CHAPTER 6

SEWAGE TREATMENT PLAN COMPONENT (2)

CHAPTER 6 SEWAGE TREATMENT PLAN COMPONENT(2)

6.1 Basic Policy

6.1.1 Purpose for Formulation of the Basic Concept of Sewage Treatment Plan

At present, most part of the wastewater from households in the urban areas of Mar de Dentro Area is being drained into rivers and drainage canals without treatment. Thus, the wastewater functions as pollution loads into Patos Lake as well as into the surrounding wetlands. As a result it contaminates the rivers and drainage canals etc., making the sanitary environment of the urban area further worse. Under these circumstances, this basic wastewater treatment plan intends to reduce the pollution loads originated from the wastewater from the households in the said area. However, the basic wastewater treatment plan will be formulated only for Pelotas and Rio Grande. It may be noted here that, in formulation of the said basic wastewater treatment plan, full attention has been paid to the progress and achievements of the on-going wastewater treatment projects as well as to the future planning being carried out in the both municipalities. The basic wastewater treatment plan, formulated for the two municipalities, may also be applied to the wastewater treatment planning in the urban areas of Sao Laurence Do Sul, Camaqua and Tapes, considering the prevailing conditions of each municipality.

6.1.2 Basic Strategies for Formulation of the Basic Concept of Sewage Treatment Plan

The target of the basic wastewater treatment plan is the wastewater and night soils generated from the households in the municipalities of Pelotas and Rio Grande. And the basic wastewater treatment plan has been prepared with the condition that the operation and maintenance of the proposed sewage system will be carried out by SANEP in Pelotas and CORSAN in Rio Grande as it is presently done. In formulation of the basic wastewater treatment plan, the following points have been taken into account.

(1) Maximum Utilization of the Existing Sewage Treatment Projects and Plans

At present, there exist no comprehensive sewage treatment projects and plans that cover the entire urban areas of Pelotas and Rio Grande. However, there exist several wastewater treatment projects and plans, that partially cover the Pelotas and Rio Grande, and some of them are already under implementation. Accordingly, the basic wastewater treatment plan will be made paying full attention to the progress and contents of the said projects and plans in the both municipalities.

(2) Target Year, Wastewater Collection Method and Wastewater to be Treated

In this basic wastewater treatment plan, the target year will be set at year 2010 in achieving the medium-term target, and at year 2020 in achieving the long-term target respectively, according to the target year highlighted in the water quality control plan proposed in this study report. And the wastewater from the target households will be collected separately, i.e., wastewater and rain water will be separately collected by the independent sewage collecting systems to be proposed. The wastewater to be treated under this basic wastewater treatment plan is that from the households, commercial areas, hotels as well as from schools in Pelotas and Rio Grande only, and the wastewater from the industrial areas will not be handled under this basic plan.

(3) Wastewater Treatment Method

For deciding the most applicable wastewater treatment method to Pelotas and Rio Grande, four methods, i.e., ① Oxidation Pond Method, ②Standard Activation Sludge Method, ③ Anaerobic Digestion Method, and ④ Combination Method of Oxidation Ditch and Wetland, have been studied with respect to their merits and demerits taking into consideration the natural, social and economic conditions of Pelotas and Rio Grande, construction and O/M cost of the wastewater treatment system to be proposed etc.

(4) Required Numbers and Scale of the Treatment Facilities to be Proposed

The wastewater treatment projects that are now under construction in Pelotas and Rio

Grande have been planned dividing the target area into several blocks, avoiding concentrated treatment of the wastewater. This method has merits of ① minimizing the influence by the treated water on the quality of water at releasing points, ② reducing the length of sewage pipe lines, and ③step-wise expansion of the treatment facility and easiness in operation and maintenance of the treatment facility etc. Considering the above merits, this basic wastewater treatment plan has also been made dividing the target area into several blocks where necessary.

(5) Target Water Quality after Treatment

The target water quality after treatment will be decided judging from the water quality of the wastewater that flows into the treatment facility, also from the effectiveness of removal method of water pollutants applicable.

(6) Recovery of Construction Cost

From the viewpoint of quick recovery of the invested cost, treatment facilities with less operation and maintenance cost have been planned. And to achieve a planned recovery of the invested cost, it has been proposed that the beneficiaries should bear the operation and maintenance cost of the proposed treatment facilities. For smooth collection of the operation and maintenance cost from the beneficiaries, it is strongly proposed that further promotion of the environmental education should be made, and through which importance of conservation of the environment and necessity of bearing the cost should be appealed to the beneficiaries. Based on the above discussions, the basic wastewater treatment plan for Pelotas and Rio Grande is summarized as follows.

6.2 Basic Concept of Sewage Treatment for Pelotas

(1) Overall Planning

Considering the technical policy of reducing pollution load given in Chapter 5 of the report, also paying attention to the design strategies applied to the existing sewage treatment projects and plans in Pelotas, the basic wastewater treatment plan for Pelotas has been so made as to treat the wastewater from the households of about 65,000

(89,000 – 24,000) including the wastewater from the commercial areas and schools in Pelotas by the year of 2010. In addition to the above, considering that the on-going sewage treatment project in Pelotas intends to treat the wastewater from the households of about 24,000, also from the viewpoint of avoiding concentrated wastewater treatment, the basic wastewater treatment plan for Pelotas has been made dividing the area with 65,000 households into two, i.e., Project Area-I with the households of about 30,000 and Project Area-II with the households of 35,000. Accordingly, two basic wastewater treatment plans have been prepared for Pelotas independently.

(2) Target Population Under the Basic Wastewater Treatment Plan

The target population of Pelotas at the year of 2010 and 2020 has been decided based on the data prepared by Estado Do Rio Grande Do Sul, Secretaria Da Coordenacao E Planejamento. The data are tabulated below.

Table 6.2-1 Statistically Estimated Population

Name of Municipalities	Year 2000	Year 2010	Year 2020
Pelotas	291,700	325,200	360,700
Rio Grande	175,200	185,900	197,300
Total	466,900	511,100	558,000
Other Municipalities			
Sao Lourenco Do Sul	23,600	29,700	36,500
Camaqua	42,800	58,100	82,300
Tapes	12,000	15,300	17,900
Total	78,400	103,100	136,700
Grand Total	545,300	614,200	694,700

(3) Design Wastewater Discharge at Each Target Year

It is anticipated that the amount of present wastewater from the households in Pelotas will increase in proportion to increase of supply of drinking water to Pelotas due to raise of living standard in the future. However, there should be an upper limit to supply of drinking water to the households in Pelotas, although the upper limit is not yet fixed at present. Accordingly, in the basic wastewater treatment plan, the upper limit of drinking water supply to the households at the year of 2010 and 2020 has been fixed at the rate of 250 l/day/person judging from several data available in Brazil as well as in other countries, also from the viewpoint of saving water. Based on this, the design wastewater discharge from a target household etc. has been fixed at 200 l/day/person, i.e., 80 % of the design drinking water supply of 250 l/day/person.

(4) Design Water Quality of Wastewater to the Planned Treatment Facility

The design water quality of the wastewater that flows into the planned treatment facility has been decided at BOD level of 300 mg/l on average, following the criteria by CORSAN and SANEP. And the design TN (Total Nitrogen) level of the wastewater after treatment has been fixed at 60 mg/l, also, design TP (Total Phosphorous) level at 10 mg/l and design SS (Suspended Solid) level at 224 mg/l, referring to the actually measured values at Parque Marinha Wastewater Treatment Facility being operated by activated sludge method in Rio Grande.

(5) Design Water Quality of the Discharged Water

The design water quality of discharged water largely depends on the water quality of the wastewater that flows into the treatment facility, applicable treatment technology, construction cost of the facility as well as on utilization condition of the water areas influenced by discharged water etc. Considering the above, in the basic wastewater treatment plan, it is recommended to plan that the discharged water from the planned treatment facility should contain BOD of less than 30 mg/l, TP of less than 6 mg/l and coliform bacillus of less than 3,000 MNP/100 ml. Regarding the disinfection of germs contained in the discharged water, three methods, i.e., ① Disinfection by Ozone, ② Disinfection by Ultraviolet Rays and ③ Disinfection by Chlorine, have been studied to decide the most suitable disinfection method both for Pelotas and Rio Grande. The brief study results are given in **Table 6.2-2**. As is shown in the Table, disinfection method by chlorine is superior to other two methods in due consideration of its effectiveness, easiness in handling etc., accordingly, disinfection method by chlorine has been recommended.

(6) Wastewater Treatment Method

Several wastewater treatment methods, i.e., ① Oxidation Pond Method, ② Standard Activation Sludge Method, ③ Anaerobic Digestion Method and ④ Combination Method of Oxidation Ditch and Wetland, have been studied to decide the most suitable wastewater treatment method both for Pelotas and Rio Grande. The brief study results are given in **Table 6.2-3**. As is seen from the Table, combination method of oxidation ditch and wetland is superior to other three methods. Also it may be noted that wetlands spread widely around Pelotas, where aquatic plants that can absorb phosphorous and nitrogen contained in the discharged water grow. This condition also justifies introduction of combination method of oxidation ditch and wetland. Accordingly, the said method has been recommended for Pelotas. For reference, a sample schematic view of the recommended wastewater treatment facility is shown in **Fig. 6.2-1** and a sample schematic view of the recommended wastewater treatment method by combination of oxidation ditch and wetland is shown in **Fig. 6.2-2**.

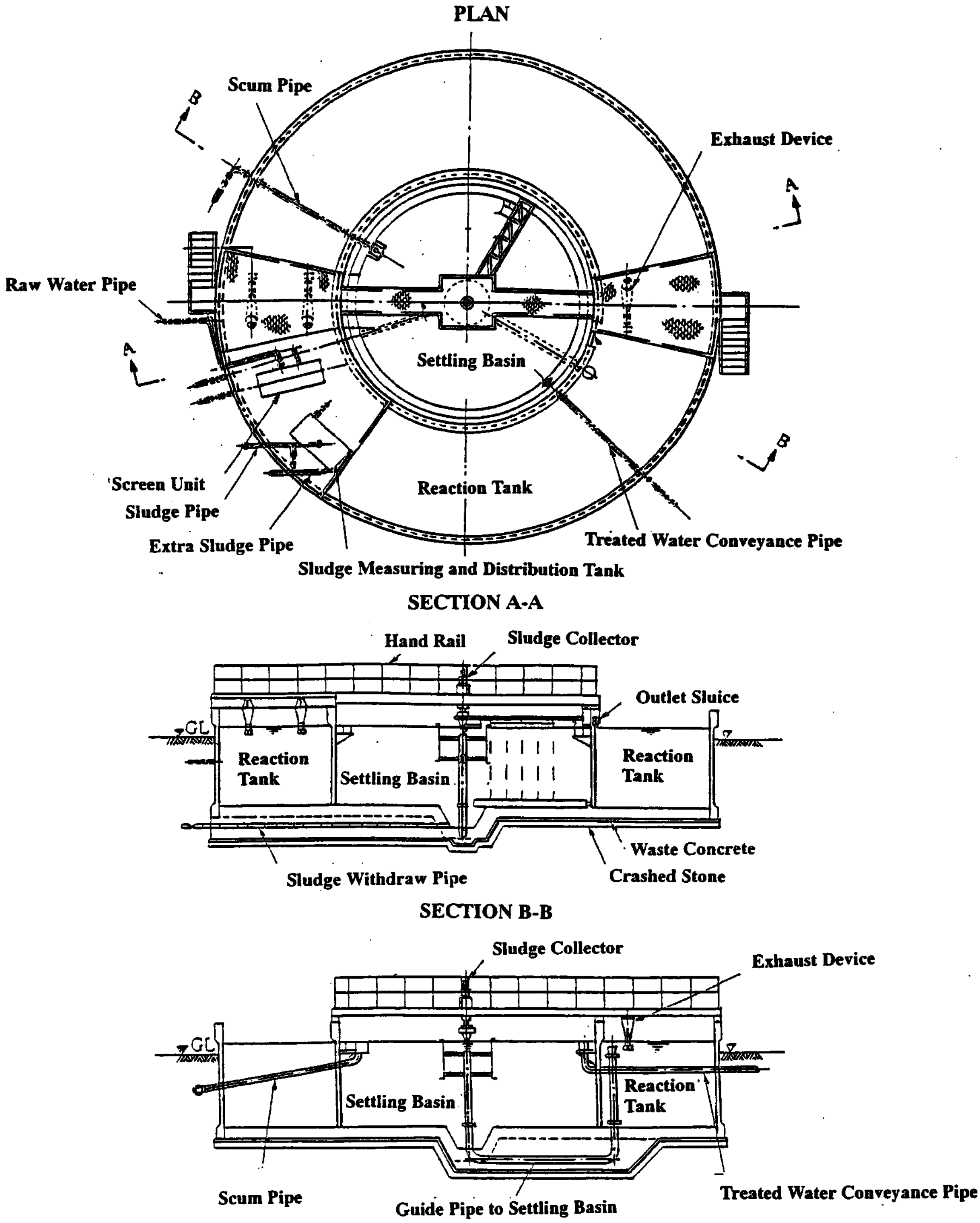
Based on the above discussions, the basic design parameters of the wastewater treatment plan for Pelotas are given in **Table 6.2-4**. And the location of the proposed project area is shown in **Fig.6.2-3**.

Table 6.2-2 Comparison of Disinfection Method

Disinfection Method	Merit	Demerit	Applicability to the Proposed Project
(1) Disinfection by Chlorine	● High disinfection effect against germs is expected within 15 minutes contact with germs. ● Easiness in handling and constant supply. ● Easiness in confirmation of residuals of chlorine. ● Cheap materials and cheap O/M (operation and maintenance) cost.	● Problem of generating organochlorine compound. ● Generating strong odor (odor like chlorophenor) through reaction to particular substances. ● Disinfection effect sharply goes down, when the wastewater become alkalic. ● Possibility of changing into chloramine with less disinfection effect.	High applicability to the proposed project.
(2) Disinfection by Ultraviolet	● Can avoid the problem of generation of organochlorine compound. ● Can disinfect wastewater in relatively short time. ● Easy O/M is expected.	● Can not disactivate protozoa syst. ● When SS, turbidity, and dissolved organic concentration are high, disinfection effect goes down sharply. ● Energy consumption rate is high.	Less applicability to the proposed project.
(3) Disinfection by Ozone	● Most strong disinfection effect is expected compared to other methods. ● Effect of removal of odor and color is expected. ● If ozone is put into wastewater before secondary treatment, it changes the difficult-to-decompose-organic substance into easy-to- compose-organic substance. ● Less problem of side-compositions compared to chlorine method. ● Less effect on the released water.	● Construction cost and O/M cost of the facility are generally high. ● Requires many facilities, also needs technical experts for O/M and safety control of the facility.	Less applicability to the proposed project

Table 6.2-3 Comparison of Wastewater Treatment Method

Method	Oxidation Pond Method	Standard Activation Sludge Method	Anaerobic Digestion Method	Oxidation Ditch + Wetland Method
Principle	By retaining wastewater in wetland or in pond for 2 to 3 weeks, organic matter contained in the wastewater is decomposed by aerobic microscopic organism generated in the wetland or pond	Aerobic microscopic organism is generated by providing oxygen by force, through which activated sludge is produced. Polluted substance is absorbed and removed by thus produced activated sludge.	Organic matter contained in wastewater is decomposed into carbon dioxide and methane by anaerobic microscopic organism that grows under the condition of non-existence of oxygen.	① Guiding the wastewater into ditch with a depth of about 1.0 m, where the wastewater will be circulated by rotor for 1 to 2 days.. Through this step, organic matter contained in the wastewater can be removed to some extent. ② Guiding the wastewater, whose organic matter is removed to some extent beforehand, into natural or artificial wetland, where nitrogen and phosphorous contained in the wastewater will be removed by utilizing absorption capacity of aquatic plants.
Flow of Treatment	Flow→Pond, Wetland→Aerobic decomposition→ Treatment by dehydration	First settling pond → Aeration tank → Final settling pond	Removal of solids → Digestion tank → Drying of digested sludge	Oxidation ditch → Final settling pond → Disinfection pond→Wetland
Merit	Cheap construction cost due to simple structure of the facility. Less energy consumption. Easy operation and maintenance due to less structural and mechanical characteristics of the facility to be maintained. Treatment efficiency is high in the area where outer temperature is relatively high.	Treatment facility with this method responds flexibly against the change of amount of pollution loads, accordingly this method enables to maintain the quality of treated wastewater constant.	Energy consumption is less. Removal rate of organic matter is low compared to aerobic treatment. Less generation of surplus sludge. Pathogenic microscopic organism dies quickly due to high temperature in reaction tank. Generation of surplus sludge is less. Generated methane gas can be recovered and used as energy sources.	Smaller area is required compared to oxidation pond method because of shorter retention time. Easiness in land acquisition and cheap construction cost is expected in the case natural wetland is available near the construction site of the facility.
Demerit	Not applicable to the area where land cost is high and densely populated, because application of this method needs relatively wide area Fear of generation of odor and chironomous. Removal rate of nitrogen and phosphorous is generally low. Treatment efficiency becomes low when outer temperature goes down.	Operation and maintenance of the facility with this method needs skill due to structural characteristics of the facility. Also it needs control of surplus sludge produced. Removal rate of nitrogen and phosphorous is generally low. Energy consumption is generally high.	Large volume of reaction tank is needed because of slow reaction speed. Inferior quality of treated wastewater compared to aerobic treatment. Treatment efficiency becomes low when outer temperature goes down.	There will be fear of generating odor and chironomus. Periodical cutting of aquatic plants in the wet land is needed to maintain the absorption capacity of the wetland.
Remarks	It is possible to make the treatment efficiency high by keeping constant level of resolved oxygen with provision of aeration device..	Other than standard treatment method, there is another method of accelerating the reaction speed by increasing supply amount of oxygen.	Volume of aerobic reaction tank can be reduced by combination of aerobic treatment.	Absorption capacity of organic mater depends on the kind of aquatic plants. Thus, it needs attention to selection of aquatic plans.
Achievement in RS State	Actually operated in Pelotas.	Actually operated in Rio Grande. Planned in Port Aregle.	Planned in Pelotas	No achievements both in Pelotas and Rio Grande.
Evaluation of Applicability to the Project	Less applicability both to Pelotas and Rio Grande. Also this method does not fulfill the requirement of water treatment of the proposed project.	Same as the above.	More applicability both to Pelotas and Rio Grande compared to oxidation pond method and standard activation sludge method. However, it is difficult to attain the target of the wastewater treatment of the proposed project.	Most applicable both to Pelotas and Rio Grande, considering the areal characteristics of the both municipalities.



Original drawing is taken from [The Design and Planning Criteria for Sewage Facilities] prepared and printed by JAPAN Sewage Association 1n 1994.

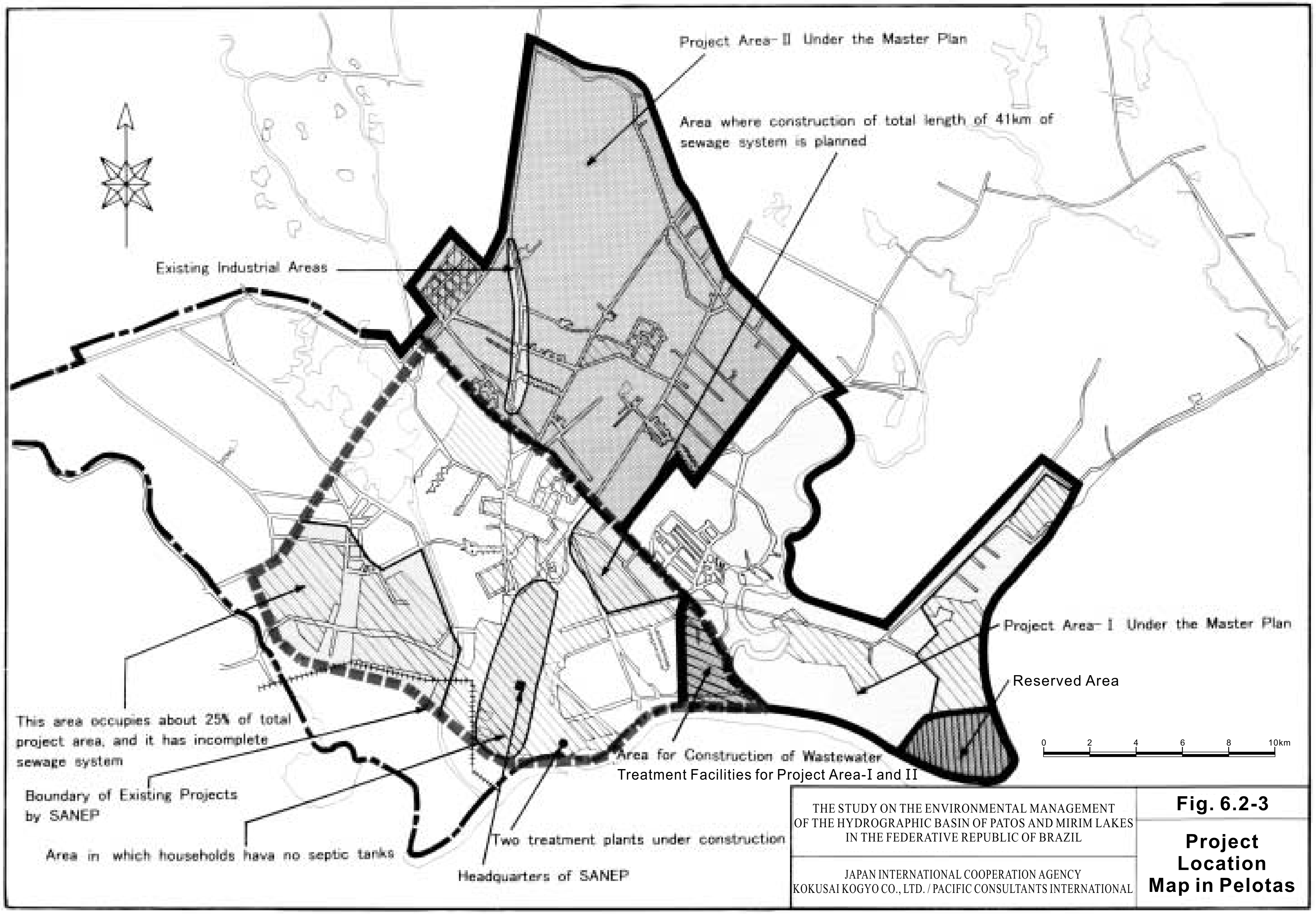
THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL	**Fig. 6.2-1**
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	**Sample Schematic View of a Treatment Facility**

THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL	**Fig. 6.2-2**
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	**Schematic View of a Sewage Treatment System by Combination of Oxidation Ditch and Wetland**

Table 6.2-4 Basic Design Parameters of the Wastewater Treatment Plan for Pelotas

Design Parameters	Wastewater Treatment Plan under the Master Plan		Existing Sewage Improvement Projects
Target Area	Area-I	Area-II	No comprehensive sewage treatment projects that cover the whole area of Pelotas exist. However, 2 treatment plants by anaerobic method are now under construction. Operation of the plants will start in 2000. With completion of the plants, the wastewater from about 24,000 households (accounting for 27 % of the total households in the urban area of Pelotas) will be brought under treatment. The total project cost is estimated at R$5,000,000. The project is being executed by SANEP.
Target Year	2010	2010	Operation will start in 2000.
Target Population	115,000	132,000	(78,000)
Number of Household	30,000	35,000	
Deign Wastewater Discharge (l/day/person)	200	200	
Design Daily Treatment Discharge (m^3/day)	23,000	26,400	
Peak Treatment Discharge (l/sec)	320**	370**	
Quality of Wastewater Flowing to Treatment Facility (BOD, mg/l)	300	300	300
Total Nitrogen Contained in Wastewater into Treatment Facility (mg/l)	60	60	-
Total Phosphorous Contained in Wastewater into Treatment Facility (mg/l)	10	10	-
SS Contained in Wastewater into Treatment Facility (mg/l)	224	224	-
Colifom Contained in Wastewater Flowing into Treatment Facility (MNP/100 ml)	$5 \times 1o^6 – 2 \times 10^8$	$5 \times 1o^6 – 2 \times 10^8$	
Design Water Quality of Discharged Water After Treatment (BOD, mg/l)	30	30	30
Coliform Level After Treatment (MNP/100 mg)			
Total Nitrogen Level After Treatment Mg/l)			
Total Phosphorous Level After Treatment (mg/)			
Wastewater Treatment Method	Combination Method of Oxidation Ditch and Wetland	Combination Method of Oxidation Ditch and Wetland	Anaerobic Method Number of Treatment Facility: 2

Note: ** Peak treatment discharge was estimated 1.2 times of the amount of average daily wastewater treatment.



THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL

JAPAN INTERNATIONAL COOPERATION AGENCY
KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL

Fig. 6.2-3

Project Location Map in Pelotas

6.3 Basic Concept of Sewage Treatment for Rio Grande

(1) Overall Planning

The basic wastewater treatment plan for Rio Grande has been so made as to treat the wastewater from the households of about remaining 10,000 (48,000 households x 20 %, which accounts for about 37,000 persons) including the wastewater from the commercial areas and schools by 2010. The basic water treatment plan also includes technical as well as financial assistance to shorten the construction period of the second phase wastewater improvement project, which is scheduled to be completed by 2015, and the third phase wastewater improvement project, which is scheduled to be completed by 2030.

(2) Target Population under the Basic Wastewater Treatment Plan

The target population of Rio Grande at the year of 2010 and 2020 has also been decided based on the data prepared by Estado Do Rio Grande Do Sul, Secretaria Da Coordenacao E Planejamento.

(3) Design Wastewater Discharge at Each Target Year

The design wastewater discharge from a target household in Rio Grande has been decided at 200 l/day/person, i.e., 80 % of the design drinking water supply of 250 l/day/person, following the same assumptions applied to Pelotas.

(4) Design Water Quality of Wastewater to the Planned Treatment Facility

The design water quality of the wastewater that flows into the planned treatment facility has been decided at BOD level of 300 mg/l on average, following the criteria by CORSAN and SANEP. As for the other items contained in the wastewater, TN (Total Nitrogen) level has been fixed at 60 mg/l, TP (Total Phosphorous) level at 10 mg/l, and SS (Suspended Solid) level at 224 mg/l, referring to the actually measured values at Parque Marinha Wastewater Treatment Facility in Rio Grande.

(5) Design Water Quality of the Discharged Water

The design water quality of the discharged water has been decided at BOD level of less than 30 mg/l, TP of less than 6 mg/l and coliform bacillus of less than 3,000 MNP/100 ml. And, regarding the disinfection of the germs contained in the discharged water, the same method applied to Pelotas has also been recommended for Rio Grande

(6) Wastewater Treatment Method

As is the case with Pelotas, 4 wastewater treatment methods, i.e., ① Oxidation Pond Method, ② Standard Activation Sludge Method, ③ Anaerobic Digestion Method and ④ Combination Method of Oxidation Ditch and Wetland, have been studied to decide the most suitable wastewater treatment method for Rio Grande. The brief study results are shown in **Table 6.2-3**. As is seen from the Table, combination method of oxidation ditch and wetland is superior to other three methods. Also it may be noted that wetlands spread widely around Rio Grande, where aquatic plants that can absorb phosphorous and nitrogen contained in the discharged water grow. This condition also justifies introduction of combination method of oxidation ditch and wetland. Accordingly, the said method has also been recommended for Rio Grande. Based on the above discussions, the basic design parameters of the wastewater treatment plan for Rio Grande are given in **Table 6.3-1**. And the location of the proposed project area is shown in **Fig.6.3-1**.

Table 6.3-1 Basic Design Parameters of the Wastewater Treatment Plan for Rio Grande

Design Parameters	Wastewater Treatment Plan under the Master Plan	Existing Sewage Improvement Projects
Target Area		No comprehensive sewage treatment plans exist which cover the entire urban areas of Rio Grande. However, As a part of the integrated sewage improvement project, Phase-I sewage expansion project is in progress. With completion of the project in 2001, the wastewater from the households of about 25,000 in Rio Grande will be brought under treatment. The said integrated sewage expansion project is divided into three phases. The second phase of the project will be completed in 2015 and the third phase in 2030. With completion of the third phase project, the wastewater from about 80 % of the total households in Rio Grande will be brought under treatment. The treatment plant designed for the project is divided into 3 modules and each module responds the phase-wise wastewater treatment amount. The said project is being executed by CORSAN.
Target Year	2010	Operation will start in 2000.
Target Population	36,500	(78,000)
Number of Household	10,000	
Deign Wastewater Discharge (l/day/person)	200	
Design Daily Treatment Discharge (m^3/day)	7,300	
Peak Treatment Discharge (l/sec)	100**	
Quality of Wastewater Flowing to Treatment Facility (BOD, mg/l)	300	300
Total Nitrogen Contained in Wastewater into Treatment Facility (mg/l)	60	-
Total Phosphorous Contained in Wastewater into Treatment Facility (mg/l)	10	-
SS Contained in Wastewater into Treatment Facility (mg/l)	224	-
Colifom Contained in Wastewater Flowing into Treatment Facility (MNP/100 ml)		
Design Water Quality of Discharged Water After Treatment (BOD, mg/l)	30	30
Coliform Level After Treatment (MNP/100 ml)	3,000	
Total Nitrogen Level After Treatment mg/l)	10	
Total Phosphorous Level After Treatment (mg/l)	6	
Wastewater Treatment Method	Combination Method of Oxidation Ditch and Wetland	

Note: **Peak treatment discharge was estimated at 1.2 times of average daily wastewater treatment.

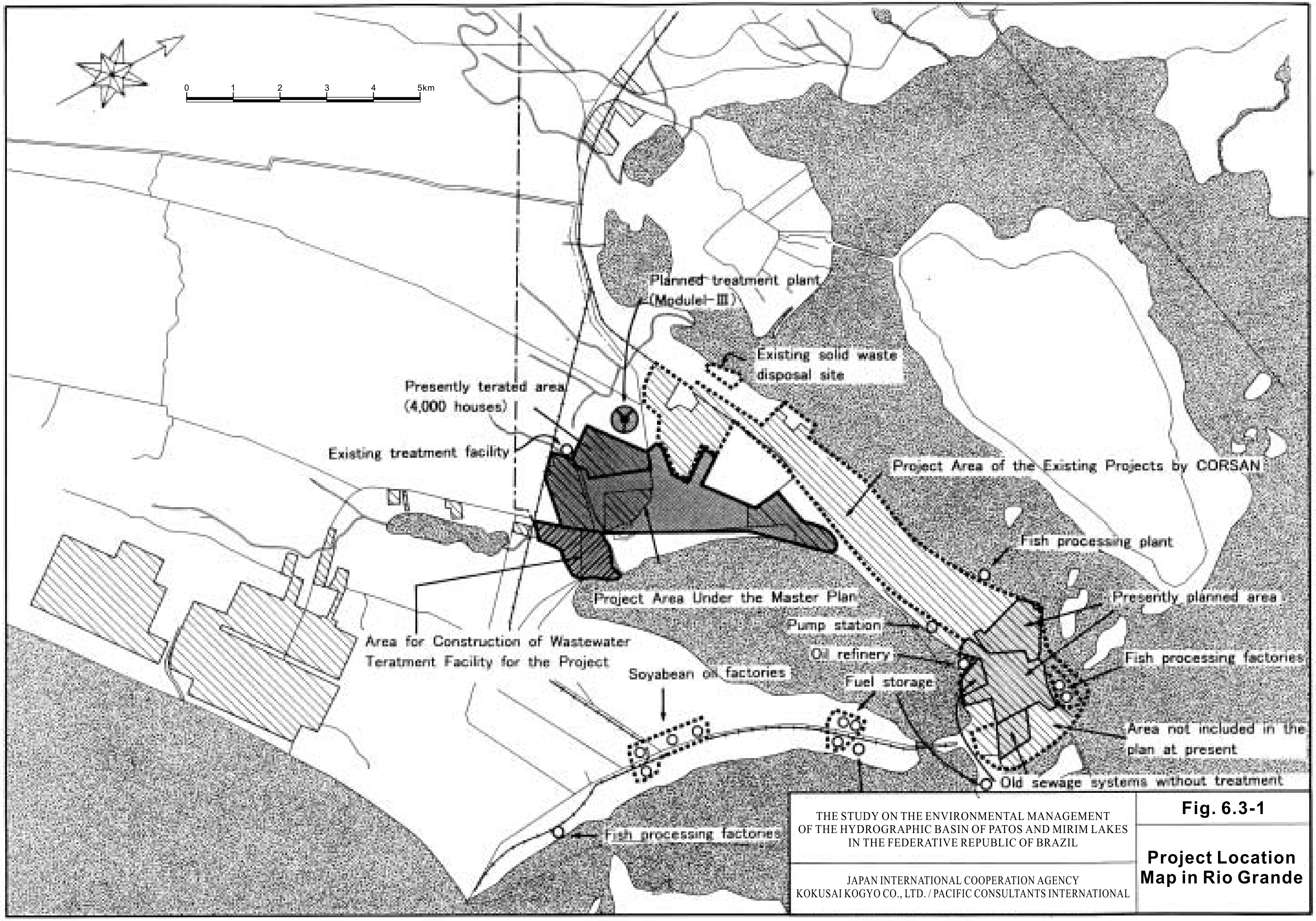


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Fig. 6.3-1

Project Location Map in Rio Grande

6.4 Expected Outcomes through Implementation of the Proposed Sewage Treatment Plan

Through implementation of the proposed wastewater treatment plan both for Pelotas and Rio Grande, BOD contained in the discharged water will be reduced to the level which is shown in **Table 6.4-1**. As is seen from the Table, implementation of the proposed wastewater treatment plan largely contributes to reduce the organic matter contained in the said discharged water. Accordingly, it is strongly recommended to implement the proposed wastewater treatment plan as early as possible to maintain and improve the water quality of Patos Lake.

Table 6.4-1 Estimated Reduction Amount of BOD of the Wastewater in Pelotas and Rio Grande at Year 2010

Name of Municipality	Amount of Discharged BOD at Year 2000 (Unit: kg/day)	Amount of Discharged BOD at Year 2010 (Unit: kg/day)	Reduced Amount of BOD (Unit: kg/day)
Pelotas	300 mg/l x 160 l/day x 291,700 = 14,000	30 mg/l x 200 l /day/person x 325,200 (total population) = 1,950	12,050 (equivalent to 4,400 ton/year)
Reduction Ratio	12,050 x 14,000 = 86 %		
Rio Grande	300 mg/l x 160 l/day/person x 160,600 = 7,700 30 mg/l x 160 l/day/person x 14,600 = 70 (BOD discharged from Parque Marinha Treatment Facility) Amount of Discharged BOD : 7,700 + 70 = 7,770	30 mg/l x 200 l/day x 185,900 (total population) = 1,115	6,6555 (equivalent to 2,400 ton/year)
Reduction Ratio	66,55/7,770 = 86 %		
Total Reduction Amount	6,800 (ton/year)		

6.5 Measures to Attain the Long-term Target by the Year 2020

The long-term target to be attained by the year 2020 should be accomplished mainly through the said environmental education. In addition to this, measures to attain the said target should be made neither by additional provision of wastewater treatment facility nor by expansion of the treatment facility, but by promotion of educational education. Namely, it should be attained by saving water use at houses, schools, and hotels, by reduction of use of detergents and shampoo, by conversion into use of non-phosphorous type detergents, also by appropriate treatment of used cooking oil at home etc.

6.6 Project Cost Estimate

Cost for the proposed wastewater treatment plan (project) for Pelotas and Rio Grande is give in **Table 6.6-1** and **Table 6.6-2**. Summary of the proposed project cost is given below.

Table 6.6-3 Summary of the Project Cost

Name of Municipality	Pelotas		Rio Grande	Total (1,000 US$)
Name of Project Area	Area-I	Area-II		
Total Project Cost, Including Contingencies	9,900	15,700	5,500	31,400
Project Cost per $1m^3$ of Daily Treated Wastewater (US$/$m^3$)	500	680	750	640 (Average)

Table 6.6-1 Rough Cost Estimate Wastewater Treatment Plan for Pelotas (Unit:US$ 1,000)

Item	Pelotas									
	Area-I					Area-II				
	Amount of Daily Treated Wastewater (19,600 m^3/day)					Amount of Daily Treated Wastewater (23,000 m^3/day)				
	Specifica-tion	Quantity	Unit	Unit Price	Cost	Specifica-tion	Quantity	Unit	Unit Price	Cost
(1) Land acquisition cost for oxidation ditch	Wasteland	15	ha	2	30	Wasteland	15	ha	2	30
(2) Cost for oxidation ditch facility		1	Lump sum		1,500		1	Lump sum		1,800
(3) Civi works for oxidation ditch (excavation, filling, compaction, embankment etc.)		1	Lump sum		300		1	Lump sum		360
(4) Acquisition cost of wetland		10	ha	2	20		12.5	ha	2	25
(5) Civil works for wetland (excavation, shaping, embankment etc)		1	Lump sum		300		1	Lump sum		350
(6) Cost for related facilities (control gate, releasing facility)		1	Lump sum		300		1	Lump sum		350
(7) Pump station	200 mm	1	Lump sum		100	300 mm	1	Lump sum		150
(8) Construction of main sewage pipelines (inclusive of excavation, filling, compaction etc.)	Steel Pipe (600 mm)	5	km	350	1,750	Steel Pipe (700 mm)	6	km	400	2,400
(9) Construction of branch sewage pipelines (inclusive of excavation, filling, compaction etc.)	Steel Pipe (200 mm)	20	km	200	4,000	Steel Pipe (300 mm)	25	km	300	7,500
(10) Pump station for sewage pipelines (inclusive of civil works)	200 mm	3	Place	150	450	300 mm	4	place	200	800
(11) Pump station for sewage pipelines (inclusive of civil works)	600 mm	1	Place	700	700	700 mm	1	place	1,200	1,200
Total of Direct Project Cost					9,450					14,965
Contingency (5 % of total direct cost)					473					748
Total Project Cost					9,923					15,713
Project Cost per 1 m^3 of daily treated wastewater					**0.5**					**0.68**

Table 6.6-2 Rough Cost Estimate Wastewater Treatment Plan for Rio Grande (Unit:US$ 1,000)

Item	Target Area : ### ha, Daily Treated Wastewater: 7,300 m^3/day					
	Specification	Quantity	Unit	Unit Price	Cost	Remarks
(1) Land acquisition cost for oxidation ditch	Wasteland	10	ha	2	20	
(2) Cost for oxidation ditch facility		1	Lump sum		900	
(3) Civi works for oxidation ditch (excavation, filling, compaction, embankment etc.)		1	Lump sum		180	
(4) cost of wetland		5	ha	2	10	
(5) Civil works for wetland (excavation, shaping, embankment etc)		1	Lump sum		100	
(6) for related facilities (control gate, releasing facility)		1	Lump sum		100	
(7) Pump station	200 mm	1	Lump sum		100	
(8) Construction of main sewage pipelines (inclusive of excavation, filling, compaction etc.)	Steel Pipe (400 mm)	4	km	300	1,200	
(9) Construction of branch sewage pipelines (inclusive of excavation, filling, compaction etc.)	Steel Pipe (200 mm)	10	km	200	2,000	
(10) Pump station for sewage pipelines (inclusive of civil works)	200 mm	2	place	150	300	
(11) Pump station for sewage pipelines (inclusive of civil works)	400 mm	1	Place	300	300	
Total of Direct Project Cost					5,210	
Contingency (5 % of total direct cost)					260	
Total Project Cost					5,470	
Project Cost per 1 m^3 of daily treated wastewater					**0.75**	

6.7 Recommendation for Recovery of Project Cost

The proposed wastewater treatment plan has been prepared, paying attention to introduction of the wastewater treatment facilities with less operation and maintenance (O/M) cost aiming at quick recovery of the invested project cost. However, since the budgetary capacity of SANEP in Pelotas as well as CORSAN in Rio Grande is very limited, it is proposed that all the O/M cost of the treatment facilities to be constructed under the proposed wastewater treatment plan should be borne by the beneficiaries. The O/M cost for the proposed wastewater treatment facilities is estimated as follows.

Table 6.7-1 Estimation of O/M Cost for the Proposed Wastewater Treatment Facilities

Name of Municipality	Name of Project Area	Number of Target Household	O/M Cost (US$/Year)
Pelotas	Area-I	30,000	696,000
Pelotas	Area-II	35,000	812,000
Total		65,000	1,508,000
Rio Grande	-	10,000	232,000
Grand Total		75,000	1,740,000

Note: In estimation of the above O/M cost, reference was made to the present O/M cost of Parque Marinha Treatment Facility in Rio Grande.

As is calculated form the above, the O/M cost to be paid by a household both in Pelotas and Rio Grande municipalities is estimated at US$ 23.2 (1,740,000/75,000 = 23.2). On the other hand, the annual income of an average household in Pelotas and Rio Grande is 3,300 US$ and 5,700 US$ respectively. This means that the said O/M cost accounts for only 0.7 % of the annual income of an average household in Pelotas and 0.4 % in the case of Rio Grande, which may be payable by each household without economic difficulty. Accordingly, it is proposed that the O/M cost for the proposed wastewater treatment facilities should be paid by the beneficiaries in the form of wastewater treatment charge. Prior to collection of the wastewater treatment charge, SANEP and CORSAN are requested to put water meter at all the households in Pelotas and Rio Grande, also the authorities are requested to construct proper water charge collecting system beforehand. Because, it has been sometimes observed that trouble with payment of drinking water charge create arguments between the beneficiaries and the authorities, which hinders to collect the charge quickly and properly. And, as a result it also hinders to execute planned wastewater treatment projects on schedule. Above discussions suggest the need of further promotion of putting water mater at each household by CORSAN and SANEP.

CHAPTER 7

SOLID WASTE MANAGEMENT PLAN

COMPONENT (3)

CHAPTER 7 SOLID WASTE MANAGEMENT PLAN COMPONENT(3)

7.1 Basic Policy

7.1.1 Objectives of the Basic Concept Formulation

Litters in the urban area not only constitute a part of the inflow load to Patos Lake and adjacent wetlands, but also contribute to the deterioration of urban sanitary conditions as these prevent smooth river flow and clog canals. Furthermore, improperly disposed solid waste also contributes to the contamination of the Patos Lake and adjacent wetlands as well as groundwater through the inflow of leachate generated in disposal sites. The basic concept proposed here aims to reduce litters in the urban area and the ill-management of solid waste disposal sites.

The basic concept herein proposed shall be utilized as a reference for the preparation of solid waste management plans for the urban areas located within the Mar de Dentro Program Area, provided that each urban area specific conditions are taken into account in the elaboration of such plans.

7.1.2 Main Policies within the Basic Concept

The basic concept targets domestic (including commerce and urban cleaning generating sources) and medical solid waste generated in the urban area of Pelotas. As in the present, SANEP is also considered for the management of the proposed solid waste management plan. The basic concept is formulated taking into account the present solid waste management conditions in Pelotas, as stated in 2.10 (Chapter 2). The main issues to be tackled in a solid waste management plan are presented as follows.

(1) Development of a sanitary landfill

- The present final disposal site does not satisfy the legal standards, as sanitary landfilling practices are not fully implemented. It is, therefore, important to terminate the utilization of this site as soon as possible complying with all technical requirements for its closure.

- A legitimate final disposal site (sanitary landfill) supplied with appropriate bottom lining, leachate and gas collection and treatment facilities, drainage system, besides all necessary items to fulfill the technical standards for a sanitary landfill shall be developed as soon as possible.

(2) Reduction of solid waste disposal amount

- The organic matter portion of the solid waste shall be as much as possible recycled into compost in order to increase the life span of the proposed sanitary landfill.
- The presently on-going recycling/environmental education program shall be further promoted for the same purpose.
- The scavengers ("catadores") activities shall be organized and supported by the municipal government as well as by the society also to improve the recycling ratio.

(3) Proper management of hazardous medical solid waste

- The medical solid waste shall be as much as possible subjected to source separation in order to reduce the amount of the hazardous portion. Alternative methods of treatment shall be studied, choosing the best alternative both in technical and financial terms.

(4) Improvement of collection rate

- The present collection system shall be expanded maintaining the present collection rate level (high) despite an increase in urban population.
- A collection system that increases the present low collection rate for bulky waste shall be studied and introduced in order to minimize improper littering.

- A truck scale shall be installed at the final disposal site in order to improve the accuracy of the collected and disposed amount of solid waste.

(5) Beneficiaries' share in the operation and maintenance cost

- Separate collection and sanitary landfilling will increase the present operation and maintenance cost. Taking this into account, the residents shall be informed about the importance of a solid waste management plan through environmental education programs, campaigns, etc., and requested to contribute with the expenses according to their ability to pay.

(6) Resident's participation in the management plan

- The resident's understanding and cooperation are indispensable for separate collection and cost sharing, among others. Their participation through representatives shall be required in the elaboration of a solid waste management plan and its further evaluation.

(7) Institutional strengthening

- A personnel capacity building shall be foreseen for the smooth implementation of the plan. These activities shall be supported by Rio Grande do Sul State Government level institutions such as FEPAM, METROPLAN, and other concerning institutions such as the Federal University of Rio Grande do Sul (UFRGS) and others.

(8) Promotion of Environmental Education

- All the issues to be tackled in a solid waste management plan depend on the understanding and cooperation of residents. Their collective and individual participation is fundamental for the smooth implementation of the plan. Therefore, environmental education programs and campaigns shall be further promoted.

7.2 Basic Concept of Solid Waste Management in Pelotas

7.2.1 Final Disposal Site (Sanitary Landfill)

The final disposal site (Sanitary Landfill) shall have a life span of, at least, 20 years. In any case, the plan shall foresee actions to extend its life span by promoting the reduction, reuse, and recycling of solid waste.

Considering the worst scenario for the future, in which no reduction, reuse, or recycling measures are taken, a rough estimation was carried out to calculate the dimensions and capacity of the Sanitary Landfill for a life span of 20 years, at least.

If the operation starts in the year 2004 (2004 to 2023), the solid waste generation amounts and thus the required disposal site capacity was calculated in approximately 3,472,000 m^3 **(Tables 7.2-1** and **7.2-2**). Considering this, the approximate necessary area for sanitary landfilling was calculated (**Fig. 7.2-1**).

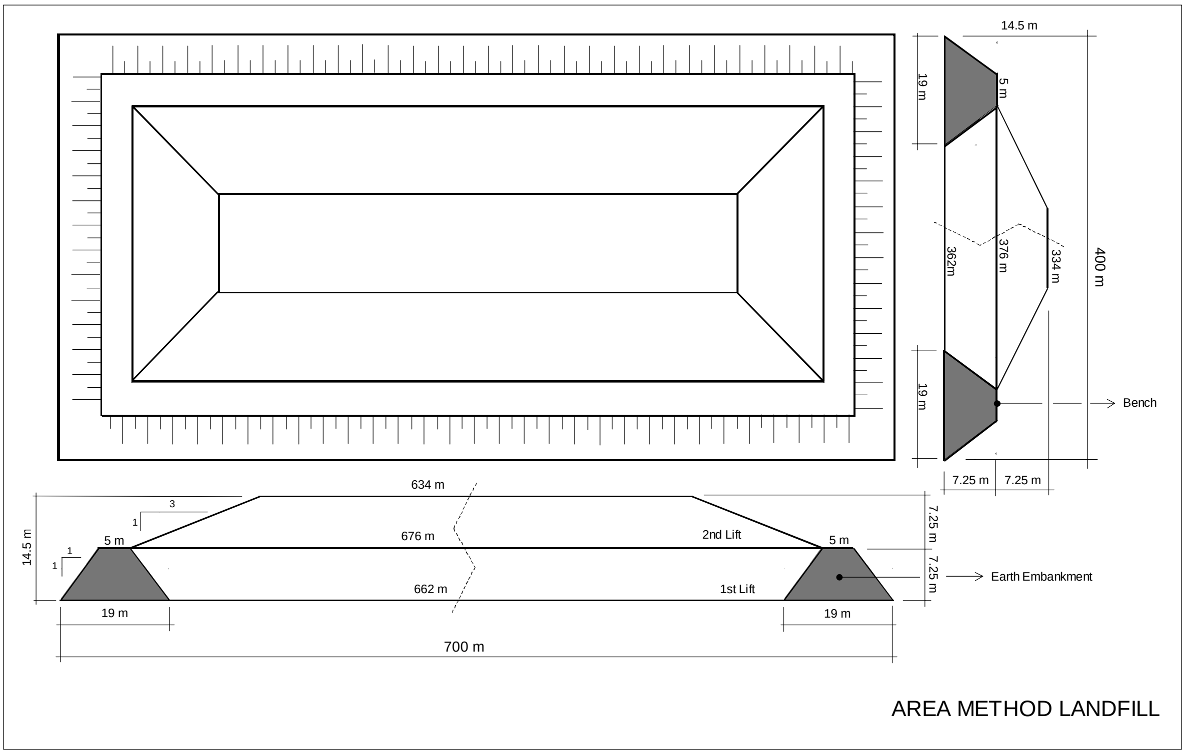


Fig. 7.2-1 Layout of the Sanitary Landfill for Pelotas (for capacity estimation purposes)

Calculation of Landfill Volume:

First Lift: $\frac{(662 \times 362) + (676 \times 376)}{2} \times 7.25 = \frac{239{,}644 + 254{,}176}{2} \times 7.25 = 1{,}790{,}097.5\ m^3$

Second Lift: $\frac{(676 \times 376) + (634 \times 334)}{2} \times 7.25 = \frac{254{,}176 + 211{,}756 \times 7.25 = 1{,}689{,}003.5\ m3}{2}$

Total Landfill Volume: 1,728,370 + 1,630,762 = 3,479,101 **m³**

Table 7.2-1 Forecast of Solid Waste Generation in Pelotas

No.	Year	Population	Domestic Solid Waste			Sludge	Medical Solid Waste				Public Cleaning Solid Waste			Sub-Total	Earth Coverage	TOTAL
									Non-contaminated					(4)+(5)+(8)+(11)	(12) x 15%	(12)+(13)
		(1)	(2) (ton/day)	(3) (ton/year)	(4) (m3/year)	(5) (m3/year)	(6) (ton/day)	(7) (ton/year)	(7) x 80% (ton/year)	(8) (m3/year)	(9) (ton/day)	(10) (ton/year)	(11) (m3/year)	(12) (m3/year)	(13) (m3/year)	(14) (m3/year)
	1999	311,674	156	56,881	81,258	3,086	5	1,967	1,574	2,248	81	29,565	42,236	128,828	19,324	148,152
	2000	314,791	161	58,598	83,712	3,117	5	1,987	1,590	2,271	82	29,861	42,658	131,758	19,764	151,521
	2001	317,939	162	59,184	84,549	3,148	5	2,007	1,606	2,294	83	30,159	43,085	133,075	19,961	153,037
	2002	321,118	164	59,776	85,394	3,180	6	2,027	1,622	2,317	83	30,461	43,515	134,406	20,161	154,567
	2003	324,329	165	60,374	86,248	3,211	6	2,047	1,638	2,340	84	30,765	43,951	135,750	20,363	156,113
1	2004	327,573	167	60,978	87,111	3,243	6	2,068	1,654	2,363	85	31,073	44,390	137,108	20,566	157,674
2	2005	330,848	169	61,587	87,982	3,276	6	2,088	1,671	2,387	86	31,384	44,834	138,479	20,772	159,250
3	2006	334,157	170	62,203	88,862	3,309	6	2,109	1,687	2,411	87	31,698	45,282	139,863	20,980	160,843
4	2007	337,498	172	62,825	89,750	3,342	6	2,130	1,704	2,435	88	32,015	45,735	141,262	21,189	162,451
5	2008	340,873	174	63,454	90,648	3,375	6	2,152	1,721	2,459	89	32,335	46,193	142,675	21,401	164,076
6	2009	344,282	176	64,088	91,554	3,409	6	2,173	1,739	2,484	89	32,658	46,655	144,101	21,615	165,717
7	2010	347,725	177	64,729	92,470	3,443	6	2,195	1,756	2,508	90	32,985	47,121	145,542	21,831	167,374
8	2011	351,202	179	65,376	93,395	3,477	6	2,217	1,773	2,534	91	33,315	47,592	146,998	22,050	169,048
9	2012	354,714	181	66,030	94,329	3,512	6	2,239	1,791	2,559	92	33,648	48,068	148,468	22,270	170,738
10	2013	358,261	183	66,690	95,272	3,547	6	2,261	1,809	2,584	93	33,984	48,549	149,953	22,493	172,445
11	2014	361,844	185	67,357	96,225	3,583	6	2,284	1,827	2,610	94	34,324	49,034	151,452	22,718	174,170
12	2015	365,462	186	68,031	97,187	3,619	6	2,307	1,845	2,636	95	34,667	49,525	152,967	22,945	175,912
13	2016	369,117	188	68,711	98,159	3,655	6	2,330	1,864	2,663	96	35,014	50,020	154,496	23,174	177,671
14	2017	372,808	190	69,398	99,140	3,691	6	2,353	1,883	2,689	97	35,364	50,520	156,041	23,406	179,447
15	2018	376,536	192	70,092	100,132	3,728	7	2,377	1,901	2,716	98	35,718	51,025	157,602	23,640	181,242
16	2019	380,302	194	70,793	101,133	3,766	7	2,401	1,920	2,743	99	36,075	51,536	159,178	23,877	183,054
17	2020	384,105	196	71,501	102,144	3,803	7	2,425	1,940	2,771	100	36,436	52,051	160,769	24,115	184,885
18	2021	387,946	198	72,216	103,166	3,841	7	2,449	1,959	2,799	101	36,800	52,571	162,377	24,357	186,734
19	2022	391,825	200	72,938	104,197	3,880	7	2,473	1,979	2,827	102	37,168	53,097	164,001	24,600	188,601
20	2023	395,743	202	73,668	105,239	3,918	7	2,498	1,998	2,855	103	37,540	53,628	165,641	24,846	190,487
21	2024	399,701	204	74,404	106,292	3,958	7	2,523	2,018	2,883	104	37,915	54,164	167,297	25,095	192,392
22	2025	403,698	206	75,148	107,355	3,997	7	2,548	2,039	2,912	105	38,294	54,706	168,970	25,346	194,316
23	2026	407,735	208	75,900	108,428	4,037	7	2,574	2,059	2,941	106	38,677	55,253	170,660	25,599	196,259
24	2027	411,812	210	76,659	109,513	4,078	7	2,599	2,080	2,971	107	39,064	55,806	172,367	25,855	198,222
25	2028	415,930	212	77,425	110,608	4,118	7	2,625	2,100	3,000	108	39,455	56,364	174,090	26,114	200,204
26	2029	420,089	214	78,200	111,714	4,159	7	2,652	2,121	3,031	109	39,849	56,927	175,831	26,375	202,206
27	2030	424,290	216	78,982	112,831	4,201	7	2,678	2,143	3,061	110	40,248	57,497	177,589	26,638	204,228
28	2031	428,533	219	79,771	113,959	4,243	7	2,705	2,164	3,091	111	40,650	58,072	179,365	26,905	206,270
29	2032	432,819	221	80,569	115,099	4,285	7	2,732	2,186	3,122	112	41,057	58,652	181,159	27,174	208,333
30	2033	437,147	223	81,375	116,250	4,328	8	2,759	2,207	3,154	114	41,467	59,239	182,971	27,446	210,416

Source: SANEP; MRS Environmental Studies Ltd.; IBGE; and Estimation carried out for the Study

Notes:

(1) The applied growth rate was 1.0% per year based on IBGE (Brazilian Institute of Geography and Statistics)

(2) The average daily generation of solid waste per person was estimated in 0.5 kg/person. Based on the 1999 data, an increase of 2%/year in the generation/person was calculated.

(3) It was considered 365 days a year.

(4) The density is 0.7 ton/m3.

(5) Increase of sludge generation is proportional to population growth rate.

(6) and (9) Based on information of daily collection amounts supplied by SANEP for 1998. Then, for the following years it was considered a generation increase proportional to the population growth rate.

(8) Assuming that 80% of the collected Medical SW is non-contaminated matter. In this case, compaction density is considered to be 0.7 ton/m3

(11) The density is 0.7 ton/m3.

(13) Earth coverage amount assumed to represent 15% of the SW volume

Table 7.2-2 Estimation of Recycling/Composting Amounts and Landfill Life Span

No.	Year	Total Collected SW		Collected SW + Earth Coverage		Recycling Actions		Composting Action		TOTAL		I - Accumulated Total Amount for Final Disposal	II - Accumulated Total Amount for Final Disposal
		(12) (m3/year)	(12) x 0.7 (15) (ton/year)	(14) (m3/year)	(14) x 0.7 (16) (ton/year)	Recycled Amount (15) x (17) (ton/year)	% of the Collect. SW (17)	Composted Amount (3) x (18) (ton/year)	% of Domestic SW (18)	Total Recycled (19) (ton/year)	% Disposal Amount (19) / (16) (20)	(21) (m3)	(22) m3
1	2004	137,108	95,975	157,674	110,372	960	1%	18,293	30%	19,253	17%	157,674	130,169
2	2005	138,479	96,935	159,250	111,475	1,939	2%	21,556	35%	23,494	21%	316,924	255,857
3	2006	139,863	97,904	160,843	112,590	2,937	3%	24,881	40%	27,818	25%	477,767	376,959
4	2007	141,262	98,883	162,451	113,716	3,955	4%	28,271	45%	32,227	28%	640,218	493,372
5	2008	142,675	99,872	164,076	114,853	4,994	5%	31,727	50%	36,720	32%	804,294	604,990
6	2009	144,101	100,871	165,717	116,002	6,052	6%	32,044	50%	38,096	33%	970,011	716,283
7	2010	145,542	101,880	167,374	117,162	7,132	7%	32,364	50%	39,496	34%	1,137,385	827,234
8	2011	146,998	102,899	169,048	118,333	8,232	8%	32,688	50%	40,920	35%	1,306,432	937,825
9	2012	148,468	103,927	170,738	119,517	9,353	9%	33,015	50%	42,368	35%	1,477,170	1,048,036
10	2013	149,953	104,967	172,445	120,712	10,497	10%	33,345	50%	43,842	36%	1,649,616	1,157,851
11	2014	151,452	106,016	174,170	121,919	11,662	11%	33,679	50%	45,340	37%	1,823,786	1,267,248
12	2015	152,967	107,077	175,912	123,138	12,849	12%	34,015	50%	46,865	38%	1,999,697	1,376,210
13	2016	154,496	108,147	177,671	124,369	14,059	13%	34,356	50%	48,415	39%	2,177,368	1,484,717
14	2017	156,041	109,229	179,447	125,613	15,292	14%	34,699	50%	49,991	40%	2,356,815	1,592,749
15	2018	157,602	110,321	181,242	126,869	16,548	15%	35,046	50%	51,594	41%	2,538,057	1,700,284
16	2019	159,178	111,424	183,054	128,138	17,828	16%	35,397	50%	53,224	42%	2,721,111	1,807,304
17	2020	160,769	112,539	184,885	129,419	19,132	17%	35,751	50%	54,882	42%	2,905,996	1,913,786
18	2021	162,377	113,664	186,734	130,714	20,460	18%	36,108	50%	56,568	43%	3,092,730	2,019,708
19	2022	164,001	114,801	188,601	132,021	21,812	19%	36,469	50%	58,281	44%	3,281,331	2,125,051
20	2023	165,641	115,949	190,487	133,341	23,190	20%	36,834	50%	60,024	45%	**3,471,818**	2,229,790
21	2024	167,297	117,108	192,392	134,674	23,422	20%	37,202	50%	60,624	45%		2,335,576
22	2025	168,970	118,279	194,316	136,021	23,656	20%	37,574	50%	61,230	45%		2,442,420
23	2026	170,660	119,462	196,259	137,381	23,892	20%	37,950	50%	61,842	45%		2,550,333
24	2027	172,367	120,657	198,222	138,755	24,131	20%	38,329	50%	62,461	45%		2,659,325
25	2028	174,090	121,863	200,204	140,143	24,373	20%	38,713	50%	63,085	45%		2,769,407
26	2029	175,831	123,082	202,206	141,544	24,616	20%	39,100	50%	63,716	45%		2,880,590
27	2030	177,589	124,313	204,228	142,959	24,863	20%	39,491	50%	64,353	45%		2,992,884
28	2031	179,365	125,556	206,270	144,389	25,111	20%	39,886	50%	64,997	45%		3,106,302
29	2032	181,159	126,811	208,333	145,833	25,362	20%	40,285	50%	65,647	45%		3,220,853
30	2033	182,971	128,079	210,416	147,291	25,616	20%	40,687	50%	66,303	45%		**3,336,550**

Sources: SANEP and Estimation carried out for the Study

Notes:

(15) Solid waste to be disposed at the Sanitary Landfill

(16) Solid Waste + Earth Coverage

(17) Recyclables from "Adopt a School" Program + Recycling/Composting Plant

(18) Only considering the organic matter contained in the domestic solid waste

(19) Total solid waste to be recycled/composted

(20) This % shall be withdrawn from the total amount in the landfill to calculate the increase of its life span

(21) Sanitary landfill life span "Without" recycling/composting actions

(22) Sanitary landfill life span "With" recycling/composting actions

The approximate necessary area for disposal is 28 ha (700 m x 400 m). Considering the installation of a composting plant and yard at the same site, the following area distribution was devised for the Final Disposal Site Complex.

Table 7.2-3 Area Distribution of Final Disposal Site Complex

AREAS DISTRIBUTION		
Destination	Area (ha)	
	ha	%
Sanitary Landfill (disposal site)	28	40.0
Composting Plant and Drying Yard	5	7.1
Medical Solid Waste Treatment Area	2	2.9
Access Roads and Administration Area	7	10.0
Leachate Treatment Facilities Area	8	11.4
Protection Park (Buffer Zone)	20	28.6
TOTAL	70	100.0

In a rough estimation, the cost breakdown of the previously described Final Disposal Site Complex is presented as follows:

Table 7.2-4 Total Cost of The Final Disposal Complex

TOTAL COST OF THE FINAL DISPOSAL COMPLEX (in US$)		
Item	**Total**	**%**
1. Basic Design and Environmental Impact Assessment Report	25,710	0.62
2. Land Acquisition	133,710	3.25
3. Detailed Design and Environmental Management Plan	66,860	1.63
4. Project Implementation		
4.1 Sanitary Landfill	2,742,860	66.70
(1) Entrance and fencing	41,145	
(2) Green belt (Buffer Zone)	13,715	
(3) Area preparation (construction of slopes)	192,000	
(4) Bottom lining	1,508,570	
(5) Drainage systems for leachate and gases	137,145	
(6) Access roads (internal, external, on slopes)	192,000	
(7) Leachate treatment facilities	274,285	
(8) Equipment and Machinery (tractors, truck scale, etc.)	384,000	
4.2 Recycling/Composting Plant	685,720	16.68
(1) Earth works	68,570	
(2) Civil works	240,000	
(3) Remodeling and duplication of existing plant	274,290	
(4) Assembling	34,290	
(5) Equipment and Machinery (tractors, bundle press, etc.)	68,570	
4.3 Autoclave Facilities	457,140	11.12
(1) Earth works	45,710	
(2) Civil works	137,140	
(3) Equipment (Autoclave)	274,290	
Total Project Implementation	3,885,720	94.50
GENERAL TOTAL	**4,112,000**	**100.00**

Source: Solid Waste Processing Division, SANEP (June/2000)

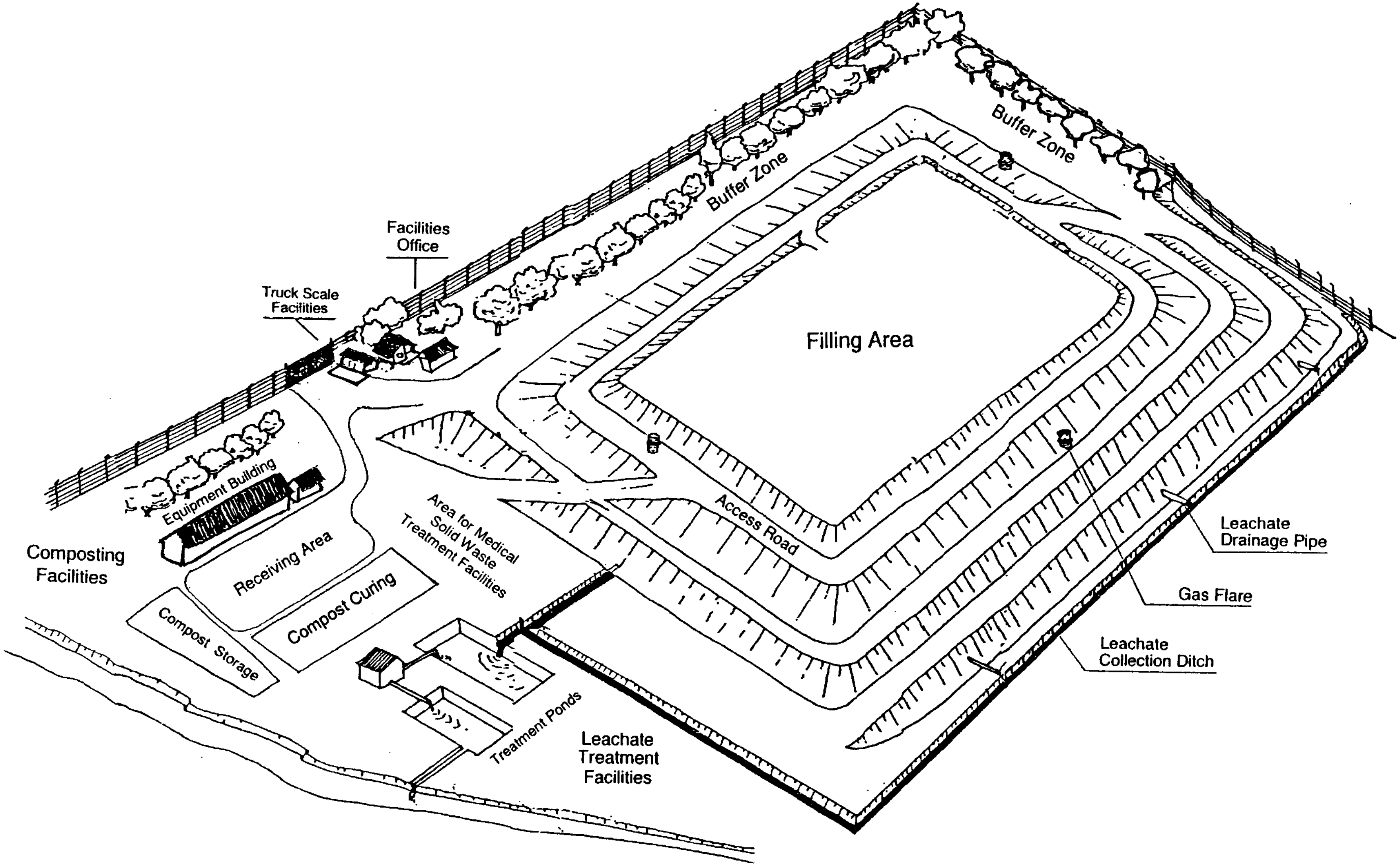
For the same Sanitary Landfill capacity, if measures regarding to reduction of solid waste disposal amount are enhanced, its life span can increase as much as up to 30 years as shown in the **Table 7.2-2**.

For comparison purposes, the following information is presented. The maintenance cost of a Sanitary Landfill is around US$ 9.00/ton while the maintenance cost of a Controlled Landfill such as the one presently being utilized in Pelotas is around US$ 2.00/ton. On the other hand, the positive aspects are shown in the following table.

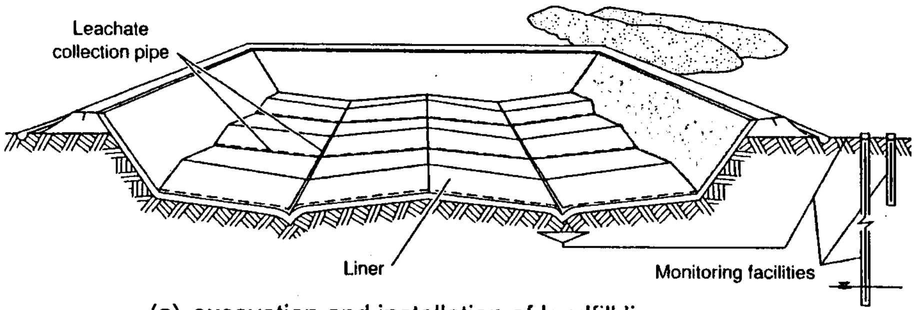
Figs. 7.2-2 and **7.2-3** present a general view and some details of a Solid Waste Sanitary Landfill.

Table 7.2-5 Basic differences between a Sanitary Landfill and a Dumping Site ("Lixão")

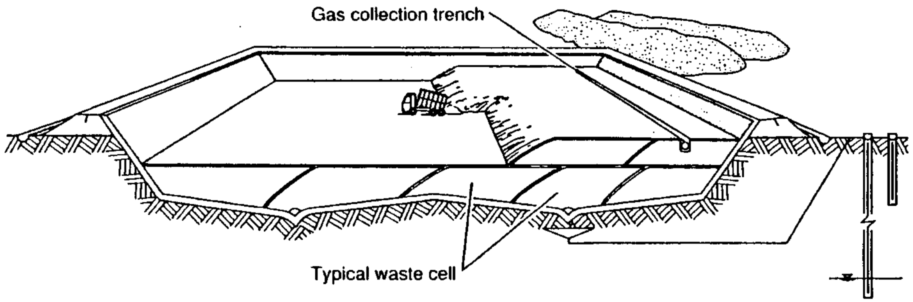
Items of Concern	Sanitary Landfill	"Lixão" (Dumping Site)
1. Soil **2. Groundwater**	The landfill bottom receives a lining of compacted clay layers and/or geosynthetic membranes used to collect leachate and reduce or prevent contamination flow to groundwater and to the soil. Besides that, pipes are placed at the low areas of the liner to collect leachate for storage and eventual treatment and discharge.	In an ordinary dumping site ("lixão") there is no provision of a bottom liner to avoid leachate and gas inflow through the soil and into the groundwater.
3. Superficial Water and Storm Water	For the implementation of the landfill, locations with water springs or streams are avoided. During its implementation, temporary storm water drainage ditches are excavated in order to impede the inflow of this water into the landfill. After the landfill closure, a definite drainage system is installed with the same purpose. Another measure to avoid water inflow is the daily compaction and coverage of the disposed SW with earth (clayey) from nearby borrow pit or from the landfill works.	The leachate is not collected and the storm water freely inflows inside of the Solid Waste mass producing more leachate than if there were no rainfall contribution. This leachate and some wastes are then conveyed to the nearby water streams causing their contamination
4. Atmosphere	Generated by the anaerobic decomposition of the organic wastes, landfill gas is mainly a mixture of methane and carbon dioxide. In order to allow the drainage of this gas, a series of vertical wells or horizontal trenches containing permeable materials and perforated piping is placed. This gas can be further used as an energy source or simply burned at the end of the pipes (gas flares).	The gas is not drained thus also inflows through the soil, into the groundwater and atmosphere. Due to the presence of methane in its composition, there is a high hazard of explosions and wide spread fires. Unpleasant odors can also be felt due to the degradation of the organic portion of the SW.
5. Public Health	The SW is disposed in a planed manner. The landfill is fenced to avoid the presence of diseases vectors, and scavengers. The "working face" of a landfill is the area presently being worked, with new refuse being deposited and compacted into it. Once the working face has been completed and daily cover material provided, it is a completed cell or "daily cell". The "working face" shall be kept as small as possible in order to avoid the attraction of birds and rodents, visual problems for passersby, and blowing paper.	Since the disposed waste is not covered, there is the presence of several diseases vectors such as rodents, insects, etc., posing a serious problem to the public health. Furthermore, due to the harsh economic conditions, the scavengers are frequently seem searching for recyclables among the disposed SW.
6. Environmental Quality after Termination	Once the landfill capacity is depleted, the landfill shall be closured according to a previously determined plan. This plan encompasses the final cover with a high water-proofing layer, definite drainage system, and planting with vegetation for post-use utilization as a park, for instance. Upon the closure of the sanitary landfill, the post-closure care begins. During this period, the landfill maintenance shall be carried out, maintaining all of the landfill's environmental protection features, operating monitoring equipment, remediating groundwater should it become contaminated, and controlling landfill gas migration or emissions.	When supposedly reaching its capacity of receiving more SW, the dumping site is usually abandoned with no closure or post-closure measures. It becomes then a long lasting environmental problem for the surrounding community.



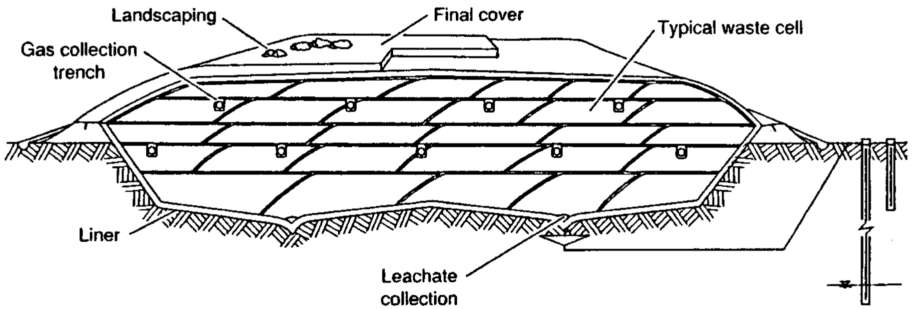
THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL	**Fig. 7.2-2**
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	**General View of a Solid Waste Sanitary Landfill**



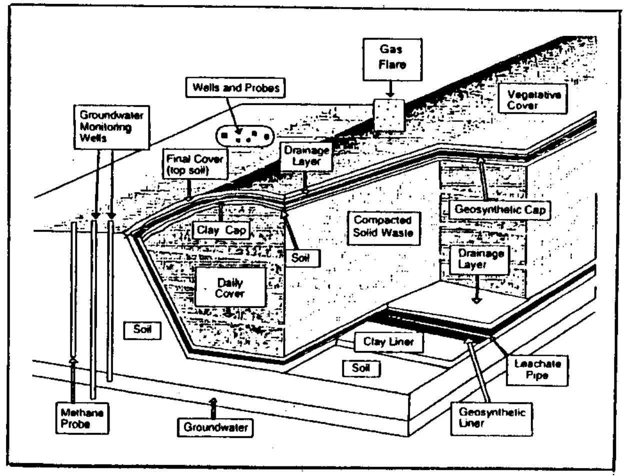
(a) excavation and installation of landfill liner



(b) placement of solid waste in landfill



(c) cutaway through completed landfill



Detail of a Sanitary Landfill Construction

THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL	**Fig. 7.2-3**
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	**Development and Completion of a Solid Waste Sanitary Landfill**

7.2.2 Reduction of Solid Waste Disposal Amount

(1) Recycling

The on-going *"Adopt a School" Program* shall be expanded for all the municipality schools. The expansion plan for this program was already elaborated by SANEP officials (Supporting Report, item 10.8.1). The total implementation cost of this program is approximately US$ 500,000. With the full implementation of this program, the collection rate of recyclables is expected to be raised as much as to 20 ton/day or 7,300 ton/year.

(2) Composting

Considering that at present the percentage of organic matter in the SW composition is approximately 50%, and even considering its probable proportional reduction in the future due to consumption habits changes, the utilization of this organic matter portion as compost shall be planed. For that purpose, the installation of composting facilities (plant and yard) at the same site of the Sanitary Landfill shall be considered. The research being carried out at SANEP's facilities about the composting processes shall also continue in order to attain a good quality and marketable compost. Furthermore, special incentive programs shall be created to stir up the utilization of this compost by local farmers to improve the agricultural properties of the soil.

(3) Scavengers Support

Despite the high rate of curbside collection, several improper dumping points were observed during the site survey. This is due to the action of scavengers who pick up the SW placed for collection, select the recyclable portion, and throw away the remains on improper areas. In order to stop this improper action, the scavengers shall be organized, trained, and oriented for a better performance. Upon their organization, they can use the recycling facilities planed in the "Adopt a School" Program to aggregate value to the gathered recyclables and thus obtain a higher income. Their training can also take place in the same facilities. This action is important not only from the environmental view point but also from the social view point considering the high unemployment rate verified in Pelotas as well as in the whole Country.

(4) Reuse

A special collection program for large size and/or reusable SW shall be planed. This program can encompass the repair for further utilization of the collected material, if possible. In this sense, repair workshops can be installed with the support of the private sector. Upon specific training, these workshops can employ former scavengers.

7.2.3 Proper Management of Hazardous Medical Solid Waste

The management of hazardous medical solid waste shall focus on three basic issues: (1) composition of the presently disposed medical solid waste; (2) generating sources; and (3) treatment and disposal methods.

(1) Composition of the presently disposed medical solid waste

A sound study on the components of the medical SW shall be carried out. First of all, the hazardous portion shall be separated from the non-hazardous one. This study shall comprise the understanding of the components of the hazardous portion of the medical SW and its amounts. Upon this study, a special environmental education program shall be implemented to promote the source separation at the generating units (hospital, health posts, clinics, etc.).

(2) Generating sources

Simultaneously to the aforementioned study, the elaboration of an inventory of the existing generation sources, private and public ones shall also be carried out. This shall allow to appraise the actual hazardous medical SW amount and to elaborate the collection and treatment projects that are to be carried out by the municipal government and/or by the private sector.

(3) Treatment and disposal methods

Up to the present, incineration has been largely utilized to treat medical SW. However, due to the increasing strict environmental control on the air emissions, gaseous and particulate emissions, many of which are thought to have serious health impacts, the cost of appropriate control systems for these emissions also increases. Furthermore, FEPAM has not yet established emission control standards for the operation of incineration plants.

However, once the reduction of hazardous medical SW generation is achieved, as well as the understanding of its components, foreseen in the previous items (1) and (2), the range of options for its treatment increases. Besides incineration, there are other treatment alternatives available. For instance, Autoclaves are utilized specially if the amount of SW is small. This technology is quite sophisticated and thus the operation staff shall be well trained. No matter the alternative to be chosen, the treatment technology shall be evaluated from the technical (safety and efficiency) and economic points of view.

7.2.4 Improvement of Collection Rate

The main issues for the collection system are as follows; (1) maintenance of the present collection rate level (high); (2) increase in the collection rate of bulky waste; and (3) installation of a truck scale for accurate measurement of collected amounts of solid waste.

Among the aforementioned issues, the 2nd one deserves a deeper consideration. The increase in the collection rate of bulky waste can be achieved by the enhancement of urban cleaning actions, educational programs for the proper disposal of this bulky waste, and the creation of a special program for its collection in order to avoid improper littering. Some of these actions are planed in the *Program "Health is a Clean City"* (Supporting Report 10.8.2).

Considering that some of the urban cleaning actions are already been carried out through contracted services as well as directly by the department in charge, the elaboration and updating of a streets sweeping system project with definition of itineraries, as well as a similar project for the weeding and cleaning of vacant land and drainage canals and ditches is fundamental to keep the system in track.

7.2.5 Beneficiaries' Share in the Operation and Maintenance Cost

In Pelotas, the solid waste management system is funded both by the municipal government (Municipal Secretariat of Urban Services budget) and by SANEP. As for the municipal government, the funds come from part of the IPTU (Urban and Territorial Praedial Tax) collection that is at present being under collected due to lack of updated real estate information and resident's lack of awareness. In order to improve this tax collection rate, the municipal government shall implement an updating program of the real estate records. On the other hand, the SANEP's share that is responsible for the payment of the contracted SW collection, final disposal and recycling actions shall be enhanced by the creation of an specific SW management tax. The creation of this SW management tax, as well as other taxes for special collection services, shall be largely discussed with the citizens in order to obtain their support.

7.3 Countermeasure to Prevent Leachate from the Existing Solid Waste Disposal Site in Rio Grande

In environmentally ideal terms, all the solid waste from the present Rio Grande disposal site (area, 23ha; average height, 6 m) should be removed from the site and disposed in an appropriate sanitary landfill, at a due distance from the lake and from the urban area. Then, measures should be taken to treat the contaminated soil and groundwater.

However, considering that this is unfeasible regarding to economic aspects, three (03) recommendations are made for the solution of the problem: (1) elaboration of an environmental diagnosis on the disposal site conditions; (2) elaboration of a remediation plan; and (3) stepwise measures to mitigate the problem.

7.3.1 Environmental Diagnosis

The Environmental Diagnosis shall encompass among others (study on the physical, biotic, and socio-economic environment of the influence area) the following surveys:

(1) Topographic survey of the area.

(2) Quantification of the volume of disposed solid waste.

(3) Geo-technical surveys aim to characterize the area’s stratigraphy (solid waste layers, soil physical-chemical aspects, and sampling).

(4) Physical-chemical analysis of the leachate, superficial waters and groundwater.

(5) Geo-physical survey for the lateral and depth delimitation of the contamination plume (electro-resistivity method is proposed, employing 2D electric imaging techniques, 56 electrodes – 6 m spacing, RES2DINV software shall be utilized for 2D modeling).

(6) Hydraulic infiltration and conductivity tests.

(7) Pollutants dispersion modeling in a porous environment.

(8) Analysis and interpretation of the modeling associated to chemical elements.

The estimated cost for the elaboration of the Environmental Diagnosis is presented as follows:

Table 7.3-1 Cost of the Environmental Diagnosis for the Rio Grande Disposal Site ("Lixão)

Item	Cost (US$)	%
1. Expenses with surveys, tests and analysis (including specialized technical staff costs)		
1.1 Infiltration tests	570	1.0
1.2 Water analysis	1,710	3.0
1.3 Soils analysis	1,150	2.0
1.4 Drilling survey	2,860	5.0
1.5 Topographic survey	1,710	3.0
1.6 Modeling	2,860	5.0
1.7 Analysis of collected material	1,710	3.0
1.8 Digital cartography	860	1.5
1.9 Geo-physical survey	8,570	15.0
Sub-total (1)	22,000	38.5
2. Expenses with material and others		
Sub-total (2)	3,900	6.8
3. Expenses with other technical staff		
Sub-total (3)	3,800	6.6
4. Administrative expenses		
4.1 Administrative cost	10,380	18.2
4.2 Profits	10,010	17.6
4.3 Taxes	7,010	12.3
Sub-total (4)	27,400	48.1
GENERAL TOTAL	**57,100**	**100.0**

Source: MRS Estudos Ambientais Ltda., June/2000.

7.3.2 Remediation Plan

Upon the elaboration of the Environmental Diagnosis, the Detailed Design of a Remediation Plan can be carried out. The list of activities to be carried out for the elaboration of this detailed design is presented as follows:

(1) Description of the technological remediation options.

(2) Qualitative analysis of the selected option.

(3) Design of solid waste confinement and compaction.

(4) Design of the already compacted solid waste final waterproof layer.

(5) Design of the superficial drainage system.

(6) Design of slope embankment execution.

(7) Design of collection and drainage of leachate and gases.

(8) Design of the leachate treatment facilities.

(9) Design of access system.

(10) Design of vegetal coverage and landscaping recovery.

(11) Quantification of the solid waste volumes to be moved.

(12) Definition of execution method.

(13) Quantification of coverage material.

(14) Monitoring Project.

(15) Description Report.

(16) Technical Report.

The total estimated cost of the detailed design elaboration is approximately **US$ 80,900**. However, excluding the cost of the environmental diagnosis which is included in the aforementioned cost, the actual cost is **US$ 23,800**.

7.3.3 Mitigation Measures

While the environmental diagnosis and the remediation plan are being elaborated, some mitigation measures can be carried out as follows (**Fig. 7.3-1**). However, it must be pointed out that any measures shall be accompanied by the installation of a new sanitary landfill at a proper area and complying with all the technical and legal requirements.

(1) The boundaries of the disposal site shall be made visible through the excavation of a retention ditch which bottom shall be compacted with clayey soil and covered with a waterproof membrane. Outside to this ditch, a small embankment

shall be constructed with the excavated earth.

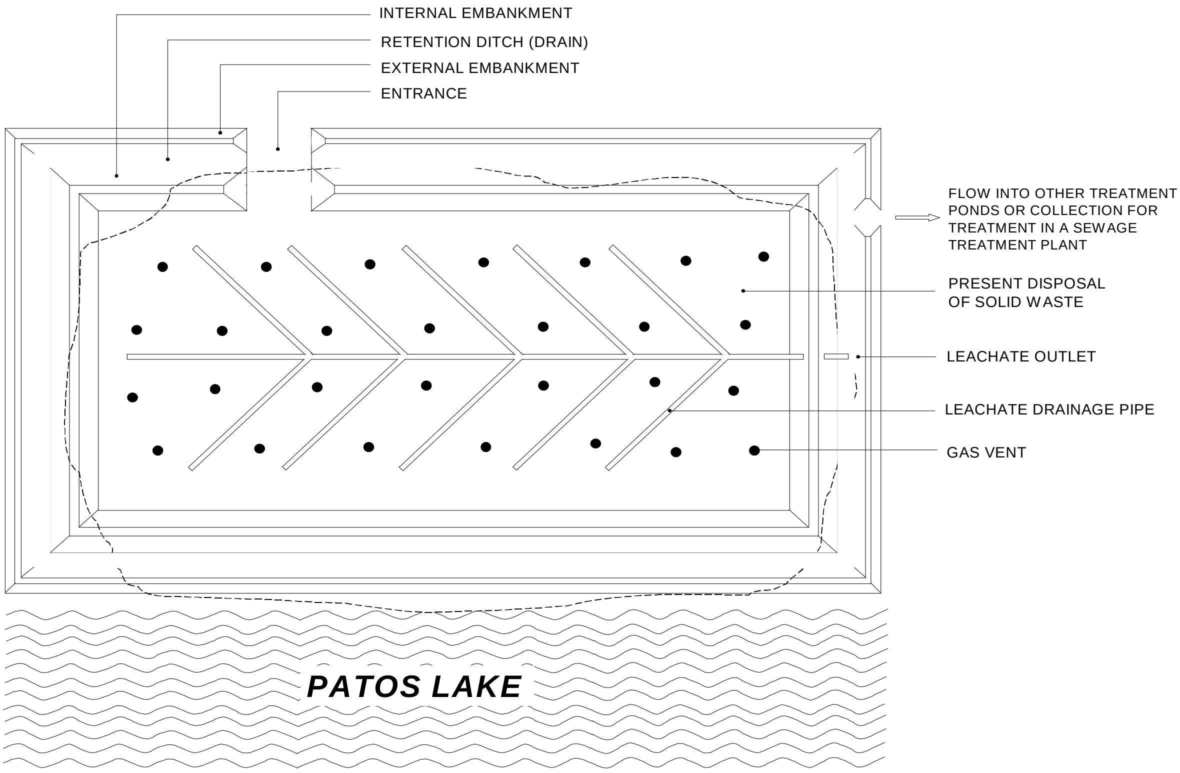
(2) A strip of the solid waste deposited at the side of the disposal site facing the lake shall be removed and utilized for the construction of a surrounding embankment to the disposal site (using the oldest and inert SW portion mixed with earth).

(3) The disposal site shall be excavated for the installation of leachate collection pipes and gas vents.

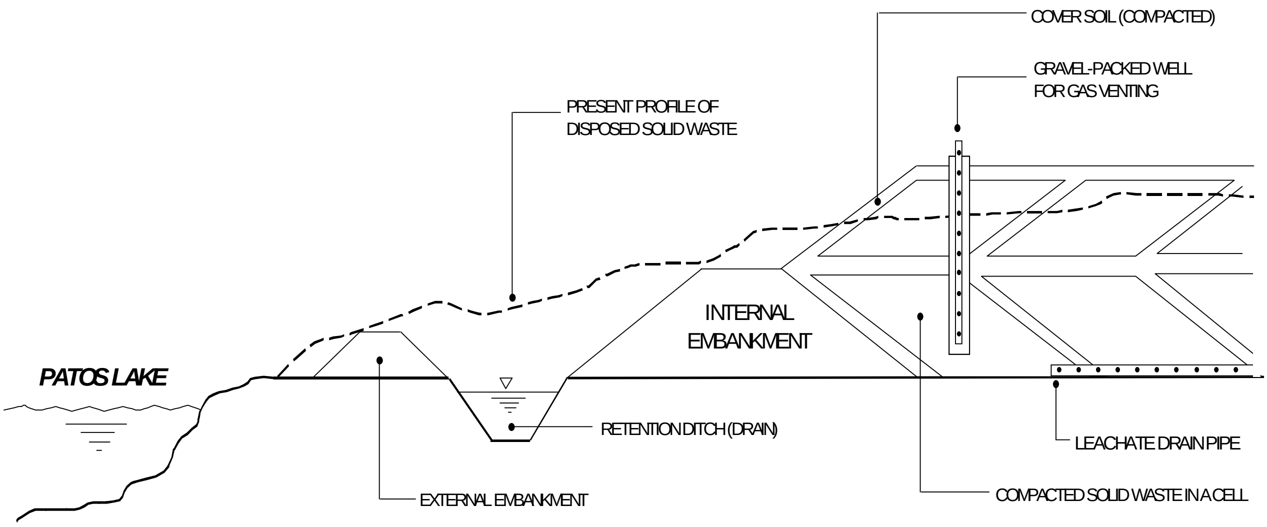
(4) The leachate shall be collected at the aforementioned retention ditch that can be used as a primary aerobic treatment pond. From there, the leachate shall be either conveyed to other ponds (if there is available land) or taken to the sewage treatment plant.

(5) After these works, the rainfall contribution shall be reduced through the compaction and covering of the SW, configured into cells, with clayey soil. Drainage drains shall also be installed for this purpose.

The remediation of the Rio Grande Disposal Site can be carried out as a Pilot Project to be used as an example for the remediation of other similar disposal sites in Rio Grande do Sul State.



SCHEMATIC LAYOUT



LATERAL SECTION (PARTIAL)

THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES	**Fig. 7.3-1**
JAPAN INTERNATIONAL COOPERATION AGENCY **KOKUSAI KOGYO CO., LTD./ PACIFIC CONSULTANTS INTERNATIONAL**	**Schematic Layout of Mitigation Measures for the Rio Grande Disposal Site**