CHAPTER 5

WATER QUALITY CONTROL PLAN

COMPONENT (1)

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5.1 Basic Policy

5.1.1 Objectives of Water Quality Control Planning

(1) Characteristics of Past Water Quality Management in RS State

Considerable effort has been put into water quality management measures in the State of Rio Grande do Sul, such as construction of sewer systems, monitoring of pollution sources (i.e. factories and corporations), and monitoring of water quality in inflowing rivers and lakes. However, despite the implementation of such countermeasures, water pollution could not be stopped or even improved. One of the main reasons is that these countermeasures did not effectively reduce the pollution loads flowing into Patos Lake.

The following drawbacks have been identified in the water quality management system implemented up until now in the State of Rio Grande do Sul: ① Too much emphasis is placed on the prevention of fecal pollution and not enough on eutrophication; ② The countermeasures target point pollution sources only and neglect nonpoint sources; ③ Pollution is judged in terms of concentration levels rather than on loads; ④ Management by basin unit has only started recently.

(2) Objectives of this Water Quality Control Plan

In reference to the above problems, the objectives of the water quality control plan are as followed: ① Compute the generation loads by pollution source, including nonpoint sources; ② Set target reduction loads by basin and by generation source; ③ Formulate water quality management measures per basin; ④ Promote water quality management measures with the support and cooperation of a wide range of concerned institutions and people.

(3) Progress of Formulation of the Plan

The work progress for the formulation of the plan is shown in **Fig. 5.1-1**. In particular, the following steps will be taken: ① Sort out the issues, ② Decide the policies, ③ Examine the measure methods, ④ Evaluate the countermeasures ⑤ Select the countermeasures, ⑥ Set reduction rates to be obtained through the countermeasures, ⑦ Examine the scopes of the countermeasures, ⑧ Examine the target reduction load, ⑨ Examine whether the target permissible effluent load has been met by implementing the countermeasures, ⑩ In case the objectives have been met, fix the contents and scopes of the countermeasures.

5.1.2 Basic Policies of Water Quality Management (Topics and Policies)

Based on the current conditions of water pollution in Patos Lake as explained in Chapter 2, the generation conditions of each type of load in the basin, and the current water quality management system, basic policies for water quality management will be set separately for each topic.

(1) Resolution of Fecal Pollution (Medium Term Target)

- As coliform contamination is especially high along the lakeshore near Pelotas (Raranjal) and Tapes, domestic wastewater from the towns located near the lake must be treated in priority in order to improve urban environment and prevent water-borne infectious diseases.
- The method adopted to treat domestic wastewater must not only eliminate fecal and organic pollution but also significantly reduce nitrogen and phosphorus through natural purification processes such as wet ponds.
- Treatment of urban domestic wastewater must be distributed over several small districts rather than large areas.

(2) Resolution of Organic Pollution (Medium Term Target)

- As organic pollution is developing rapidly in the rather closed estuary area, the hydrologic cycle must be improved by dredging the bottom for example.

(3) Prevention of Eutrophication (Long Term Target)

- Eutrophication is developing rapidly in the northern and southern areas of Patos Lake. As this phenomenon spoils the merits of the lake and is difficult to remedy, its prevention must appear as an important issue in the water quality control plan.

- Countermeasures which highly reduce the phosphorus level must be adopted, with an emphasis on countermeasures on domestic wastewater and nonpoint sources generating TN and TP – the primary factors of eutrophication.

- In consideration of the basin control plan, countermeasures on nonpoint sources which represent 80% of inflow loads must be implemented in priority on basins with high risks of phosphorus and sediment runoff.

(4) Understanding the Actual Conditions of Pesticide Pollution

- In the course of this study, we have not detected any pesticide pollution in water bodies and fish. However, as large quantities of pesticides are used in paddies and upland crops in the study area, their impact should be monitored through a basic study on pesticide concentrations in the bottom sediments and organisms, to be implemented after this Study.

(5) Reduction of Industrial Load

- In order to reduce the industrial wastewater load, the inadequate industrial effluent monitoring system should be reinforced and a target reduction load should be set in proportion to the effluent loads.

- As the actual situation of industrial wastewater is unclear, an inventory of industrial pollution sources should be established, identifying the sources of generation and discharge of heavy metals and toxic substances.

(6) Resolution of Environmental Information Inefficiency

- Environmental information are scattered between all the concerned institutions and not sufficiently shared. Moreover, the collected data are not used efficiently. To ensure that these information are properly shared, they should be organized into a database and distributed through a network to improve water quality management.

- In order to obtain the cooperation of related sectors, land owners and residents, information should be made available to the public through various events such as symposiums advocating the importance of water quality conservation.

(7) Improvement of the Residents' Environmental Awareness

- Environmental education should be promoted in order to obtain the residents' cooperation in restoration and conservation activities for the water environment.

- As residents in the basin are not very concerned about the water environment, environmental education should be promoted as a means to improve their awareness.

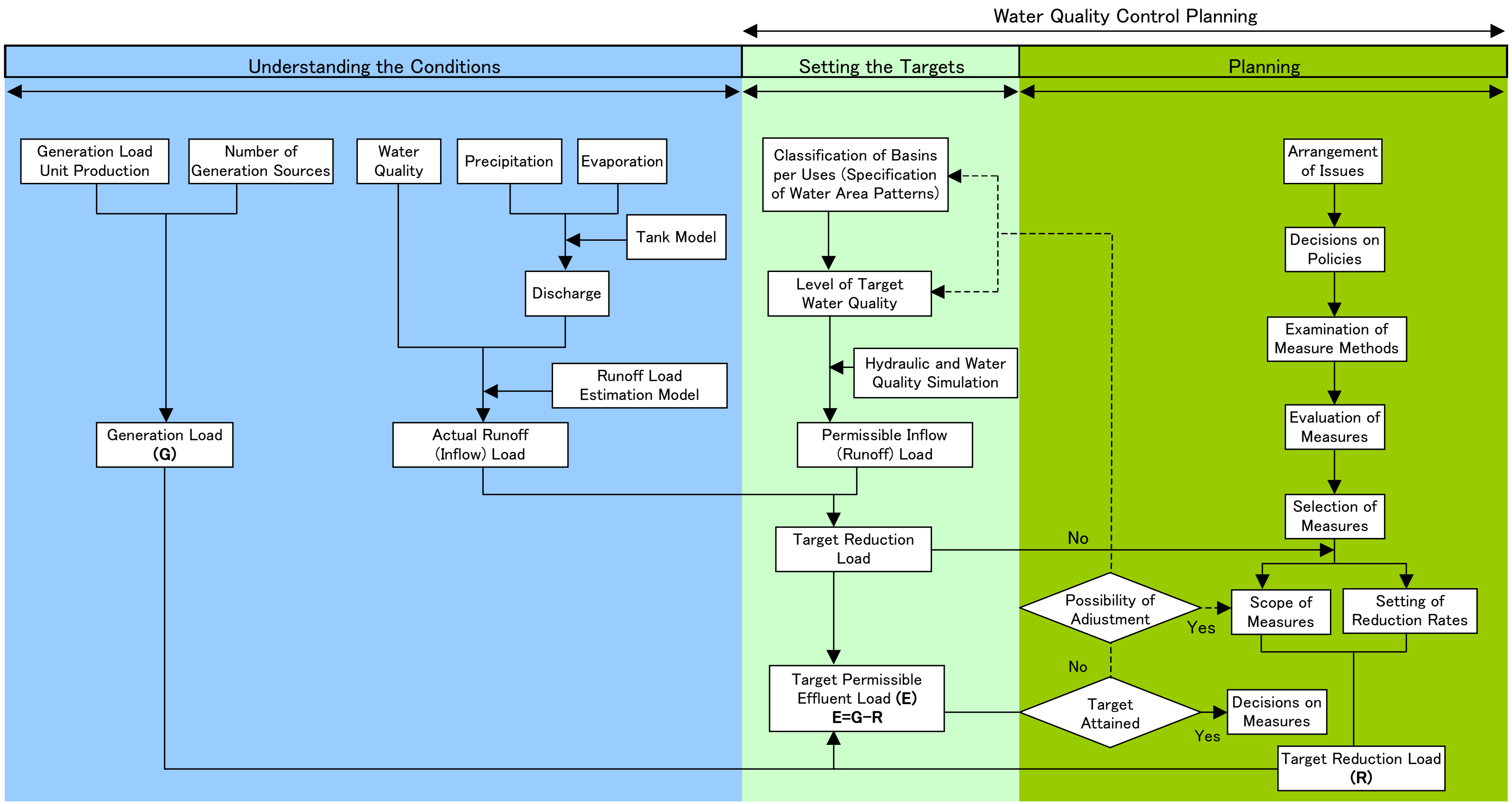


Fig. 5.1-1 Flowchart of Water Quality Control Planning

5.2 Load Reduction Plan

5.2.1 Topics and Composition of the Countermeasures

Load reduction measures, including topics and policies, are outlined in **Fig. 5.2-1**.

As part of the load reduction plan of Patos Lake basin, it will be necessary not only to implement and properly operate and maintain the domestic wastewater countermeasures that have been developed until now, but also implement countermeasures focusing on point source loads, including the promotion of nutrient load reduction measures combining sewage treatment plants with wetlands, and regulating factory wastewater including the monitoring of industrial wastewater countermeasures. In addition, load reduction measures for nonpoint sources, which account for 80% of loads in the basin, will have to be actively promoted in order to further improve water quality.

The medium term target (by 2010) will be to further reduce domestic and industrial loads, and the long term target (by 2020) will be to reduce nonpoint source loads (nutrients), such as agricultural effluents and urban wastewater.

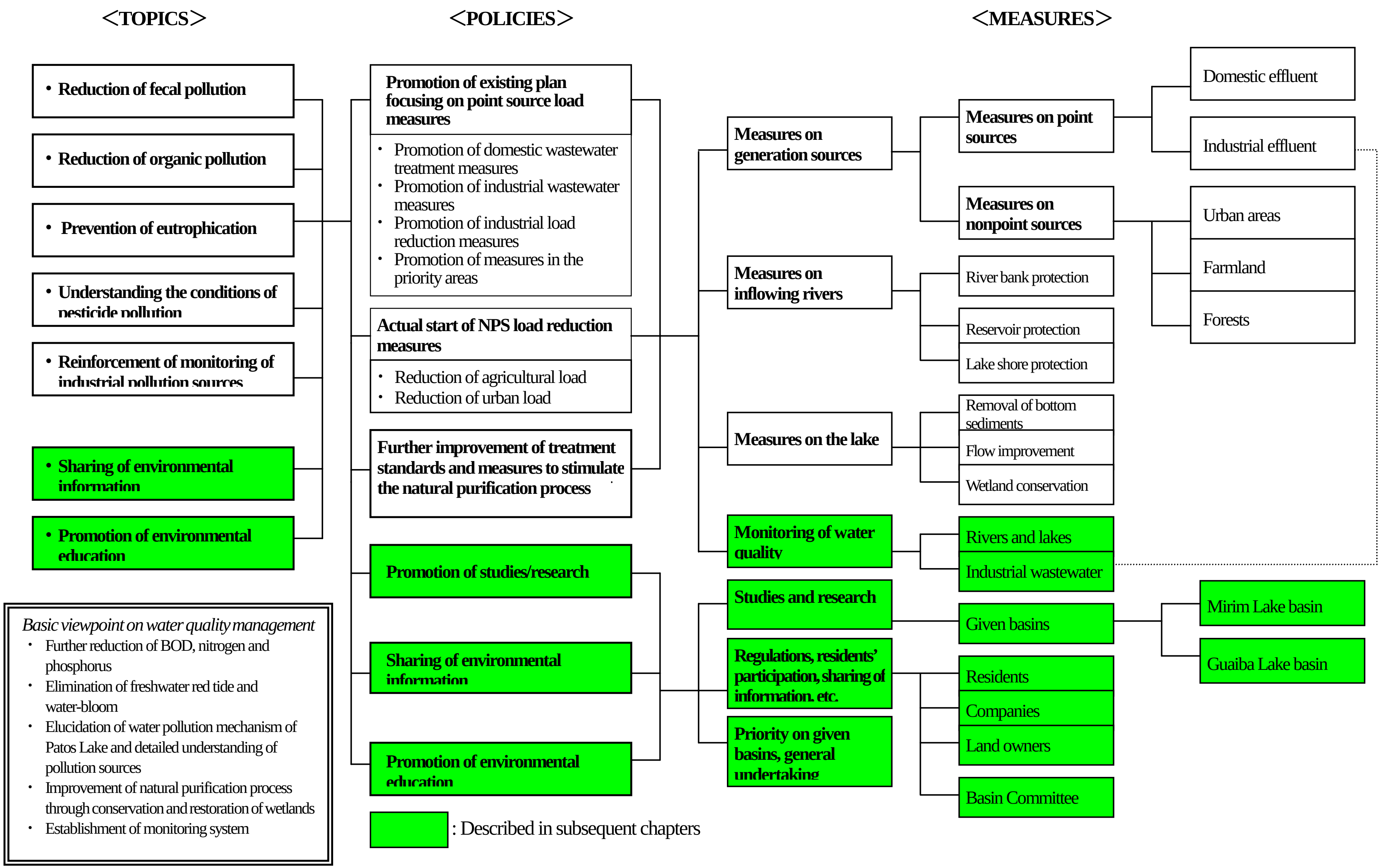


Fig. 5.2-1 Outline of Load Reduction Measures for Patos Lake

5.2.2 Examination of Load Reduction Measures

Fig. 5.2-2 shows the system of load reduction measures for the water quality control plan of Patos and Mirim Lakes. The load reduction measures are shown in **Table 5.2-1**.

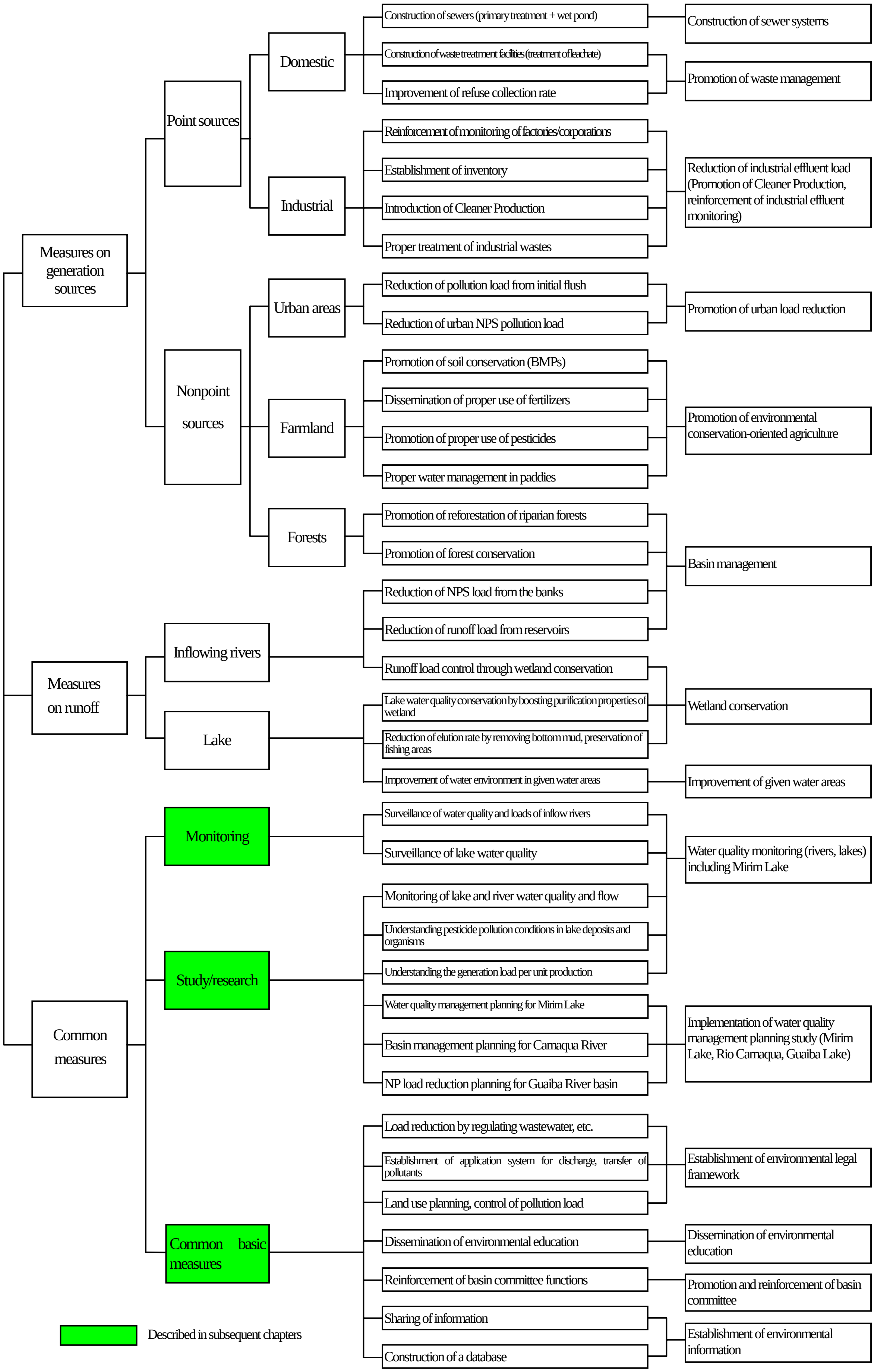


Fig. 5.2-2 System of Load Reduction Measures

Table 5.2-1 Examination of Methods of Load Reduction Measures

Classification			Countermeasures	Principles	Applicable Conditions and Effects	Applicability to Lake and Basin
Generation sources	Point sources	Domestic	• Construction of sewers (sewage treatment (primary) + construction of wet ponds and artificial wetlands)	Elimination of fecal pollution using treatment facilities for domestic wastewater, and reduction of organic pollution and N, P load. (Reduction of N, P load by discharging treated water into wet ponds and artificial wetlands).	• There should be a large wetland near the construction site of the sewage treatment plant. • Low operation/maintenance cost and high effectiveness of N, P removal by using wetlands.	• Highly applicable in the vicinity of Pelotas and Rio Grande because of numerous wetlands (experimentation in Everglades in Florida, U.S.A.) • Many good results in the U.S.A. by using wetlands.
			• Construction of waste treatment facilities (treatment of leachate in existing disposal sites)	Reduction of load from leachate through proper treatment of waste treatment facilities.	• Highly effective if the construction cost can be secured. • Environmental education for the residents must be improved. • Slow results.	• Possible if environmental education is integrated.
		Industrial (factories, corporations)	• Reinforcement of monitoring system for factories and corporations	Establishment and reinforcement of monitoring system for factories and corporations, and reduction of pollution load by recommending effluent regulations and treatment facilities.	• Effluent standards for N, P must be set by industry. • Factories must be obliged to conduct monitoring by assigning effluent management staff.	• Highly applicable if FEPAM monitoring system is established.
			• Introduction of Cleaner Production	Reduction of effluent load of factories and corporations through Cleaner Production.	• Incentives will be necessary to promote the introduction of Cleaner Production.	• Possible if financing facilities and tax relief systems are improved.
			• Treatment and proper management of industrial wastes	Runoff control of industrial load by proper management of industrial wastes.	• Monitoring must be imposed to factory and corporate leaders.	• Highly applicable if FEPAM monitoring system is established.
	Nonpoint source (Best Management Practices)	Urban areas	Reduction of pollution load from initial surge in urban areas	Reduction of loads in urban areas by storing runoff from initial surge in retardation ponds.	• Land must be secured for the construction of retardation ponds, and dredging must be carried out regularly.	• Highly possible if urban parks are converted for multipurpose use.
			Improvement of refuse collection rate	Reduction of load from scattered refuse in urban areas.	• Environmental education for the residents must be improved. • Slow results.	•

Classification			Countermeasures	Principles	Applicable Conditions and Effects	Applicability to Lake and Basin
		Farmland	Promotion of soil conservation measures in farmlands (promotion of BMPs: Best Management Practices).	Reduction of runoff load through soil conservation measures in farmlands (especially upland crops).	• Introduction of measures for farmland on slopes over 5°. • Incentives must be created for farmers.	• First, introduction in model areas.
			Dissemination of appropriate use of fertilizers (reduction of doses, etc.)	Reduction of runoff load through promotion and dissemination of low quantities of chemical fertilizers.	• Incentives for farmers and dissemination of environmental education are necessary.	• Introduction in model areas.
			Promotion of proper use of pesticides.	Reduction of pesticide load by banning toxic agricultural chemicals and disseminating proper use of pesticides.		
			Promotion and guidance on proper water management in paddies.	Control of runoff load from excess water by proper water management in paddies.		
		Forests	Promotion of reforestation along river banks and in coastal areas.	Reduction of runoff load by promoting reforestation along river banks and in coastal areas.	• This will be useful not only for runoff load reduction but also for habitat conservation.	• Possible to introduce together with habitat conservation.
			Promotion of forest conservation	Reduction of runoff load by protecting forests in the basins.	• This will contribute to stabilizing water sources.	• Possible to introduce in combination with environmental education (reforestation).
Runoff	Runoff countermeasures	River banks, lakeshore	Reduction of nonpoint source loads from riverbanks and reservoirs.	Reduction of runoff load by setting riparian buffer zones which prevent soil erosion.	• It will be necessary to secure the budget for the countermeasures. • Results are difficult to quantity.	• Possible to implement if the budget for the countermeasures is secures.
		Reservoir protection	Reduction of pollution load from reservoir protections.	Reduction of runoff load by growing vegetation on bank/shore protections with severe soil erosion.		
		Wetlands, coast	Control of runoff load through wetland conservation.	Water quality protection by preserving wetlands and maintaining water quality conservation functions.		
			Reduction of runoff load through the creation of wetlands	Reduction of loads by creating wetlands, and flowing wastewater through them before discharging it into the lake.		

<table>
<tr><th colspan="3">Classification</th><th>Countermeasures</th><th>Principles</th><th>Applicable Conditions and Effects</th><th>Applicability to Lake and Basin</th></tr>
<tr><td rowspan="3">Lake</td><td rowspan="3">Lake countermeasures</td><td>Sediments</td><td>Reduction of elution load from the lake bottom by removing sediments.</td><td>Reduction of N and P elution loads from the bottom mud through bottom dredging or removal of lake bottom sediments.</td><td rowspan="2">• Reducing inflow load through water treatment and other measures is a preconditions.
• Large funds will be necessary for the removal of bottom sediments.</td><td rowspan="2">• This is difficult to implement at this stage as the removal of bottom sediments will incur huge expenses.</td></tr>
<tr><td>Purification of water bodies</td><td>Environmental improvement of given water bodies.</td><td>Environmental improvement of water bodies through bottom dredging, the introduction of purified water, or the diversion of treated water toward other basins.</td></tr>
<tr><td>Wetlands</td><td>Conservation of purification functions of wetlands.</td><td>Conservation of natural purification function of wetlands, combined with conservation of lake habitat.</td><td></td><td>• Easily applicable in the region.</td></tr>
<tr><td rowspan="2">Monitoring</td><td rowspan="2">Monitoring</td><td>Rivers</td><td>Observation of inflow water quality/load by monitoring inflowing rivers.</td><td>Observation of water quality/load and toxic substances flowing into lakes by monitoring inflowing rivers.</td><td rowspan="2">• It will be necessary to set up a monitoring system, and to secure the necessary funds.
• Load reductions are not directly linked.</td><td rowspan="2">• The establishment of a monitoring system (standardization, etc.) will allow the implementation of efficient load reduction measures.</td></tr>
<tr><td>Lakes</td><td>Observation of lake water quality through lake monitoring.</td><td>Observation of water quality conditions by monitoring the lakes.</td></tr>
<tr><td rowspan="5">Studies and Research</td><td rowspan="5">Studies and research</td><td rowspan="3">Basic studies</td><td>Study on generation load per unit production</td><td>Understanding domestic and industrial generation loads per unit production</td><td>• Determination of values which are indispensable for rational planning.
• Large funds and efforts are necessary for this study.</td><td rowspan="2">• This is possible by cooperating with university research organs and securing study expenses, and if it is implemented according to a plan.</td></tr>
<tr><td>Study on pesticide pollution in Patos Lake</td><td>Understanding the conditions of pesticide pollution in Patos Lake.</td><td>• Large funds are necessary for the analysis of pesticide pollution.
• Although analysis need not be carried out often, many study items are necessary.</td></tr>
<tr><td>Water quality monitoring of Mirim Lake and rivers of Mirim Lake basin</td><td>Monitoring to understand the pollution conditions and mechanisms (loads) of Mirim Lake.</td><td>• It will be necessary to analyze the monitoring results since 1997 and to sort out the required items.
• Observation of flow and water quality of inflowing and outflowing rivers will be necessary.</td><td>• This measure can be implemented by Agencia Lagoa de Mirim which is already monitoring the water quality of Mirim Lake.</td></tr>
<tr><td rowspan="2">Planning</td><td>Mirim Lake water quality conservation planning</td><td>Understanding pollution conditions and mechanisms (loads) of Mirim Lake, and formulation of countermeasures.</td><td>• Planning is required to reduce inflow loads from Sao Goncalo Canal.
• Large funds will have to be secured to implement the study for planning.</td><td rowspan="2">• This will be possible with financial assistance from the Brazilian government and international aid agencies.</td></tr>
<tr><td>Camaqua River basin management planning</td><td>Formulation of a plan to reduce soil and nutrient runoff in Camaqua River basin.</td><td>• Planning is required to reduce inflow loads from Camaqua River basin.
• Large funds will have to be secured to implement the study for planning.</td></tr>
</table>

Classification			Countermeasures	Principles	Applicable Conditions and Effects	Applicability to Lake and Basin
			Guaiba River basin load reduction planning	After reviewing Pro Guaiba, formulation of a plan to reduce NP load in Guaiba River basin.	• Indispensable study for the reduction of inflow loads from Guaiba Lake.	• As this plan is currently in progress, this will be possible to implement after reviewing the budget.
Others	Social foundations (improvement or regulations, environmental education, residents' participation, information sharing)	Improvement of environmental laws and regulations	Regulations on effluents and loads, guidance	Reduction of effluent loads by regulating effluent loads and creating rules for corporations and residents	• Even when making regulations, the key is whether they are respected.	• This is possible if a monitoring system is created and if penalties are imposed.
			Creation of application system for the discharge or transfer of pollutants	Reduction of industrial effluent load by promoting a system of applications for the discharge or transfer of pollutants.		
			Land use planning	Formulation of a land use plan that would allow low runoff of pollution loads		
		Environmental education, staff training	Dissemination of environmental education	Reduction of pollution load through the dissemination of environmental education	• Though the effects will be slow, this will be effective in the long run. • Secondary effects can be expected.	• This is possible by cooperating with environmental NGOs.
		Sharing of environmental information	Reinforcement of the functions of the basin committee.	Conservation of lake water quality by reinforcing the functions of the basin committee.	• The effects will be slow but this countermeasure will be indispensable for future water quality management of Patos Lake and for residents' participation in water quality management.	• Currently, Camaqua River and other basins are starting to get organized, and committees will possibly be set up in all the basins.
			Sharing of information on lake conservation countermeasures	More efficient lake conservation countermeasures through making related study and research information available to residents, researchers, etc.	• This will contribute to the implementation of more effective and efficient environmental conservation countermeasures. • The cooperation of concerned institutions and necessary funds will have to be obtained. • The cooperation of residents, businesses and research institutions will be indispensable.	• This is possible if general institutions are identified and if the necessary funds for the implementation of the countermeasures are secured.
			Creation of database on lake conservation	More efficient lake conservation countermeasures through the creation of a database on the subject.		

5.2.3 Load Reduction Measures Applicable to Patos and Mirim Lakes

The countermeasures which are applicable for the reduction of loads in Patos and Mirim Lakes are as follows.

(1) Load Reduction Measures for Point Sources

1) Domestic Load Countermeasures

① Domestic Wastewater

Despite the fact that all 5 cities of Pelotas, Rio Grande, Sao Lourenco do Sul, Camaqua and Tapes are located near the lakeshore, the treatment rate of domestic wastewater is extremely low. Most of this untreated wastewater is discharged directly into streams, rivers and lakes. As a result, urban waterways and the lakeshore are polluted by fecal coliform, which is unhygienic and prohibits recreational activities.

Moreover, eutrophication is quite advanced in the northern and southern areas of Patos Lake. In addition, organic pollution due to untreated domestic wastewater is quite high in Saco de Tapes, Saco de Mangueira and Rio Grande Harbor, where the hydrologic cycle is defective.

Therefore sewerage treatment must be urgently implemented in the cities close to the lakeshore in order to deal with fecal and organic pollution and eutrophication. In this Study, we will formulate a plan for the provision of sewer systems in these lakeshore cities. Wastewater treatment plants and sewer networks are currently in the planning stage in Pelotas, Rio Grande and a few other cities, but these developments must be hastened.

② Domestic Solid Waste

Refuse scattered in the cities not only become part of the inflow loads toward Patos Lake and the surrounding wetlands, but also hinder the flow of rivers and streams and is detrimental to the sanitary urban environment. Moreover, when it rains, solid waste flows with rain water into the lake and wetlands. It is therefore important to reduce refuse dispersed in the cities as part of the management of the lake water quality.

In addition, pollution due to leachate from the existing waste disposal site is a serious problem in Rio Grande.

Consequently, we will plan the improvement of the collection rate of urban domestic waste and large-size refuse in order to reduce ordinary waste scattered in the streets of these cities, and the treatment of leachate from waste disposal sites.

2) Industrial Load Countermeasures (Factories, Corporations)

Industrial load reduction measures have already been taken, as factories and corporations have the legal obligation to install wastewater treatment facilities and to properly operate and manage them. Therefore, it is indispensable to monitor these activities in order to create an inventory and understand the operation & maintenance conditions of these treatment facilities.

As mentioned in Chapter 2 of the Supporting Report, no comprehensive study has been conducted on the production processes, generation load per unit production and wastewater treatment situation in the factories and corporations in Pelotas, Rio Grande and other locations around the lake. Moreover, the disposal sites of 50% of industrial waste and post-treatment sludge are unknown. Consequently, it will be necessary to establish an inventory of industrial wastewater and solid waste.

In addition, we will plan an increase of FEPAM monitoring staff and a reinforcement of the monitoring system in order to precisely understand the actual conditions of wastewater from factories and corporations. We will also plan the creation of a manual for more rational monitoring activities.

The plan will include the introduction of “Cleaner Production” to the companies which account for a high proportion of load in order to reduce the wastewater load from factories and corporations. Accordingly, it will be necessary to plan incentives to promote this system, such as low interest loans and tax relief. The plan to introduce Cleaner Production is essential, and will be introduced by FEPAM, in cooperation with Cleaner Technology National Center (POA) – SENA (Factory Union Industrial Technology Center).

These industrial (factories/corporations) wastewater countermeasures are described in Section 5.6.

(2) Load Reduction Measures for Nonpoint Sources

As 80% of pollution loads flowing into Patos Lake originate in nonpoint sources, measures to reduce these loads are crucial.

Since 1980, the Environment Protection Agency (EPA) of the United States has been conducting a dynamic research study on nonpoint source load countermeasures. The results were compiled in "Guidance Specifying Management Measures For Sources Of Nonpoint Pollution In Coastal Waters", 1990. According to this manual, nonpoint sources are influenced by a variety of factors such as, topography, weather and geology, and it is important that different suitable BMPs (Best Management Practices) are selected and adopted for each area.

The nonpoint load countermeasures recommended by this manual are summarized in Section 2.5 of the Supporting Report.

As a rule, the present nonpoint load countermeasures must be planned differently according to the areas, such as urban areas, farmlands and forests. This water quality control plan will cover nonpoint countermeasures for farmlands, such as upland crops and paddies, and urban areas.

1) Urban Load Countermeasures

As loads discharged from urban areas account for a large portion, an efficient measure to control the runoff load in urban areas with a high density of population would be to treat initial surge containing large amounts of pollutants. Therefore, the construction of retardation ponds will be planned. In addition, to reduce the pollution load from urban areas, improvement of collection/disposal rate of urban waste will be planned.

2) Agricultural Load Countermeasures

Based on the results of this study, loads discharged from farmland account for a large portion of nonpoint source runoff loads, and countermeasures will be crucial. We will plan the introduction and dissemination of environmental protection-oriented agriculture, which takes into account soil runoff prevention through contour cultivation, which reduces the loads of both N and P from upland crops, and the provision of guidance on proper management of fertilizers and appropriate use of pesticides in order to reduce the amounts of pesticides and fertilizers used for cultivation. For areas highly susceptible to soil runoff, the plan will include the introduction of terraces and forests as well as measures to reduce the loads from N and P combining soil and habitat conservation.

3) Forest Countermeasures

Woodlands often become sources of nonpoint runoff loads due to illegal felling. The plan will include the promotion of reforestation and appropriate forest management in order to reduce nonpoint runoff load from woodlands.

It must be noted that the plan for the reduction of nonpoint source loads is related to the “Plan for the Promotion of Environmental Conservation Oriented Agriculture”, a sub-program of the Plan for River and Basin Management described in Chapter 6. These two plans will be formulated in close cooperation. Soil runoff not only incurs a drop of land productivity but also carries N, P and water pollutants toward the basins and plays a role in raising riverbeds and filling lakes with sediments. Consequently, the plan for the reduction of nonpoint source loads is the most important topic in the Plan for River and Basin Management.

(3) Countermeasures for Inflowing Rivers

Among the rivers and drainage channels flowing through the urban areas of Pelotas and Rio Grande toward Patos Lake, the plan includes purification, by bottom dredging and other methods, of water bodies, especially the most polluted waterways, such as Arroio Pelotas, Canal do Pepino, Arroio Santa Barbara and Arroio Fragata. Also riverbank protection measures will be planned for waterways showing significant bank erosion.

(4) Countermeasures for the Lake (Improvement of Bottom Quality)

The plan will include bottom improvement measures, such as dredging, to improve the hydrologic cycle, as well as treatment of lake bottom, which contains large quantities of nutrients responsible for eutrophication, especially in the closed water areas in the south, such as Saco do Tapes and Saco de Mangueira

(5) Countermeasures for Given Basins

1) Measures to Reduce Inflow Loads from Guaiba Lake basin

The reduction of inflow load from Guaiba Lake, which accounts for 60% of the total pollution loads flowing into Patos Lake, is an important issue for the protection of water quality of Patos Lake, especially in the northern area. The Pro Guaiba program being currently implemented aims to prevent coliform and organic pollution, but does not aim for the reduction of pollution loads from the basin.

Therefore, it will be necessary to urgently revise the Pro Guaiba program so that it includes the prevention of eutrophication in Patos Lake, and formulate a new water quality control plan for Guaiba Lake basin. The present study will plan the reduction by 20% of pollution loads flowing into Guaiba Lake (5 rivers).

2) Measures to Reduce Inflow Loads from Mirim Lake basin

It will be necessary to formulate a plan to reduce the inflow load from Mirim Lake basin which, as previously mentioned, contributes 20% of all pollution loads flowing into Patos Lake. As this basin is shared between Brazil and Uruguay, the analysis of the amount of loads flowing into the lake must be conducted with the cooperation of Uruguay and the Mirim Lake Committee, and it will be necessary to formulate a plan for the reduction of pollution loads from the basin based on mutual understanding between Brazil and Uruguay. Therefore, we will plan the formulation of a water quality control plan for Mirim Lake basin.

5.3 Target Reduction Load

5.3.1 Permissible Inflow Load and Target Reduction Load

The permissible inflow load is taken in the sense of “inflow load which can be assimilated in the lake while sustaining good water quality”. We consider that the permissible inflow load is equivalent to the permissible runoff load, and the difference between the current inflow load and the permissible inflow load is the target reduction load at this stage.

The target reduction load is the amount of load that must be reduced from the current load in order to reach the water quality standard for Patos Lake. Any future inflow load increase must be added (refer to **Fig. 5.3-1**).

At this point, nutrients are the water quality item which largely exceeds the water quality standards set in Chapter 4 for each water area of Patos Lake, and the TN/TP ratio is below 10 for many water areas. So we can say that prevention of eutrophication is an essential environmental issue, and that reducing phosphorus would be an efficient countermeasure. Therefore, using the runoff load estimation model and the hydrologic and water quality simulation model, we computed the TP inflow load (permissible inflow load) which meets the water quality standard for TP in Patos Lake.

Based on this result, by reducing the current TP runoff load by 20% in Camaqua River and Sao Goncalo Canal, and the TP runoff load of small to medium rivers by 50%, it would be possible to approximately reach the TP standard in the center and southern parts of Patos Lake, excluding the south-west area near the lake shore.

This Study targets, in the medium term, the elimination of fecal and organic pollution by 2010, and in the long term the elimination of eutrophication by 2020.

The permissible inflow loads, for the realization of the water quality standard by 2020, are shown in **Table 5.3-1**. Average values for 1996~1997, which are the most accurate values in this study, were adopted as the standard (currently) inflow loads used as a base to fix the permissible inflow load.

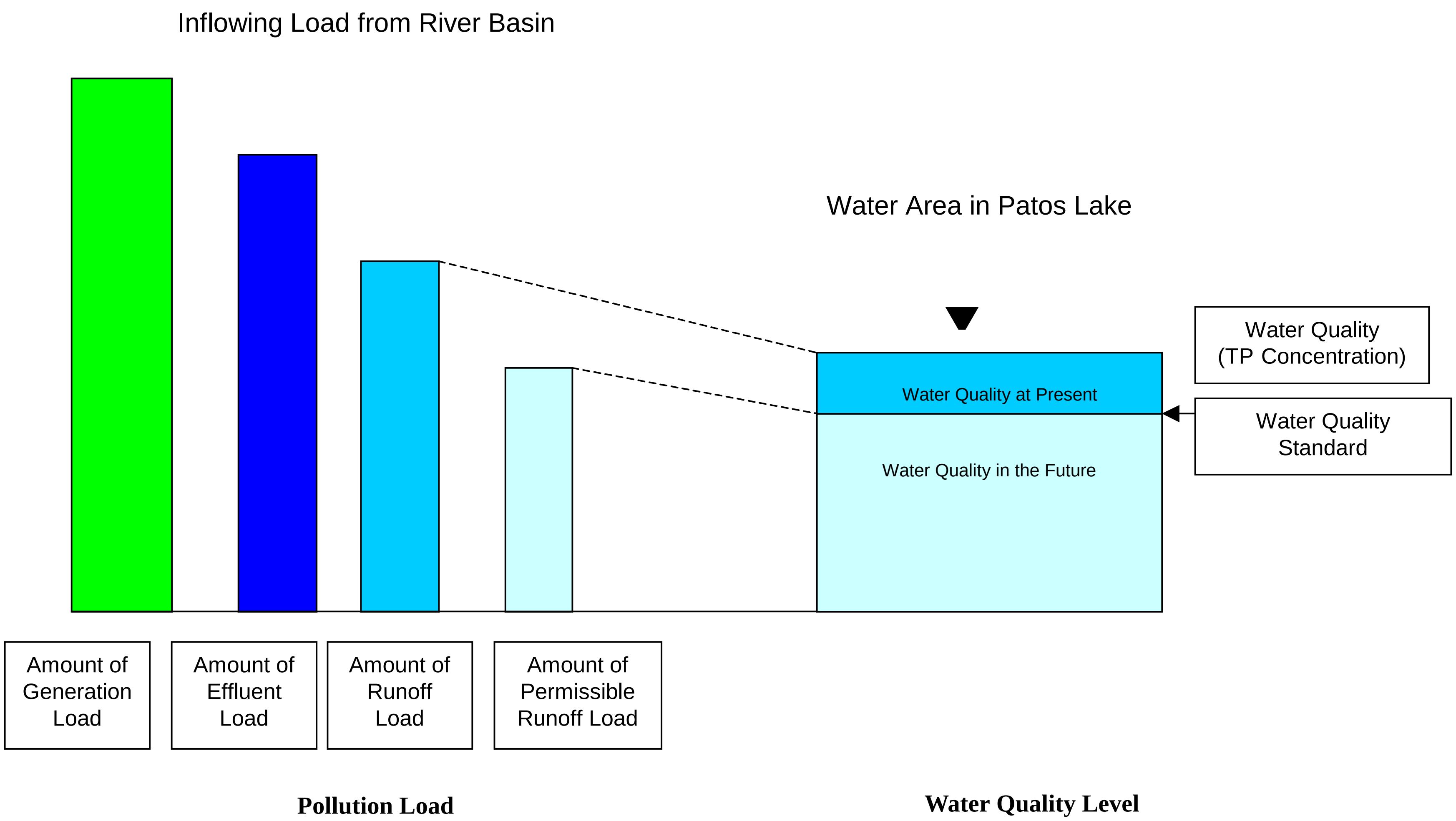


Fig. 5.3-1 Relationship between the Permissible Inflow Load and the Water Quality Standard

Table 5.3-1 Permissible Inflow Loads in Patos Lake and Target Reduction Load Ratios

RIVER NAME (Basin)	Discharge (m^3/s)	BOD			TN			TP			COD		
		Present (ton/day)	Reduction Rate (%)	Permissible Load (ton/day)	Present (ton/day)	Reduction Rate (%)	Permissible Load (ton/day)	Present (ton/day)	Reduction Rate (%)	Permissible Load (ton/day)	Present (ton/day)	Reduction Rate (%)	Permissible Load (ton/day)
Guaiba Lake (G10～90)	1841.3	250.8	20	200.6	184.1	20	147.3	28.6	20	22.9	2160.5	20	1728.4
Porto Alegre (G80)	13.4	21.7	20	17.4	12.3	20	9.8	3.6	20	2.8	32.4	20	25.9
L20 (P-7)	5.3	10.1	20	8.0	6.3	20	5.0	1.7	20	1.4	0.5	20	0.4
Rio Camaqua (L-30-1～4)	397.6	36.8	20	29.4	17.4	20	13.9	8.4	20	6.7	733.5	20	586.8
L30-5 (P-5)	7.1	13.4	50	6.7	8.4	50	4.2	2.3	50	1.1	1.6	50	0.8
L30-6 (P-6)	3.9	7.3	50	3.6	4.5	50	2.3	1.2	50	0.6	0.8	50	0.4
Canal do Sao Goncalo (L40-4～5)	539.6	91.2	20	73.0	43.4	20	34.7	7.6	20	6.1	1146.2	20	916.9
Rio Grande (L40-2)	2.5	4.5	50	2.2	2.7	50	1.4	0.8	50	0.4	5.5	50	2.8
L40-7 (M-7)	4.7	8.5	20	6.8	5.2	20	4.1	1.4	20	1.1	9.9	20	7.9
Pelotas (L40-8)	7.5	14.2	50	7.1	8.9	50	4.4	2.4	50	1.2	0.9	50	0.4
Total	2823.0	458.4	22.6	354.9	293.1	22.5	227.1	58.0	23.5	44.4	4091.8	20.1	3270.8

5.3.2 Breakdown of Target Reduction Load

(1) Policy for the Breakdown of Target Reduction Load

The runoff load per basin which is permissible to attain the water quality standard for each water area in Patos Lake, was computed by using the current runoff load (1996-1997) as a base. The computed permissible runoff load per basin was distributed to the generation sources which compose the runoff load (1996/1997) from the concerned basins using the component ratio of load per generation source.

The breakdown policy was laid down as per the following process:

① The runoff load was distributed according to the degree of contribution of each basin.

② The load from point sources which are easy to control was reduced as much as possible, and the remaining load was reduced using nonpoint source countermeasures. The following factors were taken into consideration when selecting the targets of the countermeasures: the possibility of control, the amount of generation source (effluent) per unit production and the yield per unit (property value of land).

③ We considered countermeasures which fulfill the target reduction load. In this case, the countermeasure costs per land area were taken into consideration. Also, cultivation of land on slopes above 25° is forbidden by law, but it will be necessary to enforce the law and promote reforestation. In addition, land use conversions will also be necessary to bring about land use with low generation load per unit production.

④ The actual runoff load of Mirim Lake basin is not clear due to the fact that various factors on the Uruguay side, such as land use conditions, population and factories, are not known. The amount of load reduction cannot be determined without the cooperation of Uruguay. Once Uruguay decides to cooperate, an analytical study of the load coming from the Mirim Lake basin must be conducted as early as possible.

The generation sources were divided into point sources and nonpoint sources. In addition, point sources were divided into domestic wastewater load and industrial wastewater load, and nonpoint sources into controllable load (urban effluent load, effluent load from paddy/pasture, effluent load from pasture, effluent load from upland crop/pasture) and load on which countermeasures cannot be applied or have no effect (load from forests, wetlands, seacoast/bare land, water surface). Then, the permissible runoff load was distributed to each generation source (10 categories).

(2) Estimation of Permissible Effluent Load

1) Method of Computation of Permissible Runoff Load

The method of estimation of the permissible effluent load is shown in **Fig. 5.3-2**.

- The permissible inflow load is distributed in accordance with the effluent load.
- Effluent load = Generation load × Effluent rate, and Effluent rate = 1 – Reduction rate (countermeasure). Countermeasures which are effective and applicable in the concerned region were selected for each generation source.
- The reduction load after the application of countermeasures to the generation sources (runoff control countermeasures) was as follows:
  Reduction load (ton/day) = Generation load per unit production × Load reduction rate (%) × Amount of generation load (population, area) × Countermeasure implementation rate (%)
  Note: The countermeasure implementation rate is the ratio of the target land area to the land area where countermeasures are already implemented.
- In the computation of permissible load for 2020, future socio-economic evolution trends such as population increase are not taken into consideration, but the hypothesis is that the current conditions will not change.

2) Evaluation and Selection of Reduction Measures and Estimation of the Scope of the Countermeasures

The load reduction measures for point sources and nonpoint sources, that are applicable and should be promoted in the future in Patos and Mirim Lake basins, were selected, then compared and evaluated (refer to **Table 5.3-2**). Countermeasures which are highly applicable, effective and efficient were identified (refer to **Table 5.3-3**). A trial calculation was carried out using the reduction rates indicated in **Table 5.3-3** to determine the implementation scope of the necessary countermeasures.

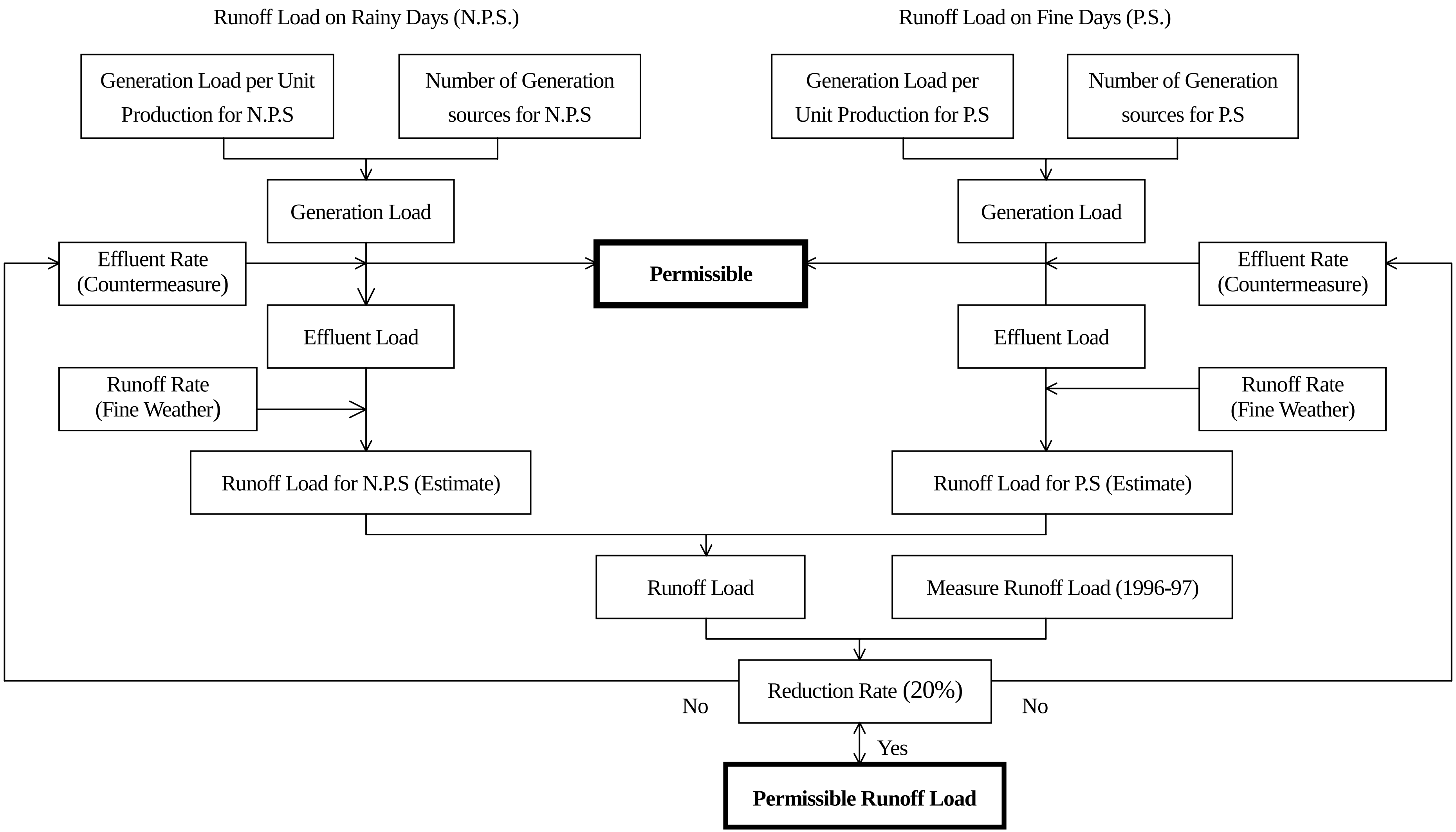


Fig. 5.3-2 Flowchart of Estimation of Permissible Load

Table 5.3-2 Comparison and Evaluation of Load Reduction Measures

Classification	Category	Countermeasures (Methods)	Load Reduction Rate (%)				Evaluation Items						General Evaluation	Measures Adopted in This Study
			BOD	TN	TP	TSS	Load Reduction Effect	Cost-effectiveness	Effecti-veness	Local Suitability	Technical Ease	Impact on Environment		
Domestic wastewater	Sewer system	Oxidation ditch + wetland	90	90	80	90	◎	○	○	○	○	○	◎	○
		Stabilization pond	90			90	○	◎	○	○	◎	○	◎	△
		Standard activated sludge	90			90	○	△	○	○	○	○	○	△
	Septic tank		65			65	△	■	○	○	■	◎	△	■
Industrial wastewater		Monitoring of factories and corporations					○	○	△	○	○	○	○	○
		Wastewater treatment plant					◎	△	○	○	○	○	○	○
		Regulations on factory effluents					○	○	○	○	○	○	○	○
		Cleaner production					○	○	○	■	○	○	○	○
Urban wastewater		Wet pond	10-90	10-90	10-90	50-90	○	○	○	○	○	○	○	○
		Artificial wetland	20-80	0-40	0-80	50-90	○	○	○	○	○	○	○	○
		Better waste collection rate	20-28	3.6	1.7	25-40	○	○	△	○	○	○	○	○
Agricultural wastewater	Upland crop	Reduced tillage systems		55	45	75	○	○	○	○	○	○	○	○
		Diversion systems		10	30	35	○	△	△	○	○	○	○	○
		Terrace systems		20	70	85	○	△	△	△	○	○	○	○
		Filter strip		70	70	65	○	○	○	○	○	○	○	○
		Fertilization management		15	35	-	○	○	○	○	○	○	○	○
		Riparian buffer strip (width: 4.1m)		4.0	28.5	61	◎	○	○	○	○	○	○	○
		Riparian buffer strip (width: 9.2m)		22.7	24.2	74.6	◎	○	○	○	○	○	○	○
	Paddy	Controlled drainage	90	90	80	90	◎	○	○	○	○	○	◎	○

Note: ◎ Excellent, ○ Fair, △ Good, ■ Poor

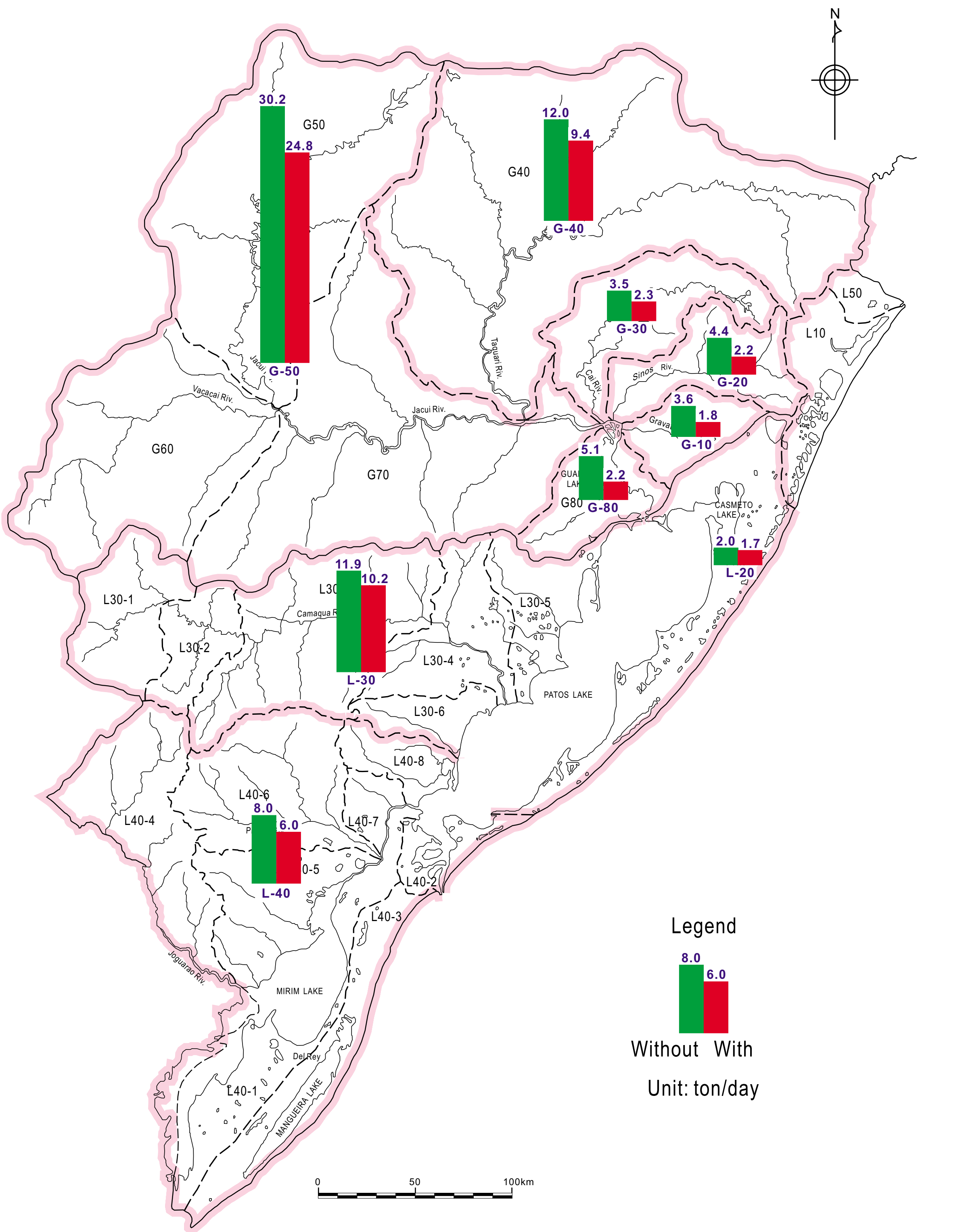
Table 5.3-3 Load Reduction Rates of Applicable Countermeasures

Generation Source	Countermeasure	Reduction Rate (%)		Effluent Rate (%)	Source
Domestic Wastewater	Construction of sewage treatment facility (oxidation ditch + wetpond)	BOD	90	10	Guidance Specifying Management Measures For Source Of Nonpoint Pollution In Coastal Waters (EPA, 1992d): 5-30
		COD	90	10	
		TN	90	10	
		TP	80	20	
Industrial Wastewater	Construction of wastewater treatment plant	BOD	69	31	Efluentes Liquidos Industriais: Cargas Poluidoras Lancadas Nos Corpos Hidrricos Do Estado Do Rio Grande Do Sul-1997 (FEPAM/GTZ, 1997)
		COD	70	30	
		TN	70	50	
		TP	70	50	
Urban area	Establishment of retardation pond	BOD	90	10	Guidance Specifying Management Measures For Source Of Nonpoint Pollution In Coastal Waters (EPA, 1992d): 7-50
		COD	90	10	
		TN	50	50	
		TP	55	45	
Rotation between paddy and pasture	Introduction of appropriate water management/riparian buffer strip/fertilizer management	BOD	70	30	North Carolina State University (1997): Selected Agricultural Best Management Practices to Control Nitrogen in Neuse River Basin.
		COD	70	30	
		TN	50	50	
		TP	50	50	
Pasture	Establishment of riparian buffer strip	BOD	70	30	North Carolina State University (1997): Selected Agricultural Best Management Practices to Control Nitrogen in Neuse River Basin.
		COD	70	30	
		TN	50	50	
		TP	50	50	
Upland crop and/or pasture	Introduction of reduced system	BOD	75	25	Guidance Specifying Management Measures For Source Of Nonpoint Pollution In Coastal Waters (EPA, 1992d):2-15
		COD	75	25	
		TN	55	45	
		TP	45	55	
Forest	No countermeasure		0	100	
Wetland	No countermeasure		0	100	
Coast and dune	No countermeasure		0	100	
Water body	No countermeasure		0	100	

(3) Effects of Distribution of Permissible Runoff Load

Fig. 5.3-3 shows the current generation load per generation source and the permissible effluent load after the implementation of the countermeasures which meet the permissible runoff load per basin.

As part of the Mirim Lake basin (Sao Goncalo Canal basin) is located in Uruguay, no data could be obtained on generation sources in this area, and it is assumed that the **same countermeasures as for the other basins can be applied to Mirim Lake basin.**



THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL	**Fig. 5.3-3**
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	**T-P Effluent Load Without and With the Countermeasures (20% Reduction)**

5.3.3 Scope of the Load Reduction Measures

Test calculations were carried out using the work progress illustrated in **Fig. 5.3-2** to determine the scope of the countermeasures to approximately attain the water quality standard for TP (20% reduction of the current runoff load).

As a premise, the countermeasures will be applied to all point sources. The same countermeasures will be applied to all areas within the same land use category. The implementation rate and scope of each countermeasure according to the calculations are shown in **Table 5.3-4**.

Test calculations showed that the reduction target would be approximately attained (20% reduction of the current runoff load) when applying the countermeasures to 50% of the land area of paddy/upland crop/pasture in each basin, and the permissible effluent load could be met.

Countermeasures will first be applied to point sources, based on the current population and land use conditions, and treatment facilities with a high TP removal rate will be constructed for the treatment of all urban domestic and industrial wastewater. In addition, it will be necessary to apply countermeasures with a high TP removal rate to 50% of the land area of nonpoint sources, i.e. urban areas, upland crops, paddies and pastures. It will be especially important to actively promote nonpoint source countermeasures, i.e. soil conservation measures such as tillage system, which could be disseminated to farmers through cooperation and spontaneous effort.

In case of a rise in future generation load due to population increase and agricultural expansion, it will be necessary to reflect this additional load in the above countermeasures. On the other hand, as wastewater treatment techniques improve, it will be possible to lower the scopes of the countermeasures in case of increase in land with small generation source unit production, i.e. through land use rotation.

Table 5.3-4 Scope of Measures to Reduce TP Inflow Load by 20%

	Target	Method	Scope
Point source	Domestic wastewater	• Sewage treatment	• Establishment of sewer systems covering the whole urban area (target population: 620,000) • In addition to existing wastewater treatment plants, establishment of wet ponds for N and P removal • Establishment of sewerage treatment plants in 5 cities, including Pelotas. • Implementation of leachate countermeasures at waste disposal sites (2 sites)
	Industrial wastewater	• Construction of wastewater treatment plants • Regulations on industrial wastewater • Reinforcement of monitoring	• Reinforcement of monitoring for the factories located in the Mar de Dentro district
Nonpoint source	Urban area	• Establishment of retardation ponds	• Implementation of countermeasures to 50% of the urban land area
	Paddy/pasture	• Dissemination of appropriate water management techniques • Establishment/dissemination of riparian buffer strip	• Implementation of countermeasures to 50% of the paddy/pasture land area • Model area (AUD area)
	Pasture	• Establishment/dissemination of riparian buffer strip	• Implementation of countermeasures to 50% of the pasture land area
	Upland crop /pasture	• Dissemination of tillage system	• Implementation of countermeasures to 50% of the upland crop/pasture land area • Model area for soil conservation measures (Sutil, Duro, Cangucu areas)

Note: It is assumed that no countermeasures will be applied to forests, wetlands, seashore/bare land and water areas.

5.4 Load Reduction Measures per Basin

Basically, it will be essential to implement the load reduction measures effectively and efficiently. Especially, concerning nonpoint sources, it is important to implement load reduction measures in all the places which are controllable but we examined selective countermeasures based on the load tendency in each basin in order to contribute even more to an effective countermeasure program.

Table 5.4-1 shows future countermeasures for each basin.

(1) L-20 Litoral Medio Basin

Based on past data, there should not be much changes in land use and population in this basin. Accordingly, load reduction measures for nonpoint source load, especially paddies, which account for a large proportion of the load, will be essential.

(2) L-30 Camaqua Basin

It is thought that the proportion of nonpoint source load, consisting of upland crop such as tobacco, will increase in the future. Accordingly, it will be necessary to combine countermeasures with soil erosion prevention for upland crops, paddies and pastures, which are currently a significant problem. Also, as the loads from mountains and forests, which occupy large land areas, are relatively high, appropriate forest management will be important.

(3) L-30 Mirim-Sao Goncalo Basin

Currently, the proportion of nonpoint source load is relatively high, and the sewer installation rate is also small compared with Guaiba River basin. Therefore, the main countermeasures at this stage will be installing sewer systems and regulating factory wastewater. It will also be essential to increase the refuse collection rate.

In addition, as there are 150,000 ha of paddy fields in this basin, load reduction measures for paddies will be important, including the introduction and dissemination of appropriate water management techniques and the proper use of pesticides.

(4) Guaiba Lake (G-10～80) Basin

Currently, as the proportion of point source load is high, the main countermeasures at this stage will be installing sewer systems and regulating factory wastewater. This proportion is expected to increase in the future, especially in urban areas, and emphasis will be laid on countermeasures for nonpoint source loads. It will be especially important to install retardation ponds to reduce the storm wastewater load in urban areas.

With the current implementation of Pro Guaiba, the treatment rate of domestic wastewater will increase in the future, so in addition to wastewater treatment, it will be necessary to build facilities with a high TN and TP removal rate.

Table 5.4-1 Load Reduction Measures per Basin

Sub-Basin	Measures for the Reduction of Point Source Pollution Load		Measures for the Reduction of Nonpoint Source Pollution Load		Measures for the Reduction of Both P.S and N.P.S Pollution Loads
	Domestic Wastewater	Industrial Wastewater	Urban Areas	Farmland (Upland Crop, Paddy, Pasture)	
L-20 LITORAL MEDIO	• Sewerage treatment in urban areas			• Promotion of environmental conservation oriented agriculture (proper water management, proper use of fertilizers)	
L-30 CAMAQUA	• Sewerage treatment in urban areas (Sao Laurenco do Sul, Camaqua, Tapes)	• Reinforcement of monitoring • Introduction of “cleaner production”	• Increase of refuse collection rate • Construction of retardation ponds	• Promotion of environmental conservation oriented agriculture (soil conservation, proper water management, proper use of fertilizers and pesticides) • Soil conservation model areas (Sutil, Duro areas) • Water management model areas (AUD area) • Reforestation • Land use regulations	• Planning of Camaqua River basin management
L-40 MIRIM-SAO GONCALO	• Sewerage treatment in urban areas (Pelotas, Rio Grande) • Leachate prevention at existing waste disposal sites (Pelotas, Rio Grande)	• Reinforcement of monitoring • Introduction of “cleaner production”	• Construction of retardation ponds • Increase of refuse collection rate	• Promotion of environmental conservation oriented agriculture (soil conservation, proper water management, proper use of fertilizers) • Soil conservation model areas (Cangucu area) • Reforestation • Land use regulations	• Monitoring of water quality in Mirim Lake basin • Planning of Mirim Lake basin water quality conservation
G-10～80 GUAIBA	• Sewerage treatment in urban areas • Installation of TN and TP removal facilities at existing sewerage treatment plants	• Reinforcement of monitoring • Introduction of “cleaner production”	• Construction of retardation ponds	• Promotion of environmental conservation oriented agriculture (proper use of pesticides, soil conservation)	• Review of Pro Guaiba