD draws on years of experience of several member states and serves as a basis for sustainable use of water resources in the EU. Its fundamental aim is to achieve, as soon as possible, the good water status. This can be done only by taking the following measures: catchment management of water resources, extending of legal protection of surface and groundwater, balancing of water resources taking into account their quality, economic principles of resources management, and broad public participation in the decision making process.

With accession to the European Union, Poland has committed itself to implement the Union's legislation. Implementation of the WFD was considerably complicated by the fact that Polish approach to various water management issues had been very different from that applied by the "old member states". In our country, information on water management is gathered by a system of administrative institutions and transformation to the catchment system is not straightforward. Moreover, the number of such institutions is quite big and database formats are incompatible.

In 2002 the State Committee for Scientific Research (KBN) launched a commissioned research project no 061/T07/2001 "Methodological Basis of the National Plan for Integrated Development of Water Management in Poland". This project was carried out by 10 domestic research teams and was coordinated by Prof. Elżbieta Nachlik PhD (Eng) from the Cracow University of Technology. Under this project, the Institute of Environmental Engineering of Wrocław University of Environmental and Life Sciences has carried out research on the assessment of pressure in the water region of the Middle Odra in a typical agricultural catchment. The Widawa catchment was selected for this purpose because of the considerable agricultural pressure. The significant percentage of arable land and urban areas in this catchment have a substantial impact on the water ecosystems. Intensification of farming increases emission of nutrients and leads to excessive eutrophication of water bodies. Systems related to irrigation and draining of agricultural land influence the hydromorphological transformation of the river bed of Widawa and most if its tributaries. Artificial water bodies are also related to the agricultural use of the catchment: the two newly-built water reservoirs (Stradomia and Michalice) have been designed mainly for agricultural irrigation.

The information presented in this monograph is drawn from partial reports compiled in 2002–2005 in the Institute of Environmental Engineering of Wrocław University of Environmental and Life Sciences [Czaban et al. 2004] and from reports of Cracow University of Technology [Nachlik et al. 2006].

2. WATER FRAMEWORK DIRECTIVE

The fundamental document that regulates water management and protection in the European Union is the Water Framework Directive [WFD], which establishes an integrated system of surface and groundwater protection and of protected areas. The WFD aims to:

- prevent further deterioration, protect and enhance the status of aquatic ecosystems and, with regard to their water needs, of terrestrial ecosystems and wetlands directly dependent on water,
- promote sustainable water use,
- enhance protection and improve the aquatic environment through progressive reduction of discharges, emissions and losses of priority substances,
- reduce pollution of groundwater,
- mitigate the effects of floods and droughts.

The Water Framework Directive obliges the EU member states to achieve the "good status" of surface and groundwater. Objectives that must be achieved until 2015 are as follows:

a) for surface waters (inland waters, transitional waters, coastal waters):
   - ✓ prevent deterioration of the status of all bodies of surface water[1],
   - ✓ achieve good surface water status (except for artificial and heavily modified bodies of water),
   - ✓ achieve good ecological potential and good surface water chemical status of artificial and heavily modified bodies of water,

b) for groundwater:
   - ✓ prevent or limit the input of pollutants into groundwater and prevent the deterioration of the status of all bodies of groundwater[2],
   - ✓ achieve good status of groundwater bodies,

c) for protected areas:
   - ✓ achieve compliance with any standards and objectives; the deadline for this goal may be specified in the Community legislation under which the individual protected areas have been established (WFD No 3-7, 2003).

For the purpose of the WFD, an impact is considered significant if it can prevent the proposed environmental objectives from being achieved, either independently or jointly with other factors. The process of analysing anthropogenic impacts and their effects consists in assessing the risk of failing the objectives. This amounts to collecting available information

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[1] A surface water body (pol. jednolita część wód powierzchniowych) as defined in the Water Law (Dz.U. 2001.115.1229 as amended) means a discrete and significant element of surface water such as a lake or other natural reservoir, an artificial reservoir, a stream, river or canal, part of a stream, river or canal, internal marine waters, transitional waters or coastal waters.

[2] A groundwater body (pol. jednolita część wód podziemnych) as defined in the Water Law (Dz.U. 2001.115.1229 as amended) means a distinct volume of groundwater within an aquifer or aquifers.

on anthropogenic impacts within water bodies, determining their influence on the status of water, assessing the current water status and evaluating the chances that deadlines will be met for stated environmental objectives.

For surface water bodies listed in Article 4 of WFD the environmental objectives specify 2015 as the year in which all surface water bodies must achieve good status, as a result of achieving good ecological status and good chemical status. This applies to all water bodies except for those that are artificial or heavily modified, which are required to achieve good ecological potential. As can be seen from the presented definitions (Figure 2.1), good status of water results from good hydromorphological, ecological and chemical status. Failure to achieve any of these three excludes reaching the good status overall.

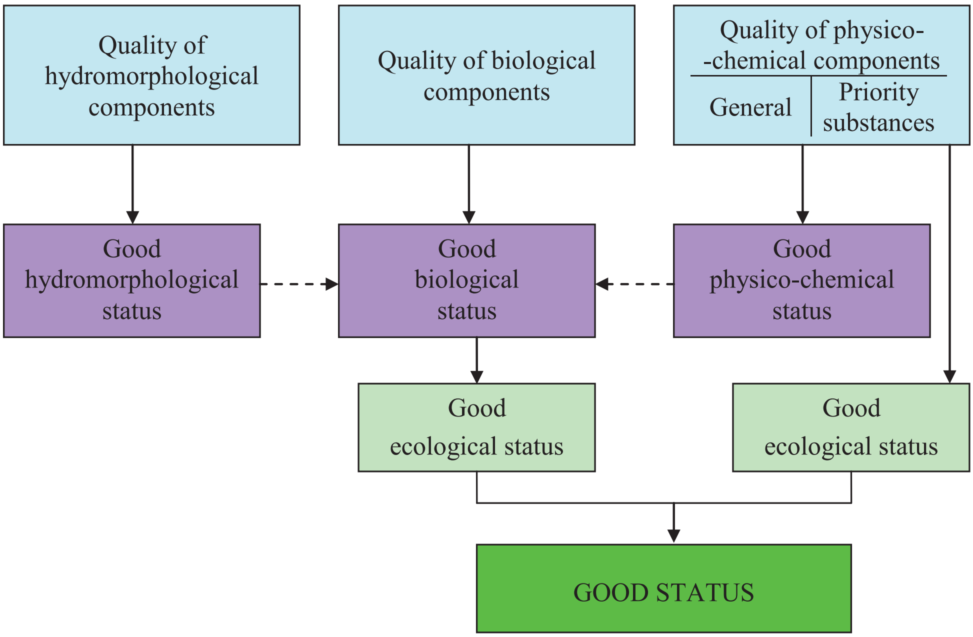


Fig. 2.1. A scheme for evaluation of the good status of water as resulting from combined assessment of ecological and chemical status

An overview of the impacts and their effect on water status is supposed to identify those water bodies for which the WFD objectives cannot be reached or are at risk of failing. Causes of such a situation must be recognized, which includes risk assessment. Results of the analysis of anthropogenic impacts on water and of their effects are used to assess the risk of failing the environmental objectives with respect to water bodies and to develop a monitoring programme to verify the causes of risk. Based on verified results of impacts analysis an action programme is defined to meet environmental objectives in those bodies of water (Fig. 2.2). Monitoring programmes will provide information essential to verifying the assessment of the risk of failing the environmental objectives, determining the status of water bodies and assessing the results of the implemented action programme.

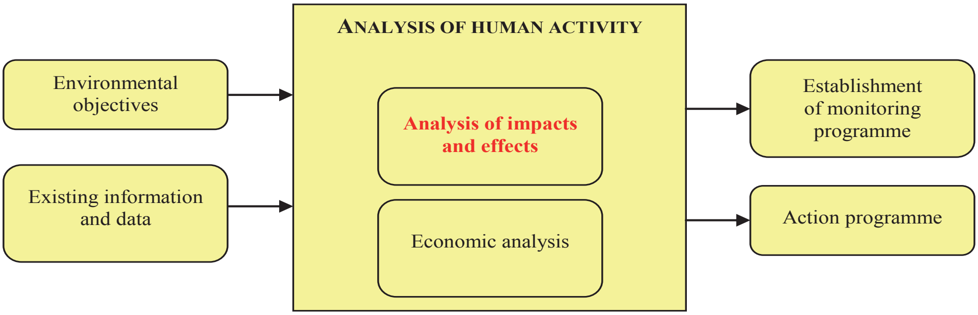


Fig. 2.2. Position of the analysis of anthropogenic impacts and their effects in the water management planning process

The IMPRESS working group, which develops the "Guidance for the Analysis of Pressures and Impacts in Accordance with the Water Framework Directive"[3], has presented a procedure for analysis of impacts and their effects in the form of a DPSIR (*Driver – Pressure – State – Impact – Response*) scheme, Fig. 2.3. It is worth noting the difficulties in distinguishing between "state" and "effect". In many cases the "effect" is hard to measure. A "state" is therefore used as an indicator of "effect" or instead of it. Usage of state as an effect indicator is based on the assumption that the dependence between state and effect is well identified (which is not always the case). As an example let us recall the use of physico-chemical characteristics of water for its ecological assessment.

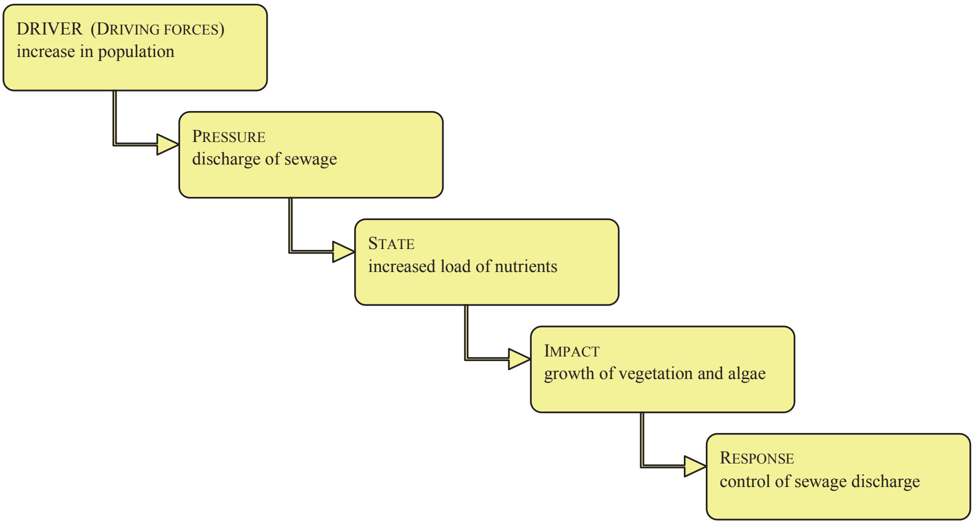


Fig. 2.3. Example of application of the DPSIR scheme

3 "Guidance for the Analysis of Pressures and Impacts in Accordance with the Water Framework Directive" (21/22 November 2002)

The Water Framework Directive defines four types of environmental objectives, namely: ecological status, ecological potential, chemical status and quantitative status, which refer to various types of water bodies (Tab. 2.1). The objective that must be accomplished by 2015 with regard to water bodies is to reach good status, accordingly to the water body type (WFD CIS No 3, No 4, 2003).

To answer the question whether an individual water body is at risk of failing the objective one must do the following:

- assess the current status,
- evaluate the likelihood that good status will be achieved by 2015.

Tasks that must be undertaken before 2015 to comply with the WFD requirements include:

- identifying the anthropogenic impacts on water and their effects including the changes until 2015,
- implementing appropriate actions to reach objectives,
- monitoring of progress in achieving objectives.

For water bodies in protected areas established under other legislation, additional objectives may be set, related to the type of protected area and forms of protection.

Table 2.1. Objectives for various types of water bodies [WFD CIS No 10, 2003, Common … 2005]

	rivers	lakes	transitory waters	coastal waters	artificial and heavily modified bodies of water	groundwater
ecological status	✓	✓	✓	✓	–	–
ecological potential	–	–	–	–	✓	–
chemical status	✓	✓	✓	✓	✓	✓
quantitative status of groundwater	–	–	–	–	–	✓

The environmental objective for surface water bodies is not only to achieve good status, but also to ensure that conditions will not deteriorate. The ecological status and the ecological potential determine three groups of quality elements: biological, physico-chemical and hydromorphological.

The biological quality elements include three groups of organisms: flora, benthic invertebrate fauna and fish fauna (except for coastal waters). Definitions of ecological statuses (from high to poor) for biological quality elements are set out in Annex V to the WFD [WFD CIS No 10, 2003, Common... 2005].

The physico-chemical quality elements can be divided into two groups: general elements and specific pollutants (Tab. 2.2).

Table 2.2. Physico-chemical elements of ecological status assessment [WFD CIS No 10, 2003, Common... 2005]

Group of elements	Element	Status	Definition
General	temperature conditions, oxygen balance, salinity, acidity, nutrient concentration, transparency (for lakes only)	high	conditions totally or nearly totally undisturbed
		good	within the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified for the biological quality elements
		moderate	conditions consistent with the achievement of the values specified for the biological quality elements
Specific synthetic pollutants (priority substances and other substances discharged in insignificant amounts)	synthetic	high	below the limits of detection
		good	within the limits of environmental quality standards
		moderate	quantities consistent with the achievement of the values that refer to the biological quality elements
	non-synthetic	high	below background level
		good	within the limits of environmental quality standards
		moderate	quantities consistent with the achievement of the values that refer to the biological quality elements

The hydromorphological quality elements are essential for expert assessment of ecological status. Inappropriate hydromorphological status may prevent a water body from achieving a high or good biological quality status, even when the physico-chemical status is appropriately high. Disadvantageous hydromorphological conditions can keep aquatic flora and fauna from developing correctly. When no information on the quality of biological elements is available, the hydromorphological quality elements make an indirect assessment of the ecological status possible.

The Water Framework Directive also defines the status of groundwater bodies. Their status is good if both the quantitative and the qualitative status is described as "good". Quantitative assessment of groundwater identifies two statuses: good and poor.

Following the definition applied in the WFD, good quantitative status of groundwater is achieved when the following conditions are met:

- ✓ resources available in groundwater bodies exceed the annual average rate of consumption;
- ✓ variations of the groundwater table due to its use or other anthropogenic impacts do not and will not significantly affect the status of surface water bodies or terrestrial ecosystems directly dependent on groundwater;
- ✓ lower groundwater table and alterations to flow direction or velocity do not and will not cause saltwater intrusion or inflow of polluted water.

Similarly, the chemical assessment also identifies good and poor groundwater status. Good chemical groundwater status means that the concentrations of substances found in waters meet the requirements set out in Table 2.3.

Table 2.3. Definition of good groundwater chemical status [WFD CIS No 10, 2003, Common... 2005]

Elements	Good status
General	The chemical composition of a groundwater body is such that the concentrations of pollutants: – do not exhibit the effects of saline or other intrusions, – do not exceed the quality standards applicable under other relevant Community legislation in accordance with Article 17, – are not such as would result in failure to achieve the environmental objectives specified under Article 4 for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to terrestrial ecosystems which depend directly on the groundwater body.
Conductivity	Changes in conductivity are not indicative of saline or other intrusion into the groundwater body.

Apart from objectives listed in Table 2.3, water bodies in protected areas must achieve goals defined in various acts under which these protected areas have been established. A list of EU directives that establish protected areas is given in Table 2.4. These directives correspond to appropriate Polish legal standards.

Table 2.4. Community legislation establishing protected areas

Directive	Reason for protection of water
2000/60/EC (Directive establishing a framework for Community action in the field of water policy)	protected areas for intakes of water intended for consumption
76/160/EEC (Directive on the quality of bathing water)	waters intended for bathing facilities
78/659/EEC (Directive on the quality of fresh waters needing protection or improvement in order to support fish life)	fresh waters intended for natural fish habitats
79/923/EEC (Directive on the quality required of shellfish waters)	waters for shellfish farming
79/409/EEC (Directive on the conservation of wild birds)	protection of birds
92/43/EEC (Directive on the conservation of natural habitats and of wild fauna and flora)	natural flora and fauna habitats
91/271/EEC (Directive concerning urban sewage treatment)	nutrient-sensitive areas
91/676/EEC (Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources)	preventing nitrate pollution

In accordance with Article 7 of the WFD, member states are obliged to establish safeguard zones for surface and groundwater reservoirs or water courses intended for human consumption providing more than 10 m^3 a day on average or serving more than 50 persons, and those reservoirs and water-courses intended for such future use.

3. ANALYSIS OF ANTHROPOGENIC IMPACTS – RUDIMENTS

3.1. Data sources

Following the procedure [Nachlik et al. 2004], the impact assessment was carried out using databases managed and maintained by various units, and in cases of incomplete data site visits were performed. Amongst other sources, this study makes use of the data collected in:

- The **Regional Water Management Authority in Wrocław (Regionalny Zarząd Gospodarki Wodnej we Wrocławiu)**:
  - ✓ **Water Cadastre (Kataster wodny).** The Water Cadastre is a water management information system and consists of two parts. Part I collects and updates all data concerned with the hydrographic system, hydrological and meteorological observation and measuring posts, groundwater resources and location of the key groundwater reservoirs. The system also collects results of observations of water, the quality and the quantity of sufrace and groundwater resources, levels of consumption of sufrace and groundwater, sources and characteristics of point-source and diffuse polution, as well as the biological status of water environment and flooded areas. The Cadastre contains data on fishing districts and the usability of water bodies for fishing (bonitation), water use including water use characteristics, water supply and sewage effluent disposal permits, hydroengineering structures, protected zones and areas as well as areas at risk of flooding. Part II covers water management plans in river basin districts, flood protection plans and terms and conditions of water use in the water region;
  - ✓ **Water Books (Księgi wodne).** These contain, amongst others, the data concerned with water supply and sewage effluent disposal permits;
  - ✓ **Registers of water bodies intended for special purposes**, useful in analysing water status with regard to increased requirements due to targeted protection of water resources;
  - ✓ **Descriptions and numerical parameters of the history of straightening of rivers and construction of hydroengineering structures**;
  - ✓ **Register of protected areas**;
  - ✓ **Register of surface and groundwater intakes**.
- **Provincial Authorities of Drainage, Irrrigation and Infrastructure (Wojewódzkie Zarządy Melioracji i Urządzeń Wodnych)**, which collect data on small water retention structures, ponds, barrages, embankments and drainage/irrigation structures.
- **Provincial Inspectorates of Environmental Protection (Wojewódzkie Inspektoraty Ochrony Środowiska)**, which run a basic environmental information database.

- The **Central Statistical Office (Główny Urząd Statystyczny)** (national-level data) and the **Provincial Statistical Offices** (**Wojewódzkie Urzędy Statystyczne, WUS**) (regional-level data). These institutions **administer the Regional Data Bank (Bank Danych Regionalnych, BDR) containing various data, the scope of which depends on the year. BDR is run in three modules: commune (gmina), district (powiat) and province (województwo).** Information on the scope and content of research, types of output information, as well as the method and time of making it available are specified in the "Public Statistics Research Programme". Availability of statistical information is subject to laws on the protection of state secrets and confidential/classified information, as well as the provisions on statistical confidentiality which, in particular, forbid disclosing information on individuals. This study makes use of information drawn from the **Regional Data Bank in its Commune** module and from documents published by the WUS in Wrocław, Opole and Poznań, including the national census and the agricultural census.
- **Marshal Offices (Urzędy Marszałkowskie)**. These run databases of entities making use of the environment. Amongst other data, these databases collect information on surface and groundwater consumption, sewage volumes and pollution loads and concentrations. Data is arranged by quarters, and its scope depends on the information required to calculate the **fees for the economic use of the environment** (the Płatnik system). Units under the Marshal Office authority also have appropriate digital maps.
- The **National Geological Institute** (**Państwowy Instytut Geologiczny, PIG**), and since 2003 its **National Hydrogeologic Service** (**Państwowa Służba Hydrogeologiczna**). These run the following databases:
  - ✓ "**Monitoring of groundwater**" – established in 1970s, this database contains measurement results collected through the observation and measurement network (over 800 points) covering all the country. Measurement and determination results are published in the "Hydrogeological Yearbook" and the "Quarterly Bulletin of Groundwater Information". These results are used to compile and diffuse forecasts and announcements on current hydrogeological situation in the country and warnings on hydrogeological risks.
  - ✓ **HYDRO Bank (Central Hydrogeological Data Bank** – since 1975**)** is a digital hydrogeological database which documents bore-holes, intakes and groundwater sources (standard, mineral and thermal) in Poland. This database covers approx. 170,000 hydrogeological structures.
  - ✓ **SOH** (**Network for Stationary Observation of Groundwater** – operates since 1987). Observations focus on groundwater in the main or secondary aquifer. The network consists of approx. 600 measurement points, including 40 Hydrogeological Stations. Measurements aim to document and assess the dynamics of groundwater resources, protect these resources from over-exploitation and deterioration of their quality.
  - ✓ **MONBADA** (**Monitoring Database** – since 1991). This database collects measurement results on the quality of standard groundwater, which includes water quality assessments. The PIG transfers these results to the Central Inspectorate of Environmental Protection (Główny Inspektorat Ochrony Środowiska, GIOŚ), from where the data is transferred to the Privincial Inspectorates of Environmental Protection. Results from 1994–2003 (monitoring of the national and regional system and of local systems) have been published by the PIOŚ/GIOŚ in the Environmental Monitoring Library (Biblioteka Monitoringu Środowiska) series.

- ✓ **Hydrogeological map of Poland (MhP)** in a scale of 1:50 000. The work on this digital map (GIS) started in 1996. It contains information on useful aquifers of fresh groundwater and expanded hydrogeologic interpretation of the main aquifer as the key source of water. This database is systematically updated with information on the range, depth, width, conductivity and quality of groundwater.
- ✓ "**Major groundwater basin (MGB – GZWP)**" – this database, established in 2003, covers the most significant hydrogeological parameters from over 160 key major groundwater basins in Poland.
- ✓ **GWB (Groundwater Body**) – exists since 2005 and provides information on the quality of groundwater bodies (GWBs).

Quality tests of surface waters have been carried out in over 2500 measurement points in Poland, [Collective work… 1971, 1972, 1975–1993, 2006]. Measurement points for water quality monitoring were located as follows: in river mouths for rivers of over 60 km in length and in impaired rivers; uniformly over the whole length of rivers over 100 km; on rivers flowing into Poland or out of the country; and on littoral rivers. The measurement programme covered about 50 physico-chemical and biological determinations. Frequency of test varied. In about 20 measurement and control points (mouth sections of rivers flowing into the Baltic See and crucial spots on Poland's main rivers – the Vistula and the Odra as well as on their main tributaries) the frequency of determination was once every two weeks, and in all other points – once a month.

Testing and assessment of river water sediments covers determining in fractions below 0.2 mm the concentrations of major elements, i.e: Ca, Mg, Mn, Fe, P, S, and C_{org} (TOC), trace elements: Ag, As, Ba, Cd, Co, Cr, Cu, Hg, Ni, Pb, Sr, Zn, V and WWA. Since 2004 monitoring covers polychlorinated biphenyls and some organochlorine pesticides. Testing is carried out in about 300 measurement and control points. Measurements are conducted by the National Geological Institute and results are stored in the GEMONOS database. In Lower Silesia there are 25 measurement locations, including 1 on the Widawa river, in the site of Świniary (3 km).

Testing and assessment of groundwater status was carried out in line with the „Project of the Regional Network of Groundwater Monitoring". Processed results of observations are available in the following editions: Hydrogeological Yearbooks (Roczniki Hydrogeologiczne), Reports of the Network for Stationary Observation of Groundwater (Raporty Sieci Stacjonarnych Obserwacji Wód Podziemnych) and Hydrogeological Bulletins (Biuletyny Hydrogeologiczne) as well as on the Internet. Quality test of fresh groundwater were carried out in 700 measurement points (wells, piezometers and sources) which cover different aquifers.

Chemical tests on atmospheric precipitation and assessment of deposition of pollutants to the ground in Lower Silesia Province is carried out in 26 measurement stations, but in Widawa catchment there are no measurement points [Collective work … 1993, 2006; National Programme... 1998].

3.2. Procedure for analysis of impacts and effects

According to the proposed procedure [Nachlik et al. 2004, 2006], the analysis of impacts and their effects (Fig. 3.1) in the pilot catchment included the following:

1. Development of digital databases compatible with GIS in terms of:

a) driving forces (drivers) in communities;

b) impacts on water;
c) results of quantitative and qualitative water monitoring in the Widawa catchment;
d) water use assessment (drinking water, bathing resorts, areas sensitive to nitrates from agricultural sources) – based on the registers compiled by the Regional Water Management Authorities (RZGWs).

2. Description of water bodies:

a) identifying driving forces (drivers);
b) defining environmental objectives based on special water use;
c) determining the set of water bodies that can impact the analysed water body;
d) determining the set of water bodies that can be impacted by the analysed water body;
e) determining the representative values of physico-chemical, biological and hydro-morphological indicators for surface water bodies and of physico-chemical and quantitative status indicators for groundwater bodies.

3. Assessment of the status of individual water bodies:

a) assigning appropriate limiting values for water body status indicators, with acknowledgment of environmental objectives based on its special use;
b) comparison of representative indicator values with the limiting values for these indicators assigned to individual water bodies;
c) compiling an initial list of water bodies that fail to meet the objectives (indicators exceeding the limiting values) or those for which the water status monitoring data display high unreliability – this list may be regarded identical with the list of those water bodies for which detailed impact analysis is required to identify the crucial impacts and decide on whether or not to qualify a water body to the class of those at risk of failing the environmental objectives.

4. Identifying essential impacts based on the analysis of:

a) the data indispensible for detailed analysis of water bodies from the initial list; the analysis will include excerpts from databases, GIS information layers with location of impacts, location of qualitative and quantitative monitoring points, etc.;
b) the causes of unsatisfactory status of water bodies (quantitative, morphological and physico-chemical indicators for surface water bodies and quantitative and physico-chemical ones for groundwater bodies);
c) the hierarchy of point-source impacts for the analysed water body;
d) the diffuse impacts, identifying human activities which constitute the greatest threat for a given water body status (e.g. animal husbandry, hydroengineering structures, poor water and sewage management, etc.).

5. Initial evaluation of the risk of failing the environmental objectives – through statement of conclusions and recommendations for individual water bodies:

Following the rules of simplified proceedings, first the potentially crucial problems have been identified. This allows for assessment of whether environmental objectives can be met or not. Ultimately, the following scope of analysis was accepted:

a) decision on whether to qualify the analysed water body to the class of water bodies at risk of failing the environmental objectives;
b) decision on dividing the analysed water body into smaller elements for the following "Analysis of impacts and their effects" (Fig. 3.1);

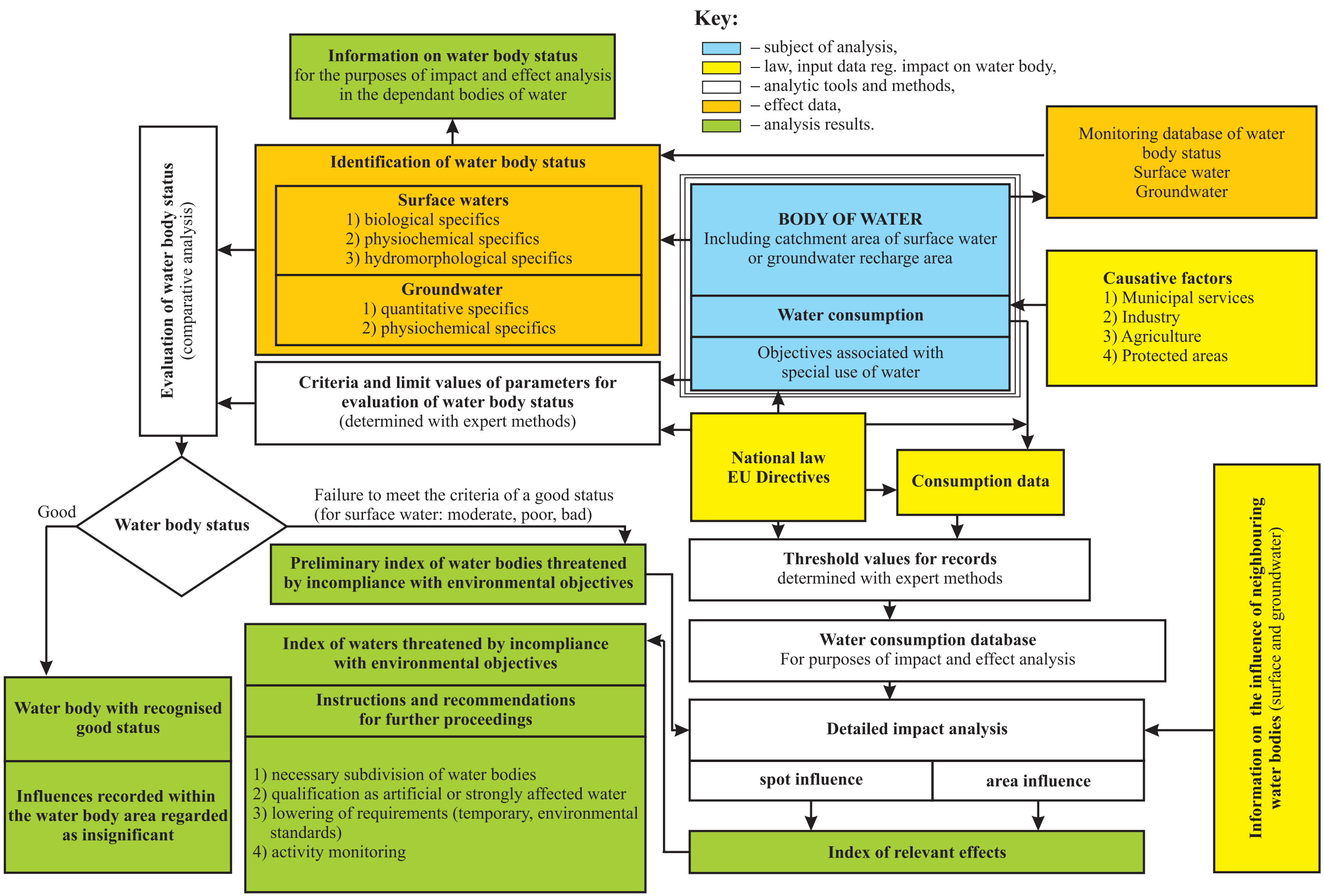


Fig. 3.1. Aanalysis of anthropogenic impact – procedures [Nachlik et al., 2004]

c) decision on qualifying the analysed water body to the set of artificial or heavily modified water bodies;
d) decision on whether attempts to postpone the deadlines for objectives are required or whether less rigorous objectives should be set;
e) assessment of data shortages, identification of causes and effects of missing data;
f) recommendations for the operational monitoring programme.

3.3. Identification of current water status

The essential factors influencing the hydromorphological status may result from transformation of the hydrologic regime (irreversible water consumption or dislocation, retention) or from artificial morphological changes such as hydrotechnical or engineering facilities, river bank engineering.

3.3.1. Hydromorphological status of rivers

In general, the following hydromorphological status of rivers principles have been adopted:

- with regard to flowing water, representative qualitative rates are determined for the cross-section closing the given water body. This pertains also to the quantitative assessment of the specific water body resources;
- with regard to lakes and reservoirs, the average value obtained at spot measurement locations within the area of given water body is considered as representative.

In this paper, the identification of hydromorphological status has been based on:

a) alterations in the runoff regime, expressed by:
   - ✓ direct value of irreversible water abstraction,
   - ✓ total active volume of flood reservoirs, in reference to yearly runoff value,
   - ✓ relation between the SSQ value in the periods 1981–2000 and 1951–1970;
b) morphological changes measured according to the following criteria:
   - ✓ total value of double-side dyke length against river length,
   - ✓ total height of recorded transverse damming-up facilities against total slope value (difference in stream altitude along their course),
   - ✓ maximum height of a single damming-up facility,
   - ✓ total length of river stretches where engineering works were performed, including longitudinal structures and documented modification of river course, against total river length.

In addition, information sources were used in order to enable:

- identification of floodplain area dynamics. Floodplains, according to this procedure, are bank-adjacent land areas of a water-course, subject to regular flooding and/or groundwater table fluctuations if left without human intervention;
- determination of flooding probility;
- evaluation of floodplain utility on the basis of aerial photos. As a rule, the predominant utility should be determined (>50%). If this is not achieved, combined utility rate is recorded.

Limit values for hydromorphological river status (Tab. 3.1).

Table 3.1. Limit values for parameters of hydromorphological river status [Nachlik et al. 2004]

No.	Parameter description	Mathematical formula	Threshold value
1.	Total active volume of flood reservoirs against yearly consumption value in the cross-section closing the catchment area of a water body	$\Sigma(V_c\text{-}V_m)/V_{SSQ}$ mln m^3/(mln $m^3 \cdot rok^{-1}$)	0.03 (3%)
2.	Total irreversible abstraction of surface water against average flow for a given period	$\Sigma P_{pow}/SSQ$ $(m^3 \cdot s^{-1})/(m^3 \cdot s^{-1})$	0.05 (5%)
3.	SSQ flow relation from a recent period (e.g. 1981–2000) and SSQ flow from 'pseudonatural' period (with marginal human intervention, e.g. 1951–1970). An additional parameter possibly indicating a changed hydrologic regime due to significant alterations in the management of the water body catchment area.	$SSQ_{ostatnie}/SSQ_{pseudonaturalne}$ $(m^3 \cdot s^{-1})/(m^3 \cdot s^{-1})$	0.1 (10%)
4.	Total length of double-side dykes in the water body catchment area, against total length of relevant streams	$\Sigma L_{wałów}/\Sigma L_{rzek}$ km/km	0.3 (30%)
5.	Total height of recorded damming-up facilities against total slope value of relevant streams in the water body catchment area	$\Sigma H_{budowli}/\Sigma(H_{kon}\text{-}H_{pocz})$ m/m	0.1 (10%)
6.	Maximum height of a single damming-up facility (weirs, dams)	Hmax m	0.70
7.	Total length of river stretches where river regulations have been made (longitudinal structures and documented river course modification against total length of relevant streams)	$\Sigma L_{regul}/\Sigma L_{rzek}$ km/km	0.1 (10%)

3.3.2. Identification of surface water status

The criteria developed specifically for each type of water body form the basis for evaluation. As a basic assessment criterion, the physiochemical and biological quality elements were adopted – according to the scope of available data. Secondly, changes in the hydrological regime were considered, mainly of quantitative character. The morphological quality criteria were accounted for, but as supplementary. However, in terms of the basic elements they are a decisive factor for the classification of some water bodies as strongly affected.

The following principles have been adopted for the purpose of evaluation of the **physiochemical and biological status of flowing waters and lakes**:

- ✓ **good quality status** occurs when at least 90% of physiochemical rates meet the threshold values, provided that all biological rates do not exceed their threshold values,
- ✓ **moderate quality status** of waters, subject to further analysis, occurs when at least 90% of the physiochemical parameters meet their threshold values, while one of the biological parameters exceeds them,
- ✓ a potentially **bad status** occurs when less than 90% of basic physiochemical rates exceed the threshold values.

In terms of **quantitative assessment of flowing water status** a good status thereof is assumed provided that all limit parameters are not exceeded. If one or more parameters fails to meet the threshold values, a threat occurs, and thus on the basis of expert's decision:

- ✓ a given water body is subjected to further analysis,
- ✓ a given water body is classified as threatened by incompliance with the environmental objectives and subjected to detailed impact assessment analysis.

3.3.3. Identification of groundwater status

The status of groundwaters was identified with the consideration of natural (geological) factors and anthropogenic impact. The basic element influencing the occurrence of groundwater resources is the geological structure of the part of the lithosphere where water resources, as well as recharge, drainage and flow conditions are formed in a rocky environment. The recognition of these factors in the pilot catchment has been considered as sufficient for the purpose of groundwater status evaluation.

The quantitative status in the specified groundwater bodies was defined by the comparison of the amount of available resources with the amount of real abstraction (yearly average value for the last 5 years, expressed in $m^3 s^{-1}$). For those bodies where available resources remained undefined, the amount of prospect resources was used (map of available groundwaters in water regions) or prospect resources of groundwaters within the area of operation of the Regional Water Management Office (RZGW).

The evaluation of relevant impact on groundwater quantitative status requires the identification of major driving forces:

- significant water abstraction (large number of minor intakes, massive abstraction by recorded intakes ($Q > 100\ m^3 \cdot day^{-1}$), regime alterations caused by mining, etc.).
- compilation of abstractions (impacts) relevant for the quantitative status,
- assessment of the abstraction range of impact with regard to water resources recognized as essential.

In this paper water abstraction data have been used according to WFD appendix III, part 2, 2003. For those aquifers where abstraction was performed in a few communes, an average value was used calculated with the account of abstraction and area of the municipality located on the boundaries of the catchment area. In case of lack of data on real abstraction, amounts originating from water management related legal permissions were applied.

By means of the disposable (available) resources volume modules – M_{Qdisp} – of the subdived water body and its yearly average abstraction volume modules (based on legal permission) – M_{Qabstr} in $m^3 \cdot 24\ h^{-1}$ per 1 km^2 – the quantitative status is determined:

- ✓ $M_{Qabstr} < 0.75\ M_{Qdisp}$ – good status,
- ✓ $0.76\ M_{Qdisp} < M_{Qabstr} = M_{Qdisp}$ – moderate status,
- ✓ $M_{Qabstr} > M_{Qdisp}$ – bad status.

Also, such a groundwater body where constant mining-related consumption is performed affecting the changeable water regime (water flow direction, hydraulic gradients, flow rate, creation of new circulation routes, establishment of a permanent drainage base) is classified as moderate or bad status.

4. CHARACTERISTICS OF THE PILOT CATCHMENT AREA

4.1. Introduction

The Widawa catchment is situated in the water region of middle Odra (RZGW Wrocław – Fig. 4.1), of an area amounting to A=1716 km^2. It stretches over three regions, 7 districts and 25 communes. Therefore, it covers the following administrative units:

- Lower Silesian region (województwo dolnośląskie):
  - ✓ Wrocław district – Długołęka commune, partially Wrocław and Czernica communes;
  - ✓ Trzebnica district – partially the communes of Wisznia Mała, Trzebnica, Zawonia, Oborniki Śląskie;
  - ✓ Oleśnica district – the communes of Oleśnica, Oleśnica Miasto, Dziadowa Kłoda, Bierutów, partially the communes of Dobroszyce, Twardogóra, Syców, Międzybórz;
  - ✓ Oława district – partially commune of Jelcz-Laskowice.
- Opole region (województwo opolskie):
  - ✓ Namysłów district – commune of Wilków, partially communes of Namysłów and Domaszowice.
- Major Poland region (województwo wielkopolskie):
  - ✓ Kępno district – partially communes of Rychtal, Perzów, Baranów, Bralin, Trzcinica.
  - ✓ Ostrzeszów district – partially commune of Kobyla Góra.

The catchment is located on the Silesian Lowland (Nizina Śląska) that belongs to the morphostructural province of the Central-European Lowland of Western Europe. Its area streches east-west and contains entirely in subprovince 318 of the Polish Lowlands [Kondracki 2000].

The largest part of the catchment is situated in the mesoregion of the Oleśnica plain which, together with a small piece of the Wrocław ice-marginal valley, belongs to the macroregion of Silesian Lowland. The following heights of three mesoregions can be distinguished in the northern section of the catchment area: Trzebnica, Twardogóra and Ostrzeszów hills that belong to the Trzebnica ridge macroregion. The source stretch of Czarna Widawa River in the North-East part of the catchment is contained in a small area of the Wieruszów height mesoregion belonging to the South Major Poland lowland macroregion [Geographic… 1994].

Meteorological conditions of the Widawa catchment are characterized by the following data:

- air temperature: maximum 18^{o}C in July; minimum -1.0 ^{o}C in January;
- mean annual precipitation: approx. 550 mm, only at the foot of Twardogóra Hills 660 mm; in dry periods approx. 400 mm (in 1959, 1989, 1990, 2003);
- the vegetation season lasts approx. 225 days [Bac, Rojek 1999, Woś 1999].

In the upper course (apart from the source stretch) the Widawa river has very small slopes, the bed is sandy and sludgy, and on most stretches it is regulated. Downstream the dammed reservoir in Michalice, the river slope becomes steeper and down to Wrocław the river frequently shows such features as relatively fast current and gravel bed.

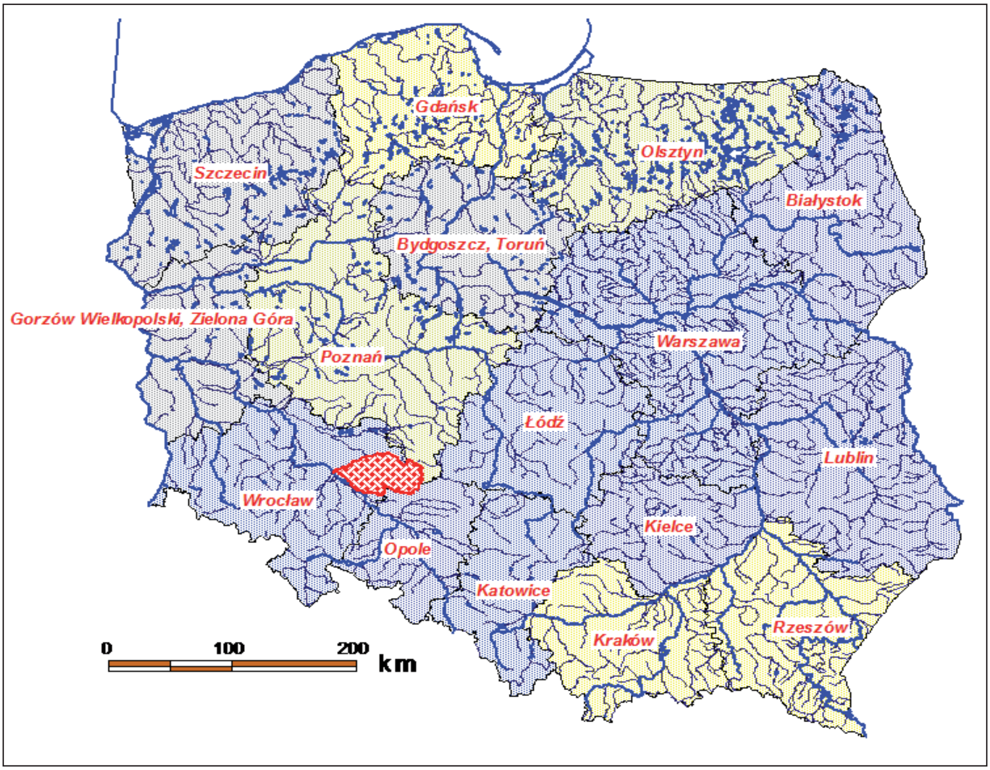


Fig. 4.1. Location of the Widawa river catchment

Acceptable fish spawning and growing conditions in Widawa occur only below the dammed reservoir in Michalice. The upper reaches of Dobra and its catchment, as well as Potok Boguszycki resemble lowland trout-inhabited gravel streams. The middle section of Widawa between Zbytowa and Chrząstawa features beneficial conditions for salmon fish spawning. The character of other Widawa tributaries is difficult to define. Due to the physiographical conditions and a great share of rheophil carp species, these waters resemble again the typical environment of *Barbus barbus*, yet without the possibility of the presence of adult representatives of this predominant species. 32 species of fish have been detected in Widawa and its tributaries below the Michalice reservoir. Some of them are protected: amur bitterling, goldside loach, stone loach and European brook lamprey [Błachuta, Witkowski 1999].

Widawa has well-developed water flora. The following plants are encountered virtually in the entire course of the river: *Sagittaria sagittifolia*, *Elodea canadensis*, *Potamogeton crispus* and C*allitriche verna,* which locally (especially downriver from Bierutów) form compact clumps covering more than 50% of the river bed. In rapid flow sections with stone bed and artificially installed stone surface, clusters of *Montia* are encountered. By the banks, in the section from Bierutów to the mouth, in spite of engineering, cane clusters have appeared, which locally and in particular above weirs form cohesive fields.

4.2. Hydrography

The Widawa river is a right-bank tributary of Odra, its mouth being located at kilometre no. 266+900 (Fig. 4.2).

The river's length amounts to 103.2 km. Its sources are located in the Trzebnica Ridge, precisely Twardogóra Hills, at approx. 200 m above sea level, and its mouth into Odra is down of Wrocław. The tallest height on a watershed near the source section is 272 m. The Widawa catchment area is hydrologically observed. Daily water levels and regular flow measurements are recorded at three water gauge cross-sections:

- ✓ Michalice at 70.6 km; closing a catchment area A = 509.4 km^2,
- ✓ Zbytowa at 41.2 km; catchment area 720.7 km^2.

Fig. 4.2. Mouth of Widawa river into Odra (Photograph by M. Mokwa)

Wrocław Sołtysowice at 13.6 km, catchment area of 1639.6 km^2. The Sołtysowice water gauge was replaced in 1995 with the Krzyżanowice water gauge located at 12 km, A = 1640 km^2. The reason for this shift was, among others, the influence of the intensive vegetation of the river on measurement conditions at Sołtysowice cross-section.

The following streams are Widawa tributaries: Oleśnica (right bank, also referred to as Oleśniczka or Oleśniczanka, catchment area of 221.4 km^2); Świerzna (right bank, also referred to as Świerzyna, catchment area of 88.7 km^2); Smolna (right bank, catchment area of 84 km^2); Czarna Widawa (left bank, catchment area of 96 km^2). Other tributaries of Widawa, not included in the Polish hydrographical division index, are: Stradomka (also referred to as Nida), Miłka and Osuch [Czamara et al. 1992, 2005].

The hydrographical relations in the catchment area of Widawa are to a great extent affected by man – with numerous irrigation ditches, mill streams, fish ponds and reservoirs. The hydrographic network is complicated by pond charge and drainage channels [Czamara 1998].

Flood flow long-term values of lower Widawa are disturbed by inflow from a drainage channel connecting Widawa with Odra. The current value of caution level is 150 cm, and of alert level – 200 cm.

4.3. Typology of rivers

The typology of rivers in Poland was determined by a consortium of the Meteorology and Water Management Institute, Environmental Protection Inspectorate and the National Geological Institute according to system 'A' WFD [Maciejewski et al. 2004]. There were distinguished 25 types of rivers, 15 types of lakes, 5 types of transitory waters and 3 types of coastal waters (criterion 'B' WFD). Also a preliminary identification of artificial and strongly affected surface water bodies was performed. Man-made bodies were qualified as artificial water bodies (channels, certain ditches, artificial reservoirs and stream sections passing through artificial reservoirs). A consolidated surface water body was qualified as strongly affected if its character underwent major change due to a physical transformation resulting from human activity. It was assumed that if more than 1/3 of a given stretch was strongly affected, then the entire stretch had to be regarded as strongly affected. As a result of the delivered analyses, 184 artificial water bodies and 424 strongly affected water bodies were found.

In the Widawa catchment 32 surface water bodies have been distinguished, including: 21 of type 17 (lowland sandy stream); 6 – type 19 (lowland sand-clay river), 2 – type 18 (lowland gravel stream), 2 – type 23 (small streams caused by peat forming processes) and 1 – type 0 (artificial water body), Figure 4.3, [Czaban et al. 2004, Czamara et al. 2005].

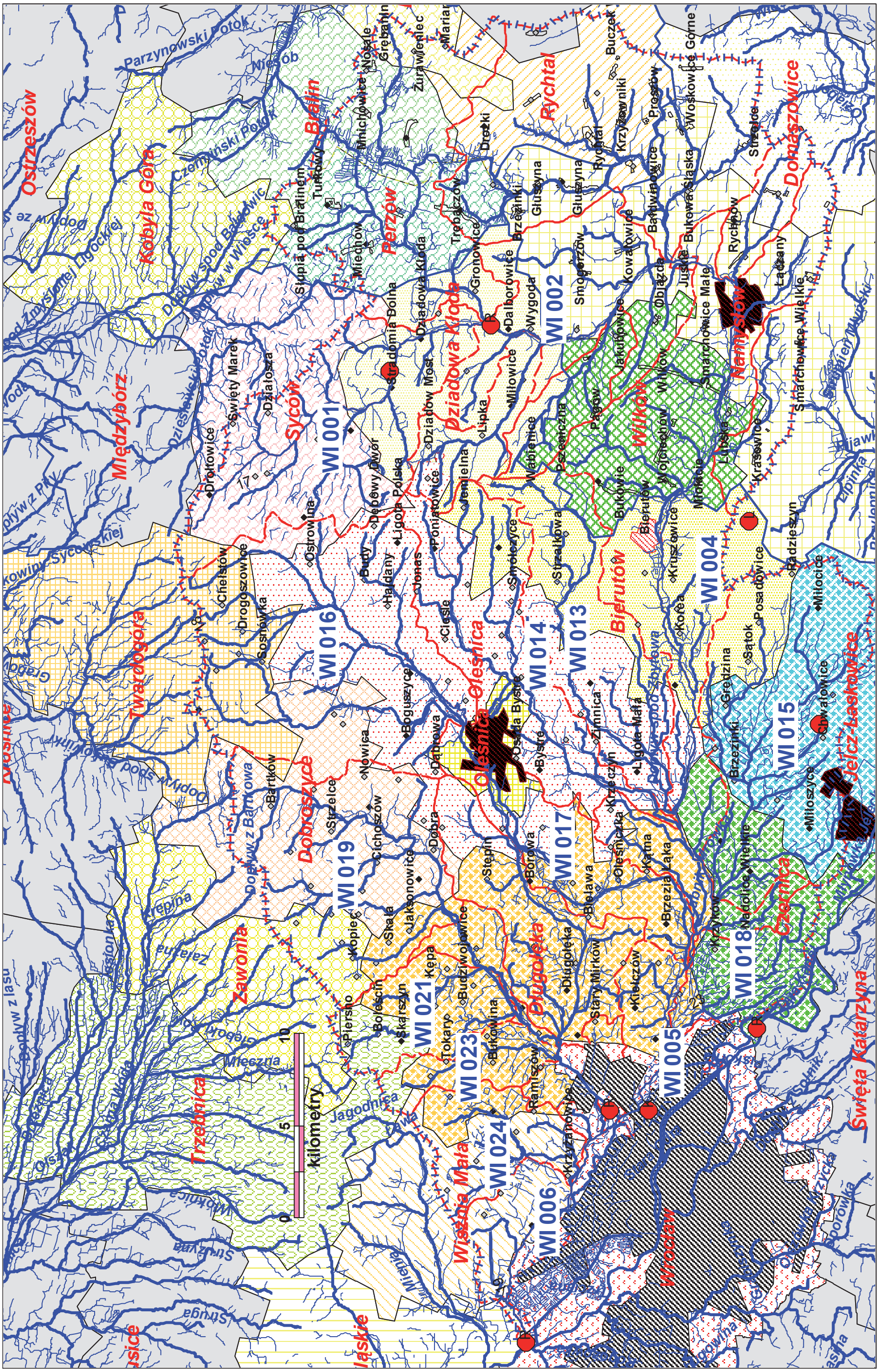


Fig. 4.3. Hydrography of the Widawa catchment

4.4. Geological and hydrogeological characteristics

The Widawa catchment is located on the Fore-Sudety Monocline, constituted by a series of sediment rocks (mainly sandstone, conglomerate) dating back to Permian and Triassic age, covered with Cainozoic sediments (Tertiary and Quaternary). Tertiary forms (sands, loams and muds with brown coal inserts) are glacitectonically distorted. Their distorted roof is morphologically varied (drops exceeding 160 m). Tertiary forms are covered with Quaternary sediments. Tertiary outcrops may be spotted locally to the South of the catchment area. Quaternary forms were created mostly in Pleistocene. Glacial sediments of the South and Central Polish glaciations are primarily shaped into clays. Loose glacial sediments (sands and gravels) occur in the northern part of the catchment area (South of Grabowno and Twardogóra). Alluvial forms collocate with river valleys formed in late Pleistocene and Holocene, consisting of muds, sands and river gravels [Badura et al. 1998, Baranowski 1976].

The catchment is situated in the Wroclaw hydrogeological region of the southern macroregion [Paczyński B., 1995]. The groundwater aquifers were established in Tertiary, Quaternary and Triassic. The Quaternary aquifer is the most accessible, and therefore most used, groundwater reservoir, characterised by good hydraulic connection with surface waters. Three types of Quaternary aquifers can be distinguished: aquifers in river valleys, ice-marginal valleys and in fluvioglacial landforms. The available groundwater aquifer may be located at a depth from few to 70 m. The thickness of sand-gravel aquifer is normally confined between 5 to 20 m (140 m in an ice-marginal valley near Oleśnica) [Michniewicz et al. 1987].

Groundwaters with free water table occur in this area, whereas near the fossil valley, confined aquifers are located. Well discharge varies from few to 250 $m^3 \cdot h^{-1}$. Within these forms, two Quaternary groundwater reservoirs are located, included in the Main Groundwater Aquifers (MGA – GZWP 322 – Oleśnica aquifer and 320 – Odra ice-marginal valley aquifer). The permeable formations are represented by sands and gravels: in reservoir 322 of fluvioglacial origin; in 320 – occurring as Pleistocene and Holocene river forms.

The Tertiary aquifer is constituted by Miocene sand sediments isolated from the top by a series of Pliocene loams. Water table is of confined character, as the pressure normally fluctuates between few hundred and more than 1000 kPa, resulting in local outflows (arthesian wells). The water table of Tertiary aquifers is situated at 80 to 120 m above sea level. Well discharge varies from few to 30 $m^3 \cdot h^{-1}$.

Fissure aquifer can be found in the base of Cainozoic forms with mineralised water (SO_4), in the Triassic and Permian formations. Triassic fissure aquifers are retained at the depth of 100 to few hundred meters. They are confined aquifers with pressure 1000 to 3000 kPa. The water table is of artesian character and it becomes stabilised above ground level. Well discharge exceed 100 $m^3 \cdot h^{-1}$. The waters occurring in the bottom of these Permian forms are scarcely identified.

4.5. Soils

Soils fitting in the scope suitable for agriculture are predominant in the Widawa catchment:

- wheat good (2) – account for at least 15% of the catchment area, that is 25% of total arable land,

- rye good (5) – 13% of the catchment area, that is 22% of total arable land,
- rye weak (6) – 10% of the catchment area, that is 17% of total arable land,
- rye very good (4) – 8% of the catchment area, that is 14% of total arable land.

Soils of other classes occupy in total 13% of the catchment area, constituting 22% of the total arable land. Permanent grasslands exist mainly in stream valleys, where grasslands account for 87% of total area. Podsolic and pseudo-podsolic soils prevail strongly in the catchment area, covering its surface in 46% [Natural… 1987].

Forms of 3rd class of permeability (weak permeability) are strongly predominant in this area, representing 58% of the total area (Fig. 4.4). More permeable soils (2nd class) stand for 25% of the catchment area and occur mainly to the North and East, coinciding with intensive groundwater recharge activity. In locations where these areas are simultaneously used as arable lands, they should be recognised as most exposed to pollution.

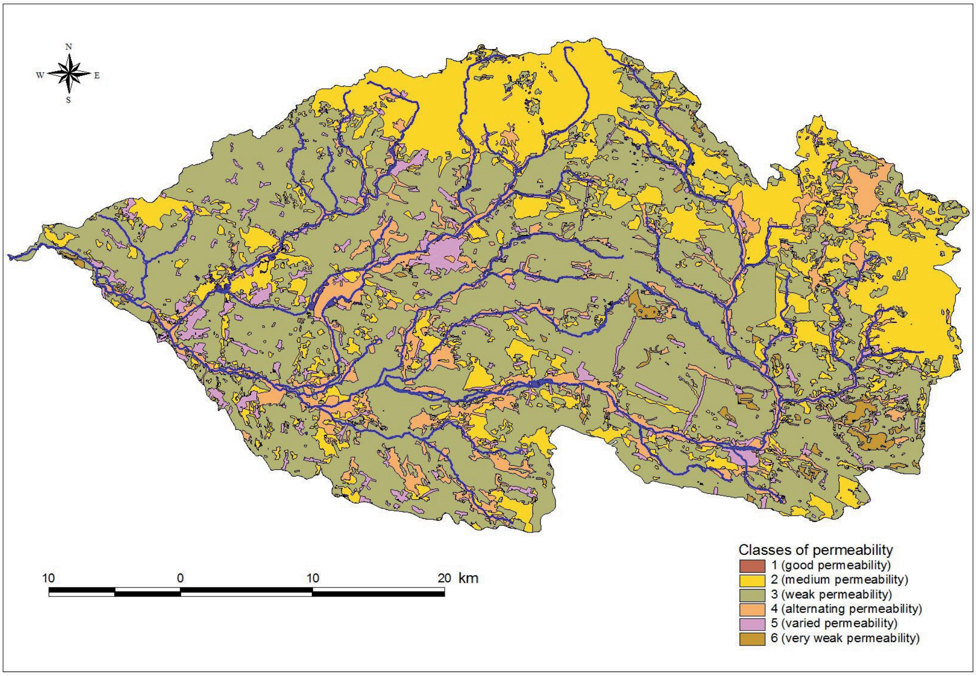


Fig. 4.4. Permeability of sub-surface forms [Hydrographic Map... 1997–2001]

The total area of drained land amounts to almost 380 000 ha, accounting for nearly 22% of the total catchment area. The level of land drainage varies – both in particular communes and in the catchments (Fig. 4.5).

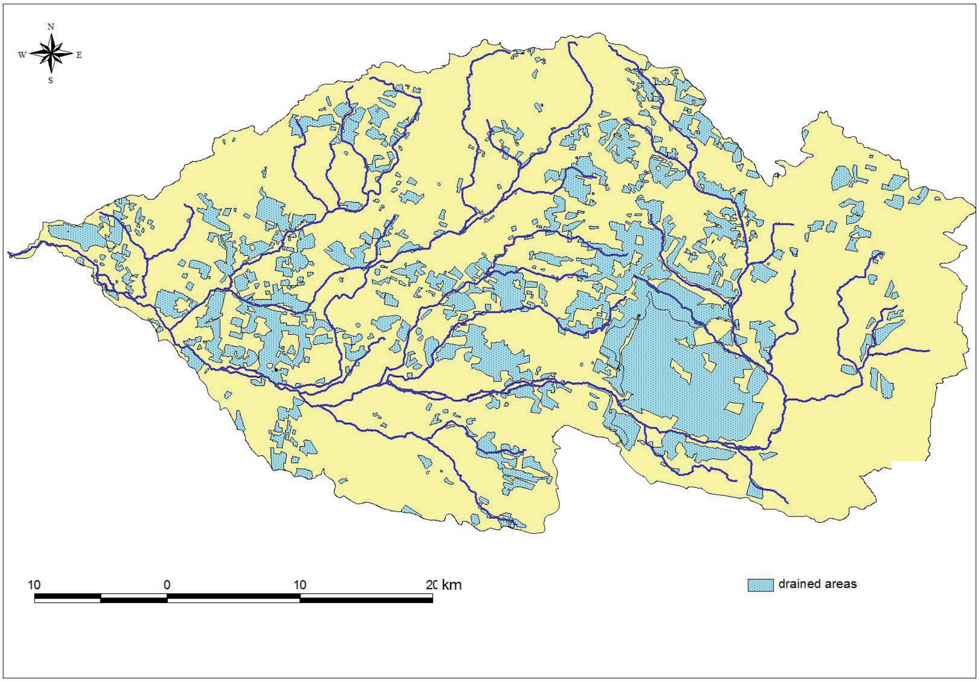


Fig. 4.5. Location of drained areas
[Hydrographic Map... 1997–2001]

4.6. Agriculture

The dominant crop are cereals – 75.5% of the Widawa catchment area. Wheat is grown on 20 300 ha, corn on 11 500 ha, potatoes on 6 850 ha and industrial plants on 6 600 ha (Fig. 4.6, 4.7, 4.8, 4.9). The area of vegetables has exceeded 1 000 ha.

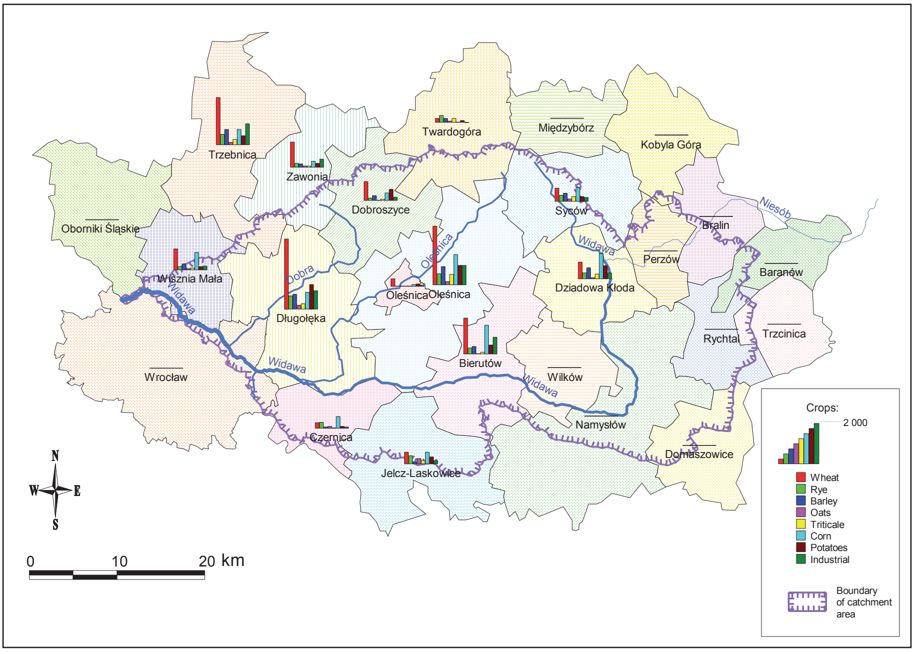


Fig. 4.6. Structure of crops in the communes
[Hydrographic Map... 1997–2001]

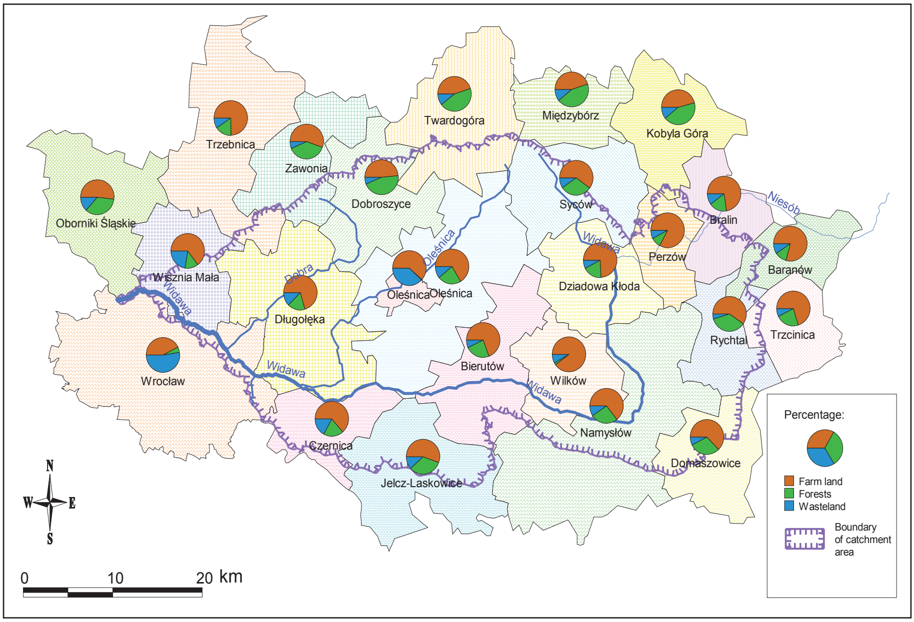


Fig. 4.7. Land use in the Widawa catchment
[Hydrographic Map... 1997–2001]

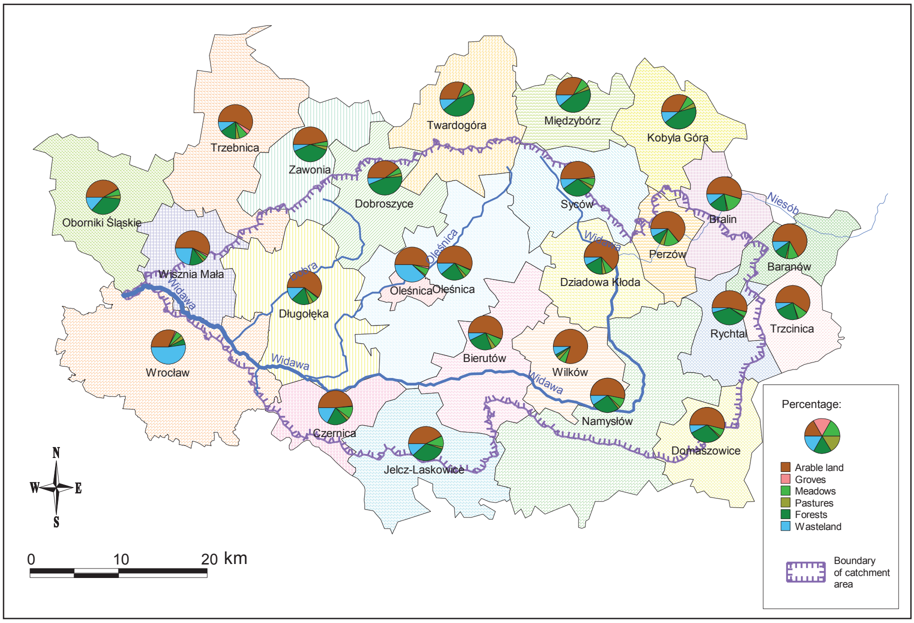


Fig. 4.8. Farmland in the communes [Hydrographic Map... 1997–2001]

Fig. 4.9. Management of the Widawa catchment (Photograph by M. Mokwa)

Over 2 mln items of poultry, 60 600 pigs and 13 400 cattle were reared within the Widawa catchment area. In the analysed area there were also nearly 3 thousand bee hives. The population of farm animals calculated on large stock unit LSU varied in the examined communes and it amounted to 4–34 pieces per 100 ha (Fig.4.10).

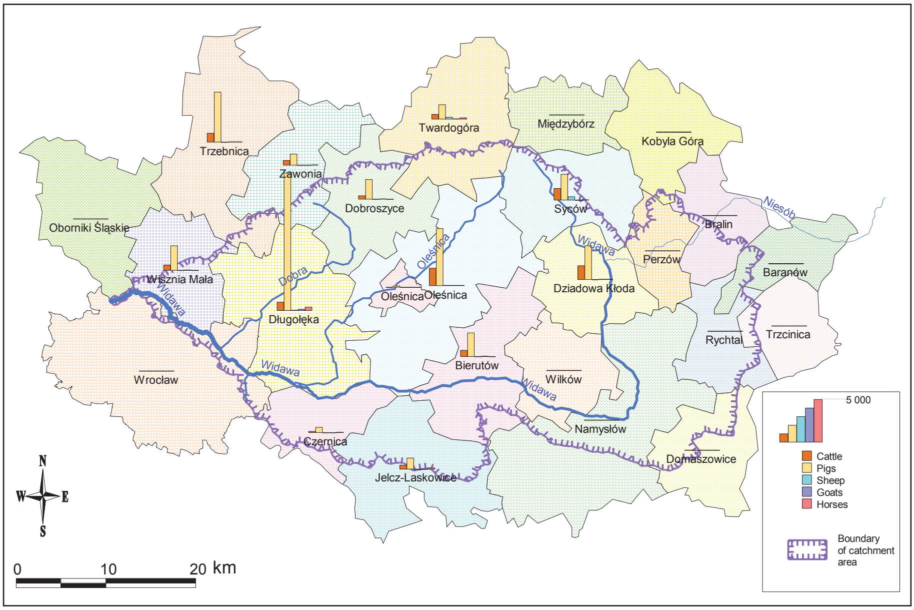


Fig. 4.10. Livestock structure in communes
[Hydrographic Map... 1997–2001]

4.7. Public utilities

In the Widawa catchment 90% of the inhabitants have access to water supply system, while only ca. 60% discharge wastewater to the sewage system (Fig. 4.11, 4.12). On average 1.6% of the inhabitants do not have water supply at their households. The worst situation in terms of water supply is in rural communes (e.g. in case of Oleśnica approx. 6% of the inhabitants do not use tap water).

The main source of water supply in the pilot catchment are the groundwaters (Fig. 4.13). Consequently, 45.4% of individual households have own water supply from excavated wells and 7.5 % from drilled wells. Water is delivered by car transport to 389 households. Average water consumption amounted to less than 120 $dm^3 \cdot day^{-1}$ per person, while greater consumption of water takes place in towns (Oleśnica, Wrocław; ca. 125 – 130 l/d.p). Average unit volume of disposed sewage varies from approx. 9 to 154 $dm^3 \cdot day^{-1}$ per person. The respective values in Wrocław and Oleśnica are noticeably higher than the unit water consumption values (Fig. 4.11).

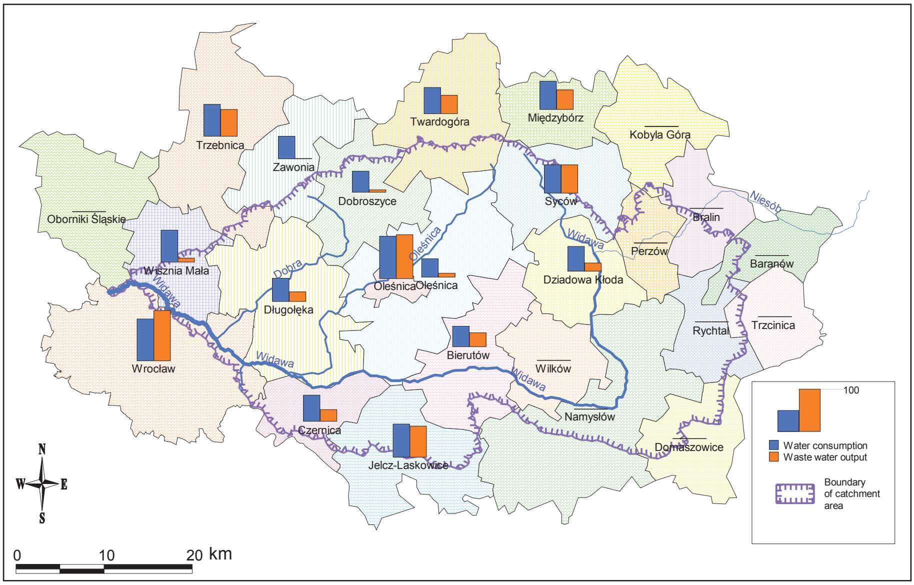


Fig. 4.11. Water consumption and sewage production in communes of the pilot catchment [Hydrographic Map... 1997–2001]

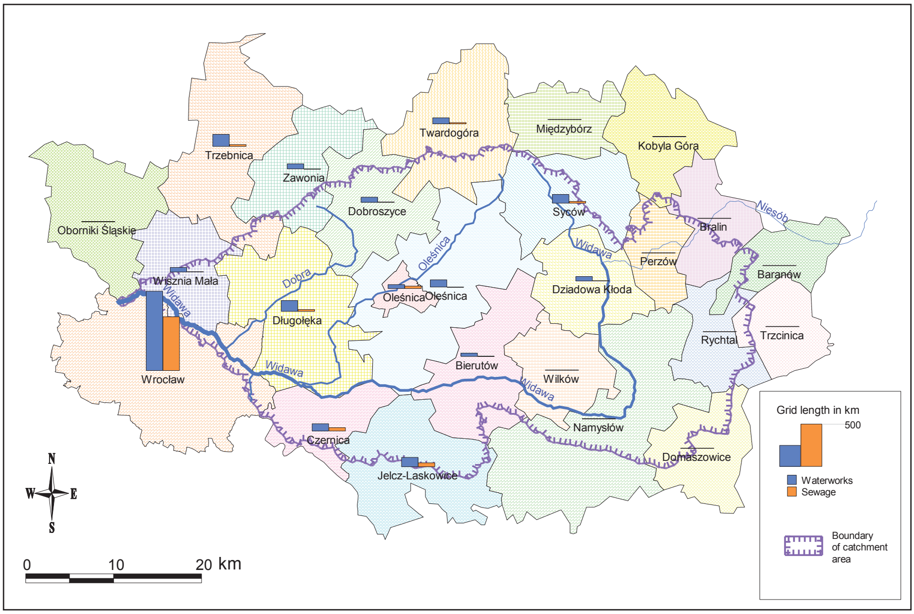


Fig. 4.12. Length of water and sewage network in the communes [Hydrographic Map... 1997–2001]

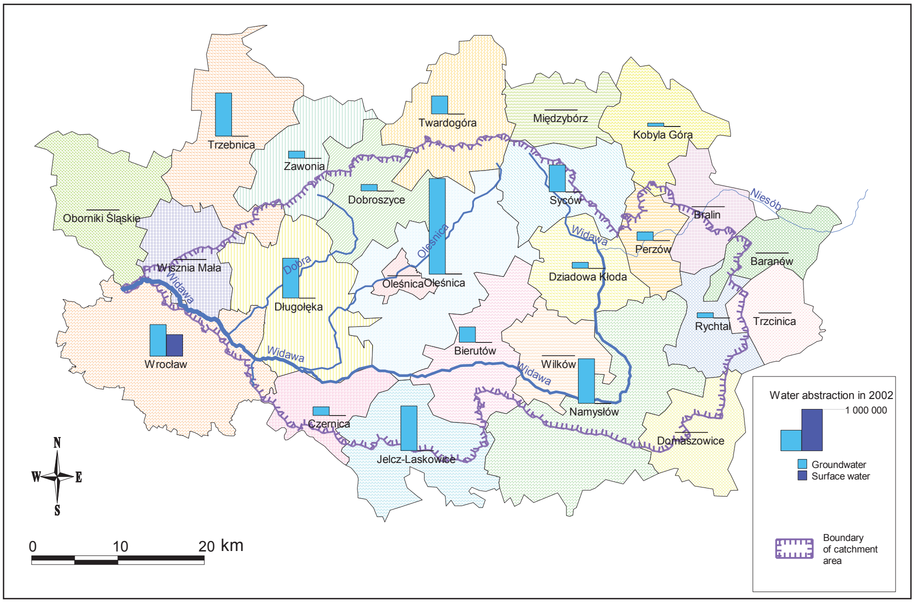


Fig. 4.13. Water abstraction in communes of the pilot catchment [Hydrographic Map... 1997–2001]

4.8. Hydrotechnical facilities

There are 91 damming-up facilities in the Widawa catchment (mostly in the community of Oleśnica – 28); their damming height is in the range 0.15–3.1 m, while their width varies from 0.6 to 32.1 m. The total riverbed retention of the catchment area has reached approx. 237 000 m^3.

In the lower section of Widawa, the following hydrotechnical facilities can be found:

- Paniowice polder, with an inflow water gate (km 1.960),
- Świniary weir (km 6.618),
- weir on Old Widawa (Stara Widawa) (km 8.00),
- embankment sluice to Old Widawa (km 10.770),
- Sołtysowice weir (km 15.830).

Paniowice polder, 2.25 km^2, is the most distant one belonging to the flood protection system of Wrocław. It is located on the right-bank side of the Odra valley at 266.5 km and 268.5 km of its course. Within the same section 3 large tributaries reach Odra: two on the left bank – Ślęza (261.6 km of Odra) and Bystrzyca (266.5 km), as well as Widawa on the right bank (266.9 km). The main task of this polder is to capture a share of flood water. Its capacity during the flow of designed and so called "controlled" discharge is 3.6 mln m^3 and 4.5 mln m^3, respectively. According to the analysis delivered by Hydroprojekt Wrocław, the polder is flooded much more often with waters of Odra (in case of overflow of its waters once per 20–25 years) than Widawa (less than once in 100 years).

Świniary weir (km 6.618) is supposed to pass water to a mill stream. The supply ditch starts on the left bank, 70 m upstream from the weir. The weir is constructed of three spans, each 4.65 m wide and equipped with a latch gate. A 1.25 m steel walkway is located on top. The weir altitude is 109.85 m (Fig. 4.14).

Fig. 4.14. Świniary gate –Widawa 6.618 km (Photograph by S. Czaban)

Old Widawa weir is situated at km 8.00. It is a concrete structure with six wooden gates.

Embankment sluice to Old Widawa is located at km 10.77 of Widawa; its purpose is to transfer a portion of flood waters to the course of Old Widawa, also referred to as the Psary channel. This channel is 2.25 km long and it joins Widawa at km 8.45. Its course being parallel to Widawa increases the capacity of this stretch of the river during floods. In the 1980s the duct to Old Widawa was reconstructed, including among others an increase in the overflow level, which resulted in decreased overflow (Fig. 4.15).

Fig. 4.15. Embankment sluice to Old Widawa (Photograph by S. Czaban)

In Wrocław area the Widawa river creates a complex system of flood protection. There are both high winter dykes protecting part of Widawa valley during the passage of high flood waters and low summer banks near the bed proper:

- winter dykes at a distance of 1200 m from each other that protect buildings located in the Widawa valley;
- summer dykes 30 to 150 m apart, related to agricultural management. The land between the dykes undergoes regular flooding (mainly meadows and pastures).

These dykes were formed in an irregular manner, and they do not occur along the entire course of lower Widawa. At some stretches there are no dykes, while in other places they stand only at one bank (mostly on the left).

Stradomia reservoir, upstream of the inflow of Stradomka to Widawa; maximum capacity V_{max} = 563 800 m^3, maximum damming level NPP = 179.00 m, catchment area A = 40 km^2, flood reserve V_{area} = 90 000 m^3. It causes flattening of flood wave and shift of its culmination.

Michalice reservoir, 71.1 km of Widawa, V_{max} = 1 216 300 m^3, flood reserve V_{area} = 557 000 m^3, maximum damming level NPP = 154.15 m, catchment area A = 510 km^2. It protects partially the city of Namysłów located 6 km downstream of the reservoir (Fig. 4.16). The reservoir belongs to hydrotechnical buildings of 4th class. The dependable flow, of overflow probability p = 1%, amounts to Q_m = 30.0 $m^3 \cdot s^{-1}$, whereas for the control flow equals p = 0.5%, aquals Q_k = 42.0 $m^3 \cdot s^{-1}$.

Fig. 4.16. View from the Michalice reservoir dam (Photograph by S. Czaban)

Water retention in the Widawa valley exceeds 6.5 mln m^3 (Fig. 4.17, 4.18, 4.19, 4.20). The basic form thereof are ponds – approx. 5.8 mln m^3. Riverbed retention is marginal, approx. 238 000 m^3, while the capacity of reservoirs is 528 000 m^3. It is worth noting that a great majority of ponds is located in the lower course of Widawa (Oleśnica and Długołęka retain over 4 mln m^3) (Fig. 4.20).

Fig. 4.17. Widawa river, pond in the town park of Namysłów (Photograph by S. Czaban)

Fig. 4.18. Widawa river near Namysłów (Photograph by S. Czaban)

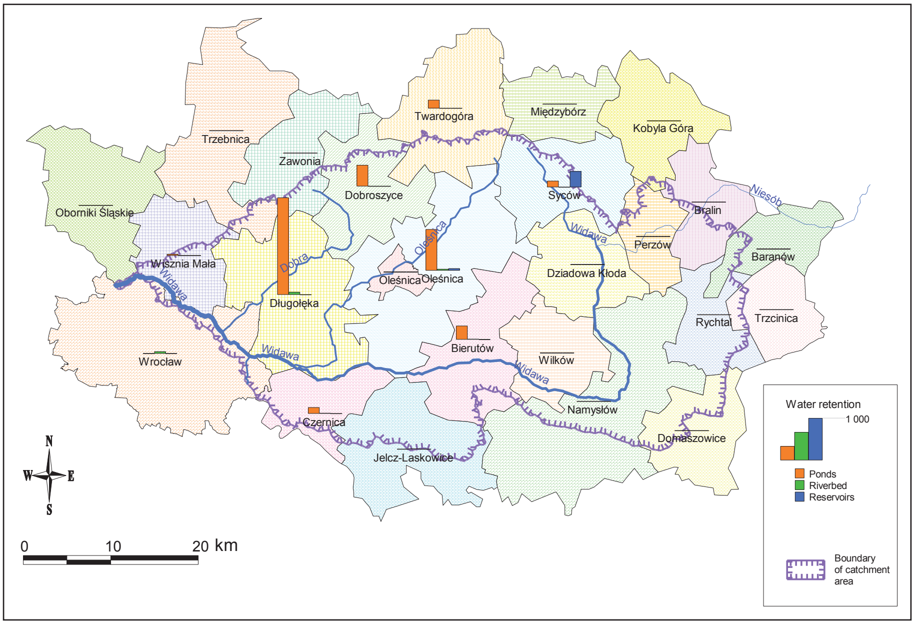


Fig. 4.19. Water retention in the communes of pilot catchment
[Hydrographic Map... 1997–2001]

Fig. 4.20. Ponds in Widawa catchment (Photograph by M. Mokwa)

4.9. Recreational use of water resources

The recreational use of water resources in the Widawa catchment is relatively small. One should expect that the natural river quality, its location and the new reservoirs enable the development of tourist infrastructure. Already now there are numerous agrotouristic farms in this area, including fisheries.

4.10. Protected areas

Ten valuable natural areas are to be found in the catchment area of Widawa [Jankowski 1998a, 1998b]:

- **Las Bukowy Reserve in Skarszyno,** area 23.7 ha. It is a precious old beech forest including sessile oak with addition of hornbeam and lime; fleece is inhabited by *Corydalis intermedia*, *Isopyrum thalictroides* and musk.
- **Odra valley**, part of the ecological corridor of EECONET – European Ecological Net, characterised by a great variety of flora and fauna.
- **Lasy Rychtalskie** Forest Promotion Area **–** a forest area with a special type of forest management.
- **Peatbog near Grabowno,** area 4.2 ha. A transitory peatbog featuring hare's-tail cotton-grass, mud cranberry (*Oxycoccus palustris* Hill) and Marsh Labrador tea.
- **Studnica Reserve** (forest).
- **Dobra Valley** – protected landscape area.
- **Mill Swamp** – environmental use, an area of swampy meadows of 18.9 ha. Organised as a zone of protected existence and prey of the black stork (legally protected species), as well as crane and waterfowl.
- **Isle on Widawa river** – Nature & landscape zone (in Namysłów), situated at the branching of Widawa, area 4.3 ha. Established for preservation of the unique landscape quality, diversity of flora and fauna – existence and prey area of mute swan and otter, as well as numerous amphibian and fish species.

Natura 2000. This zone stretches along the Widawa river down to its mouth and thereafter along Odra (261–269 km) and Rędzin forest. It mainly covers the flood areas confined with dykes, yet locally it exceeds them (up to a distance of 1.5 km from Odra). The terrain surface is mainly occupied with bank plant groupings, including riparian forests which are partially dry outside the dykes.

5. WATER RESOURCES IN THE WIDAWA CATCHMENT AREA

5.1. Surface water resources

The assessment of water resources in the Widawa catchment area has been performed on the basis of observational data from three water gauge cross-sections, acting also as balance cross-sections; six cross-sections located at the mouth sections and nine cross-sections of Widawa situated approx. 100 m downstream or upstream the mouths – in a total of 18 balance cross-sections (Tab. 5.1).

Table 5.1. Widawa river – typical flows at the water gauge balance cross-sections

No., river, cross-section	Water course point [km]	A [km^2]	SSQ $m^3 \cdot s^{-1}$	NNQ $m^3 \cdot s^{-1}$	SNQ $m^3 \cdot s^{-1}$	Q_n $m^3 \cdot s^{-1}$
1.Widawa – Sołtysowice	13.6	1640	7.59	0.39	1.52	0.88
2. Dobra	0.0	284	1.31	0.17	0.30	0.30
3. Widawa (mouth of Dobra)	14.3	1632	7.54	0.39	1.51	0.87
4. Oleśnica	0.0	221	1.02	0.13	0.23	0.23
5. Widawa (mouth of Oleśnica)	25.6	1295	5.98	0.31	1.20	0.70
6. Graniczna	0.0	126.9	0.58	0.07	0.13	0.13
7. Widawa (mouth of Graniczna)	30.6	1026	4.74	0.24	0.95	0.70
8. Świerzna	0.0	88.7	0.41	0.05	0.092	0.092
9. Widawa (mouth of Świerzna)	33.8	888	4.10	0.21	0.82	0.70
10. Smolna	0.0	84	0.39	0.05	0.078	0.078
11. Widawa (mouth of Smolna)	35.4	756	3.49	0.18	0.70	0.70
12. Widawa – Zbytowa	41.2	721	3.62	0.38	0.79	1.096
13. Widawa – Michalice	70.6	509	2.16	0.30	0.53	1.041
14. Studnica	0.0	160	0.68	0.09	0.17	0.17
15. Widawa (mouth of Studnica)	71.0	508.7	1.48	0.30	0.53	0.53
16. Czarna Widawa	0.0	96.6	0.307	0.06	0.10	0.10
17. Widawa (mouth of Black Widawa)	83.7	215.6	0.914	0.13	0.22	0.22
18. Widawa (below Black Widawa)	83.6	119	0.507	0.07	0.12	0.12

Polish abbreviations:
SSQ – average flow from multiyear
NNQ – lowest low flow
SNQ – average low flow
Q_n – ecologically stated flow

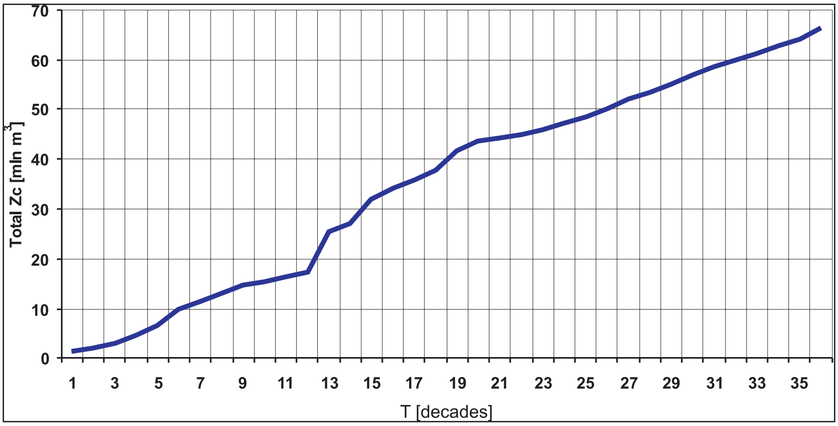
The resources of surface waters were determined for distinctive years: average (Fig. 5.1), dry and wet, at specific river gauge cross-sections. The distinctive years were determined by means of comparison of SSQ from 1963–1993 with SQ flows at the Michalice and Sołtysowice river gauge cross-sections [Bobiński, Meyer 1992, Radczuk 1972, 1986] (Tab. 5.2).

Table 5.2. The resources of surface waters for distinctive years for the period 1963–1993 at Michalice and Sołtysowice cross-sections

No.	Water gauge	SSQ $m^3 \cdot s^{-1}$	Dry year	SQ $m^3 \cdot s^{-1}$	Wet year	SQ $m^3 \cdot s^{-1}$	Average year	SQ $m^3 \cdot s^{-1}$
1.	Michalice	2.16	1964	0.95	1965	2.79	1956	2.09
2.	Sołtysowice	7.59	1983	5.42	1977	11.20	1975	6.99

SQ – average flow

a. Michalice river gauge



b. Sołtysowice river gauge

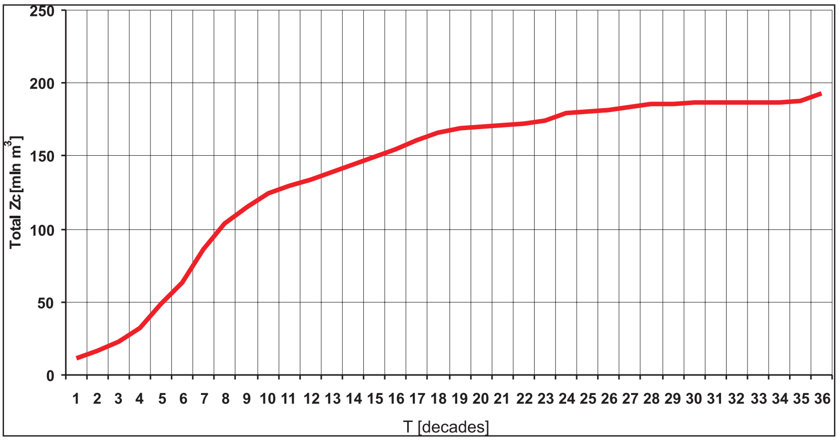


Fig. 5.1. Total resources in average year, Widawa river

On the basis of the observational material, the total and available resources per decade, month and year, have been determined. When calculating the available resources in balance cross-sections, the flows there were reduced by the ecologically stated discharges. The calculations of ecologically stated discharges were performed with two methods:

a) on the basis of average low flow SNQ, determined for the period of 1963–1983:

$$Q_n = k\ SNQ$$

The value of k coefficient was adopted according to H. Kostrzewa:

– for lowland rivers, where A < 1000 km^2 k = 1.0,
– for lowland rivers, where A > 1000 km^2 k = 0.58.

In the balance cross-sections of the Widawa river the Q_n value is the following:

Table 5.3. The values of ecologically stated discharges at the specific sections of Widawa on the basis of SNQ

No.	Cross-section, km	A km^2	SNQ $m^3 \cdot s^{-1}$	k	Q_n $m^3 \cdot s^{-1}$
1.	Michalice, 70.6	509	0.53	1.0	0.53
2.	Zbytowa, 41.2	721	0.79	1.0	0.79
3.	Sołtysowice, 13.6	1640	1.52	0.58	0.88

b) on the basis of 'małopolska' method

The ecologically stated discharges were acquired as an arithmetic average of the lowest and average low flow in a given month (for those months which did not belong to the spawning season of the predominant fish species, and also excluding July and August). For July and August the value of arithmetic average was multiplied by the coefficient K = 1.15.

Table 5.4. Values of ecologically stated discharges at specific sections of Widawa ('małopolska' method)

River section (km)	Month											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0–41	5.46	5.16	5.32	4.82	2.51	1.68	1.54	1.51	1.25	2.03	4.25	4.29
41–70	2.14	2.39	2.12	1.65	1.07	0.75	0.90	0.98	0.91	1.36	2.08	2.53
70–103	1.21	1.35	1.24	1.10	0.86	0.62	0.61	0.73	0.67	0.89	1.08	1.22

The ecologically stated discharges calculated with both the methods are quite different. River gauge data are indispensable to the so called 'małopolska' method. In case the calculations are extended over subcatchment, where river gauges were lacking, the application of this method may be subject to high risk of inaccuracy; therefore, the calculations were performed also on basis of SNQ – average low flow.

It was assumed that the impact of water users was included in the steady flows determined in 1963–1983. The information on water users who abstract water and discharge sewage was extracted from water-related legal permissions. In the mentioned period there were 102 such users.

The two reservoirs constructed at that time do not influence the flows and surface water resources to any significant extent. Their total capacity is small, that is 1.96 mln m^3, and they operate mainly for leisure purposes, although the Michalice reservoir also for the purpose of energy production. The planned water consumption in agriculture is not being achieved.

The available resources at two river gauge cross-sections Sołtysowice (13.6 km, A = 1640 km^2) and Zbytowa (41.2 km, A = 720.7 km^2) in 1984–2003 are presented in Figure 5.2. The chart presents a great diversification of resources in the years. In the dry period of 1990–1991 the resources were 2–3 times lower than in normal and wet years.

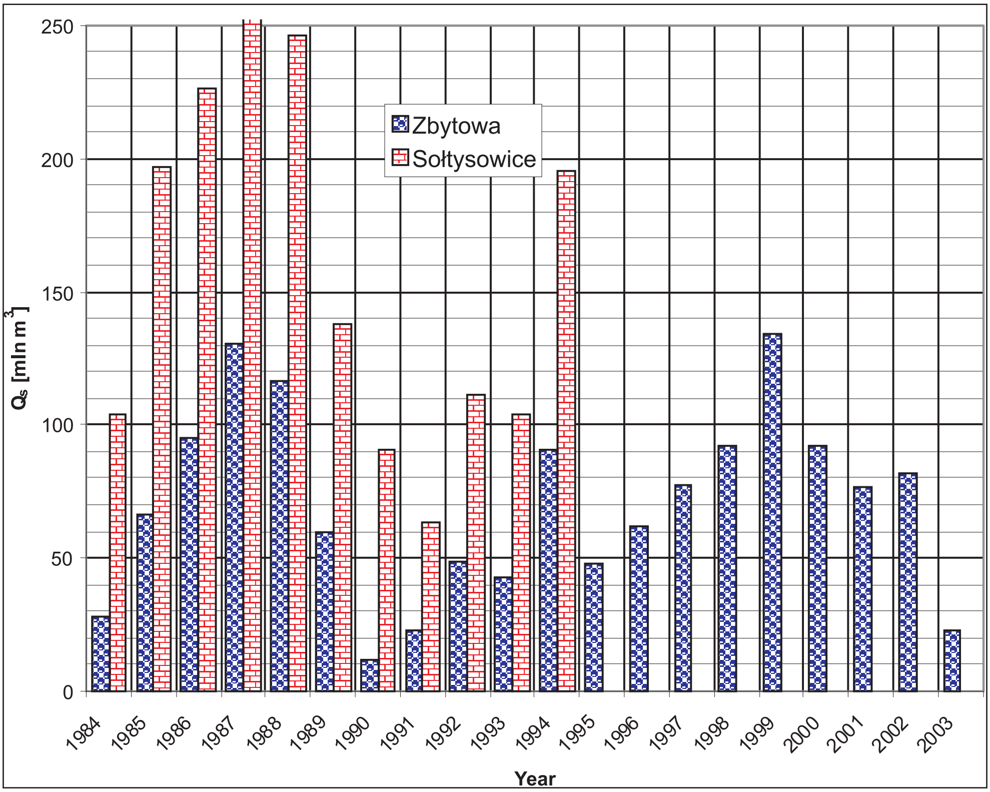


Fig. 5.2. Available resources at river gauges of Zbytów and Sołtysowice

5.2. Groundwater resources

There are two main Quaternary groundwater basins in the Widawa catchment: GZWP 320 – Odra ice-marginal valley (S_Wrocław) and GZWP 322 – Oleśnica (Fig. 5.3).

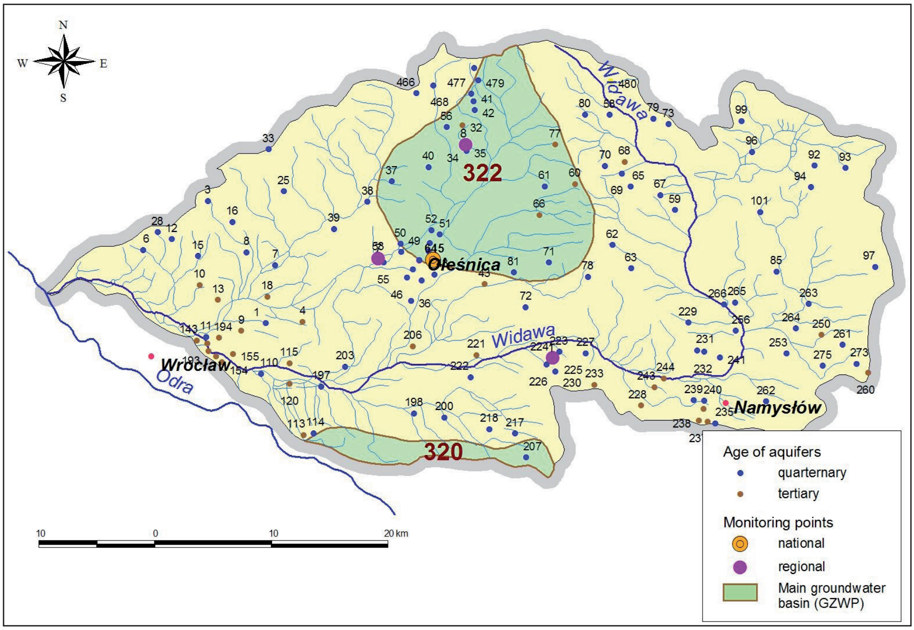


Fig. 5.3. Main groundwater basins and age of the exploited aquifers, as well as location of the monitoring points for groundwater quality on the basis of Hydrogeological Map of Poland, scale 1:200 000, sheets Wrocław and Ostrów Wielkopolski (Polish Geological Institute 1986, 1990); Map of Main Groundwater Basins in Poland of scale 1:500 000 (PGI 1990) and Reports on State of Environment in Lower Silesia Province (Polish Inspectorate of Environmental Protection (WIOS) 2001 and 2002).

The parameters of these basins are listed in Table 5.2.

Table 5.2. Parameters of main groundwater basins in the Widawa catchment – GZWP [Report WIOS 2002]

No. GZWP	Name	Age	Area		Depth	Disposable resources		Modules
			Total	Widawa catchment		Total	Widawa catchment	Widawa catchment
			km^2	km^2	m	$10^3 \cdot m^3 \cdot day^{-1}$	$10^3 \cdot m^3 \cdot day^{-1}$	$mm \cdot year^{-1}$
320	Odra ice-marginal valley	Q	231,00	37,6	12	24,09	3, 92	38,1
322	Oleśnica basin	Q	246,0	246,0	30–160	60,00	60,00	89,0

The disposable (available) resources of the catchment area were determined on the basis of average flow values SSQ and SNQ – from the period 1968–1983 for the cross-section closing the catchment of Widawa in Wrocław-Sołtysowice. In this period the renewable resources amounted to 413 720$\cdot m^3 \cdot day^{-1}$ (Hg = 88 mm year^{-1}). For the shorter measurement period 1971–1980, with higher than usual precipitation, the determined renewable resources amounted to 474 840·m^3·day^{-1}; Hg = 101.5 mm $year^{-1}$. The calculated disposable resources for a period of hydrologic drought (1991) [Dubicki et al. 2002] amounted to 220 960·m^3·day^{-1}; Hg = 47 mm·$year^{-1}$ [Czamara 1998].

The determined values of disposable resource modules vary from M_{Qdisp} = 129 m^3 ·day^{-1}·km^{-2} for drought period, M_{Qdisp} = 241 m^3·day^{-1}·km^{-2} for average conditions (for 1968–1983) to M_{Qdisp} = 277 m^3·day^{-1} km^{-2} for the period when higher than average precipitation occurred (for 1971–1980).

6. WATER ABSTRACTION AND SEWAGE DISCHARGE

6.1. Water intakes and abstraction

According to the register maintained by the Regional Water Management Office in Wrocław, 53 water intakes operate in the catchment area, summing up to a total abstraction volume of approx. 34 mln m^3, Table 6.1. However, in reality the groundwater abstraction value does not exceed 11.5 mln m^3. Therefore, it is not the quantity but quality of water that makes the issue. In the pilot catchment area mainly Quaternary waters are exploited (Chapter 5.2, Fig. 5.3).

Table 6.1. Basic information on groundwater intakes in the pilot catchment area

Municipality	No. of intakes	According to legal permission			Real abstraction	Population within the supplied area
		$Q_{av.per\ day}$	$Q_{av.\ per\ day}$	Yearly abstraction		
		$m^3 \cdot 24h^{-1}$	$m^3 \cdot 24h^{-1}$	$10^3\ m^3$	$10^3\ m^3$	10^3 pers.
Bierutów	5	1 907.20	114.54	1 033.00	427.80	8.30
Bralin	1	545.10	36.37	198.96	152.30	4.33
Czernica	1	1 544.00	140.00	563.56	392.00	8.00
Długołęka	7		366.02	2 075.69	563.60	14.30
Dobroszyce	3	1 049.40		383.00	149.70	3.62
Domaszowice	4	705.90	116.50	342.66	159.20	4.40
Dziadowa Kłoda	2		71.30	623.80	168.70	3.74
Jelcz-Laskowice	2	971.20	71.00	354.49	24.50	1.01
miasto Oleśnica	5	42 908.00	2 574.00	22 453.60	2 794.00	200.00
Namysłów	4	6 114.00	103.00	2 231.56	5 049.40	26.94
Oleśnica	6	1 023.50	240.40	1 657.70	774.00	17.62
Perzów	3		123.10	651.60	127.80	3.96
Rychtal	3	1 167.10	78.00	514.61	171.55	4.04
Syców	1	747.10	68.00	272.70	54.03	1.31
Trzebnica	2	211.40	40.00	77.20	42.23	0.43
Twardogóra	2	562.00	49.00	205.10	75.80	2.40
Wisznia Mała	2	897.26	60.16	395.00	277.20	2.51
Total	53	60 353.16	4 251.39	34 034.22	11 403.80	306.92

According to 'Płatnik' records system of the dolnośląskie, opolskie and wielkopolskie voivodeships, in 2003 water abstraction from the Widawa catchment was approx. 11.5 mln m^3, out of which surface waters accounted for as little as 660 000 m³. On the basis of the yearly average demand the abstraction modules M_{Qabstr} for the Widawa catchment was calculated for 54 $m^3 \cdot day^{-1} \cdot km^{-2}$.

Having obtained the abstraction and the disposable resources modules, the quantitative status of groundwater was determined. Both in the drought period (M_{Qdisp} = 129 $m^3 \cdot day^{-1} \cdot km^{-2}$), as well as under average conditions (M_{Qdisp} = 241 $m^3 \cdot day^{-1} \cdot km^{-2}$) the quantitative status of groundwater was recognized as good ($M_{Qabstr} < 0.75\ M_{Qdisp}$). For less favourable drought conditions the relation of $\frac{M_{Qabstr}}{M_{Qdisp}}$ equalled 0.42, whereas for average conditions (1968–1983) it equalled 0.22.

The structure of Quaternary water drawoff in 1980s was the following: municipal intakes operated 69% of total drawoff, agriculture and industry – 31% (28 and 3%, respectively); whereas in 2002 the municipal intakes used 93% of Quaternary water, while agriculture and industry – only 7% (4 and 3%, respectively).

Water abstraction from Tertiary aquifers in 1980s was the following: 18% by municipal intakes, 26% by industry and 56% by agriculture. In 2002 consumption for municipal and industrial purposes increased significantly and it reached 47 and 51% of total Tertiary water abstraction, respectively, whereas the share of agriculture in this respect was reduced down to as little as 2% of total Tertiary water consumption.

Water abstraction from Quaternary aquifers in comparison with 1980s was higher in 2002 by approx. 30%, while with regard to Tertiary aquifers – by 120%. Water abstraction for municipal and industrial purposes grew significantly, while abstraction for agricultural purposes dwindled dramatically.

Table 6.2 provides information on water consumption from water supply to households together with the sewage discharged in the Widawa catchment communities in 2003. The unit water consumption varied from approx. 60 to 130 $dm^3 \cdot day^{-1}$ per person. According to the records, unit consumption of water in Wrocław and Oleśnica was clearly higher (125–130 $dm^3 \cdot day^{-1}$ per person).

Table 6.2. Mains-water consumption in households and sewage discharge in 2003

Municipality	Water	Sewage	Water-supply consumption Q_w			Sewage discharge Q_s			Qs/ Qw
			Per capita		Per F	Per capita		Per F	
	dm³	dm³	$m^3 \cdot year^{-1}$	$l \cdot day^{-1}$	$m^3 \cdot year^{-1}$	$m^3 \cdot year^{-1}$	$l \cdot day^{-1}$	$m^3 \cdot year^{-1}$	%
Bierutów	234.0	165.0	22.6	61.9	0.159	15.9	43.6	0.112	70.5
Czernica	243.0	109.0	29.0	79.5	0.289	13.0	35.7	0.129	44.9
Dobroszyce	455.0	61.0	23.7	64.8	0.345	3.2	8.7	0.046	13.4
Długołęka	151.0	64.0	25.6	70.1	0.071	10.8	29.7	0.030	42.4
Dziadowa Kł.	122.0	42.0	27.0	74.0	0.116	9.3	25.5	0.040	34.4
Jelcz-Lask.	775.0	734.0	36.3	99.3	0.363	34.3	94.1	0.343	94.7
Międzybórz	153.0	108.0	30.9	84.7	0.173	21.8	59.8	0.122	70.6
Oleśnica	1 734.0	1 784.0	46.6	127.8	8.277	48.0	131.5	8.516	102.9
Oleśnica	228.0	48.0	20.5	56.2	0.094	4.3	11.8	0.020	21.1
Syców	508.0	505.0	31.1	85.2	0.351	30.9	84.7	0.349	99.4
Trzebnica	760.0	636.0	35.1	96.2	0.380	29.4	80.5	0.318	83.7
Twardogóra	367.0	255.0	28.7	78.6	0.218	19.9	54.6	0.152	69.5
Wisznia Mała	269.0	36.0	34.7	95.2	0.260	4.6	12.7	0.035	13.4
Wrocław	29 219.0	35 139.0	45.7	125.2	9.978	55.0	150.6	11.999	120.3
Zawonia	134.0	4.0	25.0	68.6	0.113	0.7	2.0	0.003	3.0
Total	**35 352.0**	**39 690.0**	**42.8**	**117.3**	**1.554**	**48.0**	**131.6**	**1.745**	**112.3**

6.2. Sewage management – sewage discharge

The dominant type of sewage in the catchment are those discharged by fishery facilities. In this case mostly no sewage treatment plants are used and the polluted waters from fish ponds are drained directly to the river. Mechanical treatment facilities are used for rainwater sewage drained directly to the river.

Primarily the rural household wastewater tends to affect water quality in this area . In the periods of water shortage it occasionally occurs that only sewage flows therein, as some streams do not carry water above certain villages. Stream beds within built-up zones (rural, in particular) and the adjacent transport routes are frequently heavily polluted with solid waste. Also the bad sanitary condition of rural areas poses a threat to water quality. As a habit, dung continues to be heaped up without any ground insulation. Most villages in the Widawa catchment area connected to water supply, but not to a sewage system. However, in recent years the situation keeps improving. The new sewage treatment plants produce processed water of much better parameters than the older facilities.

Due to a shortage of monitoring points in the upper section of the Widawa catchment area a complete assessment of water cleanliness is impossible. The surface water in this area is threatened by disposal of municipal and industrial sewage (Fig. 6.1).

According to the data possessed by the Regional Environmental Protection Inspectorate in Wrocław, among major water polluting facilities can be mentioned the following:

- Mechano-biological sewage treatment plant of the Fruit & Vegetable Processing Plant in Dziadowa Kłoda, discharging 69 $m^3 \cdot day^{-1}$ of sewage. In addition, household sewage from Dziadowa Kłoda is delivered to this plant.
- Mechano-biological sewage treatment plant in the town of Bierutów, where household sewage of the town is treated, amounting to 887 $m^3 \cdot day^{-1}$, as well as industrial sewage amounting to 118 $m^3 \cdot day^{-1}$.
- Mechano-biological sewage treatment plant of the town of Oleśnica, discharging municipal and industrial sewage via the Oleśnica river, amounting to 7140 $m^3 \cdot day^{-1}$.
- Mechanical sewage treatment plant of the Posadowice distillery, discharging 76 $m^3 \cdot day^{-1}$ (operates in campaign season).
- Mechanical sewage treatment plant of the Bierutów distillery, discharging 92 $m^3 \cdot day^{-}1$ of sewage via Młynówka.
- Mechano-biological sewage treatment plant in Mirków, discharging 180 $m^3 \cdot day^{-1}$ of sewage via Topór stream to Dobra river. Also sewage from the 'SELGROS' supermarket in Długołęka are transferred there.
- Mechano-biological sewage treatment plant in Dobroszyce, discharging 115 $m^3 \cdot day^{-1}$ of treated sewage to Dobra river.
- Irrigation Fields in Dobrzykowice, taken over from the Wrocław Waterworks and Sewage Company by the Public Utilities Company of the Czernica Municipality; the volume of discharged sewage is 290 $m^3 \cdot day^{-1}$.
- Overloaded district sewage treatment plant in Wrocław Psie Pole, with total sewage output of approx. 877 $m^3 \cdot day^{-1}$. In April 2001 the plant was shut down and the sewage is pumped to the sewage treatment plant in Janówek.
- Fully efficient sewage treatment plant of the 'Wrocław' sugar refinery, with a ditch output of approx. 916 $m^3 \cdot day^{-1}$ (in campaign season).

- Polar SA sewage treatment plant in Wrocław Psie Pole, discharging household and industrial sewage together with rainwater at a rate of approx. 1673 $m^3 \cdot day^{-1}$. Polar SA sewage treatment plant in Wrocław Zakrzów discharges processed sewage and rainwater to Dobra (135 $m^3 \cdot day^{-1}$), as well as household sewage from the facility, Zakrzów district and Zakrzów brewery after mechanical and biological processing (1446 $m^3 \cdot day^{-1}$) [Marchlewska-Knych et al. 2002].

The greatest amount of biologically processed sewage is discharged to the mill stream of Widawa from the municipal sewage treatment plant in Namysłów. The city of Namysłów, with a yearly output of approx. 1600 000 m^3, is the main source of problems occurring in Widawa. A noticeable share of sewage flows to Widawa via the Namysłówka river and from the municipal sewage treatment plant in Bierutów. In the remaining area of lacking municipal infrastructure one should expect degradation of surface waters due to uncontrolled and unrestricted sewage discharge from built-up areas to the ground, irrigation ditches or directly to streams. Such activity causes local water pollution resulting in higher BOD (Biochemical Oxygen Demand in a 5-day period) value, as well as sodium, potassium, nitrate and phosphate concentration, accompanied by the transgression of the acceptable bacterium levels. Also run-offs from farmland and fertilised meadows and pastures contribute to water pollution with biogenic substances (nitrates, phosphates).

The water from the mechano-biological sewage treatment plant in Perzów is discharged to Czarna Widawa. Quality monitoring data with regard to this river is missing.

Międzybórz is a town with sewage system but lacking a sewage treatment plant. The only pre-processing device is a sediment collector of the District Dairy Co-operative. Thereafter, insufficiently treated water is discharged to the Malinowa Woda stream.

Also the data provided by Regional and Marshall Office have been used for quantity and quality analysis of sewage flowing to Widawa. These data specify 43 users that pay for sewage output in 1994–2001, including specification of sulphates, heavy metals, suspensions, phenols and sewage volume BOD, COD. The largest sewage output was delivered by: Public Utilities Company of Oleśnica – 3 mln $m^3 \cdot year^{-1}$, Polar Wrocław – 1.2 mln $m^3 \cdot year^{-1}$, Public Utilities Company of Syców 0.5 mln $m^3 \cdot year^{-1}$, Waterworks & Sewage Company of Bierutów 0.22 mln $m^3 \cdot year^{-1}$. Heavy metals were detected in the sewage discharged by the Wrocław Waterworks Company – 211 kg in 1999 and 22.5 kg in 2001. Polar Wrocław reduced the amount of heavy metals from 422 kg in 1996 to 98 kg in 2001. A growing tendency in sewage output was evident for Piast SA Wrocław, Poniatowice Distillery and Public Utilities Company at Kiełczów.

In 2001, the total volume of sewage discharged to the Widawa catchment area amounted to 5.3 mln m^3, showing a descending tendency in relation to the preceding years. According to the Regional Inspectorate of Environmental Protection, in 2001 the following pollutant loads were discharged to the Widawa catchment area: BOD – 242 $Mg \cdot year^{-1}$, COD – 439 $Mg \cdot year^{-1}$, total suspensions – 243 $Mg \cdot year^{-1}$, chlorides and sulphates – 1119 $Mg \cdot year^{-1}$ and heavy metals 196 $kg \cdot year^{-1}$.

Great amounts of nitrogen pass to the water from farming. The main reason here is the overfertilisation of soil, as well as surface run-offs. According to the Environmental Protection Institute, approx. 95% of total phosphorus and approx. 50–55% of nitrogen is washed out from the soil and discharged to water. Agriculture is also a serious source of heavy metals and other contaminants.

7. WATER QUALITY IN THE WIDAWA CATCHMENT

7.1. Surface water

Monitoring of surface water quality in the Widawa catchment area was performed at 14 measurement cross-sections located on the following rivers: Dobra (3 cross-sections), Oleśnica (3 cross-sections) and Widawa (8 cross-sections), 12 measurements (at monthly intervals) were performed yearly at mouth cross-sections, primarily with regard to basic parameters (reaction, electrical conductivity, total suspensions), oxygen (biochemical oxygen demand in 5 day period – BOD, dissolved oxygen, chemical oxygen demand with the permanganate method (quite more rarely with the bichromate method) and biogenic properties (ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, total nitrogen, Kjeldahl's nitrogen, phosphates, total phosphorus) and some non-organic compounds were assayed (chlorides, sulphates, dissolved substances). At similar frequency the faecal-type coli titre was determined. Hazardous organic substances were examined at greatest time interval. In other cross-sections the measurements are performed mostly at 3 years inteval.

In Table 7.1 percentile values s = 90% are provided for selected parameters. Class 1 is marked blue, class 2 – green, class 3 – yellow, class 4 – orange and class 5 – red. Water reaction in the upper cross-section of Widawa in the entire period of analysis (1993–2004) never exceeded the normative values of 1st class of water cleanliness. Its values of pH fluctuated from 7.9 to 8.1. The highest average reaction value was recorded in 2002, while the lowest – in 1997. Electrical conductivity was within the range 630–760 $\mu S \cdot cm^{-1}$, and it was noticeably decreasing within the 10 year observation period. The concentration of oxygen dissolved in water exceeded its standard values only in 1993–1994. In 2001 the amount of oxygen in water equalled 5.5 mg $O_2 \cdot dm^{-3}$ (2nd class). A regular fall in biochemical and chemical oxygen demand was recorded. With regard to BOD water was of 2nd and 3rd class of cleanliness, and in terms of COD_{Mn} – in the 2nd. Chlorides and sulphates did not occur in amounts exceeding the standard of 1st class (only sulphates were in the 2nd class during the first year of the survey). In the entire survey period substances dissolved in water provided for its classification in the 1st class of cleanliness. General suspensions varied from 11 to nearly 22 $mg \cdot dm^{-3}$. In the entire period surveyed the water was qualified as 1st or 2nd class in terms of total suspension. In spite of the excess of nitrite nitrogen, a general declining trend of nitrogen compounds can be observed. Only nitrite nitrogen continues to exceed by far its concentration norms, even as for the 3rd class. The concentraction of ammonium nitrogen remains between 1st and 2nd class (max ca. 2.5 $mg \cdot dm^{-3}$ in 1997). The nitrite nitrogen level fluctuated in the survey period, though its concentration in Widawa keeps falling. The concentration of nitrate nitrogen did not exceed the standard level for 2nd class. The lowest value was recorded in 1996, and the highest in 1994. This concentration showed great variation in the 10 years study period. Total nitrogen did not exceed standard levels for 2nd class (in 1996 and 1997 it corresponded with 1st class quality).

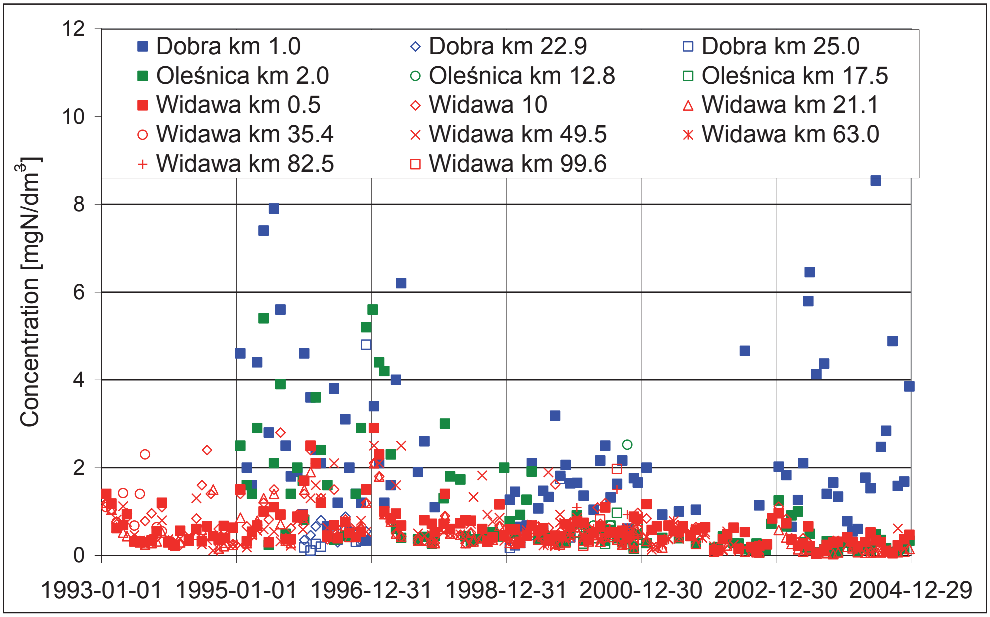
Phosphate concentration does not exceed the 3rd class, however, a slight growing tendency has been noticed. Total phosphorus in 1996 and 1997 exceeded the standard values for the 3rd class, and was retained below the standard limits for the rest of the period. In spite of the decline in phosphorus concentration in the last three years, a general growing tendency is visible. The average value of phosphate concentration amounts to 0.45 $mg \cdot dm^{-3}$, and that of total phosphorus to 0.31 $mg \cdot dm^{-3}$.

Samples collected at the following cross-sections of Widawa were subjected to analysis: 21.1 km, 1.8 km – below the Wrocław sugar refinery and the Dobra river mouth, 0.5 km – mouth to Odra. In these cross-sections higher values were recorded in relation to the initial cross-section. This indicates at a growth of pollution concentration with growing catchment area. The pH values at all Widawa cross-sections were from 7.9 to 8.2. The level of dissolved oxygen in water decreased significantly, causing degradation of Widawa waters in certain periods. The concentration of chlorides and sulphates, apart from records for cross-section 8, are growing. The values of dissolved substances and suspensions still fit into the 2nd, and mostly 1st class, respectively.

In spite of the high values of some parameters (mainly of biogenic elements), their presence in the 10 year survey has declined. A significant water quality improvement of Widawa and its tributaries – Dobra and Oleśnica – has been noticed. According to the analysis performed, biogenic compounds and the sanitary status of water determine the quality of surface water. The greatest overshoots of the 4th class standard were recorded in the Dobra river (2.8 multiple level of phosphate concentration limit in 2003).

The bed sediment survey results for the mouth cross-section of Widawa indicate that for most of the assays they are lower than those at other measurement points in the region, apart from chromium in 2004 where concentration was 80 ppm (concentration of Cr>37 ppm may affect water organisms); polychlorinated biphenyls and organic pesticides (DDE, DDD, DDT and g-HCH) [Report WIOS 2000–2003].

a. Ammonium nitrogen



b. Total nitrogen

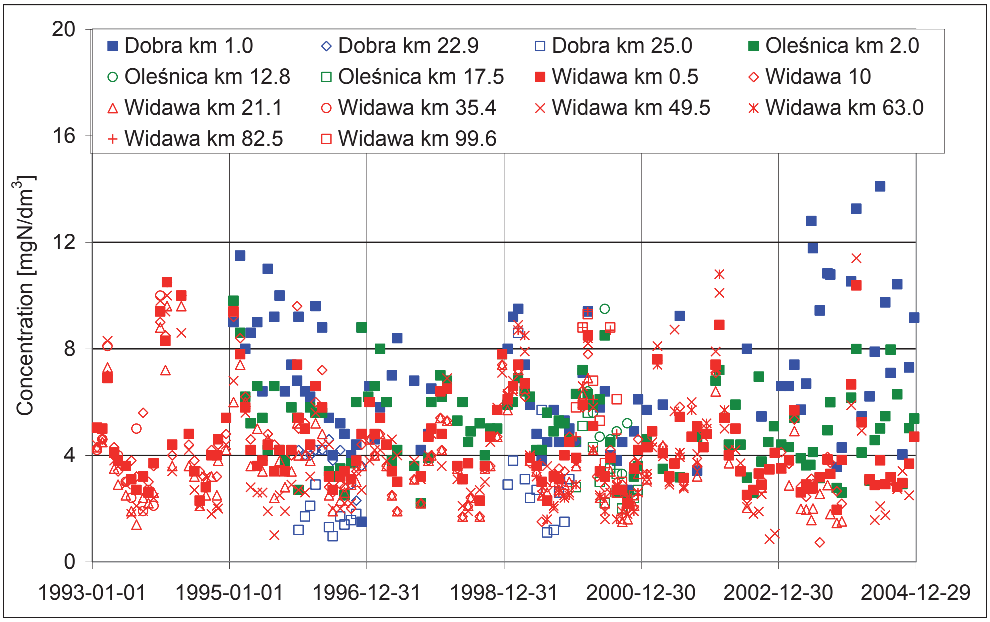
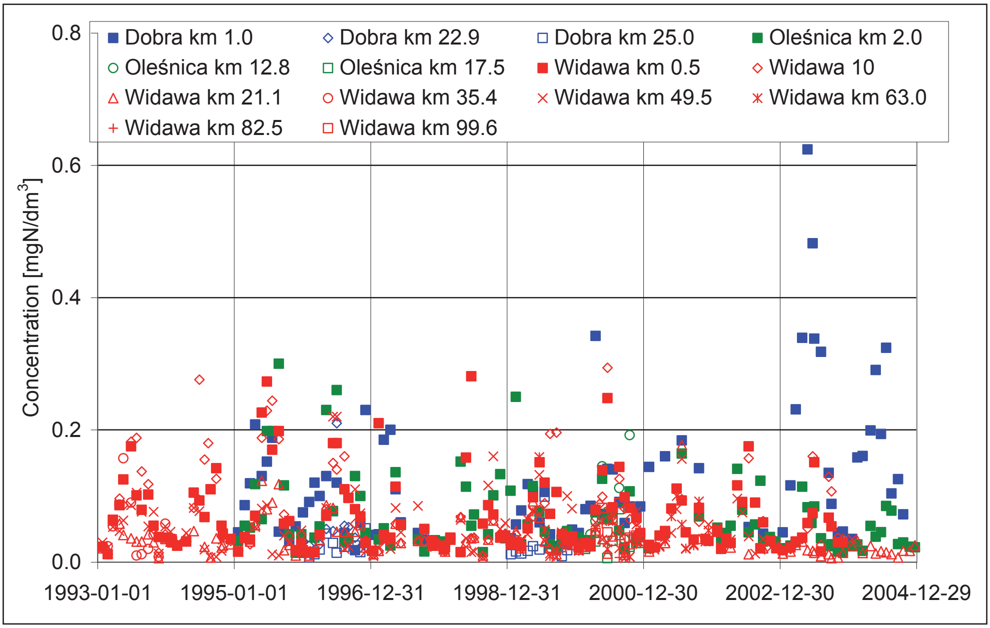


Fig. 7.1. Concentration of ammonium and total nitrogen in Widawa and its tributaries in 1993–2004

a. Nitrite nitrogen



b. Nitrate nitrogen

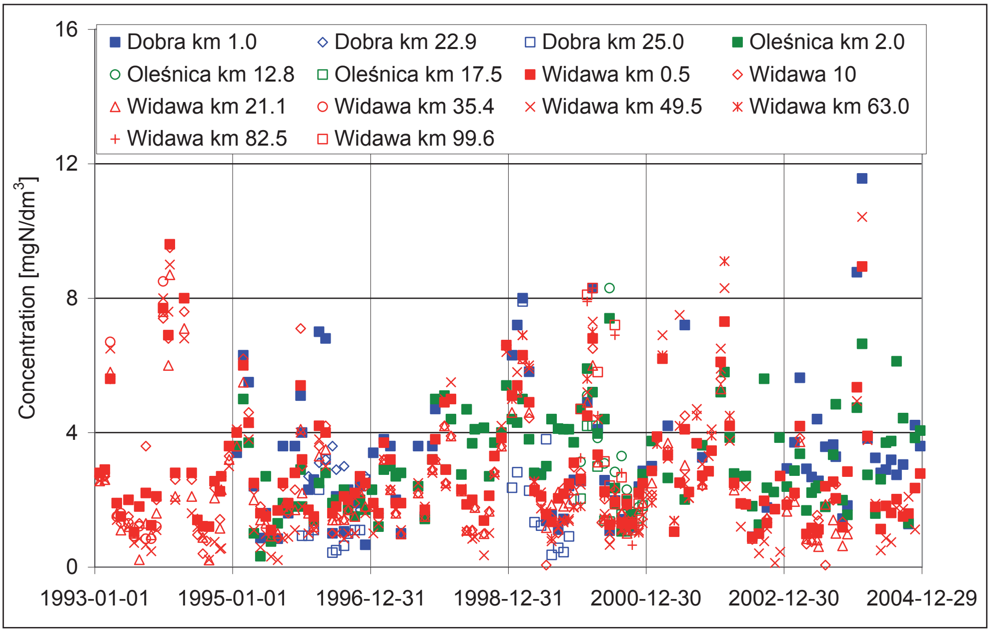
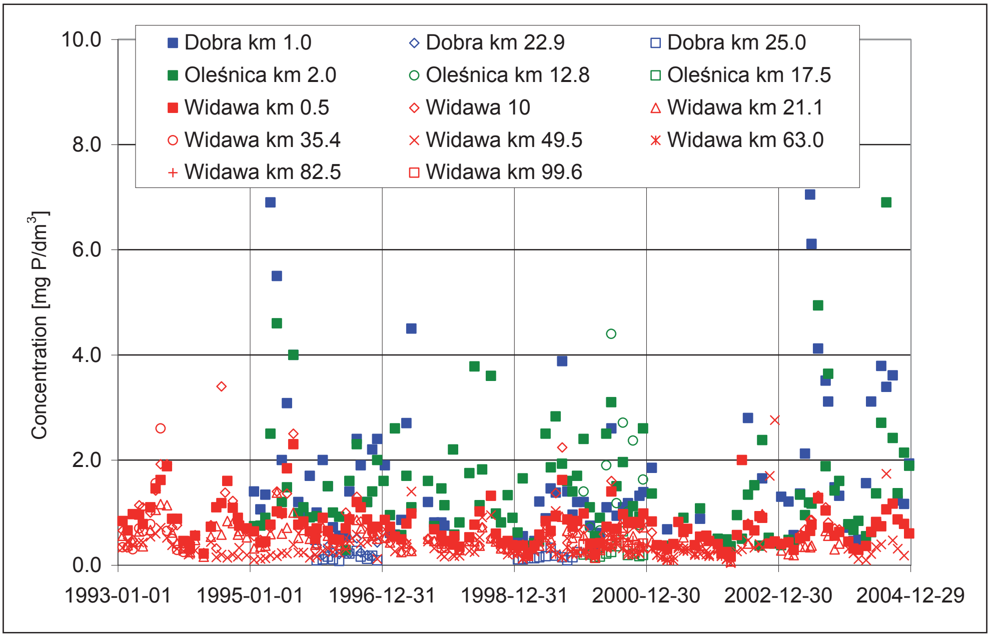


Fig. 7.2. Specific concentration of s_{90} nitrogen compounds in Widawa and its tributaries in 1993–2004

a. Total phosphorus



b. Phosphates

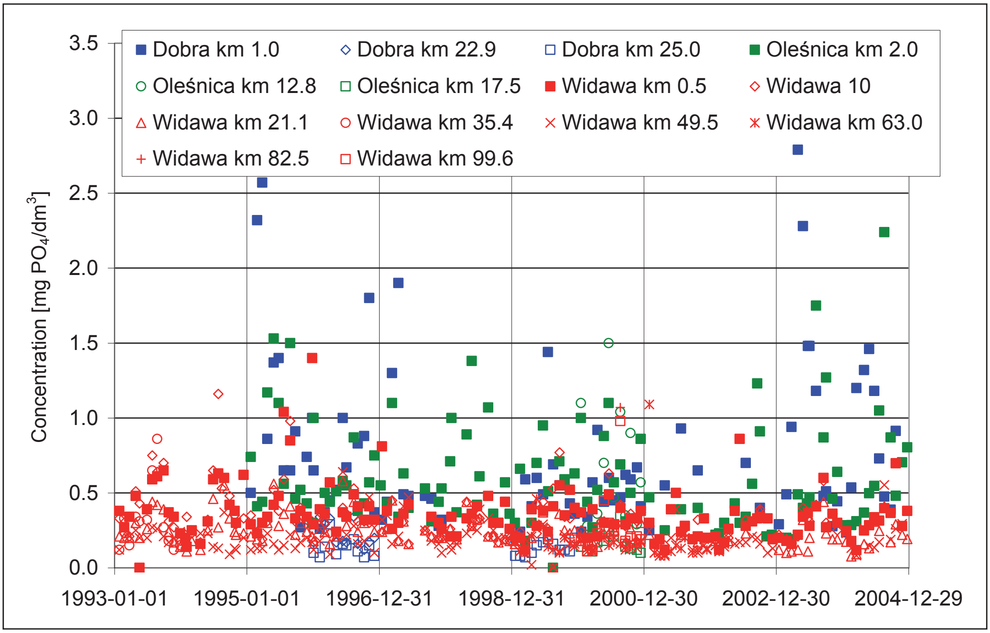
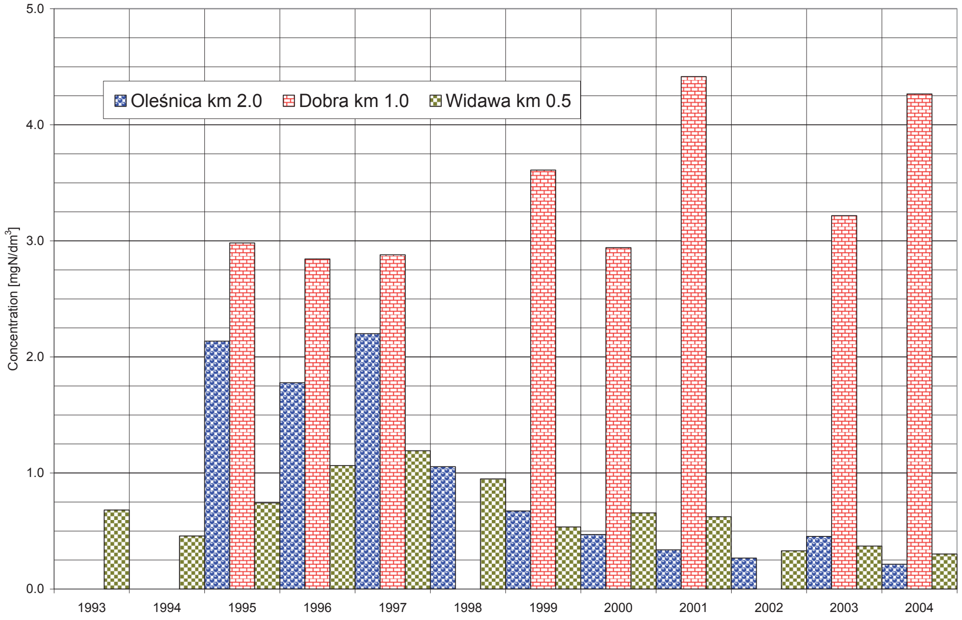


Fig. 7.3. Concentrations of phosphrous compounds in Widawa and its tributaries in 1993–2004

a. Ammonium nitrogen



b. Nitrate nitrogen

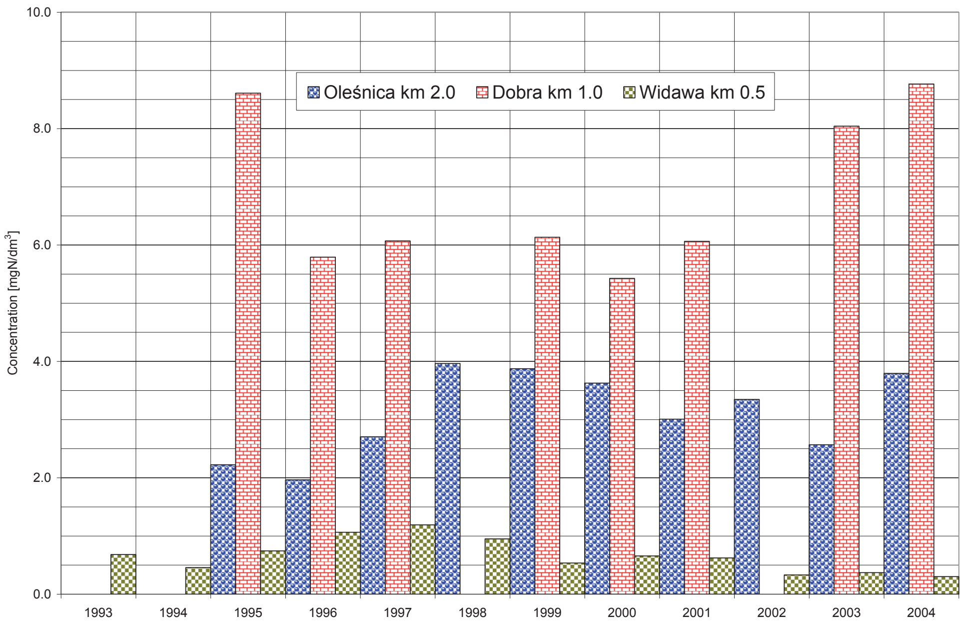
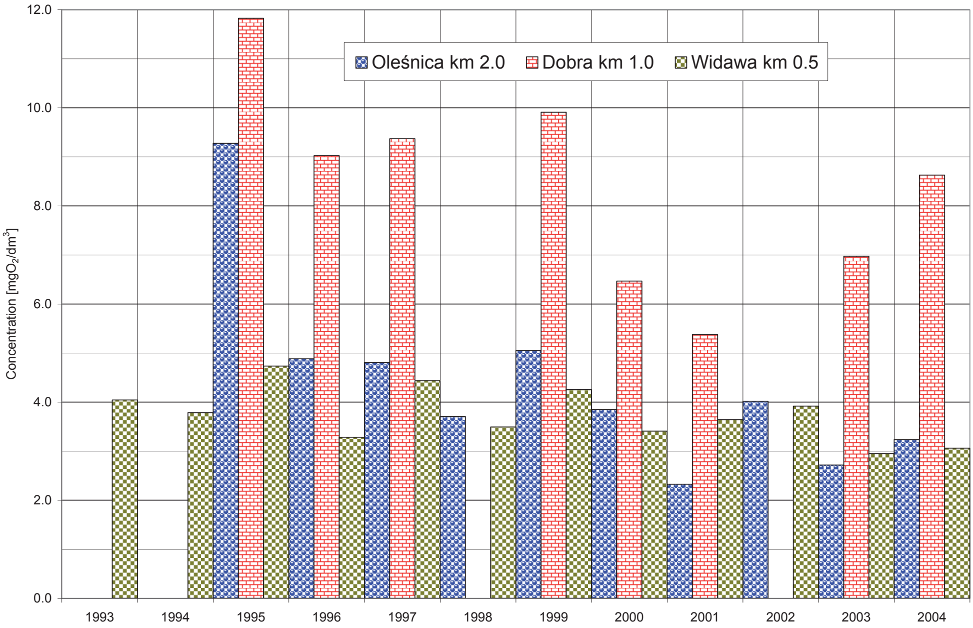


Fig. 7.4. Yearly average concentrations of nitrogen compounds in Widawa and its tributaries in 1993–2004

a. BOD_5



b. Total nitrogen

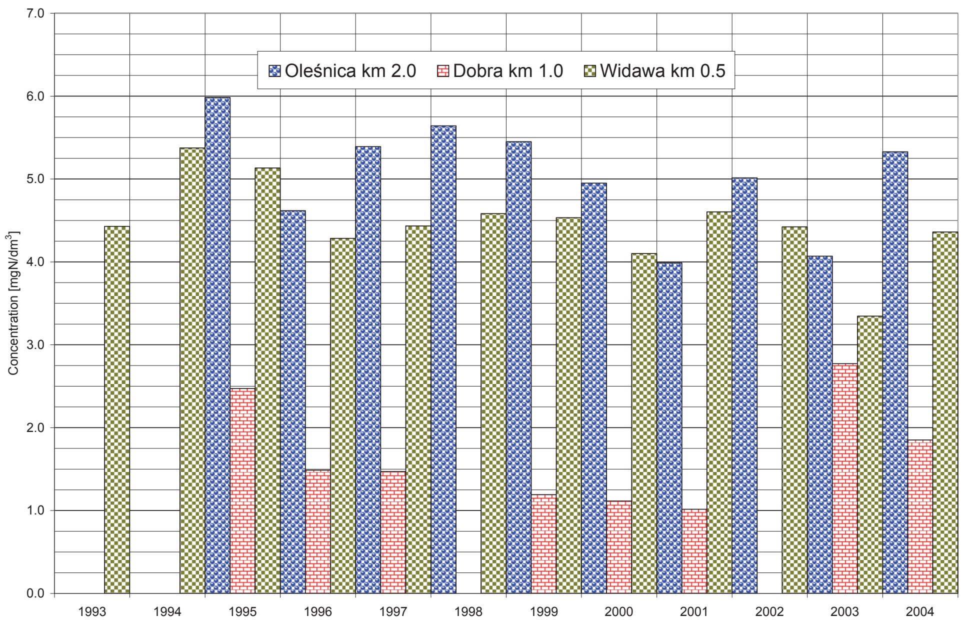
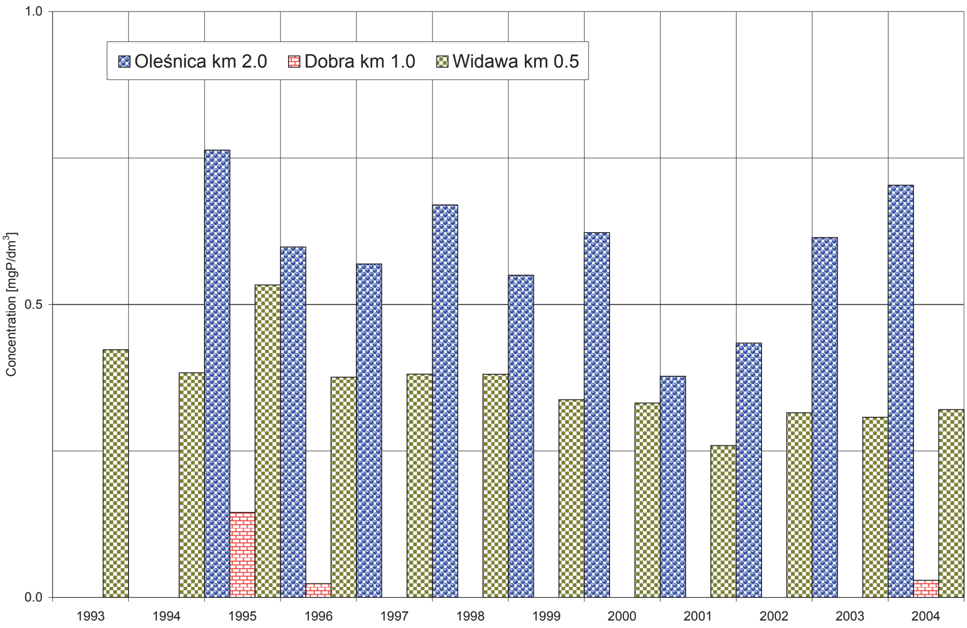


Fig. 7.5. Yearly average concentrations of nitrogen compounds at mouth cross-sections of Widawa and its tributaries in 1993–2004

a. Total phosphorus



b. Phosphates

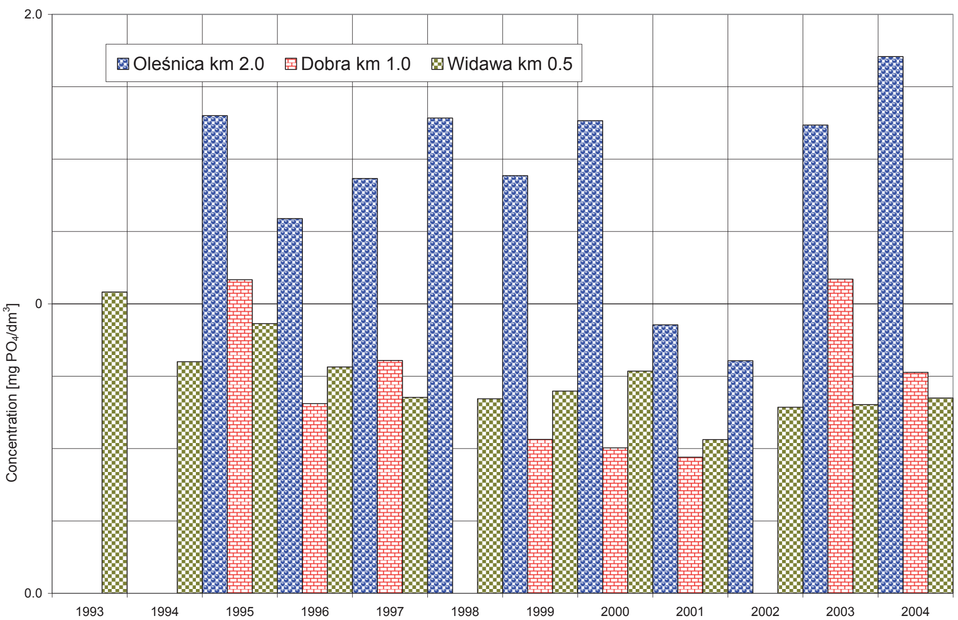


Fig. 7.6. Yearly average concentrations of phosphorus compounds at mouth cross-sections of Widawa and its tributaries in 1993–2004

Table 7.1. Characteristic concentrations of pollutants and classification of surface waters in the Widawa catchment area for 1995–2004

River	Km	Year	Reaction	El. cond.	Diss. oxygen	BOD	COD	Diss. Substances	Total susp.	Nitrogen			Phosphates	Total phosphorus	Zinc	Cadmium	Copper	Lead	Coli titre	Chlorophyll
			pH	μS/cm	mgO_2/l	mgO_2/l	mgO_2/l	mg/l	mg/l	mgN/l			$mgPO_4/l$	mgP/l	mgZn/l		mg Cu/l	mgPb/l		mg/l
1	2	3	4	5	6	7	8	9	10	11			12	13	14	15	16	17	18	19
Dobra	km 1.0	1995	8.0	868	3.0	17.4	15.4	663.4	38	7.220	5.5	10.9	5.350	2.228	0.260	0.0022	0.0180	0.0180	0.0003	0.000
Dobra	km 1.0	1996	7.9	954	3.9	15.6	11.1	715.2	20	3.780	6.5	9.2	2.380	0.988	0.042	0.0033	0.0290	0.0020	0.0003	0.001
Dobra	km 1.0	1997	7.9	950	11.3	27.0	13.7	720.0	20	6.200	4.7	8.4	4.500	1.900					0.0010	
Dobra	km 1.0	1999	7.9	776	5.5	17.3	11.2	600.0	25	2.096	7.1	9.1	1.454	0.681					0.0040	
Dobra	km 1.0	2000	7.9	744	7.5	7.6	12.8	621.1	20	2.160	4.8	7.0	1.383	0.618					0.0184	
Dobra	km 1.0	2001	8.1	774	11.5	8.4	12.2	602.0	56	2.000	7.2	9.2	1.850	0.670					0.2000	5.000
Dobra	km 1.0	2002	7.9	811	9.4	9.0	10.8	568.0	21	4.660	1.8	8.0	2.800	0.930					0.0040	
Dobra	km 1.0	2003	7.7	1028	4.7	10.9	11.0	697.8		5.648	4.3	11.7	5.911	2.200					0.0085	
Dobra	km 1.0	2004	7.9	865	3.8	16.7	10.4	666.2	22	4.777	8.3	13.0	3.588	1.308	0.041	0.0010	0.0259	0.0487	0.0005	0.042
Dobra	km 22.9	1996	7.9	530	6.5	4.1	8.3	408	21	0.788	3.2	4.2	0.425	0.339						
Dobra	km 25.0	1996	8.0	442	7.0	4.6	9.3	342	12	0.634	2.6	4.1	0.256	0.187	0.017	0.0062	0.0030	0.0001	0.1000	15.700
Dobra	km 25.0	1999	7.8	427	7.3	6.4	9.8	382	19	0.569	3.7	5.5	0.243	0.188						
Oleśnica	km 12.8	2000	7.9	529	8.2	6.0	12.8	421	33	0.716	5.2	6.4	2.676	1.094					0.0200	
Oleśnica	km 17.5	2000	7.9	461	7.4	5.9	12.4	364	23	0.675	4.1	5.0	0.349	0.237					0.0400	
Oleśnica	km 2.0	1995	7.8	598	5.0	16.4	20.9	455	57	3.800	3.7	8.4	3.850	1.467	0.130	0.0012	0.0100	0.0003	0.0100	6.800
Oleśnica	km 2.0	1996	7.9	640	10.6	8.3	12.1	506	27	5.200	2.8	8.8	2.300	1.000	0.020	0.0016		0.0001	0.0400	3.800
Oleśnica	km 2.0	1997	8.0	640	12.1	9.8	12.1	506	27	5.600	5.0	8.8	2.600	1.100	0.050	0.0050	0.0160	0.0200	0.1000	5.000
Oleśnica	km 2.0	1998	8.0	620	8.6	5.5	9.2	482	21	1.980	5.1	7.0	3.460	1.063					0.0190	
Oleśnica	km 2.0	1999	8.0	567	8.0	7.9	12.4	422	18	1.235	4.4	6.4	2.443	0.950					0.0400	
Oleśnica	km 2.0	2000	7.9	541	7.6	5.7	13.0	434	20	0.634	5.8	7.1	2.590	0.988	0.034	0.0050	0.0100	0.0002	0.0200	32.300
Oleśnica	km 2.0	2001	8.0	556	12.3	3.4	13.5	390	19	0.400	3.8	4.7	1.360	0.470					0.2000	6.800
Oleśnica	km 2.0	2002	8.0	702	7.5	5.2	11.0	522	21	0.430	5.6	6.9	1.502	0.875					0.1000	
Oleśnica	km 2.0	2003	7.7	759	6.9	3.3	8.1	516	8	0.991	3.4	5.4	3.464	1.230					0.1000	

Tabela 7.1. cd.

1	2	3	4	5	6	7	8	9	10	11			12	13	14	15	16	17	18	19
Oleśnica	km 2.0	2004	7.9	642	6.9	3.7	12.3	497	33	0.348	6.0	7.8	2.677	1.032	0.030	0.0010	0.1037	0.0005	0.2326	26.900
Widawa	km 0.5	1993	7.9	898	5.6	5.5	8.8	626	11	1.198	5.3	6.7	1.604	0.650	0.060	0.0012	0.0080	0.0004	0.0400	24.400
Widawa	km 0.5	1994	7.9	739	4.4	5.0	10.5	603	18	0.657	7.9	9.8	1.172	0.618	0.038	0.0042	0.0080	0.0005	0.0094	17.800
Widawa	km 0.5	1995	7.9	763	5.2	6.7	11.7	608	18	1.090	5.3	7.8	1.758	1.021	0.072	0.0036	0.0040	0.0004	0.0100	13.700
Widawa	km 0.5	1996	7.8	709	6.1	4.5	8.2	583	13	2.060	3.9	5.8	1.080	0.482	0.013	0.0024		0.0002	0.0370	3.100
Widawa	km 0.5	1997	7.9	700	12.4	5.9	9.4	577	17	2.900	3.8	6.0	0.980	0.810	0.050	0.0005	0.0130	0.0020	0.0400	5.000
Widawa	km 0.5	1998	7.9	750	12.4	5.9	10.1	623	19	2.900	5.0	6.5	1.320	0.810	0.050	0.0005	0.0130	0.0020	0.0400	5.000
Widawa	km 0.5	1999	8.0	691	6.4	5.2	9.2	563	18	0.677	5.4	6.7	0.933	0.509	0.050	0.0050	0.0130	0.0003	0.0400	29.000
Widawa	km 0.5	2000	7.9	644	5.2	4.4	11.3	524	23	0.875	4.4	5.8	0.980	0.399	0.057	0.0050	0.0100	0.0002	0.0200	18.000
Widawa	km 0.5	2002	7.9	712	6.1	5.4	10.2	558	34	0.620	5.9	7.2	0.927	0.376	0.020	0.0030	0.0100	0.0004	0.2000	43.600
Widawa	km 0.5	2003	7.6	957	6.2	4.6	7.3	603	14	0.723	2.8	3.8	1.013	0.406					0.1900	
Widawa	km 0.5	2004	7.8		6.0	5.2	8.0	567	12	0.463	5.2	6.5	1.041	0.396	0.042	0.0010	0.0208	0.0021	0.2326	18.600
Widawa	km 13.8	1993	7.9	953	4.4	9.4	8.6	608	17	1.094	5.4	6.9	1.870	0.694	0.089	0.0010	0.0180	0.0004	0.0040	13.500
Widawa	km 13.8	1994	7.9	739	3.9	4.3	10.3	610	12	1.580	7.5	9.9	1.364	0.638	0.044	0.0026	0.0080	0.0004	0.0100	14.500
Widawa	km 13.8	1995	7.9	737	3.2	6.5	9.8	616	17	1.680	6.0	9.1	1.396	0.583	0.076	0.0010	0.0030	0.0002	0.0040	0.700
Widawa	km 13.8	1996	7.9	707	5.1	4.9	8.9	553	12	2.040	3.5	5.9	0.991	0.397					0.0037	3.200
Widawa	km 13.8	1999	7.9	682	5.5	5.6	12.2	552	20	0.744	5.2	6.6	1.319	0.521					0.0184	
Widawa	km 13.8	2000	8.0	627	5.3	4.7	10.0	523	18	1.078	4.3	5.7	0.876	0.415					0.0040	
Widawa	km 13.8	2002	8.0	711	11.7	5.5	13.8	537	28	1.190	6.5	7.8	1.600	0.630					0.1000	
Widawa	km 13.8	2003	7.7	941	5.2	3.9	6.8	583	9	0.786	2.4	4.1	1.076	0.418					0.0940	
Widawa	km 21.1	1993	8.1	831	6.8	4.8	7.8	557	18	1.000	5.5	7.0	1.131	0.417	0.047	0.0010	0.0070	0.0005	0.0400	12.300
Widawa	km 21.1	1994	8.0	669	6.0	4.2	8.8	577	14	0.570	7.0	9.4	0.794	0.447	0.098	0.0028	0.0090	0.0003	0.0100	5.600
Widawa	km 21.1	1995	7.9	650	5.8	5.1	9.3	557	15	1.257	4.3	6.0	0.971	0.405	0.072	0.0006	0.0020	0.0001	0.0400	1.400
Widawa	km 21.1	1996	7.9	648	7.2	4.3	8.5	524	16	1.860	3.2	4.7	0.718	0.440					0.0400	6.000
Widawa	km 21.1	1997	8.0	655	11.6	5.5	9.1	546	16	2.100	3.2	4.8	0.550	0.450					0.0400	
Widawa	km 21.1	1998	8.1	669	7.8	4.0	9.6	551	21	0.663	4.2	5.4	0.508	0.329				0.0005	0.0380	

Tabela 7.1. cd.

1	2	3	4	5	6	7	8	9	10	11			12	13	14	15	16	17	18	19
Widawa	km 21.1	1999	8.0	651	8.1	4.8	11.0	498	15	0.518	5.1	6.5	0.899	0.440					0.0400	
Widawa	km 21.1	2000	8.0	597	7.3	4.1	10.4	474	17	0.529	4.7	6.1	0.706	0.296	0.030	0.0050	0.0100	0.0004	0.0400	13.300
Widawa	km 21.1	2002	8.0	649	12.0	4.7	11.6	494	17	0.420	5.3	6.4	0.970	0.380					0.4000	5.000
Widawa	km 21.1	2003	7.9	673	7.3	3.4	7.0	496	12	0.395	1.9	3.4	0.641	0.401						
Widawa	km 35.4	1993	7.8	778	5.2	15.3	11.3	598	17	1.418	6.3	7.8	1.482	0.619	0.036	0.0012	0.0140	0.0004	0.0037	28.900
Widawa	km 49.5	1993	7.9	776	4.6	10.2	10.0	587	17	1.138	6.1	7.9	0.594	0.260	0.053	0.0010	0.0050	0.0005	0.0370	29.700
Widawa	km 49.5	1994	7.9	668	3.8	6.2	10.4	575	14	0.443	7.5	9.3	0.325	0.239	0.072	0.0030	0.0070	0.0004	0.0370	5.300
Widawa	km 49.5	1995	7.9	660	6.3	6.5	8.9	565	14	0.590	4.1	6.7	0.240	0.218	0.058	0.0006	0.0020	0.0003	0.0400	1.500
Widawa	km 49.5	1996	7.9	649	7.3	5.0	9.1	510	11	1.570	2.9	4.4	0.496	0.451	0.012	0.0020	0.0010	0.0003	0.0040	1.700
Widawa	km 49.5	1997	8.0	665	11.1	12.0	11.1	550	23	2.500	3.8	4.8	1.400	0.470	0.050	0.0050	0.0150	0.0003	0.0040	5.000
Widawa	km 49.5	1998	7.9	683	7.2	5.2	9.4	545	11	1.290	5.5	6.9	0.874	0.324					0.0190	
Widawa	km 49.5	1999	7.9	659	7.2	8.7	12.5	523	18	0.907	5.9	7.8	0.519	0.400					0.0200	
Widawa	km 49.5	2000	7.8	628	7.1	4.8	10.0	504	15	0.717	5.1	6.5	0.463	0.274					0.0200	
Widawa	km 49.5	2001	8.0	662	5.3	4.1	11.4	528	11	0.556	6.7	7.9	0.320	0.293					0.2000	64.600
Widawa	km 49.5	2002	8.0	702	7.1	5.8	9.6	494	18	0.550	6.2	7.6	1.577	0.200					0.3800	
Widawa	km 49.5	2004	7.8	675	12.4	4.9	8.7	564	15	0.611	10.4	11.4	1.737	0.553	0.020	0.0010	0.0262	0.0005	0.4348	29.100
Widawa	km 63.0	1999	7.8	639	5.4	7.7	13.7	509	11	0.616	5.9	8.3	0.439	0.264						
Widawa	km 63.0	2000	7.9	607	6.3	4.5	9.5	480	17	0.729	5.4	6.4	0.396	0.198						
Widawa	km 82.5	2000	7.8	540	6.2	6.1	16.5	422	35	1.074	7.8	8.8	0.518	0.310						
Widawa	km 99.6	2000	7.8	517	6.6	5.7	12.5	406	26	0.814	8.0	8.8	0.552	0.435						

l = dm^{-3}

7.2. Groundwaters

The quality status of the groundwaters was strongly diverse, both in terms of the parameters and their spatial distribution (Tab. 7.2, Fig. 7.7–7.9), [Kolago 1987, Turek1990].

Table 7.2. Distinctive values of selected water quality parameters in Tertiary and Quaternary aquifers

Age of aquifer	Values and class of quality*	Total dissolved solids	Total hardness	Chlorides	Sulphates	Total iron	Manganese	Ammonium nitrogen	Nitrites	Nitrates
		$mg \cdot dm^{-3}$	$mg\ CaCO_3 \cdot dm^{-3}$	$mg\ Cl^- \cdot dm^{-3}$	$mg\ SO_4^{2-} \cdot dm^{-3}$	$mg\ Fe \cdot dm^{-3}$	$mg\ Mn^{2+} \cdot dm^{-3}$	$mg\ N\text{-}NH_4^+ \cdot dm^{-3}$	$mg\ N\text{-}NO_2^- \cdot dm^{-3}$	$mg\ N\text{-}NO_3^- \cdot dm^{-3}$
Quartern.	min.	128.00	70	2.00	4.00	0.02	0.00	0.00	0.00	0.01
	max.	1086.00	670	129.00	1000.00	9.00	1.60	0.86	0.60	18.00
	average	364.03	262	27.78	67.51	1.41	0.20	0.15	0.04	1.44
	class	Ia	Ia	Ia	Ib	II	II	Ib	III	Ib
Tertiary	min.	134.00	45	5.00	10.00	0.10	0.00	0.00	0.00	0.00
	max.	1928.00	965	260.00	373.00	32.00	1.27	2.00	0.17	3.00
	average	537.10	325	54.25	104.93	2.55	0.22	0.24	0.03	0.35
	class	Ib	Ib	Ia	Ib	II	II	Ib	II	Ia

* according to "Classification of fresh groundwater quality for the purposes of monitoring of the environment" [Polish Inspectorate of Environmental Protection 1995].

A great majority of Quaternary water parameters qualified as 1st class (Ia – highest quality, Ib – high quality). Only in terms of iron and manganese concentration the waters should be included in the 2nd class (average quality), whereas with regard to the average concentration of nitrites – in the 3rd class.

Waters of the Tertiary aquifer were of worse quality than Quaternary waters due to dissolved substances (dry residue), general hardness and concentration of chlorides, sulphates, total iron and manganese. In terms of nitrogen compounds the quality of Tertiary waters was clearly higher than the quality of the shallower Quaternary waters, which is obviously due to better insulation from the ground surface.

The general water assessment data correspond with the generally reasonable quality of groundwater, due to its purification need (Fig. 7.10). A great majority of the waters require simple purification, consisting primarily of iron and manganese removal. Water resources requiring complex treatment accounted for less than 10% of total waters and occurred mainly in the surroundings of Wrocław.

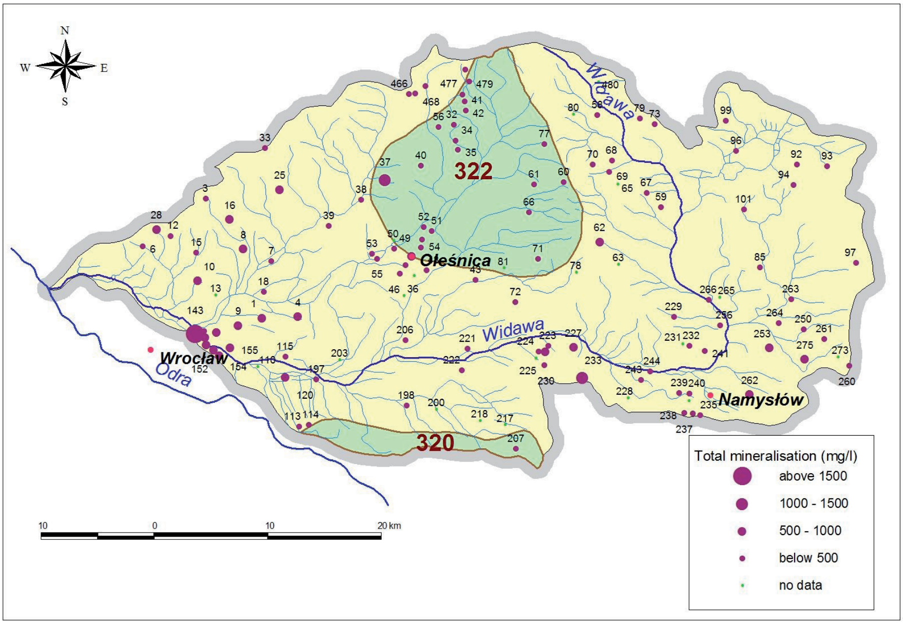


Fig. 7.7. Total mineralisation of exploited groundwaters, based on Hydrogeological Map of Poland of scale 1:200 000, sheets Wrocław and Ostrów Wielkopolski [IG 1986, 1990]

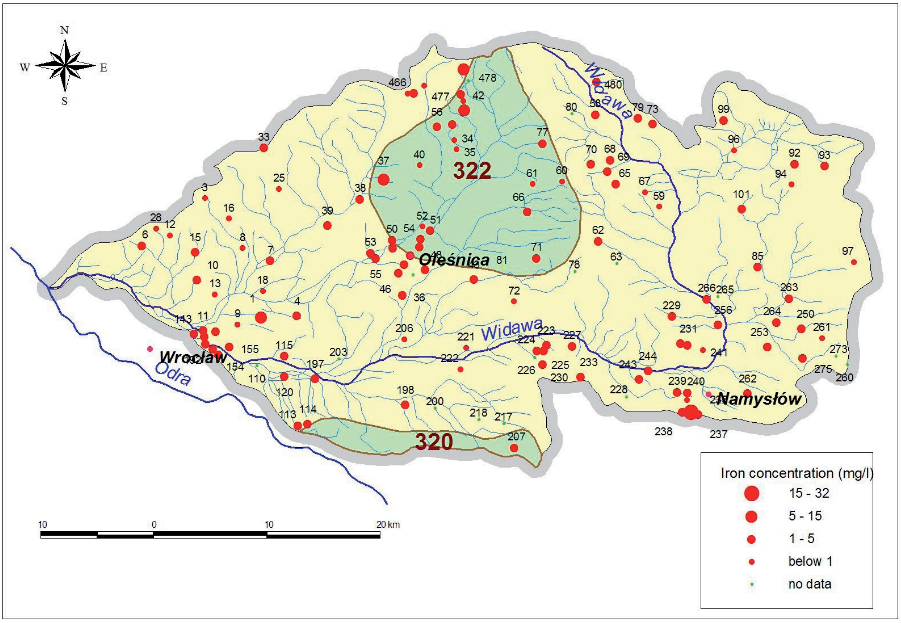


Fig. 7.8. Concentration of total iron in exploited groundwaters, based on Hydrogeological Map of Poland of scale 1:200 000, sheets Wrocław and Ostrów Wielkopolski [IG 1986, 1990]

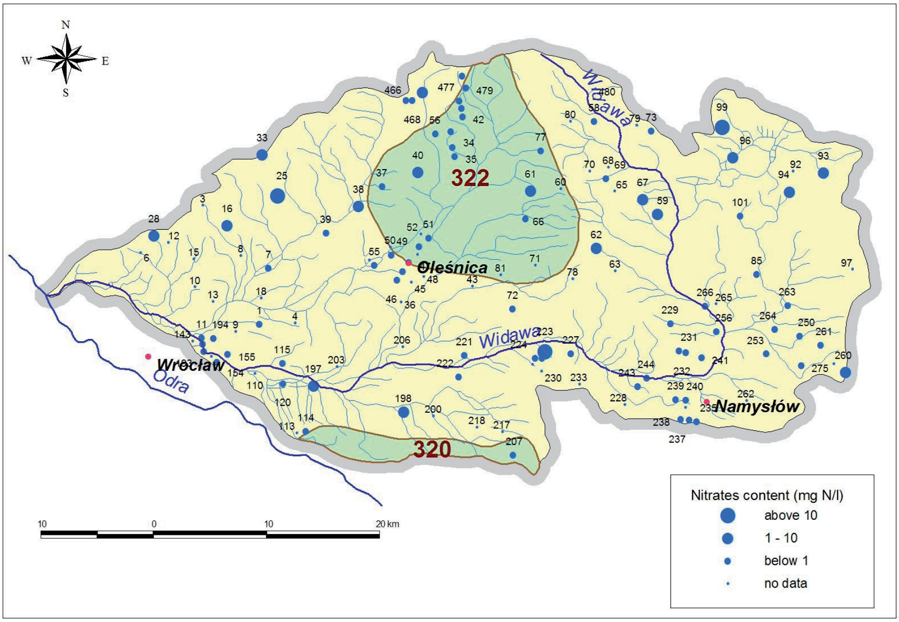


Fig. 7.9. Concentration of nitrates in groundwaters, based on Hydrogeological Map of Poland of scale 1:200 000, sheets Wrocław and Ostrów Wielkopolski [IG 1986, 1990]

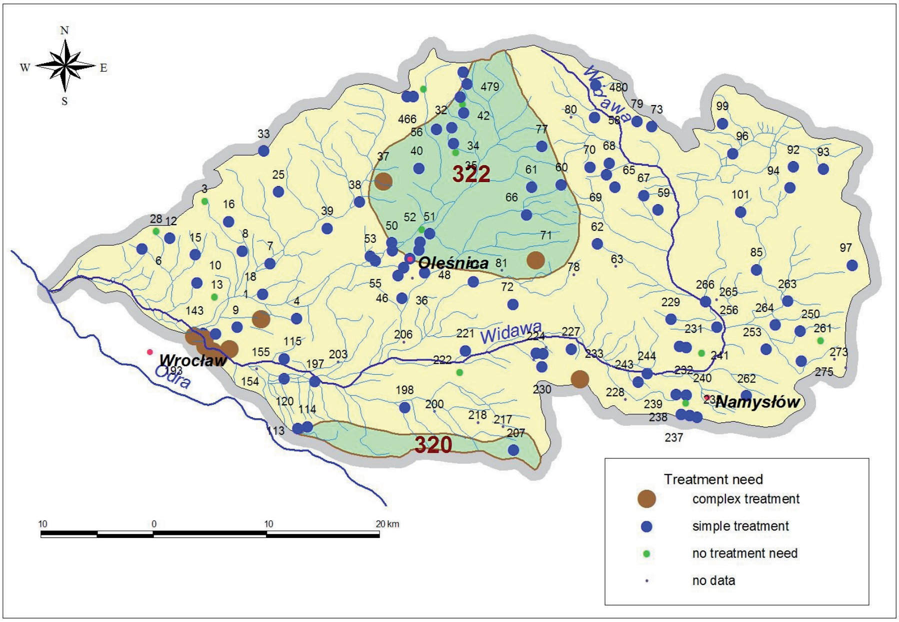


Fig. 7.10. General assessment of groundwaters in terms of treatment needs, based on Hydrogeological Map of Poland of scale 1:200 000, sheets Wrocław and Ostrów Wielkopolski [IG 1986, 1990]

The quality of groundwater in the Widawa catchment after 1990 was assessed on the basis of supervisory surveys published by the Regional Environmental Protection Inspectorate. In 1992–2000 supervisory analyses in the catchment area where performed at only one survey point of the national network – no. 645, in Oleśnica (Figure 5.3). Water in this point was Quaternary, type HCO_3–Ca, and its quality acts as a representative for groundwater of similar type in the entire area of the Main Groundwater Aquifer (MGA (GZWP) 322 – Oleśnica). In the entire period 1992–2000 water qualified to 2[nd] class (average quality, except for 1995 – class Ib). Concentrations of iron and manganese are decisive for the quality of water.

Since 2001 the catchment area was provided with water quality monitoring within a regional network, Surveys of groundwater quality are performed twice a year at three monitoring points (Table 7.3).

Table 7.3. Quality of fresh groundwater at regional monitoring points in 2001 and 2002 (Report WIOS, 2002, 2003)

Period	Monitoring point	Location	Water type	Class of quality*	Parameters in 2nd class	Parameters in 3rd class	Parameters outside classification
1st half 2001	1	Bierutów	HCO_3-SO_4-Ca	III	EC	Mn. Fe	clarity
	7	Smardzów	HCO_3-Ca-Mg	II	PO_4, Mn, Fe	–	–
	8	Sosnówka-Brzezinka	HCO_3-SO_4-Ca	Ib	Mn	–	–
2nd half 2001	1	Bierutów	HCO_3-SO_4-Cl-Ca	III	colour, EC, Mn, K	–	Cd
	7	Smardzów	HCO_3-Ca	II	clarity, PO_4, Mn	–	–
	8	Sosnówka-Brzezinka	HCO_3-SO_4-Ca	Ib	–	–	–
1st half 2002	1	Bierutów	no data	II	EC, Fe	tot. hardn.	–
	7	Smardzów	no data	No data	no data	no data	no data
	8	Sosnówka-Brzezinka	no data	Ib	–	tot. hardn.	–
2nd half 2002	1	Bierutów	HCO_3-SO_4-Ca	II	colour, EC, clarity, Fe	tot. hardn.	–
	7	Smardzów	HCO_3-Ca	II	Ba, PO_4, Mn, Fe	–	–
	8	Sosnówka-Brzezinka	HCO_3-SO_4-Ca	Ib	–	tot. hardn.	–

* according to „Classification of fresh groundwater quality for the purposes of monitoring of the environment" (Polish Inspectorate of Environmental Protection. 1995).

The quality of groundwater at regional monitoring stations does not diverge significantly from the quality of water at the national monitoring point no. 645. However, basides iron and manganese the phosphate ions and high concentration of calcium and magnesium ions in 2002 (causing general hardness of water) are the factors that affect water quality greatly in this area. Besides, also high concentration of cadmium at monitoring station no. 1 in Bierutów in the 2[nd] half of 2001, which however has not recurred in two subseqent surveys.

8. ANTHROPOGENIC IMPACT

Human activity exerts an impact on the natural environment which receives the waste and pollution generated in the course of production and consumption processes. Monitoring of particular elements of this activity is based on parameters expressed with relative and absolute values that act as a clear means of statistical description of a given phenomenon. The parameters constitute a perfect diagnostic and informative instrument, providing information on the current status of the environment, its possible hazards and the progress of works aiming at implementing the principles of sustainable development.

The parameter analysis for the catchment area of Widawa, with consideration of factors such as public utilities, agriculture and industry that exert an impact on the environment, was developed on the basis of statistical data provided by the Main Statistics Office and IMAGIS for the year 2002. The percentage values were determined in relation to total commune area, while the individual ones – to unit area. All the impacting factors were allocated to 5 classes (Tab. 8.1), according to the classification proposed by Nachlik et. al. [2004]. The classes of the anthropogenic impact were ascribed to different colours that indicate the intensity of a particular phenomenon: light blue – very low, blue – low, green – average, yellow – high and red – very high. The adopted boundaries were defined in such a way that the classes cover 10%, 20%, 40%, 60% and 90% of Polish communes, respectively [Czaban, Fiałkiewicz 2006].

The catchment area of Widawa was subdivided into 24 consolidated water bodies. Their unit and percentage rates were defined by means of software provided by the Main Sanitary Inspectorate. Therefore, each catchment area had to be divided between specific communes, whereupon average weighted values of each parameter were calculated for each catchment area. The partial areas of communities belonging to the analysed catchment area act as weights. The index were calculated by using the following formula:

$$WJ_{catchment} = \frac{\sum_{i=1}^{N\,com.} F_i \times WJ_{com.}}{\sum_{i=1}^{N\,com.} F_i}$$

where:
$WJ_{catchment}$ – unit (or percentage) index for the catchment,
F_i – area of commune belonging to the catchment,
$WJ_{com.}$ – unit index for a commune,
$N_{com.}$ – number of communes located within the analysed catchment.

The calculated values of unit and percentage indexes for all the catchment areas are listed in Tables 8.2–8.4 and classified as proposed in Table 8.1.

The characteristic parameters of public utilities are listed in Table 8.2. Population density is medium on 63%, very high on 20%, high on 15% and low on 2% of the catchment area. Water consumption by waterworks is medium on 57% high on 23% and very high on 20% of the catchment area. The part of the population connected to sewage treatment plants is medium on 58%, high on 26%, low on 10% and very high on 6% of the catchment area. The sewage output via sewage system is low on 36%, medium on 34% very low on 14%, very high on 2% of the catchment area, while there is no data for the remaining area. The share of municipalised land is high on 58%, medium on 32% and very high on 10% of the catchment area. The share of population connected to sewage treatment plants is medium on 72%, low on 21% and high on 7% of the catchment area. The ratio of the sewage system length to water supply grid length is medium on 39%, high on 22%, low on 17%, very high on 15% and very low on 7% of the catchment area. The index of granted accommodations per 1 km^2 of the catchment area is low on 45%, medium on 39%, very low on 7%, very high on 6% and high on 3% of the catchment area. The last index, that is the ratio of the number of accommodated tourists to population, is low on 54%, medium on 44% and high on 2% of the catchment area.

As a summary, the share of municipalised land in the catchment area has high and very high indexes in a major part of the catchment area, reaching in total 68%. A rate with low and very low values is the ratio of the number of accommodated tourists to population (Fig. 8.1).

The agriculture and forestry parameters are presented in Table 8.3. The proportion of farmland in the catchment area is medium on 73%, high on 19%, low 7% and very high on 1% of the catchment area. The proportion of arable land is medium on 64%, high on 34% and very high on 2% of the catchment area. The share of orchards is medium on 73%, low on 18% and high on 9% of the catchment area. The share of green lands (meadows and pastures) is medium on 92% and low on 8% of the catchment area. The share of forests and forest land is medium on 71%, high on 16% and low on 13% of the catchment area. The share of protected areas in a commune area is high on 45%, low on 35%, medium on 17% of the catchment area, while there are no data about the remaining area. Water consumption by agriculture and forestry is medium on 63%, very low on 18%, high on 15%, low on 3% of the catchment area, while there are no data about 1% of the area. The artificial fertiliser use rate is generally medium on 63%, high on 36% and very high on 1% of the catchment area. The consumption level of nitrogen fertilisers is medium on 75%, high on 13% and very high on 12% of the catchment area. The consumption of phosphorus fertilizers is medium on 70% and very high on 30% of the catchment area. The consumption of potassium fertilisers is medium on 70%, high on 21% and very high on 9% of the catchment area. Breeding measured in LSU Stock unit is low on 52%, very low on 23%, medium on 18% and high on 7% of the catchment area. Cattle breeding is low on 55%, very low on 29% and medium on 16% of the catchment area. Pig breeding is medium on 75%, high on 12%, very high on 7% and low on 6% of the catchment area. Sheep breeding is medium on 66% and low on 34% of the catchment area. Horse breeding is low on 82%, very low on 12% and medium on 6% of the catchment area. Poultry breeding is high on 59%, medium on 35% and very high on 6% of the catchment area.

Of all the distinctive parameters, agriculture, forestry and poultry breeding per 100 ha of farmland, have high and very high values on a large part of the Widawa catchment area, amounting to 65%. The parameter of low and very low values on a large part of the catchment, amounting to 95% of the area, is horse breeding (Fig. 8.2).

The indexes characteristic for industry are compiled in Table 8.4. Industrial processing is medium on 48%, high on 44%, very high on 6% and low on 2% of the catchment area. Power, gas and water generation and supply is very low on 70%, low on 19% high on 8% and medium on 3% of the catchment area. The rate of building activity is medium on 64%, high on 25%, very high on 9% and low on 2% of the catchment area. Water consumption for national economy is medium on 63%, high on 28%, very high on 6% and low on 3%. Water consumption by industry is very low on 32%, low on 28%, medium on 27%, high on 8% and very high on 6% of the catchment area. Groundwater consumption by industry is medium on 42%, very low on 35%, low on 20% and high on 3% of the catchment area, whereas with regard to surface water it is very low on 30%, medium on 9%, high on 6% of the catchment area, while there are no data about 55% of the catchment area. Industrial sewage disposal is generally medium on 42%, very low on 24%, low on 24%, very high on 6% and high on 4% of the catchment area. Generation of cooling water is very low on 60%, high on 8%, very high on 6% and medium on 1% of the catchment area, while there is no data for 25% of the catchment area. The total amount of discharged sewage (municipal and industrial) requiring further treatment is medium on 70%, high on 24%, very high on 4% and low on 2% of the catchment area. The volume of discharged sewage requiring further treatment and duly treated is medium on 70%, high on 24%, very high on 4% and low on 2% of the catchment area, while the share of non-treated sewage is medium on 72%, low on 24% and very low on 4% of the catchment area. The volume of industrial waste generated yearly per 1 km^2 is very low on 28%, low on 19%, medium on 6% of the catchment area, while there is no data about the remaining 47% of the catchment area. Emission of dust pollution is low on 33%, medium on 26%, very low on 12% of the catchment area, while there are no data about 29% of the catchment area. Emission of fumes is generally low on 37%, very low on 24%, medium on 17%, high on 6%, while there is no data about 16% of the catchment area.

Of the industrial parameters, the food processing activity is represented by high and very high indexes on the the greater part of the Widawa catchment, totalling 50%. The index of low and very low values in the catchment area, amounting to 89% of total surface, is power, gas and water generation and supply (Fig. 8.3).

Table 8.1. Classification of impacting parameters (drivers)

No.	Parameter name	Unit	Class limits					
			very low	low	medium	high	very high	diverging
Public utilities								
1	2	3	4	5	6	7	8	9
1.	Population density	m–$10^3 \cdot km^{-2}$	0–30	31–45	45100	100–550	550–4256	–
2.	Population connected to sewage treatment plants	m–$10^3 \cdot km^{-2}$	0–3.5	3.5–10	10–45	45–700	700–3000	3000–4256
3.	Share of population connected to sewage treatment plants	%	0–7	7–18	18–53	53–92	92–100	–
4.	Water consumption for water-supply	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.015	0.015–0.03	0.03–0.1	0.1–0.75	0.75–5.	5–8.1
5.	Waste disposed with sewage system	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.001	0.001–0.002	0.002–0.005	0.005–0.015	0.015–0.100	0.100–0.195
6.	Relation of sewage system length to water-supply grid length	$km \cdot km^{-1}$	0–0.1	0.1–0.2	0.2–0.8	0.8–2	2–10	10–45.3
7.	Share of municipalised land in the municipality area	%	0–0.3	0.3–1	1.0–3	3.0–10	10–40	40.0–60.8
8.	Number of granted accommodations	$person \cdot km^{-2}$	0–3	3–17	17–150	150–800	800–5000	5000–64624
9.	Relation of the number of accommodated tourists to municipality population	%	0–1.2	1.2–7.5	7.5–35	35–125	125–750	750–2720
Agriculture and forestry								
10.	Share of farmland in total area	%	0–33	33–53	53–73	73–83	83–95	–
11.	Share of arable land in total area	%	0–20	20–37	37–58	58–72	72–93	–
12.	Share of groves in total area	%	0–0.1	0.1–0.2	0.2–1	1–25	25–58	–
13.	Share of green lands (meadows and pastures) in total area	%	0–4.5	4.5–8.5	8.5–16	16–25	25–64	–
14.	Share of forests and forest lands in total area	%	0–5	5–15	15–30	30–50	50–88.5	–
15.	Share of protected areas in total area	%	0–1	1–15	15–55	55–95	95–100	–
16.	Water consumption for agricultural purposes	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.005	0.005–0.03	0.03–0.25	0.25–1	1–5	5–13
17.	Consumption of artificial fertilisers (NPK)	$kg \cdot ha^{-1}$ farm land	0–65	65–75	75–95	95–130	130–132	–
18.	Consumption of artificial fertilisers (N)	$kg \cdot ha^{-1}$ farm land	0–35	35–38	38–56	56–67	67–85	–
19.	Consumption of artificial fertilisers (P_2O_5)	$kg \cdot ha^{-1}$ farm land	0–13	13–17	17–19	19–20	20–31	–
20.	Consumption of artificial fertilisers (K_2O)	$kg \cdot ha^{-1}$ farm land	0–14	14–19	19–24	24–31	31–41	–
21.	Breeding LSU	LSU $units \cdot km^{-2}$	0–17	17–28	28–50	50–66	66–200	200–325

Tabela 8.1 cd.

1	2	3	4	5	6	7	8	9
22.	Cattle breeding	LSU units· 100 ha^{-1} farmland.	0–12	12–21	21–34	34–48	48–100	100–114
23.	Pig breeding	pcs·100 ha^{-1} farmland	0–23	23–46	46–100	100–200	200–1000	1000–1350
24.	Sheep breeding	pcs·100 ha^{-1} farmland	0–0.2	0.2–0.6	0.6–2	2–5	5–150	150–160
25.	Horse breeding	pcs·100 ha^{-1} farmland	0–0.5	0.5–1.0	1.0–2.5	2.5–5	5–300	300–305
26.	Poultry breeding	pcs·100 ha^{-1} farmland	0–150	150–400	400–1200	1200–3000	3000–10000	10000–110700
Industry								
27.	Industrial processing	pcs·km^{-2}	0–0.1	0.1–0.2	0.2–0.8	0.8–5.5	5.5–30	30–73
28.	Power, gas and water generation and supply	pcs·km^{-2}	0–0.006	0.006–0.010	0.010–0.025	0.025–0.125	0.125–0.5	0.5–0.91
29.	Building industry	pcs·km^{-2}	0–0.1	0.1–0.3	0.3–0.8	0.8–5.5	5.5–30	30–70
30.	Water consumption by national economy	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.02	0.02–0.05	0.05–0.2	0.20–1.9	1.9–10	10–615
31.	Water consumption by industry	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.002	0.002–0.010	0.010–0.075	0.075–0.75	0.75–5	5–610
32.	Groundwater consumption by industry	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.002	0.002–0.006	0.006–0.05	0.05–0.35	0.35–1.5	1.5–3.3
33.	Surface water consumption by industry	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.003	0.003–0.015	0.015–0.25	0.25–4	4–20	20–610
34.	Total disposed industrial sewage	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.002	0.002–0.007	0.007–0.085	0.085–1	1–10	10–610
35.	Cooling water		0–0.001	0.001–0.002	0.002–0.035	0.035–0.5	0.5–5	5–610
36.	Sewage (municipal and industrial) requiring further treatment, discharged, total	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.003	0.003–0.01	0.01–0.065	0.065–1.5	1.5–10	10–82
37.	Sewage (municipal and industrial) requiring further treatment, discharged, treated	$dm^3 \cdot s^{-1} \cdot km^{-2}$	0–0.003	0.003–0.01	0.01–0.065	0.065–1.5	1.5–10	10–82
38.	Sewage (municipal and industrial) requiring further treatment, discharged, non-treated	$dm^3 \cdot s^{-1} \cdot km^{-2}$		0.0001–0.001	0.001–0.008	0.008–0.05	0.05–0.5	0.5–10.9
39.	Generated industrial waste	1000 tons ·km^{-2} ·$year^{-1}$	0–0.01	0.01–0.05	0.05–0.7	0.70–3	3–20	20–167
40.	Emission of dust pollution	1000 ton·km^{-2} ·$year^{-1}$	0–0.03	0.03–0.2	0.20–3.5	3.5–9	9–20	20–79
41.	Emission of fumes – total	1000 ton·km^{-2} ·$year^{-1}$	0–3.5	3.5–45	45–1250	1250–5500	5500–25000	25000–100000

Table 8.2. Unit and percentage parameters that characterise municipal management in water bodies in the Widawa catchment

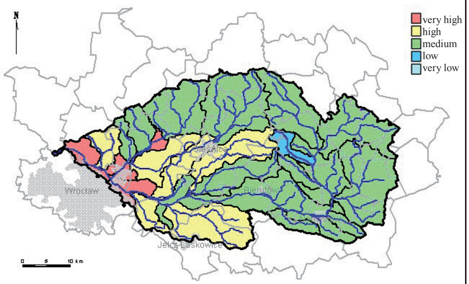
No.	Water body	Population density	Water taken by water--supply network	Population connected to sewage treatment plants	Sewage drained by sewage system	Share of municipalized land in catchment area	Share of population connected to sewage treatment plants	Ratio of sewage system to water-supply grid	Number of accommodations	Ratio of number of tourists accommodated to population
		10^3 persons $\cdot km^{-2}$	$dm^3 \cdot s^{-1} \cdot km^{-2}$	10^3 persons $\cdot km^{-2}$	$dm^3 \cdot s^{-1} \cdot km^{-2}$	%	%	$km \cdot km^{-1}$	persons$\cdot km^{-2}$	%
1.	Widawa to Czarna Widawa	87	0.102	51.6	0.0049	3.37	50.9	0.17	16	5.7
2.	Widawa from Czarna Widawa to Michalice reservoir	69.4	0.076	33.8	0.0012	4.3	40.7	0.25	6	3.2
3.	Widawa. Michalice reservoir	91.3	0.110	57.6	bd	5.33	63.1	0.43	9.9	4.8
4.	Widawa from Michalice reservoir to Oleśnica	69.2	0.066	24.8	0.0023	4.38	29.8	0.64	10.3	6
5.	Widawa from Oleśnica to Dobra	1099.6	2.016	1044.7	bd	19.79	52.3	2.06	1376.7	41.3
6.	Widawa from Dobra to Odra	882.8	1.624	833.4	bd	16.14	47.2	0.75	1091	30.6
7.	Czarna Widawa	59.2	0.06	10.4	0.0045	2.18	19.2	0	9.0	5.8
8.	Miłka	45	0.037	9.8	0.0033	3.08	20.8	0.21	5.1	5.7
9.	Osuch	48.1	0.044	5.6	0.0011	3.29	9.7	0.12	3.4	2.8
10.	Studnica	59.1	0.064	28.6	0.0018	2.55	43.2	0.15	8.2	3.6
11.	Chełszcząca	59.4	0.071	25.5	bd	3.46	27.9	0.26	6.1	3.8
12.	Kraszowska Struga	83	0.097	47.1	0.0001	4.93	52	0.38	8.7	4.5
13.	Smolna	56.9	0.046	15.7	0.0012	3.35	22.4	0.93	19.6	21.9
14.	Świerzna	168.5	0.23	127.5	0.0005	4.94	16.1	1.11	86.9	35
15.	Graniczna	112.3	0.13	76	0.0035	5.48	65.3	0.52	54.3	19.2
16.	Oleśnica to Boguszycki Potok	60.8	0.057	19.1	0.0016	2.83	18.7	1.1	25.3	25.1
17.	Oleśnica from Boguszycki Potok to Widawa	488	0.727	434.5	0.0000	10.29	28.8	2.18	220	21.4
18.	Boundary channel (Kanał Graniczny)	173.8	0.236	116.3	0.0153	9.87	42.1	0.43	138.6	10.8
19.	Dobra to Jagodna	49.8	0.036	5.4	0.0018	2.66	10.8	0.42	2.4	2.1
20.	Dobra from Jagodna to Widawa	820	1.477	757.5	bd	15.27	40.2	2.49	998.8	31.9
21.	Mielnica	95.2	0.092	24.6	bd	3.66	23.7	2.77	19.3	13.2
22.	Topór	104.1	0.102	29.7	0.0001	3.69	8.5	3.11	38.5	14.4
23.	Przyłęk	98.6	0.092	21.8	bd	3.66	15.9	3.17	23.5	10
24.	Rakowski Potok	112.9	0.141	43.6	bd	3.68	13.7	1.75	48.6	3.5

Tabela 8.3. Unit and percentage parameters for agriculture and forestry of specific water bodies in the Widawa catchment

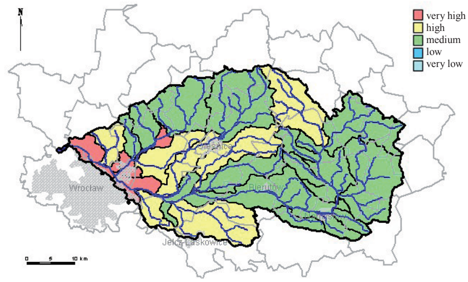
No.	Water body	Share of						Water consumption	Consumption of fertilisers				Breeding					
		farmland	arable land	groves	greenlands	forests and forest lands	protected areas		Total	N	P_2O_5	K_2O	LSU	cattle	pig	sheep	horse	Poultry
		%						$dm^3 \cdot s^{-1} \cdot km^{-2}$	$kg \cdot ha^{-1}$ farmland				pcs·100 ha^{-1} farmland					
1	Widawa to Czarna Widawa	64.2	52.7	0.77	10.7	26.7	3.0	0.063	81.1	39.7	18.6	22.8	22.5	16.5	55.4	1.6	0.9	2541.4
2.	Widawa from Czarna Widawa to Michalice reservoir	71.4	60.6	0.17	10.6	20	23	0	115.9	60.5	22.3	33.1	28.5	16.4	98.6	0.78	0.56	1771.3
3.	Widawa. Michalice reservoir	64.9	53.6	0.18	11.2	26	42.8	bd	132	70.1	24.0	37.9	31.2	16.3	118.3	0.4	0.4	1418.2
4.	Widawa from Michalice reservoir to Oleśnica	73.4	61.9	0.3	11.2	17	9.6	0.099	107.1	55.2	21.4	30.5	25.5	14.9	86.5	0.78	0.59	1646.3
5.	Widawa from Oleśnica to Dobra	56.6	47.7	0.9	8.1	11.1	3	0.423	81.1	39.7	18.6	22.8	13.5	8.8	31.7	1.94	1.56	5755.4
6.	Widawa from Dobra to Odra	53.5	45.8	1.27	6.4	10.3	2.4	0.005	81.1	39.7	18.6	22.8	17	11.1	44.1	1.44	1.43	5016.3
7.	Czarna Widawa	76	60.2	0.29	15.5	15.3	5.7	0.035	103.6	62.8	17.4	23.4	55.9	29.6	211.3	0.32	0.57	938.8
8.	Miłka	72.6	61.9	0.18	10.5	18.9	0.3	0.008	81.1	39.7	18.6	22.8	22.5	16.5	55.4	1.6	0.90	2541.4
9.	Osuch	83.9	74.1	0.21	9.6	8	1.1	0.007	116.3	60.7	22.3	33.3	28.5	16.4	98.9	0.77	0.55	1764
10.	Studnica	64.2	55.1	0.17	9	29	20.9	0.003	118.4	67.9	20.3	30.1	46.9	24.3	180.1	0.25	0.46	1009.7
11.	Chełszcząca	63.3	53.7	0.15	9.4	28.1	47.1	bd	132	70.1	24	37.9	31.2	16.3	118.3	0.4	0.4	1418.2
12.	Kraszowska Struga	69.2	58.1	0.19	10.9	22	33.9	0.005	129.9	68.8	23.8	37.3	30.8	16.3	115.7	0.45	0.42	1464.4
13.	Smolna	69.1	57.6	0.45	11	21.5	0	0.06	84.3	41.6	18.9	23.8	23	16.5	59.4	1.52	0.87	2467.1
14.	Świerzna	66.5	55.9	0.65	9.9	21.1	0	0.033	81.1	39.7	18.6	22.8	22.4	16.4	55.3	1.59	0.9	2521.5
15.	Graniczna	58.9	45.2	0.28	13.4	28.7	0	0.104	81.1	39.7	18.6	22.8	16.2	10.7	46.1	0.48	0.65	717.6
16.	Oleśnica to Boguszycki Potok	57.6	46.9	0.51	10.3	31.6	2.2	0.078	81.1	39.7	18.6	22.8	22.5	16.5	55.4	1.6	0.9	2541.4
17.	Oleśnica from Boguszycki Potok to Widawa	67.1	57.2	0.92	9	14.3	bd	0.418	81.1	39.7	18.6	22.8	18.3	12	52.3	0.99	0.75	1583.3
18.	Boundary Channel (Kanał Graniczny)	63	46.5	0.42	16	18.6	0.2	0.094	81.1	39.7	18.6	22.8	14.2	7.9	48.1	0.52	0.67	1051.8
19.	Dobra to Jagodna	51.1	41.8	0.4	8.9	40.1	0.1	0.137	81.1	39.7	18.6	22.8	21.3	14.9	56.1	1.25	0.84	2146
20.	Dobra from Jagodna to Widawa	60.4	51.1	0.84	8.5	12.8	2.2	0.532	81.1	39.7	18.6	22.8	13.7	8.5	36.6	1.52	1.3	4346.6
21.	Mielnica	70.9	58.9	1.88	10.1	17.2	1.3	0.561	81.1	39.7	18.6	22.8	16.2	9.2	54.3	0.3	0.63	843.7
22.	Topór	68.8	58.7	0.68	9.4	18.5	0	0.649	81.1	39.7	18.6	22.8	15.9	9.6	50.4	0.66	0.67	1107.5
23.	Przyłęk	70.1	59.3	1.25	9.6	16.8	0.6	0.676	81.1	39.7	18.6	22.8	15.3	8.6	51.9	0.36	0.62	793.9
24.	Rakowski Potok	63.3	55	1.18	7.1	14.1	0.1	0.245	81.1	39.7	18.6	22.8	18	10.6	58.7	0.25	0.7	1184

Table 8.4. Unit and percentage parameters for industry of specific water bodies in the Widawa catchment

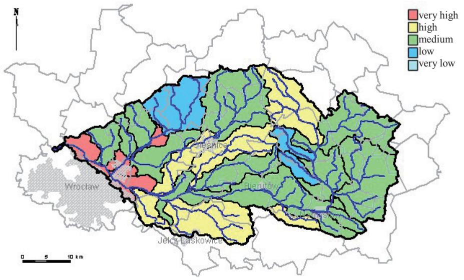
No.	Water body	Industrial processing	Power. gas and water generation and supply	Building industry	Water consumption by		Consumption		Total industrial sewage disposal	Cooling water	Sewage disposal for treatment			Generated industrial waste	Emission	
					National economy	industry	groundwater	surface water			total	treated	non-treated		dust	fume
		pcs·km^{-2}	pcs·km^{-2}	pcs·km^{-2}	dm^3·s^{-1}·km^{-2}		dm^3·s^{-1}·km^{-2}		dm^3·s^{-1}·km^{-2}	dm^3·s^{-1}·km^{-2}	dm^3·s^{-1}·km^{-2}	dm^3·s^{-1}·km^{-2}	dm^3·s^{-1}·km^{-2}	10^3 tonnes·km^{-2}·year^{-1}	ton·km^{-2}·year^{-1}	ton·km^{-2}·year^{-1}
1	Widawa to Czarna Widawa	0.91	0.004	0.62	0.17	0.001	no data	no data	0.001	no data	0.065	0.061	0.004	no data	no data	0
2.	Widawa from Czarna Widawa to Michalice reservoir	0.53	0.004	0.56	0.1	0.021	0.022	0.001	0.017	0.001	0.063	0.06	0.0023	0.02	0.18	42.5
3.	Widawa. Michalice reservoir	0.84	0.007	0.83	0.15	0.037	0.04	0.002	0.03	0.001	0.109	0.107	0.0023	0.04	0.33	79.3
4.	Widawa from Michalice reservoir to Oleśnica	0.51	0.007	0.63	0.18	0.01	0.011	0.000	0.009	0	0.038	0.037	0.0011	0.01	0.07	15.2
5.	Widawa from Oleśnica to Dobra	13.86	0.073	17.18	5.59	3.148	0.041	3.119	3.167	3.062	1.973	1.973	0.0002	0.33	2.75	2460.5
6.	Widawa from Dobra to Odra	11.19	0.057	13.88	4.13	2.498	0.032	2.475	2.513	2.429	1.573	1.57	0.0033	0.26	2.18	1952.8
7.	Czarna Widawa	0.79	0.001	0.41	0.09	0.000	0	bd	0	bd	0.016	0.011	0.0048	bd	bd	bd
8.	Miłka	0.19	0.001	0.24	0.05	0.003	0.003	bd	0.003	bd	0.015	0.012	0.0034	bd	bd	bd
9.	Osuch	0.23	0.001	0.34	0.05	0.002	0.002	0.000	0.001	0	0.008	0.007	0.0009	0	0.01	1.8
10.	Studnica	0.52	0.006	0.45	0.08	0.016	0.017	0.001	0.012	0	0.052	0.05	0.0012	0.02	0.11	25
11.	Chełszcząca	0.45	0.003	0.49	0.1	0.034	0.035	0.001	0.024	0.001	0.059	0.058	0.001	0.04	0.18	35.2
12.	Kraszowska Struga	0.72	0.006	0.74	0.13	0.03	0.032	0.001	0.024	0.001	0.088	0.086	0.0018	0.03	0.26	62.9
13.	Smolna	0.37	0.006	0.45	0.11	0.004	0.005	bd	0.004	0	0.023	0.021	0.0027	bd	bd	bd
14.	Świerzna	1.51	0.006	1.77	0.3	0.037	0.038	bd	0.018	0	0.209	0.205	0.0046	bd	0.25	32.1
15.	Graniczna	0.93	0.01	1.31	0.24	0.002	0.002	bd	0.004	0	0.101	0.1	0.0006	0	0.45	92.3
16.	Oleśnica to Boguszycki Potok	0.81	0	0.40	0.14	0.005	0.006	bd	0.004	bd	0.032	0.029	0.0034	bd	0.01	1.3
17.	Oleśnica from Boguszycki Potok to Widawa	4.69	0.014	5.58	1.26	0.114	0.118	bd	0.051	0.001	0.695	0.692	0.0029	bd	0.88	114.5
18.	Boundary Channel (Kanał Graniczny)	1.92	0.026	2.42	0.58	0.246	0.013	0.234	0.254	0.23	0.198	0.195	0.0032	0.02	0.21	184.6
19.	Dobra to Jagodna	0.44	0	0.45	0.17	0	0	bd	0	0	0.012	0.011	0.0007	bd	bd	0
20.	Dobra from Jagodna to Widawa	10.26	0.054	12.67	4.28	2.276	0.030	2.254	2.29	2.214	1.429	1.429	0.0001	0.24	1.99	1778.8
21.	Mielnica	0.95	0.005	1.01	0.65	0.001	0.001	bd	0.001	0.001	0.038	0.038	0	bd	bd	bd
22.	Topór	1.01	0.005	1.11	0.79	0.043	0.006	0.038	0.042	0.038	0.051	0.050	0.001	0	0.06	32.5
23.	Przyłęk	0.98	0.005	1.06	0.79	0.021	0.002	0.019	0.021	0.02	0.034	0.034	0.0002	0	0.02	15.1
24.	Rakowski Potok	1.27	0.004	1.47	0.49	0.103	0.002	0.102	0.104	0.101	0.078	0.074	0.0037	0.01	0.09	80.5



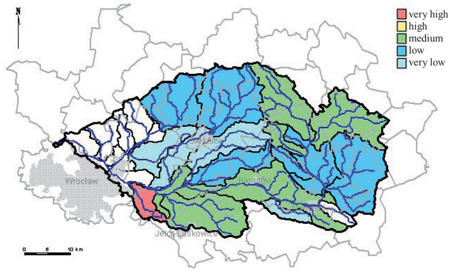
Population density
(person·km^{-2})



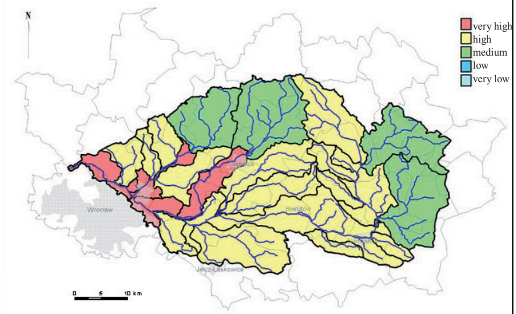
Water consumption by water-supply
(dm^{3}·s^{-1}·km^{-2})



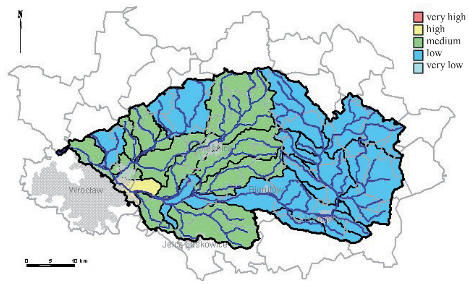
Amount of population connected to sewage
treatment plants (person·km^{-2})



Sewage disposed via sewage system
(dm^{3}·s^{-1}·km^{-2})



Percentage of municipalised land
in the catchment area



Percentage of accommodated tourists
against population

Fig. 8.1. Significant parameters characterizing public utilities management of water bodies in the Widawa catchment

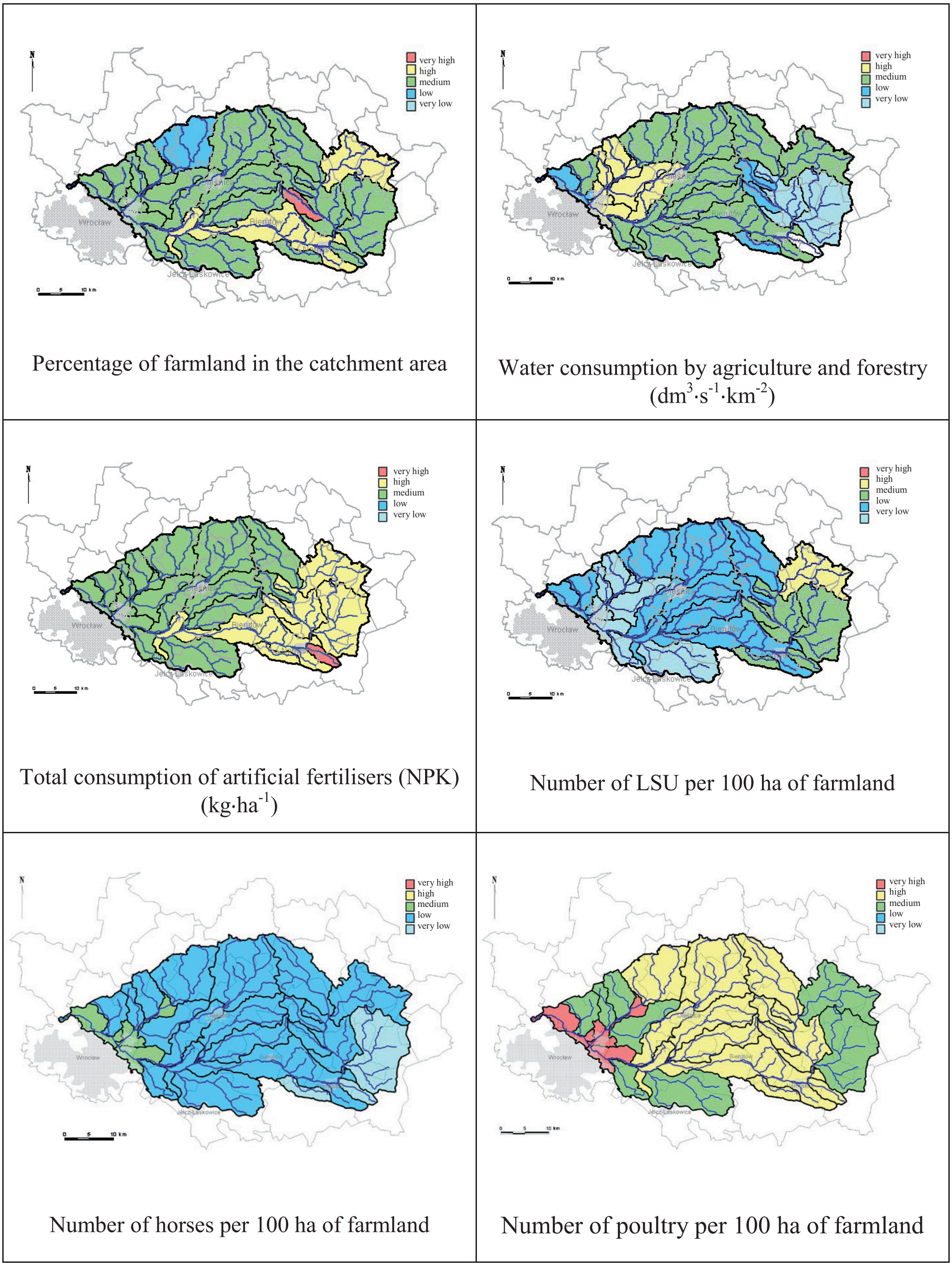


Fig. 8.2. Significant parameters that characterize agriculture and forestry of water bodies in the Widawa catchment

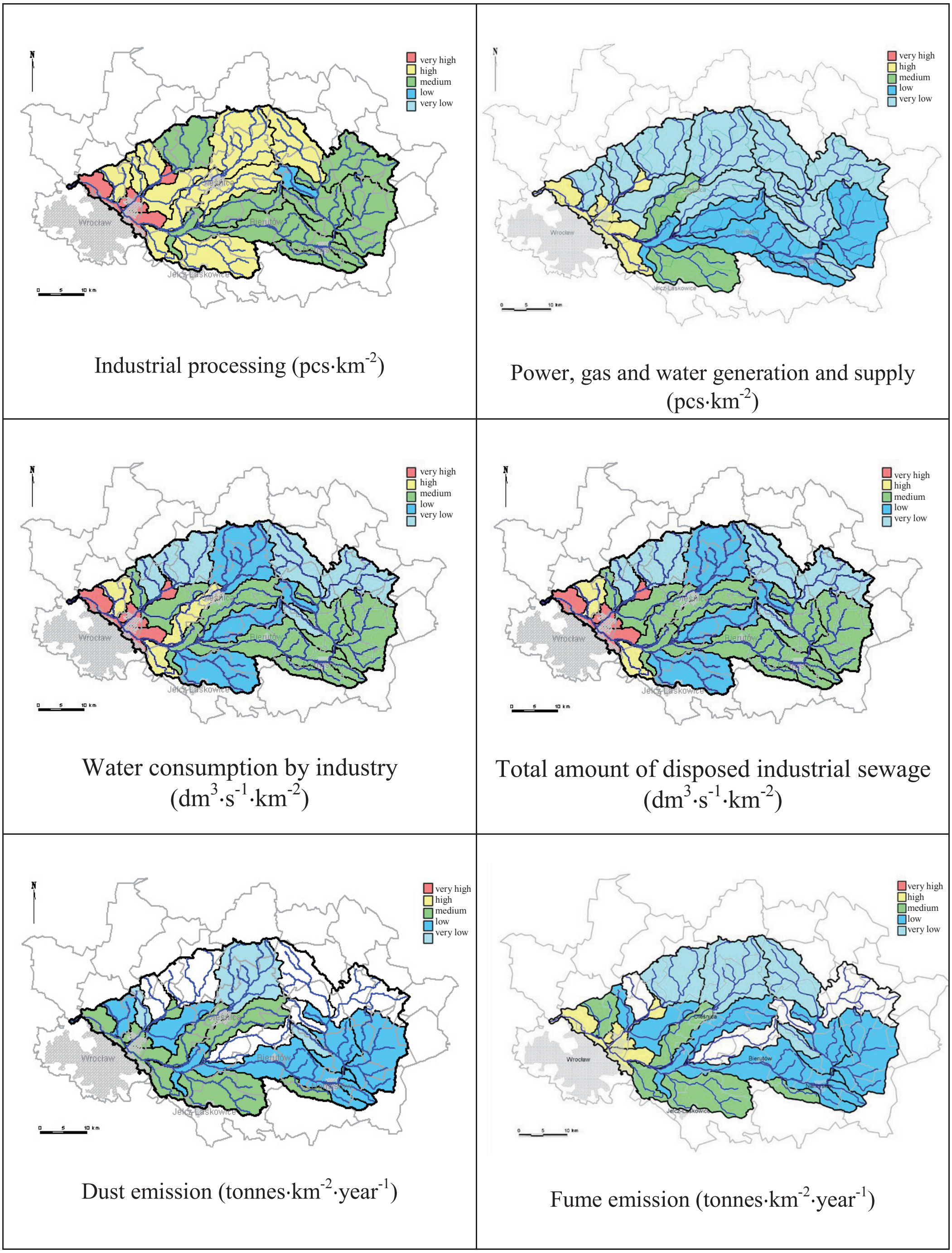


Fig. 8.3. Significant parameter that characterize industry of water bodies in the Widawa catchment

9. SUMMARY AND CONCLUSIONS

On the basis of the performed analysis of water management at the catchment scale, as exemplified by the pilot catchment area of Widawa, it can be stated that:

- ✓ Seasonal use of water resources takes place in agriculture catchment; this pertains to farms, fishing farms, as well as food and agriculture industry. Therefore, the assessment of water resources in these catchments should be performed in short periods – decades or months.
- ✓ The assessment of water resources and water balance calculation should be performed for catchments, where A ≥ 50 km^2, as many facilities located at a far distance from the main stream use the resources of fragmentary catchments. Frequently, the main stream is abundant in water, while water is lacking in catchments which are more intensively engineered or located near to a watershed.
- ✓ The assessment of surface water resources and balance calculations are proposed to be performed on the basis of distinctive years – wet, average and dry. The results obtained in this manner provide an overview of the possibilities of water supplies for consumers and the necessity of water retention.
- ✓ Balance areas and aquifers are often stretched over a number of regions. According to the so-far valid competences and the administration system, data for balance purposes are located at different regional offices and at the National Geological Institute archive in Warsaw. This fact complicates the access to basic data; therefore, creation of databases in the different Regional Water Management Offices which are in charge of water resources within the relevant hydrologic catchment should be accelerated.
- ✓ The Quaternary aquifer is the most accessible, and therefore it is the most frequently used groundwater source. Due to the well-developed hydrographic network, the Quaternary aquifer is densely connected with surface waters. As a result of these connections, occurring in river valleys, the surface water chemistry is changeable, and can locally have higher general mineralisation.
- ✓ The quantitative status of groundwaters in Widawa catchment, determined on the basis of the calculated abstraction volume modules (M_{Qabstr}) and disposable resouces volume modules (M_{Qdispl}) has been recognised as good ($M_{Qabstr} < 0.75\ M_{Qdisp}$). For average conditions ratio $\frac{M_{Qabstr}}{M_{Qdisp}}$ equals 0.22 and for drought periods 0.42.
- ✓ According to the presented analysis of archive materials of 1985 and 2002, the structure of groundwater usage has changed. In 1985 its specification in the pilot catchment was the following: 56% of total Quaternary abstraction was used by municipal services, 40% by food and agriculture facilities and 4% by industrial facilities; whereas

in 2002 – 93% of abstraction was used by public utilities and only 4% by food and agriculture facilities and 3% by industry.

✓ The Stradomia and Michalice reservoirs located in the upper part of the river catchment are of flood-protective and recreation character. They protect the towns and areas below the two reservoirs. They do not essentially affect the water resources and flood flow in the Wrocław Water Network.

✓ For the assessment of water quality it is suggested to use the method of concentrations guaranteed with 90% probability. The S_{90} decyl value is proposed to be determined by means of an appropriate statistical programme, with the use of log-normal distribution, for yearly measurement results. For the 10 year survey period, regardless of the generally high concentrations of certain parameters in Widawa (mainly biogenic elements), the concentrations are decreasing. In spite of this positive trend, the waters of Widawa, Dobra and Oleśnica do not comply to the obligatory standards because of the concentration of nitrite nitrogen. With regard to concentrations of other biogenic compounds, the water of Widawa should be rated 3rd or 2nd class of cleanliness.

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OCENA ANTROPOGENICZNYCH ODDZIAŁYWAŃ NA CZĘŚCI WÓD W ZLEWNI ROLNICZEJ

Streszczenie

Ramowa Dyrektywa Wodna UE obliguje kraje stowarzyszone do osiągnięcia dobrego stanu wód powierzchniowych i podziemnych do 2015 roku. W monografii na przykładzie zlewni rzeki Widawy, reprezentatywnej dla obszaru środkowego dorzecza Odry, przedstawiono stan gospodarki wodnej oraz przegląd oddziaływań antropogenicznych i wynikających z nich skutków dla stanów wód powierzchniowych i podziemnych na obszarze regionu środkowego Nadodrza. Rzeka Widawa jest prawobrzeżnym dopływem Odry. Powierzchnia zlewni wynosi 1716 km^2. Jest ona położona na Nizinie Śląskiej. Obszar zlewni Widawy jest zagospodarowany rolniczo. W uprawach na terenie zlewni dominują zboża – ok. 75 % powierzchni. Ważne miejsce zajmuje hodowla trzody chlewnej, drobiu i ryb. Z tego powodu charakterystyczne jest sezonowe korzystanie z wód powierzchniowych, szczególnie gospodarstw rolnych, gospodarstw rybackich oraz przemysłu rolno-spożywczego. Do oceny oddziaływań wykorzystano bazy danych znajdujące się w różnych jednostkach zajmujących się problematyką wodną. Analiza oddziaływań i ich skutków w zlewni Widawy obejmowała:

- opracowanie numerycznych baz danych współpracujących z GIS,
- charakterystykę poszczególnych części wód,
- ocenę stanu części wód,
- ocenę zasobów wodnych w latach charakterystycznych,
- zalecenia dotyczące gospodarowania wodą,
- identyfikację oddziaływań istotnych,
- wstępne oszacowanie ryzyka nieosiągnięcia celów środowiskowych.