

THE IMPORTANCE OF DAMS FOR INFRASTRUCTURE AND LANDSCAPE CONSERVATION IN SAXONY

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1. INTRODUCTION

The Free State of Saxony belongs to the states of the Federal Republic of Germany, which are characterized by a far-going strong industrialization. The first smaller dams and pond systems originate from the 15. Century, due to water requirements of the mining industry in the Ore-Mountains (Erzgebirge). The history of modern dam construction in Central Europe began with the industrial revolution at the end of the 19. Century.

In particular by the initiative of Professor Intze, dams became a remarkable instrument of water-resources management and man overcame the awe of such "dangerous" hydraulic structures. Today many Intze dams (masonry dams) still witness this epoch in Saxony.

Owing to the good geomorphology for the construction of dams -low mountain ranges in the south and gradually dropping terrain to the low country in the north- dam construction in Saxony continues until nowadays. Due to special regional features, Saxonian dams are particularly used for the supply of drinking-water and flood protection and less for the production of electricity. As a result of the profound structural changes in industry and agriculture since the breaching of the Wall in 1990, dams especially established for industrial and irrigation water use are no longer needed. Touristical issues, as well as nature and landscape protection issues become the focus of attention at these systems today. The development of dam construction and dam operation in Saxony in connection with the acceptance of these structures by society led to the fact that dams have become an indispensable element of the landscape in our country.

This report does not deal with the Saxonian tailings dams.

2. STOCK OF DAMS IN SAXONY

Saxony belongs to the states within the Federal Republic of Germany with most existing dam structures. According to the Saxonian dam register [1], there are 120 storage structures, which meet the national water-legal criteria -building height > 5 m and storage capacity > 100,000 m³ or additional "adopted" systems- (see fig. 1).

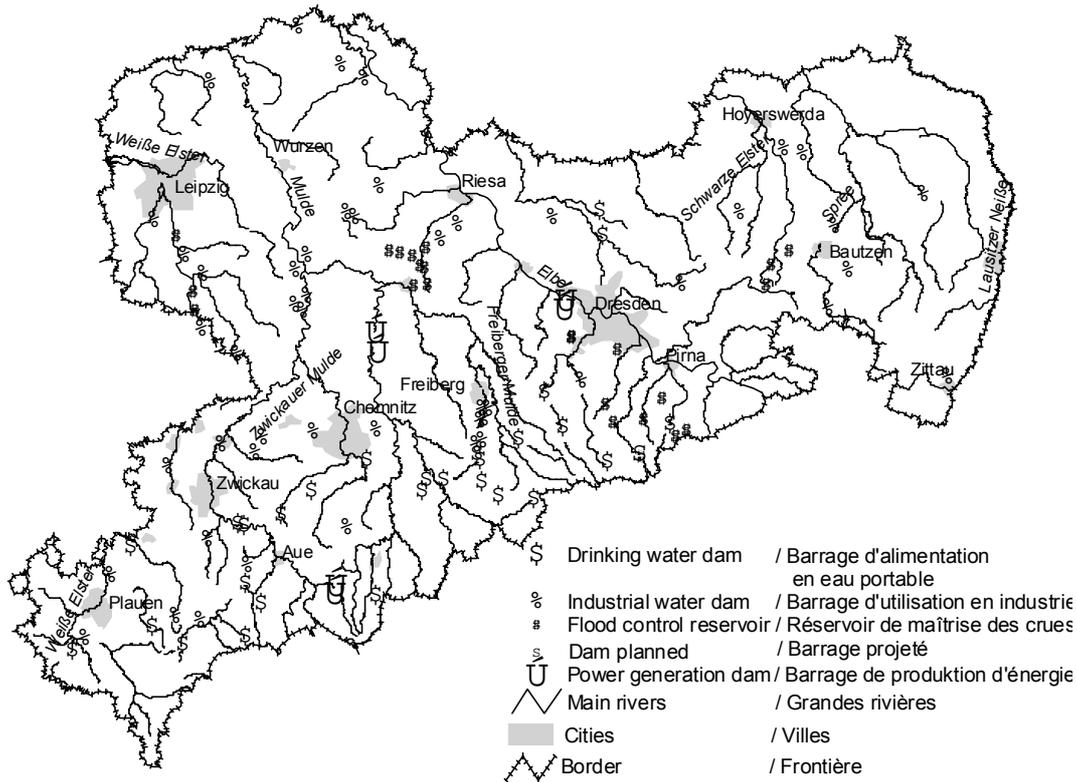


Fig. 1 ©

Overall view of the saxonian dams (without pre-dams)

République de Saxe: vue d'ensemble des barrages (sans barrages en amont)

Among them are six big opencast mining remainder lakes with large water volumes without dam structures, which will be excluded from the following reflections. Consequently there remain 114 dam structures. This corresponds to a „dam density“ of 1 dam/160 km². The ICOLD register [2] contains 43 of them.

Fig. 2 illustrates the temporal emergence of the stock of dams in Saxony from the 15. Century until today. Particularly many installations were built in the years up to World War I, during the time after the world economic crisis up to World War II, during the recovery years after World War II and in the period between 1965 and 1985, when an intensification of a non-resource considerate agriculture and water consumption-intensive industrial development took place in this country.

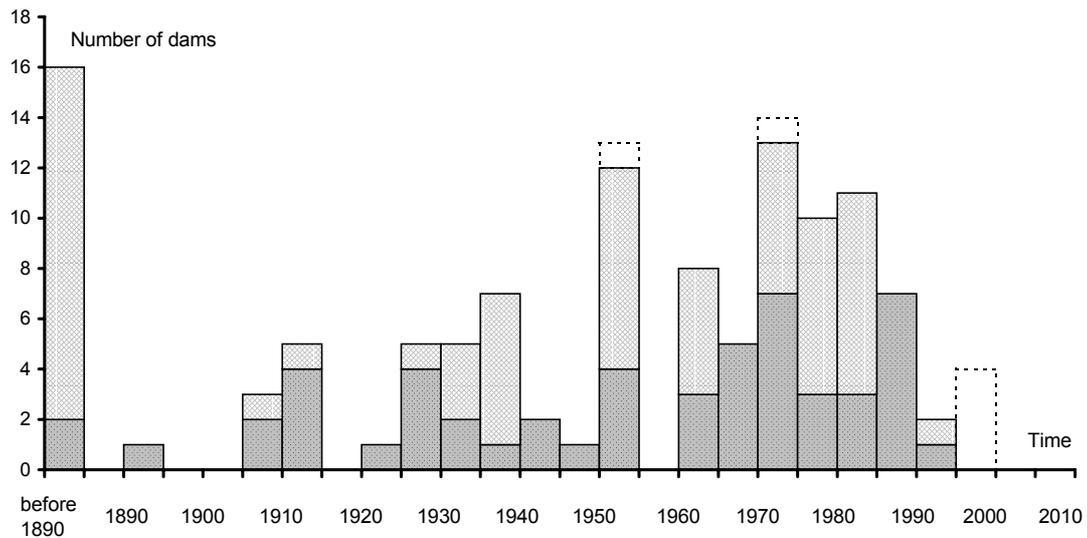


Fig. 2
Years of inauguration of Saxonian dams
Mise en service des barrages saxons

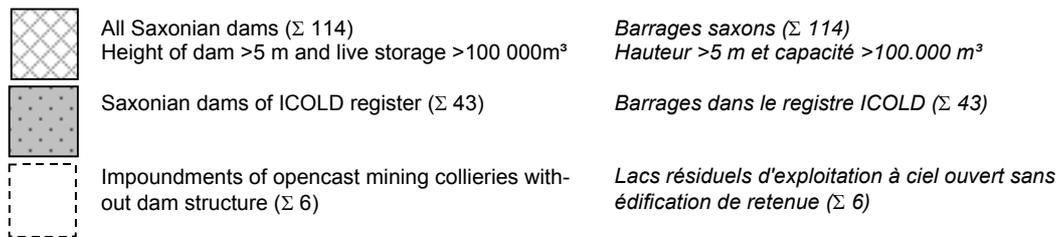


Fig. 3 shows the classification of the Saxonian storage installations according to their barrage structures. One notices that the proportion of fill dams related to all barrage structures (outer circle in fig. 3) is „about average“ with 77%. Yet there is a relatively high proportion of massive dams (44%) amongst the large storage installations (ICOLD register, inner circle in fig. 3).

Massive dams were built exclusively as gravity dams, whereby some of them may be assigned to as arch gravity dams. It is also characteristic that more than half of the gravity dams are masonry dams (i.e. older design). Almost all Saxonian dams built between 1890 and 1930 possess masonry dam structures made of quarrystone. They are characterized by special requirements of adjustment to the current „generally recognized rules of technique“ and decisively determine the rehabilitation events of today. The building of a series of concrete dams between 1960 and 1985 can be defined as the result of a perfected building technology in former East Germany.

Most of the fill dams are dams with an inner soil core (impervious core or inclined impervious zone). Five rockfill dams have an asphaltic concrete facing, two dams possess a concrete core wall and only one large dam is sealed with a synthetic membrane. Some small and old dams were constructed as homogeneous earthfill dams.

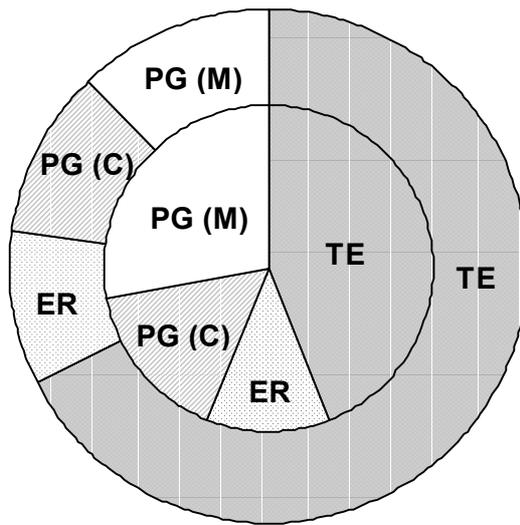


Fig. 3

Division of types of Saxonian dams

Répartition des barrages saxons selon les types d'édification de retenue

TE	Earthfill dam	TE	Barrage en remblaiement
ER	Rockfill dam	ER	Barrage à enrochement
PG	Gravity dam	PG	Barrage de retenue
(C)	Concrete	(C)	Béton
(M)	Masonry	(M)	Mur de soutènement en pierres naturelles

Outer Circle: All dams in Saxony (114)
 Inner Circle: Dams of ICOLD register (43)

Cercle externe: tous les barrages en Saxe (114)
 Cercle interne: barrages dans le registre ICOLD (43)

Fig. 4 and 5 supply an overview of the Saxonian dams and their scale of size.

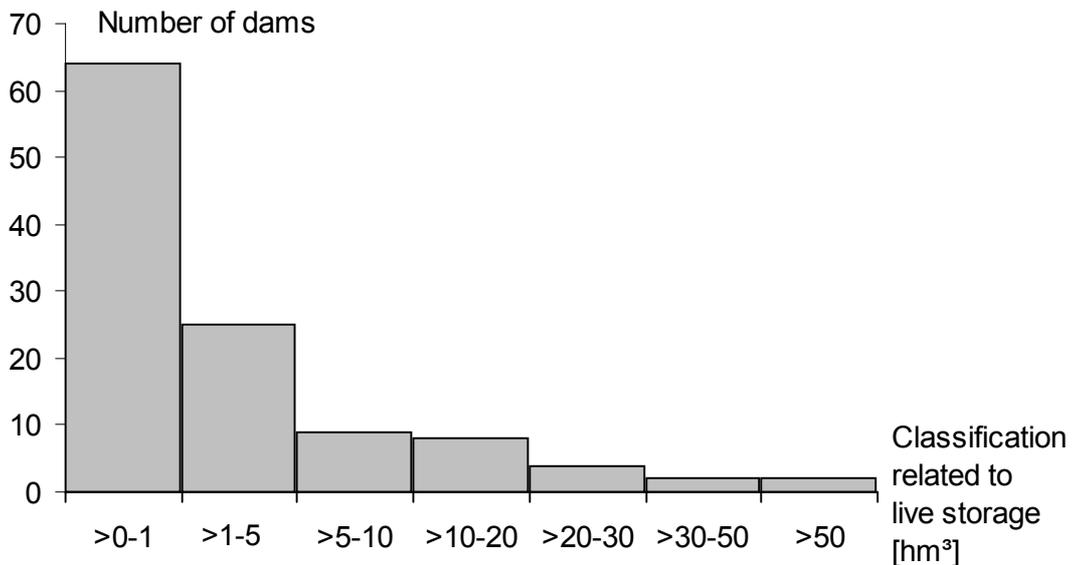


Fig. 4

Division of 114 Saxonian reservoirs related to storage

Vue d'ensemble de la taille du réservoir utilisable de tous les 114 barrages saxons.

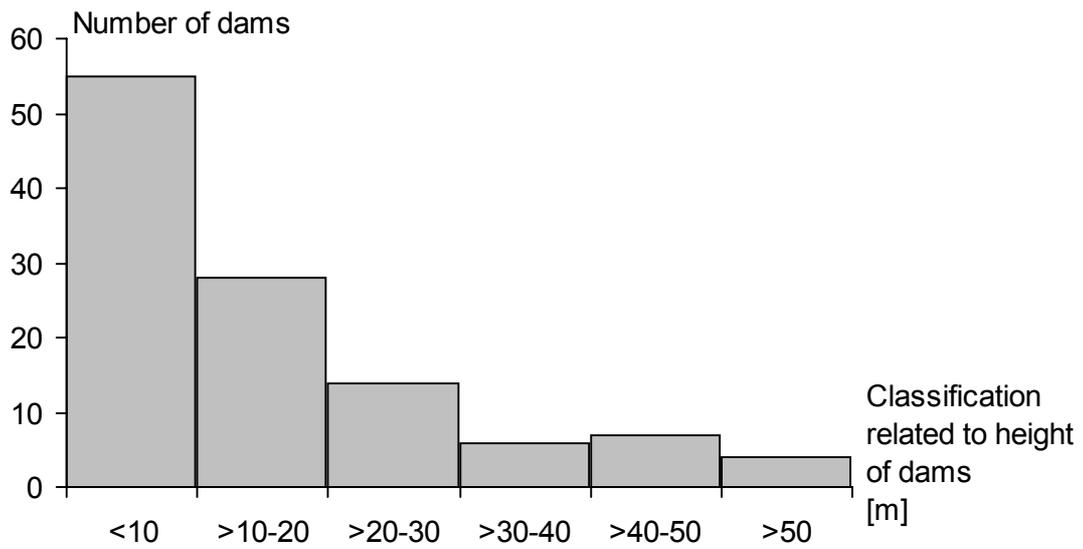


Fig. 5
 Division of 114 Saxonian dams related to height of dams
Hauteur des édifications de retenue de tous les 114 barrages saxons

According to international standards the stock is thus dominated by small storage structures. Nevertheless there are still some structures of remarkable size, of which the Eibenstock reservoir (built in 1984) being the largest shall exemplarily be mentioned (see fig. 6).



Fig. 6
 Drinking water dam Eibenstock
Barrage d'eau potable d'Eibenstock

It has a total storage capacity of approx. 82 hm³. Its concrete gravity dam has a height of approx. 66 m above foundation respectively 57 m above valley elevation [3]. In all other respects the geomorphologic conditions in the Saxonian mountain regions, the dense population in the valleys and the demands for exploitation of the reservoirs determine the order of magnitude of the Saxonian barrage structures. In particular the two last-named aspects determine that many storage structures lie at the upper course of the rivers and streams and thus only dispose of small and humanly relatively little influenced catchment areas.

The 114 classified Saxonian storage structures offer a usable reservoir capacity I_N of altogether approx. 620 hm³. The total of all reservoir surfaces (at full reservoir level) amounts to approx. 105 km². This is only 0,6% of Saxony's total area (18412 km²). On the other hand 35% of the total surface of Saxony are catchment areas for reservoirs. This high percentage results from the very few dams along the lower courses of the rivers (see chapter 4.2) and which however only have a small extension ratio compared to the average yearly flow supply and thus only play a subordinated role within the water management of a river basin but causing sedimentation problems.

It remains to be mentioned in this chapter that the major part of the Saxonian storage structures (72%) are presently in national property due to a water-legal regulation and are maintained and operated by the State dam authority of Saxony - including all drinking-water reservoirs and all supraregional flood-control basins. The remaining storage structures are in the property of municipalities - especially smaller installations of merely local concern- or in the property of private companies - as for example all storage structures, which primarily serve for hydroelectric power production.

3. TYPES OF UTILIZATION OF THE STORAGE STRUCTURES IN SAXONY

3.1 GENERAL STATEMENTS

The main utilizations of Saxonian water storage structures are:

- supply of drinking water for the public
- flood protection by means of providing flood plains
- storage of water for
 - * low-water discharge enhancement for the lower courses of the rivers
 - * supply of industrial water
 - * supply of irrigation water
 - * the production of hydroelectric power.

Tourism respectively recreation are the most substantial side effects of storage structures utilizations. Many structures besides also serve to nature and landscape protection purposes.

Fig. 7 shows the characterization of the Saxonian storage structures according to their predominant types of utilization. Related to all storage structures (outer circle in fig. 7), most of the structures serve to industrial water supply. The vast number of small irrigation reservoirs for the agriculture (which strived for import independence) in the former GDR is determining for this. Reservoirs which supply drinking-water are in second place and flood-control basins are in third place. Only few storage structures were established predominantly for hydroe-

lectric power production or recreational issues. The impression of the utilization form of the Saxonian storage structures mentioned above changes as soon as only the large structures (ICOLD register, inner circle in fig. 3) are considered. By far the majority (47%) serves to supply potable water. Structures for industrial water supply and flood protection are more or less equal with portions of 23% respectively 21%. Only 9% of the structures are hydroelectric power plants.

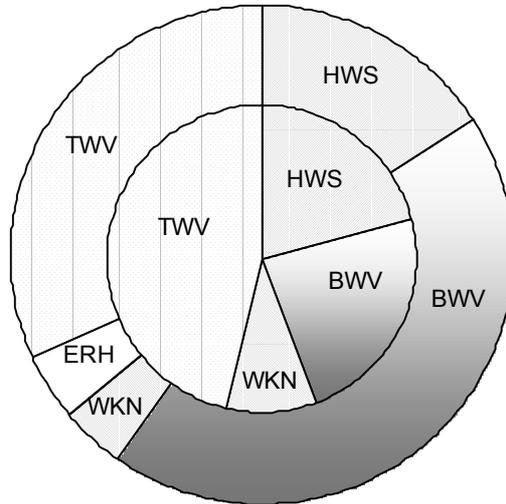


Fig. 7
Division of Saxonian dams related to their main purposes
Barrages saxons selon le type d'utilisation principale

TWV Drinking water supply
HWS Flood control
BWV Other water supply
(industry, agriculture,...)
WKN Use of water power
ERH Recreation, tourism

TWV Alimentation en eau potable
HWS Protection contre les crues
BWV Alimentation en eau
Industrielle
WKN Utilisation force hydraulique
ERH Tourisme

Outer Circle: All dams in Saxony (114)
Inner Circle: Dams of ICOLD register (43)

Cercle externe: tous les barrages saxons (114)
Cercle interne: barrages dans le registre ICOLD (43)

In addition to this it is necessary to mention that there are many multi-functional storage structures among the aforementioned. Many drinking-water and industrial water reservoirs besides serve to flood protection and hydropower production, although often only with small installed capacity in order to cover the needs of the structure itself. Therefore approx. 50% of all, respectively 65% of the ICOLD storage structures serve to flood protection and approx. 15% of all, respectively 33% of the ICOLD storage structures are used for hydropower generation.

The storage capacities specified in fig. 8 are at disposal in order to satisfy the different utilizations. For explanation purposes one needs to point out that the flood storage within the reservoir is assigned to function for the regular flood protection of the lower courses of the river, whereas the flood surcharge above spillway level particularly serves for security reasons for the structure itself. Active storage of the reservoir provides the actual water supply. Inactive storage below active storage may basically not be considered in terms of water manage-

ment. Increasing demands for better water quality in storage structures though require assessing this indispensable buffer storage too, in order to guarantee good water quality (utilization-dependent or due to ecological desires).

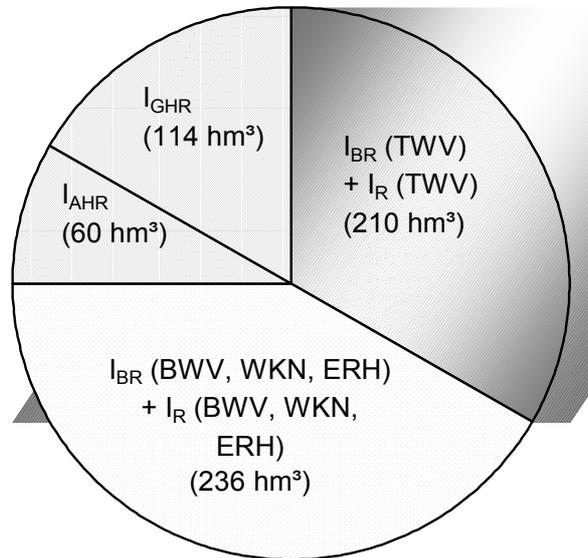


Fig. 8
 Division of storage of Saxonian reservoirs
 (114 reservoirs with 620 hm³)
*Répartition du réservoir utilisable
 tous les 114 barrages saxons avec 620 hm³*

I_{AHR}	Flood surcharge	I_{AHR}	Volume extraordinaire de protection contre les crues
I_{GHR}	Flood storage	I_{GHR}	Volume ordinaire de protection contre les crues
I_{BR}	Active storage (without flood storage)	I_{BR}	Volume d'exploitation
I_R	Inactive storage	I_R	Volume de réserve
1 hm ³	1 000 000 m ³	1 hm ³	1000 000 m ³

3.2 SUPPLY OF DRINKING-WATER FOR THE PUBLIC

In the field of the drinking-water supply, the Saxonian storage structures nowadays fundamentally contribute to a functioning infrastructure. The installations of the 26 drinking-water reservoirs -together with their 10 pre-regulating reservoirs- altogether constantly provide 5500 l/s (170 millions m³/a) of raw water to water purification and distribution plants. Reservoir operation is carried out in a way that supply failure is practically impossible also during extreme dry periods.

The Southern parts of Saxony need to be supplied with surface respectively reservoir water, due to geohydrologic conditions (no productive ground-water supply, predominantly near surface water sources only). At present a population of almost 2 million inhabitants (approx. 40% of the Saxonian population) are supplied with drinking water from reservoirs (see fig. 9). Whereas some areas supplied with reservoir water may also fall back on to other sources (e.g. the city of Dresden), there are also supply areas which are exclusively dependent on reservoir water (e.g. city of Chemnitz).

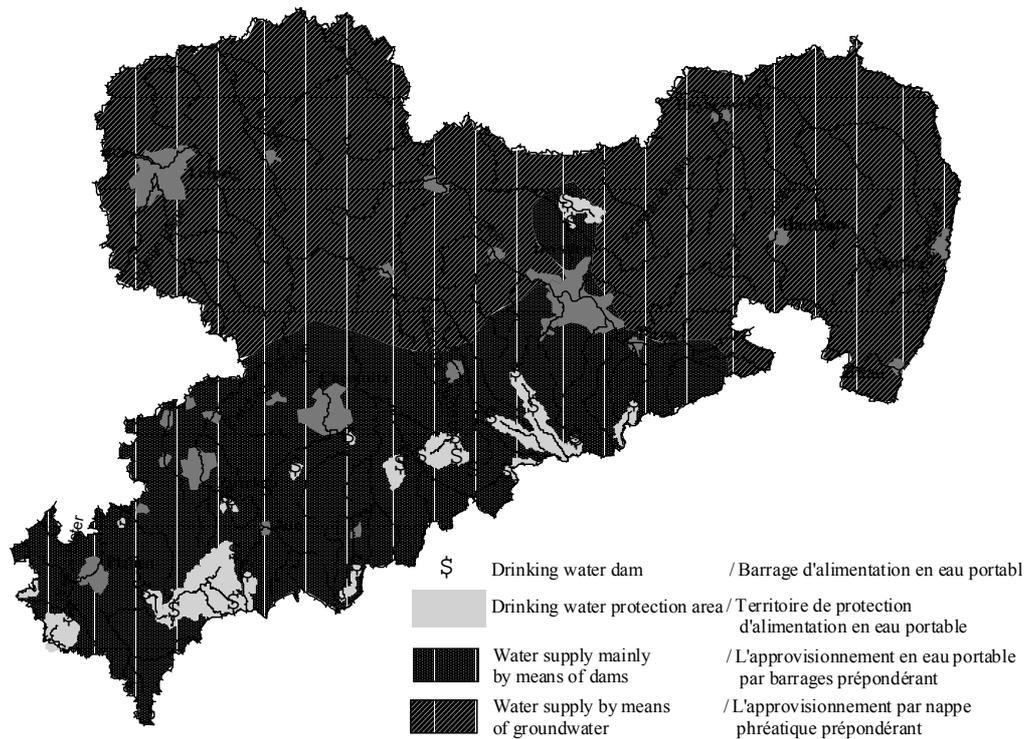


Fig. 9 ©
 Drinking water supply in Saxony
République de Saxe - alimentation publique en eau potable

In Saxony the supply of reservoir water commenced with the completion of the second oldest German masonry dam, the Einsiedel dam, already in 1894. The demand for water rose rapidly with the increase of the urban population and hasty industrial development. The construction of new dams followed inevitably. The need for provision of surplus storage capacity for public drinking-water supply continues -only interrupted by the long-term effects of the two World Wars- to a few years ago. Fig. 10 illustrates this development.

Apart from the increase of water supply capacities, former "supply islands" developed to regional supply networks over the decades. Compound systems of reservoirs developed in the field of raw water as well as supraregional remote water connecting systems in the field of drinking water. Today all subsystems together form two efficient spacious remote water compound systems in Southern Saxony. They will be linked in the near future by a gap-closing pipeline. Arising from this is a compound system of 11 drinking-water reservoirs.

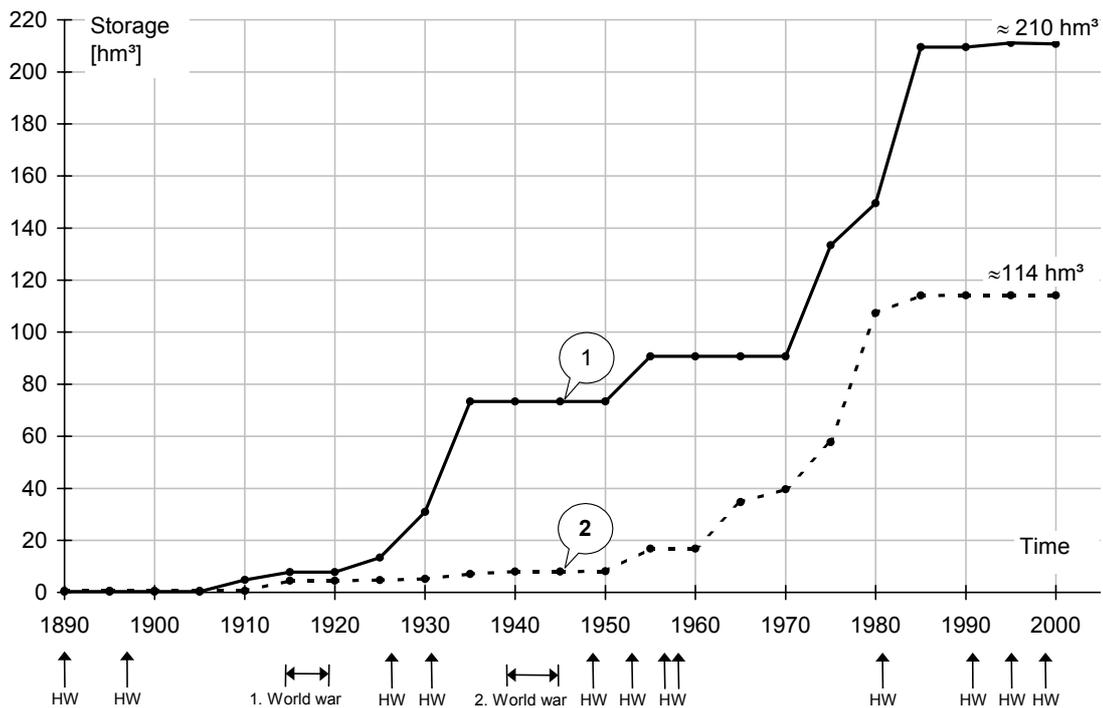


Fig. 10

Cumulative development of storage of Saxonian reservoirs
Développement du volume de retenue cumulé dans les barrages saxons

HW	Extreme flood	HW	Crue
1	Volume of live storage for rough water for drinking water supply ($I_{BR} + I_R$)	1	Volume de retenue ($I_{BR} + I_R$) pour la fourniture d'eau brute pour l'alimentation publique en eau potable
2	Volume of flood storage (I_{GHR})	2	Volume de retenue (I_{GHR}) pour la protection ciblée contre les crues

Fig. 11 schematically shows the aforementioned remote water compound system. The output of the individual dams of this system varies between fewer than 100 l/s and 1600 l/s. The new remote water compound system permits a network operation with following substantial advantages:

- ⇒ Problem-free balance of regional and supraregional supply and/or requirement fluctuations.
- ⇒ Possibilities to control critical situations like technical disasters and in particular also adverse effects to water quality in the field of raw water.
- ⇒ Possibilities to compensate rehabilitation-determined partial or complete failure of technical components within the system, such as dams, purification plants, pumping plants or pipelines.
- ⇒ High degree of supply concerning quantity of water and water quality

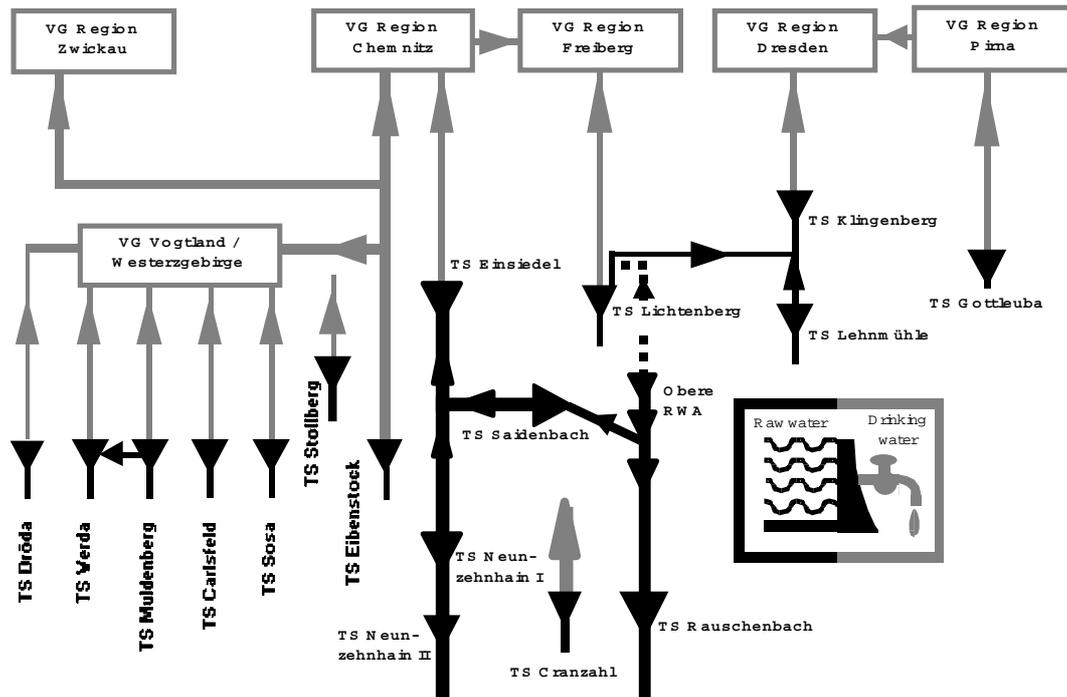


Fig. 11

Interconnected system of drinking water supply by means of dams and reservoirs in southern Saxony

Système mixte d'alimentation en eau des barrages dans le sud de la Saxe

VG supply regions
 TS dam / reservoir
 RWA System of old little dams in the Ore Mountains
 — existing connection
 - - - - - planned connection
 → flow direction

VG Zone d'alimentation
 TS Barrage
 RWA Système de petits barrages anciens dans les monts Métallifères
 — Liaison existante
 - - - - - Liaison prévue
 → Sens du courant

Although the use of surface respectively reservoir water is to be described as sensitive, the production of reservoir water by means of dams proves to be economical. On the one hand reservoir water can still be processed to potable water with relatively simple technologies. On the other hand raw water usually can be transmitted to the water companies by means of natural slope or with small pressures. The water companies themselves are mostly situated in a geodetic altitude, which permits a forwarding of the drinking water without any or with only small energy and thus cost.

In Saxony the national operator succeeds in financing the operation and maintenance of all drinking-water dams with cost-covering prices for the supplied raw water. A payment is demanded from 8 contractually bound customers (water supply companies), whose height depends on the amount of water which is held out for every specific company. As a result of the dams being owned by a single authority, a uniform specific price applies to all dams and customers.

The constantly decreasing water demand in Saxony is a current problem since 1990. Decreasing population, rising water prices, breakdown of industry in addition to the reduction of water losses in pipelines and finally counter produc-

tive water savings propaganda contributed to the fact that drinking-water demand decreased by almost 50%. In connection to this, the extent of utilization of all Saxonian drinking-water reservoirs has sunk from 100% to about 70%. Certainly this does not change the indispensability of almost all Saxonian drinking-water reservoirs. However this puts a considerable strain on the economic situation and gives to think about use modification alterations or shutdowns of smaller dams, especially when regarding the remote water compound system mentioned above.

Finally the infrastructural side effects of the existing drinking-water reservoirs are to be pointed out in this section. They can be explained by the water protection zones proven to guarantee water quality in the reservoirs. They put a heavy strain on population, industry, agriculture and forestry in the catchment areas because of prohibitions and complications, e.g. great demands on waste water disposal and road construction, transport limitations for water-endangering materials, prohibition to use certain herbicides and pesticides as well as fertilizer etc.. High national subsidies for waste water investments and damage compensations to agriculture and forestry however absorb the negative effects. The remunerationless social binding obligation of property is additionally effective. The many restrictions in drinking-water protection zones nevertheless lead to positive effects, such as an environmental infrastructure, agriculture and forestry.

3.3 FLOOD PROTECTION

High population densities and enormous property assets developed throughout the centuries, despite the knowledge about the latent dangers within the original flood plains and natural retention areas of streams and rivers. Thus flood protection demands constantly increased in these areas of Saxony, too.

The streams and rivers of the Ore-Mountains are considered to be particularly flood-endangered because very often weather conditions develop, which lead to extreme rainfall in summer. Precipitation of more than 150 mm in just a few hours and runoff factors of more than $10 \text{ m}^3/\text{s} \cdot \text{km}^2$ have been registered several times, causing devastating floods (1897, 1927, 1954, 1957, 1958, 1995, 1999). The demand for flood protection by means of flood retention in the catchment area, especially after harm-bringing flood events, led to construction of flood-control basins. The diagram in fig. 10 illustrates the creation of flood storage capacity in reservoirs on a time-dependent basis. Besides 18 storage structures established exclusively for flood protection purposes, further 39 multi-purpose storage structures contribute to flood protection. As shown in fig. 8, a total of 114 hm^3 flood storage and further 60 hm^3 of flood surcharge capacity are available today. This amounts to almost 28% of the total storage capacity of all Saxonian storage structures after all.

The flood protection effects, which can be obtained with all individual storage structures for the lower courses of the rivers, are very different. They depend primarily on the absolute amount of retention capacity in the storage structures, but however are decisively limited by the size of the catchment area (flood arising area). In smaller catchment areas ($< \approx 50 \text{ km}^2$) floods with a statistical return interval of 50 to 100 years are fairly easy to restrain, whereas in larger catchment areas this can be merely attained with very large efforts. Fig. 12 illustrates this fact. It shows, to which extent flood retention is carried out in the catchment areas of Saxonian storage structures. Apart from this actual flood retention ability, the obtainable flood protection is considerably dependent upon the performance

of the lower courses. The main targets of flood protection -according to German standards- generally are, to protect high-quality built-up areas against floods with statistical return intervals of 100 years and remaining cultivated areas and supra-regional transportation installations against floods with statistical return intervals of 50 years. The smaller damage potential becomes in the flood areas, the less worthy conservation becomes.

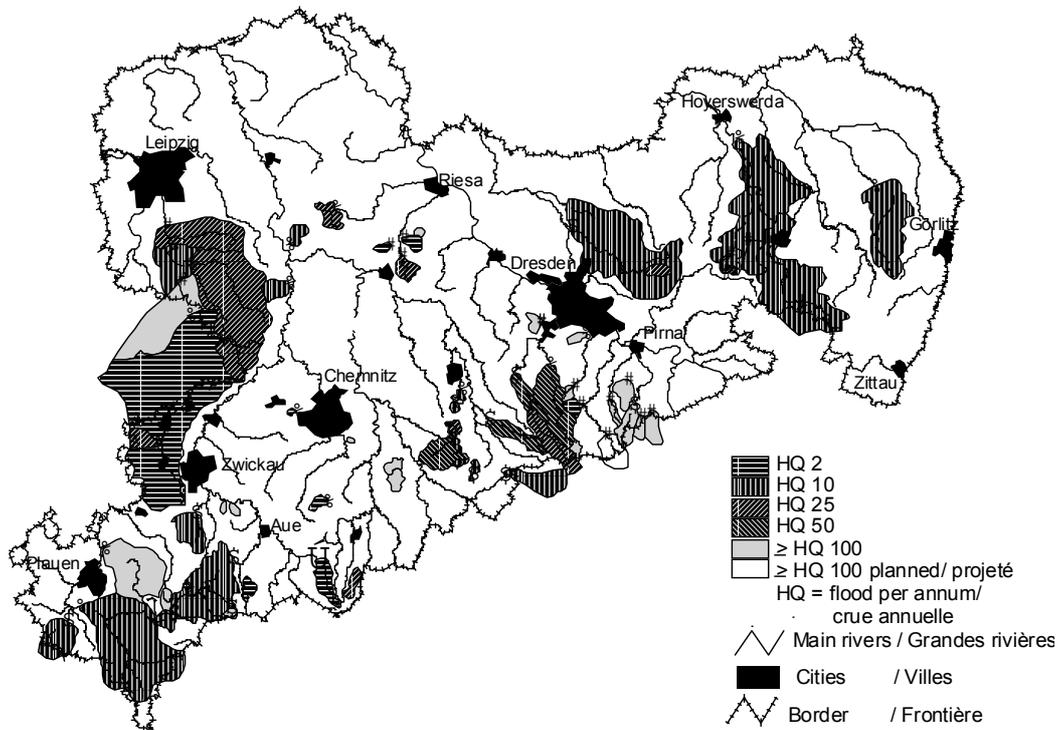


Fig. 12 ©
 Catchment areas with flood retention
Retenue de crues dans les zones à desservir des barrages saxons

In order to guarantee sufficient flood protection, systems of flood-control structures were established in some river basins of Saxony. The structures in the area of Gottleuba, Weißeritz and Müglitz (14 storage structures in the Eastern Ore-Mountains, 1 in planning stage), in the area of Pleiße (8 storage structures south of Leipzig) and in the area of Hoyerswerdaer Schwarzwasser (4 storage structures in the mountain areas of Lausitz) are to be mentioned.

A large number of cities and municipalities is protected effectively against floods with the Saxonian dams and flood-control basins. In particular the large city of Leipzig and the state capital of Dresden participate from them, whereby the large dams in the upper courses of Elbe, Eger and Moldau in the Czech Republic are important for the latter, too. Pirna, Freital, Riesa, Hoyerswerda and Aue in Saxony as well as Elsterberg and Greiz in Thuringia are further protected larger cities.

Since their existence, dams and flood-control basins in Saxony have contributed verifiably towards flood protection. For example it was possible to hold back approx. 10 million m³ once and over 22 million m³ water another time during

two large summer floods in 1995. Large damages were prevented in each case. The multi-purpose reservoir Eibenstock merely held back more than 5 million m³ and was able to reduce the discharge peak from 150 m³/s to 20 m³/s. Dams and flood-control basins remain indispensable for an effective flood protection, even if modern flood protection concepts today particularly place on the reactivation of natural flood plains, renaturalization of rivers and unsealing of built up surface. A balanced mix of all possible flood protection measures can only be the practical solution.

3.4 INDUSTRIAL WATER SUPPLY

3.4.1 *General aspects*

A total of 60 Saxonian water storage structures (14 of them are ICOLD structures) are intended for industrial water supply and for this purpose hold a total of 236 hm³ storage capacity (see fig. 8). The secured constant discharge from these storage structures amounts to almost 10 m³/s (315 million m³/a) water. The industrial water supply serves for the different purposes already mentioned in chapter 3.1.

3.4.2 *Low-water discharge enhancement*

Low-water discharge enhancement in the lower courses of rivers can be necessary for quantitative and qualitative seizure of water intakes from these rivers and/or to guarantee water-ecological demands in dry periods. Both procedures are practised with some larger Saxonian multi-purpose reservoirs, by means of controlling their water discharges depending on the discharges at certain reference flow gauging stations in the lower courses of the rivers.

Low-water discharge enhancement is carried out at the following rivers in Saxony: Weiße Elster, Zwickauer Mulde, Pleiße, Flöha, Große Röder, Spree and Schwarzer Schöps. Due to closure of many production plants at these rivers, the former use-oriented low-water discharge enhancement shifts more towards an ecologically oriented discharge control.

Today mainly fish hatcheries, fishing industry and small hydroelectric power plants benefit from low-water discharge enhancement. Low-water discharge enhancement will however be important throughout the next years for the Spree (Bautzen dam) and its tributary Schwarzer Schöps (Quitzdorf dam) when filling the old collieries in the Niederlausitzer open-cast mining district and for recreation of a balanced, self-adjusting water management from the Spree area to Berlin.

3.4.3 *Water supply for industry and agriculture*

As already mentioned before, far-reaching restructurings in industry and agriculture since the reunification of Germany led to closure of many businesses on the one hand but also to technological renewals on the other. Drastic decreases in demand for industrial and irrigation water are the consequence of these processes in Saxony. Industrial water supply from the state reservoirs decreased from 60 million m³ in 1991 to 14 million m³ in 1998. This shows that many Saxonian storage structures have lost their industrial water supply function

partly or completely today. This is a large nuisance for the authorities or companies who maintain these storage structures, because the expenditures are financially hardly covered by the receipts. This is particularly serious with a whole set of monofunctional systems, where lacking surplus functions at present do not justify further dam operation. The owners often intend to sell the dams in these cases and in general there are chances that maintenance and dam operation are gradually reduced to a safetyendangering degree. Even the State itself is no exception from this.

Since nature and population have practically taken possession of these more or less no longer necessary storage structures over the years and because these systems have also become natural sanctuaries and recreational centres, the expensive decommissioning or removal of these storage structures with complete or partial demolition of the constructions and latter renaturalization does not seem to be a suitable solution of the problem (see chapter 4.2).

Worth considering are cases, where the circumstances justify a new utilization for purposes like ecologically oriented low-water discharge enhancement or flood protection. Since these are sovereign duties according to local laws, it requires the willingness of the community to finance these duties. Experience has shown that delayed action with such decisions makes it substantially more difficult and sometimes politically impossible to reactivate reservoir management (raising and lowering of the reservoir level), because population and nature are accustomed to the constantly filled reservoir and reservoir falls in particular are disadvantageous for them.

3.4.4 Use of hydroelectric power

Contrary to many other countries, the production of hydroelectric power is not the focal point of dam operation in Saxony. Only 6 registered storage structures were exclusively established for this purpose [1]. However 5 of these hydroelectric power plants belonging to private companies are worth mentioning because of their special features:

- Kriebstein dam at the Zschopau river was put into operation in 1930 with an installed capacity of approx. 5 MW as run-of-river power station. Kriebstein dam is one of the oldest cast concrete dams.
- The pumped-storage plant Niederwartha with upper and lower basin near the city of Dresden achieved a power output of 80 MW after construction in 1929/30 and 120 MW after renovation in 1960. After inauguration it was the largest power station of its kind at that time.
- The pumped-storage plant Markersbach went into operation with a power output of 1050 MW in 1979. Even today it is still the largest hydro-power plant in Eastern Germany. The difference in altitude of the upper and lower basin is approx. 285 meters.

Electric power is currently being produced by hydro power plants at 13 Saxonian multipurpose storage structures [1]. Both river and industrial water discharges are energetically used. In total the capacity installed at these storage structures only amounts to 5,2 MW with an average yearly production of 20 GWh. The produced electricity primarily serves to cover the domestic requirements of the storage structures and only secondly to external power supply.

Except for the pumped-storage plants which produce peaktime electricity, the hydroelectric power plants in Saxony are almost negligibly important for power supply. For private operators the generation of hydroelectric power is interesting though, particularly due to legal obligations to take delivery of the produced power at excessive prices.

4. ENVIRONMENTAL RELEVANCE OF STORAGE STRUCTURES IN SAXONY

4.1 STARTING POSITION

Storage structures are a substantial interference in nature and landscape as well as in settlement, economical and infrastructural structures of the area concerned. This was obviously exactly the same at the time, when the Saxonian storage structures were established.

The interruption of the river continuum system and thus the disturbance of a (to a large extent) naturally grown ecosystem surely was the most substantial interference in the ecological system.

In many cases roads, supply lines (power, gas, water, telephone), farms and mills and in some cases even railway lines and also cemeteries had to be transferred. Settlements and industrial plants were usually also affected with large storage structures, so that substitutional housebuilding was necessary and industrial estates needed to be created. Whereas the demolition area was normally equal to the reservoir area, the demolition area usually needed to be extended to the so-called „drinking-water protection area I“ with drinking-water reservoirs. According to rough estimations, altogether about 3500 people had to be resettled (an average of about 30 people per storage structure) in the past because of storage structure constructions in Saxony (114 dams). About 600 people were affected by the resettlement in the most unfavourable case (drinking-water reservoir Lichtenberg).

In this connection one needs to explain that democracy did not really exist at the times when the Saxonian storage structures were licensed and licensing procedures under public law did not allow public participation and contradiction possibilities up to legal action. Therefore construction of storage structures was relatively simple at that time. However there were many economic problems, which are not to be dealt with in this connection.

On the basis of the existence of Saxonian storage structures, the question now is to be answered, how their „relation“ to the environment developed in the course of the time?

4.2 ASSESSMENT OF THE IMPACTS ON ENVIRONMENT

It is to be stated at first that the substitutional investments including the re-settlements in direct connection to the establishment of the storage structures led to no long-term effects of social relevance, which naturally does not exclude certain difficulties in isolated cases. At this point the reader shall again be reminded of the former political circumstances already mentioned before. In the long run these direct consequences were however assumed by the people involved.

The hazard potential emerging from the storage structures is no object of public discussion in Saxony so far. However there has been no failure of a dam or a flood-control basin yet. Beyond that people probably acknowledge that everything has been done (planning, construction) and is being done (operation, maintenance, monitoring) for the safety of the dams. The authors are aware of this.

Specific consequential problems result in the case of drinking-water reservoirs from the (lawfully assessed) drinking-water protection areas. The total area of the drinking-water protection areas for all Saxonian drinking-water reservoirs amounts to approximately 645 km². This is 3,4% of the complete surface of Saxony. The protection areas are usually divided into three different zones, to which different regulations and restrictions apply (see also chapter 3.2). In protection zone I (water intake zone) practically all actions are forbidden, which might be a potential danger to the water condition. Thus the water surfaces and reservoir banks of all Saxonian drinking-water reservoirs are a taboo with recreation (swimming, windsurfing, boat rides). Years after the assessment of drinking-water protection areas, the restrictions still lead to arguments with the affected people. Political pressure is often produced, in order to loosen these restrictions. Considering the increasing demands on reservoir water quality by the water supply businesses, preventive drinking-water protection according to the multi-barrier principle may however not be given up.

Apart from the unpopular effects of drinking-water protection areas, they inevitably also cause positive synergetic effects regarding the general objective to achieve and protect good water quality in the reservoirs and to limit human influences in the catchment areas to a permissible degree. At this point there is a congruence with interests of nature and landscape protection.

With reference to the interruption of the river continuum systems it is a relatively favourable fact that the most of Saxonian storage structures lie at the upper courses of the rivers. The percentage distribution of the expansions of the catchment areas may illustrate this. Approx. 60% of all Saxonian reservoirs possess catchment areas <25 km²; related to 100 km² the share is almost 80%. Less than 1% of all reservoirs have an own catchment area >1000 km². Therefore the interrupted rivers can further naturally develop downstream of the dam on the major part of their original courses thanks to the position of the dams at their upper courses in many cases (if other man made disturbances don't prevent it). The storage structures can often considered to be a „new spring“ of the river supported by the compulsory water outlet of the dam.

Regarding the interferences in the ecosystem with the construction of storage structures and the subsequent "counterreactions" or better "adjustments" of nature, one can basically observe that new ecological systems have developed at the reservoirs within just a few years, which are typical for still waters and in detail are determined by the respective local conditions (climate, altitude, basin morphology, water quality, storage management etc..). In very many cases conditions have thereby adjusted, which -according to current nature conservation laws- are to be classified as „worth protecting“. It is very important to know that reservoirs thereby determine or at least enrich the character of landscapes.

On closer examination approx. 70% of the 114 Saxonian storage structures are summarily connected with protection areas according to nature conservation laws. Just looking at the 43 large ICOLD structures even almost 90% are connected! 64 reservoirs are situated in 35 landscape protection areas. The assessment of almost half of the landscape protection areas goes back to the ex-

istence of the reservoirs. Nature reserves are located at 14 reservoirs, among them 3 flora-fauna-habitat-areas (FFH guideline 92/43/EWG) and 3 Special Protected Areas (SPA guideline 79/409/EWG). 16 reservoirs are situated in the nature park Erzgebirge/Vogtland and 2 in the planned nature park Dübener Heide. Moreover several so-called „nature-area-monuments“ and protected biotopes are to be found at a number of storage structures. Fig. 13 tries to visualize these facts.

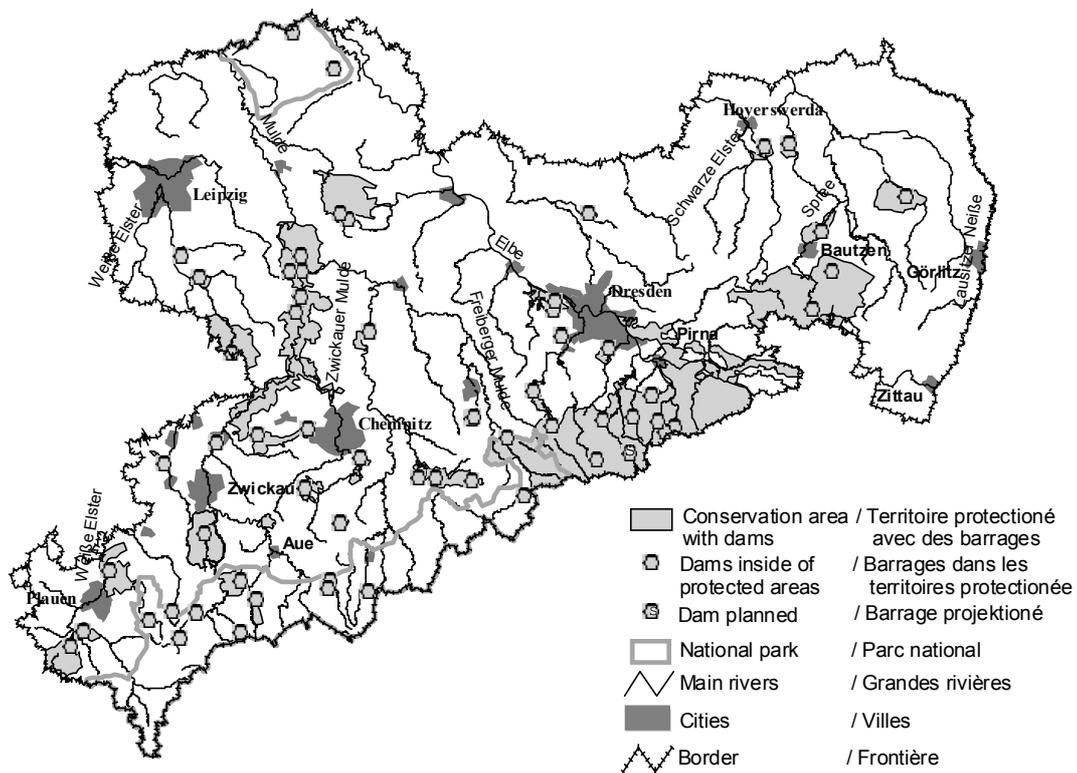


Fig. 13 ©
Dams in protected areas
Barrages en zones protégées

The Saxonian nature conservation law stipulates that all actions are forbidden, which could spoil the character of the protection areas [5]. Landscape and nature benefits are thereby included. From that point of view Saxonian storage structures are often certified to be successfully and inseparably integrated into Saxonian man-made landscape. The good integration of storage structures into their natural environment is furthermore substantiated by the fact that increasing demands are made on water quantity and water quality management of reservoirs according to conservational interests. It even occurs that competitive interests of nature conservation clash with each other. Wherever possible one seeks for solutions that satisfy all demands for utilization of storage structures. The causal and remaining functions of water management may thereby however not fall by the wayside.

A quite different aspect is that a set of storage structures considerably influenced both the technical and the cultural development of Saxony. Thus almost

20 old storage structures are listed today and are furthermore defined as cultural monuments. In particular some old masonry dams belong to them as well as the so-called „Revierwasserlaufanstalt Freiberg“, an ancient system of artificial ponds, ditches and tunnels which supplied the ore mining industry with industrial water.

At the end of this chapter the importance of the Saxonian storage structures for recreation and tourism is to be briefly examined. Despite from just a few acidic reservoirs in the upper Ore-Mountains, all reservoirs are used for fishing and therefore are popular fishing waters. That also applies to a limited amount of drinking-water reservoirs. An active water sports utilization is another side effect at many reservoirs. Ten very popular reservoirs for tourists received the official status of a „EU swimming lake“. This means that the reservoirs have been registered with the European Union and have to meet the water quality standards of the EU. But swimming, windsurfing and boating is popular at other reservoirs, too. Pleasure steamers operate on two reservoirs. As already mentioned in chapter 3.4.3, touristic utilizations have meanwhile become the main utilizations at some reservoirs. Finally the recreation value, which definitely is available at drinking-water reservoirs, is to be mentioned. Because of their location in an interesting countryside, they meet the requirements for a so-called "gentle tourism“.

4.3 FINAL EVALUATION

When summarizing the role of Saxonian storage structures in terms of land conservation, one must state that they are no disturbing elements in nature or landscape, despite the interferences certainly connected with their construction. On the contrary: the environment is obviously able to integrate storage structures into itself far better than often claimed. Nevertheless storage structures should not necessarily be built to a larger extent than absolute necessary. From today's point of view the one or the other smaller storage structure was built too much in the past in Saxony, due to the former political and economic circumstances. However that does not alter the fact that the Saxonian storage structures have become a constituent part of the Saxonian landscape.

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SUMMARY

Construction and operation of dams have a long tradition in Saxony and reaches back to the 15. Century. The construction of 114 dams and reservoirs ($H > 5$ m and $V > 100,000$ m³) in Saxony is connected to the constantly rising demand of water since the beginning of the industrial revolution at the end of the 19. Century until the 80's of this Century. 43 of these dams are filed in the ICOLD register. Today substantial infrastructure functions are fulfilled with storage structures in Saxony, for the benefit of the population and in conformity with long-term environment conservation targets.

The existing reservoirs in Saxony are assigned to:

- provide raw water for the drinking-water supply of almost 2 million inhabitants in Saxony (about 40% of the population)
- provide flood-control storage capacity of 114 hm³ (flood storage) and approx. 60 hm³ (flood surcharge) in flood-control basins and multi-functional reservoirs in order to protect the lower courses of the river
- supply industrial water for different purposes, as for example low-water discharge enhancement in the lower courses during dry periods and the provision of water for industry and agriculture
- produce hydro power
- provide utilizations for tourism (the multi-purpose reservoirs above all)
- protect water quality and conserve nature by assigning drinking-water protection areas at drinking-water reservoirs as well as protecting further banks and water surfaces in landscape protection and conservation areas.

Some of the old dams in Saxony are cultural monuments and therefore listed as well as protected.

In summary it may be said that the Saxonian storage structures have become indispensable elements of infrastructure and constituents of the Saxonian landscape. However re-organizations as well as decommissioning or removal of storage structures are being discussed in some cases, due to drastically decreasing demands for water in all supply areas since the reunification of Germany.

RESUME

La construction et l'exploitation de barrages ont, dans la République de Saxe, une longue tradition qui remonte au 15^{ème} siècle. La construction de 114 barrages (Hauteur >5 m et capacité >100.000 m³) en Saxe est liée au besoin croissant en eau depuis le début de la révolution industrielle, de la fin du 19^{ème} siècle jusqu'aux années 80 du 20^{ème} siècle. 43 de ces barrages sont enregistrés dans le registre CIGB. Aujourd'hui, les barrages saxons remplissent des tâches essentielles d'infrastructure au profit de la population et en harmonie avec les objectifs durables de protection de l'environnement.

Les barrages sont utilisés en Saxe pour les tâches suivantes:

- Mise à disposition d'eau brute pour l'alimentation publique en eau potable de près de 2 millions d'habitants en Saxe, ce qui représente environ 40% de la population.
- Fourniture de 114 hm³ de volume ordinaire et env. 60 hm³ de volume extraordinaire de protection contre les crues dans des réservoirs de protection contre les crues et barrages à usage multifonctionnel au service de la protection contre les crues des populations en aval.
- Mise à la disposition d'eau non potable pour différentes utilisations, comme l'élévation du niveau des basses eaux dans les cours inférieurs dans les périodes de sécheresse et la fourniture d'eau à l'industrie et à l'agriculture.
- Production d'énergie électrique tirée de la force hydraulique.
- Utilisation touristique surtout des barrages d'eau industrielle.
- Mise en oeuvre de tâches de protection des eaux et de la nature par l'identification des régions de protection d'eau potable avec les barrages d'eau potable ainsi que la protection d'autres surfaces de berge et d'eau dans des régions de protection de l'environnement et de la nature.

Quelques-uns des barrages saxons sont classés monuments historiques.

En résumé, on peut constater que les barrages saxons sont devenus des éléments indispensables de l'infrastructure et un élément à part entière du paysage de la Saxe. D'autre part, dans quelques cas, la restructuration voir la mise hors service des barrages est à l'ordre du jour en raison des besoins en eau qui ont considérablement diminués dans toutes les zones d'alimentation depuis la réunification allemande.