INTERNATIONAL COURT OF JUSTICE

CASE

CONCERNING THE GABCIKOVO-NAGYMAROS

PROJECT

(HUNGARY/SLOVAKIA)

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I. Executive Summary and Recommendations

The Hungarian Academy of Sciences established a Working Committee to review the situation of research and planning in relation to the agricultural and environmental impacts of the Gabcikovo-Nagymaros Barrage System (GNBS), to evaluate the work completed so far and to specify the further tasks.

During its six-month operation, the Working Committee reviewed the plans and research results prepared in relation to the agricultural and environmental impacts of the GNBS, listened to the opinions of the competent professional and political representatives of the affected areas, studied the local water conditions and formed its opinion by using experience from abroad as well.

In order to compile its report, the Working Committee reviewed the major engineering and economic issues of the implementation of GNBS in necessary depth and gathered information on the economic and political precedents of the project. It assessed the bases and the situation of technical planning, reviewed the results achieved through scientific research as well as the relation of the HAS to the work related to the Barrage System. The Working Committee was continuously gathering information on the situation of project implementation.

The Working Committee studied the scientific foundation of the planning in detail and found that the planning and research work had been organised in a uniform and co-ordinated manner -- in co-operation with the competent Czechoslovak authorities and in consideration of the views of invited Soviet experts. The research, although not showing the same depth on several occasion, met the policies necessary for the implementation of the GNBS. The results of the preparatory work and research carried out for several years during the preparations not only served the development of the plans of the Barrage System, but provided results that could be used also by scholars of other fields of science and provided a basis for the plans of other facilities as well.

Research related to the GNBS is presently also ongoing and may provide utilisable results in particular in the fields of environmental development, as well as agricultural and forestry development.

During its investigations, the Working Committee gave high priority to the issues of land use and agricultural development. It found that the development plans of the state farms located on the affected area did not yet deal with the impacts related to the GNBS. Besides considering the major factors during the ongoing plan preparatory work, the harmonisation of certain details is necessary to achieve a more favourable development. The Working Committee considers it necessary that the recultivation of the temporarily used areas still take place during the period of construction.

The Working Committee found that the plans of GNBS treated the changes in the condition of groundwater as a central environmental problem and, accordingly, they dealt with the issues of the stabilisation of groundwater conditions in the affected region, striving to prevent any damage to the present situation anywhere or, where it was possible, to promote the development of more favourable conditions. A concept based on the most recent research results can be attributed to this effort: by means of an infiltration system, it makes matching the water table to the demand of agriculture and forest management in Szigetköz possible. The method also allows the regulation of the groundwater level to the desired extent.

The Working Committee also studied the groundwater conditions in the depressions and noticed that, based on the necessary study results, appropriate plans had been prepared to protect the depressions and to ensure that the groundwater can be regulated to attain favourable levels.

The Working Committee reviewed the trends in the condition of karstic waters in the adjacent areas - primarily in the area of the Nagymaros Barrage - as well as the changes that could result from the GNBS and their consequences. It found that the Barrage System did not affect the mining activities and did not have an impact on the karstic water resources during the period of either construction or operation.

The Working Committee investigated in detail the issue of water quality as well. It found that the pollution level of the Danube had been deteriorating even in terms of several quality components over the years recent to the investigation. It found that the implementation of the Barrage System did not represent a pollution source in itself, it did not have adverse impacts on the further trends in water quality, but it considered it necessary to insist more on the construction of sewage treatment plants as far as possible, in particular, along the Danube reach upstream from Nagymaros. Furthermore, it considers it reasonable to carry out further studies on the location and extent of expected siltation to prepare the waterworks along the impounded area at Nagymaros.

The Working Committee studied both separately and together the factors shaping the natural environment and related to the GNBS. It considered the research bases appropriate in terms of land and water conservation. With respect to the protection of air quality, it did not find any deficiency worth mentioning. It considered the expected condition of the biota to be resolvable within the scope of the presently prepared surveys and development plans. It found that landscape and nature conservation as well as the development interests of the built environment could be reconciled with the Barrage System.

The Working Committee separately investigated the issue of the survival of the lowland forests, as well as the opinions on the replenishment of ecologically sound water into the old bed of the Danube. In terms of both problems, it found that the level of exploration of the issue was satisfactory. The issue of lowland forests affecting local forest management interests is favourably resolved in part by the infiltration system to be developed within the framework of the new conception and in part by the behaviour of the water body becoming stable through the grading of the branches.

The Working Committee considers it necessary to carry out further studies to assert the optimum for the national economy over and above the interests of companies and sectors. Within this framework, however, the issues of land use, agroecological potential as well as the development of the environment should be examined extending to a larger area, with a regional character. An appropriate basis is provided for the studies by the series of research carried out on the Barrage System and its implementation.

In the view of the Working Committee, an integrated synthesis of agricultural and environmental concerns and the alternative consideration of environmental impacts arising from the implementation of the Barrage System from the aspects of land use are necessary.

A considerable part of the data needed for this are available or can be explored - with appropriate research and development work - within a relatively short period of time. At the same time, the Working

Committee considers it advisable to maintain continuously the relevant sections of the plan of the GNBS and to adjust them to the demand for and results of development.

In the opinion of the Working Committee, the wide scope of the issues studied with respect to the implementation of the GNBS as well as the complexity and international context of relationships would make it necessary to work out regional development plans covering a larger area that are to be initiated by the sectors making use of it, and to fit them into a comprehensive system to make these utilisable in the most favourable way; to think within the task placed into the scope of the duties of HAS; and to organise research.

The Working Committee considers it important that the general public have appropriate information on the impacts of the Barrage System, the state of its implementation, and also on the settlement of related issues that are independent from the GNBS (but connected to it by the public). The most suitable bases for disseminating information of such nature could be, besides the educational organisations, the competent organs of the Patriotic Popular Front as well as the local Councils.

In summary, the Working Committee points out that

1. The preparation for the Gabcikovo Nagymaros Barrage System took place at such level that it can be unambiguously ascertained that there are no reasons from agricultural and environmental aspects precluding or questioning its implementation;

2. it is necessary to work out a chapter on agriculture and environmental regulation - mostly on the existing data base - as an integrated part of the planning documentation of the implementation of the GNBS;

3. fitting further research related principally to utilisation and operation into a comprehensive system is necessary and possible.

Annex 2

PRESIDENCY OF THE HUNGARIAN ACADEMY OF SCIENCE, POSITION PAPER CONCERNING THE SCIENTIFICALLY DEBATED QUESTIONS OF THE GABCIKOVO-NAGYMAROS BARRAGE SYSTEM, 20 DECEMBER 1983

The scientifically debated questions related to the construction of the Gabcikovo-Nagymaros Barrage System (GNBS) can be classified into four groups:

1. political,
2. technical, agricultural, hydraulic construction and transport,
3. economic,
4. environmental and regional planning problems.

This classification is rather arbitrary, but it correlates the most closely related factors. Undoubtedly the four problem groups are eventually in interaction with each other. As far as the details are concerned the Presidency of the Hungarian Academy of Sciences did not want to deal with the details of materials discussed earlier and it did not have the intention of analysing again the standpoints stated clearly in these materials. But he considers it its task to draw attention in his report to the activities related to the scientifically debated questions of the GNBS.

The standpoints of the Presidency:

- should be further analysed using scientific thoroughness and
- are directed to the factors for implementation after the decisions have been made.

The present standpoint of the Presidency does not deal with the political questions which might occur in the above mentioned classifications, because it was not authorised, however the Presidency notes, that the analysis of this topic - which it deemed to be necessary, - has not yet came to its notice.

The Presidency forms its position giving consideration to:

- the earlier inter-governmental agreements concerning this matter might limit the possibilities of making decisions,
- the fact also has to be taken into account that the general danger to the environment, especially the groundwater, surface waters, and the decline in the quality of soils shows a worse tendency than predicted ,
- because of the critical world economic situation the priorities of the country have to be reconsidered radically in other fields as well.

The Presidency forming its standpoints takes into consideration the documents that raise questions to be answered, because the clarification of these questions prior to the supposed construction steps of the GNBS is justified, necessary and possible. These can be summarised as follows:

1. The contractual plan did not take into consideration in detail the ecological impacts and consequences of the GNBS. (This job was done upon the request of the SPC (Scientific Political Committee) only in 1982, when the general secretary of the Hungarian Academy of Sciences with the contribution of experts prepared an analysis .) No survey has been prepared to date , where technical, ecological, economic and related risk issues are analysed within one system and with a view to their interactions.

2. According to the examinations carried out so far the real or supposed environmental damage coming from the GNBS construction can be decreased with a great probability or can be avoided with the help of further investments that are not or only partly in the joint investment budget. The prevention of the environmental damage - if they are caused by the GNBS project and represent not only the interest of one party - can not be considered a task that exclusively financially burdens the party where investment,

necessary for prevention, has to be made. All the necessary collateral investments have to be taken into account too and in many cases they have to be implemented prior to the basic construction. Considering these facts the following requirements have to be satisfied by further research, planning and construction activities:

a/ The pollution of the Danube water and changes in the biological conditions must not endanger, not even in the long term, the drinking water supply - based mainly on a bank filtered system - of the region and Budapest. For this reason the waste water of the catchment area has to be also biologically purified, prior to the putting into operation of the Dunakiliti-Hrusovo reservoir.

b/ The agricultural and forestry productivity of the region and the possibility for its enlargement have to be preserved.

c/ The regional planning benefits especially the recreational possibilities arising from the big scale construction provided options which have to be utilised.

d/ The biological degradation of the old Danube water - and its tributaries - has to be avoided and the characteristics worthy of a boundary river have to be ensured providing, at the same time, continuous operational conditions for a well designed navigational route .

3. In order to fulfil the set of requirements mentioned in point 2. a comprehensive environmental impact assessment has to be prepared within two years. In this the whole effect mechanism of the GNBS and its environmental elements has to be analysed, and, with this , the technically and economically favourable solutions have to be found which entirely enforce the regional approach. On the basis of this study an economic evaluation including all environmental impact has to be prepared. The study has to be carried out in co-operation with the relevant Czechoslovak institutions.

4. A comprehensive environmental monitoring system has to be developed along the Danube stretch mentioned - as in the case of Lake Balaton - which is capable of continual observation for changes in the environmental conditions with special regard to the forecasting of modifications related to the drinking water supply.

5. In support of the suggested environmental impact assessments certain research has to be started with special dispatch. These are first of all:

- the elaboration of the methodological directives and contents of environmental impact studies,
- examination of the expected hydrobiological changes in the Dunakiliti reservoir,
- the delineation of the nature conservation area serving for the preservation of the present ecosystem and the analysis of its protection conditions,
- analysis of the environmental and energy management impacts of the peak operation of the GNBS with special regard to the changed circumstances,
- a survey of the agricultural productivity of the GNBS impact area and preparation of lithological, pedological, soil moisture balance and geomorphological maps,
- the groundwater control, and analysis of the impacts on the agriculture and forestry caused by the ´in situ´ infiltration system and its utilisation,
- analysis of the biological, pedological and technical questions concerning the repeated inundation of the forests in the flood plain,
- an overhaul analysis of regional planning possibilities arising from the large scale investment of the GNBS.

These examinations have to be planned and executed where the necessary intellectual resources and experiences are available and the research costs need to be ensured .

6. On the basis of the experiences brought by the planning of the GNBS, the modification of Resolution 34/1974./VIII.6./CM[1] and Joint Resolution 3/1974./VIII.6./ NP-FM[2] on its enforcement is advisable. The modification would generally mean, that the environmental impact assessments should be done - as an integral part of the decision making - together with the planning of every productive investment in the future.

(The 1-6 points are practically equal with the Resolution of the Council of National Environment and Nature Protection made on 21.06.1983)

7. The investment has to be analysed from the point of view of the situation, the capability and possibility of the participating national economy so a total cost/benefit analysis needs to be completed.

a/ The further portion of the planned expenditure would not be made profitable by national navigation while agriculture and flood protection would likely produce a greater benefit faster and with much less investment.

b/ The interests of navigation would get more attention if the navigation route - as a theoretical possibility - were completed with harbours, loading machines and in addition a clarification of our possibilities for access to the Rhine - Main - Danube system and seaports .

c/ The 30 billion Forints to be borne by the Hungarian party calculated by the planners in the investment proposal of the GNBS - which merely because of price changes, would be increased significantly during the project construction - does not contain the unmentioned but unavoidable installation costs (such as the regulation of the Old-Danube, purification of the waste water of the region, etc.) which have the same order of magnitude. It is doubted that such an amount, considering the tight investment resources, can be spent on a barrage system which will optimally provide electricity only in 1993.

8. It is unavoidable to analyse the GNBS construction from a macro economic point of view with scientific accuracy. Points in this analysis could be the following:

a/ In the longer terms the Hungarian economy needs to carry on an economic policy based on re-establishment of balance and ensuring the solvency of the country.

b/ This policy has to be implemented in a globally very sophisticated world economic situation which is especially difficult for Hungary. As a consequence of this, the main economic policy objectives are the increase in the marketable and economic export capacities and the rational import replacement, namely those which influence directly the export import relations.

c/ Because an increasing part of our national income will leave the country over the coming decades (debt payment, exchange rate depreciation also in the socialist foreign trade, investment contributions), only a decreasing portion can be used at home, which means, that our investment possibilities will be tight over the longer term.

d/ Considering the Hungarian conditions primarily the development of the processing industry is necessary. This conclusion can be drawn from the mistakes of the past thirty years development policy, namely an exaggeratedly great portion of our equipment, even after 1957 approximately 70%, was oriented to material and energy production. The desired structural changes can be expected from the development of the processing industry, and only this can provide a growth in exports. At the same time

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[1] CM - Council of Ministers

[2] NP - National Planning Office

FM - Finance Minister

we are in the middle of another technical, scientific revolution where not only the developed countries can increase their already existing advantage but certain, rapidly developing industrial countries can overtake us. It is doubtful in such circumstances, that a long term investment, which only consumes and freezes considerable productive forces and financial resources over one and a half decades, is allowable.

e/ In case of commencing and during the investment significant foreign and domestic economic disturbance can be caused, because it is apparent, that in the era of debts, threatening even the international financial system with collapse, the international bank system is not willing to support the liquidity of countries (economies) which initiate investments with low productivity.

9. The presidency of the Hungarian Academy of Sciences considers it desirable that when the political and governmental leadership considers the further destiny of the GNBS investment, besides the international and internal political connections and consequences, the debated technical, economic and environmental scientific questions have to be considered. Taking into account the listed and unlisted factors, the Presidency suggests a significant postponement of the investment to a much later time and a consideration of the justified subject matter modifications, but its the abandonment of the whole project which is the most justified investment.

10. On the basis of the teachings of the investment the Presidency considers it necessary that the government prior to significant decisions, which influence the entire society and the whole economy, the opinion of the people and also institutions which are capable of an objective standpoint based on scientific analysis has to be asked.

20 December 1983, Budapest

Lénárd Pál	János Szentágothai
General secretary of the HAS	President of the HAS

Annex 3

HUNGARIAN ACADEMY OF SCIENCES, OPINION, 28 JUNE 1985

based on the discussion held at the exclusive round-table conference (June 24, 1985) on the Environmental Impact Statement of the Gabchikovo-Nagymaros Barrage System

The Hungarian Academy of Sciences (hereinafter: HAS) convened an exclusive round-table conference to form an opinion and to establish its position on the Environmental Impact Assessment (hereinafter: EIA) of the Gabchikovo-Nagymaros Barrage System (hereinafter: GNBS). (The list of names of the attendees is included in Annex 1.)

For lack of time, the members and experts of the HAS neither have been, nor will be, able to keep up with the technical experts involved in the development of the EIA for a year and a half and those involved in the preparation of the GNBS for several decades in getting acquainted with the studies, preliminary plans, documented investigations etc. For similar reasons, the Ad Hoc Committee of the HAS could not undertake the role of the arbitrator either.

In every case, the construction of a barrage represents a large-scale intervention into the order of nature, which has various impacts on the environment. Depending on the endowments of the land, the extremely intricate and complex impact mechanisms get realized "everywhere" in different ways. Since adapting Hungarian and foreign examples similar to the GNBS and its expected impacts is only proper to a limited extent due to the different economic, engineering and ecological attributes, it was considered necessary to provide information on the arguments and counter-arguments raised at the round-table conference (Annex 2).

Similarly to the discussions convened over the past period (from 1981 to 1985), there were very great differences among the opinions this time as well. For some of the remarks made, reassuring or acceptable answers were given, others were refuted, or were just not given a response to. There were some, who praised the ideas formulated in the EIA, and there were some others, who expressed condemnatory opinions, or did not agree with some of its statements.

Based on the request, the Academy has to form an opinion on the EIA of the GNBS. Because of the multidisciplinary nature of the establishment of the Barrage, however, several issues have been raised that could be rendered independent from the EIA and that we felt to be our duty to inform the Government about in order to reveal the situation.

The HAS cannot have the objective of preparing decisions. However, we consider it all the more our objective to comprehensively reveal interrelations in order to provide a basis for decision making.

Our observations are expressed separately for the antecedents, as well as for the GNBS and the EIA.

1. OPINION IN RELATION TO THE ANTECEDENTS

(a) Despite the interdisciplinary nature of the GNBS, the HAS was requested the first time only in 1982 to express its opinion. It repeatedly occurred that in issues concerning various sectors of the national economy, opinions were requested at very short notice. In this extremely complex subject, it is fairly difficult to form an opinion on the two-year work of the experienced and conversant professional staff of the water sector within a few weeks. In order to provide a basis for the government decisions, nevertheless, we consider it reasonable to make our remarks.

(b) Even without working out the conception of the GNBS and without a preliminary decision, we would agree on damming up the river to develop the navigation on and the flood control of the Danube, and on the exploitation of the opportunity for energy generation arising from the damming up of the river; ie. on the comprehensive harnessing of the Danube, which is realizable through the establishment of the Barrage System.

(c) Even in the event of developing the GNBS according to present ideas, the content put down in the position of the Presidency of the HAS on 20 December 1983 is considered to be governing:

"The pollution level and the change in the biological state of the Danube should not, in the future too, ,jeopardize the drinking water supply of the area and Budapest which is built predominantly on a bank-filtered system. Therefore, the sewage produced in the watershed should also receive biological treatment prior to the putting into operation of the Dunakiliti-Hrusovo Reservoir" (Item 2(a), p. 3).

Furthermore:

"The biological deterioration of the water in the Old Danube, as well as in its tributaries and branches, should be avoided. Regulated appropriately as boundary water, its ecologically sound character should be ensured, at the same time creating conditions for the permanent operation of a realistically designed navigational route" (Item 2(d), p. 3).

2. OPINION IN RELATION TO THE EIA AND THE GNBS

Despite the grouping of the points made at the round-table conference (Annex 2), the order presented therein is not followed in the formation of our opinion. On the one hand, because we had no intention to express our position for all issues raised, on the other hand, several issues have to be touched upon in a comprehensive way in the individual positions because of the interconnected impacts.

In our opinion, besides the decisions made and the contractual obligations undertaken so far, there are still tasks to complete, in which the Government may improve the impact of this project on the national economy. Providing a basis for such decisions requires the most thorough exploration possible of the cause-effect relationships. The position of the HAS wishes to contribute to a grounded evaluation of the possible alternative decisions.

(a) The decision made by the National Environmental and Conservation Council (hereinafter: NECC) on June 21, 1983 stated that the conventional plan prepared for the establishment of the GNBS had not dealt with the ecological impacts and the expected consequences in a comprehensive way. The incomplete state of the ecological research has not ceased to exist with the completion of the EIA. Considerable amplification was carried out in the fields of agroecology and groundwater level regulation.

We consider the environmental impact statement of the Gabcikovo Nagymaros Barrage System a pioneer undertaking. However, it only deals with the impacts to be expected upon the realisation of the Joint Contractual Plan or of its modernised concept. Therefore, the producers of the study have neglected an examination and assessment of the impacts to be expected from alternative technical solutions.

The EIA was prepared within a relatively short period of time and it is a piece of synthesizing work suitable for reaching numerous conclusions and making numerous decisions. It provided mostly reassuring answers to several concerns and controversial issues arising over the past years. In the Statement, several points made refer properly to the fact that in the system of impacts, the frequencies of the natural, economic and social elements are substantially diverse, and as a result, the consequences can be expected only with certain probabilities.

Numerous issues were also raised whose analysis was not possible. The Government should note that an unambiguous answer cannot be given to everything. Conducting further research is necessary to make the expected impacts more accurately definable. In spite of this, some impacts will certainly remain, which one will be able to find out only during operation, and to prevent their adverse consequences, measures should be taken and extra projects should be envisaged.

(b) The debates related to the GNBS are very diverging. They touch upon numerous professional fields, thus the competence of any single field cannot be complete in terms of the whole either. In certain issues, the views are in diametrical opposition. The reasons for this are various:

- the extent of some impacts cannot be shown with experiments or calculations using models, hence the debate cannot be resolved;

- prior to the signing of the Treaty, only a few of the preliminary studies exploring the expected ecological impacts had been prepared, their synthesis was missing, and the studies conducted since that time are of no full value or more time is needed for completing such studies;

- the debating parties are selecting their arguments according to their goals, and sometimes they replace them with declarations;

- by virtue of their nature, quantifying the ecological processes is more difficult that designing the operation of the engineering projects.

The difficulty of quantifying the ecological processes means, however, neither the diminution nor the overestimation of their significance. The economic consequences of the ecological impacts can be planned with greater difficulty and they imply a greater uncertainty factor. Despite the lack of their numerical expression, the environmental impacts cannot be neglected, and in fact, their role may be fundamental at the level of the national economy.

In order to learn the ecological changes, to obtain comparative data, to predict the expected impacts and to prevent the adverse impacts, a uniform monitoring network should be established as soon as possible.

(c) Based on the issues raised at the exclusive round-table conference, there are two possible alternative solutions for the operation of the Gabchikovo Hydroelectric Power Station:

According to the first alternative, ie. the original conception, peak energy is generated immediately after the completion of the project. In this case,

- the treatment of the sewage effluents in the city of Győr should be resolved at an accelerated rate before its putting into operation, otherwise, this reach of the river will become temporarily a sewer for the city;

- the Nagymaros Barrage should be constructed in time, together with that of Gabchikovo, which will represent a significant burden to the national economy;

- the treatment of the sewage effluents on both the left and the right riversides should be achieved prior to the putting into operation of the facility, otherwise the multiple use of the Nagymaros Reservoir will fail;

- in the Nagymaros Reservoir, siltation will start, the pores in the riverbed will be choked, the yield of the bank-filtered wells will fall, and regular dredging of the mud will have to be carried out;

- in the period of 1990 through 1995, there will be a lack of basic energy in the grid of Hungary, which may be substituted for with the existing oil power stations (see Item 2.1., Annex 2).

The second alternative and the economic interests as well as the elimination or the prevention of the adverse side-effects would make this one desirable, the generation of peak energy would be temporarily or definitely avoided. In this case:

- the treatment of the sewage effluents in the city of Győr and on both the left and the right riversides may be implemented at a "normal" rate (the burden on the national economy of this investment, paying for itself slowly, decreases);

- the construction of the Nagymaros Barrage may be rescheduled, and the navigation in the area of the community of Gönyü may be resolved at lower costs;

- the plants and additional facilities and projects necessary for the subsequent peak-operation may be implemented according to the carrying capacity of the national economy;

- the basic energy missing from the grid may be substituted for with hydro power (consequently, hydrocarbon energy resources should be used to a smaller extent for the generation of basic energy, and a small portion of the savings may be used for generating peak energy).

(d) In principle, the permanent use of the realistically designed navigational route on the Old Danube may be established by the measures aiming at the water supply, if the structures necessary for it are built. In order to preserve the boundary water and its ecologically sound character, it would be safer to constantly release the amount of water corresponding to the discharge prevailing at low water levels in the Danube. The Government should consider the possibility

- whether the possibility of navigation and the boundary-water character cease to exist or not in the case of a discharge of 50 to 200 m3/s?

- whether water will have to be released from the Reservoir instead of the surface run-off due to the choking of the pores in the bed of the Dunakiliti Reservoir?

- whether it should utilize the release of extra water becoming necessary because of the ecological aspects with pipe turbines built into the Barrage?

- whether it should perhaps build pipe turbines additionally according to the operational experience?

- whether any possible surplus water should be released without building turbines, ie. without utilizing it and generating energy?

- whether it should simulate the flooding of the lowland forests with major releases of water in order to protect the forests to be regenerated with other tree species?

(e) The costs of projects aiming at the elimination of additional and unfavourable impacts should be shown independently from the costs of the main facilities. For a possible failure to implement the additional facilities due to misconceived austerity aspects may have fatal consequences. A development of the area accommodating the changed endowments may result in a more favourable situation than the present one, while failing to implement the "extra" projects may cause irreversible processes in an ecological sense. It would be unfortunate, if, in the case of such a broad readiness, the number of erroneous actions prompted by ecological considerations again increased. Unfortunately, no cost calculation was available to us, and the statement of the EIA, saying that eliminating the adverse impacts requires extra costs equivalent to 2 to 3 % of the total investment, cannot be considered more than a simple statement and no grounding for it can be seen.

(f) According to our position, the pollution of the Danube should be abated to an acceptable level irrespective of the GNBS.

Our Government should take measures as soon as possible to resolve the treatment of sewage effluents, primarily the treatment of the domestic and industrial sewage of the main pollution sources: the cities of Győr, Komárom, Dorog and Esztergom and the Petroleum Co. (Szőny) as well as to prevent the slurry in the red sludge reservoirs at Almásfüzitő from entering the Danube. The water quality of the Danube should be preserved also in the interest of drinking water withdrawal. It should be included in a decision that before the putting into operation of the system, the pollution levels into the Danube reach affected by the GNBS should be decreased to a level satisfactory for a use aiming at drinking water supply and recreation. The development for recreation arising through the implementation of the GNBS can be considered a "gain", only if the water quality of the Danube is improved.

(g) In our opinion, it would be expedient to consider the new situation arising due to the dispute on the barrage planned close to the Czechoslovak and Austrian border (Hainburg), which has taken place since 10 October 1983, the date of signing the protocol on the modification of the deadline of the completion and putting into operation of the GNBS. The outcome of the dispute is not indifferent from the aspect of the GNBS either, therefore, it would be desirable to monitor it and to get involved in it on the part of the Hungarian Government.

(h) In accordance with the findings of the Presidency of the HAS on 20 December 1983, the carrying out of a social impact assessment and feasibility calculations are recommendedt. The Government should make its decision with the knowledge of the results of the economic calculations.

(i) It is desirable that our Government have a reassuring policy on information also on issues related to the establishment of the GNBS. Official reports on the decisions have to be released showing the proponents and the institutions involved in their preparation.

(j) It is recommended that the NECC should discuss the EIA supplemented with the issues raised at the round-table conference. After the usual inter-departmental coordination, the compilation prepared in this way should be submitted to the Government for approval by the National Water Office and the National Environmental and Nature Conservation Office. The proposal should include the additional tasks remaining.

Budapest, 28 June 1985

Annex 4

NATIONAL WATER BOARD FOR ENVIRONMENTAL AND NATURE PROTECTION, THE GABCIKOVO - NAGYMAROS BARRAGE SYSTEM, ENVIRONMENTAL IMPACT ASSESSMENT, SUMMARY, BUDAPEST, JUNE 1985

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I. Preceding events

The preparatory works for the complex utilization of the Hungarian-Czechoslovak reach of the Danube started in 1951. The scientific studies covered the agricultural, landscape-aesthetic, ecological and widely meant technical-economic aspects of the Barrage system too, exceeding the up to date aspiration level. Already at that time there were - with the presently used definition - Environmental Impact Assessments under way, which were continued in the 70s, with the involvement of other scientific fields and institutions.

In 1977 at Budapest the two Prime Ministers of the countries signed the agreement of the Intergovernmental Treaty about the construction and the operation of the GNBS (Gabcikovo -Nagymaros Barrage System). The preliminary works of the construction started on the territory of both countries in 1978. On Hungarian territory the activities between 1982-84 were restricted to protection of substance. The modification of the Intergovernmental Treaty was launched on 7 February 1984, which says: the Parties in the Contract will organize the activities of the joint investment in order to put the energy-production into operation between 1990-1994 .

The chairman of the Hungarian Academy of Sciences (HAS) nominated ad-hoc committees twice between 1981-82 for the scientific examination of the GNBS investment. Both committees came to the conclusion that the solution is mature, there is no fundamentally backed reason against the construction, but they recommended the complex analysis of impacts on the environment.

In 1982-83 upon the request of the Policy on Science Committee[1] the HAS (Hungarian Academy of Sciences) formed a new committee for the further examination of some questions of the GNBS. The report put forward by the Central Office of the HAS came to the following conclusion: clearing up all the cumulated effects of the environmental impacts of the GNBS in the frame of an Environmental Impact Assessment would be the most expedient.

The report prepared by the Central Office of the HAS - reported by the vice-chairman of the HAS - was discussed by the OKTT (National Environmental and Nature Protection Council). The Council in its resolution No 3/1983 (dated: June 21) ordered the preparation of an "Environmental Impact Assessment" an analysis of the environmental impacts in one system and with its interrelations by June 30. 1985. The methodology of the Impact Assessment was approved by the jury of the OMFB (National Committee for Technical Development) in December 1983.

The presidency of HAS dealt with the Barrage System in an internal standpoint formulated in December 1983. The Committee for Interdisciplinary Problems of the Presidency - to form a more solid basis for its' work - prepared its' report together with the OMFB. The committee formulated by the president of the OMFB prepared a wide-ranging, comprehensive report with the title " The long range complex utilization of the Danube", which was discussed by the plenary meeting of the OMFB in February 1984. The Economic Committee of the Government in its resolution in May 1984 - according to the "Reconciled Workplan" - imposed the execution of the tasks formulated in the OKTT (National Environmental and Nature Protection Council) resolution, in the standpoints of the Hungarian Academy of Sciences and the OMFB Plenary meeting and as such the preparation of the Environmental Impact Assessment according to the mutually agreed programme.

II. The basis of the Environmental Impact Assessment

The Environmental Impact Assessment as a method has barely longer past than 10 years in the world. Preparation of Environmental Impact Assessment first was ordered in the United States in the local environmental act (NEPA = National Environmental Policy Act) in 1969. Other countries - so far those which have introduced the Environmental Impact Assessment - followed the United States with several

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[1] Committee of the Hungarian Socialist Workers' Party

years of delay. (For example in Japan there are EIAs prepared since 1974, but at governmental level still they could not succeed to order the preparation of EIAs.)

In our country the 46/1984. (6 September) decree of the Council of Ministers about the "procedure for investments" imposed the preparation of the Environmental Impact Assessments as part of the preparatory and approval procedure.

In its methodology - both in possibilities and constraints -it is fundamental, that this Environmental Impact Assessment was the first in the country, and it can be remarkable even in international context. The Impact Assessment is prepared in line with the realization process of the Barrage System. It's task is the complete discovery of the environmental impacts, the minimization of the environmental losses and the maximal assertation of the advantages.

With all of these it can highlight that during the design process as an open system of the infrastructural investments with long construction period, with impacts of a large area and with extremely long lifetime the changing requirements can properly be asserted.

For the direction of the pioneer work the OVH (National Board of Water) organized an interministerial committee. There were representatives delegated by PM, MÉM, KM, IpM, ÉVM, HAS, OT, OMFB, OKTH, ÁFB, GATE2. Upon request of the OVH independent experts also took part in the work of the committee. The preparation of the Impact Assessment was coordinated the by the interministerial committee based on the "Reconciled Workplan".

Within the frame of the Environmental Impact Assessment the research accomplished and the papers published before 1983 on the subject were revised and reevaluated. From among them there were 58 used for the survey. For the Environmental Impact Assessment another 33 new research paper (or part of research document) was prepared. These additional papers processed the most recent research results and provided ground for systematization and with the utilization of this there was ground for the preparation of the environmental impact balance.

The sub-papers were prepared by 16 organizations (engineering and research, etc. institutes) involving further institutions and experts. Their work was coordinated by the VIZITERV (Design Institute for Water Resources) as general designer.

Simultaneously with the preparation of the Environmental Impact Assessment the up-to-datedness of the technical solutions -fixed in the frame of the Hungarian national investments and the Joint Contractual Plan - were revised as it has been prescribed in the investment decree. During the up-to-datedness examination all the findings of the research for the Environmental Impact Assessment were continuously taken into consideration.

The Environmental Impact Assessment and the enclosed Appendix 1. lists all the necessary additions to the basic investment resulting in additional costs. The Joint Contractual Plan contains the necessary smaller or bigger activities - water supply, water intake, protection against seepage water, e.g. - at all the industrial facilities effected by the construction as much as to maintain the previous operation level. These costs are included in the in the GNBS investment plan. The revised solutions are included into the basic investment following the ongoing reconciliations. The majority of these are technical-constructional details, so the Environmental Impact Assessment does not list them item by item. The reconciliation of the detailed solutions are under way and they are included into the basic investment without being especially emphasised.

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[2] Hungarian acronyms: PM = Ministry of Finance, MÉM = Ministry of Agriculture and Provisioning, KM = Ministry of Commerce, IpM = Ministry for Industry, ÉVM = Ministry for Construction and Urban Development, MTA = Hungarian Academy of Sciences,OMFB = National Committee for Technical Development, OKTH = National Board for Environmental and Nature Protection, GATE = Agricultural University of Gödöllö.

The base point of the iterative research - design process applied in the Impact Assessment is the concept in the technical plans in effect (Joint Contractual Plan) in 1983 of the Barrage System's and the state of the effected region. The steps of iteration: technical solution - recognition, examination of the impacts - modification of the technical solution - examination the modified solutions' impacts - etc. The Impact Assessment made recommendations as a result of this method and discusses their effects, judge the system of mutual impacts within the scope of the present state of the art of methodological possibilities and knowledge and sums them up in the Impact Assessment.

The solitary research works were carried out parallel. As a result of the different scientific points, concern or the objective by different scientific methods there might be slight differences, even contradictions. However these do not refer to the main line of research. They are resolved by the Impact Assessment.

The processes in effect in the examined area and their formation after the completion of the GNBS has stochastic character. Because of this the basic ambition of the Impact Assessment was to measure the extreme probably effects of the operation. Consequently the Impact Assessment took into consideration the impacts of the possible most unfavourable conditions of the discharge, the peak operation, sedimentation etc. Thus the expected impacts will remain within the interval marked by the extremities.

III. Examinations and results

The resolution No 3/1983 of the OKTT prescribed the following main environmental requirements during the completion of the GNBS investment:

- The pollution of the quality and the changes of the biological state of the Danube water cannot impose danger on the water supply of Budapest;
- The system of the criteria has to be worked out, which ensures not only the maintenance of the sustaining ability of the region, but provides possibility for the improvement;
- The regional development advantages of the giant investment has to be utilized, within this especially the possibilities for the development of recreation and tourism;
- It is necessary to avoid the deterioration of the biological state of the water in the Old-Danube and its tributaries and to provide its worthy state as a boundary river;
- The aesthetic and landscape values of the Danube-band has to be protected by the aesthetic and landscape friendly construction of the appurtenant projects of the GNBS;
- The water resources stored under the Kisalföld in the gravel layer has to be protected.

The Impact Assessment's immediate aim was that for the assertation of the requirement system - with the execution of the examinations suggested by the resolution of the OMFB plenary session, the OKTT and the presidency of the HAS -should be explored scientifically. We have to lay emphasis on the fact that the appraisal of state - carried out in the frame of the Impact Assessment - laid down a lot of environmental impacts being in effect now, which is an effect of the present land use, deteriorate and endanger the natural resources (the water treasure of the Szigetköz gravel cone, bank filtered water resources, karstic water) of the affected Danube reach and its environmental elements. Their elimination or reduction is independent from the GNBS investment, but should be carried out parallel to the construction.

These findings and their results are summarized according to the paragraphs in Chapter I. Environmental Impacts Assessment of the Reconciled Workplan are as follows:

1. Survey of the water quality and water-biological changes expected along the reach of the Danube effected by the GNV

1.1.

The impact of the Barrage System upon the water supply of the region was examined mainly from the aspect of the drinking water resources of the used Danube section. The impact assessment opens up those main processes which might influence the water resources in the sense of quality or quantity.

The quantitative and qualitative relations of the bank filtered water are influenced apart of the background pollution basically by the state of the filter layer in the riverbed. As a consequence of the peak load time production along the effected Danube reach the majority of the sediment will be transported further downstream. It is necessary to count on more intense deposition only in case of small discharges, but the major part of the deposited material will be washed downstream by the Danube in case of medium discharges already. The sections prone to sedimentation can be limited relatively easily, the actions considered to be necessary (the influence of the stream regime by river training activities, dredging, e.g.) can be made available.

During the design and the operation the areas for disposal of the dredged material has to be appointed in harmony with the land use plans and the environmental aspects.

The necessity of the actions in favour of the bank filtered wells on the Nagymaros - Lábatlan section has to be identified on the basis of the experience to be gained during the operation. This section (or its certain subsections) will get more susceptible to sedimentation. The results of model calculations show, that the growing pressure due to the permanently high water levels will be enough to compensate the growing resistance due to the sedimentation and the clogging. In case of need this unfavourable effect can be reduced by dredging. Presumably within this reach the water yield of the wells will not change. The research dealing with the circumstances of the bank filtered water resources showed, that the deterioration of its water quality is mainly due to the growing pollution coming from the background areas. It is expected as a clearly favourable effect of the Barrage System that the hight of raised water level - due to the growing portion of the discharge into the wells from the Danube side - will reduce the background pollution process.

There is only limited solid knowledge to judge the ratio; the kinds of; the effects of; the effect mechanisms of the materials polluting the filter layer in the riverbed (mainly toxic micropollutants). The sediment pollution is dependent on the actual industrial pollution. Its monitoring, the determination of the necessary actions will be the task of the planned monitoring system.

The Barrage System has no effect upon the filter layer of the Budapest Waterworks' water resources at the Szentendre Island. The changes in the filter layer are influenced by factors independent from the GNBS.

1.2.

Requirements toward the wastewater treatment are determined by the present water quality state of the Danube and the general water quality interests along the effected reach of the Danube too.

The Danube is classified as first class along the effected section between 1979 and 1983 by the CMEA water classification system in most of the components. However in case of organic materials (nitrate, ammonium and mineral oil) it is 2-3 class. The significantly deteriorating tendency of the water quality has slowed down during the last years. On the catchment area, as a result of the activities of the boundary water committees, the upstream countries upgraded their wastewater treatment and water resources protection activities faster then Hungary. The water quality of the Danube will be determined basically by the wastewater load in the future too, the construction of the Barrage System does not modify it.

The most important points of the examinations:

- The retention time in the Dunakiliti-Hrusovo reservoir and in the power channel will grow (it will pass this section in a longer period), so the sedimentation can speed up at certain places. Both effects reduce the oxygen demand. The larger surface area, the waviness, the production of the biomass of the water body increase the oxygen uptake, the slower velocity reduce it at the same time. The decomposition processes of the organic materials increase the oxygen consumption. Letting the water through the turbines contributes to the oxygen uptake and aeration. Thus the effects in the reservoir compensate each other.

- The water quality in the diversion channel downstream of Gabcikovo is in nearly natural state.

- Along the reach between Szap (Palkovicovo) - Nagymaros the velocity relations will decrease less compared to the present ones. The sedimentation will not influence the general water quality state. The average velocities will not change up to such a level that in the potentially eutrof water body - a consequence of the present pollution - significant eutrophication processes would be triggered.

According to the above the Barrage System will not cause significant changes in the general water quality relations of the Danube. At the same time the most important - at certain places already acute - water managerial (within this the wastewater treatment) problems should be treated parallel to the construction of the GNBS. (There are projects like wastewater treatment plant construction or development in Győr, Komárom, Tatabánya, Esztergom which failed during the previous plan period3 but can not be delayed any longer, being included into the investment items of the 7th five year plan.)

The Impact Assessment also lists one by one the polluting industrial wastewater outlets into the sections of the affected Danube reach strait or via the tributaries, altogether 32. Within the affected area between Rajka and Budapest the cumulated industrial wastewater load sources are approximately 1/3 of the waste load of Győr. The Táti Danube-branch has to be protected from the pollution.

According to the suggestions of the Impact Assessment - as the ratio above offers reason for - for the reduction of the effluent from industrial sources the governmental programs are the standards: saving with the water resources and increased protection of water quality. The execution of tasks defined above satisfies the water quality requirements of the Danube with or without the completion of the GNBS.

1.3.

The determining factors of the biological state of the Old Danube riverbed and the tributaries will go through significant changes. The completion of the Barrage System and its appurtenant national constructions will contribute to the conservation and the reduction of degradation of the biotopes in the Szigetköz.

In the present state the system of the tributaries in Szigetköz receives continuous freshwater supply only in case of water discharges exceeding 2500m3/day (55-70 days annually). In case the discharge is less then this - annually nearly 300 day -there are permanently stagnant water bodies, where eutrophication, sedimentation occurs.

In the future as a result of the construction of the designed infiltration system for the regulation of the subsurface water resources the majority of the stagnant water surfaces will be eliminated. Their freshwater supply will be provided from the drainage system which means at the same time that the water poor in nutrients (mainly in phosphorus and phosphorus products) will reduce the formulation of eutrophic processes. On the top of all that presently the water supply of the Mosoni-Danube and the tributaries is random, it depends on the water regime of the Danube. After the Barrage System is put into operation the plan provides water supply for the Mosoni-Danube and the tributaries from the infiltration system and from the Dunakiliti reservoir via water intake, far exceeding their present discharge throughout the entire year.

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3 It refers to the element of the socialist economy: the five year period, for which the national economy had plan.

In the riverbed of the Old Danube there will be significantly smaller discharges, depth, reduced velocities and 100-120m wide water surface will be characteristic. However significant share of the discharge will originate from "clean" seepage water. Apart of the tasks: conveying down the floods and the ice; the plan provides opportunity for flushing the Old Danube bed. The new biological state will formulate accordingly.

1.4.

The living (water) character of the Old Danube riverbed is discussed in paragraph 1.3. The discharge, which is 50m3/sec or according to the other demands operationally 50-200m3/sec is sufficient to sustain the living (water) character of the riverbed. The tributaries are provided by water via the infiltration system independently from the riverbed of the Old Danube. The sufficient training of the Danube riverbed -within the frame of the joint construction - provides character worthy of being a boundary river.

The navigability of the Old Danube channel during floods and in those cases when the storage is terminated at Dunakiliti is similar to the present state. The recreational navigation in the floodplain and on the tributaries might develop in circumstances more favourable than presently. To design permanent navigation route for other purposes have not proved to be justified.

2. Nature conservation areas

The study considered all the nature protection areas and the protected natural values situated presently in the region. It concluded that the construction of the GNBS does not impose danger on them.

The examinations and the reconciliations in wide circles proved that in the Szigetköz the stag in the Ásvány tributary system represents such a natural value which has to be protected. The infiltration system in the floodplain and other necessary structures were and are being planned considering this fact.

In the Szigetköz area the preparation to formulate 8500 ha of nature protection area is completed, the first level reconciliation is under process. The archaeological survey of the employed area is done or is under process as part of the basic investment.

3. Examination of impacts of the peak load time operation

The study started with the operational pattern causing the maximum fluctuation of water levels while examining the impacts of the peak load time operation. It set out as a target examination of the impacts of the extremely large water level fluctuations upon the environment. This way the changes in the water levels according to the operational pattern will remain within the examined limits. The possibility of reducing the fluctuation of the water levels has to be examined during the design process.

The peak load time operation in the Dunakiliti - Hrusovo reservoir will reduce the undesirable stratification of the stream. Directing the sediment transport and the construction of silt traps is a question of design.

The water level fluctuations resulted from the peak load time operation will remain within the riverbed and are characteristic for the reach between Bős - Komárom. Downstream of Komárom the water level fluctuation is less than approximately 1.0 m.

The water level fluctuation does harm the biotope covering the embankment, but the research cleared up, that its impact on the oxygen production of the Danube reach in question is insignificant.

The evaluation of the water level fluctuations are evaluated mainly for the Mosoni-Danube and the Győr region. It took into consideration too, that into the Mosoni-Danube after the completion of the Barrage System there will be permanently minimum 20 m3/s discharge available which considerably will improve the discharge and water quality of the Mosoni-Danube. It will multiply the dilution of the Győr wastewater presently untreated.

The influence of the daily 1-2 m water level fluctuation caused by the peak load time operation - together with the short term upstream current - will dilute considerably the water in the Mosoni-Danube and then while falling the reach between Győr and the mouth of the river will be flushed, which will be supported by the discharge of the Mosoni-Danube, being three times higher then presently.

In the present situation the flood waves cause more durable backwater-effect. Thus the dilution pattern will be more favourable. The increase of the daily retention time will not cause unfavourable decomposition processes in the city area. The dredging of the Mosoni-Danube has to be scheduled after the Győr wastewater treatment plant is put into operation.

The sediment movement will be within the same magnitude as present owing to the velocity regime due to the changing discharges in the reservoir of the Nagymaros Barrage. In total the peak load time operation has no environmental impact or it has no expelling consequences.

These result stress repeatedly that the connection of the Gabcikovo and the Nagymaros Barrages not only from the point of the peak load time operation (energy production), but also from hydraulic - smoothing the incoming and outgoing discharges - and flood protection and river training viewpoints composing one inseparable unit.

4. Examination of the agricultural impacts

The study did examine in detail the impacts anticipated as a consequence of the GNBS upon the potential productivity of the agriculture and the forestry.

The survey compared the present and the future (after the completion of the GNBS) agro-ecopotential. They came to the conclusion that the soil productivity decisive from the viewpoint of the agricultural production will not change substantially as a consequence of the completion of GNBS. At the same time the structures of the GNBS will constitute partly the main parts of the agricultural drainage system too.

The research made clear the question discussed for a long time that the groundwater has no significant role in the agricultural production of the Szigetköz area, it is determined by the rainfall mainly. It is showed also, that the precipitation having crucial role is not enough for the optimal growth of the plants a lot of times, very often it has to be supplied artificially. There are 3-5 thousand hectares in the Szigetköz area irrigated presently. The water base for irrigation to supply almost the whole area is available from the stabilized groundwater of the Szigetköz with the infiltration system and suitable water control.

As an impact of the planned structures the extreme water situations will be reduced substantially. Thus the safety of the production will increase and there will be possibility to utilize 1000 ha of land presently full of underseepage and overmoistured with more valuable line of cultivation, to increase the productivity compared to the present situation. The above has to be accomplished with field drainage embedded into the plans of the cooperatives' development programme within the frame of complex land reclamation. For the field drainage as part of the basic GNBS investment the main collector system will be constructed taking into account the prospective demands in land reclamation.

Following the accomplishment of the Barrage System the groundwater regime - prone to the blind whims of nature presently - will become controlled optimally for the production which has decisive role in the safety of production.

5. Impacts of the changes in the groundwater levels and the application of the infiltration system

The concept for the Szigetköz freshwater supply system attuned to the requirements was developed on the basis of detailed examinations on the spots, hydrological and hydraulic research. For the design apart of the theoretical calculations there were electronic analogous model tests and field research to provide data. With the help of the water control system the distribution of the water resources and the determination of the water levels can be carried out taking into account the soil data and morphological characteristics of the region while considering the up-to-date hydrological and meteorological circumstances. Czech-Slovak researchers starting from different theoretical basis got to similar conclusions and aimed the completion of a similar freshwater supply system.

The seepage water from the Dunakiliti-Hrusovo reservoir through the flood protection dikes are collected in the drainage channel parallel with the dikes, from where - according the ratio of the momentary needs - it is led to the Mosoni-Danube and the tributary system. The operation of the system is supported by foreign experience too. It has to be put into operation before the storage.

The water level maintained next to the terrain level so to say "supports" the water table of the Szigetköz, at the same time - apart of the 300 m wide zone along the Danube - provide water supply for the floodplain forests. The 80 - 150 m wide branches of the tributary system on the floodplain which get permanent freshwater supply from the drainage system do contribute (apart of the advantages listed above) to the maintenance of the landscape character. Thus the infiltration system is a good solution which fits to the natural surrounding.

6. Examination of the biological, pedological and technical problems related to the manifold inundations of the floodplain forests during the vegetation period

"Overloading" the infiltration system described in paragraph 5 - with water resources temporarily not utilized in power production and with suitable water control - the technical possibility for flooding the floodplain is given. Using the sluices built into the Dunakiliti barrage the discharge above the 4000 m3/sec (which are conveyed by the Old-Danube bed) at least partly can be directed to the floodplain. Its frequency is 20 days annually. The seasonal flooding - according to the international and domestic experiences - together with the water table kept near to the surface satisfies the requirements of the forestry.

The operation of the system respond to the characteristics of the processes in natural circumstances presently. However the partial absence of the deposition caused by the floods can be subject of further research, although considerations until now have not indicated it to be significant component in the production of the forestry.

Thus it can be stated that the state and production of the forests in the Szigetköz floodplain - apart of the earlier mentioned 300 m wide littoral zone - can be sustained unchanged. In the littoral zone the change of species is necessary.

7. Regional and urban development

The Impact Assessments made unambiguous that the GNBS cause only minor - not determinative - modifications in the structure of the space, land use and settlement network and in the present function of the settlements. For the construction period the plan contains the necessary increment in the supply network to satisfy the supply and social circumstances. These plans are such that the infrastructure of the region will be improved after the completion of the work.

The minor changes (improvements) in the landscape potential due to the GNBS primarily can be realized in the tourism. Their utilization has to be implemented with the mobilization of the local investments based on the future development plans for the region and settlements.

8. Protection of the water resources

The Danube is the largest available water resource of the country, we have dealt with the water quality in paragraph III. 1.

The water treasure in the gravel layer of the Szigetköz will receive freshwater supply from the infiltration system being filtered, more clear water, which brings it into better state from the water quality point.

The Szigetköz water treasure is not hampered by the local sedimentation of the Dunakiliti Reservoir. In the water quantity sense the water treasure will not change significantly. However it is very important to reduce, stop or as an immediate task to reduce the growing tendency of the pollution through the diffuse pollution from the communal and agricultural sources probably increasing and from the shattered areas (gravel mining). Similarly important from the point of view of the Szentendre Island bank filtered water resources the background pollution on the surface of the island.

The more widely considered region's water treasure is the karstic water resources of the Transdanubian region. The karstic layers are connected with the Danube, but there is a considerable sediment layer on them. The sandy gravel layer perhaps filters the water seeping toward the deeper layers equally as the operation of the bank filtered wells.

The connection of the karstic water and the Danube is influenced by the mining activities in the Middle-Transdanubian Mountains up to a much larger degree then the water level in the Danube. The quality of the karstic water is also far more influenced by the pollution washed in (especially in case of concentrated pollution sources and open karstic regions) from the Middle-Transdanubian region than the water reaching these layers with low probability and filtered by the alluvial layers from the Danube water. On the basis of this the pressure pattern altered by the GNBS will not hamper the quality of the Middle-Transdanubian Mountains' water treasure .

In total the GNBS will not deteriorate the water treasure's present social-economic usefulness.

9. The sustaining ability of the region.

In the relation of the sustaining ability and the GNBS the Impact Assessment revealed those direct potential possibilities which - in case of appropriate utilization - will contribute to modest increase of the sustaining ability of the region. There has been no components discovered which would decrease the sustaining ability.

Forecast for the formulation of the social changes could give idea for the formulation of the region's sustaining ability on the longer run. In the region even independently of the GNBS's completion there are changes expected in nature, society and economy which may have substantial impact on the new environmental state. Further impacts stimulated by them could not even be predicted in the present study. Thus it is imperative that - as there are several practical experiences to prove it - certain part of the complex environmental impacts' changes will become qualifiable, measurable during the operation of the Barrage System.

However it is necessary (and based on foreign experience it is possible) to declare that the controlled water levels and the improved water managerial conditions have attractive components inducing economic growth. Also there is international experience that the improveness of the adjacent areas to the controlled water regime is profoundly higher than those of the average, so there are new possibilities for the development of the forces of production. Tangible domestic example is the development of the previously nearly uninhibited Middle-Tisza reach during the barely more than ten years since the completion of the Kisköre River Barrage.

In the Dunakiliti Reservoir - according to foreign examples -there will be improvement in the living conditions of the carp, grass carp, bighead and silver carp, bream, crucian, barbel, tench, so it is possible to count on the increase of these species. In the Szigetköz tributary system the control of the freshwater, the relatively clean water inlet apart of the improvement in quantity will improve the quality substantially. The Mosoni-Danube will remain a living space and as a consequence of the enlarged quantity of freshwater the conditions will improve a lot.

The third point of the Joint Contractual Plan prescribed the revision of the Nagymaros Barrage's location. The documentation with detailed elaboration of the alternatives were completed by October 1984. The introduction was discussed by the OKTT and the Economic Committee too. The resolutions declared that the most suitable location for the Nagymaros Barrage is at river kilometre 1696, there is no other possibility to choose an other location. This location is the same as the one in the Intergovernmental Treaty.

IV. Important conclusions

The study provides sufficiently deep data for the economic evaluation - under process - incorporating completely the environmental impacts too. For the up-to-date cost-effectiveness examinations the expenditures (the activities to compensate the unfavourable environmental impacts included too) and the expected benefits and advantages are summarized in the impact balance. (see annex 2.)

The most important elements of the impact balance are the following:

The GNBS utilize the natural resources of the Danube reach between Pozsony and Budapest. It cause primarily changes in the water regime of the river and in the water resources of the adjacent areas, which cause further secondary changes in the natural components. These can influence the land use and habitat value relations directly on one hand and indirectly on the other.

Upon the changes in the hydrological regime of the river:

- in the riverbed the present hydrological regime will narrow down between Ásványráró-Nagymaros. Within this the water level will be stabilized in principle in the domain of the mean water levels upstream of Esztergom and in the high water levels between Esztergom-Nagymaros;

- the daily discharge will not change, the amount of water - let into the system at Pozsony and through the tributaries - will pass Nagymaros, the volume of the reservoir does not make longer retention time possible;

- within the day - according to the schedule of the daily energy utilization - the discharges between Bős-Nagymaros will be let down alternating (peak load time operation); The water levels for 5-6 hours will increase in continuously decreasing manner, for 18-19 hours will decrease. It has to be stressed that the water level fluctuations caused by the peak load time operation will remain within the mean water riverbed, it does not influence the floodplain.

- the flood protection safety on an area of 418 square kilometres - where there are 35 settlements, among them 5 cities and approximately 250 thousand people are living - will increase substantially and the high water with the frequency of once out of 200 years will be led down without causing any harm;

- in the Szigetköz area there will be two water supply plant for a smaller region and waterworks for Nagymaros, Dömös-Dobogókő and Visegrád will be enlarged, further on the water potential will increase with 230000 m3 per day, out of which 100000 will be filtered raw water quality;

- The wastewater treatment will be solved in the regions of Dunakiliti and Nagymaros;

- During the construction in the region of Neszmély, in case the study will contain resolution to suggest recreation beach 90000 m3/day presently available possibility for water intake will cease to exist;

- there will be navigation route with full value provided for a new 212 km;

- the water quality of the river

- The chemical and public hygiene (pathological microorganisms) water quality is determined by the actual pollution. The tendency realized in the change of chemical properties in the water are not accounted for the GNBS, but influenced by processes under way on the catchment area.

- There will be no significant harms done to the biological state of the water and no changes inducing ecological "catastrophes" will incur. In this respect mostly qualitative results may be anticipated, for their quantification further observations are necessary to be accomplished by the monitoring system.

The following questions have emerged as a aftermath of the changes in the hydrological regime of the littoral zone:

- The impacts of the changes in the agricultural production was measured by the study through the examination of the agro-ecopotential. The research shows that the changes (decrease) in the agro-ecopotential will remain under 1% in the Szigetköz, the drawback in the reach Gönyű-Nagymaros will remain within the calculation error level. The area presently in agricultural use which will be permanently used is 1655 ha - although the costs to expropriate them is included in the investment costs - will cease to exist as natural resource. This will be substituted by the 1923 ha which will be protected from the floods, out of which 2/3 will be utilized for agricultural, 1/3 for recreation purposes. The two kind of land uses as resources will compensate each other. On the impact of the construction included in the investment plans (with little additional investment) on 27000 ha the main drainage system will be constructed for the field drainage.

- The study discuss in details for the whole affected area the land use influencing the forestry. For the purposes of the Dunakiliti Reservoir there will be 1126 ha of land expropriated. On the Szigetköz floodplain - Between Dunakiliti and the mouth of the Mosoni-Danube - the forests on the floodplain will remain in their present state. In the littoral zone - 10% of the area, 400 ha -there is need to change the stand. This means additional costs. Further 447 ha of temporarily used forest area will be recultivated on the expenses of the construction. The plans foreseen to the careful protection of the wood during the construction period too.

- For the protection of the environmental and natural values cooperating with the technical solution of the GNBS the Ásvány tributary system and the park of the Hédervár Castle can be supplied with water. The protection of some natural and cultural heritage of Esztergom will improve through the improved flood protection safety.

- Because of the environmental impacts the basic parameters of the energy production of the GNBS laid down in the Intergovernmental Treaty does not have to be changed.

- The use of the embankment along the Moson-Danube will be reduced caused by the peak load time operation which urge solution for the canalization and wastewater treatment at Győr being necessary for a long time already.

- The safety of the main transportation lines and railroads will increase. The shallows hampering the navigation with large barges between Budapest and Bratislava (Dömös rock threshold, bottlenecks in the Szigetköz area, shallows) will cease to exist. The bridge for public use over the Nagymaros Barrage might help to distribute the recreational traffic more homogenously. The regulation of the traffic on the bridge has to be subject of traffic-regulation policy reasoning.

- New - increasing the variety of choices - possibilities for recreation, water sports and tourism will emerge in the Szigetköz, Neszmély, Esztergom, Pilismarót, Dömös and Visegrád area. At Nagymaros the possibility to use the embankment will decrease because of the waiting zone to the sluice.

The impact balance does not contain the following:

- the original and up-to-dated protection constructions of the Joint Contractual Plan, the technical measures to ensure the conservation and the maintenance of operational level and their costs since the Plan contains them originally;

- the positive environmental impacts of water borne energy production compared to others (mining, transportation, air pollution and disposal of dangerous wastes, e.g.);

- savings of energy and its environmental advantages resulted in transportation which might be re-routed to navigation routes.

The environmental requirements were kept in mind continuously during the design process and its updating. The additional cost emerging from the suggestions of the Impact Assessment's results as modifications of plans, new establishments is 580-600 million Hungarian forints compared to the originally considered investment costs which is nearly 2%.

The additional constructions and technical measures in favour of environment protection has to be considered in the plans of the Barrage System, in case of joint constructions with the Czech-slovakian partners it has to be reconciled. The further utilization of the potential advantages will be accounted up to the effective beneficiaries.

V. Further tasks

It is primary among the further tasks that the observations and research on the areas and phenomenons identified in the Environmental Impact Assessment has to be continued.

In the first place integrating the present observation network into the environmental monitoring system has to be accomplished. The monitoring system has to be developed as a basic tool for the resolution of the tasks during the operation - including the recording of data necessary to intervene in favour of the environment. In order to achieve that the impacts of the GNBS in the region will be differentiated from the other impacts in effect and for the availability of reference data of the main phenomenons for suitable long interval for the observations in the frame of the monitoring system has to start at least 3 years before the GNBS steps into operation.

The division of tasks has to be decided in cooperation of the relevant ministries for the completion and the observations of the monitoring system.

The Environmental Impact Assessment has to be updated on the based on the data of the monitoring system, further examinations and results of research.

There has to be a plan elaborated for the research activities to terminate or to be continued after the Barrage System is put into operation according to the resolution of the Economic Committee May 1984. For the main directions of the necessary further research the Impact Assessment gives the following recommendations.

The following has to be continued:

- the quality control of the surface water with special respect to its hydrobiological aspects;
- research of the heat balance;
- evaluation of the sedimentation processes and ice conditions with special regard to their water quality and biological impacts;
- examination of the bank filtered water basis and its quality aspects;
- measurement of the groundwater movements;

- examination of the structural stability of the biotopes in the water;
- mixing procedures of the water polluting materials.

To prepare ground for the decisions the following connected development strategies are suggested for elaboration (or further planning) by the study:

- regional development, within this preparation of decisions on tourism and recreation;
- evaluation of relation to the development of transportation (roads, harbours, role of Nagymaros bridge, e.g.);
- development of strategies for the operation of farms and land reclamation strategy in the Szigetköz region;
- formulation of further environmental protection and development possibilities.

To elaborate the above is in the competency of the branches of national economy involved.

VI. Standpoint

The final conclusion of the Impact Assessment is, that the Gabcikovo-Nagymaros Barrage System, fitting into the natural-economic surrounding of the region in harmony, can be accomplished according to the system of requirements set forward by the resolution No. 3/1983 of OKTT, the internal resolution of the HAS and the plenary session of the OMFB.

One of the basic conditions to put the Barrage System into operation is that until the start of operation the establishments which are to compensate or to ease the harmful impacts - envisaged by the Impact Assessment - has to be constructed. Abandoning or delaying them increase the risk of the realized environmental impacts, even may lead to inevitable environmental impacts or production losses.

During the operation of the Barrage System those measures has to be favoured which serve the management and the prevention of symptoms jeopardize the environment.

With this the complex Environmental Impact Assessment of the GNBS is completed. The continuous maintenance and bringing up-to-date serves exclusively the accomplishment of the construction plans and their environmentally detailed design.

We can conclude, that in our country there has never been such a multifold and complex preliminary investigation carried out to any giant state investment. From scientific and methodological standpoint it can be used as a prototype for the Environmental Impact Assessments included in the Governmental Decree 46/1984 (dated 6 November). For the accomplishment of the further investigations, planning, execution and operation tasks the cooperation of the state departments involved has to be provided.

Budapest July 1985.

Appendix 1.

Additional costs of abatements for environmental impacts surpassing the base investment

	Unit cost	quan- tity	Costs in million HUF	Costs rounded up to million HUF
1. Szigetköz infiltration channel				
1. Earth work, excavation of the open channels, reconstruction, reshaping with the formulation of the slope of embankment, bank protection and maintenance roads, complete	3500 Ft/m	31 km	108.5	
2. Construction of structures out of stone, concrete and reinforced concrete together with the site preparation, complete	3000 Ft/m^3 of air	3300 m^3 of air	9.9	
3. Installation, energy supply, illumination, signalling apparatus etc., complete			1.9	
			119.80	120.00
2. Drainage canal Szőny-Füzítő				
1. Earth work, with excavation of the open channel, embankment protection, flood protection dikes, maintenance roads, complete	7500 Ft/m	9 km	67.5	
2. Construction of structures out of stone, and reinforced concrete together with the site preparation, complete	3000 Ft/m^3 of air	3500 m^3 of air	10.5	
3. Installation energy complete			0.5	
			78.50	80.00
3. Protection works for the waterworks, Koppánymonostor				
1. Earth work, with the necessary service roads and seepage system, complete	4500 Ft/m	4.5 km	20.3	

	Unit cost	quan- tity	Costs in million HUF	Costs rounded up to million HUF
2. Stone pavement, bed relocations, stone stabilization	900Ft/ m^3	50 000 m^3	45.0	
3. Construction of structures with steel structures and pump installation, complete	10 000 Ft/m^3 of air	1200 m^3 of air	12.0	
4. Installation			2.3	
			79.60	80.00
4. Relocation of duck farm at Neszmély				
Demolition, liquidation			2.0	
Provision of area (purchase, expropriation)			5.0	
New buildings			25.0	
Hatching, egg-packer, hygiene			10.0	
Water supply			3.0	
Operation			1.0	
Solution for the wastewater treatment			3.0	
Transport and others			1.0	
			50.0	50.00
5. Relocation of cattle farm at Pilismarót				
Demolition, liquidation			3.0	
New buildings			30.0	
Management building			4.0	
Utilities			8.0	
Operation			1.0	
Road, transportation			2.0	
Others (relocation, haulage)			2.0	
			50.0	50.00
6. Szigetköz, floodplain forest, replacement of stand in the embankment zone, cutting off, sale				
Plantation of new stand and maintenance until first harvest	4000 Ft/ha	400 ha	16.0	16.00

	Unit cost	quan-tity	Costs in million HUF	Costs rounded up to million HUF
7. Freshwater supply for the Ásvány tributary system				
1. Earth work with preparation of the open channel with bank protection, service roads, complete	25 000 Ft/m	500 m	12.5	
2. Earth work at the dredging of branches with disposal of soil with the necessary embankment and bed stabilization, complete	300 Ft/m3	300 000 m3	90.0	
3. Structure for the water intake with the site preparation, complete	7000 Ft/ m^3 of air	2200 m^3 of air	15.4	
			117.9	120.00
8. Preparation of embankment zone at Neszmély				
Earth work at terrain smoothing with excavation from under water, embankment protection, complete	285 Ft/ m^3	140 000 m^3	39.9	
			39.90	40.00
9. Dredging of the Körtvélyes Danube branch at Tát				
Earth work at dredging, deposition with recultivation, complete	300 Ft/ m^3	100 000 m^3	30.0	
			30.00	30.00
Total				586.00

Annex 5

Gabcikovo-Nagymaros Barrage

Project Study

March 1989

Compiled and Edited by Christine Reid, Project Manager

Professor Robert D. Yaro, Project Director

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Acknowledgements

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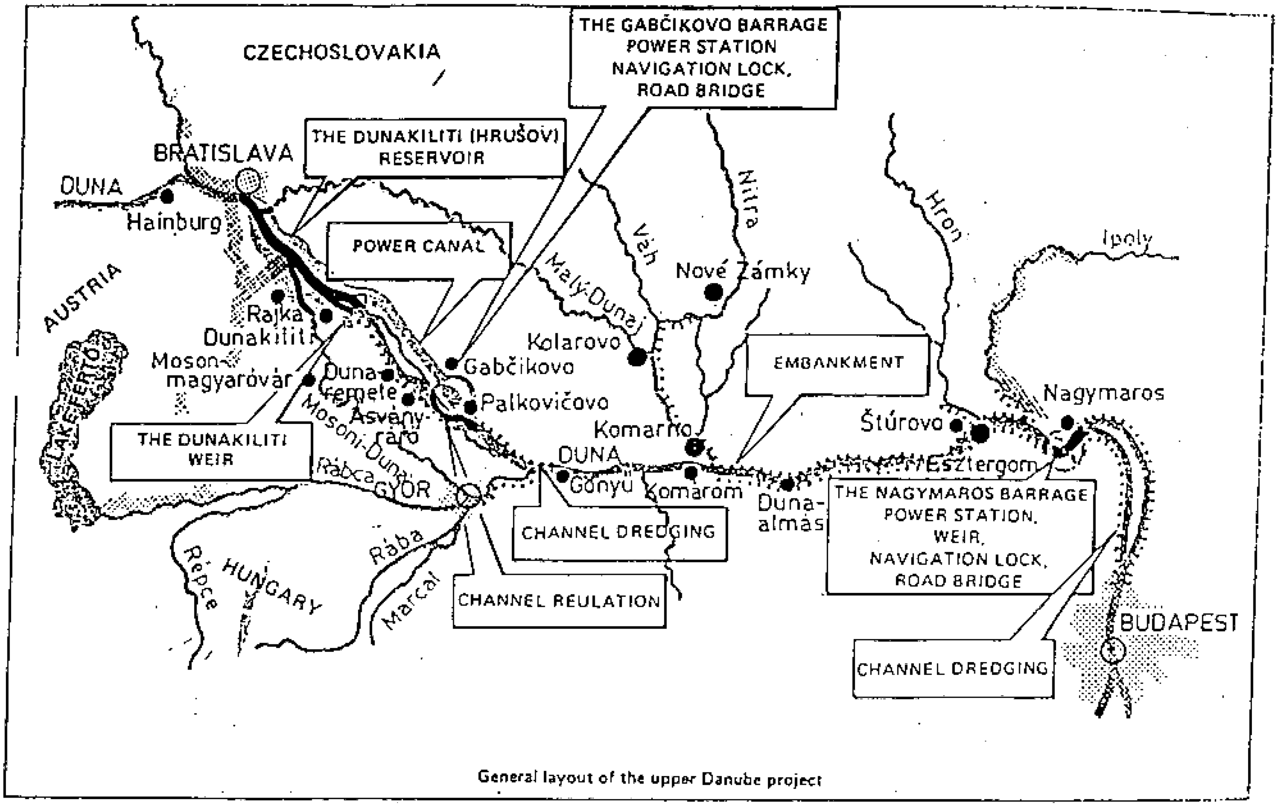

Figure 1. General Layout of the Upper Danube Project
(Reprinted from Gabcikovo-Nagymaros: Environment and River Dams; Edited by Imre Dosztanyi, 1987).

I. Overview

In October 1988, a team of ten American scientists, engineers, and planners traveled to Hungary to review and evaluate the Gabcikovo-Nagymaros Barrage (GNB) project. Through conversations with government officials, Hungarian Academy of Sciences personnel, and scientists, the team prepared both general policy recommendations and specific mitigating measures to address environmental damages the project might cause.

The concept for a large international barrage project along this stretch of the Danube dates back to the 1950s. The decision to build the GNB system was formalized in 1977, when Hungary and Czechoslovakia signed an agreement aimed at improving navigation on the Danube and generating hydroelectic power. The scheme involves the creation of three dams and alteration of some 190 km of river. The first dam will create a large storage reservoir at Dunakiliti, east of Bratislava. Below this reservoir, a concrete canal, 15 m deep and 750 m wide, will divert nearly all of this water away from the Old Danube streambed for a distance of approximately 32 km. A second dam at Gabcikovo will create a 21 m drop where turbines will generate peak-load energy. The canal rejoins the original river channel about 8 km below Gabcikovo. The third dam at Nagymaros, some 200 km downstream, will contain the water surges emitted at Gabcikovo and generate additional hydroelectric power through an 8 m drop. The three dams represent two different modes of operation: the Dunakiliti and Gabcikovo dams will be operated to meet peak demand; the Nagymaros dam will be continuously operated. Thus, over the daily cycle, water will be stored behind the first two dams to be released during periods of peak demand.

Our team was invited by INFORT (INFORMACIOS RENDSZER TECHNIKA) to provide advice to the Government of Hungary and the Hungarian Water Industry on strategies for the mitigation of potential environmental impacts of the GNB project. The agreed-upon scope of work did not include a reconsideration of the decision, made just prior to our arrival, to proceed with construction of the project. We also did not attempt to evaluate the cost-benefit analyses completed by the Hungarian government, nor did we address the political issues involved in Hungary's decision to proceed; in neither case did we have adequate information to undertake such an analysis. Given the team's mandate and expertise, and the short duration of our field studies, our research and findings focus on some of the major environmental and social impacts that could result from the Barrage project. It presents recommended actions for reducing detrimental impacts, as well as for enhancing the potential economic development opportunities the project has to offer. The following discussion of the GNB project and recommendations for mitigating adverse environmental impacts *should, in no way, be interpreted as support for its implementation.*

Over the past few years, a growing number of issues concerning the environmental, social, and economic consequences of the GNB project have surfaced. In the course of our brief stay we reviewed available documents pertaining to the project, interviewed key project officials, scientists, and other concerned parties, and visited both the Dunakiliti and Nagymaros sites. From this information, and the team's experience in engineering and resource management, we believe that effective steps can be taken to address some of the major concerns over environmental degradation. Although a great deal of construction has already taken place, and key structures are nearing completion, flexibility in project design and operation will permit mitigation of some adverse environmental impacts, provided that this flexibility is used to address the identified resource issues. In so doing, Hungary can better obtain the navigational, hydroelectric, and economic benefits expected of this project, while lessening many of the project's adverse impacts.

In reviewing the project and information gathered during our visit, we feel it is essential that four conditions be met prior to putting the system in operation:

- installation of a monitoring system to track water quality, at least five years prior to barrage operation, to create a baseline set of data;
- development of a 3-dimensional computer modeling system to better understand the complex operation of the river system, such as the movement of pollutants to, and within, the groundwater;
- establishment of a Geographic Information System to integrate the data collected from the monitoring and modeling systems, and to facilitate spatial evaluation of the potential consequences of the project; and
- formation of an independent water authority (the proposed Gabcikovo-Nagymaros Environmental Commission) to evaluate and comment on decisions made about the project, and to serve as a public forum for information dissemination and exchange.

Each of these ideas is discussed in greater detail later in this report. Only through their implementation, however, will Hungary make steps towards balancing the potential benefits of the GNB project with mitigating the adverse environmental impacts that may result from project construction and operation.

II. Potential Benefits of the Gabcikovo-Nagymaros Barrage Project

The GNB project is projected by the Government to produce three main benefits for Hungary: improved river navigation, electric power generation, and flood control. The lower dam will also serve as a important highway bridge linking Nagymaros and Visegrad.

Navigation: At present, navigation along this stretch of the Danube is restricted, especially in the region between Bratislava and Komarov, due to shifting sandbanks. Low water in late summer and fall further limits ship passage. The Gabcikovo-Nagymaros project will create a 22 km long channel permitting deep water navigation to Bratislava. According to Hungarian reports, this will extend the annual navigation period by 40 percent, tripling cargo traffic on the Danube. The value of this to Hungary, however, will depend on the development of a Hungarian shipping industry and trade connections with the West, which will require major additional investments of time and money. Although Hungary currently accounts for only 9 percent of all shipping on the Danube, the eventual opening of the Rhine-Main-Danube canal could benefit Hungarian shipping since water transport is considered a cost-effective means of moving industrial products.

Electrical Output: The two power plants in the system--at Gabcikovo and Nagymaros--are expected to produce an average of 3,675 GWh annually. Czechoslovakia and Hungary will share equally in the output from Gabcikovo; at Nagymaros, Hungary will export approximately 1,200 GWh per year for 20 years to Austria as reimbursement for its financial assistance in building this barrage. The bulk of the power received by Hungary will be delivered during peak load periods; thus it will be more valuable than the base load power Hungary will deliver to Austria. Beginning in the year 2015 when deliveries to Austria end, the completed system is expected to provide 2 to 3 percent of Hungary's energy needs. Although this is only a small percentage of Hungary's power requirements, the project could facilitate Hungary's connection to the international energy grid.

Flood Control: Flooding occurs regularly on some of the flat reaches of the Danube, especially in the Szigetkoz region which was devastated by a severe flood in 1956. Most areas through the reach of the project are currently protected by a system of dikes. However, the continuous build-up of the Danube bed through silt deposition reduces the safety of the existing dike system. The new dikes to be built as part of the GNB project, with 2 meters of freeboard, are projected to increase flood protection and represent substantial cost savings from prevented flood damage. In addition, a thorough inspection and analysis of all the dikes may assure residents and shipping interests of their safety and ability to withstand surges created by peak power operation at the Gabcikovo station.

In addition to these three goals, regional economic development offers Hungary the potential to realize significant secondary benefits from the project. These are benefits that could be realized from the variety of economic activities stimulated or induced by the presence of the project. Although realization of the full potential of these secondary benefits may require additional capital investment, the net advantages to be gained will contribute substantially to the financial success of the project and to the Barrage system's true value to Hungary.

The economic development opportunities that may be realized from the Gabcikovo-Nagymaros Barrage system fall into three major categories: ports and ship building; water-related industries; and recreation and tourism.

Ports and Ship Building: The projected increase in river traffic from improved navigation will generate a variety of economic development opportunities. Komarom and Esztergom have the potential to become river ports where products can be assembled from the interior, stored, and shipped out on barges to other Hungarian cities, as well as to international destinations. Equally important may be the off-loading and regional distribution functions that these port cities could perform. Servicing the barge fleets and tug boats with supplies, fuel, labor, and repairs could also become important local industries. Ship building is a logical extension of the port's service functions. All these activities could generate jobs and income for local residents, as well as enhance the regional economy.

Water-related Industries: New industrial uses tied to ports on the Danube are possible. Industrial opportunities may be linked with the comparative transportation advantages of newly-developed ports. For some businesses, access to improved navigation capacity on the Danube may be a critical locational determinant. In other cases, the availability of a permanent pool behind the Nagymaros dam will stabilize water deptH thereby enabling large water-using industries to operate in this region. (In either case, improved water quality may still remain a limiting factor.) Industrial opportunities could be related to local resources--food processing, for example--or be entirely new to the region, supportable upon completion of the entire project as bulk materials could be shipped in cheaply for processing and distribution on the river or by land.

Recreation and Tourism: The greatest--and, at present, seemingly unrealized--oppportunity inherent in the Barrage system is for expanded recreation and tourism. The Danube west of the Bend is now used predominantly by local residents and hosts few formal recreational facilities. Improved benefits (including lake formation) from this project would require the inclusion of recreational uses as one component in the Barrage Project's overall plans: Access to the river and newly-formed lakes for swimming, camping, fishing, and boating, as well as steps to improve water quality, should be formalized in local and national plans. The experience at Lake Balaton provides some measure of the potential human and economic benefits that could accrue from such action.

Tourism is one of Hungary's largest industries and the attractive power of the Danube and its history is widely recognized. The tourist benefits could be focused at strategic points such as dams and locks, power houses, and lake-side visitor centers. Experience at the Tennessee Valley Authority (TVA) in the southeastern United States indicates tourists are interested in understanding the dam facility, how it operates, and how it was built, as well as enjoying the scenic and lakeshore opportunities it presents. In addition to parks, camp sites, rental cabins, and marinas that serve mainly local residents, the major dams within TVA have observation areas where visitors can watch the locking-through of boats. Visitor Centers offer interpretative material regarding the engineering and operation of the entire waterway, including tours of the waterhouse and how electricity is made. Each year over 6 million people visit TVA's dams, which, in turn, has generated the need for tourist support facilities and services. The economic benefits captured by these types of tourist services could be projected for the barrages at Dunakiliti, Gabcikovo, and Nagymaros.

III. Costs and Impacts of the Barrage System

The potential benefits and economic development opportunities offered by the Gabcikovo-Nagymaros system are balanced by serious concerns over the ecological impacts that are also likely to result. Foremost among these is the potential for damaging the Little Hungarian Plain aquifer, as well as municipal water supplies for Budapest and dozens of small villages perched along the Danube. The destruction of significant archaeological and cultural resources, and disruption of large expanses of floodplain habitat and associated fisheries, are also major threats.

The recommendations listed below outline potential problems and how some of these may be mitigated.

Recommendation #1: Establishment of a new Gabcikovo-Nagymaros Environmental Commission

We believe the government can increase confidence in protective measures favoring the environment by creating a special Gabcikovo-Nagymaros Environmental Commission to advise the operating company and the government about matters involving the monitoring of environmental impacts and the implementation of mitigation measures required to offset adverse impacts during project construction and operation. Such an advisory body, to be effective, must represent the full range of environmental concerns affected by the project, and must have free access to knowledgeable persons and data in the custody of the government and the operating entity. It must be appointed by a Ministry-level official, have clearly-defined responsibilities and authorities, and have a small staff that is technically qualified in both environmental science and engineering. The Commission should report at regular intervals to government officials and the Parliament and should conduct periodic public hearings to transmit information and receive public comment. An important function will be to serve as a forum for public input and information dispersal.

Recommendation #2: Project Control, Monitoring Systems, and Planning

To achieve Hungary's environmental protection goals for the Danube basin, a management information system, including a Geographic Information System, is needed to organize and facilitate analysis of data currently available, and to incorporate new baseline environmental information (such as groundwater and ecological data), derived from monitoring operations. Without such a system it will be difficult, if not impossible, to accurately track environmental degradation. This only highlights the necessity of having monitoring programs in place prior to start-up of the system to provide baseline information.

This information management system should consist of three components:

o a computerized Geographic Information System (GIS) for the storage, manipulation, analysis, and display of spatial data, including data acquired through remote sensing/aerial photography. This system will also facilitate the study of land-use change throughout the region. A GIS would integrate, and provide access to, all environmental and spatial data needed to make the most efficient use of the barrage system, while protecting important natural and cultural resources.

  The use of a computerized information system could aid the proposed Gabcikovo-Nagymaros Environmental Commission and other decision-makers in developing the comprehensive data base needed to evaluate potential environmental mitigation measures, and in facilitating the planning of economic development and tourist/recreation projects along the Danube Corridor. In the next few decades the Gabcikovo-Nagymaros project will provide Hungary with opportunities and dilemmas; an ongoing planning effort is needed to optimize the secondary effects--positive and negative--on the Danube corridor. GIS is the most efficient tool available today to aid planners and designers in this effort.

  GIS-based planning is valuable on several fronts:

  o It can store all relevant information in a data base for easy retrieval, manipulation, and updating. During our review in Budapest we found the majority of specialists had prepared their own maps for their particular disciplines. They had limited access to the entire matrix of spatial data needed to evaluate a project of this magnitude.

  o Computerization using a GIS provides ready access to a comprehensive database for analysis of individual maps at any scale. More importantly, if located in a network, all users can have access to the entire data base.

  o Computer-aided planning and management has the potential of improving communication among engineers, scientists, planners, government officials, and the general public. The computer's ability to generate alternate plans quickly means a number of scenarios can be examined; thus it can aid in the evaluation process of finding the most feasible and the most publicly acceptable alternatives, and involving impacted communities in the decision-making process.

During our trip we learned that INFORT recently acquired a GIS package (ARC-INFO) on a PC workstation, giving it access to the latest technology to conduct computer-assisted planning for environmental mitigation and economic development. The "user-friendly" nature of this system will also facilitate technology transfer with the West. In short, given the current status of computerization of spatial data and planning worldwide, and the present capabilities of INFORT (and some state universities), Hungary should use this technology to conduct computer-assisted planning for environmental mitigation and economic development. The comprehensive planning needs associated with the GNB system make it an ideal candidate for implementation of a GIS-based planning and management program.

- a scientific monitoring system with check stations at numerous sites to detect changes in river and groundwater quality, anaerobic conditions, and the like, factors that serve as a warning that the system is not working and that resources may be threatened. It is the team's understanding that the government agreed several years ago with scientists' recommendations to install a system to monitor water quality at least five years prior to the system becoming operational in order to generate baseline monitoring constants, and we firmly believe this agreement should be faithfully carried out.

- an integrated modeling system employing the latest available technology to store and process data from the monitoring stations, and other information. This system should be able to run advanced simulation models reflecting river flows, contaminant dispersion, sediment transport, groundwater flows, and the like, to provide a better understanding of the impacts from the barrage operation. Such a system could, for example, address conflicting views over the engineering suitability of the Nagymaros site for hydroelectric power generation. Existing engineering reports indicate that this is considered the optimum site to achieve maximum energy gain and navigation at the least cost. However, Viktor Romanenko of the Ukranian Academy of Sciences, recently noted that newly-available data from Soviet rivers show that large dams on rivers in flat terrain are damaging and unlikely to meet their costs in electrical output. Simulation models might be used to clarify the necessary conditions for balancing energy production with resource protection.

Recommendation #3: Water Pollution Control and Water Supply Protection

The damming of a river has a profound effect on nearly all aspects of water quality, and consequently on the ecology of the riverine flora and fauna and on human use of the resource. The Danube is currently plagued with serious industrial and domestic waste problems, especially as it flows east from the Czechoslovakian border. Major contaminants include municipal sewage, heavy metals, nutrients, oil, chemicals, and paper mill wastes. Estimates are that 2 million tons of wastes are generated annually. The primary sources of pollution are discharges from Bratislava and several other Czechoslovakian cities bordering major tributaries; at present, less than half of Bratislava's industrial or household wastes receive any treatment, and just over 2 percent is considered "pure" upon release. In Hungary, five cities have been identified as major waste outfalls, notably Gyor. Another trouble spot will be the Old Danube channel, where river flow will be so reduced because of the canal diversion, that wastewater will compose a majority of the river's flow.

Contamination poses a serious threat to municipal water supplies throughout the Danube Corridor. Although the construction and operation of dams at Dunakiliti, Gabcikovo, and Nagymaros may exacerbate water quality problems, it is clear that the dam system is neither the cause of, nor the solution to, the River's pollution problems. Thus, a top priority must be reduction of the total pollutant load entering the Danube. Municipalities must achieve secondary treatment of wastewaters (removal of solids and biological treatment to oxidize organic compounds to inorganic compounds), while industrial wastes should be treated at the "best practicable" level given available technology. Modeling studies could play a fundamental role here in evaluating the benefits of tertiary treatment for nutrient removal, or in evaluating the health hazards posed by particular wastes. Industrial and municipal sewage treatment facilities in Czechoslovakia and Hungary, both upstream from and within the project area, should be constructed on an accelerated schedule, designed to abate contamination to the lowest possible levels. Completion and operation of dam facilities should be linked to major progress in developing upstream wastewater treatment works. The recent announcement by the Czechoslovakian government that it has no money for sewage treatment only highlights the need for the Hungarian government to consider this a <u>mandatory prerequisite</u> prior to the system becoming operational. The potential threat of contaminating its groundwater resources and municipal water supplies is too great a risk not to take action.

Other water quality issues may arise from impoundment behind the Dunakiliti and Nagymaros barrages. Flattening of tributary stream gradients will reduce energy in these streams and increase their rate of sediment deposition. Nutrient concentration behind the dams may lead to algal blooms and other eutrophication problems. Impoundment would improve water clarity through sedimentation, although the short residence time for water in the reservoirs may well be insufficient for blooms to develop. The clearer water will, in turn, have an increased capacity to erode the river bed downstream, possibly leading to a deepening of the channel. The stated plan to rapidly draw down the reservoir under conditions of algal bloom (which assumes surface withdrawal) is contradictory to efficient operation for peaking power and consequently may not be practiced; it also has great potential to expose hypolimnetic waters. Improved clarity in waters flowing downstream may also increase algal productivity in these waters, especially in relatively stagnant areas such as around the diversion dike at Dunakiliti. Mitigation through increased flow through this region would most likely be needed during the summer. This would also augment the flow of water into the Old Danube channel, a desirable feature for maintaining the floodplain ecosystem (see Recommendation #4).

Concerns have been expressed that heavy metals and other pollutants now carried downstream and somewhat diluted by the river, will settle in the reservoirs, and are likely to seep down and enter the groundwater. Development of an anaerobic layer at the reservoir bottom will allow heavy metals to dissolve from deposited particles, increasing the likelihood of groundwater contamination. Beneath Bratislava and the reservoir at Dunakiliti lies one of central Europe's largest aquifers--a 50 km wide gravel belt containing 10 to 14 billion liters of pure water, enough to supply 3 to 5 million people per day. It is also the most significant source of groundwater in Hungary and a back-up water supply for Budapest, should its wells be damaged by excessive dredging or contamination. Clearly the Little Hungarian Aquifer is a resource of regional significance. Already the southern part of the aquifer has been damaged by tailings from bauxite mining. Concerns have been expressed that the raised water surface in this reach will only increase pollutant inflow into the aquifer. Studies at Vienna's Ecology Institute conducted on small artificial lakes on the Danube in Austria suggest that 3 to 4 million m^3 of sediment will be deposited annually in the Dunakiliti; this material, laced with heavy metals and bacteria from contamination upstream, will eventually percolate into the natural aquifer, causing serious, possibly irreversible, contamination problems.

The same concerns apply at Nagymaros, where the pollutant load of the Danube is elevated by incoming water from polluted tributaries. The reduced flow will allow pollutants to settle on the riverbed and seep into the underlying aquifer. In this area, concern over Budapest's water supply is of utmost importance.

A detailed three-dimensional computer groundwater model is needed to better understand the potential for damage here. Such a model could reflect the various contaminants that might occur in the reservoir and, with reasonable accuracy, show the dispersion of pollutants and their concentrations at various points downstream in the groundwater. Development of a modeling system based on measured organic loads, expected residence time, and water circulation patterns, should permit reasonable approximation of dissolved oxygen concentrations in reservoir bottom waters. After reservoir filling, dissolved oxygen should be monitored routinely, especially during the summer months. Eminent loss of all dissolved oxygen in bottom waters can be mitigated by small releases at the dam bottom into the Old Danube channel; these releases should be mixed with surface water to avoid deoxygenation of downstream water. Such a model, combined with monitoring groundwater levels and quality at a number of points, could be used as a management tool to track and characterize contamination.

If groundwater contamination is occurring, two major avenues for mitigation exist. One would be treatment of water drawn from the aquifer to the extent needed for the purposes of the withdrawal. The other is increased treatment at the pollutants' source. In the short term it may be less expensive to simply cleanse waters as they are withdrawn from the aquifer. However, the cost of long-term degradation of the groundwater may be very high, particularly if pollutants enter the aquifer which are not amenable to treatment. This points to the necessity of establishing a monitoring system prior to operation of the system to be able to monitor the present and future groundwater quality.

A third water quality issue is the potential contamination of bank-filtered wells. It has been estimated that 45 percent of Hungary's drinking water is derived from water filtered by sands and gravel along the bank and bottom of the Danube. This is an especially serious concern for the city of Budapest, whose municipal wells are fed through bank infiltration. Bank infiltration depends on both a high concentration of oxygen and a low concentration of organic matter; the relative concentration of these will be reversed by the canal and dam operations. In the past, fine sediments were replaced by normal river flow; the dams will deprive the river beds of these fine-grained sediments, preventing re-establishment of the natural river bottom filter zone. This, in turn, will cause a half-meter average drop in the river surface, reducing water supplies from bank infiltration wells.

Dredging to improve the navigation channel will also damage the existing filter layer, allowing pollutants to enter nearby water supplies. Already small increases in contaminants have been noticed since dredging began in the stretch below Budapest. The thick bottom layer of gravel provides important filtering and biological treatment of river water. Present dredging operations remove the gravel but simply disturb the silt and displace it downstream. Dam construction, however, will necessitate further dredging to improve navigation below Nagymaros and to increase the dam head. No dredging should be permitted until a detailed investigation of groundwater contaminant flow is conducted to set rational limits on gravel removal.

After dam construction it will be necessary to remove silt collected above the dams. Techniques should be used to remove the silt--but not the gravel--to a secured sludge repository where contamination of water supplies cannot occur. Current estimates are that the Nagymaros dam will need dredging every 10 to 15 years. Upstream pollution abatement will minimize the need for careful disposal of dredged silt. In addition, deposition of river gravel should be monitored and removal limited to the amount deposited in the same period; additional gravel removal will only lower the watertable and increase the possibility of contamination breakthrough. Mitigation could involve a halt to increased dredging operations, although this would reduce navigation depth in this reach and somewhat lower the electric power output at Nagymaros. Alternatively, well water could be treated before distribution into Budapest, with the associated increase in costs.

Recommendation #4: Old Danube Channel-Szigetkoz Ecosystem Protection

For a 130 km stretch of the Danube between the Dunakiliti barrage and Komaron, over 97 percent of the river's natural flow will be diverted into the power canal. The ecological consequences of this diversion will require sensitive management. Areas affected will include the riverine forest between Bratislava and Komarom, wetlands of international importance, fisheries, agricultural lands, and the peatlands south of Moson-Nagymaros. Direct impacts will result from barrage and dike construction, flooding and disposal of dredged material, and construction of new residential-recreation areas. Indirect impacts include changes in surface and sub-surface hydrology due to impoundment upstream, and diversion of surface water flows.

I. Riverine Forest: The riverine forest between Bratislava and Komarom consists of four major tree associations: Salici-Populetum, Fraxino-Ulmetum, Ulmo-Fraxinetum, and Crataegus danubiale. One of the most productive forests in this part of Europe, it supports an especially wide variety of bird life. Of the 60 species which nest there, 25 are considered to be rare or declining. The most extensive direct impact on the riverine forest appears to be construction at Dunakiliti, and the forest clearing necessary to create the reservoir pool. Other direct impacts will result from construction of residential/recreation areas in the forested area directly below the Dunakiliti barrage, the construction of new dikes, and flooding at the upper end of the reservoir pool above the Nagymaros barrage. Published reports indicate plans to construct many small dams among and across the oxbows and side channels that border both sides of the Danube between Dunakiliti and the power canal outlet. Their purpose is not clear and they will likely adversely impact both terrestial and aquatic ecosystems.

Indirect impacts will result from reduced flow in the Danube downstream from the Dunakiliti impoundment. With diversion of water into the power canal, the existing Danube will be carrying, during average and low flow periods, only the flow of the bulb turbine at Dunakiliti and seepage from that site. Projected river flow will drop from 2000 m^3/second to a minimum of 200 m^3/second; the resulting conditions will simulate drought for the riverine forests, which have been shown to start to dry out at flow rates of 600 m^3/second, sometimes with irreversible damage. Decline in the subsurface water table directly downstream from the Dunakiliti barrage to Nagymaros in Hungary and Cicov in Czechoslovakia will also have negative consequences. For example, the eastern edge of the Szigetkoz below the Dunakiliti barrage and adjacent to the Danube is within the area predicted to experience a 5 to 6 meter depression in groundwater levels. Portions of the Szigetkoz were designated as a Landscape Protected Area in 1986, established to protect the characteristic landscape of the floodplain. It is our understanding that an irrigation system is planned to mitigate the adverse effects on groundwater depletion, but adequate information was not available for our team to evaluate the effectiveness of this approach.

In the normal course of events, the riverine forest, oxbow lakes, and side channels act as sites where flood waters deposit sediment and associated nutrients on an annual basis. A portion of these are incorporated into the substrate of the forests and wetlands, taken up by the vegetation and transformed into gases and insoluble compounds. In this fashion, the riverine forests and wetlands act to maintain water quality in the Danube. Loss of this natural treatment means that pollutants will more readily collect in sediments behind the dams and require costly removal--and treatment--by artificial measures. The no-cost water treatment function will now be transferred as an expense to be met by artificial treatment plants up or downstream. In addition, lower fertility due to reduced flooding in the Old Danube channel will probably eliminate some tree species, with a change in forest composition toward the less productive forests types found on drier upland sites. Small river tributaries are especially dependent on allochthonous inputs (inputs derived from the surrounding watershed and not generated internally within the river) of energy and nutrients. It will be important to establish which tree and bird species are most sensitive to change, and to incorporate them as factors in a management and monitoring system.

Mitigation of impacts on the riverine forest ecosystem will be difficult. It may be possible to establish some forest regeneration plots that resemble the natural community either in the narrower Danube floodway or on sites constructed from dredged material. However, it appears likely that there will be a major net loss of riverine forest. Alternative sites for residential-recreation development should be selected to eliminate further destruction of the forest community.

As much as possible, the river banks and floodplain should be managed to provide corridors and travel lands for terrestial and aquatic wildlife and fish, connecting natural areas together across lands used more intensively by humans. This may be accomplished, in part, by restricting development close to the river to those activities that are truly water-dependent. Boat marinas require waterfront development; homes and shops, while they may be desirable near the water, do not have to occupy waterfront locations. Creative engineering and landscaping design can often provide natural corridors even where human activity is intense.

Sensitive and complex management of water releases will be the most important and effective means to reduce adverse impacts on the riverine forest and aquatic ecosystems. The Dunakiliti barrage is being constructed in a manner that will permit release of significant amounts of water to achieve mitigating objectives. Several sources of water can be managed to reduce the impacts: seepage canal flows, small turbine flows, releases above needs for hydropower and navigation, and release of excessive flood flows. It will not be sufficient, however, to simply release water at times when there happens to be flow exceeding one or two project objectives. The amount of water to be released needs to be timed in concert with the seasonal life cycle requirements of the most sensitive aquatic and riverine forest species. The fact that there are several sources of flow suggests a greater opportunity to design acceptable release strategies. To achieve this will require a timely and reliable set of data from monitoring points, plus an information management and modeling system to develop, produce, and test alternative water management options. This will need to be incorporated into the daily management of the entire system from Dunakiliti and Nagymaros.

II. Wetlands of International Importance: The series of oxbow lakes and side channels that occur in several locations along the Czechoslovakian side of the Danube have been listed in the UNEP/IUCN (United Nations Environment Program/International Union for the Conservation of Nature and Natural Resources) Directory of Wetlands of International Importance in the Western Palearctic. Included are the oxbow lakes and side channels at Dedinsky ostrov (island), Isreakov, Cicov, Maly ostrov, Velky Lel, and Apali. These natural areas are enriched by river water high in calcium carbonate through periodic silt deposition during flooding. They are rich in game animals and are important breeding sites, especially for cormorants, purple heron, great white heron, pochard, and bearded tit. Associated with these natural areas are the reserve at Zlatna na Ostrave, protecting the rare Great Bustard, and the reserve near Gabcikovo protecting the threatened white-tailed sea eagle.

These important wetlands will be directly impacted by power canal construction at its junction with the Danube (Dedinsky ostrov), construction of a new dike across the lakes at Cicov, flooding from the Nagymaros pool at Maly ostrov, a new dike and proposed recreation area at Velky, and construction of a dike in the Zlatna na Ostrave reserve. A small reserve, comprising about one-third of the oxbow lakes at Topolovec has been directly impacted by canal construction below Gabcikovo, and other similar lakes have been impacted outside the reserve as well. The Gabcikovo, Dedinsky ostrov and Cicov sites are all within the area in Czechoslovakia that will experience groundwater depression and associated indirect impacts.

It should be possible to mitigate direct impacts at some sites through re-location of dikes or modification of their design. Unfortunately, our information base was inadequate to further examine this option.

III. Fisheries: According to recent ELTE (Hungarian Academy of Sciences) data, 59 species of fish are reported from the Hungarian Danube. Although detailed listings were not available, data on the commercial catch indicate that it is dominated by bream (Abramis brama dunabi), ranging from 60 percent by weight in the main Danube to 90 percent in the Szigetkoz (Table 1). The entire Hungarian Danube provides a commercial catch of 985,306 kg of fish; of this, 14.1 percent is provided by the Szigetkoz region and another 2.5 percent by the Mosoni-Danube. The productivity of the Szigetkoz is further supported by data which indicate it is the location for 80 percent of fish spawning in the Hungarian reach of the Danube.

Crucial to understanding the effect of barrages on the continued existence of fish species is the interrelationship between water flow and fish biology. Many species of fish require riverine flow and a sandy or gravelly substrate to successfully spawn or to provide appropriate habitat for food resources. Of the commercial catch, 5 fish species are strictly riverine. They comprise 64 percent of the commercial catch in the main river, and 93 percent and 82 percent of the commercial catch in the Szigetkoz and Monsoni-Danube, respectively (Table 1). These fish species will probably not continue to exist in areas where they are presently found if flow is impounded or drastically reduced.

Table 1. PERCENT COMPOSITION OF THE COMMERCIAL FISHERIES

		River Stretch[1]			
Species Name	Common Name	1	2	3	4
Abramis brama danubi	Bream	59.2	63.9	89.6	74.7
Acipenser ruthenus	Sterlet	0.2	0.0	0.05	0.0
Aspius aspius	Rapfern	1.2	2.1	1.7	1.0
Barbus barbus	Barbel	1.6	3.1	1.9	5.7
Silurus glanis	Sheatfish	0.7	0.7	0.2	0.7
Total Riverine		**63.6**	**69.8**	**93.5**	**82.1**
Anguilla anguilla	European Eel	0.3	0.0	0.03	0.1
Carassius carassius	Crucian Carp	1.9	0.6	0.2	1.1
Cyprinus carpio	Common Carp	18.6	18.6	1.6	8.7
Esox lucius	Common Pike	3.7	3.8	3.0	5.0
Ictalurus nebu	Channel Catfish	3.5	0.0	0.0	0.0
Stizostedion lucioperca	Pike-perch	2.3	1.4	1.5	2.5
Tinca tinca	Tench	0.1	0.2	0.1	0.3
Total Riverine/Lacustrine		**30.4**	**24.6**	**6.4**	**17.7**

[1]Annual fish catch for last decade on:
1. Whole Hungarian Danube Section
2. Slovakian-Hungarian Section
3. Szigetkoz Section
4. Mosoni-Danube Section

The effects of the Gabcikovo-Nagymaros project on fish species will vary depending on the stretch of the river: the section that will become a reservoir above the Dunakiliti barrage, the Szigetkoz; and the main river below the power canal outlet.

Dunakiliti Reservoir: The Dunakiliti barrage will create a 16 to 20 km long reservoir, holding 240 million m^3 at maximum storage, with an estimated flushing rate of 48 hours. Maximum depth will be 16 meters above the present river depth. Because the reservoir outflow will be from the surface, this depth may be sufficient for stratification to occur and for anaerobic conditions to develop in the isolated bottom waters, although the short residence time of water makes a detailed hydrological analysis necessary.

Impoundment usually results in the demise of fish species dependent on a lotic or running water environment, and the increase--often explosive in the first few years--fish species typical of lakes. Many of the most abundant species existing in the Danube are those able to exist only in flowing waters. Several species normally found in the Hungarian section of the Danube require sand or gravel bottom habitat for spawning. Such habitat will not exist in the Dunakiliti impoundment. Others require a stable shoreline water depth during spawning. Similarly, these species will not successfully reproduce because of the large daily fluctuations in water level resulting from operation of the Gabcikovo power plant for peak power. In addition, the high rate of sediment deposition (5 to 9 cm/year) will blanket spawning areas tha occur below the level of water fluctuation. The most abundant lentic or lake fish species in the Danube is the carp. Interestingly, the carp is considered less desirable in the United States and the best available management technique to control or eradicate the carp is to fluctuate the water level during the spawning season. Clearly, water level fluctuation inherent in barrage operation will have the same effect in the Dunakiliti Reservoir. Thus, the fishery resource in the impoundment will be largely restricted to fish which may move temporarily downstream from riverine areas above the reservoir, or those which may be introduced by man.

Mitigation measures might include sediment control in selected potential reservoir spawning areas, conversion to continuous power generation to avoid water level fluctuations, or temporary switching to continuous operation during the major spawning period. If hydrological modeling--or empirical evidence after barrage operations begin--indicates anaerobic conditions are developing in bottom waters, limited release of bottom water, mixed with sufficient surface water to avoid dissolved oxygen problems downstream, should be practiced. Mitigative measures cannot restore strictly riverine species to this stretch, but appropriate measures should provide a reasonable lacustrine fishery.

Szigetkoz Region: The Szigetkoz region accounts for 80 percent of fish spawning and is home to 14.1 percent of the commercial fish catch in the Hungarian stretch of the Danube. Eliminating the flow of water necessary to support the floodplain ecosystem will undermine the productive base of the entire river.

Functioning of the GNB system relies on peak flow. If the turbines at Gabcikovo were to produce electricity constantly, the present minimum flow through the Szigetkoz could be maintained, reducing what is considered to be the most detrimental of all the project's environmental effects. Reduction in average flow will cut spawning rates; lack of recruitment will lower standing crops of fish in the Szigetkoz as well as in the main river channel. Water diverted through the canal will mean that the normal river flow through the Szigetkoz, the last remaining shallows on the Danube, will be reduced to approximately 1.5 to 7 percent of the present average flow. There is some question as to whether this flow will be sufficient during the dry season to maintain running water in the Szigetkoz stretch or to support populations of fish and other aquatic organisms. Expected alteration of the groundwater level in the region will further reduce groundwater seepage supply to lower regions of the Szigetkoz, and because the upper groundwater layers are somewhat polluted, may further degrade water quality.

Main River below the Power Canal, the Nagymaros Barrage, and Downstream: Below the confluence of the power canal with the Danube at Komarom, the primary effect of the Dunakiliti-Gabcikovo barrages will be to increase water depth and water level fluctuations. To generate peak power loads, water released through the canal will need to be 1.5 meters above its natural level. This will require the banks of the river as far as Nagymaros be built up to compensate for these regular surges. Not only will this interrupt the natural functioning aesthetics of the river, but the erosive forces of water against the river banks will result in soil erosion and increased siltation clogging the natural bank infiltration system. If the pulse from water released at Gabcikovo can be observed 200 km downstream at Nagymaros, it is likely that the region just below the Gabcikovo dam will be severely impacted. Silt and gravel will be deposited downstream where the water is sufficiently slowed by the Nagymaros barrage. The sediment load, however, will only be that which occurs in the scouring zone immediately below the power canal confluence. No major impacts on the fisheries are expected from the operation of the Nagymaros barrage because sediment deposition and water level fluctuation will be less than in the Dunakiliti barrage, and the area is not considered a primary spawning area.

IV. Agricultural Lands: The Little Plain is a highly productive agricultural area, supporting both large farms and smaller cooperatives. There was not sufficient time nor information available during our trip to assess the direct effects of flooding or construction on agricultural lands. Nonetheless, some important points stand out. Nearly 100 square km in Hungary and Czechoslovakia will be lost to construction or inundation by the GNB project; nearly 50 percent of this is prime agricultural land. The canal diversion will result in a lowering of the watertable by 5 to 6 meters, resulting in groundwater depression that affects area wells. This could make irrigation necessary for some agricultural enterprises; while most of the larger farms are already irrigated, the largest threat is to the small cooperative farms that provide the majority of local market produce. Since the reported rate at which subsurface water moves laterally in this region is unusually high, changes in the amount and quality of water entering the subsurface aquifers in this area could have marked impacts on the future viability of farming. Lack of time and information prevented our evaluation of the proposed irrigation system.

In addition to areas predicted to experience groundwater depression are those where groundwater levels are expected to rise due to the higher head in the reservoir pool above Dunakiliti. Again, insufficient time and information prevented us from assessing how this might affect farming. Generally, wetter sites delay spring planting and may limit the growing season or types of crops grown. Construction of higher and new dikes along the river are designed to protect farmlands now subject to flooding and thus mitigate losses due to project construction. It will be important to assess the magnitude of this effect.

V. Peatlands and the Mosoni-Danube Flows: The large aquifer under the Little Hungarian Plain, including Szigetkoz and the Mosoni-Danube, is one through which large volumes of water pass at high rates of transmissivity. The system discharges to the surface in the large peatlands that lie south of Mosonmagyarovar and north of the Hansagi canal. Ditches now drain the peatlands south to the canal and the Rabca River, and west to the lower Mosoni-Danube.

An elevated head in the Dunakliti reservoir may lead to increased surface discharge of groundwater at this site, increasing surface saturation over long periods. Flows in the drainage ditches and receiving canals and rivers would likely increase. The confluence of the drainage patterns appears to be located near the city of Gyor. The consequences of this event cannot be predicted with the data available in our visit, but the implications for area vegetation and agricultural operations need to be examined. Because wetlands will be lost in other regions of the project, the potential for using any increased discharge to restore wetlands here should be explored as a mitigation measure. Restoration of former wetland sites offers a much higher probability of success than do efforts to create replacement wetlands on sites whose soils were not formed under saturated conditions.

Recommendation #5: Natural and Cultural Resources of the Nagymaros-Danube Bend Region

The natural, scenic, and historic resources of the Nagymaros region are of great importance to the Hungarian People, a national asset that cannot be expressed in terms of financial worth. The Danube Bend is also one of the most important tourist/recreation regions in Hungary, third only after Budapest and Lake Balaton. Its proximity to the capital city, magnificent scenery, and tremendous historical and cultural values have contributed to the present controversy over the project, perhaps to a greater extent than formally recognized. This region is surrounded by the highest mountains north of Budapest, and centered within the viewshed from the famous Fellegvar and Salamon Tower. There are more archaeological sites concentrated in this section of the Danube than anywhere else along the river. It is the location of numerous artifacts from the Middle Ages and was the landscape of King Matyas during the 15th century. Well before the renaissance era, this region was an important defense line of the Roman Empire; over twenty-four settlements have been discovered which date back to Roman times. The new impoundment is expected to flood dozens of these archaeological sites, and alter the natural shoreline to accommodate the rise and fall of the reservoir.

These resources raise many questions: Does the Nagymaros impoundment impair the view from the surrounding hills? Are the archaeological sites and remains invaluable resources, requiring full or partial preservation? Will alteration of the shoreline impair present--or potential--recreational opportunities? And perhaps most importantly, will the GNB project alter the quality of the region, reducing its value to the Hungarian people? In western Europe, North America, and Australia, these types of concerns have been investigated through perception studies, surveys, or public hearings. The concern of the Hungarian people for the resources in this area suggests such a study, perhaps under the auspices of the proposed Environmental Commission, is advisable here. This information would help the government, the Commission, and the Hungarian Water Industry better understand the depth of public sentiment toward the treasured aesthetic and cultural resources in this area, and the importance of taking proper mitigation measures.

Protection of the natural/aesthetic and historic/cultural resources of this area could be accomplished through several alternatives. The most radical would be elimination of the Nagymaros dam altogether; this would also reduce some of the navigational and energy benefits to be derived from the project. A second alternative would be to move the lower dam to Pilismarot, some 10 km west of Nagymaros and removed from the area with the greatest concentration of historic resources. Mitigation is also possible through changes in the operation at Gabcikovo to longer and lower peaks. However, only removal of the Nagymaros barrage from the entire system, despite the resulting reductions in power output and navigational improvements, will eliminate all concerns about maintaining the integrity of this region. The decision weighing the relative importance of historic and aesthetic values next to economic development is one that only the Hungarian people can make. Ideally, however, work on Nagyaros would be halted until a thorough assessment of its impacts and potential mitigating measures could be completed.

For the purposes of this study, the most valuable mitigation measure is establishment of public control over this significant natural and historic landscape. The most widely practiced and workable device for this type of landscape has been the creation of a National Park. If construction of the Nagymaros dam proceeds as planned leading to the unavoidable destruction of significant natural and cultural resources, adequate compensation must be made for this loss. Partial compensation could be provided through creation of a National Park, whose boundaries would include the riverfront, villages, and hills surrounding Nagymaros. A new park visitors' center would enhance public access to the recreational and cultural amenities of the region, and provide Hungarians and foreign visitors with a better understanding of the country's rich heritage. A portion of the National Park should be reserved for the relocation and display of historic and archaeological artifacts and structures that would be inundated by the new impoundment. Establishment of the Park should also involve reclamation of the surrounding hillsides from the unsightly recreation dwellings which have been erected in recent years, especially on the north side of the river. Mandatory park planning would be based on enhancing the landscape features of the Danube Bend while discouraging haphazard and inappropriate residential and commercial development.

Recommendation #6: Region-wide Planning for Coordinated Development

As discussed earlier, the Gabcikovo-Nagymaros Barrage System has the potential to provide important economic benefits to Hungary. In order to realize the full economic benefits of the project and minimize the environmental impacts, a program of coordinated regional planning is essential. For example, plans and projects must be initiated to promote the region's economic development, taking into consideration opportunities to develop ports, ship building and related maritime facilities, and water-related industries. Plans will need to be prepared for ports and industrial sites that pinpoint specific locations, proposed capital improvements and schedule, and benefits. The river corridor has also been identified as having tremendous recreational potential (dependent upon improved water quality), as well as important historical artifacts and fragile ecosystems. This range of possibilities provides planners with conflicting demands over use of the resource. These other resources could be neglected, or even destroyed, by focusing solely on the maritime or water related industries without a consideration of the effect on the entire region.

Prior to undertaking comprehensive planning for a river corridor, a series of assessment studies would need to be completed for the entire Danube from Bratislava to Budapest. Baseline assessments should include:

- recreational resources assessment such as boating, fishing, camping, and picnicking;
- scenic resource assessment to aid in the protection of unique or scenic areas and in the recreational development of other appropriate sections;
- cultural, historic and archaeological resource assessment of the river edge and cities, villages, and former estates within the corridor;
- wildlife habitat assessment, including threatened communities, fish, and wildlife resources;
- agricultural lands assessment;
- tourism assessment;
- navigational assessment;
- water quality assessment for industry and recreation; and
- economic development assessment.

Assuming that a GIS database is created, the same informational data base could be used in the planning for water pollution control, water supply protection, ecosystem preservation, and tourism and recreational development on a regional basis.

Recommendation #7: Environmental Review Process for Future Projects

We recommend the establishment of a formal government policy for the review of proposed new activities, government actions, or projects which may have a significant impact on the environment. A review program should be the formal responsibility of an independent senior government ministry, probably the Ministry of the Environment.

An Environmental Review Program should include the following elements:

- a clear policy of minimizing harm to the environment;
- activities, programs, and projects subject to environmental review should be broadly defined;
- adverse environmental impacts should be assessed and a realistic estimate of mitigation costs included in proposed project costs;
- a notice of proposed activities or projects should be filed at the review office, with notice given to other interested officials and the public, to solicit their comments on the scope and content of the study;
- the form, content, and process for review of any project should be defined by regulation, adopted in the usual and customary manner. Persons receiving notification of a proposal should also receive draft environmental studies to which they are given ample opportunity to respond. The proponents should then be required to respond in the final report to every (written) comment made about the proposed activity, and include new data, alternatives, and cost-benefit calculations, if applicable;
- projects should not be allowed to proceed until an adequate environmental impact study has been completed and reviewed by the public and the environmental review office. The office should have authority to require monitoring and investigation procedures. The office could be granted the authority to deny approval to projects. For a study to be considered adequate, it must be comprehensive and realistic in its treatment of costs and benefits of the proposed action. In addition, the report must present alternatives to the proposed action, including <u>no action</u>, which are evaluated similarly to the preferred alternative.

In the United States, the National Environmental Policy Act (NEPA) has the proposing agency (e.g., the Forest Service, the National Park Service) issue the reports--Preliminary Environmental Impact Statement, Final Environmental Impact Statement; these must meet certain minimum regulations or they can be thrown out in court. In Hungary it needs to be made clear whether the proposing agency does the EIS work and the Ministry of the Environment proposing agency does the EIS work and the Ministry of the Environment review its adequacy, and how minimum requirements will be enforced.

- o for all projects that have the potential for controversy or great public interest a program of public information, education, and participation should berequired by the review office;

- o periodically the review office should report to appropriate government officials including Parliamentary Committees in order to monitor progress in implementing the program and make necessary changes to ensure efficient operations.

V. Conclusion

The Danube changes from an alpine stream to a meandering plains river at the upstream extent of this project. The energy of the river decreases and the reach from Bratislava to near the Danube Bend is where a major amount of the transport load of gravel and sand drop out in the river bed and the silts are deposited on the floodplain. Under natural conditions this change in the energy of the river creates a rich soil, plant and animal environment of which only a small portion remains in a natural state. Man has made much use of the fertility of this area, despite the risks floods and river course changes over the centuries. The current project is basically plan to capture and transform the energy of the river into electricity and to render th river more useful for navigation.

The project construction and proposed river flow management schemes to achieve this energy conversion will have large impacts on an environment that has long been recognized on an international level as rich in culture and natural systems. Alteration of parts of the present system will result in lower fertility and lower water quality due to the loss of no-cost natural processes. These will translate into increases in local and national costs which cannot be avoided if the project is constructed. Such costs must be integrated into consideration of this and all future projects with significant environmental impacts, <u>before</u> any construction of other irreversible commitments (e.g., international agreements) are undertaken. An Environmental Impact Review process which is thorough in considering alternatives, should be institutionalized.

The present project is one for which environmental and other legitimate concerns were not fully considered until after certain decisions had been made by the Hungarian and Czechoslovakian governments, which made consideration of a "no construction of the project" alternative less feasible to policymakers. Thus the process did not follow the rule which we recommend above--that impacts and alternatives be explored thoroughly before action is taken.

Given a decision to proceed with the project, there are options to adopt a policy that will minimize the unavoidable impacts and manage the ecosystem so as to sustain and enhance the remaining natural landscape. The objective would be not only to preserve the most unique and sensitive areas, but to manage the rest of the floodplain, riverine forest, and wetland complexes so as to maintain those natural functions that provide values important to human health, welfare, and safety. <u>The announcement by Czechoslovakia that it has no money for sewage treatment casts serious doubt over the operation of the system unless Hungary makes this a pre-requisite prior to the system becoming operational.</u>

Despite the impacts of the project it would still be appropriate to create an international reserve along the whole reach of the project. This would not be a reserve from which human use would be excluded, but one that would protect the unique features, and focus human economic activity on the more resilient parts of the landscape while maintaining the basic functions of the river ecosystem. Its boundaries would include the regions affected by both the surface and groundwater hydrology of the Danube. Such a proposal could attract significant international support and economic investment, if properly managed.

In summary, three possible mitigation actions are possible in response to concerns raised by the Gabcikovo-Nagymaros project. The most important would be industrial and municipal sewage treatment in Austria, Czechoslovakia, and Hungary upstream from, and within, the project area. The second would be changes in the operation of the Dunakiliti and Gabcikovo portion of the project, delivering more water to the existing downriver areas and reducing peak power production. The most radical would be the abandonment of the Nagymaros barrage combined with changes of the Gabcikovo power plant to a run-of-the-river operation. Short of this action, relocation of the Nagymaros Barrage 10 km upstream of the present site could mitigate the adverse impacts of the project on the region's important natural and cultural resources. Preparations for the Nagymaros barrage should be stopped until a complete assessment of its impacts and potential mitigating measures is undertaken.

The magnitude of the present power-navigation project has generated an international concern of equal proportions. A policy response on a matching scale, incorporating great vision, courage and international character is recommended for implementation.

Annex 6

A Bős - Nagymarosi Vizlépcső Nagyberuházás
Cselekvési Lehetőségei És Kihatásaik

Bős - Nagymaros Barrage Study
Program Options and Impacts

Május 1989
May 1989

Munkaközi Beszámoló
Interim Report

ANNEX 6

SECTIONS OMITTED

pp 1-15, with Hungarian summaries of English text and map

INFORT
Budapest, Hungary
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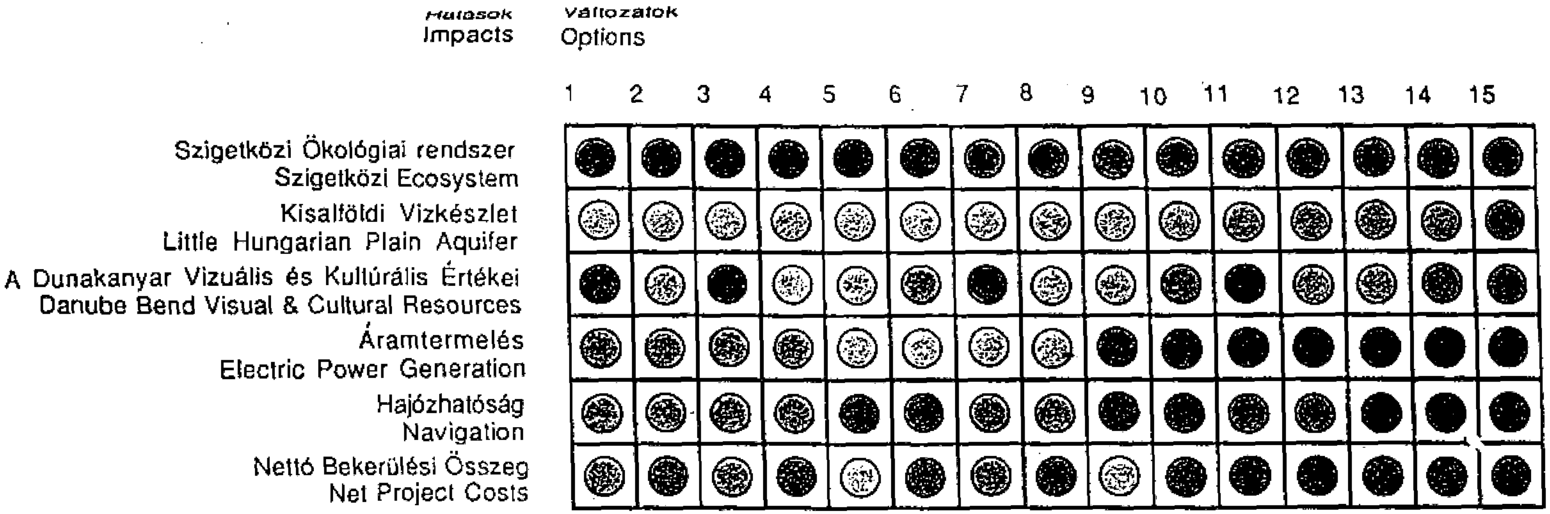

BNV Nagyberuházás Cselekvési Lehetöségei és Kihatásai Mátrix

BNB Project Program Options and Impacts Matrix

ZÖLD:
- A Környezeti Feltételek javulása a Beruházás elötti Állapothoz Viszonyitva, vagy
- A Terv Valamennyi vagy Szinte Összes Célkitüzései Megmaradnak, vagy
- A Nettó Költségek Nem Lépik Túl Jelentösen a Tervezettet

GREEN:
- Improvement In Environmental Conditions To Pre-Construction Levels, Or
- All Or Nearly All Anticipated Project Benefits Are Preserved, Or
- Net Costs Do Not Significantly Exceed Project Costs As Planned.

SÁRGA:
- Közepes Mértékü Környezeti Halások, a Terv Elönyeinek Részleges Elvesztése és Megnövekedett Költségek.

YELLOW:
- Intermediate Levels Of Environmental Impact, Benefit Reduction, And Increased Cost

VÖRÖS:
- Jelentös Negativ Környezeti Hatások, vagy
- A Terv Várható Elönyeinek Jelentös Mértékü Elvesztése, vagy
- Jelentös Növekedés a Beruházás Nettó Költségében.

RED:
- Severe Adverse Environmental Impacts, Or
- Significant Loss Of Anticipated Project Benefits, Or
- Large Additional Net Project Costs.

Findings and Recommendations

This brief summarizes the interim findings and recommendations of the *Bös-Nagymaros Barrage (BNB) Study: Program Options and Impacts* (May 1989), prepared by a team of US environmental and planning experts. Our principal finding is that the unresolved questions concerning the potential ecological and economic impacts of the BNB project require that all construction be suspended during the period of decisionmaking on the fate of this project. During the construction moratorium, a process of public decisionmaking should be established that includes all interest groups affected by the BNB project. The goal of this process should be the development of a negotiated agreement that will be subjected to ratification by the people of Hungary.

A. There are substantial economic and/or ecological impacts associated with all of the program options considered in this report, both upstream at Bös-Dunakiliti and downstream at Nagymaros. Changes in the design and operation of either complex will also affect the other. Trade-offs among expensive and/or undesirable alternatives are the rule. There are no easy answers!

B. At the same time, important opportunities can be found in the existing problematic situation for a demonstration of Hungary's ability to resolve serious national policy conflicts and to establish a process of public decisionmaking suited to an emerging democratic Hungary. In terms of national precedent, the method by which a decision is reached in this case may be as important as the substance of the decision.

C. The method of decisionmaking that we recommend will involve active participation by all of the interests affected by the BNB project. Encouraging steps in this direction have already been observed. Informed public decisionmaking can only be made if reliable independent research is available. Decisions must weight the loss of anticipated project benefits and the costs of site restoration against the expected detrimental environmental effects and other impacts of the project.

D. All construction on the BNB project, both upstream and downstream elements, should be suspended during this period of national debate on the resolution of issues surrounding the barrage project. OVIBER should be directed to cease all construction activities throughout the project, and should be released from any obligations to continue work under prior agreements. Continued investment of resources and alteration of the environment will only serve to limit the flexibility available to deal with already difficult decisions, increase the cost of many program options, and further weaken the position of the government in the face of strong and credible opposition to the project.

E. Upstream Segment: In order to successfully resolve environmental concerns about the Bös-Dunakiliti segment of the project, fundamental changes in the institutions responsible for the operation of the barrage system are necessary. The upstream components of the system should not be allowed to go into operation until all questions concerning impacts on the irreplaceable Szigetköz ecosystem have been answered through monitoring, modeling, and analysis to the satisfaction of a disinterested body possessing both the authority and expertise needed to control the project in a context of thorough public scrutiny. Any changes in the agreed upon operating regime should require approval through an equivalent publicly monitored environmental impact review process.

F. Downstream Segment: The decision on whether to cancel the Nagymaros barrage must weigh the loss of anticipated project benefits and potential consequences of project termination, and the cost of properly restoring the site to preconstruction conditions against the expected detrimental effects and the tremendous cultural significance of the Danube Bend area and its historical importance to the Hungarian people. The proposed National heritage park in the Danube Bend is offered not as a substitute for making the hard decisions needed, but as an appropriate expression of the national commitment to protect and enhance this area irrespective of the ultimate disposition of the barrage question.

G. The ultimate decisions on both upstream and downstream works should be based on carefully facilitated negotiations among parties representing the Government, environmentalists, and interests that would stand to benefit from the completion of the barrage project as originally planned. Although termination or modification of the BNB project, or any portion thereof, may result in legal consequences, the interested parties have the ability to negotiate changes in the project agreements that will address the concerns raised by this report. A thorough study of all contracts, agreements, and treaties in place among the various parties should be undertaken. Creative methods of compensation, including interests and values not contemplated in the original agreements should be systematically explored and developed. The final decision and negotiated agreement should be ratified by the people of Hungary in a referendum vote.

Introduction

This Interim Report analyzes the key environmental, cultural, engineering, and economic issues associated with the Bös-Nagymaros Barrage (BNB) System, program options, and a recommended decision-making process available to the Government and People of Hungary to resolve public concerns about the project.

This report has been prepared by a team of American scientists, engineers, economists, planners, and lawyers assembled by Ecologia, an environmental consulting firm based in Northampton, Massachusetts USA. It was prepared under the supervision of Armando J. Carbonell and Robert D. Yaro, Principals of Ecologia, for INFORT a Hungarian company engaged in technology development and transfer, at the request of the Hungarian Government and Parliament. and other groups concerned about the BNB project and its potential impacts.

This document is a product of the second phase of work by members of the INFORT--Ecologia Team. The initial phase, conducted by the University of Massachusetts under the direction of Professor Robert Yaro, was an assessment of the likely environmental impacts of the BNB project, and development of strategies for their mitigation. It was initiated by INFORT in the Fall of 1988, and the results released in March 1989.

This interim report builds on the analysis presented in the March report, by identifying specific construction and management alternatives for the BNB project, and by providing an assessment of the probable economic, environmental, and visual impacts of each alternative.

The facts and figures included in this report were obtained from official documents, and from interviews with Hungarian government officials, members of Parliament, environmentalists, scientists, engineers, and concerned citizens over the past several months. In some cases, the economic figures and legal documents needed to fully quantify the BNB project's impacts were not available to the team. In the absence of this data, the team proceeded with the best available information, or noted the inability to make precise evaluations in its absence. Any additional data that is provided to the Team will be incorporated into the final report this summer.

The research presented in this report is designed to facilitate informed discussion and effective decisionmaking within and outside the Government and Parliament concerning this important project, so that a timely resolution of the controversy surrounding the BNB project can be achieved.

Report Organization

The report begins with **Findings and Recommendations (Section I)**, which highlights the major conclusions of this report, and presents a decision-making process for resolution of concerns about the BNB project. It is followed by an **Introduction (Section II)**.

Section III provides an overview of **Selected Scenarios** for resolution of the BNB controversy, and is accompanied by a **Matrix (Section IV)** that summarizes and highlights likely ecological, groundwater, visual/cultural, electrical generating, navigation, and cost impacts of each option.

The final section of the report, **Section V**, consists of **Issue Briefs** on the following topics:

- o An Engineering Evaluation of the Dunakiliti-Bős-Nagymaros Barrage System;
- o Economic and Power Generation Issues;
- o Visual and Cultural Analysis of the Nagymaros Barrage Project
- o Proposal for a Danube Bend National Heritage Park;
- o Ecological Protection of the Old Danube Channel; and
- o Legal Issues and Data Needs

Selected Scenarios and Their Physical Impacts

For the purpose of selecting scenarios, the region has been broken into two sections. The UPSTREAM section centers around the Dunakiliti and Gabcikovo project, and the DOWNSTREAM section centers on Nagymaros. Each scenario consists of a combination of one option from both the UPSTREAM and DOWNSTREAM sections.

The benefits mentioned for the scenarios are electric energy generation, navigation, and flood control improvements. Impacts are defined as changes in the environment from present conditions. Costs, where mentioned, are those in addition to presently known project costs (or savings from those costs), but do not include any penalty payments for changes in electrical energy deliveries or unfulfilled contracts.

All numbers other than those related to the project as now planned are based only on the broadest estimates and are only included to indicate the likely magnitude of benefits or costs.

Description of Project Options

Upstream Options

I. Completion of Dunakiliti and Gabcikovo and their operation as planned in existing project documents.

II. Completion of Dunakiliti and Gabcikovo, but operated as a run-of-the-river plant without peaking.

III. Completion of Dunakiliti and Gabcikovo. Power output greatly reduced by releases through Dunakiliti that will maintain river and flood flows up to about one-half of total available stream flow.

IV. Completion of Dunakiliti and Gabcikovo operated as a navigational project only, with no peak power generation. All flows in excess of those needed to operate the Gabcikovo locks to be released through Dunakiliti.

V. Demolish all built works at Dunakiliti and Gabcikovo, and restore land completely to pre-project conditions.

Downstream Options

A. Complete Nagymaros and its appurtenant dikes and operate it as planned.

B. Move barrage to a site approximately 10 km upstream from the presently contemplated site and stabilize or fully restore conditions at the present construction site.

C. Eliminate the barrage at Nagymaros and its appurtenant works from the project, and stabilize the conditions at the work site by filling in the area inside the cofferdam, stabilizing the surface against flood damages. Strengthen the right bank protection against erosion; landscape the filled area.

D. Eliminate the barrage at Nagymaros and its appurtenant works from the project; restore the entire area to pre-project conditions.

Scenarios

1. Combination I-A

Benefits: Electricity output of 3,675 GWh/year with a peak production of 1,510 GWh.

Navigation improvements of providing a 3.5 to 4 m channel during the entire navigation season, thereby increasing its length by 40 to 50 percent, increasing loading capacity by about 50 percent, increasing loading capacity by some 20 percent, and reducing energy use per ton carrier.

Impacts: Increase of groundwater level by 0.5 m in the Little Hungarian Plain aquifer, and some increase in pollution entering that aquifer.

Reduction in groundwater level by up to 1.5 m in the Szigetkoz, and elimination of annual flooding there. Surges in canal below Gabcikovo are at about 5 m and in the river at the end of the canal of about one meter during peaking operation. Increased permanent water levels above bank ground level in many areas.

Possible accumulation of pollutants in reservoirs. Negative impact on landscape, historical, archaeological, and cultural values in the region of the Danube Bend.

Costs: No changes from present estimates.

2. Combination I-B

Benefits: Electricity output nearly equal to Combination #1, except for small reduction at downstream barrage due to reduced head.

Navigation improvement equal to Combination #1 if proper work is completed at Nagymaros work site.

Flood control benefits equal to Combination #1.

Impacts: Same as for Combination #1, except that dam is removed from Danube Bend. Reduction of landscape damages will depend on the treatment of the existing Nagymaros work site.

Costs: Increased costs due to site change and the need to stabilize or restore Nagymaros work site. Cost increases over present estimates may be as much as 1.5 to 1.75 times the cost of the presently contemplated Nagymaros barrage.

3. Combination II-A

Benefits: Total electricity output nearly equal to the planned system, approximately 3600 GWh/year. Firm output, 95 percent of the time, likely about 1600 GWh/year (firm capacity 140-230 MW). Remainder is interruptible power, available as river flow permits.

Navigation and flood control benefits same as for Combination #1.

Impacts: Same as for Combination #1, except surges are eliminated.

Costs: Same as for planned system.

4. Combination II-B

Benefits: Electricity output similar, but slightly less than Combination #3.

Navigation improvement equal to that of Combination #1, if proper work is completed at Nagymaros work site.

Flood control benefits equal to Combination #1.

Impacts: Same as for Combination #1, except that dam is removed from Danube Bend. Reduction in landscape damages will depend on the treatment of the existing Nagymaros work site.

Costs: Increased costs due to site change and the need to stabilize or restore the Nagymaros work site. Cost increases over present estimates may be as much as 1.5 to 1.75 times the cost of the presently contemplated Nagymaros barrage.

5. Combination II-C

Benefits: Electricity output likely to be about 2800 GWh/year, with approximately 1200 GWh/year firm output (90-180 MW capacity), 95 percent of the time.

Navigation improvement limited to the Bratislava to Gabcikovo reach, but overall little change from present conditions due to continued low water limitations at Nagymaros.

Little, if any, improvement in flood protection.

Impacts: Increase in groundwater level by 0.5 m in the Little Hungarian Plain aquifer, and some increase in pollutants entering the aquifer.

Reduction in groundwater level by up to 1.5 m in the Szigetkoz and elimination of annual flooding there. Reduced impact on historic, archaeological, and cultural values, with some improvement of landscape at Danube Bend.

Costs: Small reduction in overall construction cost. Cost of stabilizing present Nagymaros work site likely to be one quarter to one-half over the amount already expended at this site, not including contract penalties.

6. Combination II-D

Benefits: Same as for Combination #5.

Impacts: Increase in groundwater level by 0.5 m in the Little Hungarian Plain aquifer, with some increase in pollutants entering that aquifer.

Reduction in groundwater level by up to 1.5 m in the Szigetkoz and elimination of annual flooding there. Eliminates impact on landscape, historic, archaeological, and cultural values at Danube Bend.

Costs: Cost of restoring present Nagymaros work site likely to be one-half to one times over the amount already expended, not including contract penalties.

7. Combination III-A

Benefits: Electricity output likely reduced to about 2200 GWh/year, with peak energy production about 800 MW.

Navigation and flood control benefits are the same as for Combination #1.

Impacts: Same as for Combination #1, except that those in Szigetkoz significantly reduced.

Costs: No changes from present estimates.

8. Combination III-B

Benefits: Electricity output similar to Combination #7, although slightly reduced.

Navigation benefits same as for Combination #4.

Flood control benefits same as for Combination #1.

Impacts: Same as for Combination #7, except that dam is removed from Danube Bend. Reduction of landscape damages will depend on the treatment of the existing Nagymaros work site.

Costs: Increase in costs due to site change and the need to stabilize or restore Nagymaros work site. Cost increases over present estimates may be as much as 1.5 to 1.75 times the cost of the presently contemplated Nagymaros barrage.

9. Combination III-C

Benefits: Electricity output likely reduced to about 1400 GWh/year, with no peak power production.

Navigation improvement similar to Combination #5.

Impacts: Same as for Combination #5, except that impacts in Szigetköz are significantly reduced.

Costs: Small reduction in overall system cost. Cost of stabilizing present Nagymaros work site likely to be one-quarter to one-half times that already expended at this site, not including contract penalties.

10. Combination III-D

Benefits: Same as for Combination #9.

Impacts: Same as for Combination #5, except that impacts in Szigetköz are significantly reduced.

Costs: Cost of restoring present Nagymaros work site are likely to be one-half to one times the amount already expended at the this site, not including contract penalties.

11. Combination IV-A

Benefits: Electricity output likely to be reduced to about 800 GWh/year.

Navigation and flood control benefits same as for Combination #1.

Impacts: Same as for Combination #1, except for elimination of impacts on the Szigetköz.

Costs: No changes from present construction cost estimates.

12. Combination IV-B

Benefits: Electricity output slightly less than for Combination #11.

Navigation improvement equal to Combination #1 if proper work is completed at the Nagymaros work site.

Flood control benefits same as for Combination #1.

Impacts: Same as for Combination #1, except for elimination of impacts on the Szigetköz. Dam is removed from Danube Bend. Reduction of landscape damages will depend on the treatment of the existing Nagymaros work site.

Costs: Increase in costs due to site change and the need to stabilize or restore Nagymaros work site. Cost increases over present estimates may be as much as 1.5 to 1.75 times the cost of the presently contemplated Nagymaros barrage.

13. Combination IV-C

Benefits: Navigation improvement limited to the Bratislava to Gabcikovo reach, with little overall change from present conditions due to continued low water limitations to Nagymaros.

Little, if any, improvement in flood protection.

Impacts: Increase in groundwater level by 0.5 m in the Little Hungarian Plain aquifer, and some increase in pollutants entering that aquifer.

Reduced impact on historic, archaeological, and cultural values, and some improvement of landscape at Danube Bend.

Costs: Small reduction in overall system cost. Cost of stabilizing present Nagymaros work site likely to be one-quarter to one-half over the amount already expended at this site, not including contract penalties.

14. Combination IV-D

Benefits: Navigation improvement limited to the Bratislava to Gabcikovo reach, but overall little change from present conditions due to continued low water limitations to Nagymaros.

Little, if any, improvement in flood protection.

Impacts: Increase of groundwater level by 0.5 m in the Little Hungarian Plain aquifer, and some increase in pollutants entering the aquifer.

No impact on landscape, historic, archaeological, and cultural values at Danube Bend.

Costs: Cost of restoring present Nagymaros work site likely to be one-half to one times the amount already expended at the site, not including contract penalties.

15. Combination V-D

Benefits: None

Impacts: None

Costs: Likely to be 1.5 to 2 times the amount already expended at this site, not including contract penalties.

Guide to Selected Scenarios

Upstream Options

Downstream Options

	I.	II.	III.	IV.	V.
A.	1.	3.	7.	11.	
B.	2.	4.	8.	12.	
C.		5.	9.	13.	
D.		6.	10.	14.	15.

An Engineering Evaluation of the Bös-Nagymaros Barrage System

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This evaluation deals with the engineering features of the project and their physical effects. It is based on the result of two trips of five and four working days respectively. The area around the project was visited on these trips, as were the construction sites at Dunakiliti and Nagymaros. OVIBER and VITUKI engineers working on the project were interviewed and general maps inspected. Detailed plans, specifications and basis of design reports, items that would be available for equivalent public works in the United States, were not available. In a number of additional meetings, the opinions of those opposing the projects were heard.

The Danube between Bratislava and Budapest

This reach is the beginning of what is usually called the Middle Danube. From the Porta Hungarica, where the Danube passes between the Hainburg Hills and the Little Carpathians, it divides into three streams, the Small Danube in the north, the Mosoner Danube in the south and the main stem that, through historic time, was a braided stream. The land between the major branches includes the Large Gravel Island north of the main stem and the small one, the Szigetköz, south of the main stream. The branches combine before the river breaks through the Pilis-Borzsony Mountains at the Visigrad Gate. From 1886 and 1896, between Bratislava and Gönyű the main stream was stabilized, cuts were made, side arms closed, and curves made more gradual. Further work to improve navigation at low flow through the construction of groins and through dredging was carried out around 1900. Levees to control flooding were built in Hungary in the early 19th century and by the middle of that century along most of the major branches. Large construction works in the Budapest area followed the catastrophic flood of 1838.[1]

Further changes in the river through the construction of dams have been contemplated for some time. In the 1930s and 1950s studies of two, three, four, and five dam schemes for navigation and power production were made. Under present conditions there are ten or twelve hazards to navigation at low flows. It is estimated that navigation in this reach can proceed for an average of 200 days per year. During about 100 days, low flow conditions hinder navigation, and for about 65 days, ice or fog make it impossible.[2] Flow data for Bratislava and Nagymaros are shown in Table 1.

Table 1: Flows of the Danube River

	Bratislava	Nagyramos
Distance form the Mouth (km)	1868.8	1694.6
Drainage area (km^2)	131,300	183,530
Observation since	1823	1872
DISCHARGE (m^3/sec)		
Lowest estimated flow	570	590
	(12/28/48)	(11/4/47)
Highest estimated flow	10,400	8,140
	(7/15/54)	(6/17/65)
Exceeded 95% of the time	882	1,124
Exceeded 50% of the time	1,810	2,248
Exceeded 10% of the time	3,298	3,837
Flood probabilities (m^3/sec)		
0.01% (10,000-year flood)	15,000	11,100
0.1 % (1,000-year flood)	13,000	10,000
1.0 % (100-year flood)	10,600	8,700
5.0 % (20-year flood)	8,750	7,650

Source: OVIBER. *The Bös-Nagymaros River Barrage System.* National Investment Enterprise for Hydraulic Projects, Budapest.

The Reach from Bratislava to Dunakiliti

Current structures in this reach include an earth/rock fill dam from the entrance of the canal to the old Danube bed. There is located a gated structure to act as a flood spillway. The structure includes also a temporary lock for ships during construction and eventually a bulb turbine discharging a continuous flow of 30 m^3/sec into the river bed. The barrage will lift the water level to an elevation of 131.2 m above sea level or about 16 m above the present river bed. The sides of the reservoir created are protected by dams reinforced with concrete linings. Seepage is expected to be 40 to 50 m^3/sec and is guided by a drainage canal into the old Danube bed below the gated structure. The opening for the bulb turbine can discharge 50 m^3/sec without the turbine. There is also an outlet in the temporary navigation lock that can discharge up to 200 m^3/sec, and an outlet in the right bank dike up to 50 m^3/sec more. The main structure, consisting of seven 24 m wide gated openings, will discharge flood waters in excess of the capacity of the power canal into the pre-project Danube bed. The reservoir will contain 200 x $10^6 m^3$ with the top 1 meter containing 49 x $10^6 m^3$. It will equalize the daily water discharge of the Danube. Downstream water elevation during a 1% probability flood will be about at 124.9 msl and at about 115 msl at low flow.

At present the river at the Dunakiliti site is diverted into a bend towards the left bank so that the concrete structural portion of the project an be built within a dry pit protected by a cofferdam. Construction at the time of our visit appears to be about 85% complete. All foundations were complete, most of the superstructure was complete or nearing completion, and some of the gates were already installed. The dikes on the right bank were complete and an outlet for water to the Danube arms in its final state of completion. The work appeared to be carried out in an excellent professional manner and the work site generally well-organized and well cared-for.

It has been suggested that the completed construction could be removed and original conditions restored. Such an attempt would likely cost as much or more than building it, and there is a question if total restoration is even possible. Even with spending inordinate amounts of money, major scars on the landscape would likely remain.

The reservoir is underlain by a large and deep aquifer. The raised water level in the reservoir will increase inflows into it. The aquifer, relatively unpolluted and today only slightly used, represents a considerable regional asset for future exploitation.

Water quality in the reservoir is controlled by the inflows. The treatment plants in Austria and the treatment of a major part of Bratislava's sewage have improved the conditions in this reach. Problems exist, however, due to the poor quality of the Morava entering from Czechoslovakia. Retention time of water in the reservoir is short, and therefore will not effect surface water quality. Depending on the flow it is somewhere between 0.5 and 2.0 days.[3]

The environmental impact of the reservoir is twofold. First, it will create a large flat water body with little variation in level regardless of flow conditions. Only at the upper end near Bratislava will flood conditions be near pre-project levels. Operating variations of the reservoir are expected not to exceed one meter.[4] The second and more important impact will be on the groundwater. The raised water surface, five to six meters above ground level, will increase seepage. Much of it will be carried off by ditches along the side dams and returned to the stream, and some will enter the groundwater. Groundwater levels are expected to rise about 0.5 m, based on electric analog and digital model studies.[5] There is likely to be some increase in pollution entering the aquifer. This can only be eliminated by consistent improvement in the quality of the water entering the reservoir. It appears, however, a relatively less important component of pollution entering the aquifer when compared with local pollution from agricultural activities. This should not be considered an excuse for reducing efforts to improve treatment of Danube inflows or of reducing agricultural non-point sources.

The Dunakiliti to Gönyü Reach (The Szigetköz)

Construction in this reach consists of a 17 km long channel leading to the Bös Power Station, the station itself, and an 8.2 km downstream channel that returns the flow to the original Danube bed. The upstream channel is designed to carry 4000 m^3/sec at an average velocity of 1 m/sec. It is initially 542.5 m wide, narrowing to 267.5 m, and finally widening to 730 m to form a forebay that will dampen out wave action due to the starting and stopping of power releases. Normal operating level will be the same as at Dunakiliti, 131.2 m above sea level. Protecting side levees have a freeboard of 2 m, and are at their highest point 18 m high. They are constructed of compacted fill, and are concrete lined. The canal was located on the left of Czechoslovakian side of the river, because a canal on the Hungarian side would have required the relocation of some settlements.

The Bös power station contains eight Kaplan turbines and generators with 90 MW rated output each. Working head may vary from 16.0 to 23.4 m and through flow form 420 to 651 m^3/sec. Two lock chambers, each 34 m wide and 275 m long, provide for the navigation passage. Piers and guide structures protect the entrances and exits of the navigation locks.
The downstream channel is excavated to increase the head available to the power plant. Its bottom is 18 m below ground level. Near the power outlets, the bottom is protected from surges by layers of 70 cm row over a 50 cm sand filter layer.[6]

While we were not able to visit these works due to their location in Czechoslovakia, views from aircraft showed that most of the work is completed both on the canals and on the power station and lock. Just as at Dunakiliti, removal and restoration to pre-project conditions would be enormously expensive, and would likely leave a major scar on the landscape.

The existing mainstream of the Danube in this reach is characterized by many branches and new and old meanders. It is the home of a complex and unique riverine forest ecosystem. The entire area from the main stem to the Moson Danube is a gravel island, the Szigetkös. The unforested area is in extensive agricultural use. An extensive network of groundwater observation wells and a number of ecologic monitoring stations are planned in this sector covering the entire Szigetkös.

Original plans call for the existing Danube bed to carry, during average and low flow periods, only the flow of the bulb turbine outlet flow at Dunakiliti and the seepage at that site. The flow during such periods in the Danube may vary between 30 and 70 m^3/sec depending on the amount of seepage. During river discharges in excess of 4000 m^3/sec, the excess amount will be released into the old river bed through the Dunakiliti dam's sluiceways. Releases of approximately 4500 m^3/sec can be expected in five percent of years, and discharges of over 6000 m^3/sec in one percent. At mean high water about 500 m^3/sec would enter the old Danube beds. Also during low flow periods, the opportunities exist to release up to about 200 m^3/sec additional flow through outlets at Dunakiliti and at another point in the right bank protective dam. Flows of about 22 m^3/sec are expected to be flowing in the Moson Danube, a change from the present flow of no more than 6 m^3/sec.[7]

The concern here is for the riverine woodlands and for agriculture in the region. The lower water levels in the existing river bed would lower the groundwater level and flood inundation of the riverine forest would be reduced. This could significantly alter the ecology of the region, and make irrigation necessary on some of the agricultural enterprises.

Groundwater modeling showed that the effect of the diversion of the river into the power canal would lower the groundwater level near the existing river bed by about 3.5 meters leveling to no change at the Moson Danube.[8] This being considered unacceptable, a system of recharge ditches are contemplated in this area. Modeling shows that these ditches will mitigate the reduction of the groundwater level to no more than 1.5 m, and that only in the area near the mouth of the Moson Danube. In most other areas of this reach the reduction can be expected to be between 0 and 1.0 m.[9]

Monitoring of water and ecological parameters would be a tool for anticipating change and managing mitigation of detrimental effects on the riverine forest ecology in a timely manner. The planned observation network, if fully developed and used, would provide the necessary data. Using the sluices and even the gates in the Dunakiliti dam, and sending more water into the old Danube beds, and less to the power station, could be accomplished with the present design configuration at Dunakiliti. This type of operation must be considered as an option. Major modification of the arrangement for power distribution would have to be made, and the costs compared with the benefits to the riverine ecology.

The Gönyü to Nagymaros Reach

Works in this reach consist of the Nagymaros barrage and power station and the system of dikes lining the banks of the created reservoir following the existing shoreline of the Danube and up some of the tributaries. The purpose of the barrage is to compensate for the surges caused in water flow by the peak load operation of the Bös power station, to generate electric power, and to insure navigation above the barrage. It also assists in the maintenance of the groundwater level in the eastern end of the Szigetkös. The site selected was one of five sites studied. The selection was made on the basis of topographic, geologic and cost criteria. The barrage consists of seven 24 m wide gates, a powerhouse with six bulb turbines and generators, each with a rated output of 26.4 MW, and each discharging at design head 466 m^3/sec. Two locks, each with a chamber 34 m wide and 275 m long, and guide piers up and downstream, provide for navigation. Maximum water elevation under all conditions on the upstream face will be 107.8 meters above msl. Downstream water elevation will vary with flow between 98.4 and 107.1 during the 0.01% probability flood. Present bank elevation, 109.3 m, is above flood level at the site. The roadway elevation of the bridge that is part of the structure will be 118.2 meters. Dikes with heights of up to 5 m are generally constructed at the sites of existing flood control dikes, topping the existing ones by 1.5 to 2.5 m. At the site of the present relocated stream bed, two lagoons for recreation are planned.[10] A monitoring network will parallel the river on both sides.

At the present state of construction, the river has been relocated into a sharp bend near the right edge of the valley. This relocation seems to have narrowed the bed and increased the velocity of the flow. The material excavated for this relocation, which included the blasting of rock outcrops, was used in building a cofferdam anchored on the left bank that encloses the entire construction site for the Nagymaros barrage. The cofferdam, riprapped to protect it from erosion, is built to withstand a three-year flood. Inside the cofferdam, gravel and rock excavation for the foundation of the gate structure, the powerhouse and the navigation locks, is in progress and will soon be to full depth. In addition to a concrete batching plant, a temporary railroad siding and a group of permanent houses for workers, are under construction. The houses will be sold for local use after completion of the job. On the right bank an overlook and visitor area are also under construction. It is estimated that between 15 and 20 % of the investment at Nagymaros is now in place.

Four major concerns have been expressed relating to this reach. These are
(1) the surges created by peak operation of the Bös station;
(2) the safety of areas, like Esztergom, where water levels are permanently higher than the surrounding ground;
(3) the water quality in the reservoir;
(4) the damage to the important cultural, historic, archaeological and landscape values of the Danube bends.

During peaking operation at Bős, water levels at the powerhouse will vary up to 5 m However, by the time the flows reach the end of the outlet canal and join the existing Danube bed, the differences will be not more than about one meter.[11] Further reduction in these variations can only be produced by changes in the operation of Bős, i.e. the total or partial elimination of peak power production. The variation in flow rate will also reduce the deposit of sediments by moving them downstream during the power cycle.
The second concern can be addressed only through the quality of construction and maintenance of the dike system. Competent and periodic inspection and immediate repair of any deficiency discovered is the guarantee of safety for the low-lying areas. Serious damage from a sudden failure of the barrage by war or sabotage is unlikely. The low height of the dams and the relatively small amount of water stored would create a flood wave not greater than a natural flood.

Water quality problems will exist downstream from the mouth of the Moson Danube. The major inflows are the discharges from Győr, for which a treatment plant with a capacity of 120,000 m^3/day is planned.[12] The short retention time of flows in the reservoir and the flushing of the reservoir during floods are likely to maintain the water quality at the present level. It again must be pointed out that construction of treatment plants on both sides of the river should proceed at maximum possible speed. Continuous monitoring of groundwater levels and water quality will give early warnings of problems that might make changes in operation necessary.

Changes in the landscape and effects on elements of historical, cultural and archaeological significance will occur when and if the Nagymaros barrage is built. Some mitigation is possible through changes in the operation at Bos to longer and lower peaks. Only the removal of the Nagymaros barrage from the entire system, with the changes in power output and possible effects on navigation, would remove all concerns in this region. Such removal must include restoration of site conditions at Nagymaros. There appear two options if work is not completed on this barrage. Both will require careful studies including modeling to insure proper hydraulic characteristics. One would require to fill the present cofferdam area and stabilize the cofferdam and the filled surface to protect it from erosion during flood events. Such a course of action is likely to cost at least as much as construction costs on the site to date, create a navigation bottleneck, increase flood heights upstream, and leave a landscape that is not likely to be pleasing. The second option, full restoration to pre-project condition would probably cost as much as completion of the barrage, and interrupt river traffic for a considerable time, as much as a whole season.

Abandoning the construction of the Nagymaros barrage, and leaving the site in its present condition, would likely have catastrophic consequences following a major flood. The cofferdam would be destroyed, a large turbulent area created over the present excavation, and debris scattered in the reach below. All these would be a very serious hazard to navigation and require costly corrections to make the river properly navigable.

The Nagymaros-Budapest Reach

No further work is contemplated in this reach as part of the barrage system. Problems in the bank-filtered wells through the increase in nitrates apear to be due to inflow from the background area rather than from the Danube.[13] Continuous monitoring, especially in areas where gravel is mined from the river, would be a prudent investment.

Output of the Project

Electric Power. The two power plants of this system--located at Bõs and Nagymaros--are expected to produce an average of 3675 GWh/year, with Czechoslovakia and Hungary sharing equally in this output. Installed capacity at Bõs is 720 MW and at Nagymaros, 158.4 MW. The Bõs plant is expected to be operated in a peaking mode. Using only the top one meter of the reservoir, Bõs can operate at full output for about 3 hours each day at mean low water, for about 5 hours at mean flow, and for a full 24 hours at mean high water, in addition to discharging about 500 m^3/sec into the Old Danube bed. Nagymaros can operate at one-third load for 24 hours at lean low water, at full load for about 20 hours at annual mean flow, and at full load continuously at mean high water. Some peaking is also possible here depending on the degree of fluctuation acceptable downstream toward Budapest. The bulk of the power received by Hungary is power delivered during peak load periods. Thus, it is much more valuable than the base load power Hungary will deliver to Austria. Increases in water released into the existing Danube bed at Dunakiliti for maintenance of the ecology of the Szigetkõz will reduce power output at Bos in proportion to the releases. Removal of Nagymaros from the system requires a change of operation at Bõs from peaking to run-of-the-river.

Alternative modes of operation are possible. For example, run-of-the-river operation is feasible at Bõs. The total output would be about the same, but electricity would be produced following not a load-controlled schedule, but as water is available. Other generating facilities would have to be used to maintain output in accordance with demand.

Navigation. Navigation is presently restricted, especially in the Bratislava to Komarov region, by shifting sandbanks. Low water in the late summer and fall further limits ship passgae. The Bõs-Nagymaros project will create a 3.5 m deep channel throughout its reach and extend, it is claimed, increase annual navigation time by 40 to 50 percent. The value of this to Hungary, however, will depend on the development of a Hungarian shipping industry, new Hungarian ports, and development of Hungarian trade with the West. The eventual opening of the Rhine-Maine-Danube canal and the Elbe-Oder-Danube canal would open barge traffic from Budapest to Amsterdam and to the Baltic.

Flood Control. Most areas throughout the reach of this project are presently protected by a system of dikes. However, the continuous build-up of the Danube bed by silt deposition reduces the safety of the existing dike system. The new dikes built as part of the project, with a 2 m freeboard, will greatly increase flood protection.

Summary

The project as presently desgined is sound from an engineering viewpoint. All the studies customarily associated with such a project appeared to have been made. The design appears efficient for power and navigation, and is, at the same time, as compatible to the landscape as possible. Construction is proceeding at a rapid pace and also apears well-organized and carried out in a highly professional manner. This, however, does not invalidate concerns raised against the project, concerns that are based on different values and objectives than those used by the engineers and designers.

Three possible mitigation actions can reduce concerns raised by the Bos-Nagymaros project. Physically, the easiest changes would be in the operation of the Dunakiliti and Bös portions of the project, delivering more water to the existing downriver areas and reducing power production. More difficult and costly will be the essential improvements for industrial and municipal sewage treatment in Austria, Czechosolvakia, and Hungary upstream and within the project area. The most costly would be the abandonment of the Nagymaros barrage, combined with changes at Bös to a run-of-the- river operation, and the very costly restoration of reasonable pre-project conditions at Nagymaros.

Endnotes

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3. Nagy, L. and Ö. Starosolszky. *Environmental Impacts of the Bös-Nagymaros River Dam Project.* VITUKI, Budapest, 1989.

4. OVIBER. *The Bös-Nagymaros River Barrage System.* National Investment Enterprise for Hydraulic Projects, Budapest.

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6. OVIBER. *Bös-Nagymaros River Barrage.*

7. Flows shown are estimated based on information provided by OVIBER and VITUKI.

8. Nagy and Starosolszky. *Environmental Impacts.*

9. Nagy and Starosolszky. *Environmental Impacts.*

10. OVIBER. *Bös-Nagymaros River Barrage.*

11. Personal communication from OVIBER.

12. Nagy and Starosolszky. *Environmental Impacts.*

13. Nagy and Starosolszky. *Environmental Impacts.*

Economic and Power Generation Issues

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Economic Benefits

Hydroelectric Energy Production. Of the several economic benefits expected to flow from the Bős-Nagymaros Barrage Project, the production of hydroelectric energy is often the most prominently mentioned. This emphasis reflects both the value of hydroelectric energy production and its unique characteristics.

Hydroelectric energy differs from most other sources of electric energy in a number of ways. It is based on the use of a renewable resource (stored water) rather than an exhaustible resource (coal, petroleum, natural gas). Compared to nuclear generation facilities of similar capability, capital investment is modest and safety concerns are largely absent. The production rate can be varied between zero and full production on short notice, making hydroelectric production suitable for peaking service. There are no waste emissions to the air, land, or water, and operating costs are negligible.

On the other hand, hydroelectric generation is constrained by the availability of water. In the case of the planned impoundments on the Danube, this means that full capacity can be realized only in the spring and early summer, when streamflows are high, rather than in the winter, when electric energy requirements are at their maximums. Also, the relatively benign environmental consequences of hydroelectric generation must be balanced against significant environmental impacts of construction, inundation, river diversion, changes in flow regime, etc.

The benefits of hydroelectric generation for the domestic (Hungarian) market are equal to costs avoided elsewhere in the electric generation, transmission, and distribution system due to the availability of hydropower. If adequate generating capacity is already available (without hydropower), or if future capacity requirements are unchanged due to the need to provide for winter peaks, no capacity savings can be attributed to hydroelectric generation. In this case, the benefit is determined by the avoided cost of fuel and operations at existing facilities.

If, on the other hand, some capacity construction can be avoided or deferred due to the availability of hydropower, the avoided or deferred construction costs translate into additional benefits. All such comparisons should be made in the context of a least cost electricity supply plan, which includes consideration of demand management strategies as well as supply augmentation (see Electricity Supply section, below).

Navigation Enhancement. Benefits from the improvement of water navigation conditions are derived from two sources: (1) costs associated with existing and forecast (given pre-project conditions) shipping traffic are reduced, due to more efficient use of vessels and reduced fuel consumption; and (2) diversion of freight and passenger transport from other modes, due to improved navigation conditions. In the first case, no increase in traffic is anticipated, beyond that which would occur through economic development or through improvements elsewhere in the navigation system. The benefits accrue primarily to shipping companies and operators, and secondarily to shippers and passengers; there are no significant incremental benefits to the Hungarian economy, or to the economies of other nations using the river.

Benefits of the second type appear only when navigation costs are sufficiently reduced, and availability and convenience sufficiently improved, that some shipping traffic is diverted from surface and air carriers to water transport. There may also be some increase in the total quantity of transportation services demanded, especially in the more elastic markets such as tourism. In these situations, at least two kinds of benefits appear: (1) direct benefits due to reduced transport costs; and (2) external benefits resulting from the increase or relocation of economic activities. Direct benefits, as before, accrue primarily to owners and operators, and are equal to the incremental costs avoided as a result of the mode change. External benefits, however, are divided among operators, shippers, and the general economies of those countries which experience net increases in economic activity.

Flood Control. The Danube River, in the reaches affected by the Bös-Nagymaros project, has long been provided with an extensive system of levees and other structures for flood control purposes. The construction of the project will raise water levels in some places, potentially increasing the risk and severity of floods, while simultaneously raising and improving flood control works. The net effect will apparently be some reduction in the risk of flood, coupled with some increase (at certain locations) in the severity of any floods which may occur.

To the extent that the expected damage from floods has been reduced, flood control benefits can be claimed. These benefits are measured in one of two ways. The first is based on the least cost means of achieving an equivalent reduction in expected flood damage, without building the project. For example, existing levees could be extended, raised, and improved so that sensitive areas are accorded comparable protection to that offered by the project. The cost of these improvements is a possible measurement of the project flood control benefit.

The second possible measurement is derived from a study of potential flood damages (to persons, structures, landscapes, habitat, etc.) which could be avoided by project-related flood control enhancements. The expected present value of these avoided damages is a measure of benefits in the absence of any alternative means of achieving the same result. Since alternatives are available (improvement of existing control works), the actual economic benefit is the lesser of the two measures.

Economic Costs

In addition to the costs of constructing and operating the project, the Bős-Nagymaros Barrage will impose a variety of adverse impacts on present and future users of the affected resources. Some of these impacts may be expressed in monetary terms as external economic costs. Others may be imposible to quantify at this time, or may be difficult to measure in monetary units.

Among the external costs that may be monetized are changes in the level and quality of groundwater aquifers, changes in surface water quality, and a variety of negative impacts on historical and cultural values, or on recreation and tourism. Other potential impacts, such as damage to habitat and ecosystem changes, are more difficult to quantify and/or to express in monetary terms.

Groundwater. Completion of the project will result in a number of changes to groundwater aquifers throughout the affected reaches of the Danube. Water surfaces will rise in some locations (near impoundments) and fall in others, despite mitigation measures. Changes in the flow regime of the river, with accompanying changes in sediment deposition scouring, will alter the hydraulic characteristics of shallow aquifers near the river itself. Also, the detention of urban, industrial, and agricultural wastes in the impoundments may increase the movement of contaminants into the groundwater.

To the extent that aquifers are used for water supply at the present time, or in the future, economic costs can be identified. These costs can be measured as lost benefits (where population growth or economic development must be restricted, or where lower quality water must be tolerated by users) or as alternative costs (where new supplies must be sought or where treatment must be added). In all cases, costs are measured by comparing expected future conditions with the project to those reasonably anticipated without it.

Surface Water. Because of the detention of urban, industrial, and agricultural wastes in impoundments, it is expected that increased concentrations of contaminants may be found in the Danube as a result of the project. To the extent that users of the river may have to forgo uses or incur expense as a result of the contamination, economic costs may be measured. Reductions in the quantity or quality of fish harvests, for example, can be translated into economic cost. If the river is used for water supply by any urban area or industrial activity, additional treatment or monitoring may be needed. In every case, the costs are equal to the expected present value of the lost benefits or the incremental expense.

Historical and Cultural Values. Adverse impacts on historical and cultural values, such as those associated with the Danube Bend area, are most often experienced as losses in existence value or bequest value associated with the resource. Existence value is the value that residents of Hungary associate with the mere existence of the resource in its present condition, apart from any benefit that individuals may experience from visiting or otherwise using the site. Bequest value is that additional value associated with the knowledge that the site is preserved for future generations of Hungarians. In Western economies, these values have been successfully measured through survey research, based on the administration of carefully designed contingent valuation questionnaires.

Recreation and Tourism. From the standpoint of the Hungarian economy, recreation activities and other forms of tourism provide direct benefits to Hungarian citizens who may engage in these activities, as well as general benefits to the economy when visitors to the country (as well as citizens) do so. While changes in internal tourism and recreation (by Hungarians) may be viewed largely as transfers (recreation discouraged by changes at the Danube Bend may well be diverted to some other site in the country), this is not true for visitors. The attractiveness of a particular site, especially one so accessible as the Danube Bend, has a great deal to do with the number of tourists who enter the country, and the length of their stays. Adverse changes in any part of the river system, then, may lead to losses in net national income from tourism.

Electricity Supply

Use Trends. In 1988, Hungary used 40.5 x 10^6 MWH of electric energy, including losses and internal consumption within the electric generation industry.[1] This total has risen sharply over recent decades, growing from 18.0 x 10^6 in 1970, to 31.2 x 10^6 in 1980. Electric energy use has increased at an average rate of 4.6 percent per year over this 18-year period. This is apparently due in part to growth in economic activity and standard of living, and in part to the substitution of electric energy for other fuels.

Household annual electric use was reported at 710 KWh per capita for 1986, or about 21 percent of total electric use.[2] Per capita household use is comparable to Czechoslovakia and Yugoslavia, but significantly lower than Austria (1,370 KWh per capita). Annual electricity use for all purposes is reported at 3,409 KWh per capita for Hungary, compared to 5,153 KWh in the more industrialized Czechoslovakia and 5,605 KWh in the Soviet Union.

It should also be noted that household use is growing at a slower rate than total electric energy use. During the 1970-1988 period, household use of electric energy has increased at an average rate of 2.1 percent per ear, compared to 4.6 percent uses.[3] More importantly, growth in household use has slowed dramatically in recent years, averaging 0.4 percent per year for the 1985-1988 period, compared to 2.1 percent for total use.

Available forecasts of total electric energy use, as prepared by the National Energy Board, indicate much slower than historical growth rates. One forecast assumes annual increases averaging 1.5 percent per year through 1995, and 2.5 percent per year thereafter. Total use is expected to reach 74.5×10^6 MWH per year by 2010.[4] Alternative forecasts are based on uniform growth rates of 2.0 and 2.5 percent per year. In all cases, household energy use is expected to increase at a rate of 2.0 to 2.5 percent per year; growth in industrial use, on the other hand, will slow for several years due to energy conservation.

Electric load in Hungary is strongly winter-peaking, reaching maximum levels during the October-March period.[5] During 1988, maximum loads were recorded in November, while the minimum loads occurred in July. Daily peaks during the winter season tend to occur twice each day: the morning peak is at about 0600-0700 hours while the evening peak, of approximately the same magnitude, generally falls between 1500 and 2100 hours.[6]

Electricity Supply. Electric supply consists of a wide variety of sources, including steam-electric generation from fossil fuels (coal, lignite, natural gas, petroleum), hydroelectric generation, and net imports. Electric energy is exported to and imported from Czechoslovakia, Austria, Yugoslavia, and the Soviet Union, although exports to the Soviet Union are trivially small (about 3.0 GWh in 1986).[7] The Hungarian electric transmission grid is also used by the Soviet Union and by Czechoslvakia to convey energy to other parts of Czechoslovakia and to Yugoslavia. Generation, imports, and exports are shown for recent years in Table 1.

It can be seen that, while the rate of growth of electric energy use in Hungary has slowed since 1980, dependence on imports has grown from 25.2 percent of total supply (before losses) in 1980 to 29.8 percent in 1988. During the past eight years, the use of imports has increased at twice the rate of growth in domestic generation.

Table 1: Electric Supply 1970 - 1980 (10^6 MWH/year)

Year	Net Generation	Imports	Exports	Net Imports	Total Supply	Dist. Losses	Net Supply
1970	13.126	4.058	0.663	3.395	16.521	1.513	15.008
1975	18.638	5.802	1.678	4.124	22.762	1.955	20.807
1980	21.912	10.182	2.796	7.386	29.298	2.831	26.467
1985	24.553	12.731	1.924	10.807	35.360	3.589	31.771
1988	26.646	13.615	2.323	11.292	37.938	4.141	33.797
Average Annual Growth Rates (%/year):							
1970-88	+4.0	+7.0	+7.2	+6.9	+4.7	+5.8	+4.6
1970-80	+5.3	+9.6	+15.5	+8.1	+5.9	+6.5	+5.8
1980-88	+2.5	+3.7	-2.3	+5.4	+3.3	+4.9	+3.1

Source: Magyar Villamos Muvek Troszt, *Kozlemenyei: 1989/2*, Budapest, Hungary, 1989, p. 47.

While no marginal cost data or operating rules were reviewed, it is apparent from gross statistics that import sources (primarily the Soviet Union) are treated as the marginal supply, bearing a more than proportionate share of peaking responsibility.[8] Domestic generation is more likely to be base-loaded, or operated as seasonal cycling capacity. Anecdotal information suggests that import sources are regarded as less reliable than domestic sources.

Available domestic generating capacity is reported as 7,133 MW in 1988.[9] Import sources add an additional 1,700 MW of capacity, for a total of 8,833 MW available to the national transmission grid. The 1988 peak hour occurred at 1700 hours on 15 December; the total load was 6,523 MW, less than 74 percent of grid capacity.[10]

Future Supply Alternatives. The forecasts examined in the course of this review pertained to annual electric energy use and to changes in the structure of total energy sources. No information was obtained on forecast capacity requirements, or on any possible changes in peaking or seasonal characteristics.

However, supply capacity does not appear to be seriously deficient at the present time, and relatively modest growth rates are forecast for the near future. Demand management practices now in place include time-of-use pricing for all electric consumers, as well as demand charges for industrial users. Appropriate use of these strategies, coupled with promotion of energy conservation practices in industry and elsewhere, should be sufficient to restrain growth at or near forecast levels over the next 7-10 years. Assuming continued economic development, however, energy use may well return to higher growth rates by 1995 or 2000 unless progressively more severe conservation measures are implemented.

There does not appear to be an urgent short-term need for new generating capacity in Hungary. The principal benefit from added capacity (e.g., Bös-Nagymaros generation) will be to reduce reliance on imports, thus avoiding certain costs and perhaps increasing reliability. The extent to which these benefits can be realized depends in part on the availability of energy from the Danube project during the critical winter months. If hydroelectric generation is reduced by low flows and ice conditions, the country's ability to avoid capacity and production costs for imported energy will be correspondingly reduced. No study of this issue has yet been made available for review.

There is also a longer-term need for new capacity sufficient to meet rising energy demands in Hungary. While hydroelectric generation should certainly be considered as a possible means of providing that capacity, there is adequate time to explore other alternatives. One of these, proposed by EGI-Contracting/Engineering, involves the conversion of existing low-efficiency district heating plants to cogeneration facilities. Properly implemented, this approach could provide a significant increase in electric generating capacity with little or no increase in the use of primary fuel or in the emission of pollutants.

Generating capacity addition should be pursued as a part of a comprehensive energy plan which includes consideration of all feasible alternatives. The supply expansion program chosen should be coordinated with implementation of demand management measures, so that the energy needs of the country are met at the lowest possible total cost. Since the Bös-Nagymaros project was apparently conceived and implemented independent of any comprehensive energy planning process, it is impossible to say what role it might have in a least-cost expansion strategy. Nothing is known, therefore, of the magnitude or existence of benefits from the anticipated hydroelectric generation.

Endnotes

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2. Magyar Villamos Müvek Tröszt, p. 42.
3. Unpublished data provided by EGI Contracting/Engineerng during meeting with Harry Schwarz on 19 April, 1989.
4. Unpublished data.
5. Magyar Villamos Müvek Tröszt, p. 10.
6. Magyar Villamos Müvek Tröszt, pp. 28-29.
7. Magyar Villamos Müvek Tröszt, p. 7.
8. Magyar Villamos Müvek Tröszt, pp. 28-29.
9. Magyar Villamos Müvek Tröszt, p. 46.
10. Magyar Villamos Müvek Tröszt, p. 29.

Visual and Cultural Analysis of the Nagymaros Barrage Project

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"Minden nemzet, mely elmúlt kora emlekezetét, semmivé teszi, vagy semmivé tenni hagyja, saját nemzeti életét gyilkolja meg"

"Each nation which annihilates the memory of its bygone days, or allows this annihilation to occur, murders its own national life"

- Kölcsey

Visual Characteristics

The visual quality of the Danube Bend landscape is based both on the area's physical character as well as on the deep historic, cultural, and spiritual meaning of the region for the Hungarian people. Visual perception is based both on objective optical elements such as form, line, color, and texture as well as on the meaning derived from these elements by the viewer. In the Danube Bend, the meaning and symbolism of the landscape are of overriding importance due to the area's significance for Hungarian culture. Visual impact assessment in the Danube Bend must take this principal into account.

The international community has already recognized the unique physiography of the Danube Bend area by designating the Pilis and Börzöny districts as World Biosphere Parks. When the area's physiography is combined with its unique historic, archeological, and cultural assets, the Danube Bend truly becomes a landscape of major international significance.

In a European context, the physical landscape of the Danube Bend is important, but is overshadowed by the more dramatic physiography found in other countries. In its Hungarian context, the physiography of the Danube Bend is exceptional. Nowhere else in the country does a major river like the Danube flow through hills as high and as dramatic as the Pilis and Börzöny highlands.

The extensive woodlands covering the hills create a unique habitat for diverse wildlife and create the exceptional scenic quality for which the area is famous. The steep cliffs and curving alignment of the river produce a dramatic landscape made all the more significant by the area's unique historic resources.

The central, but often overlooked, element in this landscape is the Danube River itself. Over millennia, the Danube has carved and shaped the landscape of steep hills, cliffs, and dramatic gorges that make up the landscape of the Bend. The sheer size and speed of the river as it flows through the gorge imparts a sense of elemental power, life, and drama to the landscape. Construction of the Nagymaros Dam would still the visible power and life of the river and would halt a continuous process of landscape formation that has endured for countless millennia. The disruption of this age-old natural erosive force would signal a new era for the Danube Bend, an era of sedimentation and deposition, the geologic equivalent of middle-age fattening and hardening of the arteries of a formerly athletic and vigorous landscape. While many elements of the region's physiography would remain unchanged, the force which shaped it would be stilled.

Recent development of vacation homes on steep hillsides in the Danube Bend has reduced the visual quality the area enjoyed up to twenty years ago. The vacation homes have introduced a visual intrusion into the landscape of major proportions. While this intrusion has reduced the visual quality of the area, the Danube Bend remains a unique scenic and cultural landscape. The damage to the landscape caused by the vacation homes can be partially remedied by more tightly controlling land-use regulation and enforcement, by encouraging future development to follow traditional settlement patterns, and by purchasing and relocating the most visible structures.

Historic and Archeological Resources

The Danube Bend is a landscape laden with historic meaning and symbolism for the Hungarian people. The area has traditionally held great strategic as well as cultural significance for the nation. Continuously inhabited since the paleolithic age, the region contains an irreplaceable prehistoric, Roman, and medieval archaeological resource, the true extent of which may never fully realized if the dam is built as planned. The Danube Bend formed a crucial part of the northeastern border of the Roman Empire and is still lined with one of the densest clusters of Roman fortifications in the world, many of which would be flooded by the proposed dam. In the Middle Ages, the Danube Bend region was the very center of the Hungarian nation with former national capitals located in Visegrád and in nearby Esztergom. One of the centers of life and culture during the early Árpádian Dynasty, it contains priceless ruins from this important period in Hungarian history. The Danube Bend is also the location of the ruins of the castle and summer palace of Hungary's great King Mátyás who held back the Turks.

Archaeological resources of international significance are threatened by the construction of the Nagymaros Dam and the subsequent flooding of upstream areas rich in archaeological sites spanning 3,500 years. In their Draft Resolution of November 25, 1988, the Archaeological Committee of the HAS strongly states that in spite of efforts to excavate and remove of archaeological remains from the site of the Nagymaros Dam and upstream impoundments, large-scale destruction of precious archaeological resources in the Danube Bend area will nevertheless occur. The Resolution states that the speed with which the Austrians are building the Nagymaros project and the lack of funding provided the Hungarian National Museum is totally overloading the capacity of archaeologists to properly excavate and preserve artifacts. "The fact that we have done everything to save the archaeological relics is not acceptable, and those optimistic declarations which attempt to pacify public opinion in our country by saying that archaeological relics will not be destroyed or will only be destroyed in insignificant numbers, are even less reasonable." The Committee's Draft Resolution then goes on to point out that, due to limited time and resources, many archaeological sites will not be able to be excavated in time to save relics.

In his 1985 *Defense of Archaeological-Historical and Monumental Values and Interests in the Region Above the Nagymaros Dam,* Dr. István Horváth, Director of the Bálint Balassa Museum in Estergom states that the Nagymaros dam and its upstream impoundments will cause major damage to the historic, monumental and archaeological potential of the area. In his view, frequent total destruction of objects and sites will occur. He points out the great tourist potential that will be lost by destroying these sites and emphasizes that they also "play an important role in forming the sound local patriotism, the proper attitude to history and the national consciousness."

Dr. Horváth traces significant archaeological remains in the area back to the neolithic age (3,500 - 2,500 BC). He points out that the river terraces which will be inundated or buried by the dike system were some of the most important sites for early settlement and contain many significant finds. In Roman times, this region contained one of the densest clusters of watchtowers and fortifications in the entire empire, guarding this important border against invasion. He emphasizes the priceless archaeological and historical richness of a region that was the very heart of the Hungarian nation in the Middle Ages.

Dr. Horváth's report states that a total of 45 archaeological sites are endangered in the area upstream of the Nagymaros Dam: 5 in Dömös, 14 in Pilismarót and 26 in Esztergom. Of these endangered sites, 4 are Hungarian relics of outstanding international significance (Class I), 12 are non-Hungarian relics of universal significance (Class II), 16 are significant from a scientific, historical or archaeological standpoint (Class III), 7 are interesting from a scientific viewpoint (Class IV), 3 are insignificant remains based on surface signs (Class V), and 3 sites have already been destroyed by construction activities. The threatened Class I sites include the Royal Town of Esztergom, the remains of a Stephanite Church in Szentkirály, remains from the Bronze Age, Celtic, Roman and Medieval eras on Sziget Island, and the Viziváros Water Tower in Esztergom. The threatened Class II sites include 12 of the 22 Roman watchtowers and 4 fortifications (castra) that line the river between Esztergom and Nagymaros, one of the densest line of towers and forts in the Roman Empire.

The fact that many of these endangered resources are being excavated, removed from the site, and preserved in museums does not adequately compensate for the loss of the sites themselves. It is a well-known principle of archaeology that artifacts preserved in their original locations are usually much more valuable than individual artifacts located in museums. An archaeological site in its entirety contains valuable information that is lost when its individual pieces are removed. A similar principle is true from an interpretive point of view as well: Sites preserved in their original locations, especially in dramatic settings such as the Danube Bend, are of much greater interest to the visitor than are artifacts located in glass cases in museums. An additional concern is that many larger, structural elements, such as the walls of the Roman watchtowers, will not be able to be transported off-site and will be lost.

Our study team must conclude from this information that the proposed Nagymaros Dam project will have an extremely adverse effect on archaeological and historic resources of Hungarian, as well as international, importance. This project represents a significant loss of Hungarian cultural resources.

Symbolic Issues/National Significance

Our visual analysis of the project takes into account the strong role that meaning and symbolism plays in visual perception. This has led us to conclude that while it may be possible to somewhat reduce the objective visual impacts of the project, meaningful visual impact mitigation of the proposed barrage project may be impossible given the overriding negative symbolic and emotional connotations the project represents to many Hungarians. Recent evidence of Hungarian public opinion--including mass demonstrations, newspaper articles and editorials, and interviews--suggest that the dam may violate something sacred to many Hungarians. To others, the dam is like a fly in a bowl of soup: Its negative visual impact stems from what it means, not from what it looks like or its relative visibility.

An immediate moratorium should be placed on construction of the project to allow detailed public opinion research on popular perceptions of the Danube Bend landscape and proposed dam. Scientific visual perception studies should be conducted to further investigate Hungarians' perception of the landscape and the project. Public opinion polls should be conducted as well. For the purposes of this interim report, time constraints imposed by the on-going construction of the dam force us to make initial determinations from the available information. But it is clear from recent events that a large group of people vehemently oppose the project. Additional research could determine how deep the opposition runs and why the opposition has developed. We therefore strongly recommend conducting a nationwide public opinion poll or survey which would provide policy makers and planners with detailed information which could serve as the basis for developing a response to the project more attuned to the concerns of the Hungarian people. Conducting any additional studies, including final phases of this study, will be meaningless unless a moratorium on construction is immediately placed on the Nagymaros portion of the project. The only way to definitively gauge public opinion on the subject would be to conduct a nation-wide poll, which we recommend. But because of the limited time available and the preponderance of information already available in the form of interviews and articles, and the clear evidence of mass opposition to the project, we can develop a sound initial sense of the level of opposition to the project.

Visual, cultural and environmental quality are usually viewed as separate entities but are, in fact, inextricably linked. A landscape perceived as beautiful is often also environmentally sound and culturally significant to the viewer. Objects or landscapes perceived as ugly are often visually stimulating but contain elements that symbolize cultural upheaval or environmental degradation.

The most important justification for preserving scenic and historic landscapes is that scenic beauty--and the environmental and social well-being it reflects--is a basic human need. Beauty in the land is not just a matter of superficial and subjective visual preference; nor is it an isolated aesthetic factor separated from other environmental issues. Our perception of beauty in the land is founded in the values that we hold important: ecological diversity, clean air and water, open space, peace and quiet, agricultural productivity, historic and cultural richness, national heritage, and a sense of knowing and respecting where we have come from and where we are going. A landscape is beautiful not just because of its scenery, but because of what its scenery symbolizes to its beholders. The landscape of the Danube Bend is a place where for many centuries and until quite recently man and nature have struck a careful balance, where human activity has complemented rather than destroyed the natural environment. The Danube Bend is beautiful not just because it is visually stimulating, but because it symbolizes a one thousand year tradition of coexistence between Hungarians and their land and environment.

Because of its outstanding visual, cultural and environmental features, the Danube Bend holds tremendous national significance for the Hungarian people. The Danube Bend is both their most dramatic natural landscape, as well as one of the country's most historically significant locations. A similar situation would exist in the US if Plymouth Rock, the site where the first permanent settlers landed, were located in the Grand Canyon, one of the country's most dramatic natural landmarks. Building a dam in the middle of such a resource would be absolutely unthinkable to most Americans. Not unexpectedly, building the Nagymaros Dam appears to be eliciting a similar reaction from many Hungarians, now that they are able to more freely express their opinions in public.

Symbolic issues concerning the Danube Bend and the Nagymaros Dam are also interwoven with the current political developments in the country. Opponents of the dam link the project with the evils of Stalinism. A recent postcard distributed by the opposition shows a trick photograph of Hungary's current environment minister and Joseph Stalin standing side-by-side in front of a large dam. Protesters have planted crosses on the Nagymaros cofferdam. A photo exhibit on the effects of the dam also include pictures of the exhumed graves of political leaders executed after 1956. While obviously exaggerations, these analogies show the depth of emotion and negative symbolism that, rightfully or not, have been associated with the dam project by what appears to be a significant segment of the Hungarian population. The result appears to be that the positive symbolism of the Danube Bend has been elevated above what recent land-use actions in the area would indicate its importance to be. Conversely, the negative symbolism of the proposed dam has grown well beyond the ecological and cultural impacts normally associated with a project of this type. It would not be an exaggeration to say that the controversy over the dam in the Danube Bend has become the very symbol of the confrontation between the old and new orders in contemporary Hungarian society and politics. As such, the landscape and the proposed dam have become imbued with enormous symbolic importance that cannot be ignored in judging the perceptual impacts of the project. For many Hungarians, the Nagymaros Dam is the embodiment, the physical expression of poor planning, lack of public participation in decisionmaking and a value system willing to sacrifice the environmental health of an entire river system and the integrity of an historic cultural landscape of international significance.

Nagymaros Dam

Numerous studies have been conducted to date concerning the visual impacts of the Nagymaros Dam. OVIBER has produced a photographic simulation of an aerial view of the dam. Professor Attila Csemez has also produced an elaborate visual study of the impacts of the project, including many hand-drawn acetate overlays of the proposed project superimposed on photographs of the site. Professor Csemez's work has been instrumental in achieving certain modifications to the original barrage proposal. We do not intend to duplicate these efforts and have concentrated instead on reviewing the visual studies conducted to date and adding additional information not covered in these previous reports.

Since the OVIBER visual simulations depicted the proposed project from a distant, elevated aerial perspective, we felt it would be useful to depict the barrage as it would appear from a close-up, ground level point of view. These drawings are included in this report. We have also included an aerial perspective showing what the Danube Bend area would look like if construction of the Nagymaros Barrage were eliminated and the National Heritage Park concept implemented.

Studies by Professor Csemez show that the proposed Nagymaros Barrage will be visible from river level throughout the central portion of the Danube Bend, from the western end of Verőcemaros to Dömös. Construction of the dam has already had drastic visual impacts on the historic town of Nagymaros and from portions of Visegrád, the former Hungarian capital.
From the surrounding hills, the facility will be clearly visible over a much wider area, including the famous views from the Fellegvár and Salamon Towers. It will also be clearly visible from most of the major roadways flanking the Danube in this area.

While the proposed Nagymaros Dam is not visually large in relation to the surrounding landscape, physical and perceptual factors will greatly accentuate its visual role in the landscape. Because it is located in the very center of the Danube Bend, it will become a visual focus for the entire region. This focussing is further accentuated by the fact that the dam is located in a steep valley which itself serves to funnel views toward the valley floor. The final factor that will focus visual attention on the dam is the fact that it impacts the visual character of the river which is the central visual feature of the region. These physical factors are greatly accentuated by the cultural influences on perception discussed below.

As originally designed, the project would have had an overwhelming visual impact on the central portion of the Danube Bend. A tall smokestack, overhead transmission lines, several massive, rectilinear building complexes, and large tracts of box-like housing would have transformed the historic Danube Bend into the visual equivalent of an heavy industrial district. Recent modifications to the proposal have lessened, but not eliminated, the visual impacts of the proposed barrage complex. These modifications were the results of a design competition and the persistent efforts of Professor Csemez. The modifications include removal of the proposed smokestack, reduction of the height and bulk of the large building adjacent to the locks, burying of the transmission lines, modification of proposed grading and road alignments, and the addition of two recreational water basins on the south bank of the river.

The proposed dam complex has been designed with low, clean, contemporary industrial styling. The present design of the dam and associated structures is an improvement over former proposals, but nevertheless has no precedent in the Danube Bend landscape and introduces an alien architectural mass and form into a region of traditional village architecture. The design of the landscape surrounding the dam complex places an emphasis on revegetation and on recreational facilities. The planting program appears to be significant with major replanting of trees proposed adjacent to the dam and along the upstream banks. It will be many years, however, before the banks are fully revegetated. Replanting of trees is little compensation for the proposed destruction of over 40 km of mature riparian vegetation and bordering wetlands.

The active recreational facilities to the south of the proposed dam introduce alien, contemporary man-made landscape forms into the natural and historic landscape of the Danube Bend area. The kidney-shaped recreational ponds lined with rip-rap or beaches will be highly visible and have no visual precedent in the Danube Bend area. The recreational opportunities they provide are needed, but not in a sensitive scenic and historic landscape of national significance. The associated recreational, service and storage buildings will also stand out in marked contrast to the surrounding landscape.

If the Nagymaros Dam is completed, it will create the only automobile bridge across the Danube between Budapest and Komárom. This may cause traffic in northern Hungary to funnel through the Danube Bend, greatly increasing congestion on local roads. This would lead to pressure to expand highways in the Danube Bend and could result in greatly increased development in the area. This would cause further physical and visual degradation of this sensitive environment, as well as increase noise, air, and light pollution of the area.

In spite of recent modifications in the lighting plan for the dam, the entire structure will nevertheless need to be illuminated at night, greatly modifying the night-time character of the Danube Bend.

Visual and Cultural Impacts of Four Downstream Program Options

Downstream Option A: Completion of Dam as Planned

In spite of recent design modifications, the proposed Nagymaros Barrage will have severe and irreversible visual impacts on the Danube Bend. The extensive dikes proposed for both banks of the river for up to 50 km upstream of the

Nagymaros Barrage will also have enormous visual, historic and archaeological impacts on this scenic and historic stretch of the river as well as on the historic city of Estergom. Proposed measures to contain the new impoundment upstream of Nagymaros will essentially replace the existing densely vegetated riparian shoreline environment with a barren dike.

The attached ground level perspectives show some of the visual impacts of the proposed dam from a less flattering angle than portrayed in OVIBER publications. These physical disruptions in the visual landscape, combined with the dam's significant negative symbolism, reveal the true extent of the project's impact on a unique environment.

From a visual and cultural standpoint, this option will have disastrous consequences. The severe degradation of a scenic and historic landscape of national and international significance is reason enough to remove the Nagymaros dam and restore the Danube Bend landscape to its former state.

Downstream Option B. Relocation of the Nagymaros Dam 10 km Upstream

While this option is preferable to Option A because it would allow restoration of the landscape of the Danube Bend, it would still have severe and unacceptable visual impacts on the very scenic and historic Danube landscape east of Estergom. While this landscape is not as visually significant as the Danube Bend, it is nonetheless very valuable. The dramatic contrasts between the Little Hungarian Plain and the Pilis Hills in this area are augmented by the almost total lack of vacation homes and other forms of recent development in the area. The visual contrasts between the flat and intensively farmed Little Hungarian Plain on the north side of the Danube with the steep, wooded hills to the south enhance the visual quality of this area.

Relocation of the dam would also not prevent the major destruction of the upstream river banks as a result of the dikes required to contain the impoundment. The bordering riparian environment for up to 40 km upstream, as well as the former Hungarian capital of Estergom and a large number of historic and archeological sites, would continue to be impacted by the relocated dam.

Because the floodplain of the river is much wider at this point and because excavation would have to be much deeper to reach bedrock, construction impacts would be spread over a much wider area than at Nagymaros and the final dam would be have to be much longer.

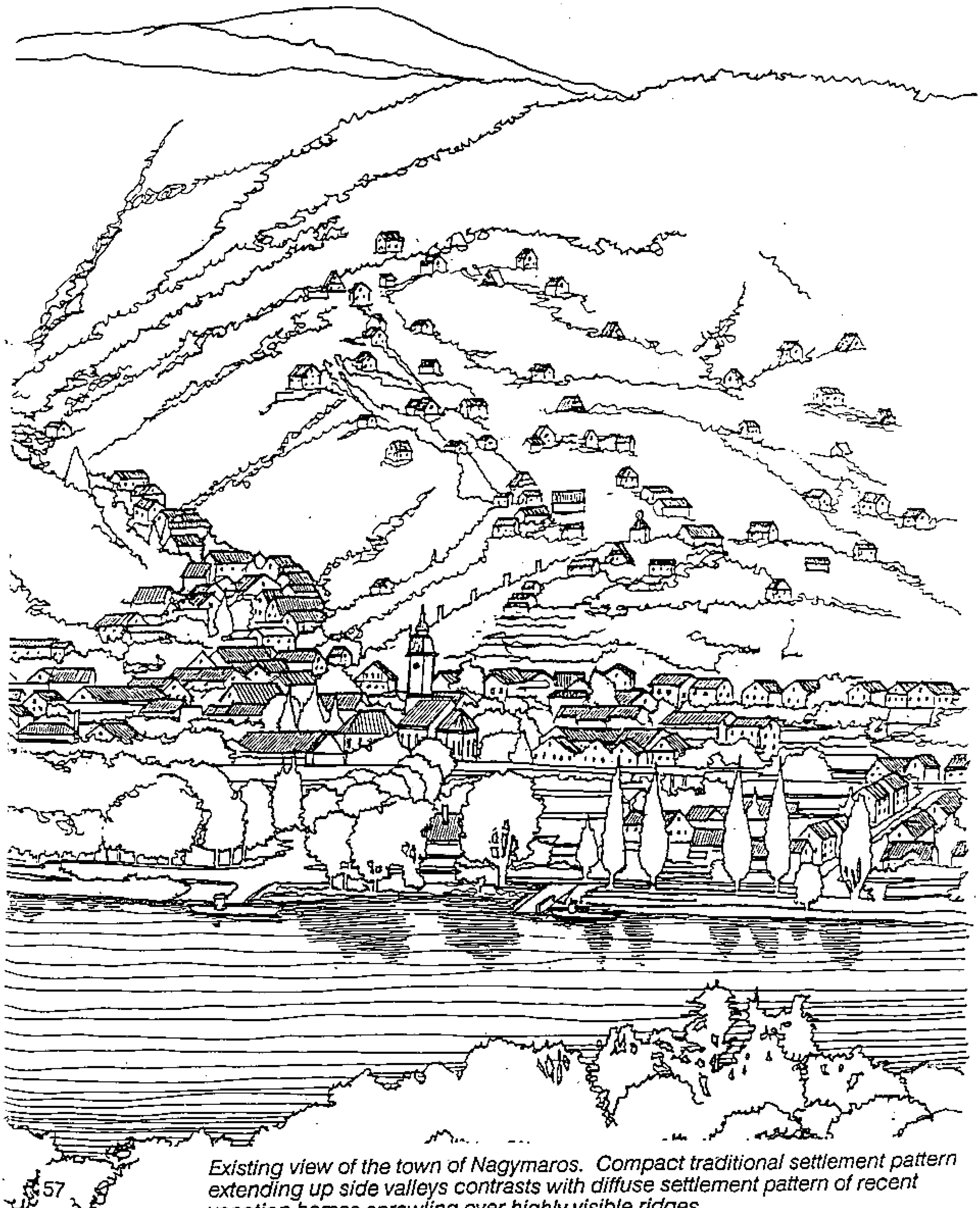
Downstream Option C. Stopping the Project and Stabilizing the Nagymaros Cofferdam

In the Danube Bend itself, the visual impacts of the existing cofferdam are greater than those of the completed project. The physical extent of the cofferdam is much greater than the size of the completed dam and, because it is a construction site, lacks the finish grading and planting that could help reduce visual and environmental impacts. In the context of the larger region, the main visual benefit of this option would be the preservation of 40 km of scenic upstream riverbanks from flooding and dike construction.

From a cultural and environmental standpoint, stopping construction without removal of the cofferdam and restoration of the site would still be preferable to completing the Nagymaros Dam. This is because most of the cultural and environmental damage would be caused by the upstream impoundment and dike system, not by the construction of the dam itself. Leaving the cofferdam in its current state, while resulting in considerable visual, navigation, and safety concerns, would still spare 40 km of environmentally and culturally senstive upstream riverbanks from flooding. The benefits and drawbacks of this option are therefore very mixed and it is not at all an acceptable alternative from a visual or cultural point of view.

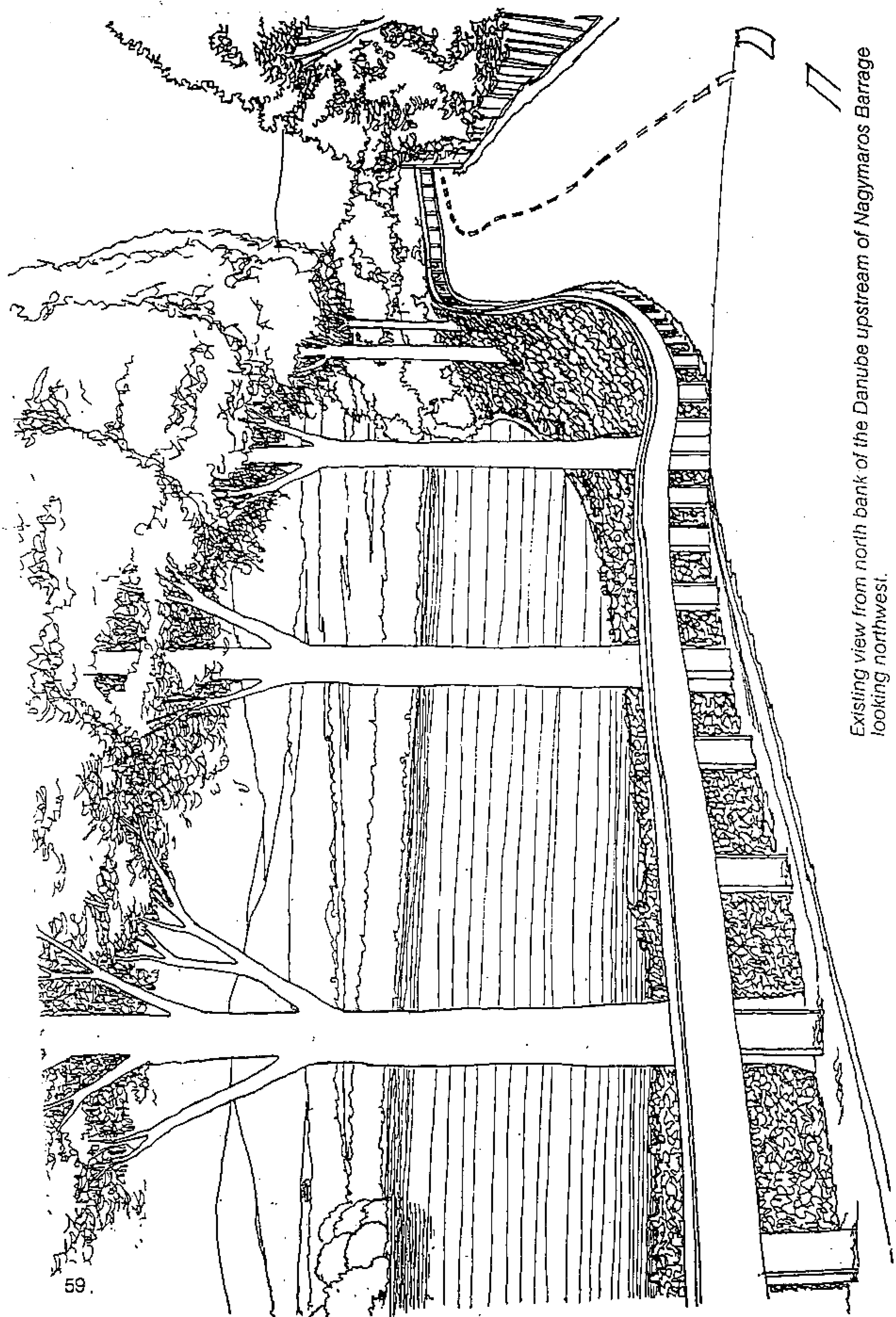
Downstream Option D. Removal of the Nagymaros Dam and Full Restoration of the Danube Bend Landscape

From a visual and cultural standpoint, this is the preferred option for the project. Given the great difficulty or impossibility of mitigating the impacts of the dam on the region's scenic and historic resources, the Nagymaros dam should be cancelled, all evidence of construction be removed, and the site restored to its former condition. Relocation of the most visually obtrusive vacation homes and exterior alterations to two areas more consistent with the region's traditional settlement patterns, is also recommended. The results of implementing these recommendations is illustrated in the attached perspective drawings. These reveal the full visual and cultural potential of a large scale restoration of the Danube Bend landscape.



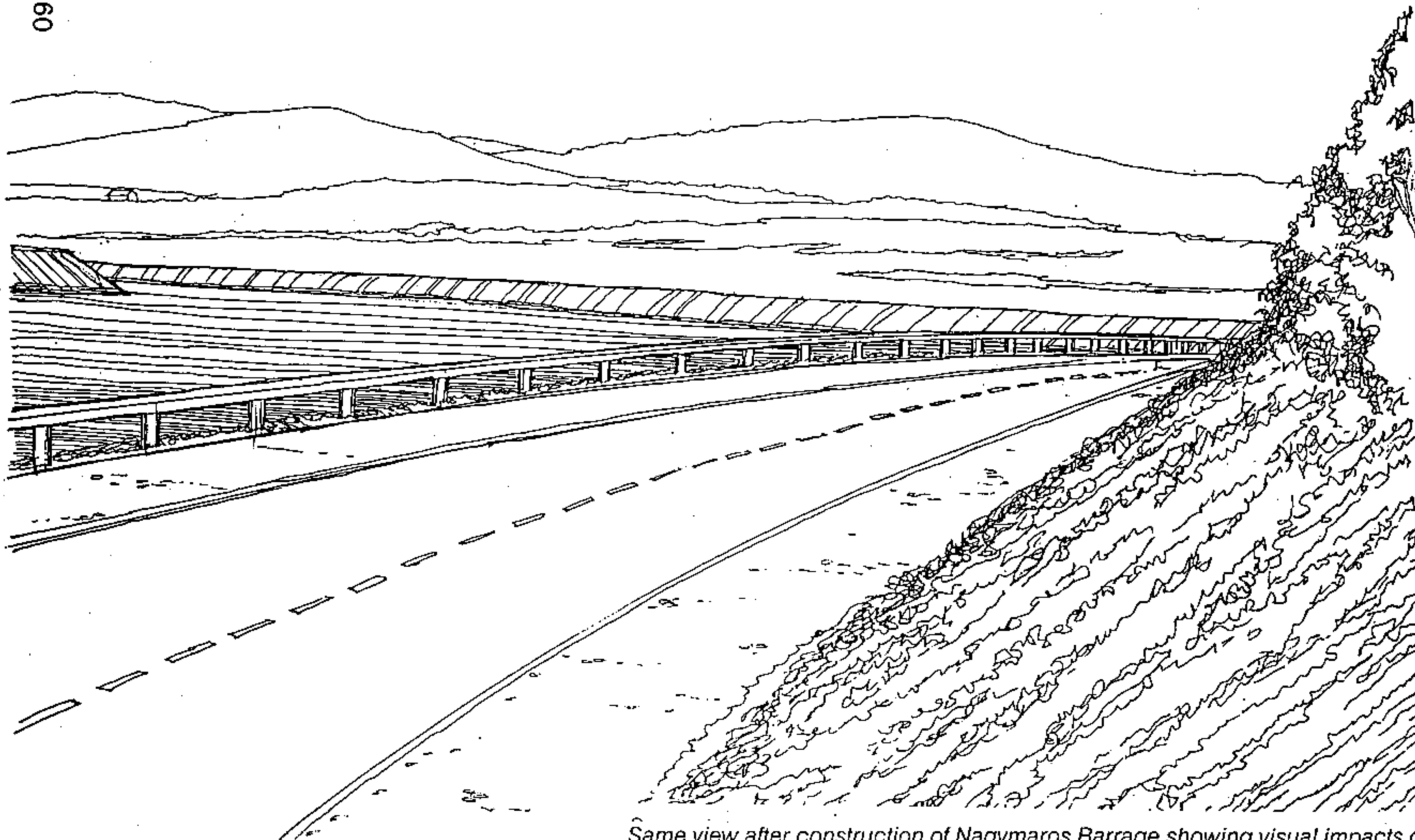
57 *Existing view of the town of Nagymaros. Compact traditional settlement pattern extending up side valleys contrasts with diffuse settlement pattern of recent vacation homes sprawling over highly visible ridges.*

58 *Proposed view of the town of Nagymaros. Pattern of new vacation homes more closely follows the traditional pattern of the town.*



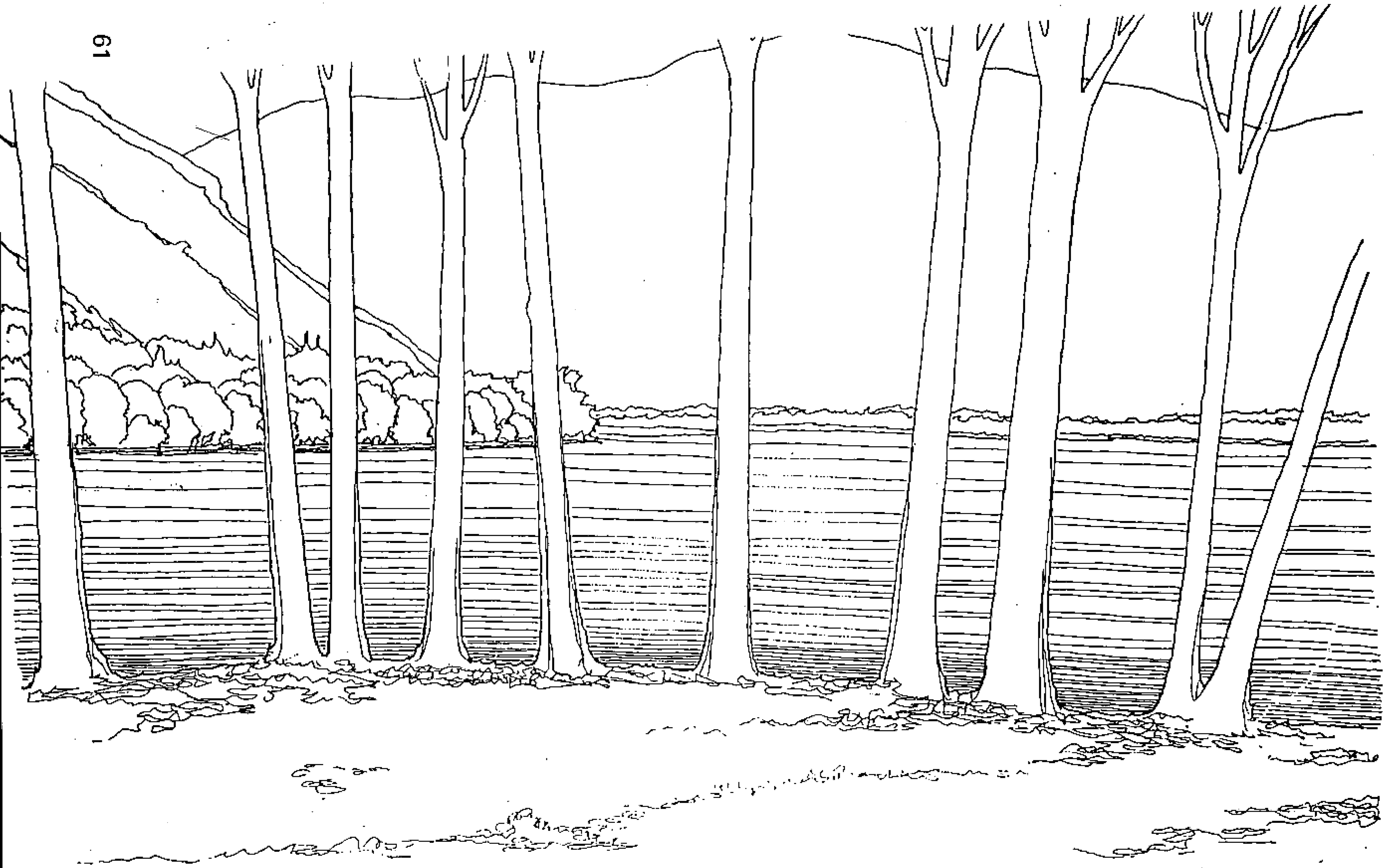
59.

Existing view from north bank of the Danube upstream of Nagymaros Barrage looking northwest.



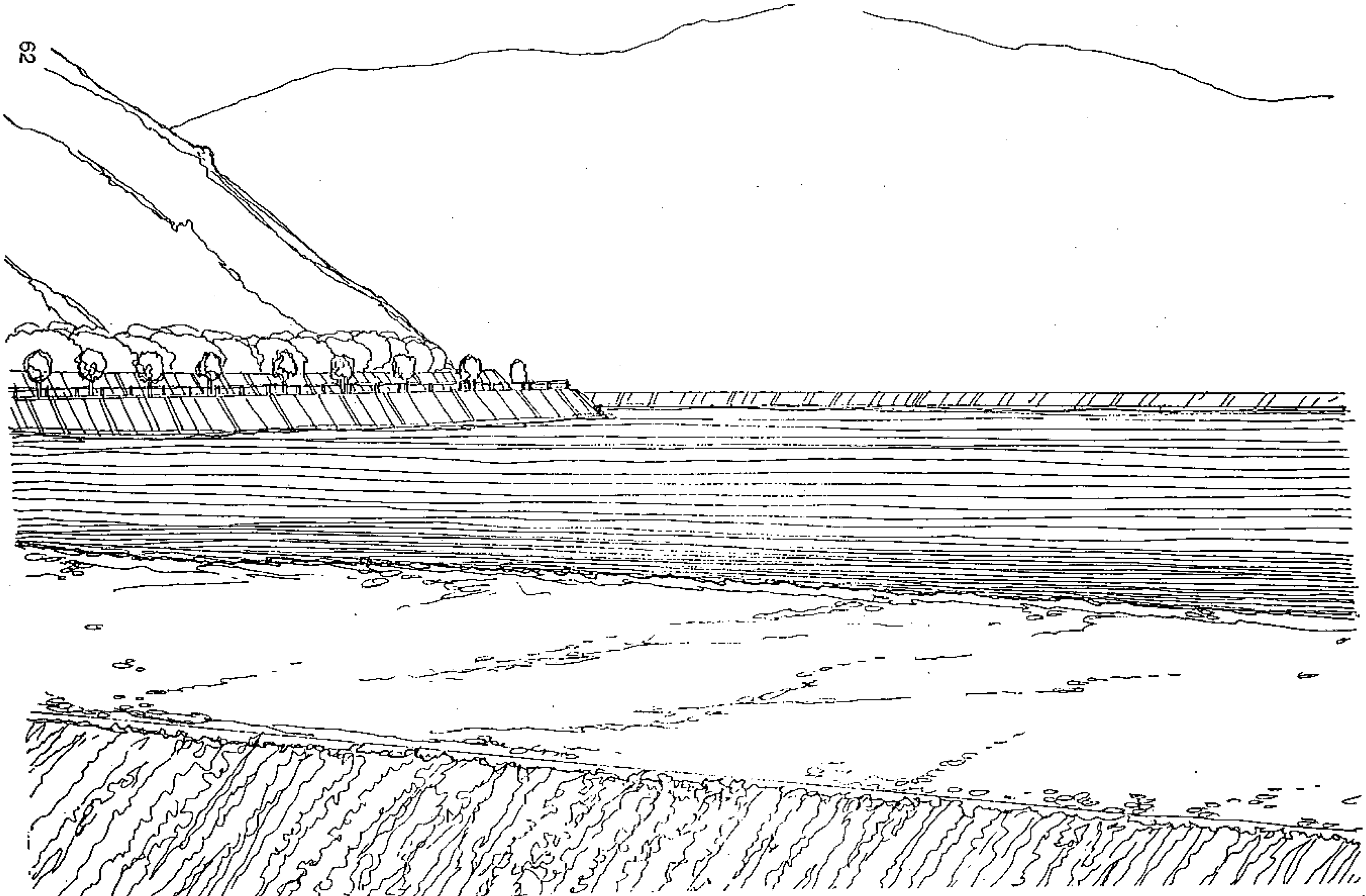
Same view after construction of Nagymaros Barrage showing visual impacts of tree clearing, dike and new road construction.

61

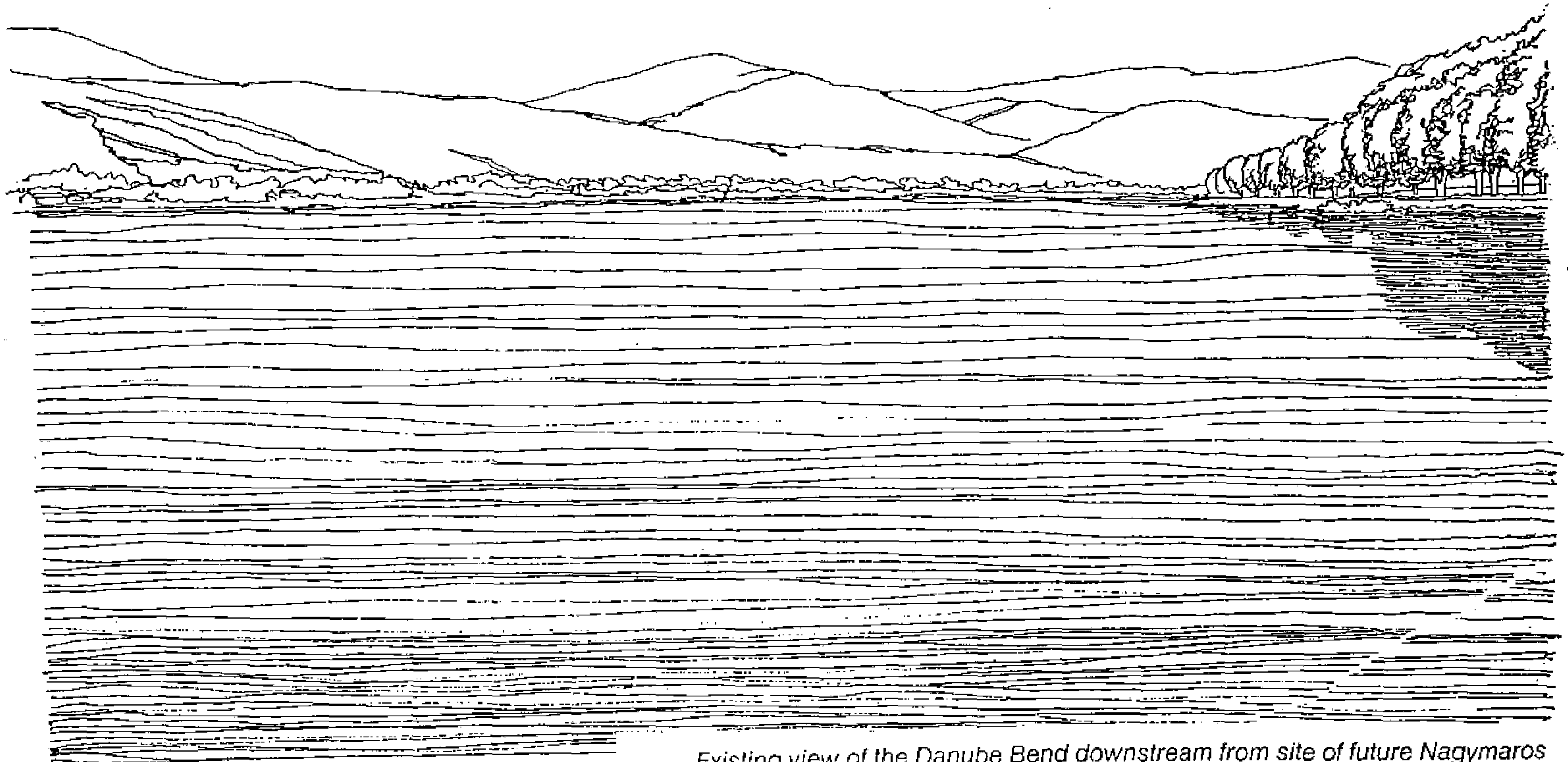


Existing view from north bank of Danube upstream of Nagymaros Barrage looking southeast.

62



Same view after construction of Nagymaros Barrage showing visual impacts of tree clearing, dike and new road construction.



Existing view of the Danube Bend downstream from site of future Nagymaros Barrage, looking southwest.

Proposal for a Danube Bend National Heritage Park

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Dam Removal and Restoration of the Landscape

If Nagymaros Dam construction were terminated, full restoration of the Danube Bend national heritage landscape could occur over a twelve year period, beginning in 1990. This would mark the 500th anniversary of the death of King Mátyás and culminate in the 1,000th anniversary in the year 2001 of the coronation of Saint Stephen and the founding of the Hungarian Nation. This bold action would not only restore an irreplaceable landscape, it would also draw together Hungarians in a process of national healing and reconciliation centered on the restoration of their nation's birthplace. This process could begin on the 500th anniversary of a sad date in Hungarian history when King Mátyás died and the Turks began their 150-year occupation of the country. The period from 1990 to 2001 would be a symbolic journey from the commemoration of a dark point in the nation's history to a great celebration: the commemoration of the founding of Hungary and the crowning of Saint Stephen. During this twelve year period, the physical scars of the Nagymaros Dam and the social and political problems it symbolizes could be removed from the Danube Bend through a collaborative effort in which every Hungarian would be encouraged to volunteer.

Signs of potential national enthusiasm for this project are already evident and are symbolized by the recent offer by an entire class of school girls to begin the removal of the coffer dam by hand. Their offer may seem naive, but efforts such as theirs, spread out across an entire nation represents a force stronger than one hundred bulldozers! If properly encouraged and organized, volunteerism of this sort can help muster the financial and material support required to undertake the removal of the cofferdam and restoration of the Danube Bend landscape. The recent multi-million dollar restoration of the Statue of Liberty in the US was made possible, in part, by a national fund-raising campaign in which school children each donated a penny or more of their savings to the project. This not only resulted in substantial financial support, it helped millions of children personally identify with the restoration of a national symbol and helped them understand that the people of a nation, including its children, can move mountains by working together.

Hungary would not be the only beneficiary of a protected and restored natural and cultural environment on the Danube. The restoration of the river and its cultural landscape could have potential benefits for Hungary's neighbors as well, especially in light of the proposed World's Fair. The removal of the dam and creation of the National Park should be coordinated with the proposed Vienna/Budapest World's Fair. Inclusion of the landscape restoration and national park project as an integral part of the World's Fair proposal would greatly increase the competitiveness of the proposal in the eyes of the international jury deciding between Vienna/Budapest and Miami. After all, the Danube Bend National Heritage Park and restored Danube River is the great, historic link that has always been the main connection between the two cities. What better way to highlight this historic bond than to preserve, restore, and enhance the river's priceless environment and cultural features. These features are not only the national heritage of the Hungarian people, they represent the physical expression of historic links between Austria and Hungary and other nations in the region as well. It is often assumed that cancellation of the project will benefit only Hungary and alienate Hungary's neighbors.

When a damaged architectural or landscape treasure is restored, more than a physical transformation takes place. An important part of the people's national consciousness, pride, and self-knowledge is restored as well. Hungary has a record of overcoming large financial and physical obstacles in the restoration of their treasured buildings and sites. The reconstruction of Budapest after the damage of World War II and 1956 is an example of this. This commitment to architectural and urban restoration now needs to be applied to the scenic and historic national landscape of the Danube Bend. The restoration project will be costly and its true expense should be clearly explained to the Hungarians. The cost to each Hungarian might be explained, both as a way to translate the magnitude of the expense into personal terms, as well as to demonstrate how all citizens working together can accomplish something truly significant through their financial contribution.

Restoration of the Danube Bend landscape could also involve the purchasing and relocation of the most visible of the vacation homes that currently cover many of the hillsides along the river. The homes would only be purchased from willing sellers on the open market. No compulsory sales of property would be involved. Current owners could sell their homes and remain on as life tenants. This approach has been successfully applied by the US National Park Service at the Cape Cod National Seashore in Massachusetts and in a number of other national parks and forests. It allows for fair compensation of landowners, respecting landowners concerns and property values, and for a gradual rather than a sudden transition to landscape restoration.

The result of the cancellation of the Nagymaros Dam and of a portion of the vacation homes would be a National Park, a landscape monument to both the Hungary of old and the Hungary of the future. It would be built through a collective national effort by the Hungarian people and be made possible by a combination of government efforts and by individual, voluntary donations of funds, labor, professional skills, and moral support by Hungary's citizens. It would be the Hungarian people's 1,000th birthday gift to their country and to their children and grandchildren.

Examples of Opposition to Large Water Projects in Other Countries

The Nagymaros Dam project is a relic of an era in Hungary when major development decisions were made without proper regard to their environmental, cultural, and visual consequences, and without citizen participation in the decision-making process. Construction of the dam and associated system of upstream dikes would have adverse environmental and cultural impacts that would not be tolerated in many countries today. For example, public opposition recently prevented the construction of a similar dam on the Danube in Hainburg, Austria, only 170 km upstream from Nagymaros The Hainburg project would have led to the destruction of an important old-growth forest, a scenic valley, and important ecological and environmental resources: a major landscape, but certainly not on the scale of scenic, cultural, and national importance that the Danube Bend is to Hungary. The Austrian government has shown that it is very responsive to cultural and environmental concerns voiced by its own citizens within its own borders.

In the People's Republic of China, efforts to build what would be the world's largest hydro-electric project on the Yangtze River have been temporarily halted due to intense public opposition. The proposed dam would have drastic impacts on the environment and spectacular scenery of the historic Three Gorges section of the Yangtze and would inundate the homes of over a million people. The project is on hold pending the outcome of environmental and social impact studies.

In the US, major opposition to large-scale public works projects with major cultural and environmental impacts began to occur with the growing environmental awareness that developed in the US and other countries in the late 1960s. One of the catalysts for this change was the unsuccessful attempt at this time to prevent the damming of the Colorado River and the subsequent flooding of Glen Canyon, a major scenic gorge. The destruction of Glen Canyon caused a major outcry throughout the country and contributed to a growing public awareness of the harmful environmental and cultural impacts of large public works projects in sensitive areas. After the Glen Canyon controversy, local and national opposition stopped such projects as the Storm

King pumped storage facility on the Hudson River in the state of New York and the proposed Dickey-Lincoln Dam on the Saint John's River in the state of Maine.

Storm King, proposed by a major utility company, would have permanently marred a famous natural landmark in the Hudson River Highlands north of New York City. This landscape of high wooded hills, castles and small villages is remarkably similar in many physical and visual respects to the Danube Bend, though its physiographic, scenic, cultural and symbolic significance to the US is nowhere near the Danube Bend's overwhelming importance for Hungary. Vocal and widespread opposition to the project based on its negative visual, environmental, and cultural impacts forced its cancellation by elected public officials. Public outcries against this and other projects also led to the enactment of strict environmental regulations and permitting procedures stressing public involvement in decisionmaking by government and autocratic private utility companies.

The Dickey-Lincoln Dam in the state of Maine would have impounded one of the last major wild and free-flowing rivers in the eastern United States. Proposed by the US Army Corps of Engineers, the dam generated national opposition from a wide range of environmental, sporting, and wilderness preservation groups. This opposition finally led federal and state public officials to decide that the increased electric generating capacity of the proposed dam was not worth the heavy costs to the environment, to recreation and, most importantly, damage to the emotional and spiritual value that this last eastern wilderness holds for the American people.

Concern for the environment is not the only reason for widespread public opposition to certain public works or development projects in the US. A concern for the impacts of these projects on the deeply held cultural, spiritual and symbolic resources is also a fundamental cause for opposition. For many Americans, the wilderness holds a spiritual significance far beyond its tangible physical attributes. Protecting the wilderness means protecting the American spirit, one of the symbols of the country. America's national parks also have an important cultural and spiritual significance; they are national shrines and represent the linking of the people to their land and history.

In summary, a project of the nature of the Nagymaros Barrage would never be permitted today in many countries. In the US, the project would be impossible for any one of the following reasons: environmental impacts (destruction of wetlands, wildlife habitat, groundwater impacts, etc); cultural impacts (history, archaeology); scenic impacts; or public outrage at the degradation of a national symbol. If these problems were combined, as they are at Nagymaros, opposition to the project would likely be insurmountable.

Examples of Cultural Parks in Other Countries

Successful examples of cultural parks exist in Britain, France, the United States, and several other countries. Perhaps the best examples can be found in Britain, where the system of national parks emphasizes both natural and cultural features. The British National Parks are located in areas of outstanding natural beauty where human cultural practices such as farming and features such as villages, estates, historic sites and unique architecture have complemented and enhanced the natural characteristics of the land. Unlike most American National Parks, the British parks contain both public and private land. The private land is regulated by controls administered by the national parks agency and local planning authorities. The controls allow certain existing uses and prevent unregulated development and expansion in the private sector from damaging the natural, scenic, and historic characteristics of the park. The system is very successful because it emphasizes the close links between the natural and cultural landscape.

The French Cultural Parks system goes even further than the British in regulating and enhancing unique cultural traditions in rural landscapes. In the French cultural parks, traditional farming practices, architectural styles, local customs, ceremonies, and dress are all encouraged through financial and regulatory incentives. Private land ownership is also continued as in the British system. Modifications to existing structures and new construction is tightly regulated to ensure that it blends with traditional features.

In the US, several national and state programs are of interest. The Wild and Scenic Rivers Program of the National Park Service provides a degree of protection to qualified river systems. While most of the rivers are in wilderness areas, some rivers of unique historic or recreational value are also included. Limited controls on new development are achieved through cooperation with local regulatory authorities and restrictions placed on the use of federal funds and on the actions of other federal agencies in these areas.

Two regional parks in the US administered by state authorities combine public and private land use and protect cultural as well as natural features. The Adirondack Park Preserve in New York State and the Pinelands National Reserve in New Jersey cover entire regions of their states. They achieve preservation goals of the park by placing tighter than normal controls on certain types of public and private land use that could degrade the environment, scenery, and cultural resources of the area. In the Pinelands, the emphasis is on preservation of groundwater resources and the unique flora and fauna of the sand plain ecology. Small village life and architecture are also protected from intensive development. In the Adirondacks, a mountainous forest preserve dotted with small villages is protected from excessive logging, and unplanned recreational and second home development. Private property rights are respected, but within constraints administered by the park agency.

National Heritage Park Concept

The Danube Bend National Heritage Park would protect and preserve a landscape of international cultural, environmental, and visual significance for the Hungarian people. As a cultural park, it would consist of a combination of public and private land ownership and would preserve and feature the social as well as the natural resources of the area. Historic towns and villages, farms, rural residences and other cultural sites would be as important to the park as the preservation of the river, woodlands, and scenic hillsides. Private land ownership would continue, but be subjected to more careful controls to prevent unregulated development from damaging the resources of the park. Incentives could be provided to landowners and local officials to renovate historic structures, continue local traditions, and protect life in the region from the negative impacts of unregulated or poorly planned industrial, commercial, or residential development. The park would enhance the tourist potential of the region while ensuring that tourism is carefully balanced with preservation of resources and respect for local concerns. Establishment of the park would also help focus national resources on the preservation of archaeological resources and historic buildings, allowing them to be properly enjoyed, interpreted, and understood by Hungarian and international visitors.

Establishment of the park would require a great and concerted national effort. The park would become a symbol of the rebirth of national values based on a respect for the landscape, for the environment, for history, and for the right of all citizens to have a say in major decisions affecting their lives.

With certain modifications, the cultural park concept is ideally suited to the landscape of the Danube Bend and surrounding areas. The region contains both a unique natural and scenic environment, as well as an extremely rich historic and cultural heritage. The Danube Bend is unique precisely because of its long tradition of human interaction with and respect for the river environment. These traditions can be preserved and perpetuated by ensuring that the mix of public and private land use in the region continues in the future under the regulatory oversight of a strong and independent parks agency.

The park would be administered in consultation with local government officials and an advisory committee made up of local residents, business and community groups, and park users. A master plan for the park would be developed through a process of public participation and decisionmaking. Local authorities and residents, as well as regional planning organizations, would have opportunities to shape the master plan within the parameters established by the national legislation creating the park. The master plan would thoroughly inventory existing conditions, analyze data, and propose a varied range of protection measures for the diverse landscapes of the park. It would target areas for public acquisition and protection, as well as areas better suited for continued private ownership and operation. The plan would also specify administrative and park management goals and objectives.

Proposed Boundaries of the Park

Our proposed boundaries are derived from five sources, namely: the plan of VÁTI; Kertészeti Egyetemi Landscape Planning Study headed by Professor Attila Csemez; Archeological Study by Dr. István Horváth and his findings supported by the Archeological Committee of the HAS, which reported on the Bős-Nagymaros barrage on November 25, 1988; the March 1989 report on the Old Danube Channel-Szigetköz Ecosystem Protection Study; and five different field surveys by the members of the study team.

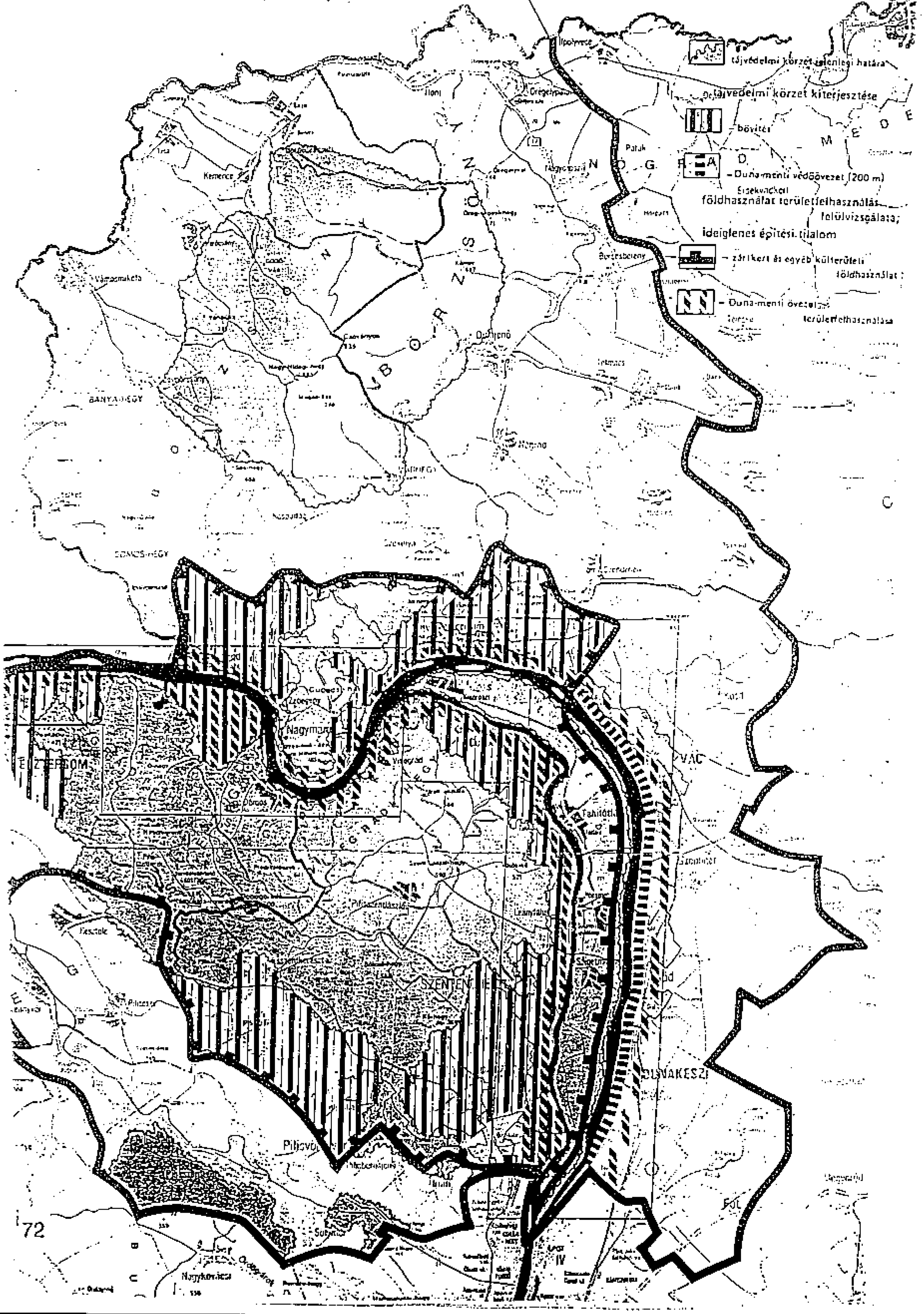
The boundary of the National Heritage Park is simple. We propose to adopt the boundary of the VÁTI Study area, as shown in the accompanying map. This includes the Visegrád, Pilis and Börzsöny Mountains, and surrounding valleys. The heart of this larger proposed National Heritage Park is the Danube Corridor itself. The concentration of valuable archaeological sites, historic structures, floodplains, wetlands, and unique river vegetation, would place this river corridor into the most significant landscape type within the park and hence into its highest protection zone.

This proposed National Heritage Park area has not only the densest concentration of archaeological and historic sites of several millennia, but also possesses the highest visual qualities within the Budapest region. The Visegrád and Börzsöny Mountains rise 500 to 600 m over the Danube Valley. The volcanic origin of these mountains on both sides of the Danube provide spectacular landscape contrast and panoramic views. The Fortress of King Mátyás has one of the best views in this region. Unfortunately, this view from the castle has been impaired by inappropriate and insensitive developments of weekend houses on the southerly slopes of the foothills of the Börzsöny Mountains. The Nagymaros dam under construction has not only a major visual impact on the heart of this landscape, but the dam would also endanger at least 45 sites between Dömös and Esztergom.

The study team has concluded that both the large and varied archaeological and historic values, and the unique landscape values present in the Danube Bend, would place this landscape in the most protected category in any of the developed countries of the West.

A Nemzeti Örökség Park Javasolt Határa
Proposed National Heritage Park Boundary

A térkép a VÁTI által készített terv felhasználásával készült
Base map courtesy of VÁTI



A third significant value of the two mountainous areas is their international biosphere designation. According to Professor Csemez, this unique natural value has been recognized by the United Nations, and the most fragile portions of the forests have been designated as protected lands because of their natural significance. Dr. Csemez concluded that there is no other large, natural forest of this size anywhere in Europe which is surrounded or located in such close proximity to five million people.

We concur with VÁTI that four additional working landscapes should be included within the Park boundaries: the Szentendre Island (Sziget); Vörösvári Árok/Bordogi Medence; Ipolyi Völgy; and Börzsöny's Easter Valley landscapes. These areas would continue to be working landscapes, but any alteration would be guided by the policies of the National Heritage Park.

Another concept worthy of consideration would be a preservation effort for the Danube River Corridor, extending south to Budapest and west to Bratislava. This corridor might be called a National River Corridor. It would remain a working landscape, although there would be numerous sites in public ownership, such as suitable recreational access along the river. All landscapes within this environmental corridor would be managed by the same agency that would administer the National Heritage Park.

Precedence for this type of nationally-significant recreation area is found in several other countries. For example, the majority of the British National Parks and several of the federally-designated rivers in the US would provide useful case studies in defining the exact boundaries and implementation strategies for this proposed National River Corridor.

At a minimum, the Recreation River corridor should include the following: all significant archaeological, historic, and cultural areas such as vernacular villages; significant visual landscapes areas along the Danube; and significant riverine forests and wetlands, including oxbow lakes and side channels of various kinds.

Tourism

Removing the Nagymaros Dam, restoring the landscape, creating the National Heritage Park, and foregoing the additional income from the generation of electricity and improvements in navigation, will be very expensive. But if Hungary can invest in fully developing the tourist potential of the region, substantial economic benefits can be generated, not to mention the added environmental, social, and cultural benefits described above.

The Danube Bend National Heritage Park could be the center of an ambitious tourist development program encompassing the entire Danube from Vienna to Budapest. This region, if properly preserved and sensitively developed, could become a tourist destination of international significance. Current changes in Hungary's political climate and its relatively low cost of living have great potential to attract tourists from the booming west European nations, the US and Japan. Preservation and development of existing tourist resources and a strong marketing campaign could help Hungary intercept the tourists who currently flock to Rumania's Black Sea coast.

The Danube needs to be managed as an integrated tourist environment. Budapest, currently Hungary's main tourist destination, could be the starting point for tours up the Danube to the National Heritage Park and beyond. The Danube River itself would be the unifying element of the tourist experience and could serve as the main means of accessing the area. Expansion of light, fast hydrofoils and other sight-seeing craft could shuttle tourists from Budapest to various sights and hotels along the river. River transportation is much more relaxing than travelling on Hungary's congested, narrow highways and would best highlight the unique assets of the Bend and upstream river stretches. Unfortunately, the new power canal from Bos to Dunakiliti will detract considerably from the tourist experience from the river unless the existing river in this area can still be used for tour boat traffic.

A network of existing and future inns and hotels should be established along the Danube with pedestrian or shuttle bus access to the tour boat stops. Emphasis should be placed on expanding and restoring existing inns and hotels, and in encouraging the development of new facilities of moderate scale that will blend with the area's environment and character. Some existing facilities could be modified to address tourist objectives.

Ecological Protection of the Old Danube Channel

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[Note: This section is excerpted from the March 1989 *Bös-Nagyramos Barrage Study*]

For a 130 km stretch of the Danube between the Dunakiliti barrage and Komáron, over 97 percent of the river's natural flow will be diverted into the power canal. The ecological consequences of this diversion will require sensitive management. Areas affected will include the riverine forest between Bratislava and Komárom, wetlands of international importance, fisheries, agricultural lands, and the peatlands south of Moson-Nagymaros. Direct impacts will result from barrage and dike construction, flooding and disposal of dredged material, and construction of new residential-recreation areas. Indirect impacts include changes in surface and sub-surface hydrology due to impoundment upstream, and diversion of surface water flows.

Riverine Forest

The riverine forest between Bratislava and Komárom consists of four major tree associations: *Salici-Populetum, Fraxino-Ulmetum, Ulmo-Fraxinetum,* and *Crataegus danubiale.* One of the most productive forests in this part of Europe, it supports an especially wide variety of bird life. Of the 60 species which nest there, 25 are considered to be rare or declining. The most extensive direct impact on the riverine forest appears to be construction at Dunakiliti, and the forest clearing necessary to create the reservoir pool. Other direct impacts will result from construction of residential/recreation areas in the forested area directly below the Dunakiliti barrage, the construction of new dikes, and flooding at the upper end of the reservoir pool above the Nagymaros barrage. Published reports indicate plans to construct many small dams among and across the oxbows and side channels that border both sides of the Danube between Dunakiliti and the power canal outlet. Their purpose is not clear and they will likely adversely impact both terrestial and aquatic ecosystems.

Indirect impacts will result from reduced flow in the Danube downstream from the Dunakiliti impoundment. With diversion of water into the power canal, the existing Danube will be carrying, during average and low flow periods, only the flow of the bulb turbine at Dunakiliti and seepage from that site. Projected river flow will drop from 2000 m^3/second to a minimum of 200 m^3/second; the resulting conditions will simulate drought for the riverine forests, which have been shown to start to dry out at flow rates of 600 m^3/second, sometimes with irreversible damage. Decline in the subsurface water table directly downstream from the Dunakiliti barrage to Nagymaros in Hungary and Cicov in Czechoslovakia will also have negative consequences. For example, the eastern edge of the Szigetkoz below the Dunakiliti barrage and adjacent to the Danube is within the area predicted to experience a 5 to 6 meter depression in groundwater levels. Portions of the Szigetkoz were designated as a Landscape Protected Area in 1986, established to protect the characteristic landscape of the floodplain. It is our understanding that an irrigation system is planned to mitigate the adverse effects on groundwater depletion, but adequate information was not available for our team to evaluate the effectiveness of this approach.

In the normal course of events, the riverine forest, oxbow lakes, and side channels act as sites where flood waters deposit sediment and associated nutrients on an annual basis. A portion of these are incorporated into the substrate of the forests and wetlands, taken up by the vegetation and transformed into gases and insoluble compounds. In this fashion the riverine forests and wetlands act to maintain water quality in the Danube. Loss of this natural treatment means that pollutants will more readily collect in sediments behind the dams and require costly removal--and treatment--by artificial measures The no-cost water treatment function will now be transferred as an expense to be met by artificial treatment plants up or downstream. In addition, lower fertility due to reduced flooding in the Old Danube channel will probably eliminate some tree species, with a change in forest composition toward the less productive forests types found on drier upland sites. Small river tributaries are especially dependent on allochthonous inputs (inputs derived from the surrounding watershed and not generated internally within the river) of energy and nutrients. It will be important to establish which tree and bird species are most sensitive to change, and to incorporate them as factors in a management and monitoring system.

Mitigation of impacts on the riverine forest ecosystem will be difficult. It may be possible to establish some forest regeneration plots that resemble the natural community either in the narrower Danube floodway or on sites constructed from dredged material. However, it appears likely that there will be a major net loss of riverine forest. Alternative sites for residential-recreation development should be selected to eliminate further destruction of the forest community.

As much as possible, the river banks and floodplain should be managed to provide corridors and travel lands for terrestial and aquatic wildlife and fish, connecting natural areas together across lands used more intensively by humans. This may be accomplished, in part, by restricting development close to the river to those activities that are truly water-dependent. Boat marinas require waterfront development; homes and shops, while they may be desirable near the water, do not have to occupy waterfront locations. Creative engineering and landscaping design can often provide natural corridors even where human activity is intense.

Sensitive and complex management of water releases will be the most important and effective means to reduce adverse impacts on the riverine forest and aquatic ecosystems. The Dunakiliti barrage is being constructed in a manner that will permit release of significant amounts of water to achieve mitigating objectives. Several sources of water can be managed to reduce the impacts: seepage canal flows, small turbine flows, releases above needs for hydropower and navigation, and release of excessive flood flows. It will not be sufficient, however, to simply release water at times when there happens to be flow exceeding one or two project objectives. The amount of water to be released needs to be timed in concert with the seasonal life cycle requirements of the most sensitive aquatic and riverine forest species. The fact that there are several sources of flow suggests a greater opportunity to design acceptable release strategies. To achieve this will require a timely and reliable set of data from monitoring points, plus an information management and modeling system to develop, produce, and test alternative water management options. This will need to be incorporated into the daily management of the entire system from Dunakiliti and Nagymaros.

Wetlands of International Importance

The series of oxbow lakes and side channels that occur in several locations along the Czechoslovakian side of the Danube have been listed in the UNEP/IUCN (United Nations Environment Program/International Union for the Conservation of Nature and Natural Resources) *Directory of Wetlands of International Importance in the Western Palearctic*. Included are the oxbow lakes and side channels at Dedinsky ostrov (island), Isreakov, Cicov, Maly ostrov, Velky Lel, and Apali. These natural areas are enriched by river water high in calcium carbonate through periodic silt deposition during flooding. They are rich in game animals and are important breeding sites, especially for cormorants, purple heron, great white heron, pochard, and bearded tit. Associated with these natural areas are the reserve at Zlatna na Ostrave, protecting the rare Great Bustard, and the reserve near Bos protecting the threatened white-tailed sea eagle.

These important wetlands will be directly impacted by power canal construction at its junction with the Danube (Dedinsky ostrov), construction of a new dike across the lakes at Cicov, flooding from the Nagymaros pool at Maly ostrov, a new dike and proposed recreation area at Velky, and construction of a dike in the Zlatna na Ostrave reserve. A small reserve, comprising about one-third of the oxbow lakes at Topolovec has been directly impacted by canal construction below Bos, and other similar lakes have been impacted outside the reserve as well. The Bos, Dedinsky ostrov and Cicov sites are all within the area in Czechoslovakia that will experience groundwater depression and associated indirect impacts.

It should be possible to mitigate direct impacts at some sites through re-location of dikes or modification of their design. Unfortunately, our information base was inadequate to further examine this option.

Fisheries

According to recent ELTE (Hungarian Academy of Sciences) data, 59 species of fish are reported from the Hungarian Danube. Although detailed listings were not available, data on the commercial catch indicate that it is dominated by bream (*Abramis brama dunabi*), ranging from 60 percent by weight in the main Danube to 90 percent in the Szigetkoz (Table 1). The entire Hungarian Danube provides a commercial catch of 985,306 kg of fish; of this, 14.1 percent is provided by the Szigetkoz region and another 2.5 percent by the Mosoni-Danube. The productivity of the Szigetkoz is further supported by data which indicate it is the location for 80 percent of fish spawning in the Hungarian reach of the Danube.

Crucial to understanding the effect of barrages on the continued existence of fish species is the interrelationship between water flow and fish biology. Many species of fish require riverine flow and a sandy or gravelly substrate to successfully spawn or to provide appropriate habitat for food resources. Of the commercial catch, 5 fish species are strictly riverine. They comprise 64 percent of the commercial catch in the main river, and 93 percent and 82 percent of the commercial catch in the Szigetkőz and Monsoni-Danube, respectively (Table 1). These fish species will probably not continue to exist in areas where they are presently found if flow is impounded or drastically reduced.

The effects of the Bős-Nagymaros project on fish species will vary depending on the stretch of the river: the section that will become a reservoir above the Dunakiliti barrage, the Szigetkőz; and the main river below the power canal outlet.

Table 1. PERCENT COMPOSITION OF THE COMMERCIAL FISHERIES

Species Name	Common Name	River Stretch[1] 1	2	3	4
Abramis brama danubi	Bream	59.2	63.9	89.6	74.7
Acipenser ruthenus	Sterlet	0.2	0.0	0.05	0.0
Aspius aspius	Rapfern	1.2	2.1	1.7	1.0
Barbus barbus	Barbel	1.6	3.1	1.9	5.7
Silurus glanis	Sheatfish	0.7	0.7	0.2	0.7
Total Riverine		**63.6**	**69.8**	**93.5**	**82.1**
Anguilla anguilla	European Eel	0.3	0.0	0.03	0.1
Carassius carassius	Crucian Carp	1.9	0.6	0.2	1.1
Cyprinus carpio	Common Carp	18.6	18.6	1.6	8.7
Esox lucius	Common Pike	3.7	3.8	3.0	5.0
Ictalurus nebu	Channel Catfish	3.5	0.0	0.0	0.0
Stizostedion lucioperca	Pike-perch	2.3	1.4	1.5	2.5
Tinca tinca	Tench	0.1	0.2	0.1	0.3
Total Riverine/Lacustrine		30.4	24.6	6.4	17.7

[1]Annual fish catch for last decade on:

1. Whole Hungarian Danube Section
2. Slovakian-Hungarian Section
3. Szigetköz Section
4. Mosoni-Danube Section

Dunakiliti Reservoir: The Dunakiliti barrage will create a 16 to 20 km long reservoir, holding 240 million m^3 at maximum storage, with an estimated flushing rate of 48 hours. Maximum depth will be 16 meters above the present river depth. Because the reservoir outflow will be from the surface, this depth may be sufficient for stratification to occur and for anaerobic conditions to develop in the isolated bottom waters, although the short residence time of water makes a detailed hydrological analysis necessary.

Impoundment usually results in the demise of fish species dependent on a lotic or running water environment, and the increase--often explosive in the first few years--of fish species typical of lakes. Many of the most abundant species existing in the Danube are those able to exist only in flowing waters. Several species normally found in the Hungarian section of the Danube require sand or gravel bottom habitat for spawning. Such habitat will not exist in the Dunakiliti impoundment. Others require a stable shoreline water depth during spawning. Similarly, these species will not successfully reproduce because of the large daily fluctuations in water level resulting from operation of the Bös power plant for peak power. In addition, the high rate of sediment deposition (5 to 9 cm/year) will blanket spawning areas that occur below the level of water fluctuation. The most abundant lentic or lake fish species in the Danube is the carp. Interestingly, the carp is considered less desirable in the United States and the best available management technique to control or eradicate the carp is to *fluctuate the water level* during the spawning season. Clearly, water level fluctuation inherent in barrage operation will have the same effect in the Dunakiliti Reservoir. Thus, the fishery resource in the impoundment will be largely restricted to fish which may move temporarily downstream from riverine areas above the reservoir, or those which may be introduced by man.

Mitigation measures might include sediment control in selected potential reservoir spawning areas, conversion to continuous power generation to avoid water level fluctuations, or temporary switching to continuous operation during the major spawning period. If hydrological modeling--or empirical evidence after barrage operations begin--indicates anaerobic conditions are developing in bottom waters, limited release of bottom water, mixed with sufficient surface water to avoid dissolved oxygen problems downstream, should be practiced. Mitigative measures cannot restore strictly riverine species to this stretch, but appropriate measures should provide a reasonable lacustrine fishery.

Szigetköz Region: The Szigetköz region accounts for 80 percent of fish spawning and is home to 14.1 percent of the commercial fish catch in the Hungarian stretch of the Danube. Eliminating the flow of water necessary to support the floodplain ecosystem will undermine the productive base of the entire river.

Functioning of the BNB system relies on peak flow. If the turbines at Bős were to produce electricity constantly, the present minimum flow through the Szigetköz could be maintained, reducing what is considered to be the most detrimental of all the project's environmental effects. Reduction in average flow will cut spawning rates; lack of recruitment will lower standing crops of fish in the Szigetköz as well as in the main river channel. Water diverted through the canal will mean that the normal river flow through the Szigetköz, the last remaining shallows on the Danube, will be reduced to approximately 1.5 to 7 percent of the present average flow. There is some question as to whether this flow will be sufficient during the dry season to maintain running water in the Szigetköz stretch or to support populations of fish and other aquatic organisms. Expected alteration of the groundwater level in the region will further reduce groundwater seepage supply to lower regions of the Szigetköz, and because the upper groundwater layers are somewhat polluted, may further degrade water quality.

Main River below the Power Canal, the Nagymaros Barrage, and Downstream: Below the confluence of the power canal with the Danube at Komárom, the primary effect of the Dunakiliti-Bős barrages will be to increase water depth and water level fluctuations. To generate peak power loads, water released through the canal will need to be 1.5 meters above its natural level. This will require the banks of the river as far as Nagymaros be built up to compensate for these regular surges. Not only will this interrupt the natural functioning aesthetics of the river, but the erosive forces of water against the river banks will result in soil erosion and increased siltation clogging the natural bank infiltration system. If the pulse from water released at Bős can be observed 200 km downstream at Nagymaros, it is likely that the region just below the Bős dam will be severely impacted. Silt and gravel will be deposited downstream where the water is sufficiently slowed by the Nagymaros barrage. The sediment load, however, will only be that which occurs in the scouring zone immediately below the power canal confluence. No major impacts on the fisheries are expected from the operation of the Nagymaros barrage because sediment deposition and water level fluctuation will be less than in the Dunakiliti barrage, and the area is not considered a primary spawning area.

Agricultural Lands

The Little Plain is a highly productive agricultural area, supporting both large farms and smaller cooperatives. There was not sufficient time nor information available during our trip to assess the direct effects of flooding or construction on agricultural lands. Nonetheless, some important points stand out. Nearly 100 square km in Hungary and Czechoslovakia will be lost to construction or inundation by the BNB project; nearly 50 percent of this is prime agricultural land. The canal diversion will result in a lowering of the watertable by 5 to 6 meters, resulting in groundwater depression that affects area wells. This could make irrigation necessary for some agricultural enterprises; while most of the larger farms are already irrigated, the largest threat is to the small cooperative farms that provide the majority of local market produce. Since the reported rate at which subsurface water moves laterally in this region is unusually high, changes in the amount and quality of water entering the subsurface aquifers in this area could have marked impacts on the future viability of farming. Lack of time and information prevented our evaluation of the proposed irrigation system.

In addition to areas predicted to experience groundwater depression are those where groundwater levels are expected to rise due to the higher head in the reservoir pool above Dunakiliti. Again, insufficient time and information prevented us from assessing how this might affect farming. Generally, wetter sites delay spring planting and may limit the growing season or types of crops grown. Construction of higher and new dikes along the river are designed to protect farmlands now subject to flooding and thus mitigate losses due to project construction. It will be important to assess the magnitude of this effect.

Peatlands and the Mosoni-Danube Flows

The large aquifer under the Little Hungarian Plain, including Szigetköz and the Mosoni-Danube, is one through which large volumes of water pass at high rates of transmissivity. The system discharges to the surface in the large peatlands that lie south of Mosonmagyaróvár.

An elevated head in the Dunakliti reservoir may lead to increased surface discharge of groundwater at this site, increasing surface saturation over long periods. Flows in the drainage ditches and receiving canals and rivers would likely increase. The confluence of the drainage patterns appears to be located near the city of Györ. The consequences of this event cannot be predicted with the data available in our visit, but the implications for area vegetation and agricultural operations need to be examined. Because wetlands will be lost in other regions of the project, the potential for using any increased discharge to restore wetlands here should be explored as a mitigation measure. Restoration of former wetland sites offers a much higher probability of success than do efforts to create replacement wetlands on sites whose soils were not formed under saturated conditions.

Needed Legal Documents and Economic Data

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There are significant gaps in the information which has been provided to us on both legal and economic issues. In order to complete a quantitative economic evaluation of program options, we need access to the data on project costs and benefits previously requested on several occasions. Furthermore, no meaningful legal analysis can be performed in the absence of complete official copies of all relevant treaties, international agreements, and contracts.

Annex 7

HUNGARIAN ACADEMY OF SCIENCES, REPORT ON ENVIRONMENTAL, ECOLOGICAL, WATER QUALITY AND SEISMIC IMPACTS OF THE NAGYMAROS BARRAGE CONSTRUCTION OR ITS CANCELLATION, BUDAPEST, 23 JUNE 1989

Background

As a request of the Council of Ministers the chairman of the Academy undertook to participate in the further analysis of the environmental impacts concerning the suspension of the Nagymaros constructions. The chairman of the Academy formed a temporary committee to detail the report. The committee acted in three taskforces:

- hydrobiological and water quality (aquatic ecosystems)
- land ecology (land ecosystems), and
- geological and seismic experts participated in the job.

The task of the Temporary Committee was first to analyse the environmental, ecological and seismic impacts expected in the event of the abandonment of the Nagymaros Barrage construction.

Initial conditions

Prior to the formulation and testing of the opinions the Committee stated, that:

- The evaluation of impacts caused by the Nagymaros construction complex can only be analysed with a consideration for the whole barrage system including the impacts of the Dunakiliti reservoir, Gabcikovo barrage and the power canal.

- The abandonment of the Nagymaros construction complex leads to a situation totally different from the planned one (further groundwater recession, formation of reefs and fords), which were not anticipated by any technical alternatives.

- The Danube, a river which can be characterised by the chain of effect mechanisms, is a sophisticated, ever changing (discharge, flow velocity, contamination, etc.) ecological system, consequently no one parameter must be exclusively taken into account and taken as constant and absolute.

- It is very easy to reach such limits in the case of a prognosis of the ecological and environmental impacts and consequences from where no further exact conclusions can be drawn because of the lack of knowledge.

- A greater emphasis has to be given to the time factor during the assessment of the ecological impacts. It determines the integration and the consecutiveness of the processes, therefore models with a short time scale can give results different from reality.

1. STATEMENTS

In spite of emphasising the complexity of the environmental impacts, and in order to underline the importance of the different factors the hydrobiological, water quality and land ecological impacts were separately discussed in a similar way to the geological consequences and the seismic questions.

1.1. Hydrobiological and water quality standpoints

The most important water quality problems concerning the Gabcikovo-Nagymaros Barrage System (Barrage System) have been discussed already in the final report of the UNDP/WHO/OVH project entitled "Representative basins for water quality control in Hungary" of 1976. In spite of this a wide ranging revised report, deep enough to constitute an appropriate basis for decisions not yet elaborated. The "Environmental Impact of the Gabcikovo-Nagymaros Barrage System" (Budapest, June 1985, 67 pages, 25 tables and 19 figures) is imperfect and contains contradictions especially from the hydrobiological, bacteriological and water quality points of view. The eight main research areas determined in "5. Further Research Tasks" prove it too because five of them are related to water quality and hydrobiology. According to the "VIZITERV" collection entitled "Summary of the Reports concerning the Danubian Barrage System" out of the 340 commissioned research studies only 24 reports dealt with water quality, (hydro)biological and ecological topics without giving answers to the questions propounded.

The above mentioned factors show, that even today there is no way of drawing water quality, or hydrogeological conclusions that require long term data based on a proper database. Similar to earlier statements the report can only be based on data determined by other Danubian surveys carried out for different purposes or statements published in international journals, which can only be partly adapted.

Evaluating the hydrobiological and water quality consequences of the cancellation of the Nagymaros Barrage, it has to be emphasised, that the changes along the Szap-Nagymaros Danube stretch are basically determined by the impacts of the Gabcikovo Barrage and related constructions such as, primarily, the Dunakiliti Reservoir, (where processes of self purification are accelerating and at the same time a damagingly large amount of organic material is being produced) and the diversion canal.

Research on certain parts of the issues - such as, for example, research on microbiology - have not yet been begun, though attention was drawn to them. These are among others the bacteriological, virological, toxic aspects and the effect of the covering soil layer and wood remaining in the Dunakiliti Reservoir or the evaluation of the micro-bacteriological metabolism.

In the event of the abandonment of the Nagymaros Barrage no damaging environmental impact caused by the lower flow velocity, the permanent high water and the peak operation of the Nagymaros Barrage will occur along the approximately 100 km long Danube stretch above Nagymaros. According to this, in the constantly flowing water the amount of algae arriving from the upper, Gabcikovo constructions and which is significantly more than the present amount (depending on temperature, discharge etc. changing species variety and changing characteristics and quantity of metabolism) will not result in a damaging over production. Without the peak operation the biologically definite negative impacts of the repeated daily water level fluctuation will not occur along both sides of the mentioned 100 km long section. Together with it the damaging impact of the damming and contra flows caused by the peak load time operation at the mouth of the old-Danube, Moson-Danube and Vág also will not take place. The lack of the permanently high water level together with a water regime more in line with the present situation, and the seasonal changing water level conditions (for example: regularly occurring low waters with shallower riverbed sections) provide more versatile living conditions, richer in species, and provide for the survival of a more valuable flora and fauna.

In the case of the abandonment of the Nagymaros barrage the peak operation - according to the original plans - can not be practised. Processes significant in the self purification of the biologically very active river bank sections will remain undisturbed. Several negative impacts disturbing to fish species reproduction would not occur, because spawn laid down along the bank and larvae and issues staying there cannot endure the silting and the water level fluctuation caused by the peak load time operation. In the event of the abandonment of the Nagymaros Barrage the non occurrence of these impacts damaging for fish biology would significantly affect the stock of the stretch below Nagymaros.

The abandonment of the Nagymaros Barrage would have a beneficial influence from a water quality point of view on the water intake used for the drinking water supply, and according to a certain group of the experts, it will even be good for the bank-filtered water intake. (According to other experts the barrage system does not damage the bank-filtered water intake at Budapest.)

It is generally very difficult to know the modification of the bank-filtering processes owing to the peak operation. As a consequence of the simultaneous presence of the water disturbance and the silting, positive as well as negative impacts are expectable. In the case of the realisation of the Nagymaros Barrage the damaging transformation (which would require certain necessary technological modifications) caused by the silting of the polluting materials are mainly expected on the Lábatlan-Nagymaros stretch . Impact on the downstream section is likely in the longer term, which would unfavourably influence certain parts of the Szentendre island wells.

1.2. Land ecological points

The land ecological impacts have partly pedological-agricultural and partly nature preservation and landscape aesthetic characteristics.

1.2.1. Pedological-agricultural-ecological impacts

The expected pedological-agricultural-ecological impacts of the barrage system cause, first of all, modifications in the hydrological regime and in the physical, chemical and biological characteristics of the soils. Changes in the groundwater level influence the aerobic-anaerobic dynamics and water supply of the native and cultivated vegetation, while the pollution of the groundwater originating from different sources has an impact on the toxicity level of the soils. Avoidance of this environmental damage requires certain indispensable and very big scale further investments, but no guarantee is available for the implementation of them. In the case of a shortage or absence of these additional investments:

- the biochemical material balance of the soil changes unfavourably,

- the biological activity and the productivity of the soils decreases , while the drought and excess water sensitivity of the soils increases ,

- the agro-ecological potential will decrease, or rather the production risk dependent on the weather will increase, - the soils' selfpurification capacity (decomposition of cancer causing carbon compounds, etc.) and its role in the absorption of toxic materials from the air (nitrogen-oxides, polycyclic hydrocarbons, etc.) is decreased,

- microbe colonies typical of fertile soils are destroyed, therefore the biological nitrogen absorption is decreased, the soil structure is ruined, and the yield diminishes.

It can be forecast for the soil water regime of the area in question, that where the present groundwater level is in the fine aquifer and where it is being lowered down to the gravel layer because of the direct and indirect effects of the GNBS the water supply through capillary action in the root zone stops, the regime of the flood area (mainly flood forestry) changes, the water level of certain ox-bow lakes and meanders is lowered. Because of this the organic material production of the mentioned area is being reduced and the already existing recreational situation is deteriorating.

The impact caused to the soil moisture regime changes the material balance of the soils. The formation of the strongly carbonated, lime accumulation levels, 'full of mites' layers, or even limestone pads change the soils to shallow, easily-dried and very drought sensitive soils. The deterioration of the soil structures and the mineralization of the vegetational residuals is being accelerated in the area of decreasing groundwater. The dynamics are moving toward the liquidisation of the soil. The fine mineral particles washed out from the covering layer result in a shallow tilth. The air content of the soils becomes low, anaerobic processes become dominant, formation of lime accumulation layers and secondary solidification might happen.

It was not taken into account during - and after -the planning of the barrage system, which kind of layers which would be penetrated by the rising groundwater, though the surface of the rising groundwater is a very intensive microbiological reaction zone . Impacts like this can cause cemented layers, toxic zones etc.

1.2.2. Values of nature conservation and landscape aesthetics

The construction of the barrage system endangers serious nature protection and landscape aesthetic values at Nagymaros and upstream of Nagymaros at Komárom as far as the surroundings of Koppánymonostor and in the greater part of the Szigetköz regions. Impact reports concerning these topics were very limited in space and dealt only with a minor part of the flora and fauna. The significant degradation of the biocenosis owing to the likely changing hydrodynamic circumstances is definite . The developed countries are well aware of the fact, that the flora and fauna are a very valuable and irreplaceable part of the national heritage . Many successful social movements have proved, the importance of this and have worked for the rescue of many areas, for example, the salvation of the unique flood plain forestry along the Austrian Danube reach (Hainburg movement). The value of the flora and fauna can hardly be forecast in advance or expressed in financial terms , though the practical benefits of certain species is not in doubt. The speckled alder of the Szigetköz adapted to the local circumstances and valuable even from the forestry point of view is a good example. It was left out of the monitoring system.

The expectable restructuring of the vegetation will be accompanied not only by the disappearance of species. One of the great discoveries of modern biology is the genetic variety of the wild flora and fauna. This variety ensures the adaptation capability of the species. In the case of any sudden change millions of gene formations having unpredictable values disappear for ever. The same loss may lead to the operational disturbance of the ecosystems, which would induce further degradation processes and which might be enlarged by the Nagymaros constructions.

The versatility of the landscape is seen essentially through the border sections of the cultivation branches, land uses or in other words through the so called margins. The characteristics of the Danubian landscape are determined by the gallery zone along the Danube. To denude both sides of the 70 km reach of the Danube (between Komárom and Nagymaros) or in other words, the clearance of the forestry in the zone of the gallery will not take place in the event of abandonment of the Nagymaros Barrage and the dam construction along the river bank.

The joining line between the Danube and its surrounding area, the confrontational surface, is the river bank. The quality of the river bank, its characteristics undoubtedly influence the establishment of the covering vegetation and the possible usage of the bank zone area. The existing gravel bank is equally appropriate for mooring and ensuring the human-Danube contact. In the case of a abandonment of the Nagymaros Barrage the bank will remain natural, untouched and no deep slope protected by a riprap dam alien to the landscape will appear along an approximately 70 km long Danubian stretch and in the recreational zone of the Danube band.

1.3. Geological and seismic standpoints

Researches done to date are not enough to judge the seismic safety of Nagymaros construction within the mentioned areas.

1.3.1. Geological information

During the work a tentative attempt was made as far as possible to determine the level of available geological information, including also the applied geology.

Research and exploration have been continued since 1951 and a certain section of the design work was documented in "summary reports" (OVF Viziterv, 1967, Viziterv 1978, KBFI 1981, BME 1989). A total survey of the documents, progress reports, exploration data and basic design material from the libraries serving as background information for these reports, of course, was not possible because of the short time available . A serious insufficiency is that the comprehensive geological report analysing the whole area of the barrage system, and the detailed map showing the deepness of the gravel layer below the surface were not available.

Maps containing geological information with scale 25000 for the wider area, 2000 for the design area, and 500 for the construction area were in appropriate condition. The level of geological and applied geological information was sufficient for design purposes. Some times it was possible to detect that the basic geological and applied geological data were used in the next phase of the design process. The regularity of this could be proved only with the help of further examinations.

The ongoing pedological examinations (pedological-tectonic and applied geological survey of the Nagymaros construction pit, hydrogeological monitoring of Szigetköz, Esztergom, auxiliary aerophotos and their evaluations, usage of the complex pedological mapping's results of the Kisalföld) could answer three questions if needed :

- identification of the geological conditions under the Nagymaros construction (structural borders, volcanic contact zones),

- the impact of backwater on flood control, groundwater changes and the karstic water system in the Dunántúli-középhegység (with special attention to the area of Szigetköz, Táti-sziget-Dorog, Esztergom, Lepence-völgy) and in addition the impact on the present situation caused by mining,

- the impact of the abandonment of the Nagymaros Barrage on the hydrogeological conditions of the area affected by the barrage system.

1.3.2. Seismic situation

The impact of earthquake is taken into account differently in the design and construction practice of certain countries. The recommendations of the MI.04.133-81 Construction Technical Directives are standard in Hungary. In accordance with this document both the Gabcikovo and Nagymaros Barrages belong to the I. class category from the seismic point of view, considering that "it is a national interest to avoid their damage".

Complying with the international practice the assessment of the earthquake risk has to be determined on the bases of geological-geophysical examinations executed using unified regulations (The assessment and mitigation of earthquake risk, UNESCO ISBN 92-3-101451-X, Building Construction under Seismic Conditions in Balkan Region, UNIDO, Vienna, 1984, Proceedings of the 8th European Conference on Earthquake Engineering, EAEE, Lisbon, 1986, etc.). The geological, geophysical and geodetical methods of determination of the seismic parameters necessary for the design are known, the examinations can be carried out.

The seismic conditions needed for the design of the barrage were determined with consideration for the valid international expectations by the Czechoslovak-Hungarian expert meeting held in Bratislava in 23-25 November 1965. The expected values of intensity were determined on the bases of the historical (first of all the Komárom 1763) quake information. But the inspection did not cover the Nagymaros region. The expert report contains the intensity scale and the relevant acceleration Mercalli-Cancani -Siegerg (MCS) values which were valid at that time (and changed significantly since owing to the introduction of the Medvegyev-Sponheuer-Karnik /MSK-64/ scale) only along the Danube as far as the national border. After this no important seismic examinations were performed by the Hungarian side. No newer Slovak results are known.

In certain cases (the total review of the complete set of documents used during the planning was not possible because of the short available time) the movement, velocity and acceleration data used during planning are significantly different from the values accepted today (see table, where the values of the 14754/9 report entitled "The consideration of the seismicity in the stability examinations of the Danubian Barrage system" /page no. 15/ are compared to the data recommended today). Impacts of these on the design documentations of the barrage system have to be examined.

Design data

Scale	acceleration	velocity movement	
	cm/s2	cm/s	cm
7	12-25	1.0-2.0	0.5-1.0
8	25-50	2.1-4.0	1.0-2.0
9	50-100	4.1-8.0	2.1-4.0
10	100-200	8.1-16.0	4.1-8.0

Data accepted presently

Scale	acceleration	velocity movement	
	cm/s2	cm/s	cm
7	50-100	4.1-8.0	2.1-4.0
8	100-200	8.1-16.0	4.1-8.0
9	200-400	16.1-32.0	8.1-16.0
10	400-800	32.1-64.0	16.1-32.0

The seismology and within it the prognosis of the expected quakes have developed a lot during the past, almost quarter, of a century, since the expert meeting at Bratislava. It was proved that planning based on the intensities and accelerations derived from known quakes was not satisfactory. The modern seismic parameters have to be calculated using complex geological, geophysical and geodetical experiments. The expected time requirement of the scientific geo-examinations can only be determined on the bases of the analysis of the existing information. Without them only the assumptions most conservative in the seismology - construction cost increasing - can be used. In accordance with it the expected intensity in the Nagymaros (and Gabcikovo) regions on the basis of the available seismic catalogue and seismic maps ranges between 9.0-10.0 (Hungarian Earthquake Catalogue /456-1986/ by T. Zsiros, P. Mónus, L. Tóth, Budapest, 1988, Seismic zoning map of Czechoslovakia-version 1987 by V. Karnik at al., Studa geoph. et geod. 32, 144-150, 1988, Scheme of earthquake provinces, by V. Karnik, Z. Schenkova, V.I. Bune, Prague, 1978).

2. Suggestions

- The implementation of the waste water treatment construction programme precondition of the full operation of the barrage system has been seriously delayed both from the Czechoslovak and Hungarian sides. It is obvious, that in the event of the cancellation of the Nagymaros Barrage the timing of the construction of the waste water treatment plants can be prolonged according to the carrying capacity of the national economy. In contradiction to the purification of domestic waste water, the treatment of a significant portion of industrial waste water has to be in any case resolved in both countries. This, among other things, decreases the further increase of the toxic material load. A new conclusion is, that even in the case of the implementation of these there is no way to avoid the water quality deterioration owing to the inevitable intensive growth of algae following the filling up of the Dunakiliti reservoir.

- If the Nagymaros Barrage is implemented an increased detention time has to be allowed for . Consequently the further deterioration of the water body trophicity conditions and smaller or larger , unwanted sedimentation is expected. Rotting processes can occur in the fermentation layer (sapropel) located in the sedimentation zones which also contain toxic material . These, (though only locally occurring) anaerobic regions can be the starting points of the health deteriorating processes. The development of these zones in the event of the abandonment of the Nagymaros Barrage would be very limited. The production of toxic material has to be prevented so much the more, because even a very limited amount of these materials can cause serious health degradation.

- A certain part of the health deteriorating material dissolved from the inert asphalt lining of the power canal in the event of the abandonment of the Nagymaros Barrage can fall into anaerobic circumstances, where toxicity is increased and depending on the reservoir operation and the water regime or on the disturbance caused by dredging can pass directly downstream. The human-biological impact of the dissolved materials from the asphalt have not yet been analysed. The dissolving impact, durable and grave risk primarily from drinking water supply point of view, has to be analysed.

- In the case of the abandonment of the Nagymaros Barrage the Gabcikovo Barrage - with different operational orders - can be used even in the form of a peak operation. This option has to be excluded because of hydrobiological, ecological, water quality control points of view.

- Owing to the abandonment of the Nagymaros Barrage the operation of the Gabcikovo Barrage will be modified, consequently water fluctuation will be decreased, the flow conditions and sedimentation will be changed in the Dunakiliti reservoir. Knowing these modifications, their impacts on the Szap-Nagymaros stretch have to be evaluated from a hydrobiological and water quality point of view. The impacts of the possible or necessary interventions along the upstream stretch have to be analysed too, for example the riverbed regulation or feed water supply of the Old-Danube or the water constructions necessary on the left hand side tributaries (dredging, river bank regulation).

- If the barrage system is constructed only in part (without the Nagymaros constructions), and with no peak load time operation, then the damaging environmental impacts will not occur in the Nagymaros region and, moreover they will be reduced along the upstream stretch as well. Construction to regulate groundwater conditions and to prevent the further degradation of the groundwater will become necessary. The realisation of these is not an economic alternative but an ecological precondition of the systems operation.

- The bank re-shaping without any tree as it is in the plans is a mockery of the landscape aesthetics and land ecology. The planting of trees - where it is possible from a flood control point of view - is suggested to break the line of the bank construction and to fit it into the landscape.

- The measuring results of an at least five-year monitoring period following the completion of the Gabcikovo construction are indispensable to the trustworthy prognosis of the ecological impacts of the barrage system. There is undoubtedly a need for the establishment and regular operation of a comprehensive monitoring system, which must be much more developed than at present . The examination of biological indicator objects that can sensitively indicate the changes happening in the environment, neglected till today, have to be included.

- A perspective of the industrial development in the region affected by the barrage system was not made either in Slovakia or in our country . The expectable pollution impacts of the industry can not be judged and the restrictive instructions pertaining organically to the long term operation of the barrage system can not be formulated. It is suggested the industrial development plans are prepared as soon as possible.

- The integration of the geo-sciences into the necessary monitoring system is necessary in the areas of geo-environment protection, hydrogeological-sedimentological sensor systems, the regular aerogeological tracing, pedological observations with geophysical penetration equipment, and dam protection observation using dispatcher system. The observation systems capable of storing weak seismic signals has special importance. Their construction is suggested in a network with the co-operation of the Czechoslovak partner.

- It seems to be necessary to prepare a summary report on the whole barrage system (and as a variant in the event of the cancellation of the Nagymaros Barrage) on the comprehensive geological-tectonic, applied geological, hydrogeological, environment pedological, regional pollution sensitivity, and the transmissibility examinations of the first geological layer under the soil. This report has to be managed by an expert team, perhaps supplemented with plans, and on the basis of these a selection of decision milestones and decisions at appropriate levels are necessary.

- Because of the imperfect seismic examinations the estimated intensity relevant to the region has to be supposed to be between 9.00 and 10.00. These rates are too high, therefore the more accurate determination of the seismic risk with the help of a complex geological-geophysical-geodetical examination is necessary, which would, for sure, allow a better prognosis. It would be advisable to examine the possibility of Czechoslovak-Hungarian scientific co-operation on this question.

- The three possible consequences caused by an earthquake in the region of the barrage have to be analysed in detail:

There has to be an analysis of the kind of damage which can be caused in the dynamically reacting construction by quakes with different intensities, and in addition the extent of modifications in initial conditions caused by the presently accepted new movement, velocity and acceleration values.

The flood passing downstream caused by the breaking of the barrage or/and the opening of the land body has to be modelled with a consideration of the riverbed material transport and its sedimentation elsewhere along the total Nagymaros - Budapest reach.

The raising of the upstream water level owing to the accidental locking of the barrage has to be analysed and the possibly necessary averting actions have to be elaborated. (The results of the Slovak calculations and model experiments related to the Gabcikovo and Dunakiliti constructions /VUVH, Pozsony/ are not available.)

Summary

It can be stated, that the environmental, ecological and water quality impacts were not taken into account properly during the design and construction period until today. Because of the complexity of the ecological processes and the lack of the measured data and the relevant calculations the environmental impacts can not be evaluated .

The data of the monitoring system newly operating on a very limited area are not enough to forecast the impacts probably occurring over a longer term. In order to widen and to make the data more frequent a further multi-year examination is necessary to decrease the further degradation of the water quality playing a dominant role in this question. The expected water quality influences equally the aquatic ecosystems, the soils and the recreational and tourist land-use.

The risk is greatest to the drinking water supply. The deterioration of the Danubian water quality jeopardises the living conditions of three million people living in Hungarian territory.

23 June 1989, Budapest

Annex 8

THE H A R D I REPORT

SUMMARY

FOR THE COUNCIL OF MINISTERS

of the results of an expert review concerning the ecological, environmental, technological, economic, international, and legal issues of the

BÖS-NAGYMAROS BARRAGE SYSTEM

BUDAPEST, September 1989

PREPARED BY THE

COMMITTEE OF INDEPENDENT SPECIALISTS

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The Council of Ministers has suspended the construction operations of the BŐS-NAGYMAROS BARRAGE in the vicinity of Nagymaros by its Resolutions Nos. 1071/1989 and 3205/1989; then the preparatory activities for the change of course in the Dunakiliti region have also been suspended. The suspension period was to end on October 31, 1989 in both cases. At the same time a decree was passed demanding that appropriate committees of specialists should, meanwhile, review the risks and the damage that may be caused by the implementation and the operation of the Bős-Nagymaros Barrage.

The appraisal of the analysis, performed during the months of suspension, has justified the decision since it identified attendant risks. Evidently, the past few months have not been long enough to carry out hitherto neglected analysis in a number of issues or to draw final conclusions. Nevertheless, this period has been long enough for a comprehensive assessment of the current situation.

Background

All the information available as well as the analyses and comments by professionals made the Government of Hungary to realise that it is absolutely necessary to avoid both the indirect dangers and the inappropriately identified risks arising from the peak-time operation of the Bős-Nagymaros Barrage (BNB) and to increase the volume of water flowing through the Old Danube. The immediate suspension of the work was based on the idea to avoid pressure due to irreversible technological operations while arriving at the final decision about continuing or stopping construction. There was a similar idea behind suspending operations in the Dunakiliti region with respect to the change of course.

Even the builders of the barrage thought that possible peak-time operation should be allowed only subject to certain conditions and the results of further analyses. This condition was accepted by Parliament during its session in October, 1988. However, the time frame required to marshal facts of justification for the peak-time operation was so wide that the idea of either postponing or cancelling the Nagymaros reservoir was rightfully raised. This led to the suspension of the construction at Nagymaros in May of 1989 and the acceleration of supplementing scientific studies and analyses (including disciplines such as biology, hydrology, seismology and fields like sewage purification and the environment) as well as evaluating risk factors.

Current analyses have indicated that the reservoir constructed at Dunakiliti for the purposes of peak-time operation, but already found superfluous for normal operation, would pose an immense environmental risk even in the course of continuous operation. Ultimately, it is realised that the BNB is caught up in a vicious circle of trying to do away with the risks arising from its construction; therefore complete reversibility needs to be reviewed as well.

As a result of the decisions about suspension, the Government's freedom to deliberate increased not only with respect to the issue of the barrage but an opportunity has been created to reconsider the utilisation of the Danube along the lines of a comprehensive and new concept and to better harmonize this with overall national interests and the changing priorities.

Ecological considerations

The debate, as old as the construction history of the BNB, has gone on parallel with the change of approach in the world. The last decade has witnessed the appreciation of the environment and other intangible assets in the world. At the same time, the prestige of material-intensive production processes with low energy efficiency has been devalued. The change in approaches has led to the revaluation of the energy production concepts.

The Hungarian Parliament passed its decision in 1988 with a view to the rising importance of protecting diminishing natural resources whereby ecological considerations were given priority over economic ones. Nevertheless, it is doubtful whether profitable operation is possible at all, considering the scientific facts and figures available. Even if only a minimum discharge is guaranteed in the Old Danube, regarded as necessary by the Hungarian Academy of Sciences (approximately 600 m^3/s), the expediency of operating the Bős Barrage for energy generation is immediately put into question although the discharge indicated above is far from being sufficient to satisfy the necessary econological conditions.

As indicated by the ecological analyses, the detrimental consecuences of a hydro-electric barrage system are irreversible in most of the cases. A full-range assessment is rendered even more difficult by the fact that the 170 km-long barrage system, comprising two dams, is located in a plain therefore the area under its direct and indirect impact is especially large. The unfavourable trend in predictable environmental changes can be clearly projected for any mode of operation, chosen for the barrage, considering the well-known, international examples of hydro-electric stations in plains.

However, the following issues carry special importance:

- the undisputable deterioration in the conditions of obtaining and supplying potable water;
- a deterioration in the self-purifying capabilities of the river and a consequential decline in water quality as a result of eutrophisation which has been proven to increase (and which may even impact the section of the river even under Budapest!);
- the decimation, even the destruction, of the natural flora and fauna; and
- the disappearance or the dramatic transformation of the historic and natural landscape whole value has appreciated substantially these days.

As a result of diverting the Danube to one side into an insulated by-pass canal and the reservoir construction, the water and nutrient supply in the soil is changed substantially, and over a longer period even the structure of the soil would be changed. The proposed supplementary water replacement systems can only reduce the impact while local potable water reserves would remain unshielded against andropogenic contamination. As opposed to hydrological conditions that change dynamically with the seasons under natural conditions, a stationary status would emerge whereas such dynamic changes are crucial elements for the eco-systems along the river and they are also vital for their survival as indicated, among others, in a study by the World Widelife Fund (WWF). The original dynamic status cannot be maintained even with the most expensive water replacement method, once the by-pass canal is opened. The unanimous view of independent specialists with no ties whatsoever to the barrage is that the overall ecological impact of the Bős-Nagymaros Barrage is clearly negative.Up to this day, nothing has been done to assess the potential genetic resources in the region therefore it is impossible either to save endagered widelife or to record complete annihilation. Widelife and natural resources constitute part of our national assets, but Hungary is poorer on both counts than Czechoslovakia. Consequently, whenever decisions are to be made about the region impacting its assets, primary consideration should be given to protecting natural resources.

If the BNB is to be implemented, the landscape along the Danube above Nagymaros would change completely. Because of the disappearance of the gravel banks and islets and the felling of the fringing forests the landscape changes dramatically and becomes much poorer. Both banks of the Danube would become a deforestated stretch of flood dams over 200 kilometers. Above and beyond the multi-faceted biological fringing effects of the gallery forests to be cut off, they could also be of help to people looking for recreation. Felling the fringing forests without replacement is contrary to the prevalent forestation efforts in the world and considering the damage to forests in Hungary, it is especially detrimental to the human environment.

The development of a monitoring system, spanning the entire ecological and hydrological complex and allowing for effective intervention, raises serious theoretical problems. As for the Bős-Nagymaros barrage. not even a simpler and less efficient risk monitoring system has been developed. A precondition to such a move would have been to have satisfactory series of historic data. The monitoring system was not available for use as late as October, 1988 and as indicated in a document by the Ministry of the Environment and Water Management, dated July 1989, the monitoring system still required extentions.

Protection of potable waters

Today, as many as 3 million people are already affected in Hungary by endangered potable water supplies. Therefore, Hungary has long-term, vested interests in protecting her potable water supplies to be derived from bank-filtration wells along the Danube.

Water supplies from bank-filtration wells along the banks of the Danube, in the Pozsony (Bratislava)-Budapest region belonging to Hungary and affected by the BNB, have been estimated to be 1.97 million m^3/day (recent studies have suggested even higher figures), of which water purification plants produce approximately 1.0 million m^3/day of potable water. In Hungary, the total wolume of water, derived from bank-filtration wells, account for 42% of all the waters derived from sub-soil waters, stratigraphic waters and karst waters. (See Figure 1)

The importance of bank-filtration, as opposed to other water production methods, lies in the fact that good quality potable water can be produced at less cost and with water replacement coming from a relatively smaller area than in the case of surface water collection.

The reservoir dams would dramatically transform the original hydrological conditions of the Danube therefore they would damage the physical, chemical and biological filtration capabilities of the river bed. Experiences with respect to hydro-electric stations hitherto constructed on the Danube in Austria and Yugoslavia have indicated that the processes triggered by the construction and the commissioning of the BNB would have an unfavourable impact both on the quantity and the quality of potable waters produced. It is to be noted that the preparatory operations of the basin for the Nagymaros barrage have significantly cut potable water production, envisaged to supply Budapest. In case the BNB project is implemented, water production with bank filtration in the Szigetköz area would be completely lost as a potential possibility. In the area of the Small Plain, the quality of the hitherto perfect undergound water reserves would be endangered although this constitutes the single substantial potable water reserve for Hungary and Czechoslovakia alike.

A shortage in bank-filtration waters would add to the already significant environmental stress of the population affected; it would also cause substantial economic damage if either the output of water purification required or its complexity would increase which would mean a three to eight-fold increase in current water production costs, subject to the water purification procedures. When drawing up a realistic socio-economic balance for the barrage system, the projected consequences must be taken into account as elements of risk, together with the cost-increasing factors amounting to many tens of billions of forints.

The appreciation of potable water reserves is supported by the fact that at the end of 1984 one of the reasons for the Czechoslovak Government to complain for the construction of the Hainburg hydro-electric station was that it would have cut potable water reserves in the regions along the Danube and the Morava.

It is to be noted that Austria can rely more heavily on the water reserves in the Alps both in the present and the future. Conversely, bank filtration water reserves, derived from the affected stretch of the Danube, constitute the most significant water resources of Hungary, satisfying upto 60% of total demand both in the current state of the river and in the future as well. In addition, the bank filtration method is the cheapest and the safest of all the possible water production alternatives. Even if the affected section of the Danube is fully exploited as a potential source of energy generation, it can yield only 3% of the total electricity demand at best, while the BNB is the most expensive project of all the possible alternatives for electricity generation.

Primarily in the interest of Hungary, water supply tasks and functions should be expanded to include microbiological, patogen bacteriological and virological tests which have been disregarded up till now. International experiences have indicated that as a result of storing water under conditions to be come characteristic on the Danube, detrimental anaerobic decomposition would commence and the sediments accumulated in the reservoirs would host microbiological processes that may be partially detrimental to health. Similarly, the impact of the substances, dissolving from the underwater asphalt insulation, upon water quality and human health is unclear.

As supported by the latest scientific findings, there is every justification to be worried about projected global warming (ie. the "Glass-house effect"). As projected, water reserves can be expected to fall in the landbound, central sections of continents as well as in the Carpathian-basin. Therefore, not even minor damage to available water reserves should be allowed as no replacement can be found under realistic conditions anywhere.

Water quality and sewage treatment

In addition to endangering the potable water supply, the operation of the barrage would also lead to deterioration in water quality (eutrophisation, the proliferation of algae), which have been pointed out with ample emphasis by several committees of specialists. Unfavourable changes in water quality are amplified by external sources of contamination. As a result of a drop in the water's flow velocity, suspended particles would settle en masse in the reservoirs (approximately 2.5 million m^3 alone in the Dunakiliti reservoir) pro year. The concentration of contaminants in the settling mud would increase manyfold. (See Figure 2)

If the construction of the BNB is to be continued, highly expensive operations would need to be carried out so that water quality in the Danube would not deteriorate as a result of the construction and the operation of the facility in keeping with the mutual commitments undertaken in the agreement signed by the two Governments. Before damming up the water, sewage collection, biological and, in some cases, chemical purification should be taken care of over the entire catchment area on both sides, that is in Czechoslovakia and in Hungary. While making arrangements for discharging, collecting and treating communal sewage, arrangements should be made concurrently to purify industrial wastes as well. Also, provisions should be made either to eliminate or to contain spot-like and diffuse sources of contamination (such as legal and illegal waste deposits and fertilizers, pesticides and herbicides, respectively) that endanger the quality of water in the Danube and its tributaries since these do not enter the sewage disposal network. It is a well-known fact that both countries have fallen behind considerably in the implementation of the sewage treatment project; this provides further justification for the postponement of commissioning the barrage.

In keeping with the common, co-ordinated plan, investment projects with respect to wastewater purification are regarded as national investments. We still do not have sufficient information about the volume of wastewaters generated over the entire catchment area on the Czechoslovak side. However, the estimates indicate that due to the size of the catchment area, the density of population and industrialisation in the region, contamination to come from the other side is many times bigger than that to come from Hungary.

The protection of the potable water reserves and water quality is defined as a precondition to implementing and commissioning the barrage under Section 15 of the Agreement signed by the two Governments. Volume 07.02 of the summary of the Common Agreed Plan, referred to under Section 15, defines that "purification facilities should be built on the territories of the Socialist Federal Republic of Czechoslovakia and the Hungarian People's Republic at all sources of contamination that flow into the Danube; the quality of water in the tributaries should be improved...". It is to be seen from a document by the Ministry of the Environment and Water Management, issued in July, 1989 under the title "Determining guarantees and actions to be taken to prevent the deterioration of water quality in the Danube" that we have all but informative data about wastewater purification plans in Czechoslovakia and the wastewater purification program for the Morava's catchment area is missing, although this is regarded as having critical importance. Figure 3 provides information about the degree of unpurification of wastewaters in Győr-Sopron and Komárom Counties which are most heavily affected by the BNB in Hungary.

All the aspects of wastewater purification need to be reviewed. In order to protect the quality of water in the Nagymaros reservoir urgent sewage purification projects would need to be postponed in other parts of the country while constructing wastewater purification facilities by the time the barrage is commissioned which, although not superfluous, could be built over several decades considering the exploitation of the Danube's natural, self-purification capabilities. The costs of these supplementary projects are in the ten billion range.

The international team of consultants from the World Widelife Fund, the oldest and the most prestigious international environmentalist organisation, called attention to the ecological dangers with special emphasis in its report prepared in response to an official Hungarian request. Considering all the ecological aspects summarized above, the team of Czechoslovak, East-German, West-German, Austrian and French consultants have proposed that the best solution would be to halt the construction of the BNB completely.

Geological and seismological risks

When reviewing the technological and technical conditions and requirements with respect to the construction and the operation of the BNB, it is to be noted from the ongoing professional debate that deficiencies began to crop up as early as in the design phase. Further analyses are required because of the insufficiency of the geological and seismological studies. They do not necessarily constitute factors that would preclude either the construction or the operation of the facility; nevertheless it is imperative to take them into consideration. As no appropriate basic research has been done it is questionable whether the dimensions designed to offer enhanced security would not imply such increments in cost that would put the overall profitability of the facility, set forth in the original concept, into question.

The absence of analyses has raised dire problems in the Nagymaros region as well, considering the experiences after the construction pit was opened. However, there is no documentation available to assess the whole of the BNB from a geological and geo-physical aspect. However, the results of research, performed in Hungary and Czechoslovakia, have not been consolidated up to this day. It would be absolutely necessary to perform a complex geological analysis (including tectonic, seismological, civil engineering, hydrogeological and environmental-geographical analyses) across the entire impact area of the barrage system. In keeping with the common view developed during the negotiations of Hungarian and Czechoslovak specialists, the designs for a complex monitoring system should be elaborated concurrently to keep track of all the necessary factors.

The set of outstanding questions still includes the issue of how to save the archeological relics found in the vicinity of Esztergom. The uncertainties with respect to technological issues also call for a postponement of the operations; they do not, under any circumstances, support the immediate continuation of the construction with an unamended concept.

Complex utilisation of the Danube

When elaborating the technological solutions, the designers were referring to the principle of complex Danube utilisation. This included energy generation, flood protection, the improvement of navigation and town development. However, it must be seen clearly that the technological implementation of the BNB at the envisaged cost and in the planned dimentions, ie. damming the water, construction of the reservoir and a barrage system to be operated at peak times, has only been justified by the aspects of energy generation. All other objectives (such as flood protection and better navigation) could be achieved at much less cost, with other technical solutions and less stress to the environment and with a different timing.

Concurrently with the pronounced advantages for flood protection (eg.: higher dams, dam reinforcement or the distribution of high floods between the by-pass canal and the riverbed of the Old Danube, new perils are also created. They include damming water between Esztergom and Nagymaros above the highest ever flood level and the huge volume of water both in the reservoir and the by-pass canal rising 6-16 m above average elevations in the vicinity. A special, hitherto unexplored risk arises from the fact that the Dunakiliti reservoir must hold retained water even at a time when trying to split the highest floods (at 10,000 m^3/s). If the dam would collapse or some accident would occur (eg.: a wave of radio-active contamination would surge through as a result of an accident in a nuclear power station) implying that water in the reservoir would have to be discharged, a flood wave would be created which would exceed the highest ever flood on the river. And the flood dams for protection against such events have not been built.

The conditions for navigation along the Danube can be improved without constructing the barrage system by co-ordinating natural endowments with technical facilities. At this point it is to be considered that Hungary has no vested interests in exorbitant financial outlays. The 25 dm navigation depth, recommended by the Danube Commission for the non-dammed sections of the Danube, is more than the depth to be ever achieved over certain sections of the Danube-Main -Rhine waterway, now under construction. The 35 dm navigation depth, to be achieved by damming the river with the barrage system, is advantageous for ships with a large draught as they can negotiate the Bratislava port (thereby reducing the significance of the Csepel Free Port). Due to the composition of her fleet, Hungary's interest in it is negligible. For us it is more important to develop a concept for the development of navigation in accordance with the demands and the priorities of today. Due to hitherto unfavourable experiences, future efforts at river regulation will have to be geared to bank filtration aspects, considering both the water production plants already in operation and the areas of potential water reserves.

When reviewing a scheme of complex Danube utilisation, there may be several occasions when we will be faced with issues that need to be addressed at macro level and their unilateral contemplation from a single sector-oriented or barrage-oriented aspect could lead to expressly erroneous conclusions. This applies primarily to the energy balance.

Evidently, earlier calculations only reckoned with the need to make up for lost energy and to ensure full substitution for lost energy generating capacities. One of the major arguments, raised as little as a year ago by the builders, was that between 1992 and 1995 there will be especially great need for the barrage system in Hungary's energy network. By now, however, it has become evident that there is absolutely no need for increases in energy generating capacities in Hungary's energy network up till 1995 because of the reserves already available. Other estimates indicate that neither the whole volume nor a part of the energy to be generated by the barrage system will be required by the economy, provided that restructuring gets off the ground. In any case, this offers an opportunity to consider prior to committing resources whether they could be put to some more effective use in some other sector of the economy while facilitating reductions in the country's energy consumption.

Economic analysis

The continuation or the cancellation of the construction of the barrage system is not an economic issue. Up to this day, decisions have been made at environmental-ecological and socio-political levels in power-groups, and the fate of the hydro-electric station will continue to be decided at the same levels. The economic aspect in this whole issue has more to do with macro-economic considerations that with micro-economic efficiency. As, at first, it has been claimed for long that the project has economic advantages to offer, then the argument was changed to suggest that although no profitability can be proven, cancellation would mean substantial additional burden for the country, it is also justified to include this issue among the ones to be reviewed by the specialists.

The blueprints for the BNB envisage the construction of two hydro-electric stations and energy generation in peak periods. The preliminary documentation, compiled for this purpose, satisfy current practices with respect to large-scale investment projects which means that costs have been routinely underestimated and the plans failed to pinpoint a number of the difficulties and consequences of the construction project. As has been customary, deficiencies have come to light in the course of project implementation at stages when the only way out the trap is to go on with it all while the scope of the task expands and costs are soaring.

However, because of its slow start, the construction of the BNB got into a peculiar situation: the need for correction, the unidentified consequences as extra requirements for provisions have arised at a time when the project was not yet irreversible. In line with the customary rules of the game, the contractor was to fight for extra financing although he could not possibly do so at the time. Therefore, the contractor was caught up with an unsustainable statement up to this day indicating that no additional financing is required for the construction of the BNB. Increases in costs have so far been attributed to inflationary reasons and references have been made later to the base year considered. The document, presented by the Ministry of the Environment and Water Management in October 1988, indicated HUF 20 billion only in outstanding provisions.

The actual scope of the project is still unclear even in the latest document by the Ministry of the Environment and Water Management: the ecological, seismological and other factors and the consequential requirements call for a revision of the blueprints but the attendant financial aspects are acknowledged by the Ministry only in the case of cancellation or suspension and not in the case of continuation Nevertheless the outstanding costs of the project have jumped to approximately HUF 40 billion (at 1988 base prices) and even the Ministry have ceased to claim that the project is profitable. This makes it sound all the weirdest when the Ministry promises to generate budgetary revenues of about HUF 100 billion by taxing away the profits "in excess of 8%" to be derived from a non-profitable project, if operated, which suggests that the continuation of the project is more favourable than anything else. Such calculations are not simply erroneous! They are replete with biased distortions and substantial cost items are disregarded in them.

The profitability analyses, prepared by the committee, have reviewed the cases of "Continuing or cancelling the Nagymaros Project" in accordance with the situation arising after the suspension of the operations in May. Although the analyses were done on the basis of the initial data, received from the Ministry of Environment and Water Management (MEWM), the results have indicated in black and white that not even micro-economic efficiency, interpreted in a narrow sense, can justify the continuation of the project.
Considering the figures in this document

- the cancellation of the Nagymaros project is slightly more favourable, if project costs are taken into account up to 1995 (at HUF 44.2 billion at 1988 prices, as against HUF 46.1 billion),

- As regards total project costs, the continuation is somewhat more favourable (at HUF 50.1 billion as againts HUF 46.1 billion).

(Both scenarios include the HUF 23.3 billion, spent up to this day as well as the costs of wastewater purification plants to be financed from the budget and the project costs of power stations to be built as substitutes in case of cancellation.)

- However, when comparing costs and benefits, cancellation looks slightly more tempting (a difference of HUF 15.3 billion at 1988 prices as against HUF 5.0 billion; but as benefits accrue in a staggered pattern over time, the "advantage" would amount only to a loss of HUF -14.0 - (-19.0) instead of HUF -16.0 - (-20.0) billion. /Figures received with a 7% discount factor are shown in Figure 4./)

- The consolidated, expenditures and revenues, balance of the budget for the implementation and the operation of the project is somewhat more favourable if the project is cancelled (at HUF -31.0 billion as against HUF - 71.0 billion).

Each and every item includes the values calculated on the basis of the technological requirements and excludes estimates for damages as we will request amendments to the agreements signed between governments. The termination of the contract concluded with the Austrian party, whether effected after the suspension or the cancellation of the Nagymaros project, would result in payment obligations (upto about HUF 10 billion) as soon as the negotiations are ended, presumably in three years' time.

It is to be noted that the above figures relate to a hydro-electric station to be operated in peak times, as set forth in the original plans; dropping the idea of peak-time operation implies a clear bias of HUF 13 billion for the costs of the continuation scenario. A similar drop in benefits would be caused if discharge in the Old Danube is to be maintained.

As indicated by the calculation, the most disadvantageous scenario is the postponement of decisions for an uncertain period of time, ie. the suspension of either the Nagymaros or the Bős Projects for a longer period. All in all, the calculations have shown that the cancellation of the Nagymaros Barrage would generate less in losses in the short term (ie. between 1989-95) than the continuation of the project and it would release resources immediately. However, the long-term analyses have not produced substantial differences between the scenarios within the permissible error range in the calculations. It must be evident from this fact that micro-economic efficiency, interpreted in a narrow sense, cannot be quoted to justify the continuation of the Nagymaros project.

If we manage to rise above an exclusively "powerstation oriented" view and adopt a more complex and comprehensive approach of national priorities and resource allocation, the comolete cancellation of the Nagymaros Project would become economically more favourable in the long run.

The traditional cost/benefit analysis was used as the method for the economic analysis. With this method certain factors that are difficult or even impossible to translate into financial terms cannot be taken into consideration although they are important for decision making (such as risk and uncertainty). Prior to undertaking risks, the feasibility of technical solutions and an acceptable risk level should be defined and an economic analysis of the underlying technological solutions should be performed. In the case of the BNB project, a substantial segment of the risks were realized only after project implementation had been started although a risk containment strategy should have been reeded in the preparatory phase, leading up to the decision, which obviously would have led to different results.

And last but not least, employment problems should also be discussed while reviewing the profitability issue, which has been raised a number of times with respect to the construction of the barrage (similarly to the Austrian Trade Union Federation's demagogic arguments in favour of the construction of the Hainburg Barrage). Although it is acknowledged that employment is a really serious problem of restructuring, employment in general and efficient employment in particular should be achieved within a new economic structure; therefore it is erroneous and deceptive to claim that the jobs of people employed by the barrage project are only linked to the BNB. Anyway, much cheaper jobs could be created from a clearly employment policy point of view (at least those would not cause economic and environmental damage).

International legal implications

As a result of the change in approach, apparent from the resolutions of the Parliament and the Government, doubts and objections against the continuation of the project in accordance with the original designs without any adjustments have been accentuated. They could not be neutralized either by raising ecological-technological or economic arguments. Then, the major argument in favour of project continuation was shifted towards references to international obligations and the presumable substantial damages payable if such international obligations are not fulfilled. Here, to separate sets of obligations are involved: one set arising from the contracts concluded by Hungarian and Austrian companies, the other set arising from the agreement between the Hungarian and Czechoslovak Governments.

The contract, concluded the DOKW, the Austrian contractor, would automatically lose validity after six months from the date of project suspension on May 13, unless the Government would decide about the continuation of the construction operations at Nagymaros, approved by Parliament. From a legal point of view, any other decision (extension of the suspension or final cancellation) would have the same impact. If so, arbitration awards will compel Hungarian companies to honour their obligations to pay damages. As seen from international experiences, such an award can be expected to be brought in at the end of about three years of litigation. As the agreements about delivering electricity will remain in force, a major part of our payment obligations can be expected to be converted into supplying electricity as a result of an agreement to be made with the Austrian party.

The outcome of the situation with respect to the Agreement between the Hungarian and the Czechoslovak Governments depends on the results of the negotiations between the two parties.

If contractual obligations are fulfilled, sustained arguments will arise due to the differences in assessing the conditions of operating the barrage system. Obviously, a long-term suspension of the construction, ie. the evasion of a clear-cut decision will generate tension. However, tension would also arise in bilateral relations if peak-time operation of the BNB is excluded and, as a consequence, the operations at Nagymaros are cancelled for good. So, tension is unavoidable in either case.

Should the Hungarian Government opt for the latter solution, it could initiate negotiations about the amendment of the inter-governmental agreements with reference to the circumstances, set forth above. It could indicate the cancellation of the Nagymaros Barrage and the postponement of the change of course at the Dunakility-Körtvélyes Reservoir as the objective of the negotiations. Should the other negotiating party be unwilling to accept such amendments, the Hungarian Government could pass a unilateral decision about the termination of construction operations at the Nagymaros Barrage and the postponement of the change of course, while referring to the mutual violation of certain contractual obligations and the emergence of an environmental emergency.

Consequently, a legal dispute would arise between the two parties. The crux of such legal disputes is that one of the parties, in this case the Czechoslovak party, finds itself in a situation where it is bound to make a compromise. In other words, sooner or later it will have to give in and negotiate. There is no court in today's international legal system that would be able to decide about such legal disputes without the consent of the parties involved, ie. to compel Hungary to construct the barrage. The Czechoslovak Government has elementary interest in reaching a compromise as this is the only way it can hope to recover some of its losses.

This decision should be accompanied by the Hungarian party's efforts at amending the agreement whose probable impact is discussed in a summary by the Ministry of Justice as well as the accompanying annexes.

On balance it is to be noted that we can expect to be faced with a legal dispute over a great many years with an uncertain outcome. However, the negotiating position of the Hungarian party is reinforced by the fact that the provisions under Sections 15 and 19 of the inter-governmental agreement have not been fulfilled. The lengthy legal dispute will release us from any immediate or short-term payment obligation. In accordance with the current and routine practice among CMEA-countries we are obliged to honour obligations to pay damages only to the extent and in the form acknowledged by us, even in the long run.

As regards the financial consequences of dropping the Nagymaros hydro-electric station, the parties affected must come to agreement. Therefore the Hungarian Government will be straddled by financial obligations only to the extent it acknowledges them. Noone can compel the Government to satisfy Czechoslovak demands it does not recognise as justified. With respect to international relations, states with financial obligations are in a better negotiating position than those with claims.

As regards the financial consequences, the following primary factors should be considered:

(a) By cancelling the Nagymaros Barrage, both parties would have losses (ie. not only Czechoslovakia) and such a decision would carry advantages as well. (Certain operating and maintenance costs would not be incurred along with some environmental investments, etc.) In the agreement to be made, the net difference of the disadvantages and advantages should be considered that accrue to the two parties involved.

(b) Losses to be incurred by the Czechoslovak party should be proven by the Czechoslovak Government while the Hungarian party should indicate how much of these losses it is going to acknowledge. All project elements that become superfluous as a result of the cancellation of the Nagymaros Barrage can be included as loss items in addition to those that cannot be put to some other use. Investments to be carried out in Czechoslovakia with the objective to make up for lost electricity cannot be regarded as either loss or damage therefore compensation for them is out of the question.

(c) The concept of "unrealised profits" is unknown in the legal practices of the socialist countries, therefore Czechoslovak claims to that effect are unfounded.

(d) There is no single, accepted and legal means of payment in use between the two countries. This implies that payment obligations incurred by the Hungarian party cannot be settled by transferring a certain amount of money immediately. The only option available is for the Hungarian party to deliver goods above the "agreed quota", the annual volume of which will depend on Czechoslovak demand and the supply capacities of the Hungarian companies. Consequently, it may take long years for the Hungarian instalments to run out. Of course, we are not obliged to make payment in convertible currency.

(e) Shifting the route of navigation on the Danube to Chechoslovak territory would seriously violate the Paris Peace Treaty and, indirectly, the Trianon Peace Treaty as well, along with the Bilateral Agreement of 1976 on River Borders and the 1977 Agreement between the two Governments. Most probably than not, the river would not be deflected as it would pose severe environmental risks for Czechoslovakia too, and technical feasibility is also questionable.

SUMMARY

The Government's decisions about suspending construction activities at the Bős-Nagymaros Barrage have come at a time of a world-wide change in approaches, given priority to the protection of the environment and natural resources.

In accordance with the unanimous views of independent specialists with no ties whatsoever to the barrage project the overall ecological impact of the BNB is clearly negative. The situation is further exacerbated by the fact that the volume of possible damage cannot be recorded as the appraisal of the current status is also extremely deficient.

The risk of endangering potable water reserves is especially large and impermissible. The construction activities in the Nagymaros region of the BNB have already had a detrimental effect on water production and supply in Budapest. As for the future, bank-filtration wells as well as the largest underground freshwater reserves of Europe may also be endangered

Wastewater purification, as demanded both in the October, 1988 resolution by Parliament and under the appropriate sections of the inter-governmental agreement as the precondition to damming the waters, has not been implemented. In the case of certain tributaries, already in a critical state (eg.: the Morava), not even the wastewater purification plans are known. In view of the projected environmental perils and risks, the optimum solution would be to terminate all the construction activities of the BNB Project for good.

With respect to certain issues concerning the technological safety of the BNB project, no decision can be made as only insufficient preliminary test and analysis data are available. There is no gelological and hephysical dodumentation available to assess the whole of the BNB, therefore it is impossible to appraise the possibilities for safe dimensioning and the economic impacts thereof.

No solution has been found as yet to provide sufficient discharge in the Old Danube or to save the archeological relics unearthed in the Esztergom region. Such outstanding questions cannot, in any way, be interpreted to support the continuation of the project without any change in the underlying concept.

The ideas with respect to the complex utilisaiton of the Danube cannot justify so huge and complex technical solutions with such exorbitant costs as the construction of hydro-electric stations combined with reservoirs in order to improve the conditions for flood control and navigation. Both the designers and the contractors have quoted points exclusively from an energy production concept which has, meanwhile, become outdated. At the same time, the Ministry of Industry has indicated that the energy industry stated at all the stages of the decision-making process that the implementation of the project is unnecessary for the purposes of energy generation and only 60% of the project costs can be born profitably by the electricity generating sector. The electricity generating sector has always had a number of efficient substitutes to the project. Therefore, implementation could only be justified if the profitable utilisation of the other 40% of the project could be supported by advantages to be achieved in other sectors. Considering these reserves, indentified in Hungary's energy network, the energy generating capacities of the hydro-electric station are not required at all in the short run; the proposed generating capacities can be substituted by others in the long run as well, with special regard to the fact that starting from 1995 most of the electricity generated by the BNB would have to be used to repay a loan in kind.

The economic analyses prepared indicate that both the continuation and the cancellation of the construction activities would generate losses which are the immediate result of the non-profitability of the project. From an economic point of view, the least favourable option is the long-term suspension of the operations. In the short-term, the final cancellation of the construction activities at Nagymaros is more favourable while in the long run there is no significant difference among the different scenarios. However, cancellation would give greater freedom to the Government to make up its mind about a different order of national project priorities.

As time goes by, the continuation of construction is justified only by references to international obligations and the dangers of having to pay damages. We must face the legal consequences arising from the termination of some of the contracts between Hungarian and Austrian companies; our obligations to pay damages will have to be honoured at a time three years from now, following the co-ordinatory meetings and the award by the arbitrators and most of the obligations could be satisfied by supplying electricity.

With respect to the Czechoslovak party, we must make efforts to amend the inter-governmental agreement. Should the Czechoslovak party be unwilling to make a compromise, the Hungarian party would be compelled to unilateral action, referring to the non-performance of certain essential provisions in the intergovernmental agreement and the emergence of an ecological emergency. In the course of the legal dispute, arising as a result, the Hungarian party cannot be compelled to accept and honour claims for damages it does not acknowledge.

Should the Hungarian Government decide in favour of cancelling construction activities at Nagymaros, it must reckon with the tasks arising from the complex regulation of the Bős-Nagymaros-Budapest section of the Danube as well as the operations with respect to potable water production, navigability and the restoration of the work pit at Nagymaros. In order to identify the technologically most acceptable and most suitable solutions, the Government should set up an appropriate committee.

RECOMMENDATIONS

The Committee hereby proposes to the Council of Ministers that it should take a preliminary stance, rejecting the peak-time operation of the BNB and, as a consequence, cancelling the Nagymaros Barrage and suspending the operations with respect to the change of course at the Dunakiliti-Körtvélyes Reservoir. The elaboration of the ecological gaurantees and the optimum operation of the Bős hydro-electric station as well as the conclusion of an appropriate agreement with the Czechoslovak party would constitute the preconditons to such a change of course.

The Committee also proposes that, in preparation for a meeting of the Hungarian and Czechoslovak Prime Ministers, the Council of Ministers should authorise the Deputy Prime Minister on the basis of Section 3 of Resolution No. 9/1989 (V.13.) by the Parliament to begin negotiations with the Czechoslovak party immediately about the conditions for the amendment of the 1977 inter-governmental agreement along the line suggested above.

Further, the Committee also proposes that the Council ofMinisters should present its proposals to Parliament subject to the outcome of the Hungarian Czechoslovak negotiations and the timing of the meeting between the Hungarian and the Czechoslovak Prime Ministers.

The Council of Ministers should set up a committee. headed by a Government Commissioner, to elaborate the underlying conditions for such change of course.

Finally, the Committee proposes that suitable technical committees should elaborate the technological tasks, arising from the final cancellation of the construction operations at the Nagymaros Barrage.

Péter Hardi
Head of the Committee
of Independent Specialists

OUTPUT BY WATER UTILITIES BY SOURCES OF WATER

(1986)

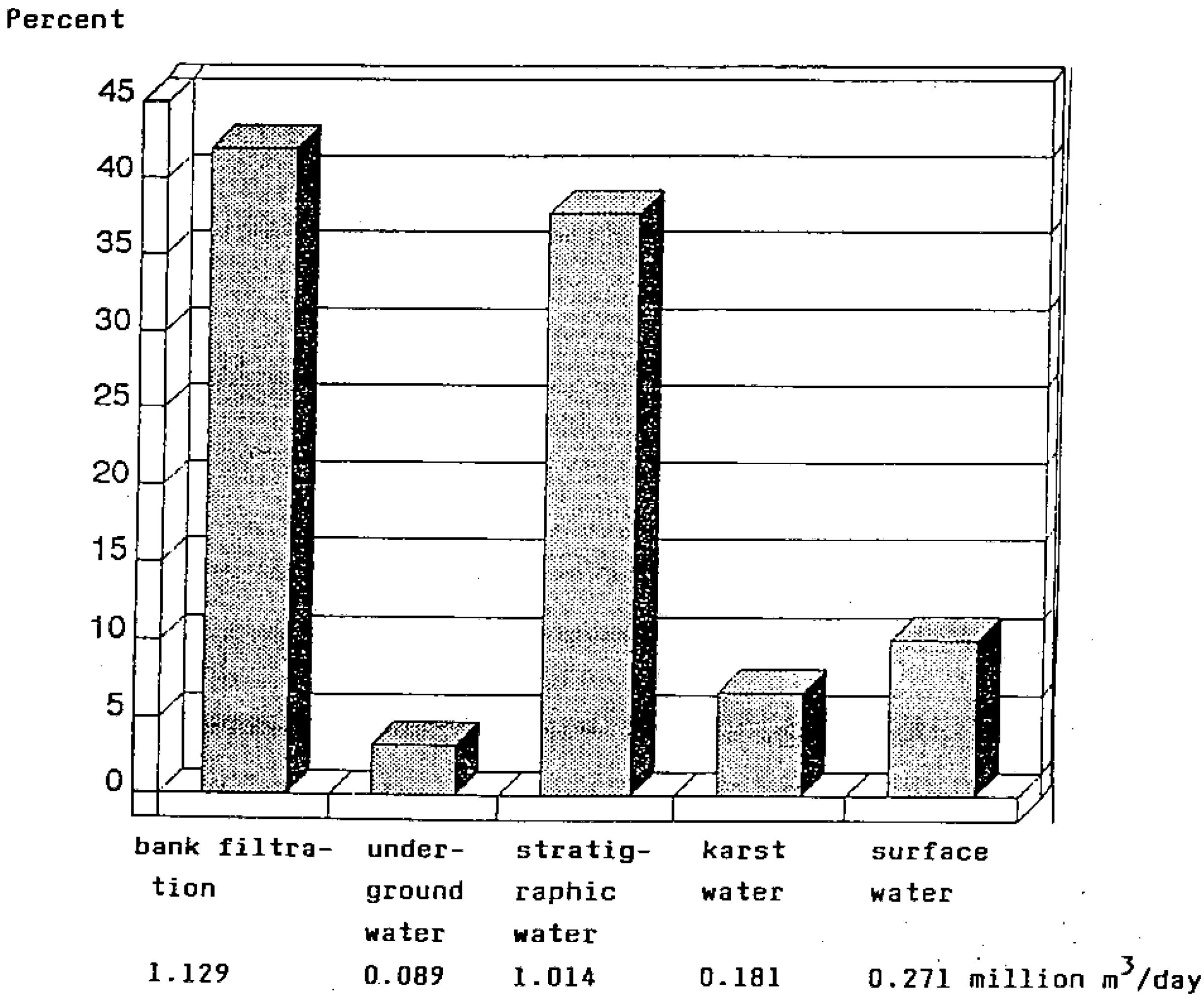
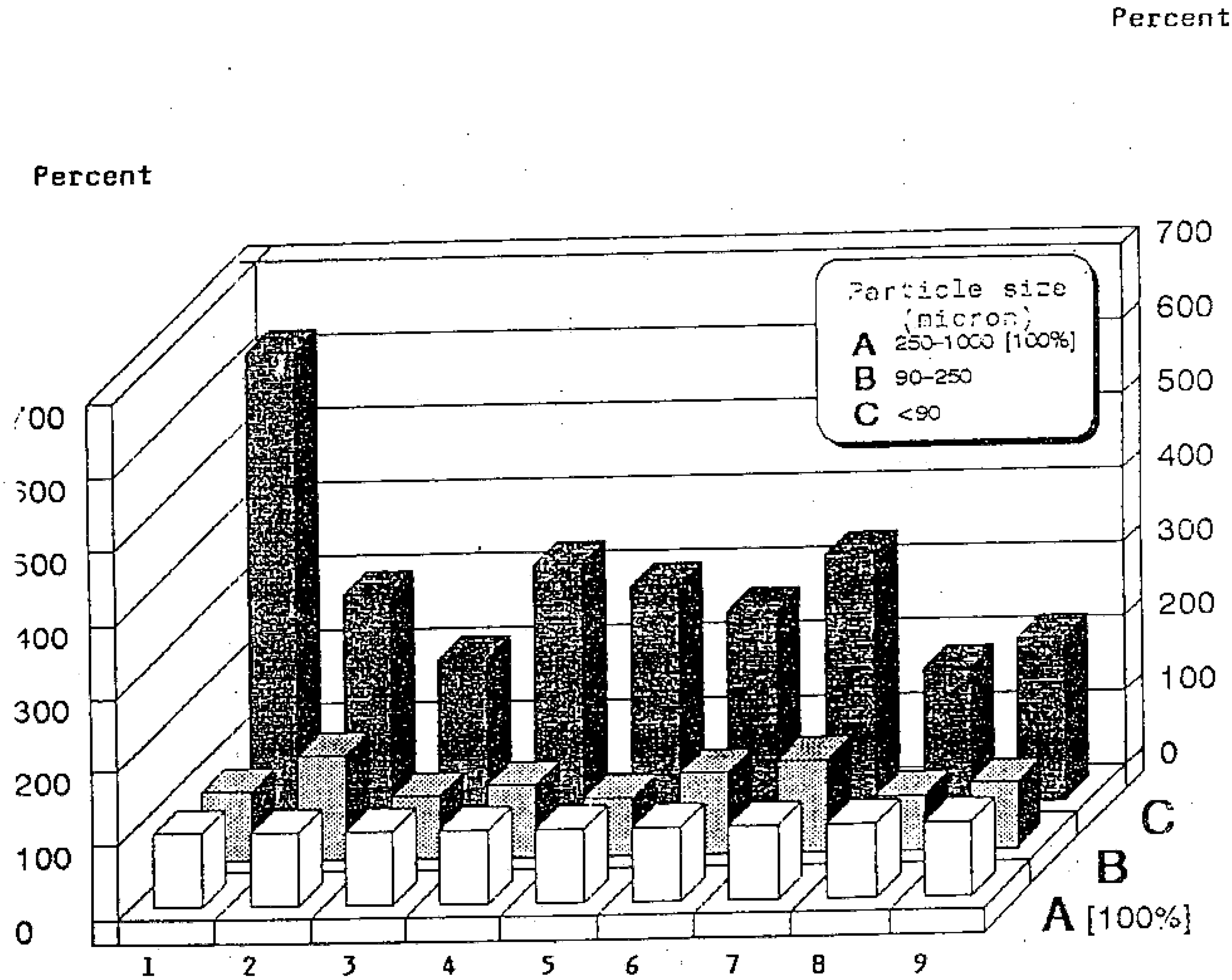


Figure 1

Source: The utilisation and protections of water reserves
KSH KVM, Budapest, 1988, p. 21

THE RELATIVE, AVERAGE CONCENTRATION OF CERTAIN CONTAMINANTS IN THE RIVER BED



1. Mercury
2. Cadmium
3. Lead
4. Chromium
5. Arsenic
6. Iron
7. Manganese
8. Total organic matter
9. Oil and grease

Figure 2

Source: Water Management Bulletin
Budapest, 1988. Vol. 4, o. 543

WASTEWATER PURIFICATION IN GYŐR-SOPRON AND KOMÁROM COUNTIES IN 1986

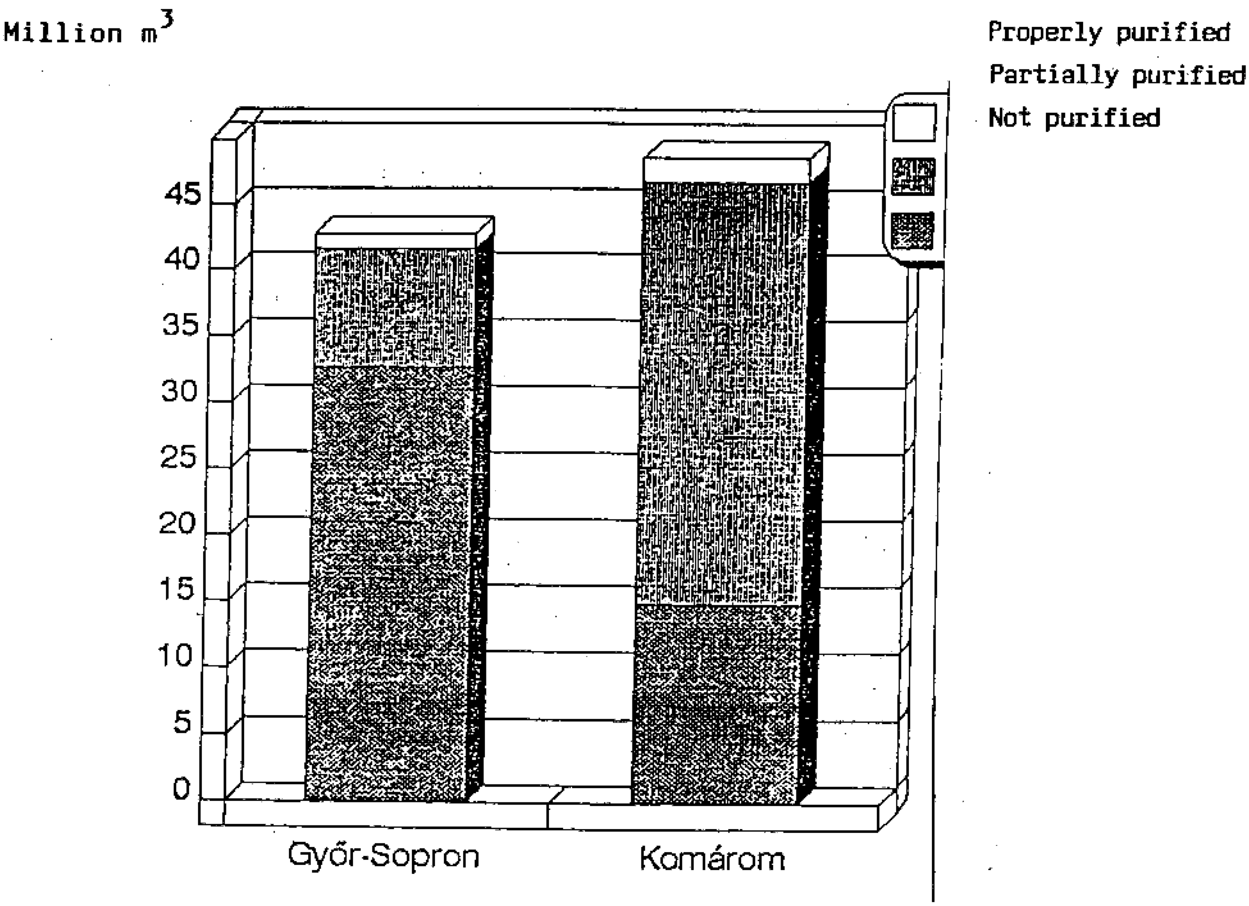


Figure 3

Source: The utilisation and the protection of water reserves
KSH-KVM, Budapest, 1988. p. 33

CONTINUATION OR CANCELLATION OF THE NAGYMAROS BARRAGE

AT PRESENT VALUE (at a 7% discount)

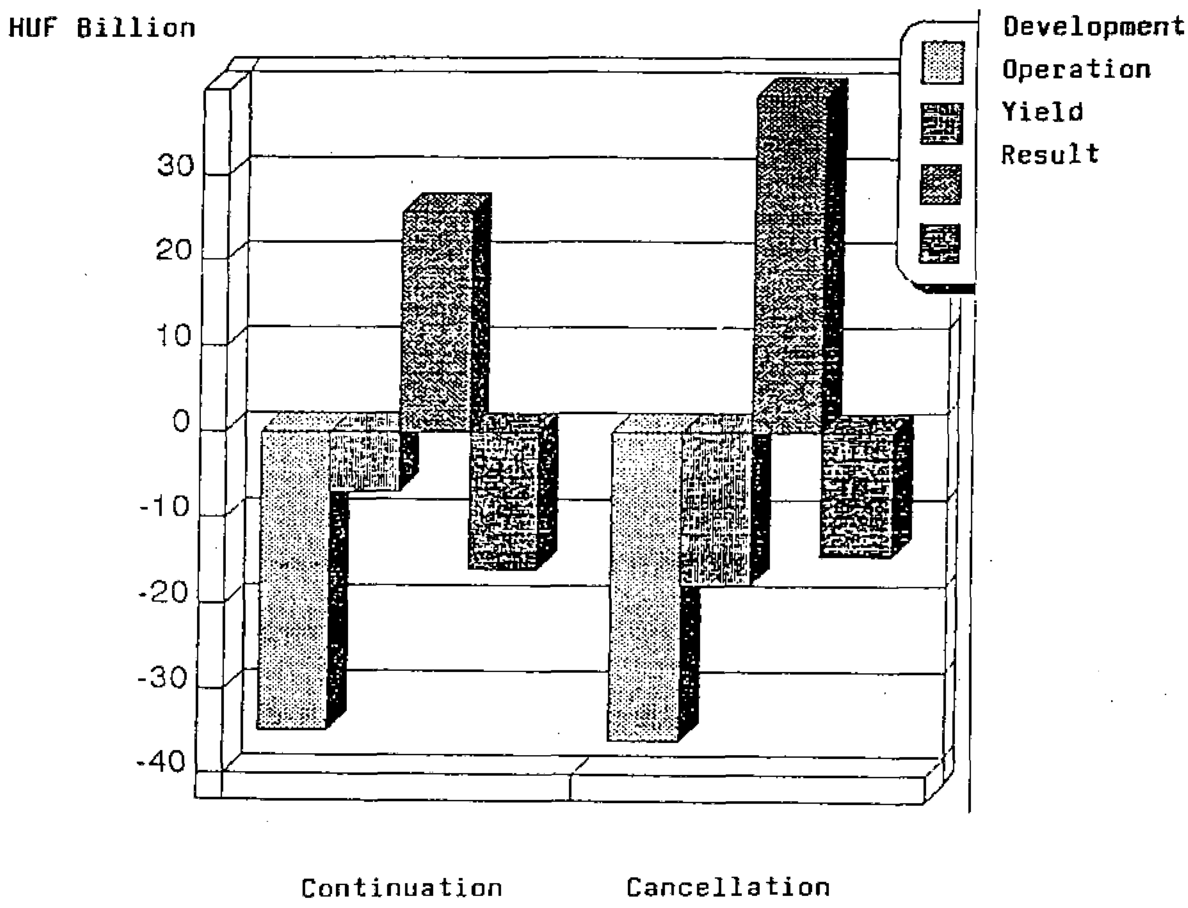
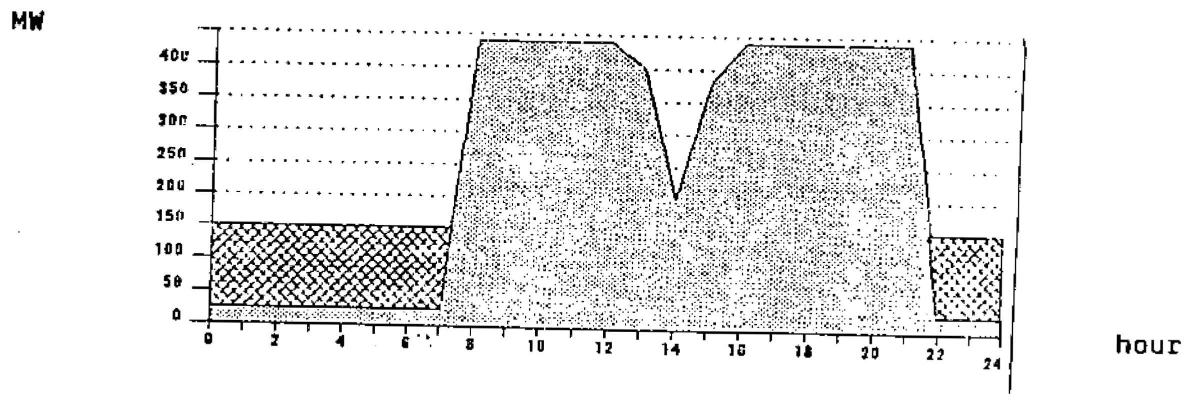


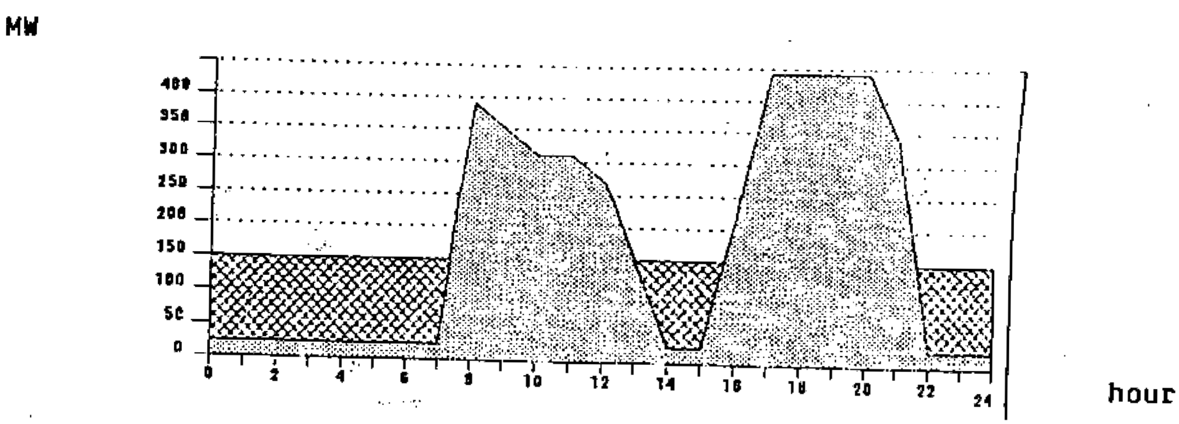
Figure 4

Source: II/c Committee report, drawn up on the basis of Resolution No. 3205/1989.(VII.20.) by the Council of Ministers, dated August 1989

BNB EXPORT BALANCE
in winter, at medium discharge

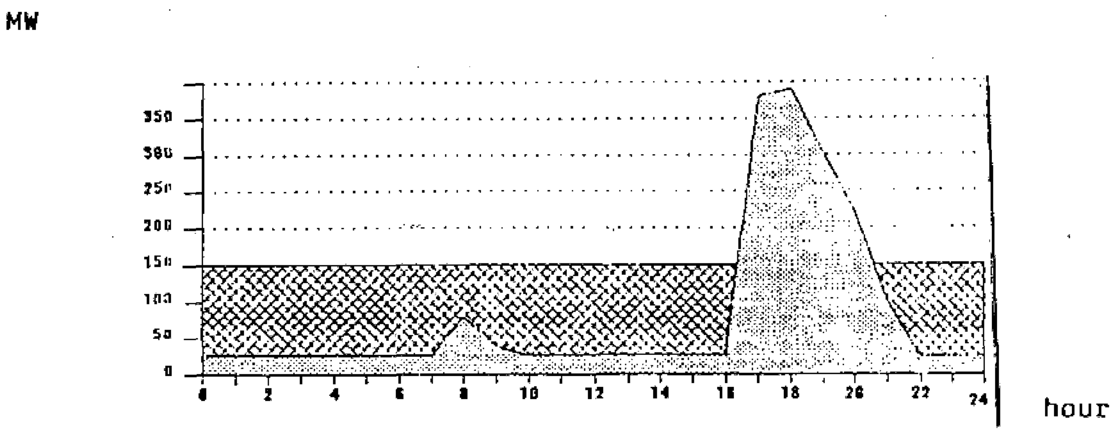


BNB EXPORT BALANCE
in winter, at low discharge



(cont'd)

BNB EXPORT BALANCE
in winter, at minimum discharge



Hungary's share in the barrage

Electricity generated in other power stations, to be exported

Source: Austrian-Hungarian agreements,
Dr. Béla Potecz: Energy possibilities, modes of operation and management

REPUBLIQUE SLOVAQUE
MINISTERE DES EAUX ET DES FORETS

Aménagement hydraulique
GABCIKOVO - NAGYMAROS

Rapport d'opinion sur certains aspects du projet affectant la mise en exploitation de la centrale GABCIKOVO

RAPPORT GÉNÉRAL

HYDRO-QUÉBEC INTERNATIONAL

Décembre 1990

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1.0

INTRODUCTION

1.0 INTRODUCTION

1.1 Contexte et but du rapport

Ce rapport d'opinion présente les résultats d'une évaluation par Hydro-Québec International de certains aspects de l'aménagement hydroélectrique de Gabcikovo.

La réalisation du complexe hydraulique de Gabcikovo-Nagymaros sur le fleuve Danube fait suite à une entente intervenue en 1977 entre les gouvernements de Tchéco-Slovaquie et de Hongrie. Ce complexe à buts multiples vise à produire l'énergie hydroélectrique, à améliorer la navigation et à fournir une protection accrue aux inondations. Il comporte deux aménagements: Gabcikovo avec une centrale de pointe de 720 MW située en territoire slovaque, 45 km à l'aval de Bratislava, et Nagymaros, une centrale au fil de l'eau de 160 MW située à 120 km plus à l'aval, près de 30 km au nord de Budapest.

Les travaux de construction ont débuté en 1978. L'échéancier prévoit la mise en service de la première turbine de la centrale Gabcikovo pour 1990 et l'achèvement du complexe pour 1994.

En 1989, le gouvernement Hongrois a remis en question la pertinence du projet et a décidé de suspendre les travaux sur son territoire. A la suite de cette décision, la Tchéco-Slovaquie s'est vu contrainte de ralentir les travaux en dépit du fait que près de 95% du projet Gabcikovo est réalisé et que plus de 20 milliards de courones tchéco-slovaques ont été investis. Et récemment, l'opinion publique en Tchéco-Slovaquie a soulevé certaines questions concernant l'exploitation de cette centrale.

Le présent rapport se veut donc une réponse aux préoccupations du Ministère par rapport à la mise en exploitation du projet Gabcikovo.

1.2 Mandat d'Hydro-Québec International

Le mandat fait suite à une convention de coopération technique intervenue à Bratislava le 7 septembre 1990 entre Hydro-Québec International (HQI) et le Ministère des Eaux et des Forêts de la République Slovaque. Le mandat confié consistait à produire une opinion sur :

- la contamination de la nappe,
- la méthodologie de prévisions de la variation du niveau de la nappe,
- la sécurité des infrastructures de retenue
- les études environnementales existantes

Dans le cadre de ce mandat, Hydro-Québec International a évalué globalement les études relatives aux quatre sujets précités. En particulier, elle a traité de la conception des ouvrages et des méthodologies employées lors des différentes phases d'étude du projet. De plus, elle a porté un jugement sur l'ensemble des études consultées pour s'assurer qu'elles respectent les règles de l'art et les standards internationaux.

1.3 Déroulement de la mission

Une délégation d'experts d'Hydro-Québec International a séjourné en Tchéco-Slovaquie du 8 octobre au 7 novembre 1990. Elle a eu l'occasion de rencontrer tous les spécialistes slovaques qui ont travaillé au projet et de visiter les sites et les ouvrages s'y rapportant.

1.3.1 Présentation du projet et visites des installations

Les séances de présentation du projet d'aménagement hydroélectrique de Gabcikovo se sont tenues dans les locaux d'Hydroconsult à Bratislava les 15 et 16 octobre 1990. Au cours de ces séances, les spécialistes slovaques rattachés à différentes institutions ont présenté l'essentiel du projet.

Ceux-ci ont présenté aux experts d'Hydro-Québec International des études dans les disciplines suivantes: géologie, géotechnique, hydrologie, hydrogéologie, hydrogéo-chimie, conception des ouvrages de retenue et environnement.

Les 17 et 18 octobre 1990, la délégation d'Hydro-Québec International a visité le complexe Gabcikovo. Elle était accompagnée des spécialistes et des concepteurs slovaques. Cette visite sur le terrain a permis de voir chaque ouvrage de génie civil du projet. Elle a été aussi l'occasion de discussions sur le contenu des nombreuses études et recherches réalisées dans le cadre de ce projet (géologie, hydrogéologie, conception, environnement, etc.). Les experts d'Hydro-Québec International ont visité les ouvrages et les sites suivants :

- le réservoir Hrusov
- les digues de la rive gauche et de la rive droite du réservoir Hrusov (seulement sur le territoire de la Tchéco-Slovaquie)
- la zone du développement touristique sur la rive droite du réservoir Hrusov
- le canal d'amenée et la digue sur la rive gauche
- la digue et les ouvrages sur la rive droite du canal d'amenée

- l'emplacement envisagé de la fermeture du Danube entre la Tchéco-Slovaquie et la Hongrie
- la zone d'inondation entre le Danube et le canal d'amenée
- la centrale Gabcikovo et les écluses
- le canal de fuite

Le 22 octobre 1990, la délégation a pu visiter le site de l'aménagement de Nagymaros en Hongrie, la rive droite du Danube jusqu'à Dunakiliti et l'ouvrage de contrôle de Dunakiliti.

Le 2 novembre 1990, les experts d'Hydro-Québec International ont également effectué une seconde visite du complexe Gabcikovo et de tous ses ouvrages.

1.3.2 Organismes et spécialistes slovaques rencontrés

Pour pouvoir réaliser cette étude d'opinion, les experts d'Hydro-Québec International ont rencontré plus de quarante spécialistes slovaques qui ont travaillé à titres divers, au projet d'aménagement Gabcikovo. Ces spécialistes proviennent de seize (16) organismes différents (bureaux d'études, institut de recherches, université, etc.). La liste détaillée des personnes rencontrées et les noms des organismes qu'ils représentent, sont en annexe B du rapport. Dans chaque spécialité et domaine d'intérêt, les experts d'Hydro-Québec International ont eu des discussions approfondies avec les spécialistes slovaques concernés. Ils ont également effectué une revue sommaire des documents soumis afin de vérifier les points d'intérêt notés lors des discussions.

Par ailleurs, les experts d'Hydro-Québec International ont visité le bureau d'ingénieurs-conseils de VIZITERV à Budapest et l'Ecole technique supérieure tchèque à Brno, pour voir le système de monitoring mis au point pour le projet.

1.4 Développement historique des travaux d'aménagement sur le Danube

Le développement des projets d'aménagement des eaux et des ouvrages hydroélectriques sur le Danube et dans son bassin versant est étroitement lié à l'augmentation de populations des régions qu'il traverse, à leur économie et à leur développement culturel et technologique.

Les premiers travaux effectués sur le Danube datent de l'Empire Romain. Ce n'est que plus tard, vers la fin du XVIII^{e} siècle, alors que la population avait sensiblement augmenté et que les relations commerciales sur le Danube étaient désormais bien établies, qu'on a procédé à des mesures plus importantes.

Les vallées du Danube sont souvent inondées et marécageuses. Elles sont de plus en plus occupées par l'agriculture et la population. L'utilisation des ressources pour l'alimentation en eau potable de la population, des animaux et de l'industrie, pour l'irrigation, et pour la production d'énergie ne cesse d'augmenter. Afin de faire face aux besoins identifiés, on a construit un grand nombre d'ouvrages hydrauliques et de systèmes d'aménagement des eaux qui ont modifié considérablement le profil du Danube et son cours.

Aujourd'hui, on ne peut plus mettre en valeur le Danube sans concertation des états qu'il traverse. Pour planifier et exécuter les grands projets, il est plus que jamais nécessaire d'informer les pays voisins, de coordonner les efforts, d'établir des accords ou même de procéder à la réalisation de nombreux travaux en commun.

A partir de 1950, de nombreux ouvrages hydrauliques ont vu le jour sur le Danube. Ces barrages sont presque toujours des installations polyvalentes importantes qui servent tant à la navigation fluviale qu'à la production d'énergie et à la protection contre les inondations.

1.4.1 Particularités d'un aménagement hydraulique entre Bratislava et Palkovicovo

Le Danube, après avoir traversé la zone étroite entre les Petites Carpates et les collines de Leitha, continue son cours en aval de Bratislava à travers le bassin de Komarno. Le fleuve a laissé ici des dépôts de graviers sableux en forme de cône d'alluvions épais. L'épaisseur de ces dépôts alluvionnaires immédiatement en aval de Bratislava atteint près de 15 m et aux alentours de Gabcikovo (45 km en aval de Bratislava) environ 300 m.

Dans la section entre Bratislava et Palkovicovo (km 1810), le gradient du Danube est de 35 à 40 cm/km. Par la suite, vers l'aval, le profil du Danube change brusquement à 13 cm/km. Plus loin cette pente diminue encore jusqu'à 10 cm/km et même 6 cm/km. Ce changement brusque de la pente résulte en un dépôt de 600 000 m^3 de gravier en moyenne par an. Des dépôts sont la cause de la désagrégation du fleuve en îlots de graviers et en branches secondaires du cours d'eau.

Le Danube dans le secteur de Bratislava à Palkovicovo coule sur "le dos" du cône alluvial, c'est-à-dire à un niveau plus élevé que le terrain avoisinant (fig. 13). Historiquement, lors des crues l'eau sort de sont lit peu profond et inonde la large plaine danubienne sur les deux côtés. Avec l'augmentation de la population dans la plaine et le développement économique plus marqué, la population a commencé à bâtir des digues de protection sur les deux côtés du fleuve et pendant la seconde moitié du 19^{e} siècle une ligne continue de défense a été construite.

La défense contre les inondations n'était ni totale ni durable. Le dépôt continuel d'alluvions surélevant le lit du fleuve et par conséquent le niveau d'eau, la hauteur relative des digues s'est trouvée inadéquate. Des ruptures de digues et des inondations catastrophiques en sont résultées. En 1965, les digues danubiennes on été largement détruites lors d'une crue exceptionnelle.

D'autre part, la réalisation d'une voie navigable dans le secteur compris entre Bratislava et Palkovicovo selon les normes de la commission du Danube rencontre des difficultés majeures. Suite à une accumulation de dépôts graveleux dans le lit, des bas-fonds et des seuils aux profondeurs insuffisantes se sont formés. Malgré des travaux de régularisation de grande envergure réalisés à des coûts très éelvés, on n'arrive pas à réaliser un chenal de navigation qui respecte les normes. Aussi, l'entretien de ce secteur coûte dix fois plus cher par kilomètre que pour tous les autres secteurs du Danube.

Enfin, compte tenu de la nécessité de fournir une protection adéquate aux inondations, et suite aux études technico-économiques, il a été décidé de lier la reconstruction des digues à un aménagement hydraulique à buts multiples, intégrant des ouvrages de génération hydroélectrique et de navigation. Le complexe Gabcikovo-Nagymaros entrepris conjointement par les gouvernements de Tchéco-Slovaquie et de Hongrie en a été le résultat.

1.4.2 Caractéristiques hydrologiques du Danube à Bratislava

Les principales données hydrauliques du Danube à Bratislava (km 1869) sont les suivantes :

-	débit moyen annuel	2 025 m^e/s
-	débit minimum observé (en 1948)	570 m^3/s
-	débit maixmum observé (en 1954)	10 254 m^3/s
-	débit de crue centennale Q 1 %	10 600 m^3/s
-	débit de crue millennale estimé à Q 0,1%	13 000 m^3/s
-	débit de crue decimillennale estimé Q 0,01 %	15 000 m^3/s

A Bratislava, le Danube charrie un grand volume de matières solides dont la quantité moyenne pour une période de 50 ans a été estimée à 632 000 m^3 par an. La quantité de sédiments en suspension transportée varie entre 2,5 et 10,0 millions de tonnes par an.

1.5. Description générale de l'aménagement de Gabcikovo-Nagymaros

Tel que décrit dans le rapport de synthèse fourni à Hydro-Québec International pour fins de cette étude

(HYCO, 1990), l'aménagement commun hongro-tchécoslovaque du Danube, dont la centrale de Gabcikovo constitue le palier amont, exploitera un tronçon long de 217 km, entre l'extrémité en amont de la retenue de Hrusov et l'extrémité en aval de l'approfondissement du lit du fleuve à Budapest. Le complexe hydroélectrique utilisera une dénivellation comprise entre 33 m et 31 m (suivant le débit) en deux paliers soit :

- la centrale de Gabcikovo (h = 23,8 m) opérant en pointe;
- la centrale de Nagymaros (H = 8,9 m) opérant au fil de l'eau

1.5.1 Caractéristiques hydrauliques de l'aménagement de Gabcikovo

Plusieurs variantes ont été considérées et suite aux choix de la solution définitive, les bureaux d'études ont effectué les calculs hydrauliques détaillés suivants :

- barrage de Dunakiliti (un modèle réduit et un modèle pour des variantes de la fermeture du lit du Danube);
- canal d'amenée (modèle réduit);
- centrale de Gabcikovo (un modèle réduit pour l'ensemble des ouvrages);
- canal de fuite (modèles physiques et mathématiques).

Les débits naturels du Danube seront emmagasinés dans la retenue de Hrusov. Une partie des débits (tout d'abord entre 50 à 200 m^3/s initialement prévu et maintenant augmenté à 350 m^3/s) sera déversée dans l'ancien lit du Danube.

Le volume d'emmagasinement dans la retenue entre les cotes 130,10 et 131,10 m (niveau normal de retenue) sera turbiné pendant les heures de pointe à la centrale de Gabcikovo équipée pour Q = 3 360 à 5 200 m3/s. Exceptionnellement, le niveau de la retenue peut descendre à la côte 129,60 m. La durée de la pointe variera d'après le débit disponible entre 4 et 16 heures par jour. Lorsque le débit est supérieur à 3 000 m3/s, la centrale peut fonctionner même pendant la nuit jusqu'à atteindre le régime de fonctionnement continu sous le niveau normal de la retenue (fonctionnement au fil de l'eau).

Dans l'ancien lit du Danube le débit réservé d'environ de 350 m3/s sera déversé par les ouvrages de contrôle de Dunakiliti d'une façon constante (la capacité de débit de l'ouvrage est de 9 770 m^3/s). Afin de maintenir le plan d'eau du Danube à un niveau constant correspondant au débit de 1 340 m3/s (comme avant la mise en service de l'aménagement), quatre (4) seuils transversaux seront construits dans le lit du fleuve. La dénivellation entre le niveau en aval et en amont des seuils sera d'environ 1 m; avec la vitesse moyenne d'écoulement de 0,5 m/s. Une ou deux fois par semaine, cet ancien lit sera lavé pendant quelques heures par un débit s'élevant à quelques 1 300 m3/s pour éliminer de dépôts limoneux accumulés au fond. Le système de méandres peut être également alimenté en eau d'une part par l'ouvrage de prise d'eau situé à l'entrée du canal d'amenée dans la digue de raccordement et d'autre part par la galerie passant sous le fond du canal d'amenée au point kilométrique 4,00 du canal. En plus, il y a possibilité de repomper les débits d'appoint du canal de fuite.

1.5.2 Aménagement de Gabcikovo

L'aménagement hydro-électrique de Gabcikovo comprend, de l'amont vers l'aval, les ouvrages suivants:

- réservoir de Hrusov - Dunakiliti;
- ouvrage de régulateur de Dunakiliti;
- canal d'amenée;
- centrale et double écluse à Gabcikovo;
- canal de fuite;
- ouvrages d'aménagement de l'ancien lit du Danube;
- ouvrages d'aménagement en aval du canal de fuite.

1.5.2.1 Réservoir de Hrusov - Dunakiliti

Le réservoir est situé à l'aval de Bratislava et occupe le tronçon du Danube entre les points kilométriques 1842 et 1858. Il aura une longueur de 24 km et s'étendra sur une superficie de 51 km2 constituant ainsi le plan d'eau artificiel le plus important du pays. Le volume total de retenue sera de $200,10^6$ m^3 dont 48.10^6 m^3. (la tranche supérieure de 1 m d'épaisseur) seront utilisés pour la production de l'énergie de pointe.

Les digues en terre d'une longueur totale de 52,6 km (dont 42,6 km sur le territoire tchécoslovaque) ont un volume de $12,6.10^6$ m^3.

Les fuites provenant de la retenue seront drainées vers l'aval par les contre-canaux longeant les digues. Ils ont été conçus pour un débit d'infiltration de 45 m^3/s.

1.5.2.2 Ouvrage de régulateur de Dunakiliti

L'ouvrage est situé sur le fleuve au point kilométrique 1842 et remplit plusieurs fonctions:

- relever et maintenir le niveau d'eau à la cote de la retenue normale de la centrale;
- évacuer les débits excédant la capacité du canal d'amenée;
- permettre à la navigation de franchir l'ouvrage pendant la mise en service de l'aménagement (durant environ 6 mois);
- alimenter l'ancien lit du fleuve;
- le cas échéant, faciliter l'évacuation de glaces de la retenue vers le lit naturel du Danube.

L'ouvrage de contrôle est constitué de six (6) passes de 24 m de largeur et d'une écluse de 24 x 125 m de surface utile. Les vannes - segments ferment les passes sur une hauteur de 11,3 m. Elles se composent d'un corps principal de 8,0 m de hauteur et d'un clapet rabattable, haut de 3,3 m.

L'ouvrage est fondé sur des couches alluvionnaires sablo-graveleuses dont l'épaisseur est d'environ 200 m. Les travaux de fondation ont été effectués sous la protection d'une cuvette étanche de 60 000m^2.

1.5.2.3 Canal d'amenée

Le canal d'amenée de 17 km de longueur prend son dèpart dans la retenue de Hrusov et sert à dériver un débit moyen de 4000 m3 vers la centrale de Gabcikovo avec une vitesse de 1,0 m/s. Pendant les pointes ce débit variera cependant entre 3 670 et 5 100 m3/s. En periode de crues, le débit peut atteindre la capacité limite du canal, soit 5 270 m3 à la vitesse 1,5 m/s.

En même temps, il constitue une voie navigable reliant la retenue au canal de fuite. Le volume d'eau dans le canal à débit nul est de 88.10^6 m^3 dont 8.10^6 m^3 sont utilisables pour la pointe.

Le fond du canal se trouve approximativement à la cote du terrain naturel. Sa largeur est variable et la conception en a été faite de sorte que la vitesse maximale pendant le fonctionnement en pointe de la centrale ne dépasse pas 1,3 m/s. Sa largeur varie:

PK	0,00	à	11,5	de	542	à	267	m
PK	11,5	à	16,0	de	267	à	737	m

A partir du point kilométrique 16,0 jusqu'à la centrale, la largeur du fond du canal diminue progressivement pour atteindre la largeur de la centrale et les écluses.

Les digues sont homogènes, constituées de matériaux graveleux compactés avec une hauteur qui varie entre 11 et 18 m au-dessus du terrain naturel. L'élévation de la crête est à la cote 133,10 m soit avec 2 m de revanche. L'élément d'étanchéité est constitué par un écran en béton bitumineux incliné dans 1 : 2. La pente aval est de 1 : 2 dans la partie supérieure et de 1 : 3 plus bas. La largeur de la crête est de 6 m.

Le fond du canal est imperméabilisé sur la totalité de sa surface (7.10^6 m^3) par une membrane en PVC plastifiée de 0,6 mm et assemblée par soudure en bande de 1,3 m de largeur. La membrane est posée sur le terrain en place, nivelé et compacté.

Dans la partie supérieure la membrane est protégée par 80 cm de matériaux sablo-graveleux, stabilisés sur 15 cm d'épaisseur par du ciment (technique Road-mix).

1.5.2.4 Centrale

La centrale de Gabcikovo, avec une puissance totale installée totale de 720 MW, est située à l'ouest du village de Gabcikovo.

La chute brute pour Q = 0 sera de 23,8 m. La production moyenne annuelle sera de 2 650 GWh et à la pointe, de 1 470 GWh. Le taux moyen d'utilisation sera de 43 %.

La centrale peut opérer également "au fil de l'eau", sans le bassin de Nagymaros. Dans ce cas, la production moyenne annuelle s'élèverait à 2 980 GWh. Cependant, la valeur de l'énergie produite diminuerait.

La centrale comprend 8 groupes à axe vertical de 90 MW chacun. Les turbines de type Kaplan, d'un diamètre de 9,3 m, sont équipées pour un débit de 420 à 630 m^3/s. Le débit peut être élevé à 660 m^3/s lors de l'évacuation des grandes crues.

Pour assurer la navigation, une écluse composée de deux sas de 275 m de longueur et de 34 m de largeur sera installée. Ces dimensions permettent de franchir la chute maximale de 23,6 m à un convoi poussé composé de 9 bateaux et d'un remorqueur déplaçant au total 26 000 t sous un tirant de 3,5 m. L'écluse est fondée sur des alluvions sablo-graveleuses à l'intérieur d'une cuvette étanche de 8,3 ha de superficie dont le point le plus bas est calé à 45 m sous le niveau du terrain (43 m sous le niveau de la nappe phréatique).

1.5.2.5 Canal de fuite

Le canal de fuite a une longueur de 8,2 km et une largeur de 185 m, et est dimensionné de sorte que le débit normal de 4 000 m^3/s soit évacué à une vitesse de 1,0 m/s et le débit exceptionnel de 5 270 m^3/s à une vitesse de 1,2 m/s. Les eaux seront évacuées dans le lit du Danube qui sera dragué au point kilométrique 1811 près de Palkovicovo. La profondeur du canal près de la centrale sera de 18 m, et diminuera vers l'aval. La variation du plan d'eau pendant le fonctionnement de la centrale sera de 5,14 m en 6 heures. Cette variation peut cependant atteindre une valeur théorique de 12,8 m correspondant à la différence du niveau du plan d'eau pour Qmax = Q_{1000}.

1.5.2.6 Aménagement de l'ancien lit du Danube

Lors du projet original entre l'ouvrage de contrôle de Dunakiliti et le point de restitution du canal, soit sur une longueur de 31 km environ, le lit du Danube n'écoulera normalement qu'un débit entre 50 et 200 m^3/s augmenté éventuellement d'une certaine quantité des eaux d'infiltration provenant du canal d'amenée. Le but de l'alimentation du lit est de rétablir des conditions biologiques normales et de modifier le lit à l'évacuation des crues dépassant la capacité du débit du canal.

Entre 1988 et 1990, la conception a été modifiée pour la zone d'innondation et le système de méandres. Cette région mérite une attention toute particulière du point de vue de la protection des forêts alluviales et du maintien de conditions naturelles pour la pisciculture.

A cet effet, l'Institut de Recherche Hydraulique a réalisé une étude qui a servi de base pour un projet de protection de l'environnement à l'aide d'interventions techniques valables. Etant donné que la conception originale ne prévoyait qu'un débit entre 50 et 200 m^3/s, le niveau moyen du plan d'eau dans l'ancien lit s'abaisserait de 3 à 4 m et, conséquemment, drainerait la nappe phréatique de la région voisine.

Pour assurer l'alimentation de cette région, on a construit une prise d'eau avec une capacité de 234 m^3/s. La prise d'eau déversera 50 m^3/s d'une façon permanente et sera équipée d'une microcentrale qui permettra d'exploiter une chute dont la hauteur est de 6 m.

La nouvelle conception prévoit également la construction de 4 seuils déversants en enrochement qui permettraient de surélever le plan d'eau à un niveau correspondant au débit moyen de 1 340 m^3/s. Ce niveau sera assuré par un débit de 350 m^3/s.

1.5.2.7 Approfondissement du lit du fleuve à l'aval de l'embouchure du canal de fuite

Pour profiter mieux de la chute disponible sur le tronçon aménagé, le lit actuel du Danube sera approfondi sur une section d'environ 20 km, à l'aval du point de raccordement du canal au fleuve. L'excavation d'environ 20 millions de mètres cubes de matériaux alluvionnaires sera fait de sorte que le débit normal de 4 000 m3/s passera 1,7 m plus bas que dans le lit actuel.

L'approfondissement du lit du Danube est proposé entre Palkovicovo et Gonyu en Hongrie du PK 1791,3 jusqu'au PK 1810,7 sur un tronçon de 19,4 km.

1.5.3 Aménagement de Nagymaros

L'emplacement de la centrale Nagymaros se trouve dans une région géologiquement et morphologiquement très favorable. Le roc volcanique (andésite) est pratiquement en surface, ce qui offre des conditions de fondations très avantageuses. Le site se trouve au PK 1696, entièrement sur le territoire hongrois.

La longueur du réservoir sera de 123 km, avec une élévation du niveau d'eau de près de 109 m. La superficie de la retenue normale sera 100 km2, avec un volume total de 550 hm^3 en utilisant un volume utile de 60 hm^3.

Pour la protection des terrains le long de la retenue, on prévoit la reconstruction des anciennes digues et la construction de nouvelles digues d'une longueur totale de 152 km en territoire tchécoslovaque et de 47 km en territoire hongrois.

La centrale aura six (6) groupes bulbes à axe horizontal. La chute brute (à débit nul) sera 8,9 m. Le débit d'équipement 2 800 m3/s et la puissance installée de 158 MW, avec une production annuelle moyenne de 1 025 GWh.

2.0

PRÉVISIONS DES VARIATIONS ET DE LA CONTAMINATION DE LA NAPPE

2.0 PRÉVISIONS DES VARIATIONS ET DE LA CONTAMINATION DE LA NAPPE.

2.1 Introduction.

2.1.1 Rappel du mandat.

Dans le cadre de l'étude d'opinion d'HQI, deux aspects des impacts potentiels du projet sur la nappe ont fait l'objet d'une étude particulière. Ce sont, d'une part, la méthodologie de prédiction des impacts du projet sur les niveaux de la nappe d'eau souterraine et d'autre part, la méthodologie de prévision des variations de la qualité de l'eau souterraine. Dans ce dernier aspect, nous nous prononcerons de façon préliminaire et qualitative sur les impacts appréhendés du projet.

2.1.2 Contexte social

En abordant la question des impacts appréhendés du projet sur les eaux souterraines, il importe de présenter brièvement certains éléments de la situation sociale concernant les eaux souterraines. En effet, le projet est construit sur un important aquifère qui fournit l'eau de consommation à une partie importante de la Slovaquie et en particulier à Bratislava. Dans cette région, des événements passés ont rendu la population très sensible aux risques éventuels ou appréhendés de détérioration de la qualité des eaux souterraines. Dans ce contexte, et en sachant que le projet aura un impact indéniable sur la nappe, des craintes spécifiques ont été formulées face au projet. C'est afin de répondre à ces craintes que plusieurs études ont été entreprises dans le cadre du projet et c'est aussi dans ce contexte que certains objectifs de la mission d'HQI visent à donner une opinion extérieure et impartiale sur les résultats des études et sur les effets appréhendés du projet.

2.2 Sommaire des conditions naturelles et actuelles

2.2.1 Préambule

Avant de présenter les impacts du projet Gabcikovo sur la nappe et d'évaluer les méthodes d'analyse et les solutions proposées, il importe de faire un rappel des conditions naturelles. Celles qui nous intéressent pour la prévision de la nappe sont la morphologie et l'hydrologie, la géologie, l'hydrogéologie (limites et paramètres hydrauliques), la qualité de l'eau souterraine, et le régime actuel d'exploitation de l'eau souterraine. Le présent sommaire des conditions naturelles est préparé à partir du résumé préparé par Hydroconsult et des informations recueillies lors des rencontres et de la consultation des documents soumis. Ce sommaire ne vise pas à présenter les données en entier mais plutôt à donner un aperçu général des conditions actuelles gouvernant la nappe d'eau souterraine. Pour ne pas alourdir le texte, les sources d'information sont indiquées dans le texte par les abbréviations des noms des organismes mises entre parenthèses.

2.2.2 Milieu physique

Morphologie

Le projet de Gabcikovo est situé au milieu de la plaine du Danube. Cette plaine est une cuvette bordée de collines de tous les cotés. Elle présente une faible pente d'ouest en est et son élevation varie de 135 m à l'ouest à 110 m à l'est. Le Danube coule au milieu de la plaine et son lit la domine de 1 à 3 m. Cette surélévation du lit du fleuve résulte du dépôt continuel des sédiments grossiers charriés dans un lit endigué progressivement depuis le 15ème siècle.

Hydrologie

Le régime hydrologique de la région peut être défini comme bimodal. D'une part, les crues du Danube se produisent de mai à juillet suite à la fonte des neiges des glaciers alpins. D'autre part, la pluviométrie est maximale au printemps (février - mars) et peu de pluie tombe durant la saison de végétation (mai - août). Le bilan d'évapotranspiration est en déficit.

Des variations de ce régime sont cependant observées avec des crues de fonte en mars et des crues rapides associées au foehn en décembre [TBD].

Lors des crues, dépendant de leur ampleur, le fleuve déborde ses berges endiguées pour inonder les terrains voisins.

En tout temps, le Danube a un cours rapide et ses eaux sont agitées et généralément bien aérées. Ce n'est cependant pas le cas des bras morts qui n'ont de courants que durant les crues majeures.

Le fleuve transporte une forte quantité de matériaux par charriage et/ou saltation (environ 500000 m^3/an) et une masse importante de sédiments en suspension (6000000 T/an) qui se traduit cependant par une faible teneur de solides dans l'eau (-40mg/L).[PDB]

Géologie

La plaine du Danube est l'expression morphologique d'un bassin d'effondrement complexe qui est actif depuis le Tertiaire (Néogène). Le bassin est comblé par des épaisseurs variables de sédiments. Au centre (près de Gabcíkovo) on observe plus de 5 000 m de sédiments marins et continentaux. La partie supérieure des dépôts date du Quaternaire et/ou de la fin du Néogène et c'est cette partie qui nous intéresse.

Les dépôts quaternaires sont formés par les alluvions du Danube. L'épaisseur totale des alluvions varie de près de 300 m au centre (Gabcíkovo) à près de 10 ou 15 m en bordure (Bratislava à l'ouest ou Komárno à l'est). La partie profonde du bassin s'étend de Samorín à Palkovicovo. Les alluvions sont principalement des graviers et des sables avec une moindre proportion de limons sableux (silt et argile) et de matière organique.

On observe une diminuation de la taille des grains d'ouest en est et les dépôts sont hétérogènes et discontinus (situation typique d'alluvions). On considère que la partie supérieure (5 à 10 m) des dépôts possède une plus forte proportion de limons.

Les formations sous-jacentes sont des roches compactes ou argileuses bien qu'on ait 300 m de sables néogènes sous Gabcíkovo [IGHP, HYCO, etc].

2.2.3 Mouvement des eaux souterraines

Hydrostratigraphie et propriétés hydrauliques

L'ensemble des sédiments quaternaires est considéré comme une seule unité hydrostratigraphique bien que localement des horizons moins perméables soient présents. En surface, on observe une couche discontinue de limons ou de sables fins plus au moins silteux. En profondeur, il est présumé que de tels horizons silteux lenticulaires sont dispersés au travers de la masse des dépôts alluviaux [IGHP, SKPZP]. Les formations néogènes sous-jacentes sont considérées comme un aquitard ou un aquiclude.

Jusqu'à dix types de matériaux ont été définis dans l'aire du projet [IGHP]. Par mesure de simplification, ces matériaux sont regroupés en trois classes : les limons, les sables et les graviers.

Les limons sont faits de silt avec les proportions variables d'argile (jusqu'à 25 % au maximum), de sable fin et de matière organique (1 à 5 %). Des sols tourbeux avec jusqu'à 80 % de matière organique sont aussi observés localement dans les bras morts. Les conductivités hydrauliques déterminées en laboratoire sur les limons varient de 10^{-9} m/s à 10^{-5} m/s. Les essais en place faits dans la zone des méandres démontrent des valeurs de conductivité hydraulique minimales de 3.5 x 10^{-7} à 1.2 x 10^{-6} m/s et des moyennes de 4 x 10^{-6} à 3 x 10^{-5} m/s [IGHP].

Les sables montrent des valeurs de conductivité hydraulique de l'ordre de 10^{-6} à 10^{-5} m/s. Les graviers présentent une conductivité hydraulique moyenne de 3.8 x 10^{-3} m/s [IGHP]. Il est bon de rappeler que ces graviers sont relativement uniformes et arrondis, ce qui explique leur forte conductivité.

Avec les variations d'épaisseur et de granulométrie des alluvions, la transmissivité de l'aquifère varie de deux ordres de grandeur au travers de la région de Zitny Ostrov. Près de Bratislava et à l'est de Palkovicovo, la transmissivité est de l'ordre de 10^{-2} m^2/s.

Au centre du bassin, i.e. de Hamuliakovo à l'ouest à Gabcikovo à l'est à Lehnice au nord, la transmissivité est supérieure à 1 m^2/s et atteint même localement 11 m^2/s. Entre ces deux zones, les transmissivités sont de l'ordre de 0.1 à 1.0 m^2/s [IGHP].(Voir figure 3).

Régime de la nappe

L'aquifère des alluvions quaternaires de Zitny Ostrov est rechargé en majeure partie par les eaux du Danube et en moindre partie par le surplus de précipitation des mois d'hiver. Le gros de l'écoulement dans l'aquifère se fait à partir du Danube vers les bords de la vallée et d'ouest en est (figure 4). Une moindre proportion de l'alimentation de l'aquifère provient des infiltrations à partir des pluies d'hiver.

A proximité de Bratislava, la nappe se trouve de 5 à 7 m sous la surface alors qu'elle affleure le terrain è l'est de Gabcíkovo. Les fluctuations annuelles des niveaux piézométriques sont maximales en bordure du Danube (jusqu'à 7 m) mais plus loin du Danube on observe des fluctuations généralement inférieures à 2 m. Ces fluctuations sont même inférieures à 1 m dans l'est. Les activités humaines d'exploitation de l'eau modifient localement les niveaux de la nappe de même que les canaux d'irrigation dans l'ouest et les canaux de drainage dans l'est. Les fluctuations de la nappe se transmettent d'ouest en est du bassin sur une période de 6 mois après les crues du Danube et le gradient régional est de près de 0.5 m/km. On estime que le débit moyen d'infiltration à partir du Danube est de 10 à 25 m^3/s [VUVH]. Cependant on avance des chiffres de volumes d'infiltrations moyennes de près de 40 m^3/s pour le segment du Danube allant de Bratislava à Kormarno [TBD] et les débits d'infiltration en temps de crue sont estimés à plus de 100 m^3/s.

2.2.4 Qualité de l'eau du Danube et des sédiments

Eau de surface

L'eau du Danube contient une minéralisation modérée (300 -400 mg/L) qui varie avec les débits de façon inverse. La qualité de l'eau s'améliore depuis 10 ans en raison de la construction de nombreuses stations de traitement d'eau usée et d'effluents industriels en amont. Néanmoins, l'eau de Maly Dunaj était de moins bonne qualité car elle a reçu durant de nombreuses années les rejets d'égoût de Bratislava [PDB]. La qualité de l'eau des canaux de drainage dans l'est de Zitny Ostrov est dégradée par les activités agricoles. L'eau du Danube est le reflet des activités présentes sur les terres qu'il draine. La plus grande partie du territoire drainé est occupée par des terres agricoles et des zones urbaines. La partie la plus rapprochée de son bassin compte les régions urbaines de Bratislava et de Vienne avec les zones industrielles de Linz en Autriche et du bassin de la Moravie en Tchéco-Slovaquie.

Malgré le degré d'occupation du bassin, la qualité de l'eau du Danube doit être décrite comme relativement bonne car on n'y décelle pas de contamination très sérieuse. A titre de référence, des données récentes sur la qualité de l'eau sont portées au tableau 1 qui présente les résultats des levés mensuels effectués en 1988 et 1989 à la station de Hrusov en aval de Bratislava. [SHMU, PDB].

TABLEAU 1

QUALITÉ DE L'EAU DU DANUBE À HRUSOV.

Paramètre	Données de qualité (mg/kg)			Normes d'eau potable
	Minima	Maxima	Moyennes	Norme CSN 75 7111
pH	7.99	8.52	8.16	6 à 8
T degré C				8 à 12
Alcalinité mmol/L	2.5	3.9	3.1	0.9 à 5
Bactéries coli /mL	130	800	315	0
Oxygène mg/L	7.2	12.8	9.8	
DCOmn mg/L	3.2	8.4	4.9	
Cl "	15.8	57.3	25.9	100.
SO4 "	27.6	62.3	39.1	250.
HCO3 "				
NO3 "	6.75	21.2	11.1	50.
NH4 "	.02	.84	.31	.5
PO4 "	.11	1.48	.43	
NO2 "	.05	.28	.13	.1
Ca "	51.6	126.3	68.5	»20
Mg "	12.1	38.9	21.1	125.
Substances dis.	192	356	273	1000
Solides susp.	16	92	34	
Hg mg/L	.0001	.0002	.00015	.001
Cd "	.0001	.0006	.00015	.005
Pb "	.001	.019	.0039	.05
Zn "	.020	.030	.025	5

Des études et des relevés faits sur d'autres segments du Danube (i.e. en aval en Hongrie) démontrent des qualités d'eau comparables à ce que montre le tableau 1.

Telle quelle, l'eau rencontre la plupart des normes de l'eau potable. On rapporte une amélioration graduelle de la qualité de l'eau depuis que des usines d'épuration d'eau usée sont construites en amont (Vienne, Bratislava).

Des variations saisonnières sont observées qui semblent reliées en grande partie aux changements de débit du fleuve. La qualité de l'eau est moindre en hiver à l'étiage et elle est meilleure à l'été durant la crue. [PDB, Int. Conf...Danube]

Très peu de données sont disponibles sur les contaminants organiques dans l'eau. Cependant, il est apparent que peu de contaminants organiques (hydrocarbures divers) sont présents en solution dans l'eau. Cet état de fait n'est pas surprenant car la plupart des hydrocarbures (à moins d'une surabondance due à un déversement majeur) auront tendance à être détruits rapidement dans l'eau oxygénée et/ou adsorbés sur les sédiments en suspension.

Le pH élevé de l'eau et sa dureté font aussi que la solubilité des métaux est basse et que les métaux fixés sur les particules en suspension ne sont pas facilement remobilisées.[Zekeova]

Qualité des sédiments

La qualité des sédiments a été évaluée par des prélèvements de sédiments de fond du fleuve. Aucune analyse de sédiments en suspension n'était disponible lors de l'étude. Les résultats disponibles incluent des fractions plus grossières qui tendent à diluer les contaminants adsorbés sur les particules très fines et sur la matière organique.

D'après les prélèvements d'eau faits en 1989 à la section de Hrusov, l'eau du Danube contient en moyenne 35mg/L de matière en suspension dont 11mg est fait de matière organique (i.e. c'est la perte de masse à 600 C) [PDB].

Les analyses de la fraction de moins de 1mm des sédiments prélevés entre Bratislava et Szob, entre novembre 1989 et janvier 1990, sont résumés au tableau 2 [VUVH]. On doit noter que ces analyses ne représentent qu'un indice de la qualité des sédiments car un nombre limité de prélèvements et analyses sont inclus en raison de la date récente du démarrage du programme de contrôle de qualité.

TABLEAU 2

QUALITÉ DES SÉDIMENTS DU DANUBE EN SLOVAQUIE.

Paramètre	Données de qualité, mg/kg			Critères de qualité des sédiments du MOE mg/kg			Critères de qualité des sol MENVIQ mg/kg
	Minima	Maxima	Moyennes	Sans effet	95% de survie	5% de survie	Critère "B" MENVIQ
Mercure	0.1	3.16	1.14		0.2	2.0	2.0
Cadmium	0.3	2.38	1.16		0.6	10.0	5.0
Plomb	3,2	69,9	23,5		31,0	250	200,0
Cuivre	1.4	42,9	11,1		16,0	110	100,0
Chrome	0,05	107.0	29,9		26,0	110	250,0
Nickel	3.1	30.2	15,9		16,0	75,0	100,0
Arsenic	1.6	24,0	7,4		6,0	33,0	30,0
Fer	4210	26500			20000	40000	
Manganèse	198	1671			460	1100	
Zinc	10,6	323,0	76,8		120	820	500,0
Huiles	20	4800	1188				1000,0
Benzopyrène	0,1	0,1	0,1				10,0
Fluoranthène	0,05	0,1	0,1				10,0
BPC	0,0001	0,0019	0,0005	0,01	0,07	530	1,0

La consultation de ce tableau permet de constater que la charge de métaux lourds dans les sédiments ne semble pas élevée.

Des analyses quantitatives de sédiments faites en Hongrie durant la même période démontrent des concentrations en métaux lourds comparables. Comme ces dernières analyses ont été faites sur diverses fractions granulométriques, on peut y observer de plus fortes teneurs en métaux et en huiles et graisses sur les fractions plus fines (<90um) se rapprochant de la taille des particules en suspension. [Int. Conf. Water Pol... Danube]

Pour fins de comparaison, les valeurs des critères de contamination des sédiments d'eau de surface, pour la province de l'Ontario au Canada, sont données. Ces critères ont été élaborés par le ministère de l'Environnement de l'Ontario (MOE) en vue des organismes benthiques dans les sédiments; ces critères sont provisoires (juillet, 1990). La consultation de ce tableau permet de constater que la charge de métaux lourds et les contaminants mesurés dans le sédiment sont proches des limites inférieures de ces critères. Seule la teneur de Hg approche les valeurs jugées critiques pour la faune benthique.

Les valeurs des critères de niveau B du guide d'évaluation des terrains contaminés du ministère de l'Environnement du Québec (MENVIQ) sont ainsi portées sur le même tableau. Pour information sommaire, le niveau B correspond aux teneurs de contaminants auxquelles des études plus poussées sont recommandées; ces critères ne sont cependant pas conçus pour des sédiments mais pour des sols.

2.2.5 Qualité de l'eau souterraine

La qualité de l'eau souterraine varie régionalement et localement selon plusieurs modes différents résultant des activités humaines ou des variations naturelles : agriculture, industries, agglomérations, recharge, etc.

L'activité agricole est une source majeure de contamination sur l'ensemble de Zitny Ostrov où on observe la présence de nitrates à des teneurs élevées (au delà des normes de l'eau potable) jusqu'à des profondeurs de l'ordre de 40 m. Ces nitrates proviennent d'engrais qui sont lessivés du sol et entrainés dans la nappe par les précipitations saisonières. Cette contamination est absente sous les zones non cultivées en bordure du Danube.

Certaines industries provoquent des contaminations locales de la nappe; mentionnons le complexe pétrochimique de Slovnaft où des pertes de produits ont entraîné la contamination des puits alimentant l'est de Bratislava entre 1970 et 1975. Des mesures remédiatrices sont en cours à cet endroit depuis cette date.

Les variations naturelles du sous-sol entrainent des problèmes d'exploitation à certains endroits en particulier avec les teneurs de Fe et Mn. En exemple, mentionnons le champ de captage de Cuñovo où le procédé Vyredox (marque déposée) est utilisé pour diminuer la teneur en manganèse. Il ne s'agit cependant pas là d'un cas de contamination mais plutôt d'une variation naturelle de la qualité de l'eau. Il est à noter que seulement la moitié des puits de ce champ de captage sont présentement affectés par des problèmes de manganèse [VKB].

La partie de Zitny Ostrov située à proximité de Bratislava en bordure du Maly Dunaj est affectée par l'infiltration d'eau contaminée en provenance de la rivière qui recevait les eaux usées de Bratislava de même que de la zone urbaine qui comprend de multiples sources ponctuelles. Il en résulte une augmentation marquée des teneurs totales en substances dissoutes et en chlorures et en sulfates.

Hors ces nombreuses variations locales et régionales, l'eau souterraine peut être caractérisée comme carbonatée calcique avec un taux de minéralisation moyen (300 - 400 mg/L).

Pour illustrer la qualité de l'eau souterraine de la région, les analyses pour trois sites d'observation (entre 2 et 3 niveaux pour chaque site) sont présentées au tableau 3. Voir la figure 3 pour la localisation des points de prélèvement.

TABLEAU 3

EXEMPLES DE QUALITÉ D'EAU SOUTERRAINE SOUS ZITNY OSTOV

SITE		BISKUPICE			DOBROHOST		JELKA		
NO		6015			6010		6002		
PROF. (m)		30	60	100	30	100	30	60	100
pH		7,55	7,55	7,40	7,90	7,90	7,65	7,70	7,80
STD	mg/l	582,3	547,7	492,6	350,8	348,8	645,7	627,1	478,2
O_2	mg/l	4,35	2,65	6,43	4,86	1,56	1,37	4,19	1,15
DCO	mgO2/l	0,64	0,48	0,72	1,12	0,88	1,04	0,88	0,88
Cl	mg/l	23,4	20,9	29,1	16,5	17,0	41,8	39,0	17,9
SO_4	"	87,7	77,2	97,5	31,4	33,7	132,5	121,7	68,5
HCO_3	"	305	299	238	201	195	280,7	280,7	256,3
PO_4	mgP/l	<,01	<0,01	<0,01	<0,01	<0,01	<0,04	0,02	0,03
NO_2	mg/l	,01	0,02	<0,01	0,01	0,06	0,08	0,05	0,09
NO_3	"	13,5	7,50	0,50	6,5	9,9	18,9	17,5	5,70
NH_4	"	<,05	<0,05	0,90	<0,05	<0,05	<,05	<0,05	<0,05
Na	"	6,1	5,6	8,2	9,3	9,2	15,2	14,5	9,6
K	"	3,2	3,9	4,3	2,7	2,4	3,1	3,0	1,9
Ca	"	106,6	94,6	76,2	57,7	57,7	108,2	106,6	80,2
Mg	"	23,35	26,3	29,2	14,1	14,1	29,9	28,7	20,4
Fe	"	0,13	0,18	0,23	0,18	0,17	0,03	0,08	0,19
Mn	"	0,02	0,03	0,24	0,04	0,00	0,01	0,01	0,03
As	ug/l	-	-	-	-	-	-	-	-
Cd	"	0,000	0,000	0,000	0,015	0,013	0,001	0,005	0,004
Cu	"	0,000	0,003	0,003	0,000	0,000	0,000	0,000	0,000
Cr	"	0,001	<,001	<,001	0,001	<,001	<,001	<,001	<,001
Hg	"	-	-	-	-	-	-	-	-
Ni	"	-	-	-	-	-	-	-	-
Pb	"	0,003	0,003	0,001	<,001	<,003	<,001	0,001	0,001
Zn	"	0,013	0,011	0,028	<,005	0,007	0,006	0,002	0,007

2.2.6 Exploitation de l'eau souterraine

L'exploitation de l'aquifère du Zitny Ostrov se fait présentement au rythme d'environ 7 m^3/s alors que la capacité totale de l'aquifère est estimée a environ 18 m^3/s. L'estimation de 18 m^3/s ne concerne cependant que le volume et aucune étude n'a démontré que la qualité de toute cette eau serait acceptable.

Environ la moitié du débit exploité actuellement sert à l'alimentation de Bratislava. Le reste sert à l'alimentation d'autres communautés ou à des fins industrielles ou agricoles. Les principaux centres de captage sont (pour Bratislava) : Sihot (1 m^3/s), Pecensky Les (0,4 m^3/s) (tous les deux en infiltration induite du Danube), Cuñovo ou Ostrovne Lucky (1 m^3/s), Kalinkovo (0,6 m^3/s), Samorín (0,8 m^3/s) (ces deux centres exportent de l'eau à Bratislava) et Gabcíkovo 0,8 m^3/s.

Les puits de contrôle hydraulique de la contamination à Slovnaft provoquent un cône de rabattement très important au voisinage de Bratislava.

Un nouveau centre de captage est proposé à Dobrohost en bordure du Danube où la capacité théorique est estimée à jusqu'à 10 m^3/s après le remplissage du réservoir [SKPZP,SHMU,VKB,VSTB].

2.3 Problématique

2.3.1 Effets présumés du projet sur les eaux

Effets sur le niveau de la nappe

La création de la retenue de Hrusov va résulter en la mise en place de l'équivalent d'un état de crue permanent avec une tête d'eau élevée sur un territoire de près de 50 km^2. Cet état va considérablement augmenter la recharge de l'aquifère et on prévoit qu'il en résultera un rehaussement substantiel du niveau de la nappe dans l'ouest de Zitny Ostrov.

En aval de la retenue, la quasi disparition des crues dans la zone d'inondation et l'effet drainant du canal de fuite (situé sous le niveau actuel de la nappe) vont provoquer un rabattement généralisé de la surface de la nappe [VSTB].

Variations temporelles

Avec le temps, il est prévu qu'une partie du réservoir va s'envaser. L'accumulation des sédiments va provoquer une diminution de la perméabilité du fond et en conséquence une diminution de l'infiltration. Cette diminution de l'infiltration entrainera une baisse graduelle du niveau de la nappe et une diminution du débit exploitable dans la nappe [HYCO].

Qualité de l'eau du Danube

Actuellement, on prévoit que la création de la retenue de Hrusov entrainera une déterioration de la qualité de l'eau par une baisse de la teneur en oxygène à cause d'une agitation moindre.

Aucune prédiction n'a été formulée quant à l'effet de la croissance d'algues qui pourra se produire dans le réservoir suite à la mise en eau [PDB]. Il est probable que les algues se multiplieront dans les secteurs à faible courant en raison de la faible profondeur de l'eau et de la disponibilité des nutriments dans l'eau. La croissance d'algues pourra augmenter localement ou temporellement la teneur en oxygène dissouds mais la décomposition de ces algues provoquera à d'autres temps une baisse de la teneur en oxygène.

2.3.2 Impacts des effets présumés

2.3.2.1 Impacts des changements de niveaux

La plaine de débordement située entre le barrage de Dunakiliti et la restitution à Palkovicovo sera drainée et il en résultera une modification majeure de l'équilibre biologique de cette région.

Le rabattement de la nappe à l'aval du projet pourra être bénéfique pour l'agriculture dans cette région où le drainage est requis. Cependant, dans le cadre de l'aménagement de Nagymaros, des coupures étanches ont été construites tout le long du Danube et de ses affluents. Ces aménagements provoqueront le rehaussement de la nappe dans ces endroits, et pourront ainsi nuire à l'agriculture à moins de mesures correctrices.

Dans un premier temps, il est prévu que le réservoir permettra une augmentation substantielle du volume d'eau exploitable dans les alluvions de Zitny Ostrov. On prévoit même presque doubler le volume exploitable de la nappe et un projet de captage majeur est ainsi prévu à Dobrohost [VSTB, SKPZP]. Avec le temps, si aucune mesure correctrice n'est entreprise, on prévoit que le colmatage du réservoir provoquera une diminution du volume d'eau disponible dans la nappe de Zitny Ostrov.

2.3.2.2 Impacts potentiels sur la qualité de l'eau souterraine

Voies de contamination actuelles

Rappelons que l'infiltration d'eau du Danube fournit la majeure partie de l'alimentation de la nappe, mais une partie moindre de l'alimentation provient des précipitations hivernales, des infiltrations d'eau du Maly Dunaj (en aval de Bratislava) et des eaux d'irrigation dans le Zitny Ostrov.

Les analyses des eaux souterraines peu profondes (0 à 30 m de la surface de la nappe) montrent une minéralisation (SO_4, Cl, NO_3) élevée par rapport aux eaux plus profondes (tableau 3). Donc, dans le régime actuel, il est évident que deux sources principales de contamination des eaux souterraines existent; en provenance des activités humaines et industrielles au voisinage des centres urbains (Bratislava) et du lessivage du sol des engrais et pesticides sur les terres agricoles.

Des analyses de chromotographie en phase gazeuse et spectométrie de masse (GCMS) indiquent que les teneurs en composés organiques en trace (hydrocarbures chlorés, pesticides, etc.) sont sous les limites de détection. Compte tenu du peu de données disponibles, on peut émettre l'hypothèse que les processus d'adsorption et dégradation biologique ont lieu dans le sol, ce qui atténue la concentration des contaminants en solution.

La troisième voie de contamination possible est associée aux eaux d'infiltration du Danube. Cependant, tel que discuté précédemment, l'eau du Danube filtrée est de bonne qualité et c'est ce que l'on constate aux captages de Sihot et Pecensky Les.

Seuls les sédiments transportés en suspension montrent des indices de contamination en métaux lourds (As, Cd, Cr, Cu, Hg, Fe, Mn, Ni, Pb, Zn) et en hydrocarbures divers en traces. Ces sédiments représentent donc une source potentielle de contamination de la nappe.

Dans les conditions d'aération qui existent dans le fleuve, la saturation en oxygène assure que le fer et le manganèse demeurent à l'état oxydé et se trouvent sous forme de précipités en phase solide. Dans ces conditions, les autres métaux et matières organiques en traces dans le fleuve sont normalement adsorbés à la surface des sédiments fins et des colloïdes ou complexés avec la matière organique. En vue de la bonne qualité de l'eau souterraine exploitée dans l'aquifère Zitny Ostrov à proximité du Danube, il est évident que l'apport de contaminants par les infiltrations du Danube n'est pas un phénomène important dans le régime actuel.

Risques de contamination à partir du réservoir

Dans le régime actuel, la plupart des sédiments sont transportés plus en aval et s'accumulent dans la région du projet seulement pendant les périodes de crue. Dans le régime hydraulique du projet Gabcikovo-Nagymaros, il est prévu que les sédiments fins vont s'accumuler au fond du réservoir. Tel que discuté ci haut, ces sédiments portent des métaux lourds et des hydrocarbures en traces en provenance des activités industrielles et urbaines en amont . Il est prévisible qu'une augmentation du volume des sédiments organiques, due à l'augmentation de l'activité biologique, se produira également.

Une hypothèse de dégradation de la qualité de l'eau souterraine a été proposée. Cette hypothèse stipule que les eaux au fond du réservoir pourraient devenir réductrices suite à la consommation d'oxygène dissous par oxydation de la matière organique. Par la suite, on prévoit la mise en solution des métaux lourds et des contaminants organiques.

2.4 Prédiction et suivi de la nappe et mesures correctives proposées

2.4.1 Méthode de prédiction de la variation du niveau de la nappe

Dans le cadre du projet Gabcíkovo, une étude sur modèle a été faite afin de prédire les variations à long terme de la nappe. Le modèle utilisé est un modèle analogique électrique et prend comme conditions limites les niveaux des plans d'eau (Dunaj, Maly Dunaj, Váh) et un état moyen de la nappe [VSTB]. La simulation est faite pour un régime permanent de nappe en écoulement d'ouest en est. L'objectif du modèle est d'évaluer l'effet du changement de niveau à la mise en service et à long terme. Certaines limites sont reconnues à la simulation car les variations des surfaces d'infiltration en crue ne sont pas reproduites par le modèle et l'effet de la montée de l'eau dans les couches supérieures en crue n'est pas pris en compte [VSTB]. C'est aussi un modèle qui reproduit le régime permanent. Il ne peut donc pas prédire les variations temporelles lors de la mise en eau et du colmatage progressif du bassin Hrusov. Ce sont là des limites méthodologiques communes qui n'infirment pas la qualité du modèle. VSTB propose de reprendre une partie des simulations sur modèle mathématique afin d'étudier les phénomènes transitoires.

Le coefficient d'infiltration au fond du futur bassin a été estimé à partir des observations des niveaux d'eau dans le fleuve et la nappe à diverses périodes [VUVH]. On estime ainsi que le débit d'infiltration stabilisé après la mise en eau sera d'environ 120 m^3/s pour le bassin Hrusov. Diverses hypothèses de coefficient d'infiltration sont testées pour évaluer l'effet du colmatage du fond du bassin de retenue. On prévoit que le débit d'infiltration sera réduit à moins de 15 m^3/s après 5 ans au maximum si aucune mesure corrective n'est entreprise.

On prétend que la précision de prédiction du modèle est de 0,5 m. Cette précision ou marge d'erreur est admise en raison de l'état dynamique de la nappe où les régimes des crues du Danube et des précipitations ne sont pas synchronisés [VUVH].

2.4.2 Monitoring

En vertu du règlement 169 du 21/11/1975 Vyhlaska, TBD est tenu de mettre en place, entretenir et faire le suivi d'un réseau de surveillance pour fin de sécurité des ouvrages. Ce réseau comprend un total de près de 1000 puits d'observation qui ont été mis en place pour contrôler les niveaux d'eau le long des ouvrages [TBD,HYCO]. Un nombre comparable d'ouvrages ont été mis en place du côté Hongrois [Viziterv]. Environ vingt puits d'observation ont aussi été mis en place et échantillonnés pour contrôler la qualité de l'eau souterraine [TBD]. La majorité des puits d'observation sont crépinés entre 10 et 15 m de profondeur.

Outre le réseau qui doit être observé par TBD, environ 600 points d'observations sont contrôlés par SHMU sur l'ensemble du Zitny Ostrov. Près des champs de captage, on trouve un nombre limité de puits d'observation à niveaux multiples atteignant 150m de profondeur [TBD]. Les relevés de ce réseau sont faits par des organismes tel IGHP et les données sont centralisées à SHMU (Centrum Monitoring Prirodneho Prostredia Uzemia Prilahleho k Vodnemu Dielu na Dunaji) où un système de gestion de données informatique est en voie d'être mis sur pied [SHMU]. Dans ce réseau, on note certains puits où un suivi des niveaux est fait depuis plus de trente ans.

2.4.3 Méthode de contrôle de la nappe

Afin de contrôler le niveau de la nappe et aussi pour la sécurité des ouvrages, des contrecanaux de drainage sont prévus aux pieds des digues. Lorsque les canaux n'atteignent pas les graviers, il est prévu d'ajouter des puits de décharge le long des digues. Le système de drainage est conçu en vue de maintenir le niveau de la nappe à une profondeur minimale de 1,5m sous la surface du sol. Il est proposé d'utiliser l'eau captée par ces canaux pour alimenter les canaux d'irrigation ou relâcher de l'eau dans la zone des méandres abandonnés [HYCO].

En raison du colmatage éventuel prévu du fond du réservoir (temps de colmatage estimé inférieur à 5 ans), des fouilles d'infiltration sont prévues sous le réservoir. Ces fouilles seront agrandies chaque année a in de contrer leur colmatage propre et atteindront une profondeur de 15 m dans les graviers. La longueur totale prévue des fouilles est de près de 5 km et leur excavation annuelle peut être répétée durant 100 ans. La conception de ces fouilles d'infiltration repose sur les études hydrauliques faites sur modèle à Brno [VSTB, HYCO].

Dans la zone est du projet, de Palkovicovo à Zlatna, près de 700 puits de pompage sont prévus afin de contrecarrer l'effet de l'endiguement avec coupure le long du Danube [IGHP].

2.4.4 Nappe dans les méandres

Pour maintenir le niveau de la nappe sous les terres émergées entre les méandres à l'aval de Dunakiliti, il est proposé de relâcher de l'eau dans les méandres. Cette eau devra recharger la nappe par infiltration; il est cependant prévu que les lits des méandres seront colmatés après 4 ans. Après ce colmatage, il est proposé de relâcher de forts volumes d'eau afin d'inonder les terres concernées pour de courtes périodes. Ces inondations devraient permettre de recharger la nappe sous ces terres [HYCO, VSTB].

2.4.5 Essais de colmatage en chantier

Une expérience de colmatage a été élaborée par une équipe sous la direction de VSTB. Dans ce programme de terrain, une série de colonnes, de 3 m de haut et 1 m diamètre, remplies de sédiment du lit actuel du Danube, ont été érigées. Ensuite, l'eau d'un bras mort du Danube était pompée et s'infiltrait à travers la colonne pendant plusieurs semaines. La diminution graduelle du taux d'infiltration et quelques paramètres géochimiques ont été suivis. Les résultats principaux indiquent :

1. un colmatage complet après un certain temps
2. une diminution de oxygène dissouds de 7-10 à < 1 mg/l,
3. le développement de conditions réductrices

4. la conversion NO_3 à NH_4+ (NO_3- de 0.24 à 0.02 et NH_4+ de 0.32 à 0.94 mg/L)
5. destruction de bactéries (Coli/ml de 80 à 0; Psychrofilni/ml de 40 000 à 200).

Ces résultats démontrent que des conditions réductrices se développent dans les sédiments. Ces résultats montrent également que ces conditions réductrices augmentent avec la diminution du taux d'infiltration et sont apparamment plus importantes avec une colmatation complète. Il apparait donc que la mobilisation potentielle des contaminants métalliques se fait parallèlement à une baisse de perméabilité.

2.4.6 Modélisation Géochimique

Dans le contexte du projet où des inquiétudes sur la qualité de l'eau ont été formulées, un projet de gestion globale de l'aquifère de Zitny Ostrov a été préparé. Dans le cadre de ce projet, une équipe de PFUKB élabore un modèle mathématique en différences finies. L'objectif de ce modèle est de prédire la variation de la qualité de l'eau dans l'aquifère associées au projet et aux autres phénomènes agissant sur la qualité de l'eau souterraine de la région. Le modèle vise entre autres à simuler la mise en solution des contaminants en provenance du réservoir et leur transport dans la nappe de Zitny Ostrov .

Également, ce programme vise la modélisation de tous les processus géochimiques, biologiques et hydrologiques qui agissent dans la nappe. La modélisation doit se faire dans trois dimensions et en régime transitoire. Le modèle à construire doit donc prendre compte de l'écoulement souterrain sur un grand territoire, de la dispersion des espèces en solution, des réactions chimiques d'équilibre entre l'eau et les formations, des transformations biochimiques , et tous ces phénomènes doivent être simulés simultanément dans le domaine du temps.

Jusqu'à maintenant, seul le code d'écoulement du modèle a été écrit. La partie géochimique n'a pas encore été élaborée.

2.5 OPINION

2.5.1 Prédictions hydrauliques

L'étude de la variation future du niveau de la nappe comprend plusieurs aspects qui méritent chacun une discussion sommaire.

En premier lieu, la définition des paramètres hydrauliques a été effectuée à travers un série de travaux menés par divers organismes impliqués soit dans les études d'approvisionnement en eau, soit dans les études associées au projet Gabcikovo. Le genre d'essais effectués (pompages, essais de perméabilité, suivi de la piézométrie et des régimes des crues) et leur nombre de même que leur interprétation ont été faits d'une façon très acceptable selon les standards internationaux. Nous devons même signaler de nombreux cas où les hydrogéologues consultés ont fait preuve d'ingéniosité.

En second lieu, afin de définir un régime stationnaire pour une nappe continuellement en changement, une étude mathématique des variations piézométriques a été faite à VSTB. C'est là une approche originale que nous n'avons pas évaluée dans ses détails, mais qui nous apparaît fondée dans ses principes.

En troisième lieu, la simulation de la nappe a été faite sur un modèle analogique de résistances électriques à Brno . Ce genre de modèle est maintenant peu utilisé, mais avec la disponibilité des ordinateurs de l'époque (étude terminée en 1975), c'était une méthode appropriée. Dans l'approche de la modélisation, on a d'abord procédé à un calage par simulation des conditions de régime permanent (tel que défini précédemment).

Les conditions limites ont été définies en fonction des frontières hydrauliques de l'aquifère (rivières, barrières hydrauliques, etc.). Une attention particulière semble avoir été apportée à définir les conditions limites. L'étape du calage du modèle semble avoir été faite soigneusement et de façon correcte.

Pour la modélisation de prédiction, des hypothèses de coefficient d'infiltration ont été formulées de façon relativement élaborée de même que leurs variations dans le temps.

Cet aspect de la modélisation peut prêter à discussion, cependant plusieurs hypothèses ont été simulées afin de parer aux incertitudes. Une telle approche est la démarche généralement recommandée et acceptée dans les cas où des incertitudes existent. L'opinion qui se dégage est que les simulations (pour la prédiction des variations de niveau de la nappe de Zitny Ostrov) ont été faites selon des standards internationaux même si des imperfections mineures demeurent. HQI juge donc que les prévisions globales faites à partir de ces simulations sont raisonnables.

Si une étude similaire était entreprise aujourd'hui, la simulation numérique serait cependant préférée. En effet, la simulation numérique est maintenant plus facile d'utilisation et démontre une plus grande flexibilité; de plus, les hypothèses y sont généralement plus explicites.

En quatrième lieu, l'évaluation des paramètres d'infiltration pour la modélisation du bassin a été faite essentiellement par rétroanalyse d'inondations passées. Cette approche est valide, mais HQI aurait préféré voir un plus grand effort de quantification des paramètres d'infiltration potentielle par le biais d'essais sur le terrain combinés à une bonne cartographie (avec photographies aériennes) et un traitement géostatistique des données .

En cinquième lieu, depuis 1988, une nouvelle étude a été entreprise afin de trouver une solution à l'assèchement potentiel des zones des méandres abandonnés. Cette étude a compris des essais de colmatation sur place avec des colonnes mobiles. Ces essais démontrent une approche intéressante qui a du mérite. Avec ces essais, des simulations numériques ont été effectuées afin de prédire les effets locaux sur la nappe des inondations artificielles de courte durée qui sont proposées pour alimenter la nappe. L'approche de modélisation locale ainsi suivie est correcte pour l'évaluation de phénomènes locaux. Cependant, HQI ne peut pas se prononcer sur le programme utilisé dans cette modélisation.

2.5.2 Monitoring

Le programme et les moyens de suivi de la nappe proposés et mis en oeuvre peuvent être qualifiés d'impressionnants bien que quelques lacunes soient relevées. Les lacunes notées sont de trois types.

En premier lieu, le réseau piézométrique est limité en profondeur et ne comporte que peu de points sous 20 m de profondeur alors que la puissance de l'aquifère atteint 300 m par endroit.

En second lieu, le réseau et le programme de relevés avant la mise en eau du réservoir n'a pas été conçu en vue de bien documenter le régime qualitatif et piézométrique de la nappe dans le voisinage du Danube et sous le futur réservoir Hrusov. Spécifiquement, on manque de points d'observation à coté des digues du réservoir. De tels points serviraient à déceler le plus tôt possible une éventuelle contamination en provenance du fond du réservoir.

En troisième lieu, le programme de contrôle de qualité de la nappe semble moins bien élaboré que le contrôle piézométrique dont la première fonction est la sécurité des ouvrages. Les efforts de suivi semblent dispersés entre divers organismes dont la coordination n'est pas évidente.

2.5.3 Général

Une observation se dégage de l'ensemble des entrevues et des documents consultés : les techniciens et les travaux font généralement preuve d'une compétence et d'un souci du détail élevés. Cependant, on observe un manque de communication entre les divers organismes impliqués de même qu'une subdivision poussée des tâches. Un tel état, si la perception est juste, présente le risque d'une lenteur de réaction inacceptable en cas de phénomène négatif. Par exemple, les données de niveau d'eau et de qualité doivent être relevées par un organisme (IGHP) et compilées par un autre (SHMU); SHMU produit ensuite des sommaires annuels de données et ne produit d'autres rapports que sur réception d'une demande explicite d'un organisme payeur. Dans ce cas, on risque de ne constater des tendances néfastes qu'après un an au minimum.

2.5.4 Risque de contamination suite à la submersion d'hydrocarbures

Certains ont exprimé des craintes concernant la submersion de sédiments contaminés dans le futur réservoir Hrusov. Les substances craintes sont des hydrocarbures (non spécifiés) qui se seraient accumulés dans les sédiments déposés dans les bras morts lors des crues. Si de telles accumulations ont eu lieu, il parait peu probable qu'elles soit effectivement demeurées en place. En effet, les sédiments en question sont peu profonds et exposés à l'air, l'activité biologique dans ces sédiments est élevée et la température moyenne annuelle est relativement élevée; tous ces facteurs font que les processus de biodégradation sont favorisés dans cet environnement. Il en résulte que la plupart des hydrocarbures devraient être dégradés et ne pas s'accumuler. Les substances susceptibles de s'accumuler sont les métaux et leur sort n'est pas documenté en détail. Enfin, on doit se rappeler que les hydrocarbures sont relativement peu solubles dans l'eau et que les composés susceptibles de s'accumuler dans un tel environnement ont généralement une forte tendance à s'adsorber sur les fractions fines et la matière organique des sols.

2.5.5 Eléments d'évaluation des risques de contamination de la nappe

2.5.5.1 Analyse des sédiments du Danube

L'étude sur la qualité des sédiments du fleuve n'a pas défini tous les paramètres de contamination possibles dans le futur réservoir. En plus des métaux lourds, on ne trouve que trois hydrocarbures dans le programme de monitoring des sédiments. Une gamme d'analyses de composés organiques plus large est nécessaire pour mieux caractériser la fraction organique des sédiments. D'ailleurs, une étude approfondie de la qualité des sédiments en suspension dans le Danube, apparament déjà entreprise mais encore sans résultats disponibles, sera d'importance majeure.

2.5.5.2 Étude des cas similaires

D'autres études géochimiques sur la qualité des sédiments et de l'eau du Danube ont été faites dans les pays voisins. Mentionnons à titre d'exemple : "Proceedings of the International Conference on Water Pollution Control in the Basin of the River Danube", Novi Sad, Yugoslavia. Bien que certains soient conscients de ces études, il est nécessaire de les incorporer dans une étude d'impact potentiel du projet Gabcikovo-Nagymaros. Aussi, sur la rivière Vah, des barrages et des réservoirs existent qui pourraient servir d'analogies potentielles des impacts environnementaux.

Par exemple, l'aménagement de Piestany sur la rivière Vah et les eaux souterraines de Drahovce fournissent une telle analogie potentielle. A première vue, les quelques données géochimiques fournies n'y indiquent aucune contamination de la nappe.

2.5.5.3 Essais de colmatage

Les expériences de terrain sont la meilleure façon de simuler les processus géochimiques qui se produiront au fond du réservoir. Les résultats de la première série d'expériences de colmatage indiquent clairement la formation de conditions réductrices dans l'eau d'infiltration. Malheureusement, l'effet sur la solubilité des métaux lourds n'a pas été examiné. Une étude plus complète devrait aussi inclure des analyses de matière dissoute inorganique et organique afin de prédire la mobilité des contaminants et leur transport vers la nappe.

Cependant, les résultats suggèrent que ces conditions réductrices augmentent avec la diminution de perméabilité. Cet effet tend à diminuer le transport de contaminants vers la nappe.

2.5.5.4 Processus géochimiques

Afin de pouvoir apprécier de façon qualitative les risques de contamination de la nappe à partir des sédiments du Danube, il importe de décrire brièvement les processus géochimiques susceptibles d'agir dans le fond du futur réservoir.

Métaux lourds

Une hypothèse de contamination par mobilisation des métaux lourds a été décrite précédemment. Afin d'évaluer cette hypothèse, examinons les processus géochimiques. Le tableau 2 montre des teneurs en Fe et Mn assez élevées (fer de 4210 à 26500 mg/kg; manganèse de 198 à 1671) dans les sédiments. Avec les conditions géochimiques actuelles dans le Danube (O_2 dissous proche de la saturation), tout le fer et le manganèse se trouvent à l'état oxydé (Fe(III) et Mn(IV)), et précipité en phase solide (oxyhydroxide) insoluble. Cependant, ces éléments se transforment en état réduit dans les conditions de redox avancées (Eh– -50 mV).

Dans les eaux de surface, le plomb est en état Pb(II). Il est peu soluble à cause de sa capacité d'adsorption aux surfaces solides (matière organique, colloïdes, argiles, oxyhydroxides). Dans les conditions réductrices, Pb reste normalement en état oxydé et s'adsorbe facilement aux complexes organiques, argiles et colloïdes. Le chrome (Cr(VI) et l'arsenic (As(V) peuvent se réduire dans les conditions réductrices. As(III) est plus mobile, mais il forme facilement des complexes organiques. Cr(III) est moins mobile que Cr(VI) à cause de la basse solubilité de ses hydroxydes. Les autres métaux lourds sont moins sensibles aux conditions redox et demeurent près des limites de détection dans l'eau en étant fixés par :

i. la solubilité des phases hydroxy-carbonates
ii. complexes métal-organiques
iii. adsorption aux solides (organiques, argiles et colloides, oxyhydroxydes de fer et de manganèse) qui portent généralement une charge négative à la surface.

D'ailleurs, plusieurs cations, dont le Zn, Co, Cd, et Pb, se trouvent souvent co-précipités en oxyhydroxyde de fer et de manganèse. Les caractéristiques géochimiques des contaminants organiques varient beaucoup, mais généralement leurs teneurs en phase aqueuse sont atténuées par adsorption aux particules d'argile, limon et matière organique solide.

Dans la colonne de sédiments au fond du réservoir, l'approvisionnement d'oxygène est limité, ce qui entraine une série de processus géochimiques :

i. l'oxygène dissous est consommé par l'oxydation des matières organiques (produites dans le réservoir ou transportées par le fleuve)
ii. l'oxydation de matière organique continue en utilisant NO_3 puis SO_4
iii. les conditions redox deviennent réductrices
iv. conversion de Fe3+ à Fe2+ et Mn4+ à Mn2+ (états solubles et mobiles).

Les autres métaux ne sont pas si sensibles aux changements redox.

La mobilisation des métaux lourds, à la fin, est liée avec la capacité d'adsorption et de complexation dans les sédiments (incluant la matière organique non-oxydée, les argiles et les colloïdes).

Afin de prédire la solubilité des contaminants dans ces conditions réductrices, il faut examiner la capacité d'adsorption des sédiments à la lumière des expériences en chantier. D'ailleurs, selon cette hypothèse, le taux de sédimentation de matière fine dans le réservoir doit être assez important pour soutenir ces processus géochimiques.

Contaminants organiques (hydrocarbures)

Les caractéristiques géochimiques des hydrocarbures varient beaucoup, mais généralement leurs teneurs en phase aqueuse sont atténuées par adsorption à la phase solide de la matière organique. Leur état chimique et leur mobilité ne sont pas affectés par les processus de redox. Les solubilités des contaminants organiques sont fonction de :

a. la teneur dans la phase solide (sédiment)
b. le coefficient de distribution octanol-eau (K_{o-w}) (rapport de solubilité en octanol et en eau)
c. le pourcentage de matière organique solide totale dans le sédiment
d. la porosité du sédiment

Un calcul avec ces paramètres pour un hydrocarbure donné peut indiquer sa teneur en phase aqueuse. A titre d'exemple:

Benzopyrène :

Teneur dans le sédiment (sec) = 0.1 mg/kg (tableau 2)
= 0.2 mg/l sédiment saturé
Coefficient de distribution, K_{o-w} = $10^{6.02}$ (litérature)
Pourcentage de matière organique totale ~ 35% pour le sédiment et porosité ~ 30%

Donc : Teneur dans eau interstitielle (eau d'infiltration en contact avec ces sédiments) pourra être de:

~ $(0.2)/(10^{6.02})/(0.35)/(0.30)$
~ 1.8×10^{-6} mg/l
~ .0018 µg/l

ce qui est très en-dessous des limites admissibles pour l'eau potable.

2.5.6 Évaluation qualitative du risque de contamination

Dans les sections précédentes, nous avons décrit sommairement les conditions physiques de la nappe de Zitny Ostrov dans la zone du projet de même que la qualité de l'eau et les modes de contamination possibles. Nous avons aussi revu et discuté divers aspects du projet de même que les processus géochimiques susceptibles d'affecter la qualité de l'eau.

Suite à cette analyse sommaire, il nous apparait que les risques de déterioration de la qualité de l'eau sont faibles. Les principaux arguments en faveur de cette opinion sont les suivants:

- l'eau infiltrée du Danube sur de courtes distances est de bonne qualité (voir captages de Bratislava)
- la mobilisation éventuelle des métaux dans les sédiments sera contrecarrée par la baisse de perméabilité des sédiments et l'apport d'eau rapide et massif dans l'aquifère à partir des fouilles au fond du réservoir.
- aucune évidence d'hydrocarbures mobiles n'a été décellée dans la zone du réservoir
- les nappes alluviales comparables montrent peu de cas de contamination dans ces conditions.

Le seul phénomène susceptible de détériorer la qualité serait la mobilisation du fer et manganèse et cette éventualité peut n'être que lointaine en raison de l'apport rapide d'eau au fond des fouilles d'infiltration. Dans la pire des éventualités, le fer et le manganèse sont faciles à retirer de l'eau et ne posent pas de risque pour la santé.

2.5.7 Modélisation Géochimique

Une modélisation mathématique du système géochimique (à base thermodynamique) liée à l'écoulement d'eaux souterraines, comme proposé, est un programme de recherche très ambitieux. Le but d'un tel programme, au bout de plusieurs années de travail, serait le modèle lui-même plutôt que la prédiction de l'impact sur la nappe.

La consommation de matière organique dans les sédiments par les processus biologiques causera des changements au système redox. Ces changements géochimiques peuvent provoquer la mise en solutions des métaux lourds et contaminants organiques. Par contre, la matière organique, argiles et autre sédiments fins ont une grande capacité d'atténuation pour les contaminants par l'effet d'adsorption. Cet effet est différent pour chaque élément et contaminant organique. Les processus biologiques exacts sont mal connus en général, et sont différents pour chaque système géochimique organique et inorganique.

La réalisation d'un tel modèle suppose la solution de multiples équations d'équilibre et d'écoulement pour l'hydrodynamique sur un ensemble d'éléments rectangulaires aux dimensions variables simultanément à la résolution d'équations de transport et d'équilibre géochimique pour de nombreux paramètres. La réalisation mathématique d'un tel modèle sera très difficile et la simulation résultante risque d'être impossible à vérifier. La capacité de calcul requise est énorme. Enfin, les processus chimiques et biologiques impliqués ne sont pas suffisamment connus pour faire l'objet d'une description mathématique quantitative.

Pour les fins du projet, un programme limité de modélisation à deux dimensions à partir des données géochimiques des expériences de colmatation est recommandée (voir section 2.5.5.3). Une telle étude serait plus facile à monter et aiderait à l'évaluation des impacts.

Le potentiel d'atténuation dans l'aquifère lui-même n'a pas été évalué dans le cadre des études d'impact. Il existe dans les strates de l'aquifère Zitny Ostrov des couches de sable silteux et aussi des couches de tourbe. La capacité d'adsorption élevée des couches de sédiments fins sert à atténuer le mouvement des métaux lourds et contaminants organiques dans la nappe.

2.5.8 Mesures préventives

Dragage du fond du réservoir

Il est prévu d'avoir des fouilles d'infiltration dans le fond du réservoir afin de maintenir une alimentation constante de la nappe. Ces fouilles pourront servir également à réduire la contamination potentielle de la nappe. L'infiltration par cette voie peut réduire le gradient à travers la colonne de sédiments, où se développent les conditions réductrices et la mise en solution possible des contaminants.

Collecte de Pétrole

Deux stations seront construites dans le réservoir en vue d'enlever les nappes de pétrole à la surface de l'eau . Cette mesure aidera à améliorer la qualité des sédiments aux bordures et au fond du réservoir en assurant une protection en cas d'épandage accidentel.

2.6 Recommandations

Suite à l'étude sommaire de certains aspects du projet Gabcikovo-Nagymaros, HQI formule quelques recommandations pour la suite des travaux ou des études. Ces recommandations visent à améliorer les connaissances acquises ou à apporter des ajustements à certains des programmes de travaux prévus dans le cadre du projet. La mise en oeuvre des recommandations ici présentées devrait permettre de vérifier les hypothèses formulées et de sécuriser les autorités en fournissant des réponses aux inquiétudes de la population.

2.6.1. Caractérisation complète du fond du futur réservoir

Afin de mieux cerner les conditions d'infiltration dans le lit du futur bassin Hrusov, nous recommandons que des investigations supplémentaires soient entreprises. Ces investigations devraient comprendre les éléments suivants :

- cartographie des divers types de sols par sondages et photographie aérienne.
- réalisation d'une campagne d'essais de perméabilité dans diverses zones.
- intégration des données acquises par géostatistique ou une autre méthode visant à permettre une évaluation quantitative des coéfficients d'infiltration effectifs et de leurs variations.

Les investigations devront être complétées par la définition de la qualité des sols afin de vérifier la présence présumée de résidus d'hydrocarbures ou autres contaminants.

2.6.2 Réseau de monitoring

Trois types de modifications sont suggérées aux programme de monitoring. D'une part, il est proposé de modifier le réseau en lui ajoutant un nombre modeste de puits d'observation profonds pénétrant l'aquifère sur toute sa puissance ou jusqu'à une profondeur de 60 m sous les captages les plus profonds. D'autre part, il est proposé de compléter la banque de données sur l'état avant mise en eau en obtenant plus d'information sur la qualité des eaux sous le futur réservoir. Cette dernière recommandation pourra se matérialiser grace à une série de sondages où l'eau serait échantillonnée.

Troisièmement, il est suggéré d'ajouter au réseau de monitoring de qualité d'eau quelques points le long des digues, le plus près du réservoir possible. Ces points serviraient à déceler toute trace de contamination potentielle dans la nappe, avant de s'écouler vers les champs de captage ou autres ouvrages.

2.6.3 Essais de colmatages - Deuxième Phase

Nous comprennons que le Centre de Recherche Hydraulique National se chargera d'une deuxième série d'essais de colmatage au mois de mai 1991. Nous recommandons, en premier lieu, que ce programme d'essais soit devancé au mois de mars, si possible, afin d'obtenir les résultats le plus tôt possible. Dans ce nouveau programme, il est conseillé d'entreprendre une étude géochimique plus détaillée, avec les mesures suivantes :

1. pH, Eh (redox)2) sulphure (H_2S)
2. alkalinité
3. nutriments (NO_3, NO_2, NH_4, PO_5)
4. métaux lourds dissous (As, Cd, Cr, Cu, Fe, Mn, Hg, Ni, Pb, Zn)
5. ions majeurs (Na, K, Ca, Mg, Cl, SO_4, F, Br)
6. matière organique (BOD, COD)
7. hydrocarbures, contaminants organiques

Un tel profil géochimique sera d'une grande utilité pour l'évaluation de l'impact éventuel sur la nappe des sédiments qui s'accumuleront au fond du réservoir.

2.6.4 Étude des cas analogues

Des informations existent au sujet de la qualité des sédiments et l'eau du Danube et de la qualité de l'eau de la nappe en Slovaquie. Il est plus que probable que des informations similaires existent pour le Danube dans les pays voisins (e.g. Autriche) ou pour d'autres rivières (e.g. Rivière Vah). Mentionnons aussi que le Rhin et le Rhône sont des fleuves qui présentent des conditions comparables à de nombreux points de vue et qui sont bordés par des aquifères importants. Une étude de la littérature scientifique est recommandée afin de résumer et comparer ces informations afin de mieux comprendre les impacts potentiels du réservoir sur la nappe.

2.6.5 Étude de prédiction d'impact sur la qualité de la nappe

Dans le cadre de l'évaluation d'impact du projet et afin de répondre aux inquiétudes soulevées, il est proposé de faire une étude de synthèse pour évaluer l'impact probable du projet sur la qualité de l'eau souterraine.

Cette étude devra intégrer les données acquises par la caractérisation du fond du réservoir, les essais de colmatage, l'étude des analogues recommandés ci-haut. De plus, des données géochimiques et hydrodynamiques devront être acquises pour évaluer le potentiel d'atténuation de l'aquifère.

Cette étude pourra être complétée par la simulation sur modèles mathématiques de certains phénomènes. L'objectif de telles simulations sera de mieux évaluer les fourchettes de valeurs que pourraient prendre divers paramètres (cas meilleur et cas pire).

A partir des résultats d'expériences de terrain (discutés au chapitre 2.4.5), un programme de modélisation pourra être élaboré. De telles données de chantier représentent au mieux le système géochimique des sédiments et de la nappe. Des modèles de transport en deux dimensions existent et pourraient s'adapter aux configuations et paramètres de l'aquifère Zitny Ostrov. En utilisant les paramètres géochimiques fournis par les expériences de colmatage comme conditions limites du modèle, une étude de simulation en deux dimensions prédirait les scénarios d'impacts possibles et probables (cas meilleur et cas le pire). En répétant l'exercice pour plusieurs sections et en plan, on peut examiner les processus d'adsorption, advection et dispersion des contaminants potentiels dans l'aquifère Zitny Ostrov.

En parallèle, une simulation géochimique peut être faite, afin de corroborer les résultats des expériences. Par exemple, les codes mathématiques WATEQF et PHREEQUE, élaborés par les chercheurs du USGS, traitent les données géochimiques inorganiques, en calculant la solubilité des phases aqueuses et solides des métaux lourds. En particulier, les phases de carbonate, de sulphure et des hydroxides de métaux lourds sont très insolubles, et tendent à limiter les teneurs de ces métaux (e.g. Pb, Ni et Zn). Cependant, ces codes n'adressent pas les processus de complexation organique ni d'adsorption.

3.0

LA SÉCURITÉ DES INFRASTRUCTURES DE RETENUE, COTÉ TCHÉCO-SLOVAQUE

3. LA SÉCURITÉ DES INFRASTRUCTURES DE RETENUE CÔTÉ TCHÉCOSLOVAQUE

3.1. Introduction

Le projet Gabcikovo-Nagymaros vise à aménager le fleuve Danube afin d'assurer, à travers un aménagement hydraulique à but multiple, une sécurité accrue contre les crues. La lutte contre les crues a commencé dès 1740 par un endiguement partiel et progressif cherchant à assurer la protection des agglomérations. L'endiguement systématique n'a débuté que sur la période 1876 à 1899; un renforcement progressif était effectué de 1901 à 1958 par rehaussement et élargissement des digues (fig. 10). La crue de 1965, qui provoqua des dégâts considérables, nécessitait un renforcement supplémentaire qu'il fut décidé d'intégrer au projet de Gabcikovo - Nagymaros. Ce projet implique la construction des ouvrages de retenue suivants (fig.2), sur lesquels a porté la présente étude d'opinion:

- Les digues de fermeture du réservoir de Hrusov, en amont, dont le volume (et donc le tracé des ouvrages de retenue) était imposé pour assurer le fonctionnement de la centrale de Gabcikovo en énergie de pointe.

- Les digues du canal d'amenée qui assurent la dérivation des eaux vers la centrale de Gabcikovo.

- Les digues existantes avant la réalisation du projet, qui conservent toujours un rôle de protection contre les crues. Un ouvrage de régulation à Dunakiliti permettant d'évacuer les débits de crue ne pouvant être évacués par la centrale de Gabcikovo.

- Un canal de fuite et de restitution en aval de la centrale de Gabcikovo.

La protection contre les crues s'effectue non pas à travers un stockage des crues mais à travers un renforcement de l'endiguement. Les ouvrages de retenue qu'implique le projet, sont sensiblement plus importants que ceux qu'aurait nécessité un simple endiguement du lit naturel du Danube. Il y a donc lieu de s'assurer que ces ouvrages n'apportent pas de risques supplémentaires liés à leur exploitation.

Suite aux inondations de 1965, un important travail d'analyse des causes de rupture des digues était entrepris et montrait clairement que la cause était liée à des phénomènes d'érosion interne (renards) au niveau des fondations qui étaient constituées par les alluvions du Danube. Les manifestations de ces phénomènes existaient alors pratiquement tout le long des digues existantes en aval de Dunakiliti. Au droit du bassin de retenue de Hrusov, ces manifestations étaient moins abondantes bien que l'on y retrouve les mêmes alluvions; par contre, des débordements de digues y avaient déjà été observés lors de la formation de barrières de glace.

Ces alluvions comprennent, en surface, des matériaux silteux et sableux particulièrement sensibles à l'érosion interne reposant sur une puissante couche graveleuse elle-même caractérisée par une matrice sableuse potentiellement instable.

On se penchera donc plus particulièrement sur l'analyse de la sécurité des ouvrages de retenue qui sont de taille modeste et sur les dispositifs de protection prévus vis à vis de ces phénomènes. Ceci est particulièrement important pour les ouvrages du bassin de retenue Hrusov pour lequel on a adopté une solution qui accepte les écoulements souterrains afin, en particulier, de permettre une alimentation de la puissante nappe aquifère qui caractérise ces alluvions.

De plus, les matériaux sensibles (sables et silts) aux phénomènes d'érosion interne étant en général sensibles aux effets sismiques, on appréciera la prise en compte des phénomènes de liquéfaction dans la conception des ouvrages bien que le contexte de séismicité y soit de faible à modéré.

3.2. Travaux de reconnaissance

3.2.1 Contexte géologique et sismique

L'ensemble des ouvrages du projet de Gabcikovo s'étendent sur une distance d'environ 40 km suivant un axe transversal à la structure de graben qui va des massifs des Alpes de l'est et des Petites Carpates, marquant le relief de la région de Bratislava, jusqu'à la région de Komarno où le rocher remonte (fig. 5). Au fur et à mesure de l'effondrement de la structure, le remplissage sédimentaire se développait tout d'abord par les séries du néogène qui atteignent une puissance de l'ordre de 5 000 m au droit de Gabcikovo, puis par les alluvions graveleuses quaternaires qui définissent la morphologie actuelle du delta continental. Ces alluvions qui atteignent 300 m d'épaisseur au droit de Gabcikovo ont pu se développer dans la partie inférieure suivant un mode fluvio-glaciaire, puis principalement suivant un mode fluvial. Dans les zones touchant les ouvrages, ces alluvions gravelleuses sont recouvertes d'une couche de matériaux argileux, limoneux, sableux ou organiques, d'épaisseur et de nature variable. L'analyse des nombreux forages profonds ou relevés géophysiques a permis d'établir en 1967 une bonne description de la structure profonde du graben pour localiser le système de failles qui affecte les épaisseurs d'alluvions graveleuses. Ces données ont en particulier été utilisées pour la localisation de l'ouvrage de Gabcikovo. Elles montrent que ces failles peuvent jouer vraisemblablement à notre époque. Pour le moment il n'a pas été établi de relation entre ces données et celles de néotectonique.

Du point de vue sismique, les catalogues de sismicité historique établis en 1975-1978 permettent de fournir une description extrêmement détaillée de localisation des séismes et leurs effets sur la période s'étendant de l'an 1 400 à nos jours. Les données associées à la région montrent que, sur cette période d'observation, les épicentres susceptibles d'influencer le projet se situent soit dans la région des Alpes de l'Est et des Petites Carpates à proximité de Bratislava soit dans la région de Komarno, (fig.6) vraisemblablement en liaison avec les zones de remontée du socle rocheux, bien qu'il ne nous ait pas été présenté de cartographie mettant ou cherchant à mettre une relation entre la séismicité et la tectonique. Les catalogues de séisme montrent une certaine rythmicité dans l'activité, suivant des périodes de 100 à 200 ans. Des contours d'iso-intensité ne montrent pas d'amplification des signaux au droit de la structure de graben (toute épaisseur de matériaux meubles), intéressant les ouvrages. Ainsi le séisme destructeur qui a secoué la région de Komarno en 1763, bien que ressenti très loin, n'aurait fait des dommages, dont certains pouvaient être attribués à la liquéfaction des alluvions de surface, que dans la zone épicentrale où le socle se situe à faible profondeur.

Sur la base de ces données, les intensités maximales envisagées pour la conception du projet étaient de 6 M.C.S.(*) sur la zone du projet et de 7 M.C.S. en voisinage de Bratislava et Kormarno aux deux extrémités. La corrélation entre les intensités en échelle M.C.S. et les accélérations maximales utilisées en 1965 pour la conception amenait à envisager des accélérations maximales de 0,010 g pour une intensité de 6 M.C.S. et de 0,025 g pour une intensité de 7 M.C.S. Une révision de la carte de zonage des intensités maximales suivant les échelles M.S.K.(*) (qui constituent une norme européenne) préparée en 1987 par M. Broucek, pour les fins de l'établissement d'un code de la construction, indique des intensités de VI pour la zone du projet et VII pour les zones voisines de Bratislava et Komarno (fig.6). La corrélation des accélérations avec les intensités maximales, recommandées par M. Broucek, conduit à des valeurs de 0,035 g pour l'intensité VI M.S.K. et de 0,075 g pour l'intensité VII M.S.K. Ces valeurs sont sensiblement plus élevées que celles envisagées lors de la conception et sont en accord avec les valeurs utilisées ailleurs.

Note: Échelles d'intensité: M.C.S. = Mercalli-Cancanni-Sieberg
M.S.K. - Medvedev-Sponhener-Karnik

3.2.2. Reconnaissance au droit des ouvrages

Des investigations géologiques, dont deux principales campagnes en 1965 et 1975, ont été effectuées suivant un même principe au droit des digues de retenue du bassin Hrusov et du canal d'amenée, du canal de fuite de Gabcikovo et sur les digues existantes:

- reconnaissance à l'aide de puits et de tarières à main de la couche de surface recouvrant les alluvions graveleuses suivant un maillage approximatif de 100 x 50 m. Au cours de ces travaux les échantillons étaient prélevés aux fins d'essais en laboratoire : identification, granulométrie, compressibilité, résistance et perméabilité. Ces essais en laboratoire étaient complétés par des essais in situ dans les puits à l'aide d'essais de perméabilité, de déformation à la plaque, de cisaillement sur les alluvions graveleuses.

- reconnaissance à l'aide de forages de 30 m de profondeur en 1965 espacés de 500 mètres environ (en 1975 ces forages avaient entre 10 et 20 m de profondeur). Ces forages, qui ont permis un échantillonnage plus profond de la couche de surface, étaient poursuivis dans les graviers à l'abri d'un tubage de gros diamètre permettant le prélèvement en continu des échantillons remaniés (à l'aide d'un échantillonneur à soupape). Ces échantillons étaient ensuite analysés du point de vue granulométrique.

Des perméabilités étaient déterminées à partir d'essais en bout de tubage; des mesures de perméabilité plus globales étaient effectuées à partir des essais de pompage.

Cette méthodologie est bien adaptée au contexte géologique décrit plus haut et aux problèmes posés pour la conception des ouvrages. Elle comporte cependant certains inconvénients:

- les tarières à main lorsque effectuées sous la nappe peuvent fausser les résultats de la stratigraphie;

- les forages à la soupape peuvent masquer des intercalations sableuses ou limoneuses dans les horizons gravelleux;

- les données de densité pour les matériaux situés sous la nappe ne sont pas accessibles.

En ce qui concerne la reconnaissance des horizons gravelleux, la comparaison entre les données de forage et essais avec les terrains rencontrés lors de l'exécution des fouilles de l'ouvrage de Gabcikovo tend à montrer que ceci n'a eu que peu d'importance d'après (IGHP). Les essais de vitesse d'écoulement au micromoulinet de type de ceux effectués dans les forages de la centrale de Gabcikovo permettent de mieux évaluer l'importance de ces intercalations.

En ce qui concerne la détermination de la densité des matériaux en place, des essais au pénétromètre dynamique Borros ont été effectués en 1981 afin de l'évaluer d'une façon indirecte la densité des matériaux en place. Ces données ont posé des problèmes de corrélation stratigraphique avec les sondages voisins; elles n'ont donc été utilisées qu'à titre de caractérisation des terrains vis à vis des problèmes de liquéfaction. Ce problème de corrélation peut être lié soit au premier point soulevé plus haut, soit à une interprétation trop rigide des essais de pénétration en terme de stratigraphie.

Les données obtenues lors des deux premières campagnes ont été compilées sous forme de profils transversaux et longitudinaux qui mettent en évidence une assez grande variabilité des caractéristiques de la couche de surface.

Au sujet de l'analyse des phénomènes d'érosion internes, on doit noter l'étude importante effectuée par IGHP sur les phénomènes de renard se développant lors de la crue de 1965 (fig.7). Les études en laboratoire ou in situ destinées à analyser le développement de ces phénomènes suivent différentes conditions. Les résultats variables obtenus devraient toutefois permettre de bien apprécier le comportement des ouvrages lors de la mise en eau. Les essais de colmatage GEOTEST qui sont les derniers effectués en date apportent également des renseignements précieux à exploiter pour les études géotechniques.

3.3. Digue de la retenue de Hrusov

3.3.1 Conception

Les ouvrages de la retenue de Hrusov s'étendent sur 25 km en rive gauche, du km 0 au début du canal de dérivation au km 25 où les travaux de renforcement du projet de Gabcikovo s'arrêtent. L'élévation de la crête des ouvrages est définie ainsi:

- Du Km 0 au Km 18 le niveau maximum du réservoir est défini par le niveau correspondant au débit maximum d'exploitation de la centrale de Gabcikovo, car lors des crues la mise en fonctionnement de l'ouvrage de Dunakiliti y entraîne des niveaux inférieurs. L'élévation de la crête est définie pour assurer une protection suffisante vis-à-vis des vagues.

- En amont du Km 18 (qui correspond approximativement au point kilométrique 1856 du lit du Danube actuel) les digues retiennent la crue; c'est-à-dire le niveau d'eau lors des crues s'élève au-dessus du niveau de l'exploitation des réservoirs. L'élévation de la crête est définie pour assurer une revanche de 1,5 m vis-à-vis de la crue centennale, 0,50 m vis-à-vis de la crue millénale (Hydroconsult).

La conception des digues en terre au niveau de la protection contre l'érosion interne au sein des fondations suit le même principe (fig.9) qui consiste à assurer une longueur minimum d'écoulement d'environ vingt fois la charge d'eau afin de limiter les gradients dans les graviers et d'éliminer les gradients de sortie au pied de la digue qui furent la cause principale des ruptures de digue lors des crues précédentes. Ce dispositif est conséquent avec la décision de se servir du bassin de retenue comme zone de réalimentation de la nappe. Il comprend: un tapis étanche à l'amont terminé par une clef ou un écran d'étanchéité traversant les niveaux silteux et sableux de surface jusqu'au gravier, et un drain ouvert (ou contre-canal) à l'aval de 5 m de profondeur atteignant le même niveau de gravier, complété par des puits de décharge lorsque la profondeur du drain était insuffisante. Des recharges étant prévues en amont ou en aval lorsque nécessaire, les remblais ou les tapis amont ont été conçus de façon à s'adapter au niveau de sollicitation prévu et à optimiser l'utilisation des matériaux :

- du km 0 au km 5, où les charges d'eau peuvent atteindre de 8 à 10 m, le corps de digue est constitué de tout-venant graveleux étanché à l'amont par un parement bitumineux qui constitue également le tapis étanche à l'amont. Pour plus de sécurité, ce tapis est complété par un tapis en limon à l'amont sur toute l'étendue du canal. Dans les zones de terrains compressibles, une substitution partielle des terrains accompagnée d'une préconsolidation a été effectuée sous la partie amont du remblais afin de diminuer les tassements pouvant affecter le parement en béton bitumineux.

- du km 5 au km 13, où les charges hydrauliques maximales passent de 4 à 8 mètres, une coupe identique à celle du tronçon précédent était prévue et une modification a été apportée durant la construction en vue d'optimiser l'utilisation des matériaux imperméables pour rencontrer la décision d'exécuter des tranchées d'infiltration à l'intérieur de la retenue. Cette modification a consisté à mettre en place un noyau argileux incliné sur le parement amont muni de filtres en géotextile, une protection en dallots en bétons contre les vagues reposant sur un coussin de granulaire enveloppé dans des géotextiles. Le tapis étanche en amont est constitué de matériaux argileux d'une épaisseur variable modulée suivant la nature du tapis naturel constitué par les matériaux en place.

- du km 13 au km 18, où la charge hydraulique est de l'ordre de 4 mètres, les digues étaient construites suivant un principe semblable, à l'exception de la protection contre les vagues; une berme était constituée au-dessus du niveau du réservoir avec une protection en gravier.

- du km 18 au km 21, où les digues avaient été reconstruites dès 1965 pour protéger les installations industrielles (à l'aide d'une conception semblable à l'exception du filtre aval qui avait été constitué en sable), les travaux consistaient en un renforcement de la berme amont, une surélévation de la crête et le creusement de la tranchée de drainage aval.

- du km 21 au km 25, l'élévation des terrains n'a pas nécessité le creusement de la tranchée aval.

Notons que le drain aval a été protégé par un géotextile, au niveau des matériaux fins de surface, puis recouvert d'une couche de gravier. La fondation du remblai de gravier a été couverte d'une couche de limon compacté légèrement inclinée, un drain collecteur de pied était prévu pour collecter les eaux d'infiltration. Des regards situés au pied aval permettent de suivre les écoulements et de mesurer les débits. Ce système de surveillance est complété par un imposant dispositif de piézomètres situé au niveau de la couche graveleuse de fondation suivant un espacement de 100 mètres au pied aval et complété tous les 500 metres par l'instrumentation de profils transversaux. Ces piézomètres sont de gros diamètres et permettent l'installation de dispositif de mesure automatique de niveau d'eau, des prélèvements d'échantillons, des mesures de vitesse d'écoulement. Les drains aval permettent la mesure des débits et l'observation de la nature des eaux d'infiltration. Des seuils variables permettent de contrôler les niveaux dans les contre-canaux avec un espacement d'environ 3 km; ils pourraient en général permettre de réduire les charges d'eau citées plus haut, de deux mêtres, en laissant remonter le niveau d'eau dans les drains.

En rive droite, les ouvrages construits pour le projet s'étendent du km 0 à la frontière hongroise (au km 13); ils sont de conception semblable à celle de la rive gauche, à l'exception de la protection de pentes du drain aval a été constituée exclusivement en gravier mais avec une plus grande épaisseur. Notons qu'en amont, près de Petrzalka, des écrans en paroi moulée ont été utilisés en raison de la proximité du substratum étanche et de l'espace disponible qui était insuffisant pour le creusement du contre-canal.

La conception de ces ouvrages a été optimisée à partir des calculs de déformation et de stabilité classique pour vérifier les coefficients de sécurité normalement prévus pour ce type d'ouvrage. Une attention particulière a été apportée pour simuler les conditions d'écoulement suivant différentes combinaisons de perméabilité et d'épaisseur pour une série de matériaux imperméables, suivis de sable limoneux, puis de graviers très perméables recouvrant une couche profonde de graviers moins perméables munis de coefficient d'anisotropie moyen. Les simulations ont cherché à vérifier si les gradients locaux étaient dans des limites admissibles. Les calculs ont pris en compte les valeurs mesurées en forage et celles provenant de relevés plus globaux d'écoulement, ce qui a conduit à des valeurs de perméabilité légèrement plus faibles que les valeurs les plus fortes mesurées par forages. Ces résultats ont été confrontés avec l'expérience acquise dans les niveaux graveleux, en particulier lors de la crue de 1965. Cette crue a été extrêmement bien documentée en ce qui concerne la fréquence des phénomènes de renard en fonction de la distance du pied de la digue alors que des charges de l'ordre de 2 mètres pouvaient être appliquées (fig.7). Les variations toujours possibles de conditions géologiques justifiaient l'important système d'auscultation prévu dans la conception, qui sera en mesure de noter les anomalies de comportement. Lorsque le concept de tranchées d'infiltration, situé à l'intérieur du réservoir, a été développé, des distances minimum de 200 à 500 mètres ont été respectées vis-à-vis de l'extrémité amont du tapis.

De plus, en 1982, des vérifications de stabilité des digues sous la sollicitation de secousses sismiques ont été effectuées au niveau de la liquéfaction possible des sables silteux. Ces calculs ont été basés sur des densités relatives estimées à partir des essais de pénétrations dynamiques suivant plusieurs méthodes, dont la méthode simplifiée de Seed et Idriss qui est la méthode généralement utilisée en Amérique du Nord pour ce type de problème. À partir de ces calculs, l'accélération maximale susceptible de provoquer ce type de phénomènes était évaluée. Cette valeur lorsque comparée aux accélérations envisagées alors, à partir des intensités M.S.C. (même en les majorant d'une unité) montrait que ces phénomènes n'étaient pas à craindre, comme l'indiquaient les données historiques. Les dernières valeurs d'accélération envisagées à partir des intensités M.K.S. montrent que l'on ne disposerait pas du degré de sécurité envisagé comme indiqué plus haut. Notons qu'en raison de certains doutes lors de l'interprétation des essais de pénétration dynamique des valeurs pessimistes de densité ont été envisagées.

3.3.2 Construction

Les travaux de construction ont été menés à partir de plans adaptés à la conception envisagée, en particulier pour la construction du tapis, conçu pour s'adapter à des conditions de terrain assez variables. Un profil longitudinal était établi à partir des résultats des campagnes de reconnaissance. Des profils transversaux étaient établis tous les 50 mètres affichant les données de sondage obtenues lors des reconnaissances ainsi que les épaisseurs de tapis variables et tout traitement particulier des fondations. Ces plans étaient accompagnés de spécifications techniques qui faisaient appel aux normes standard existantes ou définissant de façon plus précise les travaux spéciaux lorsque requis. Les critères de fuseaux granulométriques et les paramètres de compactage y étaient spécifiés.

Le contrôle des travaux était effectué de façon permanente par un représentant du concepteur. Lorsque des modifications aux travaux se présentaient, elles étaient soumises au concepteur pour approbation. Le contrôle de la qualité était effectué par le laboratoire de l'entrepreneur pour les essais de routine. De plus, un laboratoire du ministère de la Construction effectuait le contrôle des essais de l'entrepreneur et les essais spéciaux prescrits par le maître-d'oeuvre. Ces essais étaient consignés dans des rapports établis suivant des fréquences plus élevées, présentant les données sous forme de statistiques. Lors de la remise des lots de travaux, leur approbation était soumise à l'approbation de ce même laboratoire.

L'exécution des tranchées aval et de la clef amont faisait l'objet d'une inspection. Il n'est cependant pas clair si cela a permis un relevé précis des conditions de stratigraphie rencontrées. Pour le contrôle du compactage, la définition des spécifications était précisée en fonction de la nature des matériaux. Dans le cas du tout venant gravelleux, ce dernier a fait l'objet de planches d'essais préalables.
En plus des repères de nivellement placés régulièrement en crête, des relevés de tassement systématiques ont été effectués dans les zones de remblais les plus élevées entre les km 0 et 5 à partir de cellules de tassement hydrauliques qui étaient doublées en trois points de la fondation. Bien que ces données n'aient pas été contrôlées par d'autres types de relevés comme des plaques de tassement, les résultats paraissent cohérents avec la progression des remblais. Ils montrent des tassements variant entre 5 et 30 cm, qui se développaient relativement rapidement et étaient stabilisés lors de la mise en place du parement bitumineux.

3.3.3 Auscultation et inspection lors de la mise en eau et exploitation

Le consultant (Hydroconsult) est en train de finaliser le programme de suivi lors de la mise en eau et de l'exploitation pour le bureau technique (TBD) chargé d'effectuer ce suivi pour le compte du maître d'ouvrage (Podovie Dunaja).

Il est prévu,en particulier, de faire un suivi des piézomètres sur une période d'un an avant la mise en eau. Aucun rapport permettant de juger des mesures effectuées sur ces piézomètres mis en place en 1989 n'avait encore été produit. Bien qu'un système automatique de mesure de piézomètres soit prévu, il ne devrait pas être mis en place lors de la mise en eau. Il est également prévu d'entrer les données recueillies dans une base de données informatiques.

Lors des discussions il a été permis de juger que l'inspection visuelle était considérée aussi importante que les données d'auscultation.

En cas d'urgence, des stocks de gravier et des sacs de sable sont prévus pour se protéger contre des manifestations d'érosion apparaissant au pied aval des digues. En cas d'affaissement en amont, il est envisagé d'avoir recours à des matériaux de type scories.

Notons que le concepteur se fait du souci à l'effet que si les travaux retardent trop, ce retard peut entraîner des effets néfastes à la végétation sur la partie submergée.

3.4. Canal d'amenée

3.4.1 Conception

Afin d'assurer une meilleure sécurité vis-à-vis des phénomènes d'érosion interne, la conception du canal d'amenée qui doit subir des charges d'eau comprises entre 10 et 15 m, au-dessus du fond du canal, repose sur une étanchéité complète (fig. 8).

Le corps du remblai était constitué de sable et gravier étanché à l'amont par un parement de béton bitumineux et le fond du canal, quant à lui, était étanché à l'aide d'une géomembrane.

Le béton bitumineux était prévu en deux couches placées suivant des directions perpendiculaires, une première couche de béton poreux puis une deuxième couche de béton étanche. La membrane de 0,6 mm était placée sur un fond décapé puis compacté, recouvert d'une couche de limon compacté puis d'un grave ciment type roadmix et d'une couche de gravier sélectionné pour limiter les effets du courant ou des ancrages de navires. Des détails étaient prévus pour les raccordements des deux types d'étanchéité, prenant en compte la présence de la route de construction. La jonction du tapis avec la structure de la centrale inclut des détails permettant les ajustements aux tassements différentiels : joints d'étanchéité noyés dans un béton bitumineux plastique. Notons que ces types d'étanchéité avec des matériaux artificiels ont déjà été utilisés depuis plusieurs années sur d'autres ouvrages en Tchéco-Slovaquie, apparemment avec succès.

Pour éviter les tassements différentiels sous le corps du remblais il était prévu une excavation totale des terrains compressibles. Ceci entraînant des excavations sous l'eau, les matériaux de substitution gravelleux devaient être densifiés par compactage dynamique, suite à des essais comparatifs avec la vibroflottation.

Les calculs étaient effectués pour vérifier la stabilité des remblais, prenant en compte des écoulements liés à une fuite éventuelle. Les calculs de tassement effectués envisageaient les tassements sous le poids des remblais et le poids de l'eau agissant sur la membrane étanche.

Les calculs dynamiques (simulant l'effet des séismes), du même type que ceux effectués précédemment, ont montré une plus grande sécurité sous le remblai lui-même du fait de l'augmentation des contraintes effectives. De plus, des calculs de déformation ont été effectués par des méthodes de type Newmark et ont montré que même pour des séismes très élevés, les déformations étaient admissibles.

Comme pour les ouvrages de la retenue Hrusov une auscultation importante est prévue à partir de piézomètres; les fossés aval n'étant pas requis pour le drainage (l'étanchéité étant totale), ils permettent néanmoins le suivi du comportement des ouvrages. De plus, des mesures de déformation par chariot inclinométriques étaient prévues sur le parement amont; des relevés de mouvement de crêtes et du fond du canal étaient prévus par altimétrie.

3.4.2 Construction

Pour le traitement des zones compressibles, il est apparu préférable lors des travaux, de faire une excavation totale des matériaux (incluant les sables) jusqu'au gravier sous toute l'emprise de la digue. Le contrôle du compactage était effectué à l'aide du pénétromètre dynamique sur la base de critères de résistances à l'enfoncement, définis par corrélation avec les densités en place à partir de remblais d'essai. Ces compilations prennent en compte l'effet de la nappe. Il semble que des résultats satisfaisants ont été obtenus à part quelques fines couches où avait pu se déposer quelques matériaux silteux sous l'effet de la ségrégation. Les quelques résultats qui nous ont été présentés pour des substitutions de faible épaisseur montrent qu'une résistance équivalente à celle des terrains en place était obtenue. Les mesures de tassement effectuées confirment l'efficacité du traitement: les valeurs obtenues, situées entre 2 et 5 cm, sont beaucoup plus faibles que celles obtenues sous les remblais moins élevés de la retenue Hrusov.

Pour vérifier les critères de conception, les éléments d'étanchéité étaient contrôlés suivant des méthodes adaptées (réception des matériaux par essais en laboratoire, vérification des joints in situ...etc.).

3.4.3 Suivi de comportement lors de la mise en eau et de l'exploitation

Un programme d'auscultation et d'inspection similaire à celui proposé pour le réservoir Hrusov est en cours d'élaboration.

Notons que l'aval de la centrale a également été instrumenté à l'aide de nombreux piézomètres. La centrale elle-même fondée sur les alluvions fait l'objet d'une instrumentation importante.

Le programme de mise en eau prévoit une mise en eau du réservoir Hrusov jusqu'à l'élévation 127 mètres, d'octobre à décembre, lors de la fermeture du Danube (qui est du ressort de la partie hongroise). Le remplissage progressif du canal est prévu de décembre à janvier jusqu'au niveau 122 mètres, puis de janvier à mars jusqu'au niveau 128 mètres. La première période doit servir à remplir le canal d'amenée à partir d'un système de pompage, une protection partielle à l'entrée permettant de vidanger le canal à tout moment. Le remplissage final de l'ensemble se fait de mars à avril avant l'arrivée des crues.

Le seuil de l'ouvrage de Dunakiliti se trouvent au niveau du lit actuel du Danube. Il est donc possible de vidanger l'ensemble à tout moment.

Si les délais avant la mise en eau sont prolongés, des problèmes pourraient surgir sous l'action des animaux et des plantes sur la membrane; aussi est il actuellement envisagé de remplir partiellement le canal afin de limiter les effets néfastes.

3.5. Canal de fuite

Le canal de fuite, qui correspond à une excavation d'une quinzaine de mètres de profondeur, sera soumis à des fluctuations rapides de niveau d'eau d'environ 5 mètres lors de l'exploitation en énergie de pointe. Les pentes de ce canal ont été dimensionnées pour tenir compte de ces phénomènes de vidange rapide. Dans la zone de marnage, ces pentes sont protégées par un filtre de type Binet (maille fine de l'ordre de 5 mm et maille grossière de quelques centimètres) recouvert de gravier. Des réseaux d'écoulement ont été établis pour tenir compte de la vidange rapide en prenant en considération l'effet du drainage du gravier sur les couches silto-sableuses de surface, ce qui constitue des hypothèses réalistes dans la mesure où ces couches ne sont pas trop épaisses.

Dans certains cas où ces couches sont plus épaisses, des instabilités locales peuvent éventuellement exister. C'est pour ces raisons que les levées de retenue ont été placées à une distance raisonnable pour limiter l'effet d'une rupture éventuelle. De plus, l'on a envisagé une mise en opération progressive afin de permettre une certaine stabilisation des pentes.

La réalisation du creusement du canal de fuite a été effectuée sans problèmes majeurs, seulement quelques ruptures locales ont nécessité des recharges en matériaux gravelleux.

3.6 Digues existantes

Suite à la crue de 1965, les digues existantes situées entre les ouvrages de Dunakiliti et le canal de fuite ont fait l'objet de renforcements: relèvement de la crête, endiguement du pied aval pour diminuer les gradients de sortie des écoulements et canaux de drainage.

La mise en exploitation du projet de Gabcikovo entraînera par rapport à l'état naturel une réduction des niveaux d'eau d'environ 1 mètre lors des crues centennales. Ceci implique une amélioration des conditions de stabilité par un facteur de 1,5 indépendemment des renforcements cités plus haut. La partie des crues exceptionnelles (du type déci-millennale) véhiculées par le lit existant du Danube impliquerait alors des conditions moins défavorables que celles connues lors de la crue de 1965. Il y aura lieu de s'assurer que les endiguements envisagés pour le relèvement des eaux lors de l'assèchement ne diminuent pas sensiblement le degré de sécurité, en particulier dans les zones protégeant les villages situés entre les levées et le canal de dérivation.

Lors des travaux d'exécution de la centrale de Gabcikovo un dispositif de drainage par puits de relâche a été installé au pied des levées voisines et a montré son efficacité à la période des crues.

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3.7 Opinion

La revue des infrastructures de retenue présentée plus haut, permet de constater qu'à l'état actuel le projet de Gabcikovo offre déja une protection accrue contre les crues.En exploitation, bien que ces ouvrages aient été conçus pour la crue millénale,la revanche prévue devrait permettre, moyennant certaines vérifications ou ajustements mineurs, de se protéger des crues plus élevées de l'ordre du décimillénale en accord avec le dimensionnement des ouvrages hydrauliques.La protection contre les crues exceptionelles est ainsi en accord avec les règles généralement utilisées pour des évacuateurs de crue. Le projet assurera donc un niveau de protection nettement amélioré vis-à-vis de la période avant 1965, niveau que l'on devra s'efforcer de conserver lors des modifications éventuelles, en particulier lors de l'aménagement de l'ancien lit du Danube envisagé dans les travaux de mitigation.

Les principes de conception des ouvrages ont pris en compte la complexité de fonctionnement du projet et les difficiles conditions de fondation des ouvrages de retenue.Leur application a nécessité une optimisation très poussée entre l'économie du projet et la sécurité des ouvrages, particulièrement en ce qui a trait à la susceptibilité à l'érosion interne des fondations alluvionnaires. Ainsi, lorsque les charges hydrauliques dépassaient des valeurs de l'ordre de 8 à 10 mètres, on a cherché à assurer une étanchéité complète du fond de la retenue. Pour des têtes d'eau inférieures, on a pris des mesures importantes pour limiter les gradients d'écoulement qui sont la cause première des phénomènes d'érosion interne. Ces mesures, appliquées suite à une analyse approfondie de ces phénomènes dans les conditions du site,sont accompagnées de/ façon cohérente d'un dispositif d'auscultation important adapté à un ouvrage de grande longueur, où il existe toujours une possibilité de rencontrer localement une conjuguaison de conditions défavorables. Les données présentées telles que décrites plus haut indiquent que les réparations éventuelles seront d'ampleur limitée et devraient avoir peu d'impact sur le projet.

Les plans et devis ,leur application et le controle de qualité correspondent en général aux standards appliqués pour ce type d'ouvrages.

Le remplissage contrôlé et la possibilité de vidange totale des ouvrages, fournissent le degré de sécurité requis, à travers les possibilités de réparations que l'on pourra toujours effectuer à temps en raison de l'auscultation prévue. Notons qu'il s'agit d'une précaution normale dans le cas de fondations difficiles en l'absence de coupure totale ou lorsque l'on a recours à des matériaux synthétiques de faible épaisseur plus vulnérables que des matériaux naturels aux défauts d'exécution ou au vieillissement.

Pour la surveillance lors de la mise en eau, les moyens nécessaires nécessaires au suivi du comportement sont prévus pour pallier aux défauts éventuels; des équipes expérimentées sont disponibles pour les mettre en oeuvre dans des conditions qui ne devraient pas poser de problèmes majeurs vu les dispositifs adoptés.

Par rapport à l'automatisation et à l'informatisation des données, rappelons qu'il est nécessaire de décider très tôt si l'on désire les utiliser pour la courte période de mise en eau prévue. Si l'on décidait d'y avoir recours, ce qui est possible, on doit se rappeler que la mise au point d'un tel système nécessite un engagement important en temps et en argent. Un tel travail ne devrait, en effet, en aucun cas dissiper les efforts nécessaires pour assurer l'inspection visuelle des ouvrages et l'analyse des données instrumentales.

3.8 Recommandations

Les commentaires présentés ci-dessous ,sur certains points, correspondent à des discussions courantes dans le cycle normal de revue de la conception avant la mise en eau des ouvrages. Cette revue est particulièrement importante pour de tels projets où il s'écoule un délai important entre les travaux de reconnaissance et la mise en eau. On présente les points sur lesquels il nous parait nécessaire de clarifier le dossier de synthèse actuellement en cours de préparation pour assurer un bon suivi des ouvrages et également pout vérifier leur sécurité .

3.8.1 Tenue des ouvrages aux séismes

Nous avons vu qu'il était nécessaire de revoir l'évaluation du potentiel de liquéfaction des terrains de fondation. Ceci devrait être fait à deux niveaux différents, soit:

- Par la mise à jour des données de séismicité ayant servi à la conception. Ceci devrait porter sur la mise à jour des catalogues de séisme voisins pour la période de 1975 à 1990,l'établissement de cartes associant épicentres et magnitude, la mise à jour des données tectoniques (incluant la néotectonique) en particulier à partir des données de télédetection (images satellites ,photo aériennes). Bien que ce type d'études soit en général effectué pour des ouvrages de type des centrales nucléaires et qu'elles n'apportent pas toujours les éclaircissements recherchés , elles nous paraissent souhaitables dans le contexte de sécurité recherché. Elles devraient permettre de compléter ce dossier avec les données du type de celles utilisées pour les analyses de liquéfaction qui font appel aux corrélations magnitudes et distances aux épicentres. On gardera toujours en tête les données d'intensité qui constituent, lorsque disponibles comme c'est le cas, les meilleurs éléments de jugement dans un contexte de faible à moyenne séismicité.

- Par la revue des évaluations des densités de matériaux susceptibles de liquéfaction (sables silteux):

A partir des données existantes, il devrait être possible de procéder à une meilleure corrélation des données de pénétration dynamique avec les données de stratigraphie obtenues lors des reconnaissances géologiques.

Ceci peut être effectué par superposition des résultats de ces essais aux profils longitudinaux ou transversaux déja établis pour le projet et devrait d'ailleurs s'inscrire dans la synthèse des données recommandée plus loin.

Si l'on ne disposait pas à l'issue de ce travail d'une confiance suffisante dans la corrélation entre la résistance et la nature des matériaux,on pourrait procéder à des reconnaissances de type "Standard Penetration Test" (qui permettent la corrélation directe des valeurs de résistance à la pénétration à l'échantillon récupéré), ou mieux, de type pénétromètre statique (qui permet une description plus fine de la stratigraphie) au voisinage de forages exécutés précédemment.

Les quelques données qui ont été présentées font présumer qu'une telle revue ne devrait pas modifier les conclusions de la conception.Advenant qu'il n'en soit pas ainsi, les conséquences en seront faibles pour le projet pour les raisons suivantes:

- Les intensités les plus fortes se situent dans la zone du canal de fuite ou bien près de Bratislava où les ouvrages sont du type des levées contre la crue. Donc les probabilités d'avoir une simultanéité de crue et de séisme exceptionnels sont pratiquement nulles.

- Les digues les plus élevées bordant le canal d'amenée sont à l'abri de tout risque du fait de la substitution des matériaux liquéfiables.

- Les parties les plus faibles des ouvrages vis-à-vis des risques de liquéfaction sont constituées par le pied aval des ouvrages et surtout par les pentes des canaux de drainage, car ils sont soumis à de faibles contraintes effectives.

  Un renforcement éventuel pourrait être défini si nécessaire sur la base de l'amplitude des tassements à envisager et d'une stabilisation des matériaux liquéfiés suivant la méthodologie présentée dans l'article de H.B. SEED intitulé "Design Problems in Soil Liquefaction" publié par l'ASCE en août 1987. Si requis, ce renforcement devrait être facilement exécuté à l'aide des matériaux gravelleux qui seront disponibles en abondance lors du draguage de la retenue.

3.8.2 Surveillance des ouvrages lors de la mise en eau

Il est important de mettre à la disposition des équipes chargées de la surveillance un document de synthèse des données géotechniques. Un tel dossier est actuellement en cours de préparation, mais il n'est jamais inutile de rappeler la nécessité d'un tel travail surtout pour un projet s'étendant sur une longue durée impliquant des équipes de surveillance différentes de celles impliquées lors de la conception ou lors de la construction.

Ce travail devrait comprendre à notre avis:

- Une analyse des photos aériennes existantes avant les travaux, si disponibles , ou à défaut, après exécution de nouveaux relevés qui seront de toutes façon utiles pour d'autres disciplines.

  Une telle photo interprétation permet souvent à travers une vision plus globale de fournir des guides intéressants pour une meilleure corrélation entre les données ponctuelles de forages.

- Une mise à jour des profils longitudinaux et transversaux établis à l'issue des reconnaissances à partir des données de construction (informations fournies par l'excavation des drains aval ou des clefs amont,disposition des ouvrages tels qu'exécutés...)et des données obtenues lors de la mise en place du réseau d'auscultation, qui pourraient, par exemple, aider à compléter les logs de perméabilité.

- Une revue synthétique des éléments de conception des digues, en s'assurant d'y intégrer les dispositifs des ouvrages de génie civil qui, en règle générale, peuvent constituer des zones de faiblesse et de plus, dans le présent cas, ont souvent été faits par d'autres organismes (de la partie hongroise du projet). Cette revue cherchera à définir des classes de surveillance propres aux différents tronçons de digue, en faisant ressortir les comportements défavorables. On ne devrait pas sous-estimer la surveillance du tapis amont des ouvrages qui dans certains cas pourra être fortement sollicité, nécessitant en cas de comportement défavorable le recours à un écran étanche de type paroi moulée.

Une telle documentation devrait viser à permettre une interprétation rapide du comportement observé lors de la mise en eau, ceci étant particulièrement important pour les digues de retenue du bassin Hrusov. Advenant un problème éventuel,il sera nécessaire d'évaluer immédiatement les solutions les mieux adaptées sous la forme la plus définitive possible et d'apprécier par voie de corrélation les zones sensibles où le même type de comportement pourra être rencontré.

En terminant rappelons que les délais encourus par le projet sont préoccupants et ne sont pas favorables du point de vue de la sécurité des ouvrages:

Le maintien prolongé hors de l'eau des parties conçues pour un fonctionnement submergé risque d'en diminuer la durée de vie et d'augmenter les risques de dégradation.Dans ce sens, une mise en eau anticipée du canal d'amenée parait une disposition à considérer fortement.

La mise en eau des ouvrages doit faire l'objet d'une concertation importante avec la partie hongroise et devrait être conduite de façon à éviter toute opération précipitée.Le délai d'un an disponible avant la mise en eau prévue au plus tôt au cours de l'hiver 1991-1992, devrait être mis à profit pour suivre le passage de la prochaine crue et préparer les dossiers, tel que recommandé plus haut.

4.0

ANALYSE DES ÉTUDES ENVIRONNEMENTALES CONCERNANT LE MILIEU NATUREL ET LE MILIEU HUMAIN

4. Analyse des études environnementales concernant le milieu naturel et le milieu humain

4.1 Introduction

4.1.1 Rappel du mandat

En ce qui concerne les études environnementales qui ont été réalisées pour le projet Gabcikovo-Nagymaros, les objectifs poursuivis visaient à porter une opinion sur la connaissance du milieu, l'identification des sources d'impacts, l'évaluation des impacts, et les mesures proposées. De plus, des recommandations devaient être émises sur les mesures à prendre pour les impacts non considérés dans les études existantes.

4.1.2 Méthode de travail

L'analyse effectuée et les opinions émises sont basées sur les méthodes d'études d'impacts pour les projets de centrales utilisées au Québec, Canada et dans la communauté internationale. Le présent rapport est le résultat de la consultation de documents synthèses et des entrevues de personnes ressources rencontrées sur place et sur la traduction de quelques textes.

Compte tenu du nombre de dossiers existants, du manque de traductions écrites françaises ou anglaises et de la difficulté, dans les délais imposés par la mission, de rencontrer plusieurs spécialistes en environnement, il s'est avéré impossible d'acquérir une connaissance détaillée des travaux déjà réalisés sur les multiples aspects des milieux humains et biophysiques. Les efforts ont donc porté sur la connaissance globale du projet et sur une vue d'ensemble du milieu environnant et de sa problématique.

4.2 Description sommaire du milieu

En sus de ce qui a été dit en détail plus haut, concernant le milieu naturel, il faut ajouter que ce milieu traversé par le Danube est mixte et para-urbain. On y pratique l'agriculture de façon intensive de même que l'exploitation forestière. La région comprise entre le Danube (Dunaj), le Petit Danube (Maly Dunaj) et le Vah se dénomme "Ile de Blé" (Zitny Ostrov) , et on considère ses sols à l'échelle nationale comme étant les plus fertiles pour des fins agricoles.

Bien que l'urbanisation ne soit extensive qu'à Bratislava, on retrouve une quinzaine de villes et villages dans la portion tchécoslovaque des rives du Danube, pour une population de plus d'un demi-million d'habitants, en incluant la ville de Bratislava.

Le fleuve Danube et ses rives, majoritairement colonisées par la forêt alluviale, sont également utilisés pour la pêche et la chasse. La zone des méandres est particulièrement reconnue pour sa richesse et sa diversité en termes végétal et faunique; cette zone revêt de plus un caractère d'unicité et de rareté au plan biologique, non seulement en Tchéco-Slovaquie, mais dans toute l'Europe.

Pour fins de navigation internationale, un chenal dragué a été aménagé sur le Danube dans la région du projet. Les trains de péniches y transportent des volumes importants de cargo annuellement.

4.3 Études existantes

4.3.1 Historique des études

En 1975, le groupe URBION (Institut d'urbanisme et d'aménagement du territoire de Bratislava) et l'Académie Slovaque des Sciences se voyaient confier le mandat d'analyser le projet Gabcikovo-Nagymaros du point de vue environnemental.

A cette époque, la conception technique était déjà finalisée. Les travaux de déboisement commencèrent en 1976, alors que l'étude d'environnement visait la description et l'analyse de la situation, de même que l'élaboration de propositions visant à éliminer les impacts.

Il y a donc eu essentiellement deux études consécutives dénommées "Bioprojet". En 1975, on a réalisé la définition d'un territoire d'influence du projet (zone d'étude), de même que les inventaires du milieu biophysique. On y trouve également une analyse de l'exploitation des ressources au plan économique. En 1976, une brève analyse des impacts ainsi que des propositions ont été fournies.

Le début de la construction de l'ouvrage remonte à 1978, suite au déboisement du réservoir.

Entre 1976 et 1986, Hydroconsult était mandaté pour intégrer les propositions fournies par URBION et l'Académie des Sciences. Plus d'une trentaine d'organismes ont aussi collaboré à des mandats sectoriels. A titre d'exemple, l'Institut de recherche sur la fertilité du sol s'occupait de l'aspect de l'exploitation agricole, incluant la problématique de drainage et d'irrigation des sols; l'Institut de recherche en foresterie étudiait la problématique d'exploitation forestière, l'optimisation de la production de bois et l'état de santé des forêts; l'Académie des sciences traitait particulièrement des aspects d'ordre biologique; l'Institut de recherche en hydraulique était chargé de caractériser l'écoulement des eaux du Danube et de ses principaux tributaires. D'autres organismes s'occupaient de monitoring, comme entre autres l'Institut d'Hydrométéorologie chargé du suivi de la qualité des eaux de surface et de la nappe phréatique, ainsi que des données climatiques.

En 1986, une autre étude a été réalisée dans le cadre du bioprojet. Cette étude portait exclusivement sur la zone de détournement du Danube, incluant le lit du fleuve ainsi que toute la zone de méandres comprise entre le fleuve et le canal. La recherche et l'optimisation des mesures d'atténuation se poursuivent encore en 1990, entre autres sur le concept de débit réservé dans la zone de détournement et des niveaux à maintenir pour assurer la pérennité du milieu biophysique et de son utilisation à des fins multiples.

Au début de 1990, une commission d'enquête, mandatée par le gouvernement et réunissant 41 experts, a fourni une série d'opinions et de recommandations sur le projet au point de vue de l'environnement (rapport de synthèse, Hydroconsult, octobre 1990, chapitre 4.3.8). Six thèmes ont été discutés, soit:

- l'agriculture;
- l'ichtyologie et la pêche;
- la forêt, la foresterie et la chasse;
- la protection de la nature et l'écologie;
- les géosystèmes, le socio-économique et le développement urbain;
- l'hydrologie, la climatologie et l'hydrotechnique.

Un groupe de l'Académie des Sciences se penche actuellement sur la zone en rive gauche du réservoir et du canal de dérivation. Leur rapport, dont les résultats n'étaient pas encore disponibles, devait être finalisé en 1990. Il s'agit d'une analyse globale de planification écologique du territoire, "Landscape Ecology Planning", appelée LANDEP.

Six groupes de travail ont été formés en 1990 par le gouvernement slovaque pour analyser sept variantes du projet. Ces variantes vont d'un extrême à l'autre, soit de la variante initiale (Gabcikovo-Nagymaros) jusqu'à la démolition complète des ouvrages réalisés. Chaque groupe s'est vu attribuer les thèmes suivants:

- lois internationales;
- écologie et productivité;
- écologie et environnement;
- gestion des eaux;
- techniques hydrauliques et énergétiques;
- économie et production.

Les résultats devraient être connus et commentés par la Commission slovaque de l'environnement à la fin de l'année 1990. Cette dernière n'intervient à date qu'en tant qu'observateur.

Finalement, Hydro-Québec International a été informée que, bien que les études de la partie slovaque aient comme limite la frontière du Danube, les Hongrois ont produit des études équivalentes pour leur territoire. Des comités et des réunions se tenaient entre les deux parties jusqu'à tout récemment.

4.3.2 Inventaires du milieu

Les informations suivantes ont été recueillies lors des entrevues avec les responsables des Bioprojets de 1975-1976 et de 1986. Un ingénieur forestier et un agronome ont été également rencontrés en ce qui concerne les aspects du projet touchant leur discipline respective.

4.3.2.1 Zone d'étude

Une étude spécifique a été effectuée dans le but de cerner l'influence du projet au plan physique. A priori, c'est l'étendue des modifications de la nappe phréatique appréhendées avec l'exploitation du projet qui a servi de base à la délimitation de la zone d'étude. Les éléments qui ont été considérés pour déterminer la configuration de la zone d'étude incluaient le climat, l'hydrologie, la géologie et la nature des sols ainsi que les limites administratives des communes et villages.

Sans être explicite, la détermination du territoire d'influence du projet impliquait une forme préliminaire d'identification des sources d'impact. Aussi la zone d'étude a-t-elle été subdivisée en cinq sous-zones associées aux caractéristiques techniques et hydrauliques du projet, soit: le réservoir Hrusov, le canal d'amenée, le canal de fuite, l'ancien lit du Danube et ses méandres, et enfin la portion à l'aval du canal de fuite.

Malgré le fait qu'il n'ait pas été possible de réviser en détail tous les éléments analysés pour cette définition de la zone d'étude, cette dernière semble appropriée, du moins en ce qui concerne l'influence physique du projet.

4.3.2.2 *Bioprojet 1975-1976*

Suite à des discussions avec l'Académie des sciences, la Faculté des sciences naturelles et différents instituts, le gouvernement slovaque décidait vers 1975 d'aller de l'avant avec le concept de dérivation du Danube et commandait les premières études environnementales.

Ces études ont été confiées conjointement à l'Académie des sciences et à l'*URBION*. Elles visaient à évaluer la solution technique retenue et à proposer des mesures pouvant éliminer les impacts sur l'environnement. Le Bioprojet 1975-1976, ainsi dénommé, incluait d'abord un volet inventaire et description du milieu et, ensuite, la détermination des solutions pour optimiser l'intégration du projet à l'environnement. Il faut rappeler ici que le concept du projet étant déjà choisi, aucune comparaison de variantes n'était requise par le gouvernement au plan environnemental .

"

- climat;
- hydrologie;
- sols;
- géologie;
- géomorphologie;
- végétation;
- zoologie;
- hydrobiologie;
- hygiène et épidémiologie;
- conditions spatiales;
- foresterie;

- agriculture;
- drainage et irrigation des terres;
- pêche sportive (pisciculture);
- chasse;
- qualité de l'eau;
- eaux usées;
- esthétique du paysage. "

(extrait de la table des matière, Bioprojet 1975-76, vol 1)

Milieu humain

A propos du milieu humain, l'exploitation des ressources naturelles (agriculture, exploitation forestière) fait l'objet de descriptions détaillées et la connaissance des données de base semble appropriée.

Les types de pratiques culturales sont connues à l'aide de cartes cadastrales régulièrement mises à jour, à l'échelle de 1: 2800, et on dispose également d'un grand nombre de données sur le potentiel des sols, la qualité des sols, le drainage et les systèmes d'irrigation. Il s'agit d'ailleurs d'une région particulièrement importante au niveau de l'agriculture connue sous le nom de " l'île de blé ". Les principales cultures sont celles du blé, de la betterave, du maïs, de la luzerne, de l'orge. On y retrouve également des cultures d'arbres fruitiers et des vignobles de façon dispersée dans le territoire.

L'exploitation forestière est également une activité économique importante dans le territoire. On trouve une industrie de fabrication de meubles à Bratislava principalement alimentée par la coupe forestière en provenance des méandres.

Les rives du Danube sont utilisées pour la pêche et la chasse. Les autres utilisations du territoire jugées marginales sont peu détaillées, surtout en ce qui a trait à la villégiature. Par ailleurs les documents de 1975-76 font peu état de la situation socio-économique et démographique de la population qui occupe la zone d'étude. De la même façon, on ne traite pas de l'aménagement du territoire, du nombre de villages, des structures administratives alors qu'une vingtaine de localités se retrouvent dans la zone d'étude.

Deux pages sont consacrées à l'analyse esthétique du paysage. Les éléments dits "positifs" ou "négatifs" de la composition du paysage ont été répertoriés et leur résultats s'expriment en superficie.

Il n'y a pas de mention dans les documents synthèses quant à la valeur patrimoniale de certaines zones ou au potentiel archéologique. Cependant Hydro-Québec International a été informée que certaines recherches archéologiques auraient été faites par un institut spécialisé.

Milieu biologique

Le milieu biologique a été étudié en rapport avec l'exploitation faunique et forestière. Bien que des données de superficies et de productivité soient disponibles dans les cinq sous-zones à l'étude, l'accent des études a été mis dans la portion de détournement du Danube, étant donné l'importance reconnue de la zone des méandres en termes de productivité faunique et forestière.

Dans la zone des méandres, la végétation est bien documentée par le biais des études pour l'exploitation forestière, surtout en termes d'association d'espèces et de capacité de production à l'hectare. L'étude de la nappe phréatique a aussi permis d'établir la profondeur préférentielle pour chaque groupement végétal.

De façon générale, la forêt alluviale se compose en majeure partie d'associations de saules et de peupliers, accompagnés ou remplacés, selon le caractère d'humidité du sol, par du frêne, de l'orme et du chêne. Le saule et surtout le peuplier constituent les essences les plus recherchées au plan de l'exploitation forestière. En effet, la croissance rapide de ces essences permet de fournir en moyenne de 15 à 30 m^3/ha annuellement. Dans la zone des méandres, on exploite la forêt à raison de 5% de sa superficie totale sur une base annuelle. On procède à des plantations de saules et de peupliers, et des essais de plantations d'autres essences sont également en cours. En effet, le dragage continu du Danube pour la navigation ayant abaissé le niveau de la nappe phréatique dans le secteur des méandres, on tente actuellement d'évaluer la croissance de d'autres espèces de milieu plus sec, tout de même intéressantes au plan économique, dans des aires déboisées et clôturées, appelées "Biocentres". Le niveau de la nappe phréatique et l'évolution de la végétation font également l'objet d'un suivi rigoureux.

Les informations sur la faune sont nombreuses. Elles proviennent des récoltes sportives compilées annuellement par diverses associations régionales de chasse et de pêche et dont les données sont centralisées au ministère des Eaux et Forêts. Un permis est nécessaire pour exploiter ces ressources dans des secteurs bien définis et les captures doivent être obligatoirement déclarées et enregistrées.

Les chasseurs recherchent particulièrement le cerf (deux espèces), le lapin, le faisan et le sanglier. Le réservoir Hrusov, avec sa végétation en régénération, ainsi que le secteur des méandres, constituent les meilleurs sites pour la pratique de cette activité, comme en font foi les nombreuses caches qui y sont érigées.

D'autre part, le Danube abrite quelque 63 espèces de poissons et les méandres constituent le site de reproduction par excellence pour les espèces de poissons d'eau chaude. La carpe et le brochet sont les espèces les plus fréquemment pêchées. La biomasse planctonique et benthique, ainsi que la biomasse piscicole récoltée étant connues, des calculs théoriques ont permis d'évaluer la biomasse totale potentielle de faune ichtyenne dans différents secteurs à l'étude. Des données sont disponibles sur la contamination de la chair des poissons, mais aucun résultat n'a été inclus dans le Bioprojet, étant donné l'impact apparemment nul du projet sur cet aspect. L'état de contamination des espèces pêchées est jugé "normal".

Outre ces données de récoltes, il n'y aurait pas eu d'inventaire faunique spécifique sur le terrain. Les espèces sujettes à l'exploitation ont néanmoins été associées à de grands ensembles d'habitats (aquatique, riverain, boisé, prairie, etc.) dont les superficies sont calculées, mais il ne semble pas y avoir de connaissances de base sur la densité ou encore l'abondance des diverses populations qui permettent de comparer certains secteurs autrement que par la pression de chasse ou de pêche. Il serait intéressant d'acquérir ce genre d'information de façon à mieux suivre l'état de santé des populations et de juger des différents facteurs limitant leur développement en termes d'évaluation des conditions du milieu et d'exploitation.

Les espèces rares ou menacées ont été identifiées et localisées. Dans la zone des méandres, mentionnons l'aigle-pêcheur et le cormoran. Selon certaines sources, cette dernière espèce serait pratiquement disparue depuis la construction du canal de dérivation.

Les insectes nuisibles pour l'homme ou vecteurs de maladie sont identifiés en rapport avec l'hygiène du milieu et ses utilisateurs. Le secteur des méandres constitue d'ailleurs, par l'abondance des eaux stagnantes des bras morts du Danube, un site de choix pour le développement des moustiques.

Tel que souligné dans la section 2.0 de ce rapport, la qualité de l'eau constitue un des éléments environnementaux les plus suivis dans le cadre de ces études, surtout en rapport avec la qualité des eaux souterraines pour l'approvisionnement en eau potable de l'industrie et de l'agriculture. Cette qualité de l'eau est également importante quant aux autres usages associés à l'eau, soit par exemple la baignade ou la vie aquatique.

Il faut enfin souligner que l'aspect de conservation de la nature n'est considéré qu'en rapport avec la pérennité de l'exploitation économique des ressources végétales et fauniques. Certains groupes, souhaiteraient que la zone de méandres reçoive un statut de parc national, où la conservation des écosystèmes serait intégrale, et la pêche, la chasse et l'exploitation forestière interdites. D'autre part, plusieurs secteurs le long du Danube ont été proposés comme réserve faunique par les auteurs du Bioprojet. Il serait en effet souhaitable, étant donné le caractère d'unicité et de rareté de la zone des méandres, d'harmoniser la conservation avec l'exploitation de la nature. Des recherches et des propositions devraient être effectuées en ce sens.

4.3.2.3. Bioprojet 1986

Le Bioprojet de 1986 a mis l'emphase exclusivement sur la zone de détournement du Danube, incluant l'ancien lit du fleuve et ses méandres. Cet approfondissement des études faisait suite aux recommandations datant de 1976, suite à la réalisation de l'ouvrage de Dunakiliti. Il est à noter que la zone de méandres incluse dans cette portion du Danube est considérée comme un milieu unique dans toute la Tchéco-Slovaquie, voire même dans toute l'Europe.

Ce projet portait aussi sur la recherche de solutions à la coupure de débit, débouchant sur des recommandations spécifiques. Pour cela, il y a eu une mise à jour des données de base dans le secteur des méandres. A titre d'exemple, on trouve des données concernant l'évolution démographique, les activités économiques de même qu'une analyse sur l'exploitation des ressources pour les trois villages en rive droite du canal de dérivation. Contrairement à l'étude de 1975-76 où ces données avaient peu d'importance, on met aujourd'hui en interrelation la baisse démographique appréhendée de 35% , l'évolution de la pyramide d'âge, et les modifications économiques du secteur suite à la construction de Gabcikovo. Les inventaires du milieu naturel ont également été raffinés et plusieurs zones écologiques ont été déterminées.

4.3.2.4 Planification de l'aménagement du territoire

Une méthodologie particulière a été développée par le centre des études biologiques et écologiques de l'Académie des Sciences de la Slovaquie. Il s'agit d'une base de données et d'un système d'informations graphiques appelés la méthode LANDEP inspirée du concept de " Landscape Ecology ". Cette approche est issue de plusieurs disciplines comme la foresterie, l'aménagement faunique, et la géographie. Le concept vise essentiellement à reconnaître l'interrelation entre les activités humaines et le milieu naturel de même que les nouveaux équilibres qui s'établissent entre les deux.

L'équipe du groupe de recherche slovaque travaille sur ce projet depuis le début des années 1980 et, selon les informations obtenues, aurait influencé le contenu du Bioprojet de 1986. L'ensemble du territoire du projet cité doit être analysé par l'Académie des Sciences et une priorité a été donné à la rive gauche du réservoir Hrusov et du canal de dérivation. Les résultats devraient être connus à la fin de 1990.

Bien que cette méthode aide à planifier l'utilisation du territoire, elle ne constitue pas une méthode d'évaluation d'impact pour un projet précis.

4.3.3 Identification des sources d'impacts

L'identification des sources d'impacts est une étape particulièrement importante à l'intérieur d'une démarche propre aux évaluations environnementales de projet. Cette phase permet de déterminer toutes les activités détaillées liées à la construction, à la présence de l'ouvrage et à son exploitation susceptibles de créer des impacts, et ceci en relation avec les éléments du milieu qui peuvent être modifiés. Plusieurs méthodes peuvent être utilisées et celle préconisée par Hydro-Québec revet une forme matricielle où sont définies en abcisse tous les éléments du milieu naturel et humain susceptibles d'être touchés par le projet, et en ordonnée toutes les activités associées à la construction, la présence et l'exploitation des ouvrages.

Aucun chapitre des documents-synthèses consultés ne couvre l'identification systématique des impacts. Par contre, la définition même de la zone d'étude et son découpage en cinq sous-zones impliquaient une connaissance implicite des sources d'impacts. De la même façon, des éléments de compréhension apparaissent dans l'analyse du milieu et dans l'élaboration des mesures. Par ailleurs, lors des entrevues, les différents intervenants semblaient très conscients des impacts générés par les aménagements.

Compte tenu de l'importance de cette étape, il demeure important de dresser une liste des sources d'impacts, qui permettra de visualiser et de rendre systématique la relation de cause à effet propre à l'évaluation d'impacts.

4.3.4 Évaluation des impacts

a) Méthodologie suivie:

Les pertes de superficies (agricoles, forestières, fauniques, etc), ont été évaluées pour chaque zone du projet, en l'occurence: le réservoir Hrusov, le canal d'amenée, le canal de fuite, la zone des méandres et la portion aval du canal de fuite (voir résumé-synthèse, chapitre 4). Une évaluation sommaire coûts-bénéfices a été produite par rapport au volet exploitation des ressources. Cette estimation a été faite en couronnes et n'a pas servi à la comparaison d'alternatives. L'ensemble du projet a également été soumis à une analyse économique en raison des objectifs multiples de l'aménagement: soit la navigation, le contrôle des inondations et l'aménagement hydroélectrique.

Pour chaque élément du milieu inventorié dans les études de 1975, une analyse du milieu en relation avec le projet a été réalisée et a fait l'objet d'un tome parmi les documents produits en 1976. On parle bien d'une analyse et non pas d'une évaluation des impacts sur le milieu, ce qui est très différent au point de vue méthodologique.

D'après les documents consultés et les entrevues réalisées il n'y a pas d'estimation faite sur la durée, la portée (ponctuelle, locale, régionale), la signification (fort, moyen, faible), et l'importance de l'impact. Parallèlement, les éléments du milieu ne semble pas avoir fait l'objet d'une priorisation ou encore d'une analyse de sensibilité. Les impacts jugés de faible importance ou ceux pour lesquels aucune mesure d'atténuation ne pouvait être élaborée, n'étaient pas documentés. Une partie de l'évaluation des impacts est dispersée dans les recommandations et les mesures d'atténuation. Les aménagements proposés sont justifiés par l'impact appréhendé. Mais il n'est pas possible de dresser une liste d'impacts en relation avec leur importance relative. Toutefois, bien que non explicite, l'identification des enjeux les plus importants semble adéquate. soit le régime des eaux souterraines en rapport avec la qualité de l'eau et la productivité agricole et forestière, de même que l' importance des méandres.

La valorisation des éléments par les publics n'a pas non plus été considérée dans un exercice de pondération. Par exemple les préoccupations de certains groupes à propos de la conservation pourrait être intégrée à l'évaluation des impacts.

b) *Impacts considérés:*
Peu d'éléments ont été relevés à propos de l'évaluation des impacts sur le milieu humain, notamment en ce qui a trait aux impacts sociaux, à l'aménagement du territoire, au milieu visuel. Les impacts socio-économiques portaient exclusivement sur l'exploitation économique des ressources, la production et la productivité du milieu (agriculture, exploitation forestière).

Selon les informations obtenues, l'évaluation des impacts n'a porté que sur le projet à sa phase exploitation. Aucun impact n'a été associé au temps écoulé entre la construction du canal de dérivation et du réservoir Hrusov et la mise en eau. De façon évidente, cet élément pourrait faire l'objet d'analyse car il y a clairement des impacts perceptibles liés à cette construction d'autant plus importants que tous les aménagements et mesures n'ont pas été mis en oeuvre pour pallier aux effets négatifs.

D'autre part, si les études récentes ont mis l'accent sur la zone de méandres en raison de son importance au plan végétal et faunique, il semble que les autres zones d'étude aient été mises de côté depuis le Bioprojet de 1975-1976 quant à l'évaluation des impacts du projet. Par exemple, aucune des informations recueillies ne fait mention des impacts des variations du niveau d'eau dans le réservoir Hrusov, variations associées à l'exploitation de pointe envisagée, si ce n'est que pour la navigation. L'aspect visuel, la sécurité du public aux abords du réservoir, les populations de poissons et la contamination de leur chair ainsi que l'éventualité de prolifération d'algues et de dégagement d'odeurs dans les zones d'eau calme du réservoir ne semblent pas avoir été traités directement.

Il en est de même pour le secteur du Danube situé en aval du canal de fuite qui subira des fluctuations fréquentes du niveau d'eau. Malgré le fait que l'excavation prévue du lit du Danube abaisse le niveau et limite l'ampleur des inondations, aucun impact de la gestion de la centrale de Gabcikovo dans cette zone, entre autres sur la forêt alluviale, l'aspect visuel, la qualité de vie des résidents riverains et la pêche sportive, n'a été soulevé. Mis à part les superficies de forêt à déboiser et le calcul économique du bois à récupérer, l'importance du déboisement en tant que perte globale de forêt alluviale n'a pas été évaluée. La protection des terres contre les fortes crues, la qualité de l'approvisionnement en eau pour sa consommation et le drainage agricole constituent des éléments importants qui ont été grandement considérés dans l'analyse du projet.

De façon générale, outre les pertes économiques liées à l'occupation du territoire par le projet et les aspects de qualité des eaux souterraines, l'information fournie n'a pas permis de juger des impacts directs ou indirects associés à la gestion courante des débits et des niveaux sur les différents aspects de l'environnement.

4.4 Analyse des mesures proposées

4.4.1 Mesures initiales

Le résultat d'une évaluation d'impacts consiste habituellement en l'élaboration de mesures d'atténuation où l'effort consenti doit être équivalent en principe, à la signification ou à l'importance de l'impact.

En 1976 un volume complet de l'étude du Bioprojet a été consacré à la proposition de mesures d'atténuation. Au-delà de deux cents mesures d'atténuation ont été élaborées. Plusieurs propositions concernent l'identification d'études complémentaires pour certains domaines particuliers ou encore pour l'aménagement de zones spécifiques (aménagements récréo-touristiques).

Les différents intervenants et la revue de la littérature a permis de dégager quatre aménagements majeurs qui ont fait l'objet d'analyses complémentaires:

- l'aménagement récréo-touristique de la tête du réservoir Hrusov
- les aménagements recréo-touristiques entre les trois villages isolés en rive droite du canal d'amenée
- les aménagements en rive gauche du canal de dérivation;
- les aménagements écologiques dans la zone de méandres et dans l'ancien lit du Danube.

Les autres mesures d'atténuation sont très générales, fixent des objectifs à rencontrer et identifient les superficies concernées. Elles sont localisées selon les cinq sous-zones déjà identifiées et sont présentées selon les différentes étapes de construction: avant, pendant et après.

L'information obtenue n'a pas permis de préciser quelles mesures ont été mises en application parmi les quelques deux cents recommandations préconisées en 1976. Il serait donc approprié d'en dresser un bilan par rapport aux impacts identifiés. Compte tenu de l'état d'avancement du dossier, il serait souhaitable d'effectuer une vérification de l'application des diverses mesures proposées dans les études.

4.4.2 Aménagement récréo-touristique de la zone amont du réservoir Hrusov

Un plan d'ensemble pour un aménagement récréo-touristique a été élaboré en 1988 pour la zone en rive droite de la tête du réservoir Hrusov.

Selon les informations obtenues en entrevue, l'élaboration des propositions n'était pas basée sur les impacts du projet Gabcicovo mais plutôt sur les problèmes urbanistiques de la nouvelle extension de la ville de Bratislava, en rive droite du Danube, appelée Petrzalka. Il est cependant évident, que par la même occasion, ceci permettait de remettre en valeur des portions affectées. Ainsi ce plan de développement récréatif redonnait des espaces aux citoyens de ce secteur où des édifices en hauteur ont été construits sans prévoir de parcs à l'intérieur de la zone résidentielle. Les prévisions de fréquentation ont été établies à 15,000 personnes pour une zone urbaine de 150,000 habitants.

L'aménagement est ainsi localisé sur les rives du Danube en amont du réservoir sur un espace de dix kilomètres de longueur par 500 mètres de largeur Une portion de ce territoire est actuellement boisée et une digue contre les inondations protège la moitié de cette superficie. L'autre moitié peut donc être inondée lors des crues printanières Les constructions de bâtiments sont limitées à la partie protégée.

En zone inondable, les aménagements suivants sont prévus: des tennis, un golf, une piste cyclable pour les enfants, un bassin de navigation (aviron et canotage) et de baignade avec une aire de pique-nique, une zone de pêche avec l'aménagement de quais dans le bassin et, sur le Danube, des petites îles pour la récréation.

Dans la portion protégée, d'autres aménagements sont prévus: un centre d'équitation pour des compétitions régionales, un parc, un stade municipal pour les sports organisés, un centre de sports universitaires, un cimetière , une station d'épuration et un poste de transformation d'électricité. Des stationnements sont également prévus afin de faciliter l'accès aux diverses installations.

Après une analyse sommaire, il appert que cet aménagement soit relativement lourd pour la capacité écologique de cette zone, tout au moins dans la partie inondable. Par ailleurs, on peut également s'interroger sur les principes urbanistiques qui ont guidé un tel regroupement d'infrastructures séparées de la zone résidentielle par une route régionale. Il serait sûrement souhaitable d'élaborer une alternative qui pourrait être comparés et même soumise à la consultation publique. Des méthodes propres aux concepts de "Landscape Ecology", tel qu'utilisées par l'Académie des Sciences de la Slovaquie, ou à la matrice d'atteinte des objectifs (Hill 1968) pourraient être utilisées à titre d'aide à la prise de décision. Un des critères qui devrait être respecté est la capacité de support du milieu.

4.4.3 Aménagement récréo-touristique en rive droite du canal de dérivation (villages isolés)

La construction du canal de dérivation a provoqué l'isolement d'un large territoire d'une quinzaine de kilomètres qui constitue maintenant une île bordée au sud par le Danube et au nord par le canal. L'étude de 1986 démontrait une détérioration économique et démographique pour les trois villages isolés et la nécessité de trouver une solution à ce problème.

L'une des solutions élaborées pour créer des emplois et pour redonner à ce secteur une dynamique économique consistait en l'aménagement d'une zone touristique intensive localisée entre deux villages sur le pourtour de deux anciens bancs d'emprunts. Des complexes hôteliers sont prévus autour de ces deux bassins qui sont voués à la pratique de sports nautiques. La capacité maximale de ce complexe a été fixée à 6550 visiteurs occupants excluant le nombre de visiteurs quotidiens et le personnel requis pour l'exploitation des hôtels.

Il est également prévu de doter le village central de services autant commerciaux que sociaux. Un centre d'artisanat est prévu et des installations saisonnières sont planifiées. Ce village sera par ailleurs relié à la terre ferme par un traversier. Il est également prévu favoriser la construction de chalets et la restauration de résidences dans les trois villages.

Ce plan d'aménagement n'a pas été soumis à une évaluation environnementale pour analyser la capacité écologique du milieu de supporter un tel projet. Aucune alternative n'a été analysée. Il a été mentionné que ce projet a été soumis à la population et que ces derniers étaient surtout en accord avec les équipements de services. Cependant les groupes écologiques ont contesté l'aménagement. L'analyse des impacts sociaux semblent également avoir été négligée (changement de vocation des villages, pression du développement sur l'agriculture). Ce type d'aménagement peut également créer des pressions sur le milieu via la pêche et la chasse, l'accès au site étant facilité. Aucune mesure de contrôle additionnelle n'est prévue.

Il est possible que ce plan soit une bonne solution mais, compte tenu des lacunes analytiques dans un milieu aussi sensible du point de vue tant écologique que social, il est difficile de se prononcer. Il serait souhaitable d'élaborer des variantes et de les soumettre à comparaison. Il est possiblement encore envisageable de mettre de l'avant des solutions plus légères du point de vue de l'aménagement en ayant en tête le respect de nouvelles valeurs de conservation. Les infrastructures touristiques pourraient être un peu plus réparties dans le territoire (en rive gauche du canal, par exemple).

4.4.4 Aménagements récréo-touristiques sur la rive gauche du canal de dérivation

Des complexes récréo-touristiques sont également prévus sur la rive gauche du canal de dérivation. En effet, il est démontré qu'il y a un potentiel de développement de sources thermales qui permettrait un développement touristique important. Les objectifs qui sont fixés dans le cadre de la planification régionale de l'aménagement du territoire privilégient les villages à proximité de la digue du canal de dérivation pour atténuer les impacts dit "psychologiques" du canal. Plusieurs complexes hôteliers sont prévus.

L'exploitation de la rive gauche du canal de dérivation peut s'avérer intéressante mais il ne faudrait pas délaisser des aménagements qui visent à contrer les impacts importants au point de vue visuel reliés à la digue du canal. En ce sens, il serait souhaitable d'aménager une bande boisée de même qu'un parc linéaire le long des contre-canaux.

4.4.5 Projet d'aménagement de la zone de détournement

Suite au détournement des eaux dans le canal de Gabcikovo, l'abaissement du niveau d'eau du Danube et l'assèchement de la zone de méandres a suscité de nombreuses études pour remédier notamment aux impacts sur le drainage souterrain et maintenir la forêt alluviale pour l'exploitation forestière, la chasse et la pêche.

Selon les informations obtenues, les mesures mises de l'avant dès 1975 et particulièrement développées de 1988 à ce jour sont les suivantes:

- un débit minimum garanti de 350 m^3/s en tout temps dans l'ancien lit du Danube, déversé par l'ouvrage de Dunakiliti;

- le déversement hebdomadaire d'un débit de 1300 m^3/s par ce même ouvrage pour éliminer la sédimentation fine dans le lit du fleuve

- la construction de quatre seuils dans le lit du Danube pour le maintien du niveau du fleuve et de la nappe phréatique des méandres avoisinants;

- une passe à poissons adjacente à l'écluse de l'ouvrage de Dunakiliti; le même projet proposé pour la centrale de Gabcikovo a été abandonné du fait que les poissons pourraient emprunter l'écluse pour remonter le canal et accéder au réservoir Hrusov;

- la construction d'un ouvrage régulateur dans le canal de Gabcikovo pouvant déverser un minimum garanti en tout temps de 20 à 50 m^3/s dans la partie amont des méandres. Ce débit sera révisé selon le colmatage du sol qui sera suivi en phase exploitation du projet. Il pourrait être élevé à 140 ou à un maximum de 234 m^3/s plusieurs fois par année, durant la saison de croissance de la végétation, de façon à optimiser la production piscicole et forestière. A noter que normalement, ces méandres ne sont inondés complètement qu'environ une fois à tous les deux ans. Selon l'avis des experts consultés, cette gestion procurerait des conditions d'écoulement améliorées par rapport aux conditions actuelles, en évitant entre autres la stagnation de l'eau dans certains méandres et l'assèchement d'autres portions de ceux-ci;

- une digue surmontée d'une route d'accès le long de l'ancien lit du Danube pour contenir l'eau déversée par l'ouvrage régulateur dans les méandres, et pour limiter les inondations liées aux fortes crues. Cette digue possèderait des seuils abaissés permettant le passage des poissons du lit du Danube vers les méandres lorsque le débit évacué dans ce fleuve atteint 1300 m3/s, soit en l'occurence une fois par semaine en pratique courante;

- construction de six seuils dans les méandres pour conserver un niveau adéquat de la nappe phréatique selon les besoins. Ces seuils sont émergés avec une partie plus basse permettant le passage des poissons, et comprennent des ouvertures pour le contrôle du niveau d'eau;

Les efforts techniques consentis pour le maintien du niveau d'eau dans les bras du Danube démontrent bien l'importance reconnue du secteur des méandres. On s'interroge toutefois sur le degré d'artificialisation de ce secteur naturel une fois tous ces ouvrages érigés. Par ailleurs, bien que tous les usages liés à l'eau dans le secteur des méandres aient été identifiés et leurs exigences connues en termes de niveaux à maintenir à des périodes définies dans l'année, il n'a pas été possible de juger du mode de gestion courante qui sera appliquée précisément et concrètement à l'intérieur d'une année pour satisfaire ces besoins. Il est clair toutefois que l'exploitation forestière est nettement privilégiée, au détriment de l'aspect conservation. Aussi la regénération du peuplier est-elle souhaitée dans les méandres, et les niveaux de conception des seuils ont été choisis en ce sens.

Pour s'assurer de la mise en application de toutes ces mesures, il serait souhaitable qu' une seule équipe multidisciplinaire soit chargé d'intégrer les objectifs reliés aux multiples usages proposés du secteur de détournement pendant les diverses périodes de l'année. La gestion courante du complexe s'en trouvera facilité.

De plus, un système de suivi de la végétation et de la faune devrait immédiatement être mis en place, parallèlement à celui déjà existant pour l'évolution de la nappe phréatique. Cette surveillance permettrait d'une part de mettre à jour les connaissances sur le milieu biologique lui-même en termes de végétation, frayères, faune terrestre et avienne, de raffiner la connaissance des exigences de chaque élément, et enfin de suivre leur évolution autrement que par leur exploitation, ce qui permettrait de réagir plus rapidement dès que des modifications d'habitats sont observées. L'harmonisation et l'intégration des différents usages, tant du point de vue de l'exploitation que de la conservation des ressources biologiques, seraient également fort souhaitables.

4.5 Opinion

La conception du projet Gabcikovo-Nagymaros remonte à plus d'une vingtaine d'années. Il va de soi qu'à cette époque, l'intégration des préoccupations environnementales revêtaient moins d'importance qu'actuellement, et ce,partout dans le monde. A cet égard, des études environnementales ont été entreprises parallèlement à la construction des ouvrages du complexe, soit vers l'année 1975. La solution technique étant déjà choisie, ces études ne portaient donc pas sur une comparaison de variantes, mais bien plutôt sur l'optimisation du projet retenu. En ce sens, les études réalisées à cette époque étaient comparables à celles qui furent effectuées en Amérique du Nord, sur le territoire de la Baie James par exemple.

De façon générale, les principaux enjeux environnementaux considérés dans ces études ont trait surtout à la qualité et la propagation de la nappe d'eau souterraine liée à l'agriculture, l'exploitation forestière, l'industrie et l'approvisionnement en eau potable. Pour ces aspects, les données de base semblent nombreuses et font l'objet de plusieurs analyses. Il convient toutefois de mentionner que ces éléments ont été étudiés presqu'exclusivement en rapport avec leur exploitation économique.

Quant à l'évaluation des impacts du projet, elle ne respecte pas un cadre méthodologique précis. En effet, l'identification des sources d'impacts ainsi que les impacts eux-mêmes ne se retrouvent pas de façon systématique et explicite dans les différents rapports de synthèse consultés. Les impacts se retrouvent plutôt dans la définition de la zone d'étude et dans les mesures proposées. Ces mesures proposées relèvent plus d'un objectif de mise en valeur du milieu que de l'atténuation ou la correction des impacts appréhendés. Certaines d'entre elles visent notamment la résolution de problèmes liés à l'aménagement du territoire, alors que d'autres identifient des études complémentaires ou encore demeurent très générales.

En somme, pour l'ensemble du projet, trois thèmes principaux se dégagent: les effets sur le régime des eaux souterraines, la conservation et la mise en valeur de la zone de détournement et l'aménagement des abords du réservoir et du canal d'amenée.

La question des eaux souterraines est déjà traitée dans le chapitre 2 de ce rapport. Pour ce qui est des deux autres thèmes, il y aura lieu, pour bien répondre aux inquiétudes soulevées par rapport à l'environnement, d'effectuer une mise à jour des études existantes en mettant l'emphase sur l'analyse systématique des impacts et d'entreprendre une validation des mesures d'atténuation et de la mise en valeur proposées pour le projet. Une telle mise à jour et une telle validation doivent être entreprises immédiatement car ses résultats seraient pertinents aux discussions concernant la mise en exploitation de la centrale Gabcikovo. Cependant, il n'est pas nécessaire que toutes les études soient terminées avant une mise en exploitation car certaines décisions, concernant par exemple l'aménagement de débits résiduels dans la zone du détournement, doivent être basées sur le monitoring des conditions d'exploitation.

4.6 Recommandations

Pour bien répondre aux préoccupations concernant l'environnement pour le projet Gabcikovo, Hydro-Québec International recommande essentiellement une mise à jour des études existantes, une évaluation systématique des impacts, une validation des mesures d'atténuation et de la mise en valeur proposée pour le territoire à l'étude ainsi qu'un programme de suivi environnemental suite à la mise en service de la centrale. Plus précisément, il est recommandé de:

4.6.1 Données de base

- mettre à jour les données de base pour tous les éléments environnementaux humains et naturels, compte tenu du temps écoulé entre la réalisation des études initiales le début de la construction, et l'éventuelle mise en service des ouvrages. Cette mise à jour serait facilitée du fait que la majorité des données sont disponibles sur une base annuelle (exploitation agricole et forestière, utilisation du territoire, qualité de l'eau souterraine, etc.) et que, par conséquent, peu d'études sectorielles exhaustives seraient requises;

- effectuer un inventaire faunique pour la région du détournement permettant d'établir des connaissances de base sur la densité ou l'abondance des diverses populations et, ainsi, de suivre l'état de santé des populations et de juger des différents facteurs limitant leur développement.

4.6.2 Évaluation des impacts

- développer une approche globale et intégrée de tout le territoire touché par le projet, incluant le réservoir Hrusov, le canal d'amenée, le canal de fuite, l'ancien lit du Danube, ses méandres, la portion aval du canal de fuite, et le bief Nagymaros, de même que les grands ensembles territoriaux dont ils font partie;

- effectuer un examen environnemental comparatif, selon une méthodologie internationalement reconnue des variantes retenues suite aux recommandations des groupes de travail sur les sept scénarios d'aménagement actuellement envisagés. Avec l'ensemble des mises à jour recommandées, cette évaluation devrait pouvoir se faire assez rapidement;

- reprendre, sur la base des données récentes et de façon systématique, l'évaluation des impacts, en mettant l'accent sur la présence actuelle des équipements, leur exploitation en termes de fluctuations des débits et niveaux d'eau, l'état du milieu (par exemple, la réutilisation actuelle du réservoir Hrusov pour la chasse) et en tenant compte aussi de la sensibilité de chaque élément environnemental;

- intégrer une quantification, ou tout au moins une qualification des impacts, tant directs qu'indirects, en rapport avec leur durée, leur intensité et leur portée;

- tenir compte des valeurs sociales concernant entre autres la conservation de la nature, la récréation extensive et l'aspect visuel;

- évaluer de façon détaillée les effets de la gestion de pointe envisagée, et ce particulièrement en ce qui concerne les différents usages du réservoir Hrusov et de la portion du Danube à l'aval du canal de fuite; une comparaison d'ordre environnemental entre la gestion de pointe et au fil de l'eau serait souhaitable;

- faire de l'information publique serait souhaitable avant la mise en service des ouvrages. Certaines propositions d'aménagement pourraient même faire l'objet de consultations. Une transparence complète au niveau de la divulgation des impacts est recommandée. L'évaluation comparative des variantes, tant sur les plans technique qu'économique et environnemental pourrait être soumise lors de ces séances d'information ou de consultation.

4.6.3 Validation des mesures proposées et de la mise en valeur proposée

- réviser les mesures proposées à la lumière de l'importance des impacts identifiés et selon des valeurs sociales privilégiées;

- intégrer les préoccupations environnementales ainsi que les recommandations à toutes les étapes du projet et ce pour l'ensemble des aménagements;

- élaborer un mode de gestion précis des niveaux et des débits, dans le temps et l'espace, pour le secteur de l'ancien lit du Danube et des meandres, qui intègre les différentes utilisations de cette zone et revoir les mesures proposées de façon à harmoniser les concepts de conservation du milieu naturel et de récréation extensive;

- réviser les aménagements proposés à des fins récréo-touristiques dans le secteur des villages isolés par le canal de dérivation, et améliorer l'accessibilité à ces villages;

- revoir les propositions d'aménagement récréatif intensif à la tête du réservoir Hrusov en fonction des nouveaux critères d'aménagement, tels la récréation extensive, la conservation du milieu naturel et les nouvelles valeurs sociales;

- revoir le concept et la planification des mesures récréatives proposées pour les villages adjacents en rive gauche du canal de dérivation en ce qui concerne notamment les aménagements récréo-touristiques liés aux sources thermales;

- mettre en valeur le canal de dérivation par des aménagements paysagers, des accès aux rives du canal pour la randonnée pédestre et le cyclisme et un parc linéaire sur la digue de façon à étendre l'utilisation récréative au maximum et à limiter l'affluence à des sites restreints.

4.6.4 Suivi environnemental

- élaborer de façon précise un plan intégré de surveillance des travaux qui restent à effectuer ainsi qu'un programme de suivi environnemental en vue de valider l'évaluation des impacts et de faire les corrections qui s'imposent de façon immédiate. A ce sujet, il serait important qu'un seul organisme formé des différents spécialistes concernés dans le domaine naturel et humain soit responsable de cette étape;

- élaborer un mode de suivi environnemental supplémentaire et intégré à celui de la nappe phréatique qui tient compte des aspects phytosociologiques et fauniques de la zone de méandres, en relation avec les nouveaux concepts d'aménagement;

- effectuer un suivi rigoureux de l'utilisation du secteur des méandres par les visiteurs suite à la mise en place des aménagements récréatifs dans la zone de méandres, de façon à prendre immédiatement les mesures qui s'imposent pour la sauvegarde du milieu naturel et de sa productivité;

ANNEXE A

LISTE DES DOCUMENTS CONSULTÉS

ANNEXE A

LISTE DES DOCUMENTS CONSULTÉS

Auteurs	Titre	Date
Géologie, tectonique		
Geofyzikálny ústav Bratislava SAV	Záverecná správa Seizmicita Slovenska a jej vtah k stavbe Karpatskej oblasti I.,II. cast	11/75
IGHP Bratislava	Tektonický výskum v oblasti VD Dunaj	03/67
UAPG	Atlas of isoseismal maps	1978
Hydrogéologie		
A.A.BALKEMA Rotterdam/Brookfield	Groundwater effects in geotechnical engineering	1987
IGHP Bratislava	Vplyv hladín povrchových a podzemných vôd na vlahovú bilanciu pôdy v inundovanom území pri starom koryte - Mapovanie pokryvných vrstiev a urcenie hydropedoparametrov R 05-531-139-03.02 - záverecná správa etapy ciast.úlohy ev.c.14 (2 ks)	1988
IGHP - " -	Mapa izoliní genetických koeficientov zitného Ostrova 1 : 50 000	1975
Reconnaissance, ouvrages de retenue		
IGHP Žilina	VD GA, derivacný kanál A,B - inz. geolog. prieskum	06/65
IGHP Bratislava	VDD - Zdrz Hrusov A,B inž.geolog. prieskum	09/65
IGHP Bratislava	SVD GN, stupen Gabcikovo inž.geolog. prieskum	1975
IGHP Bratislava	SVD GN, zdrz Hrusov - Dunakiliti	11/75

IGHP Bratislava	Doplnenie udajov najnovsimi vysledkami prieskumnych prac	1965
IGHP Bratislava	Zdrz Hrusov - doplnok k rajonizácii I.etapy	11/75
IGHP Kosice	SVD GN, km 0,0 - 4,0 CS Penetraené skúsky	1981
IGHP Bratislava	SVD GN, vaňa VEGA obj.c 1-41.102 - ochrana stav. jamy proti podz. vodám II.st., stav.jama - podrobný prieskum, realizacná dokumentácia	05/85
IGHP Bratislava	SVD GN, stupeň GA, plav.komory obj.c. 1-43.102 - realizaená dokumentácia	01/86
IGHP Bratislava	SVD GN, prívodný kanál obj.c.1-36.115 a 215 - sondy pre meranie prúdenia podz.vôd - realiz.dokum.	12/89
IGHP Bratislava	SVD GN, zar.na meranie a pozor. - poz.sondy - l.e, prív.kanál, pravá strana, obj.c.1-36.204 -real.dokum.	12/89
IGHP Bratislava	SVD GN, prív.kanál, pozorovacie sondy,II.e., obj.e. 1-36.118 a 218 - real.dokum.	12/89
IGHP Bratislava	Vplyv výskytu raselino-ílovitého súvrstvia na zakladanie st.GA - geolog.pr. SZP	1983
VVB + OVIBER	SVD GN 0-7-3 Podklady stúdie 0.7.1.1 Podklady,inz-geolog. prieskum, súhrnná správa	1978

Etudes et plans, ouvrages de retenue

IGHP Bratislava	SVD GN, obj.SO 1-64.215	1990
VÚIS Bratislava	Zhutnovacia skúska vysokého zásypu hlbinným zhutňovaeom typu RF 3000/46 fy Ferro-konzult l.c. - ciastkový výstup st. úlohy	1981

VUT Brno		
VÚIS Bratislava	Metodika overovacích skúsok dynamického zhutnovania ťažkou doskou - návrh	01/81
VÚIS Bratislava	Znizovanie pracnosti pri zvysovaní objemu vykonávania zemných prác	
1.Z	- specifické problémy zhutnovania zemín	
1.2Z	- zhutnovanie násypu vibracným valcom VV 200	1983
VUT Brno VVÚVSH (Dr.Hálek)	Analyza proudení pravostrannou hrází priv. kanálu HC GA - záverecná správa	03/90
VVB + OVIBER	SVD GN, jednotné proj.smernice V.- Dalsie prípravné práce SZP	1974
Váhostav Zilina	Technolog.predpispre vymenu nevhodného podlozia a hutnenie strkového zásypu pod hrádzami prív.kanála	10/82
Inz.stavitelstvo Bratislava	Velkopokus AB tesnenia na stavbe VdGA - vyhodnotenie realizácie	12/85
Doprastav Bratislava	SVD Dunaj - pokusné úseky pre posúdenie moznosti realizácie plástového tesnenia	04/80
SVST - Katedra geotechniky	Správa o riesení ciastkovej úlohy S-52-547-008-00-02/16-2 Súvislosti stability dunajských zemín	04/73
Techn. a skús.ústav stavebný - Štátna skúsobna Bratislava	Správa o výsledkoch kvality stav.prác na SVD GN, za rok 1983	03/84
- " -	Prehladná správa o výskumoch, výrobno a úradnokontrolných skúskach pri kontrole kvality stav.prác na SVD GN za 1.polrok 1987	07/87
- " -	Správa o výsledkoch v kvalite stav.prác na SVD GN, za rok 1986	01/87

SVST Bratislava	Stupen Gabcikovo-Parametre pohybu podzemnej vody pred napustanim prévodneho Canada	05/90
HYCO Bratislava (Ing.Báno)	(SVD GN, spreukázna dokumentácia k SE 1981 - Stabilitné a konstrukcné riesenie hrádzí zdrze Hrusov - Dunakiliti TP	04/83
- " -	- stabilitné a konstrukcné riesenie hrádzí prív. kanála TP	12/82
- " -	- Presetrenie stability svahov a ochranných hrádzí odpad.kanála TP	05/83
HYCO Bratislava (Ing.Hobst CSc.)	Seizmická stabilita zemných hrádzí prív.kanála VD GA - techn.pomoc pre konzultácie so ZSSR TP	04/80
HYCO Bratislava (Ing.Comaj)	SVD GN, prív.kanál - úprava podlozia kanálových hrádzí - techn. správa	03/82
HYCO Bratislava (pg. Gregor)	SVD GN, prív.kanál - labor. a terénne skúsky objemových hmotností strkov - dopln. geol.práce	07/84
HYCO Bratislava (Ing.Comaj)	SVD GN, prív.kánál Smernica pre postup stav. prác pri výmene podlozia hrádzí prív.kanála	08/81
Vodné toky Bratislava MLVH Praha	Povoden na Dunaji v r. 1965	1969
HYCO Bratislava	Prívodný kanál - úpravy návodného svahu kanálovej hrádze príl. 17731 - G 10447 ÚP	06/83
- " -	Prívodný kanál - príl. 20420 - E 82076 2/2	
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- " -	Zdrz Hrusov є. 0.1.11.101,105	

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HYCO Bratislava	G-N project, ECOLOGY VERSUS ECONOMY	1990
HDS Bratislava	Výstavba podzemných stien na stupni Gabeíkovo	
IGHP Bratislava	Poznatky z overovania tesnosti vane DLU st.GA - geolog.pr.	1987
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IGHP - " -	TIEFE BAUGRUBEN FUR DIE WASSERKRAFTWERKE Gabeikovo; DEEP FOUNDATION PITS FOR THE Gabeíkovo HYDROPOWER PLANT	1986
IGHP - " -	Výsledky pol'ných zat'ažo- vacích a smykových skúsok V-2.4 (1-3) a	
IGHP Bratislava	Zhutňovací vel'kopokus V - 2.4 (1-3) cl	02/77
IGHP - " -	SVD GN, derivaený kanál pre HC GA - podrobný prieskum - správa	06/65
IGHP - " -	HYDROUZOL GABEIKOVO - ruský text	03/82
HYDROCONSULT	Aménagement hydraulique de Gabcikovo-Nagymaros Rapport de synthèse	03/90
VUVH Bratislava	Hydrologické a hydrotechnické riesenia regulovania hladiny podzemnej vody pozdlzstarého koryta Dunaja pod hatou Dunakiliti, rezortná výskumná úloha R 05-531-139-00	1989

VV Bratislava	Sustava Vodnych diel Gabcikovo Nagymaros, ciaskova sprava o dohlade jrocas vystavby na VD Gabcikovo C.7 pocas	03/90
VVÚVSH Brno	Overenie funkcie ramennej sústavy a závlah v inundovanej oblasti Dunaja pod hatou Dunakiliti. Posúdenie vplyvu na hladiny podzemných vôd v prilahlom území	1990
BME Budapest	Priesakové skúsky ako podklad pre bilanciu rezimu vodného hospodárstva starého Dunaja, výsk. úloha є. 241.332/88	02/89
VITUKI Budapest	Modelové výskumy prehlbenia úseku Dunaja pod Palkovicovom	1988
Hydroconsult Bratislava (Ing Uhlár)	Úprava lavostranného inundacného územia v rkm 1811 - 1819, stúdia	10/90
VUVH Bratislava (Ing Svoboda CSc, Ing Szolgay ml.CSc, Ing Stancková CSc)	Odtokový rezim Dunaja v podmienkach uvádzania a po uvedení VD Gabckovo do prevádzky, výsk. úloha R-05-531-139.01	1989
VUVH Bratislava (Doc.Ing.Hálek Drc, Ing Misüt CSc, Ing Lindtner)	Regulácia hladín podzemnej vody v inundovanej oblasti starého koryta v návaznosti na upravený vodný rezim Dunaja, ramenných sústav a priesakových kanálov, výsk. úloha R-05-531-139.02	1988
VUVH Bratislava (RNDr Petrovie CSc)	Vplyv hladín povrchových a podzemných vôd na vlahovú bilanciu pôdy v inundacnom území pri starom koryte, výsk.úloha R-05-531-139.03	1989
VUVH Bratislava (Ing. Bacik CSc)	Vplyv nestacionárneho rezimu na vyvoj pozdizneho profilu starého koryta, výsk. úloha R-05-531-139	04/87

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VV Bratislava	Objekt:	Stupen Gabcikovo - PLK-graficka cast	01/90
VV Bratislava	Objekt:	Stupen Gabcikovo Textová cast'	01/90
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ANNEXE B

LISTE DES ORGANISMES ET SPÉCIALISTES SLOVAQUES RENCONTRÉS

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LISTE DES ORGANISMES ET SPECIALISTES SLOVAQUES RENCONTRES

HYCO-HYDROCONSULT BRATISLAVA

RNDr.	SRNANEK	Jan	CSc
Prof.Dr.	DANISOVIC	Peter	
Ing.arch.	THOLT	Tadeas	
Ing.	DURKOVSKY	Andrej	
Ing.	LANYI	Ladislav	
Ing.	POLKO	Ivan	
Ing.	COMAJ	Miroslav	
Ing.	DOBRUCKY	Miroslav	
Ing.	MIKLAS	Oliver	
Ing.	BINDER	Julius	
Ing.	LISKA	Miroslav	CSc
Ing.	ROSINA	Rudolf	
Ing.	HRASKO	Vojtech	
Ing.	SCHULZ	Ervin	
Ing.	SEKERKA	Juraj	
Ing.	BANO	Ivan	
Ing.	MARTINICKY	Pavol	
Ing.	LOKVENC	Vladimir	
Ing.	UHLAR	Ivan	
Ing.	ORAVEC	Ladislav	
Ing.	KOHUT	Frantisek	

VODOHOSPODARSKA VYSTAVBA BRATISLAVA

Ing.	VADKERTI	Stefan
Ing.	GAJDOS	Roman
Ing.	PRIDALA	Jan

IGHP - ORGANIZACIA PRE INZINIERSKU GEOLOGIU A HYDROGEOLOGIU BRATISLAVA

RNDR.	VARGA	Ladislav
RNDR.	JALC	Dusan
Ing.	TICHY	Stefan

URBION - STATNY INSTITUT URBANIZMU A UZEMNEHO PLANOVANIA BRATISLAVA

Ing.	KRALIK	Jan	CSc
Ing.	HORAK	Emil	

TECHNICKY SKUSOBNY USTAV STAVEBNY BRATISLAVA

Ing.	PERDOCH	Ladislav

VODARNE A KANALIZACIE BRATISLAVA

Ing.	CARABOVA	Viera	
Ing.	MAREK	Vojtech	

PDB-POVODIE DUNAJA BRATISLAVA

RNDr.	KANALA	Alexander	CSc

PRIRODOVEDECKA FAKULTA UNIVERZITY KOMENSKEHO BRATISLAVA

Prof.Dr.	MUCHA	Igor	DrSc

SLOVENSKA KOMISIA PRE ZIVOTNE PROSTREDIE BRATISLAVA

RNDr.	REPKA	Tomas	CSc

VUVH-VYSKUMNY USTAV VODNEHO HOSPODARSIVA BRATISLAVA

Ing.	MISUT	Oto	CSc
Ing.	Z.ZEKEOVA		

STAVOPROJEKT BRATISLAVA

Ing.	MACAI	Stefan	

GEOFYZIKALNY USTAV - SLOVENSKA AKADEMIA VIED BRATISLAVA

RNDr.	BROUCEK	Ivan	

VIZITERV BUDAPEST

	POROSZLAY	Jozsefné	

VYSKUMNY USTAV PODNEJ URODNOSTY BRATISLAVA

Ing.	FULAJTAR	Emil	CSc

SHMU-SLOVENSKY HYDROMETEOROLOGICKY USTAV BRATISLAVA

RNDr.	DROPPA	Vladimir	
RNDr.	MISIGA	Pavel	
Ing.	DRAKO	Jaroslav	PhD
Ing.	MATUSKA	Milan	CSc
	BERTEKOVA	Emilia	
Ing.	MIKLOS	Ladislav	CSc

VYSOKA SKOLA TECHNICKA - BRNO

Prof.	HALEK		DrSc.

ANNEXE C

DESSINS

ANNEXE D

PHOTOGRAPHIES

SECTION OMITTED

Annex 10

GOVERNMENT OF THE HUNGARIAN REPUBLIC, STANDPOINT OF THE GOVERNMENT OF THE HUNGARIAN REPUBLIC AND THE HUNGARIAN ACADEMY OF SCIENCES CONCERNING THE ECOLOGICAL AND ENVIRONMENTAL IMPACTS OF THE GABCIKOVO BARRAGE, BUDAPEST, 22 APRIL 1991

Basic principles to be taken into account in the review of the expected ecological risks caused by the operation of the barrage:

1. The dynamic equilibrium of the Danube and the surrounding water system was formed after the last glacial period. It has not been significantly disturbed for ten thousand years. According to the plan, the Danube will be elevated, moved and directed into a lined canal. There is no evidence that this move will not have potentially harmful consequences.

2. The Danube is a sophisticated, ever changing ecological system. Consequently, no parameter(discharge, flow velocity, contamination, etc...) can be taken as constant to the exclusion of others.

3. The limits of ecological and environmental forecasts, from where no further accurate conclusions can be made, is quickly reached because the research and examinations are lacking.

4. Time must be taken into greater account in the assessment of ecological impact. It determines the combination and sequence of processes. Models with short time scales may predict results that are quite different from reality.

The ecological and environmental consequences of the operation of the Gabcikovo Barrage will be primarily caused by the hydrological, hydraulic and by changes in the pollution levels of water that it will affect. The interactions of these changes with each other will result in even more drastic consequences.

(A) Result of the important, the water velocity in the reservoirs will decrease, stagnant areas will develop, piling of sedimentation will accelerate and groundwater levels will rise.

Expected risks:

1. Owing to (i) the decrease in stream velocity in the reservoir and in the main stream, (ii) separation from the tributaries and (iii) the construction technology of the new banks, severe degradation of the ecosystem is expected, while a nutrient surplus (S,P) increases eutrophication and the damaging production of organic materials. The self purification capacity of the water along the river stretch concerned is decreasing.

2. The anaerobic processes are gradually becoming dominant in the sediment at the bottom. This is apparent even on the surface of the water and as a result of it seriously damaging anaerobic, fermenting bacterial decomposition and rotting can occur, and the organic and non organic industrial contaminants can infiltrate into the metabolic biological product.

3. Gene damaging, mutagenic, carcinogenic and teratogen metabolic side products are entering the water and sediment is transforming into a dangerous, industrial sewage-sludge with rotting characteristics of decay.

4. The biological filter layer formed on the surface of the bottom sediment is being severely damaged, therefore sedimentation indirectly also pollutes the water of the bank-filtered wells .

5. In the damned up territories and in its connected areas the soil becomes ill ventilated, the anaerobic processes become dominant, the danger of waterlogging is increasing, and secondary solidization is able to occur in the area with bad drainage conditions primarily on the left side of the Danube, East of the mouth of the Vag, along the backwaters and the related area.

6. Because of the special hydrogeological condition of the 'Szigetköz and Zitny Ostrov (continually fed from the Danube, this is a gravel aquifer with high transmissivity in some places and a thickness of over 350 metres) the damaging material reaching the groundwater will eventually pollute the total subsurface water resources (in a few decades). The planned, regular dredging of the accumulated silt will not only be damaging for the quality of the surface water but, by destroying the filtering layer, the intrusion of organic micro polluters and microorganisms into the groundwater will be possible.

7. The several thousand square metre asphalt surface of the dam of the power canal and the reservoir at Dunakiliti will be covered by epibiotic bacterium. The catalyzing effect of these bacterium can contribute significantly to the transfer of cancer causing polycyclic and aromatic coal compounds passing from the asphalt into the water.

(B) Water supplementation and moisture content of the flood plains in th old Danube's abandoned bed and along surrounding areas will decrease and the groundwater level may also decrease as a result of the siphoning of groundwater.

Expected risks:

1. Swampy areas are being formed in the abandoned water bed where the tree type vegetation is becoming weedy.

2. The mineralisation of the decaying vegetable matter is being accelerated, the organic content of the soils is decreasing, the danger of the leaching of nutrients and the deterioration of the soil structure is being increased.

3. The water supply through capillarity into the root zone stops where the present groundwater level is in the fine aquifer and is being lowered down to the gravel layer because of the barrage, consequently the yield, or more exactly the security of the yield of the cultivated vegetation is significantly decreased. The drought sensitivity of the area has increased too and the regular water supply of the flood plain forest is changing.

4. The quality of the water supply used to compensate for groundwater recession and dependent on the nourishing raw water supply and the situation of the colmatage in the flood plain is deteriorating the quantity of the total water resources stored there.

(C) The Changes in the hydrodynamic situation and the displacement of the bio-geochemical processes thereby induced, and the deterioration in water quality will lead to the impoverishment and the degradation of the ecosystem.

Expected risks:

1. The present connected flood plain ecosystem will be broken into isolated areas, the organic material productivity of the vegetation is decreasing, and woodland ecosystems adapted to oxygen rich water will be seriously degraded.

2. The composition of the ecosystems is being displaced, the pattern of them will be restructured over a short period and during this process the diversity (number of species and their genetic variety) will decrease which means a significant degradation.

3. The rapid changes will destroy numerous (likely millions of) gene variants over the affected area for ever. This endangers the adaptability of the remaining members of the ecosystem which is critically important in the modified environment.

4. The planned water supply system increases the disturbance caused in the flora and fauna population. This, through the degradation of their growing space, leads to a lower reproduction capability.

5. Fry and spawn deposited along the bank owing to the unnatural circumstances can not endure the flow changes and the silting. Consequently the fish population is decreasing and its composition is significantly modified.

(D) From a geological point of view, is the lack of knowledge regarding the region represents the greatest risk. Numerous preparatory and planning steps (for example environmental impact assessment, technical design) can only lead to valid results if this information is available.

1. No geological or geophysical documentation of the area affected by the Gabcikovo Barrage was ever prepared. The majority of the necessary research concerning this problem is still lacking. A further problem is that there has been no integration of research carried out by the Hungarian and the Czechoslovak sides so far.

2. A specific problem is the seismic question related to the Gabcikovo barrage. The seismic values agreed upon in the Joint Contractual Plan are not acceptable. Because of the lack of the necessary examinations it is not possible to give a valid answer to the seismic questions.

Budapest, 22 April 1991

Volume 1, number 5, 1991 13

I. Mucha and E. Paulikova

Ground water quality in the Danubian lowland downwards from Bratislava

The majority of ground water in the river Danube lowland area downstream of Bratislava has oxidizing conditions and is of high quality, usable for water supply without additional treatment.
The area has been influenced by human activities. Straightening and dredging the river bed, closing the Danube branch system, construction of dams upstream from Bratislava, etc., has resulted in erosion and deepening of the river bed and substantial lowering of the ground water level. Direct industrial and agricultural pollution of aquifers has been observed Under these conditions the hydraulic structure at Gabcikovo was constructed. Its influence on ground water and the whole ecosystem, especially riverside vegetation, can be negative but also positive.

INTRODUCTION

Water in rivers, lakes, and ground water from springs and wells with natural oxidizing conditions, if not directly polluted, is usually of a water quality suitable for drinking without additional treatment. At the beginning of the 20th century in Europe oxidizing conditions prevailed in nearly all shallow alluvial aquifers. Nowadays, in some European regions, one can scarcely drink water directly from a well. Contamination and degradation of ground water is also detected in the Slovak river Danube area. Protection of drinking-quality ground water resources is the present aim of engineering and ecological approaches to water resources in the area.

THE STATE OF GROUND WATER QUALITY

Water of unpolluted mountainous rivers and lakes generally has oxidizing conditions due to the dissolution of oxygen from the atmosphere and the absence of eutrophication. According to the hydrogeological conditions present, ground water can either have oxidizing or reducing conditions. Oxidizing conditions are often present in uncontaminated surface regions and regions of traditional agriculture and forestry activities. Under such conditions ground water is replenished with oxygen-rich water and with atmospheric oxygen transported through the soil and the unsaturated zone above the capillary fringe. In regions where water which recharges the aquifer contains organic compounds and little or no oxygen, or oxygen is not transported to the ground water level, the aquifer becomes anaerobic. The oxygen-consuming agent is generally the organic matter, which is mainly the result of human activity. Similarly, the changes in the oxygen input via the unsaturated zone and throughout the places where the river bed infiltration takes place, are usually caused by human activity, for example, by river regulations.

The majority of ground water in the river Danube lowland area downstream of Bratislava has oxidizing conditions and is of a high quality, usable for water supply without additional treatment. The total available was estimated at 20 m^3/s and approximately 3 m^3/s has already been used for water supply.

WHAT DOES GOOD GROUND WATER QUALITY MEAN?

Ground water can be protected against pollution by appropriate prohibiting regulations, removing the pollution sources, removing the pollutants by remedial actions and by restricting the propagation of pollutants. Additional remedial measures are usually expensive.

Water quality can be degraded by changing oxidizing conditions to reducing ones. The solubility of oxygen in water is comparatively low (about 10 mg/l). This is why the presence of even small amounts of organic carbon or oxygen-consuming substances due to their oxidation, consumes the free oxygen and water conditions become reducing. If not all of the organic carbon has been consumed by this its oxidation continues, taking the necessary oxygen from nitrates and oxygen-containing compounds of trivalent iron, tetravalent manganese and sulfates. These components are almost always present in water or rocks. Nitrates and sulfates are comparatively harmless and, according to the Czechoslovak standard (CSN 75 7111—Drinking Water), their content in drinking water can be 50 and 250 mg/l, respectively. The compounds of trivalent iron and tetravalent manganese are, under oxidizing conditions, insoluble. Under reducing conditions, and in the presence of organic matter, nitrites, ammonium salts and free ammonia, hydrogen sulfide, and soluble bivalent forms of iron and manganese are formed, whose permitted contents (according to CSN 75 7111) are only 0.1, 0.5, 0.01, 0.01, 0.3 and 0.1 mg/l, respectively. This means that, just by a change in redox

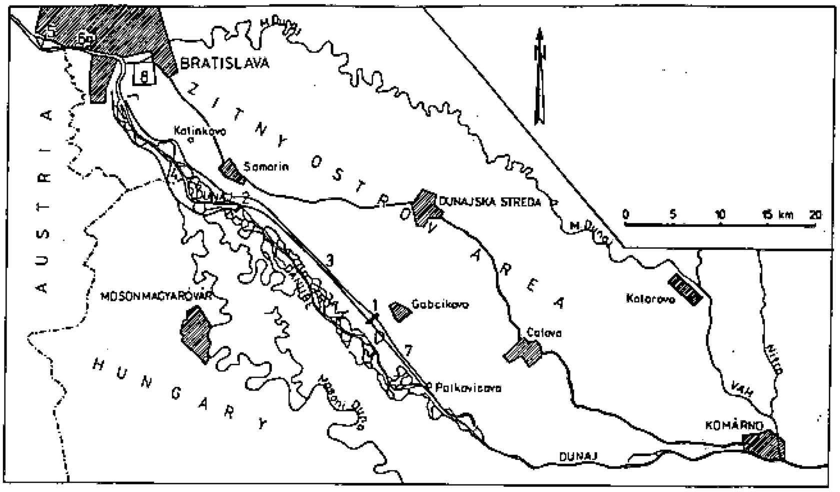

Figure 1. The Zitny Ostrov area. 1 = Gabcikovo: power station, navigation lock and road bridge; 2 = Hrusov Dunakiliy weir; 3 = suppl canal; 4 = Hrusov reservoir; 5 = Sihot water supply; 6 = Bratislava castle; 7 = canal dredging; 8 = Slovnaft oil refinery.

conditions, originally harmless water can be turned into ground water which is not suitable for supply without treatment. This change also occurs easily in the area downstream of Bratislava.

PROBLEMS OCCURRING IN THE RIVER DANUBE LOWLANDS

The River Danube lowlands, called the Zitny Ostrov area (Fig. 1), and the adjacent territories in Hungary have been influenced by human activities since ancient times. Straightening the river, closing its meanders, dredging the river bed, mining gravel, raising and closing the Danube branch system thresholds, and stream controlling structures, all carried out mainly in order to improve navigation, caused further changes in the region. Construction of dams upstream from Bratislava has changed the relation of suspended material to bed load. In particular sand and gravel movement has been decreased. As a result of all these measures the erosion of the river bed downstream from Bratislava and a substantial lowering of the ground water level (caused partially also by the hydraulic protection of ground water against pollution from the Slovnaft oil refinery) has been noted. A drop in the ground water level (by 3–6 m) has resulted in a changed landscape, with the drying up of riverside forests downstream of Bratislava, and degradation and drying up of the river branch system. These processes have affected fish and forest ecology and have had a negative influence on ground water and soil and increased the necessity for irrigation.

The Danube is a very dynamic river with high flow rate and great water level fluctuations. The minimum, average and maximum flow rates observed in Bratislava are 570, 2025 and 10254 m^3/s, respectively and the amplitude of the water level fluctuation is ovc 8 m. The slope of the river Danube downstream c Bratislava is from 0.03 to 0.04% and at Gabcikov from 0.02 to 0.03%. The steep slope and high flo rate mean that the river bed consists mainly of grave and coarse sand, almost without any solid organic mat ter. The water in the Danube is of a rather goo quality, it is nearly fully saturated with oxygen an it has comparatively small values of biological oxyge demand (BOD) (Table 1). During infiltration of suc water, any organic matter is oxidized but the groun water still contains oxygen in concentrations sufficien for the prevention of reducing conditions. Apart fron the steep slope, water at the river bottom is kept i motion due to the variability of the flow rate, so ther is no clogging (colmatation) of the bottom (known t be caused, for example, by artificial recharge).

As far as the ground water is concerned, the are shows some peculiarities. Downstream from Bratislav the river Danube forms an "inland delta". This mean that, after having passed the granite threshold situate beneath Bratislava castle, the River Danube flows ove

TABLE 1. Selected chemical components of the Danube water a Hrusov

Parameter	Minimum (mg/l)	Maximum (mg/l)	Averag (mg/l)
pH	7.99	8.52	8.16
O_2	7.20	12.80	9.80
BOD_5	1.50	5.10	2.14
COD_{Mn}	3.20	8.40	4.90
NO_3	6.75	21.20	11.10
NO_2	0.05	0.28	0.13
PO_4	0.11	1.48	0.43
NH_4	0.02	0.84	0.31
SO_4	27.60	62.30	31.10

BOD = biological oxygen demand; COD = chemical oxygen demand.

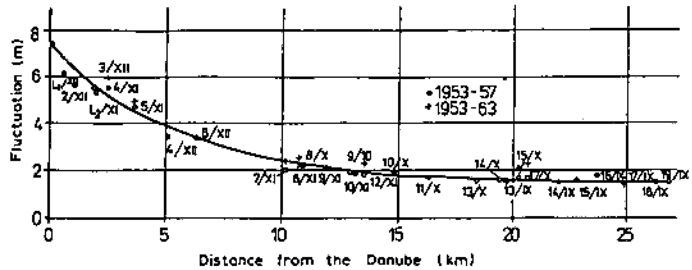

Figure 2. Amplitude of ground water level fluctuation with distance from the River Danube.

her own sediments. In the upper part of the Zitny Ostrov area, the river bed of the Danube is situated higher than the surrounding area. Water from the River Danube can, therefore, permanently infiltrate into the aquifer and renew the ground water resources. The ground water flow is comparatively fast (about 1–3 m/day, sometimes even more). As a consequence of tectonic processes, the layer of river gravel attains extraordinarily great thickness. In Bratislava it is 15 m, at Samorin 120 m, in the surroundings of Gabcikovo it surpasses 350 m and towards Komarno it diminishes again to 10 m. The water infiltrated in the upper part of the Zitny Ostrov area flows in the lower part back into the Danube and channels. The great amplitude of the water level fluctuations in the Danube also causes a great fluctuation in ground water levels (Fig. 2), which enables it to be supplied naturally with atmospheric oxygen. In the past the River Danube meandered, the ground water level was close to the surface and the whole area was extremely fertile. In spite of numerous adverse effects and intensive agricultural production, the ground water in the upper and central part of the Zitny Ostrov area is still generally of excellent quality. This can be explained by the fact that the ground water level fluctuates over a large area, which has ensured not only the transport of the atmospheric oxygen into the ground but also its transfer to deeper layers, thus preserving oxidizing conditions over a comparatively extensive area.

Ground water in this area is partially polluted directly by industrial waste from Bratislava and its surroundings, and indirectly by, for example, sulfates and other air pollution. Apart from this, the ground water is polluted by unsuitable agricultural technology and irrigation, inappropriate waste deposits, the absence of sewerage, and the filling of the old meanders by waste material, among others.

THE GABCIKOVO HYDRAULIC STRUCTURE

In the past the river ecosystem and the whole lowland area altered greatly as ground water and river levels fluctuated. The hydraulic structure at Gabcikovo was imposed on this unsatisfactory situation. Its influence on ground water and the whole ecosystem, especially riverside vegetation, can be negative but is also sometimes positive.

The proposed Hrusov reservoir, which forms part of the Gabcikovo hydraulic structure, threatens ground water for the following reasons:

(1) There is a possibility of eutrophication in the reservoir in the same way that, in the old river bed, meanders and branches caused a greater concentration of organic matter. From the point of view of ground water, eutrophication in the Danube will have a negative influence on the quality of infiltrated water.

Stagnation and slowly flowing water show a tendency to eutrophication, where there are enough nutrients and correct temperature and light conditions. In the projected reservoir these conditions will exist.

(2) Fine sediments containing organic matter will be deposited in the reservoir. This will result in consumption of oxygen during infiltration, a higher organic matter content in ground water and consequent reducing conditions. The recent flow regime in the river Danube at, for example, the Sihot Island and downstream of Bratislava ensures a continuous infiltration resulting in good quality of ground water.

(3) Clogging of the reservoir will occur. After a while the clogging will become widespread and a further drop in the ground water level in the upper part of the area may occur.

(4) The water level fluctuations in the reservoir will be reduced (to approximately 1 m) and, due to the influence of infiltration canals, ground water level will stagnate. This will decrease the amount of atmospheric oxygen transported to the aquifer.

Due to the above-mentioned reasons it will be necessary to take into account the costs of the construction of water supply treatment plants, the higher cost of irrigation, artificial infiltration, dredging in the reservoir, disposal of settled fine sediments, etc.

POSSIBLE SOLUTIONS

Basic measures, ensuring minimal eutrophication, avoiding unwanted sedimentation and ensuring river bed permeability, are:

(1) Maintaining the River Danube high water quality (which means carrying out waste water treatment, construction of sewage systems, optimization of agricultural technology, irrigation and fertilizer application).

(2) Influencing the river bed sedimentation by ensuring river water flow velocities are as high as possible. Correct flow velocities and their control have to be determined experimentally and by modelling.

(3) Forcing the fluctuation of ground water levels.

Under the conditions in which the hydraulic structure will work while not generating peak power, it is possible to resolve the negative influence of the reservoir and to minimize the ecological risks, even to improve the recent situation. By optimization of the water flow to the supply canal, for example, by the adaptation of the reservoir shape, flow controlling structures, islands, elongation of the supply canal, seeking the optimal position and construction of the weir, as well as weir management from the point of view of the bed load, it would be possible to gain some additional ecological benefits. Benefits would consist of improvement in the recent water regime in the riverside forest and its spread towards Bratislava. In the adapted reservoir the sedimentation processes could be optimized in order to satisfy the future ground water infiltration requirements. By means of a correctly projected weir, sedimentation processes could be gradually adjusted so that the recent bed bottom would rise. All the proposed measures, together with the opening of the branch system, could contribute to the improvement of riverside forests, the branch system and agriculture, as well as to the ground water. Serious consideration must be given to the optimization of agricultural activities, especially in respect of the ground water and a definition of water supply territory, which should be strictly protected. Apart from this, waste water treatment plants should be built, waste deposits removed and environmentally friendly practices followed.

DANUBIAN LOWLAND—EC PHARE PROJECT

The problems in the Zitny Ostrov area are complex, because the ground water is not only influenced by operation of the hydraulic structure. In this connection the ground water plays a crucial role, not only for the drinking water supply, but for ecological questions as well. The problems are extraordinarily complex, interdisciplinary in their basis, unique from the expert point of view and of extreme importance for the whole of Slovakia. In November 1990 an interim group "Ground Water" at the Faculty of Natural Sciences of the Comenius University in Bratislava was established. This group deals with the questions of ground water in this area. There is also a chance to involve the best World experts in this work through the PHARE program of the European Community. At present, international tender documents are being drawn up. The work, with international participation, should start at the end of 1991. The goal of this project is to bring together research and survey organizations to co-operate in research on the ecology of surface water and ground water, mainly by a study of their biochemical systems and the construction of a model. The will be to solve a set of practical problems in the area interconnected with the ground water, and to prepare a correct impact assessment model, which will enable authorities to ensure the protection of natural resources and balanced ecological development, as well as optimizing decision making and management.

The modelling method was chosen as the basis for the solution of problems connected with ground water because it can render the best information about various interacting factors, their variability and the space requirements of the system. The model will enable examination of different proposed solutions and optimization of results. A detailed three-dimensional ground water flow and quality model, interconnected with an agricultural model and models of river and reservoir behaviour could reflect the various possible problems. The set of models will also serve for ground water management, agricultural production, building activities, ground water protection, ground water level control, management of the weir, etc. We do not want to investigate the influence of the different variables of the hydraulic structure, but to look for a solution by the opposite procedure. To ensure defined goals (ground water quality, ground water level, sedimentation processes, etc.) we want to seek an optimal solution for the adaptation of the reservoir, weir, agricultural production and control of sedimentation processes in the old River Danube bed downstream from the weir, so that the recent negative changes may be gradually improved. Use of hydraulic structure could bring benefits not only for power supply but also for ecology.

The hydraulic structure can be used for the solution of problems existing in the Danube lowland, but can also exacerbate them. In any case, it is necessary to look first at providing optimum ecological conditions, especially where ground water is concerned. A symbiosis, or artificial ecological equilibrium, acceptable for both nature and man can surely be found. We must admit that, in the Zitny Ostrov area, an acceptable ecological equilibrium did not exist prior to starting the construction of the hydraulic structure. Let us, therefore, utilize the hydraulic structure for the protection of the nature. Perhaps it will now succeed in obtaining general approval. If the hydraulic structure is not put into operation the major ecological problems of this area, especially preservation of ground water quality will still not be solved.

Annex 12

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THE DANUBE... FOR WHOM AND FOR WHAT?

THE GABCIKOVO DAM: A TEXTBOOK CASE

Equipe Cousteau

September 1992

Equipe Cousteau, association régie par la loi de 1901.
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The Danube... For Whom and for What?
The Gabcikovo dam: a textbook case - September 1992

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SUMMARY AND RECOMMENDATIONS

SUMMARY

The first contacts that the Equipe Cousteau had with the Gabcikovo dam date back to September 1990, when Captain Cousteau flew down the Danube by helicopter. Seen from the sky, this major branch canal strongly resembles a scar cutting through the alluvial forest.

The problem posed by Gabcikovo is one of the key points in our expertise on the Danube as it has typical features. It covers a wide range of sectors (touching on facets such as energy, transportation, water resources and the protection of natural ecosystems) and illustrates the complexity of environmental problems within the context of a wide range of ecological, political (national and international), economic and social challenges and the need to treat them in an overall manner.

The Gabcikovo dam is now nearly completed and this needs to be taken into account. This does not necessarily mean that all has been decided and that the situation is therefore irreparable. A certain number of alternative solutions are possible, if the means are given to achieve them. The choice we make will need to take the impact of the dam, as currently designed, and a number of different alternatives into account, as well as the role that the dam could play in the economies of the Danube countries, Czech and Slovak Republics. This evaluation of the economic interest of the dam, essentially the production of electricity, and increased navigational possibilities, should be treated as a preliminary approach used to guide the choice of alternatives which will need to be studied in a more detailed manner

The aim of this report is not to offer technical studies of the impacts caused by the Gabcikovo dam and the alternative solutions, but rather to simply offer an analysis and assessment based on accessible documents and our field experience.

However, we do offer an overall consideration of the advantages of the dam in terms of production of electricity and increased navigation.

The history of this dam goes back some time as the initial work were begun at the beginning of the 1950s. Since then, a vast number of modifications have been made to its technical design and, in the last few years, the dam has been marked by major conflicts, both within and outside the country.

At present, the situation is at a standstill. The Hungarians have denounced the treaty linking them to the Czechoslovaks and these latter have been carrying out work to make it possible to fill the dam without Hungarian cooperation.

The impacts

The dam has major potential impacts on the environment. The most serious threats concern the quality of the aquifer in this region, the largest in central Europe, and the integrity of the alluvial ecosystems along the banks of this part of the Danube, diverted by the project. These two systems are of great ecological and economic interest.

The controversial discussions between experts, from whatever camp, concerning these impacts and their consequences show a clear lack of environmental studies. The Slovak Environmental Commission has implicitly recognised this failure by imposing 19 conditions which determine the issuing of the building permission for the "provisional" solution (alternative "C"). These conditions are no less than a complete programme for a vast impact study.

Whether it be the initial project or alternative "C", it had never been question that these environmental studies could lead to major project modifications. Insofar as alternative "C" is concerned, the time period imposed for the application of the conditions (1 year between the decision to build and filling the dam with water) make it questionable as to the seriousness of these studies and whether there was really any point to them.

A certain number of questions still exist as to the safety of these works and their capacity to prevent flooding.

This dam is a factor in the international tension existing between Slovakia and Hungary, as well as between a national problem between the Hungarian minority and the Slovaks in a region of the world where there there are already too many problems.

Could the economic advantages of the dam, which might well counterbalance the negative points given above, justify the precipitate filling of the dam?

Production of electricity

Czechoslovakia and Slovakia are characterised by a major overconsumption of energy and electricity, a fact which hampers their current difficult economic development.

Efforts made in terms of energy efficiency could allow these countries to reach energy intensities comparable with those in Europe today by the year 2020. Electricity consumption would then be lower than its present level: being about 23 TWh less for all of Czechoslovakia and 6.5 TWh less for Slovakia.

Within this context, the electricity produced by Gabcikovo would meet no future needs and be of no interest in quantitative terms.

The capital invested in Gabcikovo has been removed from other sectors which are far more crucial to the country's economy. Although it is not possible to go back on the initial investments, part of the 5.7 billion Crowns (1.3 billion Francs, 260 million US$) recently earmarked for the construction of alternative "C" could have been used for economically affordable operations aimed at improving the efficient use of electricity, leading to energy savings at least equal to the electricity produced by Gabcikovo. The difference could have been used to modernise industry which, in turn, would lead to greater energy savings, thus creating capital for new investments. This solution would have created a dynamic approach favourable to reviving the country's economy.

The value of Gabcikovo as a substitute to existing sources of electricity (thermal and nuclear) can only be evaluated within a framework of a general redefinition of the country's energy strategy. In any case, it remains a highly marginal source in quantitative terms.

Navigation

Navigational problems essentially concern the Vienna-Budapest sector but, in itself, Gabcikovo is not capable of resolving them. This simple fact should be sufficient to show that Gabcikovo is of no value in terms of navigation.

If we look at the problem within a larger framework,,where Gabcikovo represents part of a system aimed at improving navigation conditions, there would be a need to build four additional dams, representing a 1 billion dollar investment, being 707 million dollars with value updated at 8%.

On the other hand, the advantages in terms of navigation would attain an overall amount of 78.3 million dollar by the year 2020. In updated values, these advantages would amount to 180 million dollars in the lower hypothesis and 360 million dollars in the hypothesis where a more generalised view of the advantages is taken into account.

The development of the Vienna-Budapest sector offers no direct profit for navigation as the internal profit rate is negative. The impact of these investments on the overall productivity of the fleet is far from being minimal but, at a maximum of 2.5%, does not represent a significant level of profitability.

The only direct beneficiary of these developments would be the Austrian iron and steel industry which would be able to use them to establish a strategic positioning in the sector.

An investment made in Hungary and Slovakia which would most benefit Austria cannot be considered a main priority. In other words, this would create a paradoxical situation whereby Slovakian investments in the construction of Gabcikovo would endanger its own iron and steel industry.

On the other hand, the analysis shows that it is essential, inexpensive and profitable to invest in the structures around the Danube.

RECOMMENDATIONS

It is clear that if it were question to build Gabcikovo today, it would never be built. The risks it would represent for the environment, for a resource as important as drinking water and for safety, as well as the weakness of the economic arguments, represent a sufficiently clear-cut evaluation.

But Gabcikovo is nearly completed and this must be taken into account.

Despite this, nothing justifies the current rush to make the dam operational. The questions raised are too important to let them simply be skimmed over.

The possible alternative solutions deserve to be given a reflective and in-depth analysis. All the ecological, technical, social and economic aspects need to be carefully examined.

This objective reanalysis would be a good opportunity to make up for the lack of democracy that presided over the decisions concerning Gabcikovo, whether from the old or the current executive powers. To accomplish it seems to us that international arbitration is needed to eliminate the problems generated by the tensed relations between the two states concerned.

We recommend that work be stopped on Gabcikovo and that a moratorium be called. This would make it possible to set up a multi-disciplinary and international study committee which would bring together experts from the two implicated countries alongside experts who are both neutral and independent.

This committee would be responsible for making a detailed, unhurried analysis of all the possible alternatives for this project. The range of possibilities are particularly wide as there are no priority economic interests at stake. The committee's work should be accompanied by major efforts made to inform and discuss the alternatives with the population living along the river who will be directly implicated by the effects of the dam and its future.

INTRODUCTION

LARGE DAMS

For many years, both the public and the decision-makers have seen dams in a particularly positive light.

Hydroelectricity is an attractive energy source. Apart from being cheap because nature benevolently ensures its constant renewal and non-polluting in terms of sulphuric emissions or the long-life radioactive waste from other types of power stations, it also offers a great deal of flexibility in terms of its use. These qualities have led it to be seen as a "clean", and even "ecological", power source.

The reservoir lakes created by dams also represent a water reserve for irrigation, making it possible to increase agricultural production and overcome climatic uncertainties.

Dams have meant the end of catastrophic flooding. By being regulated and domesticated, rivers no longer impede human activities by unexpected rises or falls. On the contrary, they become economic development vectors and, more particularly, a practical and judicious transport axis.

Finally, dams, particularly large ones, are major work which sometimes assume Pharaoh-like proportions (such as the Aswan dam) requiring massive investment. These characteristics ensure, for obvious reasons, that they are backed by investors and large companies as well as by political decision-makers for whom it is an opportunity to leave a mark on their country's future (the Aswan dam, for instance, led to the creation of Lake Nasser).

Over the last few years, the experience acquired on the older dams and the progress made in terms of river ecology have somewhat tarnished this proud reputation. We have progressively, and sometimes spectacularly, discovered that these types of river developments can have serious consequences, such as the eutrophication of artificial lakes, the upsetting of river dynamics (where the main consequences are the progressive hollowing out of the riverbed and the downstream erosion of the banks), contamination of groundwater tables and drinking water reserves, modification to the quality of farmland, drying out of naturally watery areas, local climatic modifications, etc... Mechanical deterioration severely disturbs river ecosystems, acting in synergy with chemical pollution and increasing its impact. Unlike pollution, mechanical deterioration is both permanent and irreversible, which worsens its long term consequences.

In addition, the benefits expected from dams do not always compensate their harmful effects. Production of electricity often falls below forecasts, the excessive use of pesticides and fertilisers and the salification of farmland can cancel out the benefits offered by irrigation and, although there is less flooding, those that occur can have disastrous consequences.

The balance sheet, once established in a realistic manner, are not necessarily positive.

The Gabcikovo dam fits perfectly into this scenario. Its construction was first mooted in the 1950s, its capacity was increased during the first oil crisis and it is now being built in an economic and political context that has been completely transformed and created high controversies.

GABCIKOVO AND THE COUSTEAU TEAM

The first contacts that the Equipe Cousteau had with the Gabcikovo dam date back to September 1990 when Captain Cousteau made a helicopter flight down the Danube. Seen from above, the major branch canal strongly resembles a scar cutting through the alluvial forest.

This was the starting point of an interest in the situation which led to the writing of the present report.

Since that first visit, we made other trips to Slovakia in autumn 1990 and summer 1991. We visited the site, met the people living along the river, questioned specialists in the hydraulics and ecology sectors, and filmed demonstrations held by those opposing the construction of the dam.

The study made of Gabcikovo is one of the main points of our expert survey of the Danube, as the problems have typical features. It clearly illustrates the complexity of the environmental problems and the large number of issues at stake, be they ecological, political (domestic and international), economic or social, and the need to treat them in an overall manner.

AIMS OF THE REPORT

Most impact studies, even when carried out according to the legislation in force in Western countries, simply evaluate the consequences that the structure being surveyed could have on the environment and propose compensatory measures. It is rare that a counter-expertise evaluates the very relevance of the objectives that the structure aims to achieve, or seeks out alternative solutions to offer the same end result, using means less harmful to the environment. The need for this type of upstream evaluation is crucial when it comes to the effects of major work which, once built, are irreversible.

Insofar as Gabcikovo is concerned, it is clear that this preliminary phase has not gotten beyond wishful thinking. It should also be added that even had it existed, it would now be totally obsolete, given rapid changes that have taken place in these countries over the last few years.

The Gabcikovo dam is now nearly finished and it is important that this be taken into account. Nevertheless, nothing has been irremediably decided and a certain number of alternative solutions remain possible, if the means exist to bring them about. The choices to be made need to include the impact of the dam in its current design configuration as well as the different alternatives and the role that the dam could play in the economies of the Danube countries, Czech and Slovak Republics. This evaluation of the economic interest of the dam, being essentially the production of electricity and increased navigational potential, should be treated as a preliminary step which will then be used in helping to choose the different potential alternatives, once these have been studied in greater detail.

The aim of this report is not to offer a technical study of the impacts made by the Gabcikovo dams and the alternative solutions. It is simply an analysis and an assessment based on accessible documents and our own field experience.

However, we do offer an overall consideration of the value of the dam in terms of electricity production and increased navigation.

BACKGROUND AND DESCRIPTION OF THE GABCIKOVO DAM

BACKGROUND

The idea of developing this portion of the Danube, which acts as a frontier between Hungary and Czechoslovakia, goes back to the beginning of the 1950s. At that time it was incorporated into a much wider scheme aimed at developing international river-borne trade by linking the Rhine, Maine and the Danube. The construction of this project would make it possible to sail from the Black Sea to the North Sea without interruption.

Soviet pressure was important in the development of the project as the possibility of bringing large ships this far up the Danube was of great military and strategic interest.

The first aim was therefore that of transportation. At that time, the production of electricity on this nearly flat part of the Danube was not considered of any great interest.

The oil crises led to a different approach. At the beginning of the 1970s, the production of electricity became the main objective and the dam project has been enlarged to fully assume this production function. The hydroelectric station planned for the Danube was enlarged and relocated at Gabcikovo, which in turn led to the creation of a major branch canal and the Hrusov reservoir. The development of the Danube for navigational purposes was relegated to third position, behind the prevention of flooding.

The intergovernmental contract for the construction of this new project was signed on 16th September 1977. It planned for the commissioning of the Gabcikovo dam in 1986 and the creation of a second power station at Nagymaros in 1989.

1981: Due to financial difficulties, Hungary stopped the work and proposed that they be suspended for a 10 year period. Czechoslovakia began work on its side of the frontier.

1983: - A protocol was signed on 10th October in Prague between the two countries in order to postpone the end of the work by 5 years, with the limit date fixed for 1995.

- In December, the study committee set up by the Hungarian Academy of Sciences submitted a report in which it underlined the insufficiencies of the technical, ecological and economic studies, and concluded that it would be reasonable to delay the construction of the dam by a significant period, to modify the plans and even abandon the project once and for all. This report was not taken into account by the authorities and its publication was forbidden.

1985: Beginning of the protest movements against the Gabcikovo-Nagymaros project in Hungary.

1986: A contract was signed in May between Hungary and an Austrian company, Donaukraftwerke. This contract stated that 70% of the Hungarian work would be provided by this company and that the Austrian investments would be reimbursed in electricity over a 20 year period (2/3rds of the Hungarian part of the electricity produced at Gabcikovo would be used to service this debt).

1988: In October, the Hungarian parliament confirmed that work would be continued at Nagymaros but that they would be subject to strict conditions in terms of environmental protection.

1989: - On the 6th February in Budapest, the two countries agreed to modify the date fixed for the end of construction work and delay it until 1994.

- Temporary stoppage of work at Nagymaros in May and the same decision taken in July for the Dunakiliti dam which was to divert water towards the Gabcikovo dam.

- A WWF study in August underlined the negative effects of the project on the environment and concluded that the technical and ecological data was insufficient to justify continuing the work. This organisation proposed a minimum 3 year moratorium.

- Two meetings took place in July and September between experts from the two countries. They agreed on the potential risks of the project, but not on their consequences or on the possibility of compensating for them by taking appropriate measures.

- On the 31st October, the Hungarian parliament authorised the government to amend the 1977 treaty so that Nagymaros could be finally abandoned and that the construction of Dunakiliti be subject to environmental guarantees.

1990 : - In February, in answer to a letter from the Hungarian authorities confirming the abandoning of the Nagymaros project and proposing a renegotiation of the 1977 treaty, the Czech authorities accepted the renegotiation on the condition that the Gabcikovo dam be filled in 1991 (which presupposed the completion of the Dunakiliti facility). The Hungarians reiterated their proposal in May by demanding that work be stopped at Gabcikovo.

- In November, Hungary and Austria agreed on the compensation conditions for the Austrian companies having suffered from the abandonment of the Nagymaros project.

1991: - In April, the Hungarian parliament adopted a resolution whereby the government was only mandated to negotiate the cancellation of the 1977 treaty and return the sites to their initial condition.

- On the 23rd July, the government of the Slovak Republic, followed on the 25th by the federal government of the Czech and Slovak republics, basing themselves on the report prepared by Slovak experts, approved the work for alternative "C". This solution was chosen amongst 7 others (ranging from retention of the initial project to returning the sites to their initial condition) and allowed for the filling of Gabcikovo without Hungarian cooperation, by limiting the site perimeter of the project to Slovak territory.

- On the 30th October, the Slovak Environmental Commission gave construction permission for alternative "C", whilst formulating 19 conditions (see annexe) that had to necessarily be filled prior to starting up the work.

- 18th November: beginning of work.

- In December, the Hungarians sent a number of ultimatums to the Czechs demanding suspension of the work.

1992: - On the 26th February, the Hungarian authorities gave the Czechs a one month period to suspend the work, otherwise they would unilaterally denounce the 1977 treaty.

- In April,

  - The European Communities Commission submitted an offer of assistance to the two countries. It proposed the setting up of a tripartite committee of experts (Hungary, Czechoslovakia, Europe) which would rule on the future of Gabcikovo. This proposal was conditional on the reception of an official request from the two countries and an assurance that neither of the two parties would begin work that could bring prejudice to bear on the actions which might be undertaken on the basis of the results of the studies carried out by this committee.

  - The two governments rapidly sent an official request and undertook to respect the conclusions reached by the committee.

  - The second condition was subject to a different interpretation. The Hungarians considered that the work should be stopped, whilst the Czechoslovaks continued to construct alternative "C", considering it as provisional and undertaking to dismantle the constructions if they were contrary to the conclusions reached by the committee.

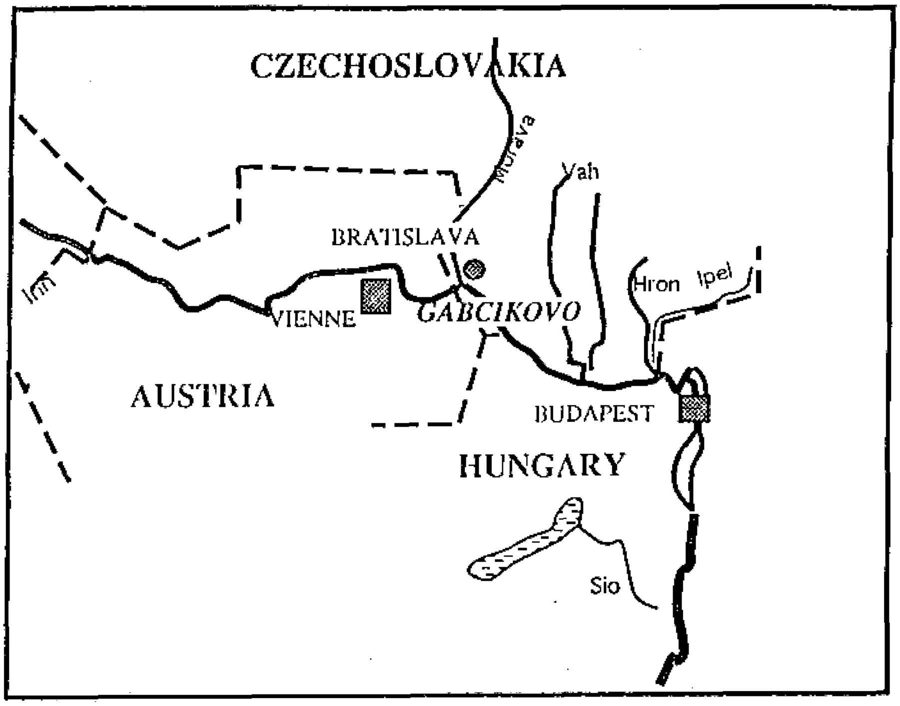
- 25th May 1992: the Hungarian government unilaterally terminated the 1977 treaty.

To date (September 1992), the situation remains blocked at this point. The forthcoming independence of Slovakia is unlikely to make the Slovak position any more flexible and the filling of alternative "C" is still anticipated for October 1992. The EEC has withdrawn and is waiting for the two governments to prove that they really intend to resolve the problem.

DESCRIPTION

The Gabcikovo dam is located on the Hungarian-Slovak sector of the Danube (see general location map).

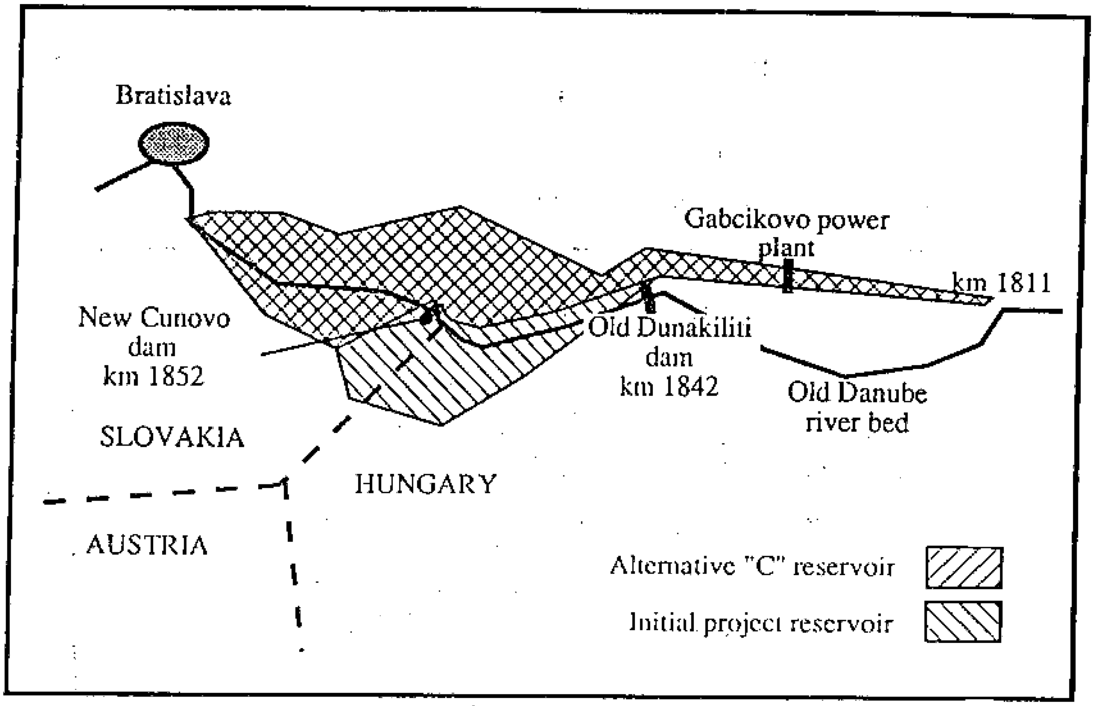
Gabcikovo dam: general location map.



In the initial design, the system included a set of dikes containing the reservoir, a dam at Dunakiliti (in Hungary) blocking the Danube and diverting water towards the supply canal, a hydroelectric station at Gabcikovo, an outlet canal returning water to the Danube at km 1811.

Alternative "C" consists of a new dam at Cunovo (in Slovakia) and new dikes modifying the right bank of the reservoir, limiting its perimeter to within Slovak territory (see diagram).

Diagram of the Gabcikovo dam and alternative "C"



Alternative "C" was chosen by the Slovak authorities from amongst 7 possible solutions:

- Alternative A: the initial project: completion of the Gabcikovo and Nagymaros work, with peak flow operation.
- Alternative B: work completed at Gabcikovo and Dunakiliti, but Nagymaros not built. Dam working continuously.
- Alternative C: land perimeter limited to Czechoslovak territory and avoiding the Dunakiliti dam.
- Alternative D: the reservoir is omitted, the main canal is extended to the entrance to Bratislava. Production of electricity is maintained. Weirs are installed on the old river bed to limit falls in the water level and in the groundwater table.
- Alternative E: same system as the previous alternative, but the canal only being used for navigation. The flow retained for the old Danube river bed would then be sufficient to avoid the installation of weirs.
- Alternative F: this represents the status quo, the work are not completed and the constructions are left as they are.
- Alternative G: the site is returned to its original condition after destruction of the existing constructions.

The method used to determine this choice is as follows (Liska (Hydroconsult), see annexes; Sibl (Slovak group for defence of the environment)): 6 specialised commissions classified the 7 alternatives in function of the following points of view:

- international relations and law .... (coefficient of 7),
- influence on water resources .... (coefficient of 7),
- economic feasibility .... (coefficient of 6),
- influence on the environment .... (coefficient of 6),
- social and psychical influences .... (coefficient of 3),
- feasibility and risks represented by the work .... (coefficient of 3),
- hygiene and epidemiology .... (coefficient of 3),
- preference expressed by the contractor............ (coefficient of 1).

Those responsible for the various commissions defined the criteria to be evaluated and proposed balancing coefficients attributed to each point of view (in parentheses above). Mr. Liska carried out the final evaluation and classification. It should be said that those responsible for the commissions and Mr. Liska were either directly or indirectly linked to the designers and builders of the dam. No independent experts participated in this evaluation.

Although the method used may appear surprising, the same cannot be said for the results!

Production of electricity

Gabcikovo was initially designed to operate on a peak flow basis, with water being stored in the reservoir for part of the day and then released at a high flow rate to produce electricity when the demand was at its highest. The Nagymaros dam was to be used downstream to absorb the wave caused by the massive release of water.

Without Nagymaros, it could only theoretically be used on a continual flow basis. Nevertheless, the project managers decided that it could be used on a peak flow basis when the flow rate exceeded 1,200 m^3/s. This solution is also applicable to alternative "C".

The installed 720 MW power corresponds to that required to operate on a peak flow basis for flow rates ranging from 4,000 to 5,000 m^3/s. They cannot be justified for a continuous flow operation. But as the turbines were ready, the builders decided to install all of them. They could be used when the flow rate made it possible.

The production of electricity anticipated for the different situations are shown in the table below. They will be shared with Hungary on a pro-rata basis in function of the investments made by each country.

Production of electricity anticipated in function of the different configurations. 1 TWh = 10^9 KWh
For alternative "C":
1: before installation of transversal weirs in the old river bed,
2: after installation (see explanations on pages 25 and 26).

	Installed capacity	Anticipated production		Czechoslovak part	
Initial project	720 MW	2,6 TWh		65% 1,7 TWh	
Alternative "C"	720 MW	1 1,34 TWh	2 2,33 TWh	1 85% 1,15 TWh	2 85% 2 TWh

ANALYSIS AND ASSESMENTS OF IMPACTS

INTRODUCTION

There was a major difficulty in preparation of this chapter. As the background analysis above has shown, the project has undergone major modifications over the last few years. From a twin system working on a peak flow basis, it has now become a single system operating on a continual flow basis, and it is now highly probable that alternative "C" will be the chosen solution. The potential impacts have therefore also been modified and we do not have documents assessing the impacts of this solution which was prepared and set up less than a year ago. Nevertheless, there are a great number of uncertainties concerning these impacts; proof of this can be seen in the 19 conditions imposed prior to filling with water by the Slovak Environmental Commission (see annexes). As given, these 19 conditions represent no less than the programme for a complete impact study, and underline the far-reaching nature of the remaining questions. Despite this, the work were begun a mere month after the conditions had been imposed. When given a written question on this point, the project managers stated that these conditions would be fulfilled prior to filling, in other words, by October 1992 (Mr. Liska, see annexes). We find it hard to imagine how such a major task could be carried out within the given time period and we question the worthwhile nature of these studies, given that, in the circumstances, they could not question the very nature or even modify the project!

This said, the impacts of solution "C" remain similar, in terms of their principles, to those of the initial project (insofar as the Gabcikovo dam without Nagymaros is concerned).

This impact assessment is based on the analysis of different documents from various sources and meetings with scientists and decision-makers. It does not represent an impact study as such, but rather an inventory of knowledge and points of view concerning the environmental impacts of the Gabcikovo dam. The list of impacts does not attempt to be complete and we have only examined the main points.

Current scientific knowledge and the complexity of the mechanisms being studied do not always make it possible to state with any certainty what the future impacts of these types of constructions will be. Nevertheless, this knowledge makes it possible to define probable impacts by, in particular, using the experience acquired from similar constructions.

Inasmuch as the construction of the Nagymaros dam has been abandoned by the Hungarian authorities, we have focused our attention on the consequences of the Gabcikovo dam.

Gabcikovo-Nagymaros is fairly well documented, but most of the accessible information is either represented by studies carried out by foreign organisations at the request of one or other of the two countries or synthesis reports prepared in the interests of "public relations". In both cases, the information gathered is rarely totally impartial and the opinions held by the editors are quite clearly expressed in the conclusions.

SITE BOUNDARY

Covering 51.5 km^2 (between km 1842 and 1868), the catchment lake will be the largest in Europe. All trees on the site of the future reservoir have been felled which implies that even if the surface area of the reservoir for alternative "C" is only half as large, the land impact remains the same. Most of this region was covered by alluvial forest and represented a leisure area for the inhabitants of Bratislava and the surrounding region. Certain of the destroyed areas represented well-known areas of great interest in terms of their flora and fauna.

In their synthesis report (4), the project managers created a difference between "temporary" and "permanent" occupation, without defining the significance of these terms. Data is given for both countries and for all work. These are as follows:

Farming land	3,766 ha of which 1,037 "temporary" ha
Forests	4468 ha of which 782 "temporary"ha
Buildings	561 ha

SEDIMENT STORAGE

Although the Danube's solid waste is already reduced by German and Austrian dams located upstream, the river at this level still transports 6.9 million tons of sediment a year. Part of this load, precisely estimated at 68.1 - 73.4% by the contract managers (4), will be deposited on the reservoir bed. This deposit will not be uniformly spread and range from a few centimetres in the calm accumulation zones to a few millimetres in more turbulent zones.

It should be noted that heavy metals and hydrocarbons are absorbed by this sediment, as can be seen by the analyses (3).

The extraction of this sediment will become necessary as from 2010. The cost of the work will be compensated by the use of the sediment for public work and to enrich arable land (5). An additional constraining cost could intervene if the pollution level (particularly the heavy metal content) made it difficult to use and store these materials.

Condition n° 10 imposed by the Slovak Environmental Commission (concerning the construction of alternative "C", which requires that "*the storage of sediment dredged from the bed of the reservoir be outside the Zitny Ostrov protection zone, in a form guaranteeing the protection of the quality of the soil and underground water sources*", proves that this hypothesis has even been considered by the project managers. All of which gives a very poor impression of the quality expected from the sediment that they expect to find on the reservoir bed.

Another proposed solution, which envisages a massive flushing out of the sediment to the bed of the old Danube, would have disastrous effects on the ecosystems.

The lack of sediment downstream from the dams would increase the erosion caused by the river. Sediment deposited at this level would be picked up and deposited further downstream, causing modifications to the river hydrodynamics even further downstream. The bed would hollow out and the normal water level would fall ("incision" phenomenon). This reduced water level would lead to a depression of the groundwater table and a progressive drying out of the peripheral floodable areas, caused by reduced frequency and extent of flooding (see below).

ALTERATION TO WATER QUALITY IN THE RESERVOIR

The reduced speed of the current, the resulting increased temperature and the clarification of the water through settlement of solid loads, favours the development of algae. Their growth is fed by nutrients (nitrates and phosphates) contained in the water originating from domestic waste and leaching from farm land.

This eutrophication could become critical and seriously reduce the oxygen content of the water, particularly in calm or shallow areas.

The deterioration of the exogenous and endogenous organic matter (product of the eutrophication) settled on the bed can create anaerobic and reducing conditions. This mechanism is further encouraged by the absence of water movement and leads to a vertical stratification and confinement of the lower layers.

IMPACT ON WATER RESOURCES

In its flow from a mountainous region down to the plains around Bratislava, the Danube has, over its geological history, created the largest alluvial table reservoir in Europe, representing 14 km3 of drinking water. The aquifers to either side of the border, Zitny Ostrov (wheat island) in Slovakia and Szigetkîz in Hungary, have a capacity of approximately 1 million cubic metre per day. On one side, they supply Bratislava and its surrounding region, and represent a providential potential resource for the Hungarians who are having to come terms with continuing reduction in the capacities of their water catchments, some of which now have pollution problems. This aquifer could supply 60% of Hungary's drinking water.

The increased water height compresses the filtering sedimentary layer, separating the river from the aquifer. The immediate effect of this is to increase the flow of water percolating through the aquifer. Thus, the actual flow rate of 10 to 40 m^3/s (depending on sources) between Bratislava and Komarno would be increased to 120 m^3/s after filling of the reservoir. The catchment capacity would increase from 10 m3/s to 16 m^3/s.

This mechanism is progressively cancelled out by the settlement of fine particles (due to the reduced water velocity) which block this natural filter. One estimates that the infiltration flow would fall from 120 to 15 m^3/s over a five year period. In the long term, the drinking water resources obtained through this filtration would be quantitatively reduced (3).

To compensate for this blocking, it suggested that infiltration boreholes could be made in the reservoir to permit large quantities of water to enter the aquifer.

The underground water in the Zitny Ostrov region are already polluted by nitrates produced by agricultural activities. The contents exceed normal drinking water standards in certain areas. Industries cause local contamination, such as the Slovnaft petrochemical complex which contaminated the wells supplying the area to the east of Bratislava between 1970 and 1975 (3).

The creation of a reservoir could lead to the contamination of underground water as the pressure exercised on the polluted deposited sediments could force the pollutants through the filtering layer and thus contaminate the aquifer. If reducing conditions developed in the sedimentary layer (see above), the heavy metals adsorbed and fixed to the deposited sediments could be moved even further through the interstitial waters and contaminate the underlying groundwater table.

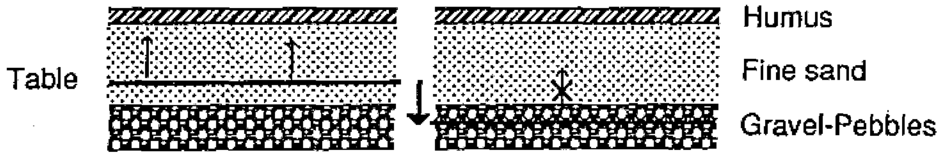
To study this hypothesis, on-site clogging tests were carried out. These showed a complete clogging after a certain period, a reduction in dissolved oxygen (from 7-10 to less than 1 mg/l) and the development of reduction conditions (3). The contamination of the groundwater table by heavy metals can therefore not be discounted and is even probable.

According to the authors, infiltration excavations could reduce or remove these risks by locally eliminating this reducing layer and by providing more oxygenated water. Nevertheless, they do not indicate what the consequences of these excavations might be on the efficiency of the natural filter. The question remains as to whether they might not in fact make it easier for pollutants to penetrate.

IMPACT ON FARMLAND

Upstream, the filling of the reservoir would lead to a rise in the groundwater table level in the surrounding area. The average rise is estimated at 0.5 m and this would lead to a permanently flooded condition over a 50 km^2 area (3). The quality of the soil would be appreciably modified, with consequences to the natural environment as well as to farmland and agricultural practices.

Downstream, the groundwater table would fall (3, 4), but the only values available are those provided by the Ecologia group (2): 2.5 m. This fall would bring the average level of the table down to its lower extremes where capillary phenomena is not possible (see diagram).



This region, called the "island of wheat" (Slovak territory) is particularly favourable for agriculture, despite low rainfall, due to the dampness caused by the groundwater table.

Some indications show that 26,000 hectares of farmland would be dried out with subsequent considerable production losses. This provision in natural water would need to be compensated by restricting and costly irrigation systems.

IMPACT ON ECOSYSTEMS

Ichthyofauna

In terms of the reservoir, all populations, especially the fish population, will be affected by the transformation of their habitats. All freshwater species or species requiring the presence of sand or gravel during their cycles will be eliminated and replaced by lacustrine or more opportunist species.

The work also represent an obstacle for migrating species, should there be any left! Nonetheless, a fish ladder is to be provided at Dunakiliti (which will not be used if alternative "C" is built) and a similar project was abandoned for the Gabcikovo station because the fish could use the lock (it was not explained whether or not they would have to pay a toll to use it).

The old Danube.

However, the most important impact is that concerning the 31 km of the river located between km 1842 and 1811 which will be bypassed by the development. If alternative "C" is built, this portion will be extended to 41 km between km 1852 and km 1811. It is envisaged, as stated by condition n°8 imposed by the Slovak Environmental Commission, that this moving back of the dam by 10 km would accentuate the draining of the groundwater table from the old riverbed.

This area corresponds to a fossil delta of the Danube and is characterized by the development of a dense and complex network of interconnected secondary channels and oxbows. The minor rocky banks of the bed and the flood protection dike demarcate an "active" alluvial plain submitted to regular flooding which covers 4,000 ha, 70% of which is used for willow and poplar plantations and 30% being covered by water. This region, whose vitality depends on regular flooding, is already affected by the lowering of the average level of the river following its dredging to improve navigation.

It is unanimously recognised that the geomorphological and ecological characteristics of this area make it a river system that is quite unique in the central European environment (6, 4).

The "active" alluvial plains also provide an important self-purifying function for the surface and underground waters, and largely conditions the richness of the rivers as they are indispensable to the vital cycles of a large number of aquatic species (6).

The current average 2,000 m^3/s flow of the river (minimum of 600-700 m^3/s) will be considerably reduced in what could be called the "old Danube" once the dam is operating. Under pressure from protest movements, the reserved flow and the anticipated compensation methods were modified. Initially, the reserved flow represented 50-200 m^3/s without any compensation measures and the riverbed would have been lowered by 3 to 4 m, draining the groundwater table. As from 1988 and until recently, a groundwater table refilling system had been designed which consisted in (3, 4):

- A guaranteed reserve flow of 350 m3/s.
- The creation of rockfill weirs making it possible to maintain a water level with a 350 m^3/s flow, corresponding to a natural flow of 1,340 m^3/s.
- A weekly discharge of 1,300 m^3/s to drain away the fine sediment which, in association with the dikes, represents a natural flow of 2,200 m^3/s.

If the aim of the system were really to combat the fall in the level of the groundwater table, it nonetheless remains unclear whether it would guarantee the integrity of the alluvial ecosystem. The flowing river would become a succession of lakes containing stagnant water which would be swept through by the daily discharges and where overflows would be artificially controlled. The consulted documents presenting this system (3, 4) included no information as to its impact on the ecosystems.

The construction of these weirs requires the cooperation of the two frontier countries. The conflict that currently exists between them is not propitious to this type of cooperation and, in all probability, will delay the work. In the meantime, there is a need to ensure a reserve flow greater than the forecast 350 m^3/s, to the detriment of the production of electricity. In its condition n°18, the Slovak Environmental Commission indicated that this flow should be between 1,300 and 1,500 m^3/s for half of the year (March to September), which is far from negligible. This particularly direct level of competition between ecological and economic interests has had a number of consequences, especially since it would be easy to blame the responsibility for any lack of water in the old Danube bed on the Hungarians, by accusing them of having prevented the installation of weirs.

Recreational and tourist developments

Because they appear to be of secondary importance, the recreational and tourist developments forecast for the project are often neglected in terms of their impact. They include (3):

- Over a 10 km by 500 m strip along the banks of the Danube upstream from the reservoir, with half of this area being in a floodable zone: sports infrastructures, boating area, fishing area, small recreational islands on the Danube.

- On the right bank of the branch canal which has become a 15 km island following construction work: development of an intensive tourist area, creation of hotel complexes with a maximum capacity of 6,550 visitors, social and commercial facilities and encouragement in the creation and renovation of residences.

- On the left bank of the canal: creation of recreational and tourist complexes in liaison with the potential development of balneological stations.

In its report (pages 100-103), HYDRO-QUEBEC INTERNATIONAL states that these developments appear to be rather too great, given the ecological capacities of the environments under consideration, that the development plans appear to have been prepared without having been submitted to an environmental evaluation and that no alternatives have been analysed.

RISKS OF ACCIDENTS

Geological and seismic risks

Hungarian specialists draw attention to the lack of data in the geological and seismic sectors and to the number of risks existing due to this lack. They particularly criticize (1):

- The insufficiency of the preliminary geological studies.

- The non-integration of Hungarian and Slovak research which was separately carried out.

- The fact that Gabcikovo is built next to a geologically young fault.

- The uncertainties concerning the position of the frontier between the Alpine and the Trans-Danube tectonic plate.

- The underestimation of seismic risks.

- The insufficient safety of the reservoir dikes, particularly due to the risks of "land liquification" risks.

It is beyond our competences to arbitrate a dispute in this sector and, consequently, we turn to the HYDRO-QUEBEC INTERNATIONAL experts report (1990) which states (p.79): *"it was necessary to review the evaluation of the potential subsoil liquification... By the updating of the seismic data used during the design phase... The updating of tectonic data. By the review of the evaluations of the densities of materials that might be subject to liquification ".*

We do not know if these measures were taken.

However, the reports specifies (p.81): "*The elements of data presented make one presume that such a review would not modify the design conclusions*"

Finally, a last point (p.83): "*the delays incurred by the project are worrying and are not favourable from a work safety point of view:*

- The prolonged maintaining out of water of the parts designed for submerged operation risk reducing their operational lives and increasing the risk of deterioration.

To this end, an anticipatory filling of the supply canal should be seriously considered.

- The filling of the work with water should be subject to a great deal of planning with the Hungarian parties and be carried out in such a way as to avoid any precipitate actions..."

To conclude, we believe that over and above the technical discussions and competences of the Slovak engineers which we do not question, the delays incurred by the project, the difficulties that Hungarians and Slovaks have in cooperating with one another and the current desire to rush through the construction of alternative "C" (including the construction of new dikes), does not represent a favourable context for setting up the highest levels of safety.

Risks of flooding

A further question mark lies over the reliability of the system in terms of its design, to ensure protection against flooding. By splitting the flow into two, it should provide better protection from "normal" flooding.

Nevertheless, as explained by Mr. Liska, representing the HYDROCONSULT firm, the project manager, in answer to my questions (see annexes): "*Man's activities upstream from Bratislava: deforestation of mountains, construction of houses, reduction in the permeability of the soil and reduction of flooding, have caused increased flow and a reduced natural retention level. As a result, the flooding high water levels are rising... The August 1991 flood has been evaluated and the level was much higher than in the past (up to 1 metre).*"

This statement admits the failure of the developments in protecting against flooding (there are more than 40 dams upstream from Bratislava) and designates the causes: increased surfacewater and reduction of buffer zones to absorb the floods. The result is an increased amplitude of flooding and more serious consequences.

This implies two points insofar as Gabcikovo is concerned:

- Can we be sure that the increased amplitude of flooding (recent phenomenon) will not lead to the capacities of the system being exceeded (old project) in exceptional circumstances? As the volume of water transits through the branch canal at a height of 18 m above ground level, any overflowing could have serious consequences.

- Inasmuch as the system contributes to reducing the buffer flooding areas, it participates in increasing flooding downstream. As a result, what happens at the junction between the old riverbed and the outlet canal?

The efficiency of the system also depends on the way it is operated and on the competition between the functions to be provided: the production of electricity requires the reservoir to be full but the protection from flooding is more efficient if the reservoir is empty and can absorb part of the flow. The increased surface water and the amplitude of the floods described above contribute to increasing the propagation of flood waves, and this limits the operator's capacity to anticipate situations. As the surface area of alternative "C" is reduced by half, its absorption capacity is reduced by the same amount.

The recent experience, particularly in the Rhine, has shown the failure of systems aimed at controlling flooding. The size of Gabcikovo makes it even more important that these risks be analysed as far as is humanly possible. The Slovak Environmental Commission agrees with this point of view, as shown by its conditions 15 and 19 (see annexes).

The project managers anticipate that the dam will be able to operate on a peak flow basis if the flow rate exceeds 1,200 m3/s, although the downstream systems have not yet been built. When questioned on this subject, Mr. Liska (Hydroconsult) confirmed this hypothesis but did not indicate whether any studies had been carried out on the impacts of this type of operation (see annexes).

SOCIAL AND POLITICAL IMPACTS

The construction of the dam has had direct impacts on the adjoining populations. 250 families have had to move and their houses destroyed. The small villages of Dobrohorst, Vojka and Bodisky, located between the branch canal and the Danube river bank will have to suffer the difficulties of being isolated once the canal is filled, inasmuch as they will have to use a boat to reach the rest of the region. The forecast tourist developments imply radical modification to lifestyles which, for a large part, will exclude the existing populations. As we were able to see, the exodus has already begun.

Gabcikovo has also modified the social climate in the region. The unhappiness of the local people, submitted to the negative effects of the project and excluded from the decision-making process (both before and since the political transformation of the country's politics), is a factor that heightens social tensions. This is aggravated by the current political recuperation, manifested by the fact that the local residents are mostly made up of the Hungarian ethnic minority. Their protests are therefore interpreted by certain nationalistic political factions as being "anti-Slovak" activities.

Gabcikovo has been a key element in the political relations between the Czech and Slovak republics. For the latter, the more impoverished sector of the federation, this dam represented a factor in their economic wealth, their independence in terms of power (in 1989 Slovakia only produced 82% of the power it consumed) and their national pride.

It might well be thought that as far as the Czechs and the federal authorities were concerned, Gabcikovo was a good sacrifice to make to avoid the Federation being broken up. This might partially explain the Federation's alignment around the Slovak positions during negotiations with the Hungarians.

The announced partition of Czechoslovakia has done nothing to resolve the problem, inasmuch as there is now a need to negotiate the rights to the revenue produced by this dam (production of electricity) which was partially financed by federal funds.

Finally, Gabcikovo is a source of tension between Hungary and Czechoslovakia and/or Slovakia. The conflict between the two governments associated in its construction, and which led to the unilateral termination of the treaty linking them to Hungary, has developed on the back of historic bitterness.

The construction of alternative "C" risks seeing this conflict raise its head once more as Hungarian experts see it as being a violation of international law and, in particular, a de facto modification of the frontier (1). In fact, the Trianon treaty fixed the frontier as being the main navigation channel, which will now be modified. The Slovaks challenge this interpretation and the dispute will either be settled by negotiations between the two parties (so far, badly started) or by internationally recognised authorities.

Conclusions

- *The construction of the dam has had major impacts on the environment, but its filling and operation risk causing even more serious impacts.*
- *The most serious threats concern the quality of the aquifer in this region, the largest in central Europe, as well as the integrity of the alluvial ecosystems along the banks of the Danube where it has been diverted by the project. The two systems represent a major ecological and economic interest.*
- *A certain number of questions remain concerning the safety of these work and their capacity to anticipate flooding.*
- *The discussions between the experts from both camps concerning these impacts and their consequences, although highly polemic, show a lack in environmental studies. The Slovak Environmental Commission has implicitly recognised this failure by imposing 19 conditions which determine the issuing of the building permission for the "provisional" solution (alternative "C"). These conditions are no less than a complete programme for a vast impact study.*
- *The role of these environmental studies were, in any case, limited as there was never any question that they could seriously modify the project. In addition, the time period imposed on the studies recommended by the Slovak Environmental Commission (1 year) places the seriousness of their conclusions in question.*
- *Gabcikovo also has social and diplomatic impacts which need to be very seriously considered. It represents a major tension in a part of the world that already has enough problems.*

GABCIKOVO AND THE PRODUCTION OF ELECTRICITY

INTRODUCTION

It should first be reiterated that at the very beginning, the project did not integrate the production of electricity. The modifications made at the beginning of the 1970s to introduce this function had major consequences as it raised the total cost by 40% and largely increased the environmental impacts.

In the documents supplied by the HYDROCONSULT firm analysing the economic value of the dam (4,5), the production of electricity is considered as a net profit. However, this is only true if it meets a quantitative need both now and in the future and if the production is coherent with the most applicable energy strategy. Is this true for Gabcikovo? To answer this question, we need to analyse the country's present and future energy policy.

The data given below is extracted from the "Energy in the Danubian Countries - Current Situation and Outlooks - Energy Policy Proposals" report, written by the International Concil on Energy (ICE), within the framework of the Equipe Cousteau programme "The Danube ...For Whom and for What?" (7).

PRODUCTION AND CONSUMPTION OF ENERGY IN CZECH AND SLOVAK REPUBLICS

Czechoslovakia has major lignite resources (8.4 billion tons, half of which being economically exploitable) and coal (1 billion tons), most of which is found in the Czech republic. There is little oil, but a natural gas field, estimated at 15-20 billion cubic metres, has recently been discovered in Slovakia.

The exploitable hydroelectric potential is estimated at 10863 GWh, of which 2650 GWh produced by the Danube. 68% of this potential is located in Slovakia (7360 GWh), including all of the Danube's potential.

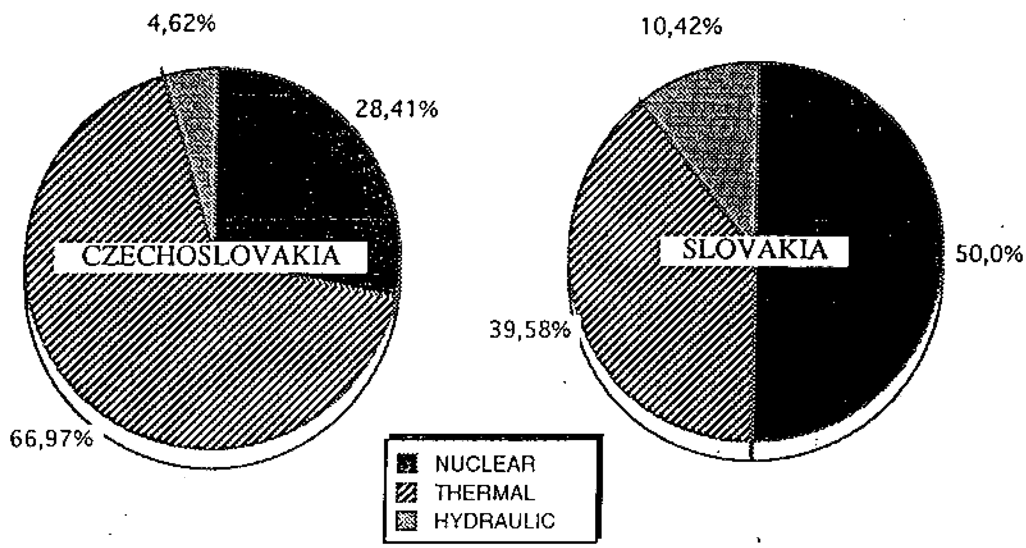
Resources in other renewable energy sources is fairly poor, but could be developed in the biomass sector.

Czechoslovakia provides 60% of its energy consumption, the rest being imported, with nearly all of this (90%) from the ex-USSR. In terms of electricity, net imports represent 2.6 TWh (10^9·KWh), being 2.9% of total production in 1989 for Czechoslovakia and 1 TWh, being 4.1%, for Slovakia.

The main primary energy source is coal (57% of total consumption) and then, in order: oil (21.1%), gas (12.5%), nuclear (8.7%), hydroelectricity (0.5%). Total consumption of primary energy in 1989 represented 73.7 millions toe (ton of oil equivalent), being a consumption per capita of 4.64 toe and greater than that of western Germany (4.44) which is the largest consumer in the EEC.

The primary energy intensity (primary consumption/GNP) is equal to 0.80, being twice that of eastern Germany (0.40) and three times that of Italy (0.26).

Total electricity production in 1990 was 86.8 TWh (for the first time a reduction of the previous year's production: 89.2 in 1989), of which 11% provided by industry, in Czechoslovakia, and 24.1 TWh in Slovakia. The main source of electricity in Czechoslovakia is thermic coal, whilst nuclear energy is more important in Slovakia (see diagram below). Hydroelectric production in 1990 represented 4 TWh in Czechoslovakia and 2.5 TWh in Slovakia being, in both cases, just over 30% of the economically exploitable potential.



Breakdown of electricity production according to sources in 1990 (Source: Czechoslovakian statistical year-book)

The final consumption of electricity (total consumption minus transport losses and self-consumption by the stations) in 1989 was 85 TWh, most of which being used by industry (59.2%).

Similarly to energy, electric intensity is very high: 0.92, being two to three times greater than the values of EEC countries (western Germany: 0.56, Italy: 0.36).

The essential point is therefore the overconsumption of energy and electricity. This is the result of the previous energy policy which was based around production and resulted in a low level of efficiency in terms of production and consumption systems. This overconsumption is a heavy weight to bear in the country's current transformations. It is incompatible with a modern economy.

FORECASTS: ANALYSIS AND DISCUSSION

The federal energy authorities forecast (1991) two scenarios for the development of consumption: a "high" corresponding to favourable economic conjuncture and a "low" corresponding to a particularly unfavourable conjuncture. These are developed in the following table, to which we have added the corresponding electric intensity values.

According to these scenarios, the electric intensity will reduce a little over the next 15 years but remain far greater than current European values or, in the worst case, continue to remain abnormally high. In both cases, the overconsumption of electricity will represent an unacceptable burden for the economy, which itself has a great potential.

In comparison with the above, the scenario developed by ICE corresponds with the hypothesis that states that the electric intensity in 2010 will be the same as the current European standard (0.50) (see table), with a 2% GNP growth from 1992 to 2000, then 3% from 2000 to 2010. This aim is reasonable and could be attained by setting up a rational electricity use programme (7).

The result is a 23 TWh reduction in final consumption by 2010, being around 30%. This reduction is even greater in absolute values in terms of production: 26 TWh. If the same reduction rate is applied to Slovak production, a savings of 6.5 TWh is obtained.

The different scenarios for the development of electricity consumption in Czechoslovakia

Final Consumption	**1990**	**2000**	**2005**	**2010**
High scenario (TWh)	85	88.9	96	
Low scenario (TWh)	85	84.5	87	
Intensity. high scenario (KWh/$)	0,92		**0,72**	
Intensity. low Scenario (KWh/$)	0,92		**0,94**	
ICE scenario (TWh)	**85**	**65**	**64**	**62**
Int. ICE scenario (KWh/$)	**0,92**	**0,70**	**0,60**	**0,50**

BENEFITS OF GABCIKOVO

Does Gabcikovo meet the quantitative needs for the future?

As shown above, Czech and Slovak Republics do not need any more electricity up to 2010 or even beyond. From this point of view, Gabcikovo serves no purpose.

Is Gabcikovo coherent with the most relevant energy strategy?

Priority actions in terms of energy should be aimed towards making the greatest savings. At best, Gabcikovo will only produce between a quarter and a fifth of the savings that Slovakia might be able to attain according to our scenario (see table below). In terms of our calculations, we have excluded the hypothesis of a shared production with the Czech republic following partition.

	Gabcik.production initial project without Nagymaros **1.7 TWh**	Alternative "C" without thresholds **1,15 TWh**	Alternative "C" with thresholds **2 TWh**
Relation with possible savings up to 2010 in Slovakia (6,5 TWh).	26%	18%	31%
Relation with possible savings up to 2010 in Czechoslovakia (23 TWh).	7%	5%	9%

The creation of new production sources has a double negative effect:

- It accentuates overproduction.
- It deviates financing which could be invested in far more important activities, such as modernising industry.

To illustrate this latter point, we offer a simplified but demonstrative example: what would be the consequences of replacing lightbulbs in Czech and Slovak Republics by "low consumption" lightbulbs? We have carried out a feasibility study for this type of operation in Bulgaria, and have retained the principles for this example.

The initial *hypothesis* is that residential lighting in Czechoslovakia uses 75 W incandescent bulbs, with one bulb per inhabitant (conditions met in Bulgaria), used for an average of 5 hours a day.

All these lightbulbs are replaced by 18 W "low consumption" lightbulbs producing an equivalent amount of light.

The electricity company makes the initial investment and replaces the lightbulbs. It reimburses itself on the users' bills by not taking the reduced consumption into account (the electricity bill does not go up for the consumers). The given cost of the bulb corresponds to a bulk purchase, but could be reduced if local production was developed or created.

The calculation elements and results are given in the following table.

	Slovakia	Czechoslovakia
Number of inhabitants	5,275,000	15,639,000
Power saving in MW (75 W-18 W x N° inhabitants)	around 300	around 890
Energy saving per year in TWh (gained power x 5 h x 365 days)	0.55	1.6
Initial investment in millions of Crowns (1 bulb = 300 Crowns)	1,58	4,692
Cost of energy saved per year on the basis of the sales price to private individuals (1 KWh : around 2 crowns) in millions of crowns.	around 1,100	around 3,200

It can be seen that if a billion and a half Crowns were invested in Slovakia (around 364 million Francs or 73 million $), the following energy savings would be made:

- Approximately the power of Gabcikovo in its continual flow configuration. But unlike the dam's production, the savings would nearly all be made during the peak period, as people light their homes in the evening.
- Depending on the configuration, half to quarter of its energy production.

The initial investment is reimbursed in under two years on the basis of the sales price to private individuals during peak period (source: Tariffs of Electrical Energy in Czechoslovakia, April 1991 - Czech Power Work, Prague).

It is clearly more advantageous to invest in the economy rather than in production. A new power station, whether it be gas run (cheapest solution) or nuclear (the most expensive), producing a quantity of electricity equal to that saved, would represent an investment 5 to 10 times greater, whilst retaining an identical service (lighting) to the consumer. The difference could be allocated to the modernisation of industry which, in turn, would generate greater energy savings and lead to greater amount of capital being freed to jump-start the country's economy.

This type of operation would also make it possible to develop new technologies, producing products that could be exported to the east as well as to the west. Finally, unlike the construction of a new source of production which does no more than bet on future developments, this operation ensures that savings remain the same no matter what developments there are in future requirements and production costs.

Gabcikovo can therefore only be of interest as a substitution to an existing source, in other words replacing thermal or nuclear stations.

The thermal stations in Slovakia produced 9.5 TWh in 1990, including industrial installations (source: Czechoslovakian statistical year-book). Gabcikovo could replace 14 to 25% of this production.

It might be considered that in the current situation, Slovakia would do better to use its own lignite resources which are sufficient to supply its power stations. The advantage of the substitution is therefore essentially environmentally based.

Therefore, in order to evaluate the situation, there is a need to compare the respective environmental effects of the dam as against a 14 to 25% reduction of the total pollution generated by the thermal stations. This exercise falls outside the scope of our investigation, but should take into account the fact that the modernisation of thermal stations through the introduction of more efficient and less polluting technologies is, in any case, inevitable.

Insofar as nuclear stations are concerned, Slovakia has 4 VVER-430 reactors atBohunice, two of which will be closed in mid-1992 according to the statement made by the Czech authorities in June 1990 (8). Four reactors, currently being built at Mochovce, are the object of an EDF contract to ensure that they comply with European standards (9). We do not know what the effects of partition will have on the above points.

In all, the Slovakian nuclear stations produced 12 TWh in 1990.

The risks linked to the operation of old reactors and the problems linked to waste management demand careful examination of all replacement possibilities. Nevertheless, the production level offered by Gabcikovo is largely insufficient and cannot be realistically seen as a replacement. In addition, the current construction of four new reactors completely contradicts this possibility.

ALTERNATIVES

Major efforts being made in terms of the rational use of electricity could make it possible to reduce needs and remove some of the energy constraints shackling the economy. There would then be a greater freedom in the choice of energy sources and the weight they would have in balancing the country's energy resources.

Basing itself on its scenario, the ICE proposes a development in the Czech energy balance up to 2010. The broad outlines are as follows:

- Reduced use of coal whilst retaining a certain production level allocated to the production of electricity or heat, using high performance technologies (fluidized bed).
- Development of renewable energies and, in particular small hydroelectric plants, the biomass (which has a potential of 3 million toe).
- Reduced oil consumption, with use limited to transportation.
- Development of gas use, particularly for producing electricity, with diversification of supply sources (Norway, maybe Algeria, the future Iran-Europe gas line, exploitation of reserves discovered in Slovakia).

- No new nuclear reactors should be built after the commissioning of Mochovce; the priority aim for capital should be to modernise industry.

Conclusions

- *The Czech and Slovak republics are characterised by a particularly high overconsumption of energy and electricity which exacerbates the difficulties encountered in developing their economies.*

- *Efforts made in terms of energy efficiency could allow these countries to attain energy intensities comparable with those that currently exist in Europe by 2010. Electricity consumption would then be lower than its current level: 23 TWh for all Czechoslovakia and 6.5 TWh for Slovakia.*

- *In this context, the electricity produced by Gabcikovo meets no requirements for the future and is worthless in terms of quantity.*

- *The capital invested in Gabcikovo has been subtracted from actions that are far more important to the country's economy. Although it is not possible to redirect the initially invested capital, part of the 5.7 billion Crowns (1.3 billion Francs, 260 million dollars) recently earmarked for the construction of alternative "C" could have been used to carry out operations to improve the efficiency of economically profitable electricity production installations. This would have led to energy savings at least equal to the Gabcikovo production. The difference could have been earmarked for modernising industry which, in turn, would lead to greater energy savings and thus provide capital for new investments. This solution would have set up a dynamic favouring the revival of the country's economy.*

- *The value of Gabcikovo as a source of energy substituting existing sources (thermal and nuclear) can only be evaluated within the framework of an overall redefinition of the country's energy strategy. Nonetheless, it would appear to be relatively unimportant in quantitative terms.*

GABCIKOVO AND NAVIGATION

INTRODUCTION

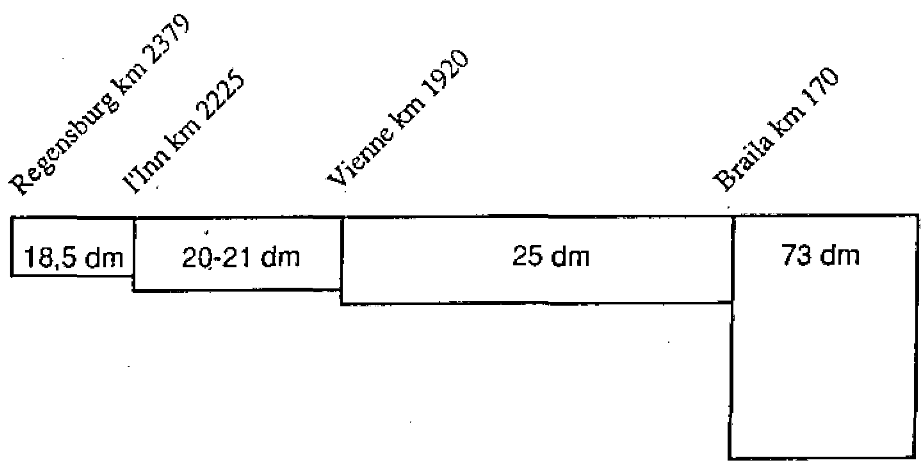
Evaluating the advantages of a project like Gabcikovo requires an overall assessment which includes the following phases:

- Clearly set out the existing traffic hindrances caused by bad navigational conditions and define the developments and investments required to remedy the problems.
- Establish a forecast on the potential future traffic using the Danube, taking the developing economies of the local populations and the opening of the Rhine-Main-Danube canal into account. This will make it possible to define the quantity of traffic that will use the river as a result of the developments.
- Evaluate the profits to be gained from the increased traffic and the improvements that would be made to the fleet following the developments, and identify the beneficiaries.
- Compare these profits with the costs of the developments in order to calculate the profitability and their economic and social efficiency.

This assessment was studied within the framework of a programme, "The Danube... For Whom and for What?", defined by the Equipe Cousteau and carried out by Patrice Salini: "The future of navigation on the Danube" (8). We based ourselves on this study to prepare this chapter.

IDENTIFICATION OF NAVIGATIONAL HINDRANCES AND NECESSARY DEVELOPMENTS

The navigational conditions on the Danube are characteristic of those to be found on a river where large sections have free-flowing currents. Sandbanks, alluvial deposits and rocky beds create thresholds where the depth can be under that recommended by the Danube Commission (see diagram).



Gauges recommended by the Danube Commission (source: Routier du Danube)

The main problems are caused by the Hungarian-Slovak and the Slovak sectors as the recommended depth (25 dm) is only attained 35% of the days of the year. These problems are further exacerbated as they occur during periods when other sectors of the Danube are navigable.

The main area where a respect of the Danube Commission recommendations represent a clear advantage is on the Vienna-Budapest bottleneck.

The thresholds do not just concern the sector to be developed by Gabcikovo (km 1858-1811), as a number of other sectors lie downstream from this section (see Routier du Danube). They would even be worsened by the creation of the dam, due to a lowered downstream water level and the presence of rocky riverbeds which make dredging difficult.

In itself, Gabcikovo does not resolve navigation problems and this simple assessment should be sufficient to show that Gabcikovo is not a factor in terms of navigation.

However, we need to go into greater detail. The development of the Danube bottleneck requires major work to guarantee the desired depths. According to the Danube Commission, they would need to include a set of 4 dams equipped with double locks, located next to Vienna, Hainburg, Wolsfthal and Nagymaros. These work, excluding Gabcikovo and electricity production investments, would represent a billion dollars, being 707 million, with value updated at 8%.

These values were calculated for locks and dams corresponding to the characteristics imposed by the Danube Commission, using simple estimation calculations used in France and on the basis of 1990 French prices.

PROSPECTIVE ANALYSIS OF THE FUTURE TRAFFIC ON THE DANUBE

One of the characteristics of countries giving onto the Danube is the hypertrophy of the transport systems in comparison with western countries. The traffic level is comparable with that in European countries, whilst the GDP is 3 to 5 times lower. To maintain the level of transport intensity (Transport/GDP) at its current level up to 2020 is difficult to imagine. For a country like Czechoslovakia, traffic would then be comparable to that which currently exists in France and this would be enormously expensive and difficult to accept in such a small area. It is far more probable that the transport level will match that of EEC standards.

In addition, it is possible to forecast that the essential transport needs in the future will be for flexible, well organised and rapid transportation systems. This particularly requires the development of road and, to a lesser extent, rail infrastructures to make it possible to meet the needs of the internal markets.

The development of traffic along the Danube will depend on the future of certain branches of activity representing its potential commercial basis. The challenges offered by the future of these strategic factors are detailed in the study prepared by P. Salini, which we have used here for the Bratislava and Slovakian regions.

The river traffic in Slovakia represents 8 million tons, of which 2.5 million involving international traffic. The remainder concerns local trade (sand and gravel) over an average distance of 19 km. Slovakia essentially uses the Danube to import minerals and scrap iron from the ex-Soviet Union and to re-export scrap iron and metals to Rei, Izmail and, more particularly, Linz.

The current use of the Danube is therefore concentrated on two market segments: building materials and the Czech steel industry. This latter still receives 80% of its ore from the ex-Soviet Union and 1.3 million tons is transported by the Danube. Its development (modernisation rather than expansion) should increase the quantity of ore imported by boat. Despite this, its future is extremely precarious as only the iron and steel industry in Kosice and eastern Slovakia would appear to remain competitive in today's context. However, its geographical position excludes use of the Danube.

In addition, the Linz iron and steel industry is in competition with the Czech iron and steel industries. This leads to a paradoxical situation whereby the two potential traffic flows on the Danube are in contradiction. If the Linz iron and steel industry develops and increases its ore traffic on the river, the Czech iron and steel industry as well as its associated traffic would be endangered.

To conclude, it is probable in the future that ore (1.3 million tons) will no longer be transported along the Danube and that there will be a growth in the importation of semi-finished laminated products (0.5 to 1 million tons) following the penetration of the Linz iron and steel industry into the Czech market. The growth of local traffic ought to continue as long as the river diversion work have not been completed. However, this local traffic will decline once work are completed (the volume of transported materials between 1981 and 1990 is estimated at 20 million cubic metres for the sector concerning Czechoslovakia).

The transport of cars could grow following the agreement signed between VAG and the Bratislavske Automobilov Zadovy company but will nevertheless only represent a low tonnage.

In his conclusions on the future traffic along the Danube, P. Salini states that:

- The development of the Danube artery will be directed towards the North Sea.

- The role played by the improvements to navigational conditions is limited. It is concentrated on the Vienna-Budapest bottleneck and is relatively unimportant beyond that point when seen in relation to the overall traffic movement.

- The potential for development is not entirely sure due to competition from other forms of transport, especially by rail, which will probably increase. The introduction or transferral of traffic is far from sure.

In overall terms, the traffic will increase from 34.7 billion tons/km in 1989 to 55.5 billion tons/km in 2020. 11 billion tons/km shall be introduced or transferred over to other transportation systems as a result of the developments, and the remainder of the gain will simply be due to economic growth.

ECONOMIC EVALUATION OF THE DEVELOPMENTS

Profitability

The overall traffic needs to be broken down into three categories:

- Traffic which gain very little from the new developments on the Danube, particularly between Vienna and Budapest.

- Traffic which will continue to use the Danube but will benefit from the developments as these will make it possible to use more laden and frequent convoys. This advantage was estimated by examining the difference between the cost price for vessels transporting 2,500 tons and vessels and convoys transporting up to 8,000 tons.

- Traffic introduced or transferred to other forms of transport. The standard formula is to consider that the advantage is equal to the half product of the divergence of the generalised transportation cost by the traffic under consideration.

It is therefore possible to evaluate the overall cost of the advantages for navigation resulting from a theoretically complete development of the river bottleneck.

For the reference year under consideration, 2020, the sum represents 78.3 million dollars, 33.2 for traffic introduced or transferred due to the developments (3rd category) and 45.1 for the advantages linked to increased productivity of the fleets (2nd category).

It should be reiterated that the development work represent a sum of 707 million dollars, with an updated value of 8%. The chosen hypothesis is the starting up of all development work in 2000, and a progressive increase in traffic over that same period. The cost of Gabcikovo is not taken into account.

We can therefore, using updated values, compare this sum with the advantages offered to navigation. The advantages are evaluated at 180 million dollars, using the hypothesis that only the direct advantages linked to the development of the Vienna-Budapest sector are taken into account, and at 360 million dollars using the hypothesis that a more overall level of advantages is used (see table).

As a result and up to 2020, the advantages for navigation represent 50% at best of the amount of the required work.

Updated balances 1992-2020	Previous traffic	New traffic or traffic brought in from others transport sectors	TOTAL
Direct effect of development	150	30	180
Indirect effect (productivity)	90	90	180
TOTAL	240	120	360

Balances at 8%		Internal profitability
Overall balance favourable hypothesis = 360-707 million $	- 347 million $	2,5 %
Balance restricted to direct effects = 180-707 million $	- 527 million $	- 2,6%

The development of the Vienna-Budapest sector does not represent any direct level of profitability for navigation: the internal profit rate is negative.

The impact of these investments on the overall productivity of the fleet is far from negligible but does not offer any significant profit: a maximum of 2.5%.

The beneficiaries

The awaited advantages offered by the development of the Vienna-Budapest sector do not include all countries giving onto the Danube. The two main beneficiary zones are the CIS (Ukraine and Moldavia) and Romania (its agriculture and the port of Constanza) for exports and Austria and its iron and steel industrial complex for imports. Over and above these two zones, the Hungarian and Serb economies hope to capture some of these profits.

However, these advantages are only really strategic when it comes to the Austrian iron and steel industry as this is where it positions itself on the central European market, a sector which may well represent its long term survival. The only way for this iron and steel industry, located 1,700 km from its two supply port, to retain its advantage is to improve transportation systems. In fact, the RMD canal, far from leading to more traffic on the Danube as has all too often been claimed, will simply create a higher level of competition. The potential of increased traffic towards the East and the West do not add up together, the traffic will find itself divided. A slight difference in fees could lead traffic to use one port rather than another.

We are led to a paradox whereby what the developers of the dam have advanced as an economic advantage (improved navigational conditions) will in fact lead to endangering and accelerating the decline of the Slovak iron and steel industry due to the competition offered by Linz. This is a clear example of an oversimplified logic in terms of economic evaluation.

Priority investments

A more overall assessment needs to be made of the transport systems in this part of the world.

The development of exchanges between countries in this region and with the rest of Europe demands an important level of investment into infrastructure network. The lack of bridges, adapted roads and railway lines meeting European technical standards is such that the priorities become self-evident.

The needs also concern port infrastructures which, at present, are either inefficient or deficient. Massive investments are required in these areas and should also concern the accesses to the port installations. To equip the ports, link them to their surrounding regions, favour the setting up of transport organisation network able to deal with grouped cargoes and distribution, could well be more important than making investments in the river itself.

If the aim is to economically develop the Danube and give it a chance of survival, then there is a need to invest in the structures around the Danube.

Conclusions

- *Navigational problems essentially concern the Vienna-Budapest sector and, in itself, Gabcikovo cannot resolve them. This elementary statement is sufficient to show that Gabcikovo serves no purpose in terms of navigation.*

- *To resolve the problems, there is a need to build 4 dams. This represents a 1 billion $ investment, being 707 million $ based on values updated at 8%.*

- *On the other hand, the advantages for navigation would attain an overall amount of 78.3 million $ by 2020. In updated values, these advantages would represent 180 million $ in the lower hypothesis and 360 million $ in the hypothesis where a more overall view of the advantages is taken into account.*

- *The development of the Vienna-Budapest sector does not offer any direct profit for navigation: the internal profit rate is negative. The impact of these investments on the overall productivity of the fleet is far from negligible but does not offer any significant profit level: a maximum of 2.5%.*

- *The only direct beneficiary from these developments would be the Austrian iron and steel industry for whom they would offer powerful position for the future. It might then, by offering direct competition, endanger and accelerate the decline of the Slovak iron and steel industry.*

- *However, the analysis shows that it is essential, inexpensive and profitable to invest in the structures around the Danube.*

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ANNEXES

APPENDIX 1

Questions asked on April 3, 1992, to Mr. Liska
Hydroconsult - International Affairs
and answers

ASPECTS FINANCIERS

1 Quelles-ont été les sources de financement du projet depuis son origine, et quel type de contrat lie les investisseurs, les gouvernements Tchèques et Slovaques, les entreprises qui réalisent le projet ?

2 Quel est le coût total du projet aujourd'hui ?

Il y a certaines différences dans les documents que vous m'avez fournis : dans le "rapport de synthèse" on parle de 25 billions (10^9) de Kcs, alors que dans "Gabcikovo-Nagymaros project - basic informations about its actual state and perspectives" on annonce 20 billions de Kcs. Quel est le bon chiffre ?

3 Quels sont les coûts annuels des intérêts correspondant aux sommes prêtées ?

Dans "Gabcikovo-Nagymaros project - basic informations about its actual state and perspectives" page 28, vous annoncer 2 billions de Kcs par an *("each year of delay causes a loss exceeding two billion Kcs only on interests")*. Ce chiffre parait très élevé, le confirmez vous ?

4 Quels sont les montants des dédomagements réclamés par les Tchécoslovaques et les Autrichiens aux Hongrois pour avoir interrompu les travaux de leur côté ?

J'ai lu dans une revue spécialisée qu'il s'agissait de 3,52 billions de $ pour les Tchécoslovaques et 1,296 billions de $ pour les Autrichiens. Ces sommes paraissent très élevées (environ 5 fois le coût total des travaux) : les confirmez vous ou s'agit-il d'une erreur ?

5 Quel est le coût estimé de la réalisation de l'alternative C ?

Il y a là des informations contradictoires : M. Holcik (lors de la réunion du 24/2/92) nous a dit 8,5 billions de Kcs, vous annoncez 5,7 billions dans *"The Gabcikovo-Nagymaros project - latest developments in 1991"*, et le rapport de synthèse d'Hydroconsult indique 2 billions de Kcs. Quel est le bon chiffre ?

6 Etant donné les difficultés économiques que traverse la Tchécoslovaquie, de telles sommes sont-elles disponibles pour une solution dite "temporaire", et quelles sont les sources de financements envisagées ?

PROCESSUS DE DECISION

7 Pouvez-vous nous expliquer comment sont prises les décisions concernant Gabcikovo : attribution des financements, choix techniques, définition des études d'impact ? Quels sont les organismes compétents et quels sont les rôles respectifs des gouvernements Fédéral et Slovaque dans ces processus de décision ?

8 L'alternative C a été choisie parmi 7 autres solutions : Comment ce choix a t-il été fait, selon quelle méthode et quels critères d'évaluation, quels paramètres ont-été pris en compte, et qui a réalisé ce travail ?

9 Le choix de l'alternative C est-il définitif, ou d'autres solutions sont-elles encore à l'étude ?

PRODUCTION D'ELECTRICITE

10 Quelles sont la puissance installée et la production d'électricité prévues dans le cadre de l'alternative C ? Et selon quels calculs ces prévisions ont-elles été faites ?

11 Envisage t-on de faire fonctionner Gabcikovo en mode de pointe dans le cadre de l'alternative C, et si oui une étude d'impact a t-elle été faite sur les conséquences pour l'environnement de ce mode de fonctionnement ?

12 Pourriez vous m'indiquer de façon détaillée les éléments de calcul de la rentabilité de Gabcikovo en ce qui concerne la production d'électricité ?

NAVIGATION

13 Si la création du grand canal facilite la navigation, les problèmes sont aggravés en aval (creusement du lit et présence de seuils rocheux) : comment ce problème pourrait-être résolu dans le cadre de l'alternative C ?

14 Selon quel mode de calcul a-t-on évalué les bénéfices consécutifs à l'amélioration des conditions de navigation sur le secteur de Gabcikovo, pour les économies Tchèques et Slovaques ?

PROTECTION CONTRE LES CRUES

15 Depuis 1965 le Danube a beaucoup changé, il a en particulier été aménagé de façon importante en amont de Bratislava avec des dispositifs de régulation des crues. Dans ces nouvelles conditions, les risques d'innondation sont-ils les mêmes aujourd'hui ?

En Août 1991, il y a eu une crue centénale : a t'on fait une étude sur les conséquences de cette crue pour évaluer les changements survenus depuis 1965 en ce qui concerne les risques d'innondations dans le secteur de Gabcikovo ?

16 Dans le cas d'une crue importante :

- Si un problème technique à la centrale de Gabcikovo limite l'écoulement de l'eau, n'y a t-il pas un risque à faire transiter des débits considérables à 18 m au dessus du niveau du sol dans le grand canal ?
- Si les débits sont séparés en deux entre le canal et l'ancien lit du Danube, que se passe t-il, en cas de débits importants, à la jonction du canal et du fleuve ?

IMPACTS SUR L'ENVIRONNEMENT

17 La Commission Slovaque pour l'Environnement a prescrit 19 points qui devraient être respectés avant la mise en route de l'alternative C :

- Comment se fait-il que les travaux aient déjà commencé alors que les 19 conditions n'ont pas encore été étudiées ?
- Le respect de ces conditions implique la réalisation de mesures compensatoires importantes et coûteuses : a-t-on évalué les coûts de ces mesures ? Quels sont-ils ? A t-on pris en compte ces coûts dans les calculs de rentabilité de Gabcikovo ?

Réponses aux questions du Fondation Cousteau de 3.4.92

ASPECTS FINANCIERS :

1. Sources de financement du projet : le budget du Ministère des Eaux et des Forêts de la République Slovaque. Le Ministère Fédéral des Finances a réparti chaque an les ressources financières entre les ressorts. Un contrat financièr entre les gouvernements Tchèque et Slovaque n'a jamais existé.

2. Coût total actuel du projet (1991) :

	en milliard Kčs
- projet original, partie ČSFR	20,44
- projet original, partie des travaux au lieu de RH	0,42
- protection contre les crues	0,20
- mesures environnementales dans le lit ancien	0,41
- solution temp.jusqu'à la mise en opération (el.129,0)	2,56
- solution temporaire, achèvement des barrages (el.131,1)	2,12
- usine hydroélectrique (éventuelle)	2,71
- total	28,86

Le "Rapport de synthèse" donne les coûts au niveau de 1989 ($18,4.10^9$ Kčs - v.p.37) et le chifre 25.10^9 Kčs (p.62) comprend aussi les intérêts pendant la construction.

3. Coûts annuels des intérêts : zero, parce que jusqu'à ici le financement a été sans prêts. Les pertes intercalaires nous calculons avec un taux d'escompte de 8 %.

4. Montants de dédommagement : D'après notres informations, la RH devait payer à l'Autriche 2,9 milliard Schilling dans la forme de l'énergie électrique 1,2 TWh/an depuis 1994 à 2013. La somme des dédommagements pour ČSFR n'est pas encore complète. Mais seulement la valeur de l'énergie perdue (si on abandonne le projet) est de 6.10^9 Kčs/an, environ. Capitalisée avec un taux de 8 pourcent, ca fait 75 milliard Kčs. Avec les coûts des investissements nécessaires, pour assurer la protection contre les crues et amélioration des conditions de navigation sur le Danube et Váh (tout a été inclu dans le projet G+N) et avec les autres bénéfices perdues, les pertes peuvent monter à une somme proche à 100 milliard Kčs, ce que représente 3,5 milliard US$.

5. Coût estimé de la réalisation de l'alternative C :
Les chiffres indiqués dans le point 2.. correspondent avec les chiffres de M.Holčík. La somme 5,7 milliard Kčs est sans usine hydroélectrique, qu' on va réaliser seulement, si la RH ne va changer son avis, ni après la mise en opération de Gabčíkovo.

6. Coût approprié d'une solution temporaire : Etant donné les difficultés économiques de ČSFR, nous ne pouvons pas perdre 6 milliard Kčs par an. Nous avons esseyé presque trois ans, de trouver une solution commune, parce que nous ne considérons pas la solution C comme idéale, mais nous n'avons pas un autre choix. Les sources des finances pour cette solution vont être prêts, qui peuvent être repayés dans délays assez courts.

PROCESSUS DE DECISION

7. Rôle des gouvernements dans le processus de décision :
D'après la répartitions des compétences, le développement des ressource énergetiques appartient aux gouvernements nationales, mais dans le cas d'un investissement international, le Ministère Féderal des Affaires Etrangères est compétente pour les négotiations bilatérales. C'est la raison, pourqoi les décisions sont pris dans tous les deux gouvernements.

8. Choix de l'alternative optimale :
Tous les solutions alternatives ont été évaluées dans six commisions spécialisées, des points de vue suivants :
- rélations et loi internationales (poids 7),
- influence sur les ressources de l'eau souterraine (poids 7),
- faisabilité économique (poids 6),
- l'influence à l'environnement (poids 5, par Min. elevé à 6),
- les influences sociales et psychiques (poids 3),
- possibilités et risques de la réalisation (poids 3),
- l'hygène et épidemiologie (poids 3),
- préference de l'entrepreneur (poids 1).
Les chefs des commisions respectifs ont inventé, ils mêmes, les critères évalués et ils ont proposé aussi les poids des critères. L'évaluation des alternatives a été fait par moi, en-

semble avec les chefs des commisions spécialisés. Avant de présenter le rapport au gouvernement, le Ministère des Eaux et des Forêts a augmenté le poids du critère environnemental et des ressources des eaux souterraines. La solution optimale a été l'alt.A (d'après la Traité), puis l'alt.C, la seule qui a été réalizable sans coopération de la RH et faisable économiquement.

9. Le choix, est-il définitif ?
Si l'Hongrie changerait son avis et accepterait un compromis, s'ouvrirait aussi la possibilité B - finir ensemble Gabčíkovo et ajourner la décision de l'achèvement de Nagymaros.

PRODUCTION DE L'ELECTRICITE

10. Paramètres énergétiques de l'alternative C :
- puissance instalée 720 MW
- production d'electricité annuelle - premiers ans 1,34 TWh
- après la constr.des seuiles dans le lit ancien 2,33 TWh.

11. Mode de fonctionnement d'usine, alt.C :
On n'envisage pas le fonctionnement en mode de pointe, sans l'existence de Nagymaros. Mais, quand les débits surpassent 1100 - 1200 $m^3 s^{-1}$, le surplus on peut stocker dans le reservoir et lâcher pendant la journé, dans la forme d'une onde modérée.

12. Eléments de calcul de rentabilité :
Prix de l'electricité (au niveau du prix de l'import): 2 Kčs/kWh,
partie appartenante à ČSFR (d'après les coûts) 85 % .
coûts d'opération - 0,8 pourcent des coûts d'investissement.

NAVIGATION

13. Problèmes de navigation en aval de Gabčíkovo :
Les problèmes de navigation peuvent être solués seulement par le complex des aménagements G + N. C'est une des raisons, pourquoi l'article 1 du Traité parle "d'un investissement commun, composé de deux aménagements hydrauliques Gabčíkovo et Nagymaros qui font une unité, inséparable en fonction." Lui, qui veut sépa-

rer cet unité, devait refléchir les conséquences et proposer une solution. La partie Hongroise n'a pas proposé aucune solution pour le cas d'abandonnement total du projet, ni pour la navigation, ni pour la protection contre les crues. Mais les problèmes avec la navigation en aval de Gabčíkovo, ne sont pas liés spécialement avec l'alternative C.

14. Bénéfices de l'amélioration des conditions de navigation :
Dans l'évaluation économique du projet, faite en 1980, on a calculé seulement avec des bènéfices de ČSPD (companie tchécoslovaque de navigation). On a estimé ces bénéfices à une valeur 5,4 Kčs/t dans le secteur de Gabčíkovo et 2,7 Kčs/t dans le secteur de Nagymaros. Le volume des marchandises transportées (en million tonnes), dans les horizons différents on a estimé comme suit :

comme suit :	1990	1995	2000	2050
Volume total transporté	14 04	20,63	30,31	60,71
Partie de ČSPD (pourcent)	7,00	9,50	12,00	22,00
Volume transporté par ČSPD	0,98	1,96	3,64	13,36
Bénéfices calculés (million Kčs/an)	7,94	15,87	29,46	108,18

D'après notre avis, les bénéfices sont souestimés. Nous n'avons pas supposé la collection des taxes des bateaux étrangères passant les écluses. Les bénéfices de navigation ont fait une partie moindre des bénéfices totaux (environ 2 pourcent).

PROTECTION CONTRE LES CRUES

15. Les risques d'innondation, ont-ils changé depuis 1965 ?

Les activités de l'homme amont de Bratislava : deforêstation des montagnes, construction des maisons, réduction de perméabilité des surfaces dallées et réduction des inondations- causent une augmentation d'écoulement et réduction de la rétention naturelle. Donc les points des crues montent. Les solides sedimentés surhaussent le niveau du terrain de l'inondation. Pendant chaque crue, la dégradation du sousol par suffosion s'aggrave - le nombre des "renards" et leur diamètres s'agrandent, le débit de l'eau infiltré monte. La crue d'août 1991 a été evaluée. Le niveau d'eau a été beaucoup plus haut comme avant (jusqu'à 1 m).

16. Passage d'une crue important :

Il y a huit groupes à la centrale - la probabilité d'avoir un problème technique à plusieures groupes est très faible. Mais, une partie significant du débit, peut être lâchée par les deux écluses de largeur de 2 x 34 m. La possibilité de divider le débit des crues, permet de lâcher une demie du débit plus rapidement par le canal, pendant que l'autre demie se transforme par la retention naturelle de l'innondation. Comme ça, on peut modérer la tête de la crue.

IMPACTS SUR L'ENVIRONNEMENT

17. 19 conditions de la Commission Slovaque de l'Environnement :

Toutes les conditions préscrites, devaient être acquittées avant la mise de Gabčíkovo en opération. Les mesures compensatoires sont inclus partiellement dans les coûts d'investissement, partiellement dans le volume abbaïssé de l'electricité produite pendant les premiers ans d'opération. On a ajouté au budget de projet environ une milliarde Kčs pour la construction des stations d'épuration de Bratislava (coté droite) et d'autre villes et villages lelong de Danube. La recherche concernant l'eau souterraine de la region danubienne - fait en coopération avec des firmes danois et hollandaise - est financé par le programme PHARE

18. Quelles seriont-ils les conséquances d'abandonnement du Gabčíkovo à l'environnement ?

Le processus d'érosion du lit de Danube va continuer. Pendant la dernière decade des années, le niveau des débits bas s'abbaissé jusqu'à de 1,5 m. L'abbaissement correspondant des eaux souterraines a causé sèchage des forêts voisines, tassement additionnel du terrain, causant des fissures des maisons. Les niveaux d'eau abbaissés empirent aussi l'accès difficil au port de Bratislava. Si l'érosion va emporter la couche épaisse des graviers quartères aval de Bratislava, l'explosion d'érosion des formations fins tertiaires, peut créer une chute d'eau arrêtant la navigation.

19. Quelles provisions a-t-on assuré dans le projet de Gabčíkovo pour maintenir la nature danubienne dans une meilleur condition ?

On a construit une prise d'eau au début du canal, qui permet de lâcher continuellement 30 m^3s^{-1} dans le système des bras morts et maintenir une humidité optimal des sols, contrôlée par le monitoring. Un barrage mobil permet d'augmenter ce débit jusqu à 240 m^3s^{-1}, ce que va permettre de créer une inondation artificielle de 80 pourcent du terrain entre le Danube et des digues anciennes. Une autre prise d'eau permet de lâcher continuellement un débit de 20 m^3s^{-1} au Mosony Danube et diluer son forte pollution. Par le barrage (Dunakiliti ou Čilistov), un débit moyen de 600 – 1300 m^3s^{-1} va assurer, au début de l'opération, le niveau d'eau nécessaire dans le lit ancien du Danube, pour éviter l'effet de drainage de lit vide. On prévoit une construction des seuilles (comme sur le Rhin) qui vont assurer un niveau d'eau correspondant au débit de 1350 m^3s^{-1}, mais avec un débit lâché du barrage seulement 350 m^3s^{-1}. La diminuation de la chute moyenne du Danube va arrêter définitivement le processus nuisible d'érosion.

20. Etat actuel et impact envisagé de Gabčíkovo aux eaux souterraines de la région ?

Les eaux souterraines sont alimentées de la section de Danube entre les km 1849 – 1866, où les couches aquifères montent au niveau du lit, formé par des gravières perméables. Le volume d'eau, qui alimente les ressources souterraines est en présent 2 – 8 m^3s^{-1}. Maintenant, on utilise seulement 2,0 – 2,5 m^3s^{-1}. Si on veut augmenter l'utilisation à 15 m^3s^{-1} en 2015, sans Gabčíkovo, c'est impossible. La couche superficielle de l'eau souterraine, jusqu'à une profondeur de 40 m est si poluée, qu'on ne peut pas l'utiliser ni pour irrigation (à présent, en absence de sources meilleurs, on l'utilise, enrichissant le sol par polluants). Le reservoir va augmenter l'infiltration, surhausser le niveau d'eau souterraine aval de Bratislava et procurer en abondance l'eau propre dans les canaux d'infiltration. L'eau du reservoir va alimenter en préférence la couche superficielle de l'eau souterraine, parce que le coefficient de perméabilité dans la direction horizontale est environ dix fois plus grande comme dans la direction verticale (les couches de qualité différente existent sans se mélanger, depuis des dizaines des années). Il existe une possibilité théorique de contamination des eaux souterraines par les sédiments organiques du reservoir. Mais pratiquement, les conditions sur le Danube ne vont pas permettre l'eutrophisation de léau dans le reservoir (bon qualité, température bas, haut quantité dóxygène, court delai de retention, hauts débits en été et basses en hiver), qui conditionne perte d'oxygène et les réactions réductives produissants la pollution. Les premiers résultats des études et de la tas de recherche, fait en collaboration avec des firmes ouest-Européen ont preuvées, qu'on peut effectivement influencer les processuses de sédimentation et d'infiltration dans une manière désirée, donc, la menace d'une catastrophe n'est pas actuelle.

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REMAINING APPENDICES OMITTED

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