(a) SHORTAGE OF WATER FOR HUMAN CONSUMPTION

(i) Magnitude of the Problem

32. Figure III-7 above shows that three out of the region's four river basins (Tubarão, Urussanga and Araranguá) are highly polluted by coal mining and that 22 tributaries of these river basins in the AMREC sub-region are unsafe for human consumption or industrial use.

33. In the Tubarão river basin, the tributaries, including the Hipólito, Laranjeiras, Otatório, Rocinha and Bonito rivers, are polluted with pH levels varying between 3 and 5 depending on the rain falls and heavy metal content (such as iron, manganese and zinc) at least 3 times higher than Brazilian norms. As a result, the municipalities of Lauro Müller and Orleans, which are deserved by some of these tributaries (Laranjeiras, Otatório and Rocinha) get their water from outside the region. The only major town to use the Tubarão river is the city of Tubarão (100,890 inhabitants). It is also the city with the highest water cost in the Santa Catarina state (R$1.50-R$2.0 per m^3) as a result of the need to treat and clean the water before consumption.

34. With regard to the Urussanga basin, practically all the rivers on the right bank of the Urussanga river, with the exception of the Ronco river and smaller ones such as the Tigre river, are both unsafe for human consumption and unsuitable for industrial or agricultural use. As a result, localities in the vicinity (Santana, Rio América and Rio Salto) as well as the city of Urussanga (the third highest populated municipality in the AMREC sub-region with 17,749 inhabitants) have to get their water from the Maior and Barro Vermelho rivers through the network of the Pedras Grandes municipality, about 25 kms away.

35. Finally, in the Araranguá basin, the pollution of the major waterways south of the Araranguá river (the Mãe Luzia, Kuntz, Fliorita, Morosini, Sangão, Maina, dos Porcos, and Primeira Linha rivers) make that Criciúma, the "capital" of AMREC and a major city in the Santa Catarina state (159,032 inhabitants), has no secure source of water to meet its urban and industrial demand. At present, water for the city comes from the non polluted tributaries of the Mãe Luisa river (the Manim and Jordão rivers which are located on the right bank of the Mãe Luisa), but these sources will not be able to meet the demand within the next five years.

36. To remedy the shortage of potable water in the area, alternatives include (i) construction of a dam on the São Bento river; (ii) cleaning up of the Mãe Luzia river; and (iii) exploitation of the near-by clean aquafiers. Shortage of funds prevent the realization of any of these projects with the consequence that many areas, particularly the low-income ones, do not have access to clean water. These include the following:

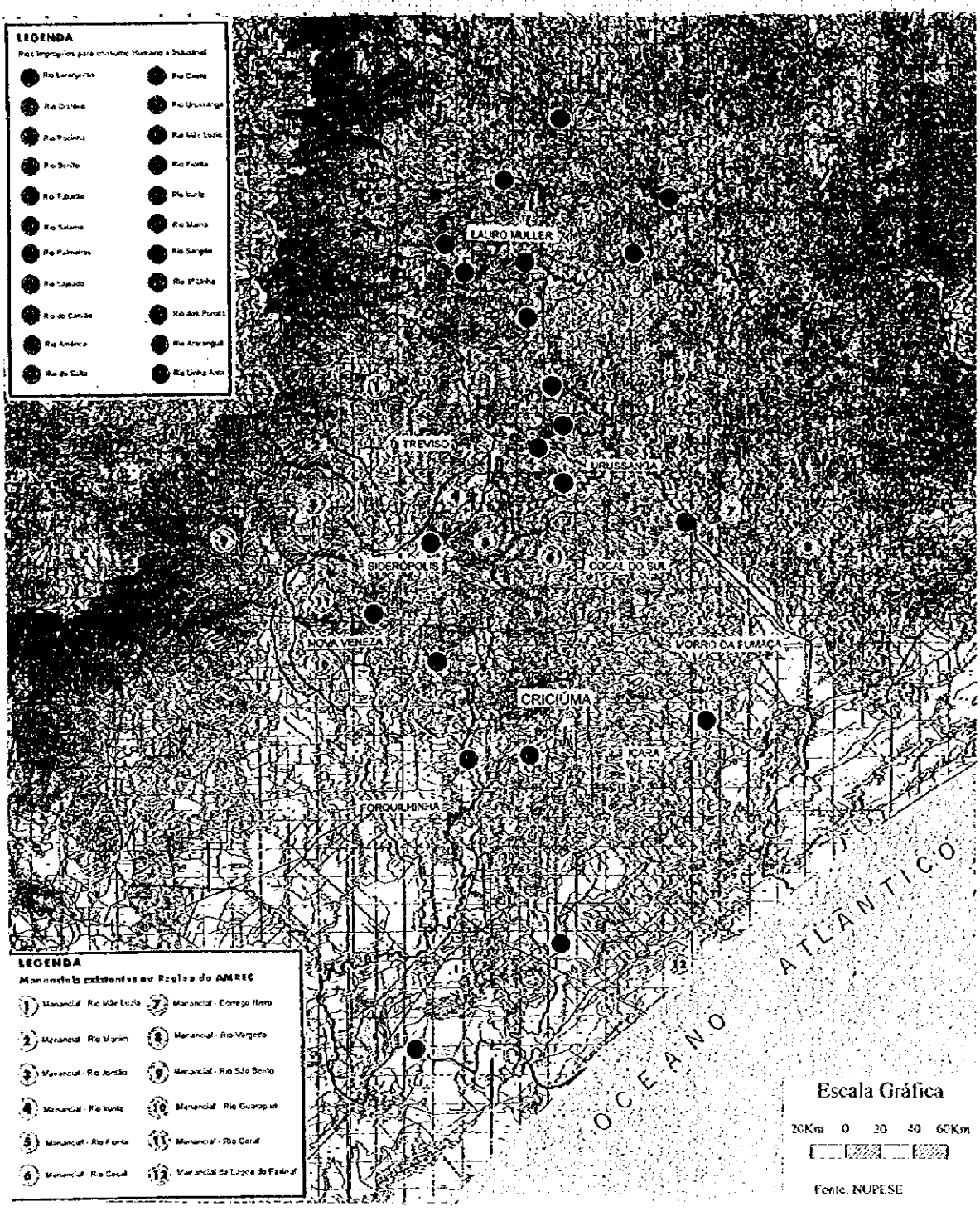

Figure III-8 Coal Pollution of AMREC's Rivers

- *Criciúma Municipality*: Verdinho, Quarta Linha, Linha Demboski, Linha Batista and the localities of Mina do Toco and Cristo Redentor;
- *Nova Veneza Municipality*: the district of São Bento Baixo and the urban center; and
- *Içara Municipality*: Without water connection: Linha Demboski. With sporadic water supply: Jardim centenário, Marili, Jardim Silvana, Cristo Rei, Elizabeti II, Jardim Pinheiro, Raichaski, President Vargas and Planalto.

37. In total there are 5,994 areas with a population of 27,000 without water supply, in addition to numerous other areas (particularly in Siderópolis and in the municipalities of Morro da Fumaça, Maracajá and Meleiro) with precarious and unreliable water connections. It is also estimated that about 25,000 people, i.e., 17% of the municipalities deserved by CASAN (*Companhia Catarinense de Águas e Saneamento)*, the region's main water utility company, are without potable water because of CASAN's inability to serve them due to the high cost of service as well as CASAN's own capability.

38. Thus, about 52,000 urban dwellers living in the areas deserved by the region's main water utility company do not have access to clean water as a direct or indirect consequence of the pollution of surface water by coal mining. For those who do have access, the cost of producing the water is much higher than the rest of the state, a heavy burden for the region's economy.

(ii) Quantification of the Benefits

39. The shortage of potable water has the following impacts which can be quantified: (i) high water production cost; (ii) need for additional investments to deal with the situation; and (iii) high cost of bringing potable water to those without water connection.

i) Cost of Water

40. Table III-9 below shows the volume of water produced by CASAN for the AMREC municipalities and Tubarão city, as well as the actual production cost per cubic meter for Criciúma and Tubarão calculated from information provided by CASAN and discussions with its regional office in Tubarão (*Gerência Regional da CASAN de Tubarão*) and Florianópolis (*Directoria de Expansão da CASAN)*. CASAN data are not desegregated enough to do the same exercise for the other AMREC municipalities.

41. The cost of water in municipalities covered by CASAN is therefore between 67% and 122% higher in Criciúma and Tubarão than in the rest of Santa Catarina. Thus, only taking these two cities (which account for 65% of the population of AMREC + Tubarão city and 85% of the water produced by CASAN for AMREC and Tubarão in 1996), it is estimated that the region would have saved between

R$13.3 million and R$24.4 million a year had the water been clean and the cost comparable with the rest of the state.

TABLE III-9

WATER PRODUCTION AND COST IN AMREC AND TUBARÃO CITY
(In thousands of m^3 and R$/$m^3$)

Municipality	Population	Water Production	Cost/m^3
Cocal do Sul	12,461	563	N/A
Criciúma	159,032	14,633	1.5-2.00
Içara	42,088	1,659	N/A
Lauro Müller	13,351	683	N/A
M. da Fumaça	13,392	423	N/A
Nova Veneza	9,972	169	N/A
Siderópolis	13,750	453	N/A
Tubarão/Capivari	100,890	7,545	N/A
Total	364,936	26,128	0.90[a]

Source: *CASAN - Gerência Central de Florianópolis e Gerência de Criciúma*
[a] Average for the state.

42. Assuming that the actual cost of water in the rest of AMREC is the same as in Criciuma and Tubarão (R$1.5-R$2.0/m^3), the savings would be between R$15.7 and R$28.7 million per year.

ii) Additional Investment Requirements

43. As discussed in paras. 33 and 34, additional investments are urgently needed to ensure continued adequate water supply to Criciúma and neighbouring localities. These include (i) emergency investment to double the water supply from the Manin and Jordão rivers from 400 liters to 800 liters per second (US$5.5 million); (ii) construction of a dam on the São Bento river (US$25 million); and (iii) cleaning of the Mãe Luzia river (US$22 million). These investments totaling US$52.5 million would not be needed had the rivers deserving the Criciúma area not been polluted by indiscriminate exploitation of the region'coal resources.

iii) Cost of Bringing Water to Non-Connected Areas

44. The cost of bringing water to the 52,000 people living in areas without water connection (paras. 35 and 36) is estimated at R$948,440 per year. It is based on a cost of R$1.52/person/month calculated with data given by the Criciúma municipality, which has two trucks to provide that same service to areas without water connection within its jurisdiction[6]. The calculations are detailed below:

[6] These areas are: Verdinho, Quarta Linha Demboski, Linha Batista, Mina do Toco and Cristo Redentor. In the dry season, the service is also extended to localities with precarious water supply such as: Próspera, Ana Maria, Ciudade Mineira, Distrito de Rio Maina, Santa Luzia, São Luiz, Wosocris, Vila Olímica, Pinheirinho, Nossa Senhora da Salete, Santa Bárbara, Santo Antônio Michel, and Pio Correa.

TABLE III-10

ANNUAL WATER TRANSPORT COST

Volume[1/] (1000)	Trips[2/] (No.)	Cost/Trip[3/] (R$)	Cost/Month (R$)	Population (No.)	Cost/Person/Month (R$)
800	114.3	26.64	3,044.6	2,000	1.52

Source: Criciúma municipality. Calculations: NUPESE

[1/] Average per capita consumption: 400 liters/month. [2/] Truck capacity: 7,000 liters

[3/] Average length of trip: 6 kilometers; average cost/km: R$4.44

(b) SHORTAGE OF WATER FOR RICE IRRIGATION

(i) Magnitude of the Problem

45. Southern Santa Catarina is a major rice producer with production reaching 372,523 tons in 1996. AMREC and AMUREL, the two areas affected by coal mining, account for about a third of that total. In these two groups of municipalities, 25,625 ha are currently being used for this type of culture, mainly in the Tubarão basin where clean water is readily available. This basin accounts for nearly 60% of the acreage under irrigation as shown in Table III-11 below. Further expansion there is not possible as practically all the land suitable for rice cultivation had already been used. On the other hand, in the Arraganguá and Urussanga basins, there are plenty of good land which remains unexploited because of the pollution of the Mãe Luzia and Urussanga rivers. The cleaning of these two rivers, particularly the Mãe Luzia river which runs through many areas suitable for rice cultivation (Figure III-9), could add some 7,650 ha (about 30% of the present acreage under cultivation) to the cultivation of irrigated rice.

TABLE III-11

AREAS SUITABLE FOR IRRIGATED RICE

River Basin	Cultivated Area (ha)	(%)	Suitable Area (ha)	(%)	Total Potential (ha)	(%)
Mãe Luzia	9,800	38	6,175[a/]	79	15,975	48
Urussanga	1,025	4	1,474[b/]	19	2,499	7
Tubarão	14,800	58	200[c/]	2	15,000	45
Total	25,625	100	7,849	100	33,474	100

Source: Secretariá de Estado da Agricultura e do Abastecimento.

[a/] Estimated by the *Instituto de Pesquisas Hidráulicas da Universidade Federal do Rio Grande do Sul (IPH FRGS).*

[b/] Estimated by CASAN *magna Engenharia.*

[c/] Estimated by the *Instituto Nacional de Pesquisas Espacias (INPE)* and *NUPESE*, based on 1992 satellite pictures

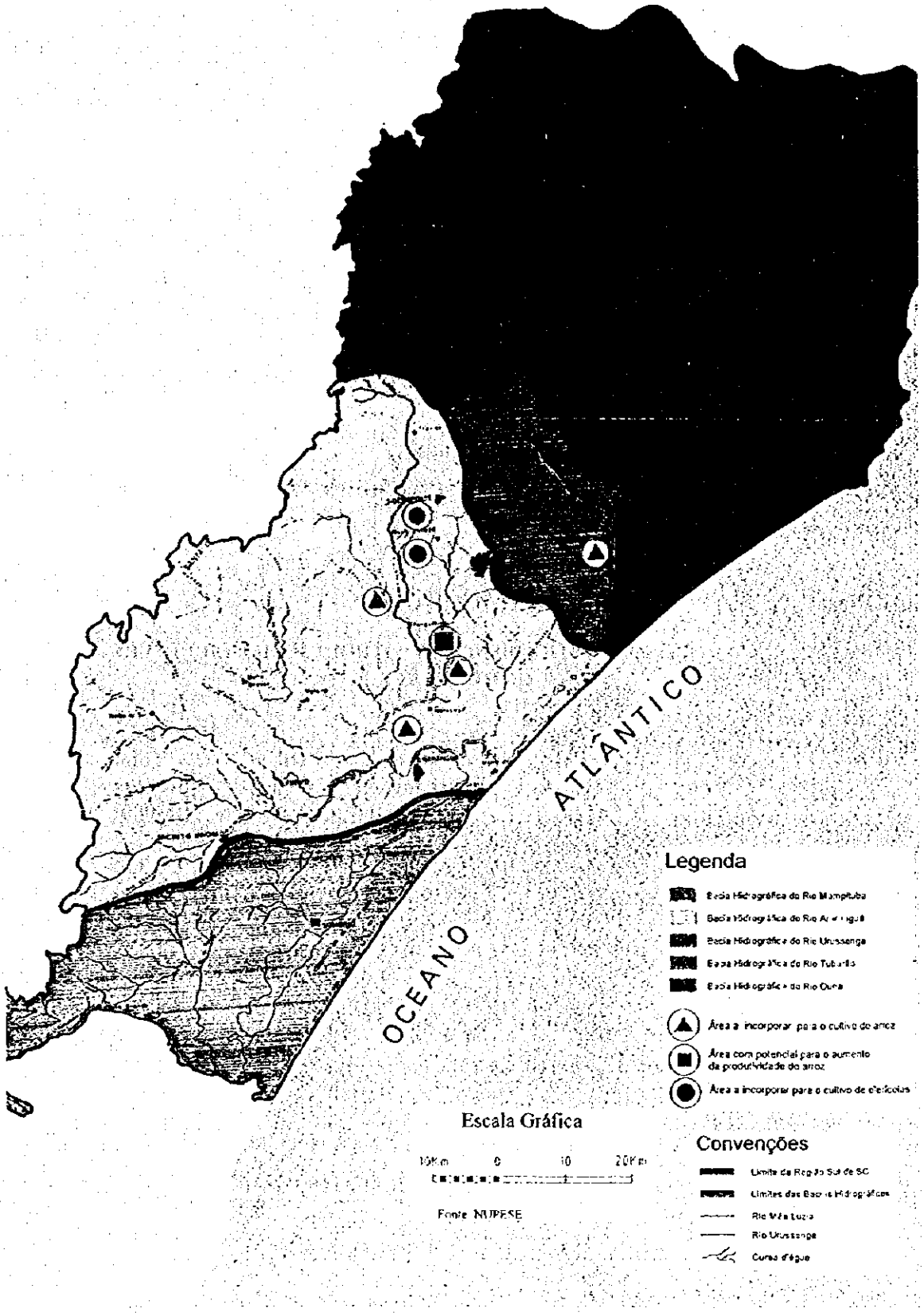

Figure III-9 Areas Suitable for Agriculture Following a Clean up of the Region's Rivers

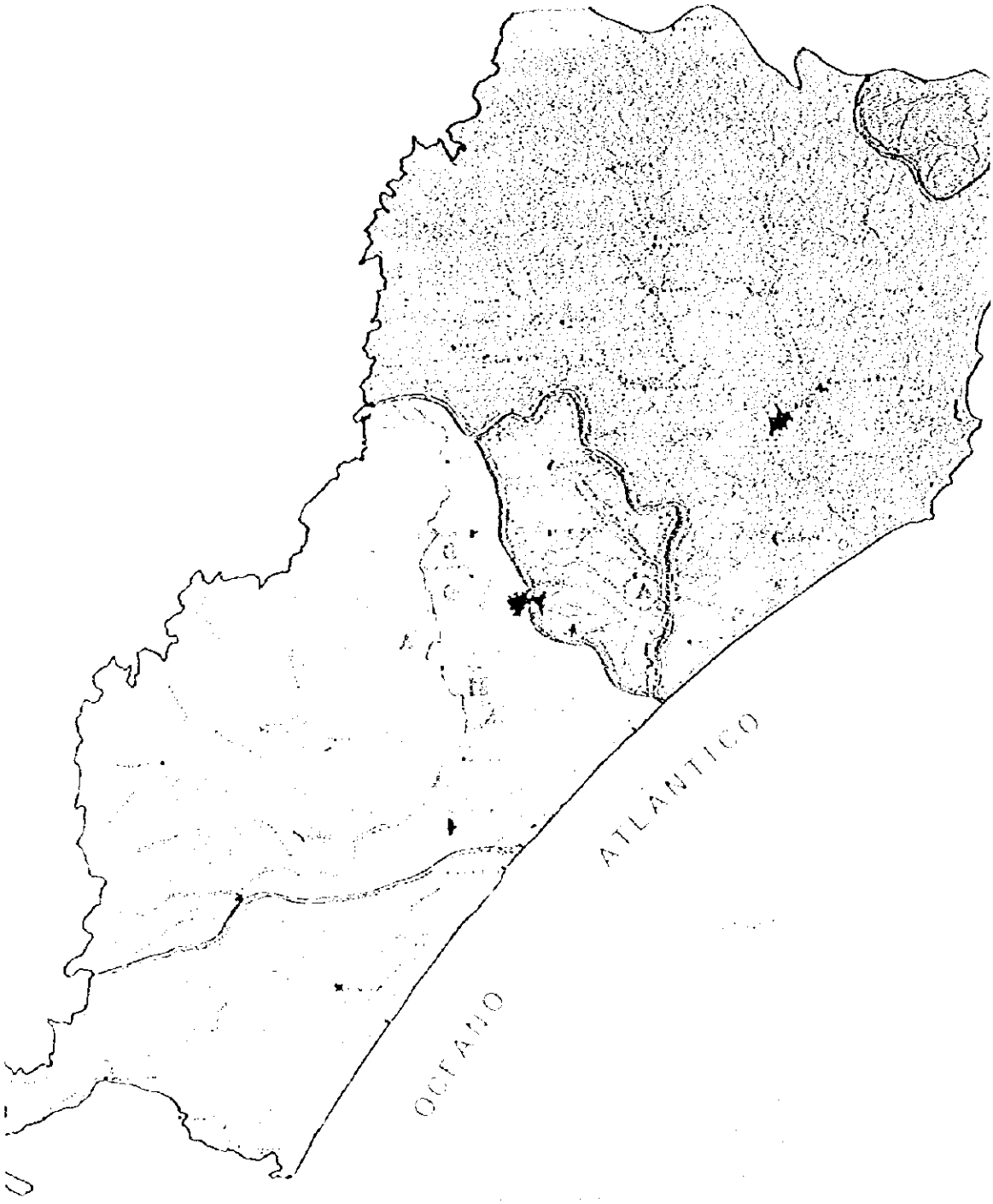

Figure III-9 Areas Suitable for Agriculture Following a Clean-up of the Region's Rivers

(ii) Quantification of the Benefits

46. According to IPH (*Instituto de Pesquisas Hidráulicas*), the average yields of irrigated rice in the three basins are as follows: Mãe Luzia: 5,700 kg/ha; Urussanga: 4,300 kg/ha; and Tubarão: 4,500kg/ha. Rice price is R$207.4/ton and net benefit is estimated to be 40% of that sale price as inputs (seeds, labor, water, energy, etc.) account for 60%.

47. In addition, in the Mãe Luzia basin, 2,500 ha which are presently under irrigation using polluted water would benefit througha productivity increase from 5,700 kg/ha to 6,500 kg/ha. This would add about R$410,000 per year to the benefit stream. Also, in the Mãe Luzia basin, there are 1,000 ha of land suitable for the cultivation of potatoes, beans, tomatoes, etc. The yield for these products is estimated at 15 tons per hectare and the sale price R$200/ton. Net benefit is a third of the sale price, i.e., R$1 million/year.

48. Table III-12 below summarizes the benefits as discussed above, assuming no rizipisciculture, which is being introduced in Santa Catarina.

TABLE III-12

SCENARIO I: REMEDIATION BENEFITS WITHOUT RIZIPISCICULTURE (IN HA AND KG)

River Basin	Available Area (ha)	Average Yield (kg/ha)	Rice Production (R$000)	Other Benefits (R$000)	Total Benefits (R$000)
Mãe Luzia	6,175	5,700	2,900	1,410	4,330
Urussanga	1,474	4,300	530	-----	530
Tubarão	200	4,500	75	-----	75
Total	7,849	5,406	3,525	1,410	4,935

Source: NUPESE-UNESC.

49. As mentioned above, rizipisciculture is being introduced in Santa Catarina in the Paulo Lopes municipality (150 kms north of Criciúma) through a project financed by the World Bank. Fish production in rice fields varies from 1,000 kgs to 3,000 kgs and can be sold for R$0.50/kg. In addition, rizipiciculture reduces the incidence of noxious weeds and eliminates the need for defensive systems in the rice fields, reducing the cost and inputs from 60% of the value of the production to 20%.

50. Assuming that all the 7,849 ha made available by the remediation program are put under rizipiciculture, the results will be as shown on Table III-13 below.

TABLE III-13

SCENARIO II: REMEDIATION BENEFITS WITH RIZIPICICULTURE

River Basin	Available Area (ha)	Rice Production (kg/ha)	Fish Production[1/] (R$000)	Other Benefits (R$000)	Total Benefits (R$000)
Mãe Luzia	6,175	5,840	4,632	1,820	12,292
Urussanga	1,474	1,060	1,105	-----	2,165
Tubarão	200	150	150	-----	300
Total	7,849	7,050	5,887	1,820	14,757

Source: NUPESE-UNESC

[1/] Assuming an average fish production of 1.5 ton/ha

(c) HEALTH IMPACT

51. Coal mining-induced water pollution in Santa Catarina is characterized by a high level of acidity with pH between 3 and 4 (compared to Brazilian norms of 6-9) and concentrations of heavy metals such as sulfate, manganese, iron, and zinc in quantities exceeding up to ten times the norms. If consumed in large quantities, the polluted water can cause diarrhea, fever, vomiting and if not properly treated, it can be fatal.

52. A thorough analysis of 20 years of health statistics provided by Santa Catarina's Health Secretaria (*Secretaria de Saúde do Estado de Santa Catarina*), supplemented with visits to local hospitals and interviews with medical personnel does not establish a significant correlation between the level of gastrointestinal diseases and the pollution of water in the region. If anything, comparison with other cities in the state shows that Criciúma is better off than Blumenau, Chapecó, Florianópolis and Itajai both for gastrointestinal diseases and "ill-defined" diseases.

53. It appears that the region is blessed with abundant surface and ground water resources relatively easy to exploit and, as a result, the population has not generally been exposed to the polluted water. In rural areas, where the water consumed is not treated and comes directly from wells, the population may have used polluted water. The impact of this consumption, if any, has not been reflected in the health statistics analyzed by the Team.

(d) DEVELOPMENT OF RIVER FISHING

54. According to EPAGRI, remediation of the region's river systems would allow the development of river fishing and bring an additional source of income to the population. To a certain extent, it would also somewhat help absorb the excessive fishermen, presently not fully employed. EPAGRI suggests the

following development pattern, taking into account the available human and financial resources in the region (Table III-14).

TABLE III-14

DEVELOPMENT OF RIVER FISHING
(IN TONS)

Basin	Year 5	Year 10	Year 15	Year 20	Year 25
Urusanga	130	332	784	1,537	2,983
Araranguá	509	1,507	3,463	5,661	13,187
Tubarão	1,312	4,715	11,133	21,837	42,390
Total	1,951	6,554	15,380	29,035	58,560

Source: EPAGRI/UNESC-NUPESE

55. Given an average price of fish of R$0.6/kg, the benefits are as shown on Table III-15 below.

TABLE III-15

BENEFITS FROM RIVER FISHING
(IN R$000)

Basin	Year 5	Year 10	Year 15	Year 20	Year 25
Urusanga	78	199	470	922	1,790
Araranguá	305	904	2,078	3,397	7,912
Tubarão	787	2,829	6,680	13,102	25,434
Total	1,170	3,932	9,228	17,421	35,136

Source: EPAGRI/UNESC-NUPESE

56. However, as some rivers in the region are also polluted by pig farming and other agricultural and industrial activities, it may be difficult to achieve the EPAGRI's estimates. To be conservative, only 50% of the benefits will be included in the low case.

(c) IMPACT ON THE ARTISAN FISHERIES SECTOR

(i) Definition of the Problem

57. Unlike the issues discussed above, the role and impact of coal mining in the artisan fisheries sector is less clear and more difficult to quantify. From an thorough analysis of existing information and research supplemented by interviews with local fishermen associations, the following picture emerges:

- The southern region, particularly the lagoon area, has lost substantial fisheries resources; and

- The region's artisan fisheries, which was a major economic sector, has been decreasing steadily over the past 15 years. From 16,159 active fishermen generating some 24,575 other jobs in 1980, the sector only provided employment for 9,950 (and 15,080 related jobs) in 1995, a 38% reduction in 15 years. The average monthly income of the typical fisherman was reduced from R$268 to less than R$150, i.e., about 60%, forcing him to supplement this activity with other works;

- However, while coal mining has contributed to pollute the lagoons and other fishing grounds in the region, so have other economic activities, such as industry, tourism (in the lagoon area, particularly) and municipal waste; and

- Also, while the southern region's artisan fisheries is sinking, this is also taking place elsewhere in Santa Catarina and, for that matter, in other parts of the world as well. It is a world-wide phenomenon brought about by the development of industrial fisheries. The loss of fisheries resources in the lagoon area and other fishing spots is only a factor among other equally important economic factors responsible for the difficulties facing the artisan fisheries sector. In the rest of Santa Catarina, which does not suffer from coal mining pollution, artisan fisheries production fell from 15,912 tons in 1984 to 6049 tons in 1995, i.e., a decrease of 69%. During the same period, artisan fisheries in southern Santa Catarina decreased by 91%. It is therefore safe to say that under the best assumptions, coal mining could only be responsible for the difference between the two rates.

58. In conclusion, while coal mining activities have contributed to pollute fishing ground, causing substantial losses of fisheries resources and the near destruction of the artisan fisheries sector, it is by far the only culprit. Other factors were at work, including the expansion of tourism in the lagoon area, and the fast urban development during the past ten years, particularly in the lagoon area.

59. Thus, to have any impact on the fisheries sector, remediation of coal mining pollution should be accompanied by other actions aimed at curbing pollution from other sources.

(ii) Quantification of the benefits

60. Assuming that actions are taken in parallel to curb pollution from urban waste and beach tourism in the lagoon area, the benefits which could be claimed from a coal mining pollution program, would be as follows:

- Restoring the artisan fisheries sector to the level it would have been without coal mining pollution, i.e., the level it would have reached following the same developments as the Santa Catarina's artisan fisheries sector as a whole. In concrete terms, this means a production decrease of 78% from its 1984 level instead of 91% and a reduction of its direct labor force of 32% instead of 38%. The sector would thus have 11,000 professional fishermen instead of 9,950; and

- Assuring to the fishermen the same income they enjoyed in 1980 when pollution of fishing grounds was not a problem, i.e., R$380/month instead of R$150/month.

61. Table III-16 below shows the results of the calculations, given an average price of fish of R$0.6/kg.

TABLE III-16

POTENTIAL BENEFITS FROM RESTORING FISHING RESOURCES

	Before Remediation		After Remediation		Remediation
	Quantity (Tons/No)	Value (R$000)	Quantity (Tons/No)	Value (R$000)	Benefits (R$000)
Fish Production	1,061[a/]	637	2,598[a/]	1,559	922
Fishermen Income	9,950[b/]	17,910	11,000[b/]	50,160	32,250
Total		18,547		51,719	33,172

Source: NUPESE
[a/] In tons. [b/] Number of fishermen

2.3 CONSTRAINT TO TOURISM DEVELOPMENT

(i) Definition of the Problem

The Region's Tourism Assets

62. EMBRATUR (*Empresa Brasiliera de Tourismo)*, Brazil's national tourism agency estimates that 25 municipalities in southern Santa Catarina has considerable assets to develop tourism. These include cultural heritage (Italian), vineyards and a reputable gastronomic tradition (Orleans and Urussanga), thermal waters (Gravatal), beaches and lagoons (Imbituba, Içara, Arraranguá, and Sombio), shopping (Criciúma, Tubarão) and mountains and caverns (Lauro Müller and Bom Jardim da Serra).

63. However, EMBRATUR also cautions that tourism is constrained by the severe coal mining pollution in a number of municipalities, including Criciúma, Tubarão, Siderópolis, Içara and Arraganguá. The reputation of the region as a coal mining-polluted area does not project a good promotional image either.

64. Despite this potential and fairly adequate hotel infrastructure, tourism is still very underdeveloped in southern Santa Catarina. It has reached a respectable size only in Arraganguá and the Laguna area and mainly consists of beach tourism with a sizable proportion of visitors coming from neighboring Mercosur countries. Arraganguá is the municipality which has the most tapped into this international market. In 1995, its R$14.1 million tourist revenues came almost exclusively from international visitors, most of whom from Uruguay and Argentina.

65. In the interior, tourism is practically non-existent despite the natural parks, beautiful mountains and many other attractions the region offers. Criciúma is the only exception, with tourist revenues reaching R$6.8 million in 1995. However, 90% of it is business-related tourism. "Real tourism" only accounts for 10% of the total.

Constraints to Tourism Development

66. Tourism in the region faces many constraints. While hotel infrastructure is not a major problem, the shortage of clean water poses a serious threat to the development of eco-tourism. In Urussanga, for example, plans to build several inns to tap into a relatively large tourist potential (the Pousada da Vinicola, the only inn in the area cannot satisfy the growing number of visitors) had to be abandoned because of lack of clean water. Cleaning the Urussanga river would also allow the development of water sports, swimming and fishing, increasing the region's tourist attractiveness.

67. Other constraints include pollution of the lagoons and beaches by municipal waste and other industries, pollution of the region's river systems by pig farming and, last but not least, lack of a well developed planning and tourist promotion program to erase the region's image as a coal polluted area and to advertise the region's attractiveness. As in the fisheries case, coal mining pollution is only one among many problems constraining tourism development in the region. Unless parallel actions are taken to address the other issues, remediation of coal mining pollution by itself will not be sufficient to induce ant tangible increase in tourism in the area.

(ii) Quantification of the benefits

68. Table III-17 below shows Santa Catarina's tourist revenues in 1995, the last year for which data are available.

TABLE III-17

TOURISM REVENUES IN SOUTHERN SANTA CATARINA
(IN R$000)

Araranguá	Criciúma	Laguna	Imbitubá	Others	Total
14,100	6,800	20,800	7,670	3,000[a]	52,370

Source: SANTUR (*Santa Catarina Turismo S.A*). [a] JICA Team's calculations

69. Assuming that adequate measures are taken in parallel to address the issues discussed above, remediation of coal pollution would help the region's tourism development in the following ways:

- Accelerate the development of eco-tourism in the following coal mining affected municipalities: Lauro Müller, Urussanga, Içara, Siderópolis and Tubarão; and
- Help sustain the present growth of beach tourism in Arraganguá, Laguna and Ibituba, which could be affected if coal mining pollution problem remains unsolved.

70. Beach tourism (Araranguá, Laguna, and Imbituba) has been increasing at a rate of 5% per year during the past seven years, while eco-tourism in the interiors has been fluctuating up and down, but on

average has been creeping up at a rate varying between 1% and 3% per annum. Assuming that eliminating coal mining pollution helps sustain the historical growth rate of beach tourism, which otherwise would be reduced by half (2.5% instead of 5% per year), while accelerating the development of tourism in the interior to 5% per annum from its past level of 1%-3% p.a., the benefits of recuperation would be as shown in Table III-18.

TABLE III-18

TOURISM BENEFITS FROM COAL MINING REMEDIATION

	With Remediation		Without Remediation		Net Benefits
	Growth (%)	R$000	Growth (%)	R$000	R$000
Beach tourism	5.0	2,128	2.5	1,064	1,064
Eco-tourism	5.0	150	2.5	75	75
Total		2,278		1,139	1,139

Source: JICA Team's calculations

2.4 SUMMARY OF BENEFITS

71. Total quantifiable benefits from coal mining remediation are summarized in Table III-18 below. Benefits contingent upon other actions are marked with an asterisk (*).

TABLE 19

SUMMARY OF BENEFITS
(RS MILLION)

	Minimum	Maximum
Land Pollution		
- Increase in Land value	77.0	191.2
- Forestry resources	19.5 every 7 years	19.5 every 7 years
- Fauna and flora	2.3/year from year 5	9.3/year from year 5
- Recreational use	2.2/year from year 5	8.5/year from year 5
Water Pollution		
- Higher water cost	13.3/year	28.7/year
- Additional investments	52.5	52.5
- Bringing water to non-connected areas	1.0/year	1.0/year
- Rice cultivation	5.0/year	14.8/year
- River fishing	0.6 in year 5 to 16.7 in year 25	1.2 in year 5 to 35.2 in year 25
- Fisheries resources*	33.2 in 5 years	33.2 in 5 years
Land and Water		
- Tourism development*	1.1/year	1.1/year

Source: JICA Team's estimates

72. However, there are many other benefits from remediation which, unfortunately, cannot be quantified. These are described below:

- **Constraint to Industrial Development**. From discussions with ACIC (*Associação Commerrcial e Industrial de Criciúma)* and other industrial promotion organizations, it appears that the high cost of water, the pollution of surface and ground water reserves, and AMREC's image as a coal-polluted area discourage the establishment of new industries in the region. While diffuse and difficult to capture, this constraint is an important factor in the region's continued economic difficulties;

- **Pollution Ground Water Reserves.** There is growing evidence that the region's ground water reserves has been polluted by coal mining activities. Tests and analyses made by NUPEA (*Núcleo de Pesquisasambientais)* show that pH level and iron content exceed the norms in 20% and 65% of the samples, respectively, sometimes by wide margins (e.g., Fe content of 17.7 against the norm of 0.3, or pH of 5.0 compared to the norm of 6.5-8.5). NUPEA further estimates that 9% of the ground water reserves in the region is contaminated (Figure 10). While it is impossible to quantify the potential benefits of remediation in this case, it is safe to conclude that the continued pollution and depletion of ground water reserves is threatening the very future of the region; and

- **Multiplier Effect.** No attempt has been made to quantify the secondary (and tertiary) effects of the increased economic activity and production (irrigated rice, timber, firewood, river and lagoon fishing, tourism development, etc.) induced by the remediation of coal mining pollution. They are, however, thought to be important, and may add 1%-1.5% to the region's economic growth rate.

3. REMEDIATION STRATEGY AND ESTIMATION OF THE TOTAL COST OF THE PROGRAM

3.1 TECHNICAL CHARACTERISTICS OF THE AREAS TO BE RECUPERATED

73. The objective area (4,723.8 ha) to be recuperated consists of: (i) area which was mined in the past and is now abandoned (3,292.0 ha, or 69.7% of the total area), (ii) area still being actively mined (1,153.5 ha, or 24.4% of the total area); and (iii) inactive mining area, which are temporally not mined because of the depressed market conditions (278.3 ha, or 5.9% of the total area). For remediation purposes, the area is divided into three types of wastes, i.e., black shale; white waste; and polluted water, which comprise 48.6% (2294.6 ha), 46.2% (2182.4%) and 5.2% (246.8ha) respectively. The share of each type of waste for the three different areas is shown in Table III-20.

74. In the black shale dumped area, there are 425 ha areas (28% of total black shale area) not directly connected with rivers or ground water reserves.

TABLE III-20

THE SHARE OF EACH TYPE OF WASTE
(IN HECTATE)

	Abandoned	Active	Inactive	Total
Black Shale	1,222.6	924.6	147.4	2,294.6
	(37.1%)	(80.2%)	(53.0%)	(48.6%)
White Waste	1,878.4	181.4	122.6	2,182.4
	(57.1%)	(15.7%)	(44.0%)	(46.2%)
Water	191.0	47.5	8.3	246.8
	(5.8%)	(4.1%)	(3.0%)	(5.2%)
Total	3,292.0	1,153.5	278.3	4,723.8
	(100%)	(100%)	(100%)	(100%)

75. The pollution load from abandoned area and active mines is presented in Table III-21, which also shows that active areas are much more polluted than abandoned area. Further more, as shown in the result of simulation for water quality in the whole area, which is described in Water Quality Monitoring of Section II- B of Technical Annex, recuperating only abandoned areas will not improve the water quality in the whole area. On the contrary, recuperating only active areas will not improve the water quality. Unless both the areas are remedied, no significant benefits are to be expected.

TABLE III-21

POLLUTION LOAD FROM ABANDONED AREA AND ACTIVE MINES

			Abandoned Area	
		Active Mines	Black Shale	White Waste
pH	(-)	2.81	3.3	3.2
SO^4	(mg/l)	2,838	645.0	494.0
Dis. Fe	(mg/l)	391	94.8	29.5
Al	(mg/l)	123	44.8	32.7

76. In the abandoned area there is no mining operation and all the land are remained as wasteland with many black shale on it. At present 6 mining companies are producing coals in the active mining area and have ceased their operation in the inactive area.

3.2 REMEDIATION STRATEGY

77. The mined-out areas are so polluted with black shale that only a wet cover method would be effective. However, it would be very expensive if wet cover is adopted for all the area covered with black shale. Since in-depth analysis indicates that dry cover can also be used in polluted areas not directly connected with rivers or ground water reserves with little risk, wet/dry cover system would be used. As mentioned in para. 75, active areas are much more polluted than abandoned areas. Thus remediation of abandoned areas will most likely not bring any improvement unless active areas are also remedied.

78. Given this fact, a two phase approach is proposed. In the first phase, remediation would be limited to active areas which is smaller than abandoned ones to be recuperated. As mentioned above, active areas are the most polluted and their clean up is a sine qua none condition for the success of any remediation program. As these areas are still being used by mining companies in their normal extraction and beneficiation activities, the first phase should also include measures to help these companies conduct their operations in an environmentally responsible manner and address the issue of strengthening FATMA (and other agencies involved in monitoring mining operations, such as DNPM) to ensure that mining companies fully comply with environmental regulations, particularly with regard to water discharge and regulation of mined-out land. It is only when active areas are totally remedied and mining companies in full compliance with environmental regulations that the second phase focusing on remediation of abandoned areas would be implemented. This strategy is safer, cheaper, and easier to manage.

3.3 BASE OF COST CALCULATIONS

(i) Market Price

79. Based on the Feasibility Study for four selected sites, project cost for the whole area (4,723.8 ha) was estimated based on the unit costs determined by the study team with cost information collected from SETEP, a construction company in Criciuma and from the Department of Road, Santa Catarina State Government in March 1997. The remedial unit cost for the overall area was calculated in $Real at market prices as of June, 1997. In this pre-feasibility study, cost estimation was not done precisely since detailed investigation of the whole area has not been conducted except for the F/S sites.

(ii) Force Account

80. In the first step, cost was estimated assuming that all the works in the project would be contracted out to Brazilian companies as described in Civil Engineering and Cost Estimates in Section II-D of Technical Annex. Thus, all the equipment, materials and labor would be newly procured or hired for the project. The cost of this case is called as "Calculation Base" in this report.

81. However, considering the fact that most of the land belongs to mining companies which have the equipment and the time (given the low mining production level) to do the work, will do it themselves, by force account. This may also be the case for the municipalities (owners of 7% of the polluted land) which can rely on the Santa Catarina Government to help them carry out the work. Thus, 89% of the remediation is likely to be done by force account instead of being contracted out. For simplicity, we assume that the Santa Catarina Government will also help the private individuals, owners of the remaining 11%, so that all the work would done by force account. Thus, the costs for materials estimated on the basis of contract-out and retail prices would be decreased by 15%, while costs such as depreciation, profits, etc.

would be ignored.

3.4 BASE CASE

82. The project cost and its breakdown in the case of force account was estimated in the following table. This cost is adopted as base case for the economic evaluation.

TABLE III-22

BREAK DOWN OF THE PROJECT COST

($R1,000-)

Item	Calculation Base	Force Account
Labor	21,198	0
Parts	9,654	9,654
Tire	520	520
Fuel/Lubricant	9,950	9,950
Depreciation	6,027	0
Overhead	17,889	0
Cement	3,878	3,296
Sand	493	419
Gravel	15,198	12,918
Board	2,182	1,855
Timber	237	201
Nail	63	54
Cobble	1,997	1,697
Mortar	1,818	1,545
Lime Stone	30,666	26,066
Clay	52,371	44,515
Chemical Fertilizer	3,854	3,276
Seeds	1,008	857
Cellulose	2,668	2,268
Emulsion	949	807
Bar	4,415	3,753
Organic Matter	2,256	1,918
Royalty for Clay	15,757	0
Mobilization etc.	10,252	0
Engineering	10,765	5,705
Contingency	22,607	13,112
Total	248,672	144,387

3.5 CONSIDERATION OF UNIT COST

83. A few data is available for comparing the unit cost of this project with other similar projects in the area. One data from EPAGRI (trial, not yet conducted) shows a unit cost of land recuperation with dry cover systems, estimated at R$18,820/ha. The JICA Study Team estimated at R$18,330/ha with the

identical systems. It can be said that these two estimates are practically on the same level.

4. ECONOMIC EVALUATION

4.1 EVALUATION METHOD

84. Economic evaluation of projects is usually done by comparing the project's total stream of benefits to its total stream of costs, both valued in economic terms. The benefits of the project are estimated by comparing the situation "with" the project to the situation "without" the project.

85. For the evaluation, the Cost Benefit Ratio (B/C), the Net Present Value (NPV) as well as the Economic Rate of Return (ERR) are calculated.

4.2 ASSUMPTION OF EVALUATION

86. Basic assumption of the evaluation are as follows:

Evaluation period	30 years
Project period	10 years
Discount rate	12 %

87. The project cost discussed in the previous chapter which is in market prices is converted into economic cost by eliminating the tax portion using the tax rate in Brazil obtained from SETEP, a construction company in Criciuma. Economic Cost is shown in the following table.

TABLE III-23

ECONOMIC COST

($R1,000-)

Item	Project Cost in Force Account	Economic Cost
Labor	0	0
Parts	9,654	8,013
Tire	520	432
Fuel/Lubricant	9,950	8,756
Depreciation	0	0
Overhead	0	0
Cement	3,296	2,736
Sand	419	348
Gravel	12,918	10,722
Board	1,855	1,539
Timber	201	167
Nail	54	44
Cobble	1,697	1,409

Mortar	1,545	1,283
Lime Stone	26,066	21,635
Clay	44,515	36,948
Chemical Fertilizer	3,276	2,883
Seeds	857	754
Cellulose	2,268	1,996
Emulsion	807	710
Bar	3,753	3,302
Organic Matter	1,918	1,687
Royalty for Clay	0	0
Mobilization etc.	0	0
Engineering	5,705	5,021
Contingency	13,112	11,539
Total	144,387	121,923

(Cont.)

88. Since it is very difficult to quantify environmental benefits in monetary terms, 2 cases (a minimum case and a maximum case as mentioned in the previous chapter) will be calculated.

4.3 RESULT OF ESTIMATION

89. Evaluation indicators were estimated in the minimum case as follows, and benefit and cost streams are shown in Table III-24:

- Net Present Value (NPV)* : R$ 38,276,000- (price in June, 1997)
- Economic Rate of Return (ERR) : 16.75 %
- Cost Benefit Ratio (B/C) : 1.74

*assuming a discount rate of 12%

90. From the above figures, the project can be judged to be viable. A positive net present value of R$38,276,000 assuming a discount rate of 12% could be large. However, the project also bring many other benefits which could not be quantified, such as restoration of the region's landscape, remediation of ground water reserves, etc. as discussed in the previous chapter.

4.4 SENSITIVITY ANALYSIS

91. Given the uncertainities usually associated with this type of projects, a sensitivity analysis is made, assuming a 15% increase in the project's cost and to a 15% reduction in total benefits. The results of the analysis are shown below.

- Net Present Value (NPV)* : R$ 19,926,000- (price in June, 1997)
- Economic Rate of Return (ERR) : 14.30 %
- Cost Benefit Ratio (B/C) : 1.40

*assuming a discount rate of 12%

92. As can be seen, the ERR remains high at 14.30% which is indicates that the project would likely be able to sustain unexpected changes.

PROJECT PERIOD = 10 Years

TABLE III-24
BENEFIT-COST STREAMS
(IN RS000)

Year	Cost		Benefit												Balance
	A	Total (1)	Land				Water						Other	Total (2)	(2)-(1)
			Land Value	Forestry	Fauna Flora	Recreation	Higher Water	Add. invest	No-connected	Rice	Fish	Indus.	Fishery	Tourism		
1	12,192	12,192													-12,192
2	12,192	12,192												0	-12,192
3	12,192	12,192												0	-12,192
4	12,192	12,192												0	-12,192
5	12,192	12,192												0	-12,192
6	12,192	12,192												0	-12,192
7	12,192	12,192												0	-12,192
8	12,192	12,192												0	-12,192
9	12,192	12,192												0	-12,192
10	12,192	12,192												0	-12,192
11		0	77,000				13,300	52,500	1,000	1,000				145,900	145,900
12		0					13,300		1,000	2,000				17,400	17,400
13		0					13,300		1,000	3,000				18,400	18,400
14		0					13,300		1,000	4,000				19,400	19,400
15		0			2,300	2,200	13,300		1,000	5,000		600	33,200	58,700	58,700
16		0			2,300	2,200	13,300		1,000	5,000	1,405			26,305	26,305
17		0		19,500	2,300	2,200	13,300		1,000	5,000	2,210			46,610	46,610
18		0			2,300	2,200	13,300		1,000	5,000	3,015			27,915	27,915
19		0			2,300	2,200	13,300		1,000	5,000	3,820			28,720	28,720
20		0			2,300	2,200	13,300		1,000	5,000	4,625			29,525	29,525
21		0			2,300	2,200	13,300		1,000	5,000	5,430			30,330	30,330
22		0			2,300	2,200	13,300		1,000	5,000	6,235			31,135	31,135
23		0			2,300	2,200	13,300		1,000	5,000	7,040			31,940	31,940
24		0		19,500	2,300	2,200	13,300		1,000	5,000	7,845			52,245	52,245
25		0			2,300	2,200	13,300		1,000	5,000	8,650			33,550	33,550
26		0			2,300	2,200	13,300		1,000	5,000	9,455			34,355	34,355
27		0			2,300	2,200	13,300		1,000	5,000	10,260			35,160	35,160
28		0			2,300	2,200	13,300		1,000	5,000	11,065			35,965	35,965
29		0			2,300	2,200	13,300		1,000	5,000	11,870			36,770	36,770
30		0			2,300	2,200	13,300		1,000	5,000	12,675			37,575	37,575
														IRR	16.75%
														B/C	1.74
														NPV	$38,276

COST BENEFIT STUDY

METHODOLOGY NOTE

I. GENERAL METHODOLOGY

When a project is planned, the feasibility of the project can be judged with the results of its financial analysis and economic analysis. The former is applied to projects intended by private enterprises and the latter is mainly applied to the social and economic improvement projects by the public sector. The financial analysis is also applied to the public sector's projects such as toll road project, because this type of project is required the operation based on the self-supporting system. The financial analysis and the economic analysis are often thought to be similar, however, their essence is quite differed.

The financial analysis is composed of inflow and outflow of money of the project . On the other hand, in the economic analysis the outflow is shown in terms of the money itself like the financial analysis, however, the inflow is shown in terms of money or the benefit valuated by money, because there are various benefits which are difficult or impossible to quantify with the money-term. Since private enterprises are not trade good and services without price, the economic analysis is never applied to projects planned by them. The economic analysis is applied to the public projects, because the public projects include many benefits which can not convert to money term. Therefore, in the economic analysis it is problem how the benefit can be converted by monetary terms.

Nowadays some items of benefits can be quantified by the monetary terms with some method, however, in the environment-relating projects the methods of quantifying benefits with monetary terms are on the way of developing. The following three are major methods proposed in the latest research or study;

① Contingent Valuation Method
Through the questionnaire survey, the environmental asset value is estimated, based on the answer of the questioners.

②Travel Cost Model
Based on the idea that people place much value on visiting recreational area and observing the nature than the cost necessary for traveling there, the appropriate travel cost model is constructed. The benefit of recreational activities and observation to the nature is evaluated in money terms with this travel cost model.

③Hedonic Approach
The living environment variables is added to the house and land transaction model. With this model, the living environmental value can be estimated in terms of money.

However, these there methods are difficult to be applied to the empirical analysis, because of difficulties of the data collection, necessity of much time and cost for survey and analysis. Therefore, in this study the traditional method is applied, that is, picking up many quantifiable benefits as much as possible and summed up these benefit. At first, benefits are

picking up in the followings.

The purpose of this study is to recuperate 4,724 ha of land destroyed by open pit mining and to improve the quality of the water of Santa Catarina southern region's three river basins contaminated by coal mining effluent. The operation is expected to bring valuable benefits to the region, including an increase in the value of the recuperated land, the possibility using the rivers' water for human consumption and for industrial and other commercial purposes, and improved economic opportunities brought about by an expansion of tourism, better fisheries and forestry resources..

Many of these benefits are not readily available in monetary terms, but nevertheless need to be quantified in order to calculate the project's economic rate of return by comparing them to the cost of the operation. To do so, proxies are used, e.g., the value of the land to be recuperated is estimated by taking the market value of land in the vicinity. The improvement of the region's water quality is equated with the cost of bringing potable water from neighboring rivers into the affected region.

The followings are summary of benefits and estimation methods;

Item of Benefit	Benefits in terms of money	Method or Data
Land	Increase of land price	Transaction Data
Forestry Resources	Profit from selling timber and wood	Transaction Data
Fauna and Flora	Existence value of fauna and flora	Willingness-to-pay survey
Recreation	Valuation of Recreational activities	Willingness-to-pay survey
Water Quality	Decrease of Potable Water Cost	Potable water cost survey
	Saving of alternative facility construction	Estimation of construction cost
	Saving of potable water transportation cost	Transportation cost survey
	Increase of agricultural income	Estimation of rice productivity
	Income increase of fisheries activities	Estimation of fisheries resource
	Increase of tourism income	Forecasting tourist expansion
Industry development	Not quantified	
Protection of underground water pollution	Not quantified	
Multiplier effect of economic activities	Not quantified	

II. DESCRIPTION OF THE MAIN QUANTIFIABLE BENEFITS

Benefits Resulting from Land Remediation

Recuperating the 4,724 ha of land is expected to bring in the following benefits: (1) increase in land value; (2) possibility to exploit the recuperated areas for timber and fire wood; (3) re-vegetation and partial recovery of the loss fauna and flora; and (4) possibility of using the recuperated areas for recreational purposes.

Land Value

As explained above, the value of the recuperated land is based on the value of land in the vicinity using the municipalities's land use plans (classification of land into urban, industrial and rural areas) and their market values obtained from the region's major real estate agencies. This method is thought to fairly well reflect the reality.

Forestry Resources

In the past, some of the areas now polluted were used to produce timber and fire wood. Once the areas are recuperated, they could be used again for that purpose and this possibility should be counted as a benefit of the project. The quantification of this benefit in monetary terms is based on the market prices of timber and fire wood and the time for the trees to grow to the optimum size to be cut. This method is also thought to fairly well reflect the reality, but it should be pointed out that exploitation of forestry resources is only one benefit of the land recuperation.

Recovery of Fauna and Flora and Recreational Use of Recuperated Land

As explained in the report, the region possesses many varieties of fauna and flora and has many valuable assets for eco-tourism and recreational activities. However, data to directly estimate the monetary value of these assets are not available, and the Team had to use indirect techniques. One of these indirect methods (very much in use in the US and Europe in environmental projects) is the Willingness-to-Pay study i.e., the willingness of the people affected by the environmental problem to pay to improve the situation. Thus, surveys and interviews were conducted in the major municipalities affected by coal mining to determine the monetary value that the people living in the polluted areas are willing to contribute to recover the loss fauna and flora and to be able to use the recuperated land for recreational activities. The monetary value is then taken as representing the benefit of the project. Experience in other similar cases show that this proxy generally represents the low end of the real benefit but is thought to be acceptable as it is the only possible way to quantify important benefits of the operation.

Benefits Resulting from Water Quality Improvement

Improving water quality in the region's main river basins would bring in the following

benefits: (1) reduction in the cost of potable water; (2) savings on investment for water supply; (3) savings on transportation cost of potable water to areas not connected with water infrastructure; (4) increase in agricultural production; (5) increase in fisheries activities; and (6) expansion of regional tourism.

Reduction in the Cost of Potable Water

Data obtained from the regional water utilities company show that the cost of producing potable water for municipalities affected by coal mining pollution is higher because the water has to come from outside the affected areas. With the project, the region's rivers would be used, thus reducing the cost of potable water. The difference between the current cost of producing water for the affected areas and that for the rest of the state is taken as a measure of the benefit of the project. It must be pointed out that this measure somewhat underestimates the benefits as the value for the region of being able to use its own water reserves and not rely on neighboring communities is by far more important.

Savings on Investment for Water Supply

An analysis of planned water supply investments to meet the region's increasing demand for the next five years show that additional expenditures are needed because the water has to come from outside the region. With the project, these investments will not be needed and the savings are taken as a benefit of the project.

Savings on Transportation Cost of Potable Water

There are many localities in the region which are not connected with the urban water network. To deliver potable water to these localities, the municipalities maintain a few trucks to transport the water from nearby rivers. With the project, the region's river system can be used to connect these localities to the main water network. There is no more a need to transport water and the savings are taken as benefits of the project.

Increase in Agricultural Production

Here the benefits of the project are as follows: (i) increase in the productivity of irrigated rice. At present, some areas are using water with high acidity which does not permit a high productivity. With clean water as a result of the project, the productivity in these areas are expected to increase; (ii) increase acreage for irrigated rice cultivation. The project will make available some additional 7,900 ha for rice cultivation; and (iii) introduction of other cultures such as beans, vegetables and tomatoes. The benefits are quantified using existing yields and prices.

Increase in Fisheries Activities

One of the major consequences of the mining pollution is the substantial decrease in fisheries resources in the lagoon areas, resulting in the near disappearance of artisan fisheries. With the project, fisheries resources are expected to gradually be reconstituted, while river fishing

will be possible as a result of clean water. However, it is recognized that the decrease of fisheries resources is also due to other factors such as urban pollution. Thus, for the project, these benefits are contingent upon the resolution of the other problems. To be on the safe side, the base case does not include these benefits.

Increase in Tourism Activity

While the region's coal mining pollution problem is a deterrent to tourism, it is also recognized that the expansion of tourism in the region is conditioned on other factors, such as a more aggressive tourism promotion. As for fisheries discussed above, this benefit is not included in the base case.

III. UNQUANTIFIABLE BENEFITS

Rather than trying to put a number on some of the benefits which do not lend themselves to quantification, the Team only describes them and do not take them into account in the calculation of the rate of return. They are: (1) higher industrial development; (2) pollution of ground water reserves; and (3) multiplier effect of the different benefits described in the section above.

CALCULATION OF THE ECONOMIC RATE OF RETURN

Calculation of the economic rate of return is made under the most unfavorable assumptions to test the viability of the project. First, given the uncertainties inherent to this type of projects, the benefits are estimated within a range with a maximum and a minimum. Second, in the base case, only the minimum of the most likely benefits are included. Third, sensitivity analyses assuming a decrease in the benefits stream of 15% and an increase in the cost of the project of 15% are made. They all show that the project remain highly profitable.

LAND VALUE CALCULATION SIMULATIONS

The land values in the text are estimated by taking the maximum and minimum values of the different categories of land as indicated by the region's two real estate agencies. The estimates below are made using different price series, such as (ii) administrative values; (ii) No. 1 real estate agency's prices; (iii) No. 2 real estate agency's prices; and (iv) median values of the highest and lowest price quotations of the two agencies.

1.	Administrative values:	R$15.2 million
2.	No.1 real estate agency:	R$ 104.1 million - R$ 263.5 million
3.	No.2 real estate agency:	R$ 112.5 million - R$ 271.5 million
4.	Median values:	R$ 233.5 million

TABLE 1

ADMINISTRATIVE VALUE OF THE LAND TO BE RECUPERATED

(IN HECTARE AND R$1000/HA)

Municipality	Urban Area				Rural Area			
	Central		Peripheral		Agriculture		Industrial	
	Ha	Value	Ha	Value	Ha	Value	Ha	Value
Capivari de Baixo	----	----	----	----	----	----	162	10.0
Cocal do Sul	----	----	----	----	41	0.4	----	----
Criciúma	84	12.0	964	1.9	267	3.0	242	5.0
Forquilhinha	----	----	----	----	145	0.1	352	4.5
Içaca	----	----	----	----	62	2.5	----	----
Lauro Müller	----	----	147	2.5	790	1.5	----	----
Morro da Fumaça	----	----	----	----	20	0.8	----	----
Siderópolis	----	----	333	10.8	943	0.2	----	----
Treviso	----	----	----	----	486	0.2	----	----
Urussanga	----	----	----	----	1,176	0.5	----	----

Source: Southern Santa Catarina's municipalities and real estate agencies

TABLE 2

MARKET VALUE OF THE LAND TO BE RECUPERATED
(NO. 1 REAL ESTATE AGENCY)

(IN HECTARE AND R$1000/HA)

Municipality	Urban Area						Rural Area					
	Central			Peripheral			Agriculture			Industrial		
	Ha	Max	Min	Ha	Max	Min	Ha	Max	Min	Ha	Max	Min
Capivari de Baixo	----	----	----	----	----	----	----	----	----	162	15.0	7.0
Cocal do Sul	----	----	----	----	----	----	410	10.0	7.0	----	----	----
Criciúma	84	210.0	136.1	964	150.0	60.0	267	140.8	62.2	242	111.0	4.7
Forquilhinha	----	----	----	----	----	----	145	44.0	9.5	352	8.5	7.5
Içaca	----	----	----	----	----	----	62	11.5	5.0	----	----	----
Lauro Müller	----	----	----	147	20.0	3.3	790	4.3	2.5	----	----	----
Morro da Fumaça	----	----	----	----	----	----	20	25.0	4.0	----	----	----
Siderópolis	----	----	----	333	6.7	2.5	943	5.2	3.1	----	----	----
Treviso	----	----	----	----	----	----	486	5.6	3.1	----	----	----
Urussanga	----	----	----	----	----	----	1,176	6.1	2.9	----	----	----

Source: Southern Santa Catarina's Real Estate Agencies

TABLE 3

MARKET VALUE OF THE LAND TO BE RECUPERATED
(NO. 2 REAL ESTATE AGENCY)

(IN HECTARE AND R$1000/HA)

Municipality	Urban Area						Rural Area					
	Central			Peripheral			Agriculture			Industrial		
	Ha	Max	Min	Ha	Max	Min	Ha	Max	Min	Ha	Max	Min
Capivari de Baixo	----	----	----	----	----	----	----	----	----	162	15.0	7.0
Cocal do Sul	----	----	----	----	----	----	410	8.5	7.5	----	----	----
Criciúma	84	283.3	140.0	964	154.2	57.9	267	142.2	65.7	242	111.0	44.0
Forquilhinha	----	----	----	----	----	----	145	30.0	9.0	352	8.0	7.0
Içaca	----	----	----	----	----	----	62	12.0	6.0	----	----	----
Lauro Müller	----	----	----	147	20.0	3.3	790	4.0	2.2	----	----	----
Morro da Fumaça	----	----	----	----	----	----	20	16.0	4.5	----	----	----
Siderópolis	----	----	----	333	6.4	2.6	943	5.6	3.5	----	----	----
Treviso	----	----	----	----	----	----	486	5.6	3.1	----	----	----
Urussanga	----	----	----	----	----	----	1,176	6.0	2.5	----	----	----

Source: Southern Santa Catarina's Real Estate Agencies

WILLINGNESS TO PAY STUDY

Introduction

1. A Willingness to Pay (WTP) study was conducted with NUPESE's assistance in six AMREC municipalities (Capivari, Cricúma, Lauro Müller, Siderópolis, Treviso and Urussanga) to assess the importance that the people living in the affected areas give to the coal mining pollution problem, and to learn more about their relative priorities with regard to the objectives of an eventual clean up operation.

Characteristics of the Sample

2. The questionnaire (Appendix 1) was designed in September 1996. Field work was conducted in October 1996 when 1,112 persons (4% of AMREC's total population) was interviewed. Forty five percent of the interviewees were male and 55% female. The characteristics of the sample are discussed below.

TABLE 1

CHARACTERISTICS OF THE SAMPLE

	Number	Percentage
Age Structure		
16 - 20	123	11
21 - 55	848	76
56 and over	141	13
Total	1,112	100
Education		
Junior High School	741	76
High School	256	23
University	47	4
No Formal Education	64	6
Total	1,112	100
Income (per month)		
R$ 120 - 360	474	43
R$ 360 - 600	366	33
R$ 600 and more	164	15
Unemployed	105	18
Total	1,112	100

3. The sample is fairly representative of the AMREC population in terms of income, as well as age structure and education level. The only possible bias seems to be the higher percentage of women in the sample (55% as against 45% for men) as it is generally known that they are more sensitive to environmental issues than men. This is, however, thought to be insignificant to invalidate the results.

Main Results of the Interviews

4. The quasi-totality of the interviewees (99.6%) declared concerned about the environment and that the region's fauna and flora is important to them (98.9%). They are also unanimous (99.5%) to say that the area polluted by coal mining should be recuperated. Their reasons for doing so are as follows:

TABLE 2

RESULTS OF THE INTERVIEWS

	Number	Percentage
Industrial Use	376	34
Land Value	193	17
Environmental Reasons [1/]	174	16
Agriculture	163	15
Tourism	23	2
Recreational Use	16	1
All of Above	164	15
Total	1,112	100

[1/] Health as well as loss of fauna and flora

5. The interviewees are also willing to contribute financially to the recuperation of the polluted areas as can be seen below:

TABLE 3

"How much per month are you willing to contribute for the recuperation of the polluted areas and for what reason(s) ?"

	Fauna/Flora		Recreational Use		River Pollution		Forestry	
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)
R$ 1 - 5	443	40	417	38	428	38	424	38
R$ 5 - 10	92	8	81	7	104	9	85	8
R$ 10 - 15	29	3	23	2	27	2	29	3
R$ 15 +	13	1	12	1	15	1	11	1
One workday	308	28	288	26	308	28	321	29
Nothing	225	20	253	23	228	21	240	22
Total	1,112	100	1,112	100	1,112	100	1,112	100

6. Between 77% and 80% of the interviewees are willing to contribute financially to the recuperation of the polluted areas. This is extremely favorable and shows the importance that the very people living in the affected areas accord to the problem.

SECTION IV. STRATEGY AND PROGRAM FOR RECUPERATING MINED-OUT AREAS

1. REMEDIATION STRATEGY

1.1 Conclusions of the Technical Evaluation

1. As discussed in Chapter III above, the mined-out areas are so polluted that the most economical cover system, i.e., dry soil cover system, has little impact. Both heavy metal concentrations and pH levels remain practically unchanged. Using more effective methods, i.e., wet cover or capillary break system and passive wetland treatment, would also not restore water quality to the level required by existing Brazilian norms for surface water quality within the FS sites themselves. However, the significant reduction in acidity and metal concentrations resulting from these methods would allow natural healing forces originating from growing water plants and increased bacteria activity to play, thus further neutralizing the water. Simulation models built by the JICA Team to test water quality show that the water outside the FS sites partially meets Brazilian norms.

2. The technical evaluation further shows that:

1. Using wet cover for the whole black reject area[1] is relatively expensive. However, as in-depth analysis indicates that dry cover may be used in polluted areas not directly connected with rivers or ground water reserves with little risk and similar results (425 ha), a wet/dry cover system could be used. It is in fact the most cost effective method.

2. Active areas (i.e., areas still being used by mining companies for waste deposal and washing) are much more polluted than abandoned areas[2]. Thus, remediation of abandoned areas will most likely not bring any improvement unless active areas are also remedied.

1.2 Proposed Remediation Strategy

3. Given the conclusions of the FS study, particularly the fact that the areas to be remedied are so polluted that no cost-effective method would restore water quality to the level of Brazilian ambient standards for surface water, several alternatives are possible:

- **Do nothing.** This alternative is not acceptable because the pollution problem will continue and most likely get worse;

[1] Total polluted area: 4724 ha, Black reject area: 2,526 ha, Overburden waste area: 2,198 ha
[2] Abandoned area: 3,292 ha, Active area: 1,154 ha, Inactive area: 278 ha

- **Make mining companies comply with environmental regulations. Do not do any remediation.** This alternative does not appear feasible because it is not reasonable to expect mining companies to discharge mining water according to norms when the surrounding rivers where the discharged water will finally end up remain polluted; and

- **Address the problem using the most cost-effective approach, i.e., using a wet/dry cover system.**

4. To solve the problem requires remediation. There is no other alternative. Also, as discussed above, although the water inside the FS sites does not meet Brazilian standards, outside the SF sites partially meets these standards. Even if it did not, growing water plants and increased bacteria activity in the FS sites will further neutralize the water and eventually achieve Brazilian standards.

5. However, to minimize the risks, a two phase approach is proposed. In the first phase, remediation would be limited to active areas. As mentioned above, active areas are the most polluted and their clean up is a *sine qua none* condition for the success of any remediation program. As these areas are still being used by mining companies in their normal extraction and beneficiation activities, the first phase should also include measures to help these companies conduct their operations in an environmentally responsible manner and address the issue of strengthening FATMA (and other agencies involved in monitoring mining operations, such as DNPM) to ensure that mining companies fully comply with environmental regulations, particularly with regard to water discharge and recuperation of mined-out land.

6. It is only when active areas are totally remedied and mining companies are in full compliance with environmental regulations that the second phase focusing on remediation of abandoned areas would be implemented. This strategy is safer, cheaper, and easier to manage.

- Safer because no remediation investment will be made unless mining companies properly discharge used water and comply with environmental regulations. Measures and actions to strengthen FATMA and DNPM and improve mining operations would be implemented first. Thus, the financial loss resulting from an eventual project failure (e.g., mining companies' non compliance to environmental regulations) would therefore be relatively small;

- Cheaper because remediation of active areas, coupled with environmental compliance of mining companies, are likely to lower pollution loads in abandoned areas, thus decreasing their remediation cost; and

- Easier to manage because breaking the project down into two phases facilitates financing as well as implementation.

7. **It should, however, be noted that unless the two phases are implemented, no significant benefits are to be expected.**

2. *REMEDIATION COST AND BENEFITS*

2.1 Cost Estimates

8. The total cost of the remediation program has been estimated using the following assumptions:

- The overall remediation program will use a wet/dry cover system. Prices for the major items of the program (labor, equipment, spare parts, and materials, such as cement, gravel, limestone, sand, clay, etc.) have been calculated using quotations given by local construction companies, such as SETEP (*Sociedade de Estudos de Topografia e Construções*), and double-checked with the *Departemento de Estradas de Rodagem de Santa Catarina*; and

- It is likely that mining companies which own 81% of the polluted land will do the remediation work themselves as they are equipped to do so. This may also be the case for the municipalities (owners of 7% of the polluted land) which can rely on the Santa Catarina Government to help them carry out the work[3]. Thus, 88% of the remediation is likely to be done by force account instead of being contracted out. For simplicity, we assume that the Santa Catarina Government will also help the private individuals, owners of the remaining 12%, so that all the work would done by force account. Thus, the market prices for materials estimated above would be decreased by 15%, while costs such as depreciation, profits, etc. would be ignored.

9. Table IV-1 below shows that the total cost of the remediation program is estimated at R$145.0 million, including 10% physical contingency, i.e., an average cost per hectare of R$30,700.

TABLE IV-1

TOTAL REMEDIATION COST

	R$million
Materials	98.2
Consumables	10.0
Parts	10.2
Seeds, Chemicals, etc.	7.2
Engineering	6.2
Contingency	13.2
Total	145.0

[3] Santa Catarina's Agriculture Secretariat as well as the Road Construction Department of the Transportation Secretariat have the necessary equipment to do the work by force account.

10. Abandoned areas account for about two thirds of the total cost (R$93.5 million and active areas (including some 278 ha currently not used by mining companies because of a temporary stoppage of production) for about one third (R$51.5 million).

2.2 Benefit Estimates

11. An in-depth study undertaken with UNESC's assistance to quantify the likely social and economic benefits to the region resulting from the remediation of the environmental damages caused by coal mining pollution appears in Section III of Technical Annex.. A summary of the quantifiable benefits is shown on Table IV-2 below.

TABLE IV-2

SUMMARY OF BENEFITS
(R$ million)

	Minimum	Maximum
Land Pollution		
- Increase in Land Value	77.0	191.2
- Forestry Resources	19.5 every 7 years	19.5 every 7 years
- Fauna and Flora	2.3/year from year 5	9.3/year from year 5
- Recreational Use	2.2/year from year 5	8.5/year from year 5
Water Pollution		
- Higher Water Cost	13.3/year	28.7/year
- Additional Investments	52.5	52.5
- Bringing Water to Non-Connected Areas	1.0/year	1.0/year
- Rice Cultivation	5.0/year	14.8/year
- River Fishing	0.6 in year 5 to 16.7 in year 25	1.2 in year 5 to 35.2 in year 25
- Fisheries Resources*	33.2 in 5 years	33.2 in 5 years
Land and Water		
- Tourism Development*	1.1/year	1.1/year

Source: JICA Team's estimates
* Benefits contingent upon other measures.

12. The project also generates many important non-quantifiable benefits such as improvement of environmental protection in Santa Catarina and arresting pollution of ground water. The calculations also ignore the multiplier effect of increased economic activity and production as a result of the remediation. These are described in Annex Section III and should be taken into account when evaluating the merits of the project.

2.3 Economic Viability of the Project

13. Taking the economic value of the cost estimated in Table IV-1 above (i.e., total cost of R$145.0 million minus taxes estimated to average 16%) and only minimum benefits as calculated in Table IV-2 (Base case), the project's economic rate of return (ERR) is estimated to be 16.8%, assuming an implementation period of 10 years. Sensitivity analysis, assuming an increase in cost and a decrease in benefits of 15%, shows that the ERR remains acceptable at 14.3%.

3. THE FIRST PHASE: ENVIRONMENTAL IMPROVEMENT OF MINING OPERATIONS AND REMEDIATION OF ACTIVE AREAS

3.1 Description

14. The first phase would have two components:

1. **An institutional strengthening component** to address the needs of FATMA, DNPM and other public agencies involved in monitoring coal mining operations, as well as those of the mining companies themselves. Financing would include staff training, improvement of operating policies and procedures, equipment, such as vehicles and computers, to increase staff efficiency, water quality monitoring equipment (mining companies only), as well as improvements of the coal mining's policy and institutional framework as described in paras. 2.58 - 2.72 of Chapter II above; and

2. **An investment component** to finance the remediation of the active areas and other capital requirements of mining companies (such as water neutralization plants) to help them comply with environmental regulations.

15. *Remediation investments would start only when mining companies have improved their operations (with the assistance financed under the project) and fully comply with environmental regulations.* This phased approach minimizes risks and simplifies project execution, as efforts are first concentrated on implementing the institutional strengthening component and on ensuring that mining companies properly carry out the water neutralization investments. This simplification should improve the project's chances of success.

3.2 First Phase Cost Estimates and Financing

16. Cost estimates of the first phase as well as illustrative financing schemes are presented on Table IV-3 below for discussion. They are not based on detailed project information which does not exist at present. Their main purpose is to give an order of magnitude of the project. Detailed cost estimates will be prepared when the decision to go ahead with the project is taken.

TABLE IV-3

PHASE I: PROJECT COST AND FINANCING

	R$ MILLION	%
Cost		
- Institutional Strengthening Component	5.3	7.4
- FATMA	(3.3)	(4.6)
- DNPM	(1.0)	(1.4)
- Mining Companies	(1.0)	(1.4)
- Investment Component	66.7	92.6
- Remediation of Active Areas	(51.5)	(71.5)
- Water Neutralization[a]	(15.2)	(21.1)
Total	**72.0**	**100.0**
Financing		
- Mining Companies	51.7	71.8
- Remediation	(36.5)	(50.7)
- Water Neutralization[a]	(15.2)	(21.1)
- Santa Catarina Government	10.0	13.9
- Remediation	(10.0)	(13.9)
- Federal Government	10.3	14.3
- Remediation	(5.0)	(6.9)
- Technical Assistance	(5.3)	(7.4)
Total	**72.0**	**100.0**
Sources of Financing		
- Loan from International Lenders[b]	40.0	55.5
- Mining companies	11.7	16.3
- Federal Government	10.3	14.4
- Santa Catarina Government	10.0	13.8
Total	**72.0**	**100.0**

[a] Passive wetlands. This investment is needed only to the extent that mining water cannot be evacuated from the mines fast enough to be contaminated with pyrite acidity. A thorough assessment should be done during project preparation. On the other hand, investments, such as improvements of settling ponds or closed circuit systems, may be needed to make current operations in compliance with environmental regulations. They should also be estimated at the time of project preparation.

[b] In addition to the loan from bilateral or multilateral lenders, it is possible that JICA accept to finance partly or totally the strengthening of DNPM and/or FATMA on a grant basis.

17. Mining companies would finance about 72% of the total cost of the first phase, including 100% of the water neutralization cost and over 70% of the remediation cost. However, they are

expected to recuperate most of it through an increase in land value[4]. The sector as a whole would not be financially affected, although the situation may be different at the individual company level, depending on the value of the land. Mining companies would also benefit from technical assistance available under the project to improve mining operations.

18. Contribution by Santa Catarina state would amount to R$10 million (about 14% of the total project cost). However, it is expected to recover most of it, if not all, through increases in sales taxes resulting from the recuperation work. In addition, Santa Catarina would receive resources from the Federal Government to strengthen FATMA.

19. Finally, the Federal Government would contribute the remaining R$10.3 million (14% of the project cost) but, like Santa Catarina, it would also recuperate part of it through an increase of profit taxes brought about by the recuperation activities.

20. An external loan in an amount of R$40 million would be contracted from bilateral or multilateral lenders to help finance the investment component (remediation and water neutralization). These funds would be passed on to BADESC (Banco de Desenvolvimento do Estado de Santa Catarina, Santa Catarina's development bank) for on-lending to mining companies at prevailing market conditions. It is possible that, in addition to the external loan from bilateral or multilateral lenders, JICA accept to finance the strengthening of DNPM and/or FATMA on a grant basis.

3.3 Organization, Management and Implementation

(a) Overall Coordination

21. Because of the important role that the state of Santa Catarina will play (either as the borrower of the external loan or as the main public institution responsible for the remediation program), it is proposed that the Special Projects Division within the Office of the Governor be the project's overall coordinator. It will be assisted by FATMA. Also, a Project Management Unit (PMU) would be created within the Special Projects Division to help manage and coordinate the various components of the program. PMU's main tasks are to: (i) monitor overall project implementation. This includes preparing periodic progress reports for the Brazilian authorities as well as for the external lender(s) and helping solve technical problems which may arise during implementation; and (ii) be the external lenders' main contact. The Unit will have a small technical staff and will report directly to the Governor.

[4] Mining companies are expected to finance R$36.5 million toward the cost of remediation, while the value of the recuperated land is estimated between R$32.1 million and R$76.5 million.

(b) The Institutional Strengthening Component

22. Given the importance of strengthening FATMA, as well as the central role it will play in the project, it is proposed that FATMA be responsible for the implementation of this component under PMU's overall supervision, with the exception of DNPM strengthening, which would be managed by DNPM itself. The principles governing the implementation and disbursement of funds for the various beneficiary agencies are as follows:

- **Coal Mining Policy and Institutional Framework**. A federal commission composed of representatives of MME, DNPM and SIECESC would be established to prepare a program aimed at strengthening the policy and institutional framework for coal mining operations along the lines of the recommendations in paras. 187 to 204 of Section II-A;

- **FATMA** would prepare and implement a strengthening program based on the directives outlined in paras. 26 to 40 of Section II-B. Disbursements of funds will be conditioned upon the successful implementation of the various actions included in the strengthening program;

- **DNPM** will be asked to make a comprehensive assessment of its needs and to prepare a plan of action to improve its capacity to monitor the activities of coal mining companies. Approval of such a plan would be a condition of disbursement of funds for DNPM's technical assistance; and

- **Mining Companies.** There are at present six companies extracting and washing coal in Santa Catarina. They all need strengthening, although the needs may vary from company to company. To help them prepare strengthening programs (including detailed mining plans specifying waste materials control measures) tailored to their specific needs, funds for short-term consultant services would be available under the project. Approval of individual strengthening programs would be a condition of disbursements for technical assistance to each mining company. Given the delicate financial situation of most of them, subject to the Brazilian authorities' approval, it is proposed to provide the technical assistance on a grant basis. This would also provide an added incentive for the mining companies to comply to environmental regulations.

(c) The Investment Component

(i) *Financial Arrangements*

23. Funds for remediation would be on-lent from the Federal Government or the state of Santa Catarina (depending on who is the borrower of the external loan) to BADESC for re-lending to mining companies. Terms and conditions for the transfer of funds (i) from the Federal Government or the state of Santa Catarina to BADESC and (ii) from BADESC to the mining companies (interest rates and

maturity of the subloans, foreign exchange risk, subproject risks, subproject appraisal and supervision, disbursement of funds, etc.) would be agreed between the various parties during project preparation. However, they should, by and large, reflect on-going market conditions in Brazil.

(ii) *Administrative Arrangements*

24. BADESC would manage the investment component under PMU's overall supervision. The bank would be responsible for appraising the remediation proposals (subprojects) presented by mining companies, for assessing their soundness, for disbursing the funds and supervising the implementation of the remediation work. BADESC would assume the project risk and be responsible for loan collection.

25. FATMA and DNPM would be responsible for ensuring that remediation proposals are technically and environmentally sound. They should approve the proposals before the bank can finance them. Refusal by a mining company to remedy mined-out land would result in the revocation of its operating license.

4. THE SECOND PHASE: REMEDIATION OF ABANDONED AREAS

4.1 Governing Principles

26. The second phase would consist of recuperating the 3,292 hectares of land abandoned after being mined-out and left without any remediation. As discussed in para 7 above, it is imperative that all the polluted land be remedied for the environmental benefits to materialize.

27. As a principle, owners of the polluted land should be responsible for the remediation as they will benefit through an expected increase in the value of the land which could be substantial. As shown on the table below, 76% of that land belong to mining companies, 14% to private individuals and the remaining 10% to municipalities. These owners are thus expected to pay for the remediation cost.

TABLE IV-4

OWNERSHIP OF ABANDONED AREAS
(IN HECTARES)

	Polluted Land	
	(ha)	(%)
Private Individuals	448	14
Mining Companies [a]	2,504	76
Municipalities	340	10
Total	3,292	100

Source: JICA Study Team
[a] Including CSN (*Companhia Siderúrgica Nacional*)

28. However, given the externalities and the fact the present owners may not be the original polluter, it is proposed that the Federal Government and the state of Santa Catarina also help by contributing 10% each toward the total remediation cost. The cost sharing among the different parties involved would be as follows:

- Landowners:	80%
- Santa Catarina state	10%
- Federal Government	10%

29. A landowner who select not to remedy his land may do so by giving it to the municipality where the land is located. Like the first phase, funds would be made available through BADESC to help landowners who do not have the cash to finance the remediation work.

30. A commission chaired by FATMA and composed of representatives of AMREC and Santa Catarina state would be established to oversee the remediation process. SIECESC and representatives of individual landlords could also participate as observers. The commission's main responsibilities would be to: (i) check the authenticity of land titles; (ii) approve remedial proposals presented by landowners; (iii) register land donations to municipalities by landowners who do not want to remedy; and (iv) ensure that the whole process is fair and transparent.

4.2 Description

31. Like the first phase, the second phase would have two components:

1. **A technical assistance component** to (i) help landowners prepare remedial proposals as well as loan requests to BADESC; and (ii) support the work of the Commission in areas where its technical expertise is lacking; and

2. **An investment component** to help finance the remediation cost.

4.3 Second Phase Cost Estimates and Financing

32. At this stage, cost and financing of the second phase can only be rough estimates. Firmer costs would be calculated when the first phase is completed and a technical assessment conducted on the level of pollution reduction achieved. The rough cost estimates are presented on Table IV-5 below only for discussion and to show the magnitude of the project.

TABLE IV-5

PHASE II: PROJECT COST AND FINANCING

	R$ MILLION	%
Cost		
- Technical Assistance Component	5.0	5.1
- Remediation Commission	(0.5)	(0.5)
- Landowners	(4.5)	(4.6)
- Investment Component	93.5	94.9
Total	**98.5**	**100.0**
Financing		
- Landowners[1/]	74.8	75.9
- Mining Companies[2/]	(56.9)	(57.8)
- Private Individuals[2/]	(10.2)	(10.3)
- Municipalities[2/]	(7.7)	(7.8)
- Santa Catarina Government	11.8	12.0
- Remediation[1/]	(9.3)	(9.4)
- Technical Assistance	(2.5)	(2.6)
- Federal Government	11.9	12.1
- Remediation[1/]	(9.4)	(9.5)
- Technical Assistance	(2.5)	(2.5)
Total	**98.5**	**100.0**
Sources of Financing		
- Loan from International Lenders[3/]	60.0	60.9
- Landowners[3/]	14.8	15.0
- Santa Catarina state	11.8	12.0
- Federal Government	11.9	12.1
Total	**98.5**	**100.0**

[1/] Based on the cost sharing formula on para. 28

[2/] Based on landownership structure as shown on Table IV-4

[3/] Assuming a debt/equity ratio of 80:20, i.e., landowners will finance the recuperation with a loan from BADESC (through international lenders) representing 80% of the cost and will cover the remaining 20% with their own funds.

4.4 Organization, Management and Implementation

(a) Overall Coordination

33. The Remediation Commission would be the overall coordinator of the project. It is, *inter alia*, responsible for (i) managing the technical assistance funds available under the project to help landowners prepare remedial proposals and loan requests to BADESC; (ii) monitoring overall project implementation progress; and (iii) relations and contacts with the Brazilian authorities and the external lender(s).

(b) The Investment Component

34. Like in the first phase, funds for remediation would be passed to BADESC for re-lending to landowners at the same conditions as in the first phase. BADESC would be responsible for appraising the remedial proposals, for assessing their soundness, for disbursing the funds and supervising the implementation of the remediation work. It would assume the project risk and would be responsible for loan collection.

POST SCRIPT

PS1. In spite of indication from the title of this Study, "Feasibility Study on Recuperation of Mined-Out Areas in the South Region of Santa Catarina in the Federative Republic of Brazil", the Team's conclusions and recommendations have turned out to be the clean-up of active mining and reject re-washing areas first. It is because, in addition to the fact that the four FS sites are so polluted that even using most effective technologies would not restore water quality to the level required by existing Brazilian norms for surface water quality within the FS sites themselves, that overall water quality simulations for the region's three major river basins show that the active areas are much more polluted than the abandoned areas, so that remediation of the abandoned areas will most likely not bring any improvement unless the active areas are also remedied.

PS2. Remediation of both the areas, i.e., (a) the whole polluted area would be remedied using a wet/dry cover system and wetland treatment method; and (b) effluent discharge from all active areas would comply with Brazilian effluent standards, which is expected to be more than pH 5 in the large part of the region's river systems, would reduce acidity and metal concentrations to reach significant levels that would allow natural healing forces originated from growing water plants and increased bacteria activity to play, thus further neutralizing the water.

PS3. To solve the problem requires remediation. There is no other alternative. Since , in addition to the most polluted area, the active areas (1,432 ha) account for less than half the abandoned area (3,292 ha), a two phase approach is proposed to minimize the risks. In the first phase, remediation would be limited to the active areas. In response to a strong request from the counterpart, FATMA, the proposed program has included improvement of coal mining operations and strengthening of environmental protection in Santa Catarina with a view to formulating a comprehensive program aimed at ensuring that this severe pollution from coal mining and non compliance with environmental regulations would not occur again in the future. It is only when active areas are totally remedied and mining companies are in full compliance with environmental regulations that the second phase focusing on remediation of the abandoned areas would be implemented. **It should, however, be noted that unless the two phases are implemented, no significant benefits are to be expected.**

PS4. NEXT STEPS FOR THE FIRST PHASE: Given the project's change of focus (from remediation of abandoned mined-out areas to active areas), the Team recommends that more work be needed to complete the Study prior to implementation of the first phase. This additional work includes, *inter alia,* (a) review of individual mining and reject re-washing plans to have a better handle of the project cost; and (b) thorough assessment of the financial condition of the mining companies to ensure that they can meet their financial obligations under the project.