社会開発調査部報告書

No.1

HIS MAJESTY'S GOVERNMENT OF NEPAL
Ministry of Population and Environment

Kathmandu, Nepal

JAPAN INTERNATIONAL
COOPERATION AGENCY
Nepal Office
Kathmandu, Nepal

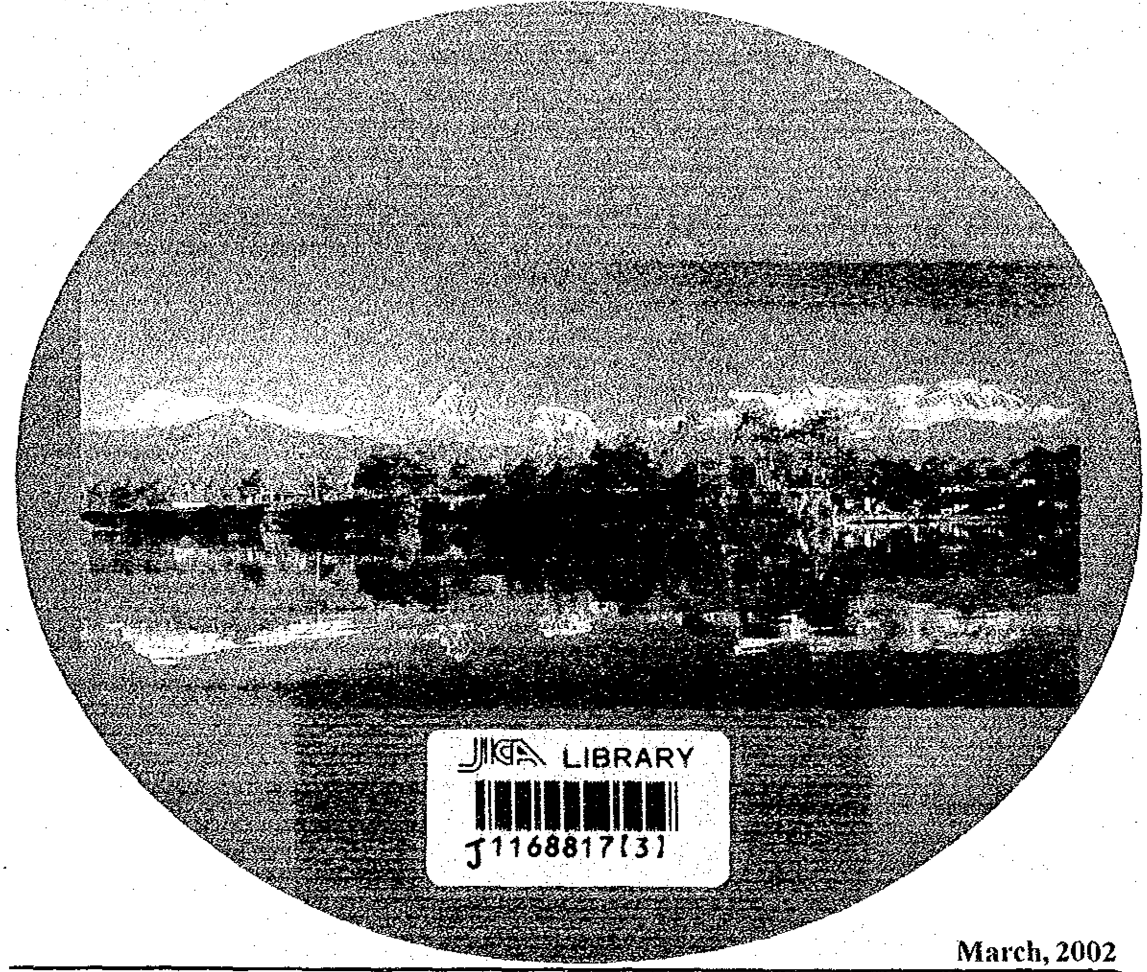
FINAL REPORT

VOLUME - III
ANNEXES

On

The Development Study on

THE ENVIRONMENTAL CONSERVATION OF PHEWA LAKE IN POKHARA, NEPAL



JICA LIBRARY
J1168817[3]

March, 2002

SILT *Consultants (P) Ltd.*
P.O.Box 2724, Baneshwor, Kathmandu
Tel. : 473573, 470866, 487598, 495163
Fax : 977-01-473573
Email : silt@mos.com.np
Website: www.silt.com.np

SSS
JR
02-89

HIS MAJESTY'S GOVERNMENT OF NEPAL
Ministry of Population and Environment

Kathmandu, Nepal

JAPAN INTERNATIONAL
COOPERATION AGENCY
Nepal Office
Kathmandu, Nepal

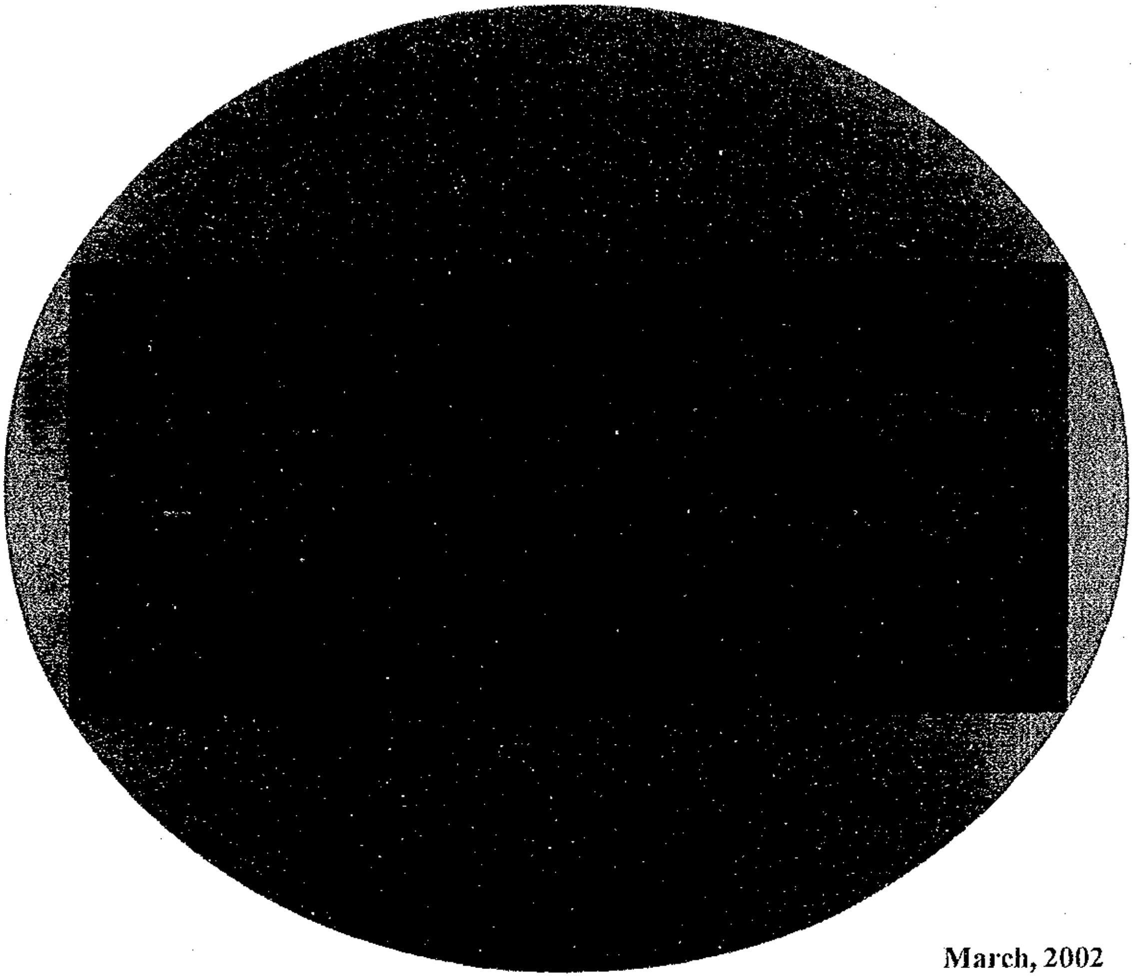
FINAL REPORT

VOLUME - III
ANNEXES

On

The Development Study on

THE ENVIRONMENTAL CONSERVATION OF PHEWA LAKE IN POKHARA, NEPAL



March, 2002

SILT *Consultants (P) Ltd.*
P.O.Box 2724, Baneshwor, Kathmandu
Tel. : 473573, 470866, 487598, 495163
Fax : 977-01-473573
Email : silt@mos.com.np
Website: www.silt.com.np

1168817[3]

TABLE OF CONTENTS

VOLUME I – EXECUTIVE SUMMARY

Page

VOLUME II – MAIN REPORT

VOLUME III – ANNEXES

ANNEX –1

Hydrological And Water Quality Simulation

HYDRAULIC AND WATER QUALITY SIMULATION MODELS FOR PHEWA LAKE

1.1 INTRODUCTION

1.1.1 Objectives

One of the main objectives of this Study is to formulate a Water Quality Management Plan for Phewa Lake and its watershed. In order to attain this objective, a tool to assess the impacts of the water quality improvement measures is required. The Numerical Simulation Model is one among the most commonly used such tools.

Harpan khola and Phirke khola, are two tributaries, which significantly contribute to the inflow load in the Lake. Since the Lake is shallow overall and partially closed, it is vulnerable to water environmental problems such as runoff contaminated from organic and agrochemical substances of the watershed, excessive thus supplying nutrient salts resulting in eutrophication. The Proliferation of blue-green algae near the sides of the Lake every autumn from September to November is evidence to this face. In consideration of the fact that studies were rarely carried out on eutrophication in the Lake, emphasis was placed on the development of a numerical model that would simulate this phenomenon.

The numerical model to be developed under this Study will be used to simulate the hydrological characteristics of Phewa Lake and Lake water quality detailed in **Chapter 2** if the river runoff load pointed out in **Table 1.4.6** is adopted.

This Appendix deals with the numerical simulation model structure, the calculation procedure, and the modification of parameters.

These diffusion models consider coliforms as parameters, and do not, therefore, contribute to the accurate measurement of COD, T-N and T-P levels, the parameters to determine eutrophication.

1.1.2 Simulation Process

For the purpose of this Study, diffusion type of numerical model based on water circulation and pollution mechanism was developed. **Fig. I-1.1** is the flow chart explaining simulation procedure and algorithm.

1.2 EXISTING CONDITION OF PHEWA LAKE

1.2.1 Water Quality Distribution

The spatial distribution and seasonal change of the water quality in Phewa Lake are described in **Chapter 2** of this Report.

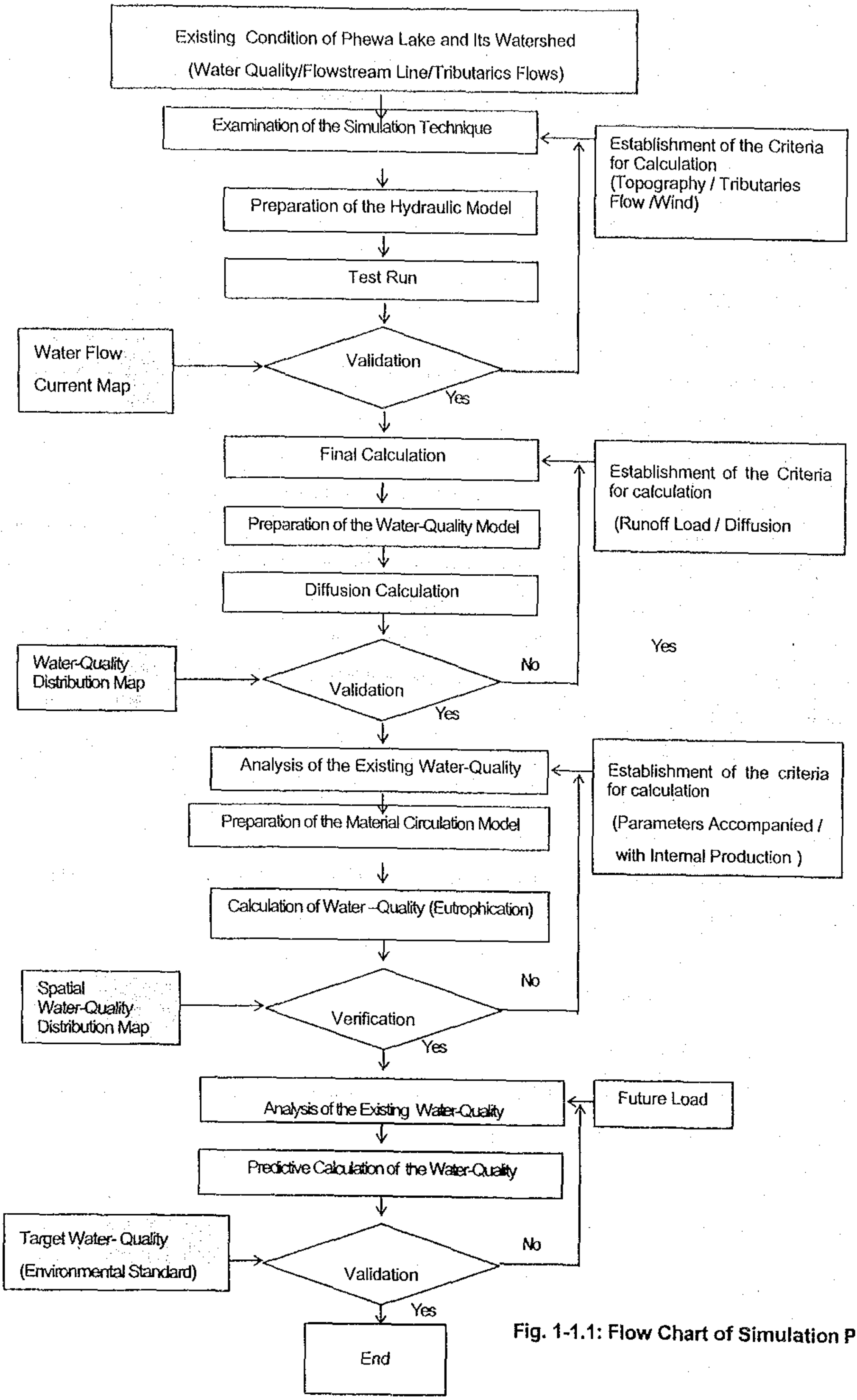


Fig. 1-1.1: Flow Chart of Simulation Process

Fig. 1-1.2 Presents Spatial Distribution of Water Quality Data (University of Shimane Nov. 1999 & Nov. 2000).

Based on spatial distribution of water quality data collected during October and November 2001 by the Study Team and data collected by Japanese Team from University of Shimane during November 1999 and Nov. 2000, the trophic level of different zones of the Lake are identified with reference to categories suggested by Vollenwider (1984).

Fig. I-1.2 shows the eutrophication relationship between T-P and T-N in Japanese Lakes.

The following **Table I-1.1** presents the value of different parameters for different trophic state and the value of these parameters for Phewa Lake.

Table I-1.1: Trophic State and Condition of Phewa Lake

Trophic State		TP mean Concentration (mg/l)	Chlorophyll-a (Mg/l)		Secchi disk (m)	
			Mean	Max	Mean	Max.
Ultra-oligotrophic		≤0.004	≤1.0	≤2.5	≥12.0	≥6.0
Oligotrophic		≤0.01	≤2.5	≤8.0	≥6.0	≥3.0
Mesotrophic		0.01 – 0.035	2.5 – 8	8 – 25	6 – 3	3 – 1.5
Eutrophic		0.035 – 0.100	8 – 25	25 – 75	3 – 1.5	1.5 – 0.7
Hypertrophic		≥0.100	≥25	≥75	≤1.5	≤0.7
Phewa Lake						
Eastern Area (L6)	Eutrophic	0.1	16.1*		2.6	
Central Area (L2)	Eutrophic	0.06	15.6		2.48	
Western Area (L5)	Eutrophic	0.07	12.1*		2.8	

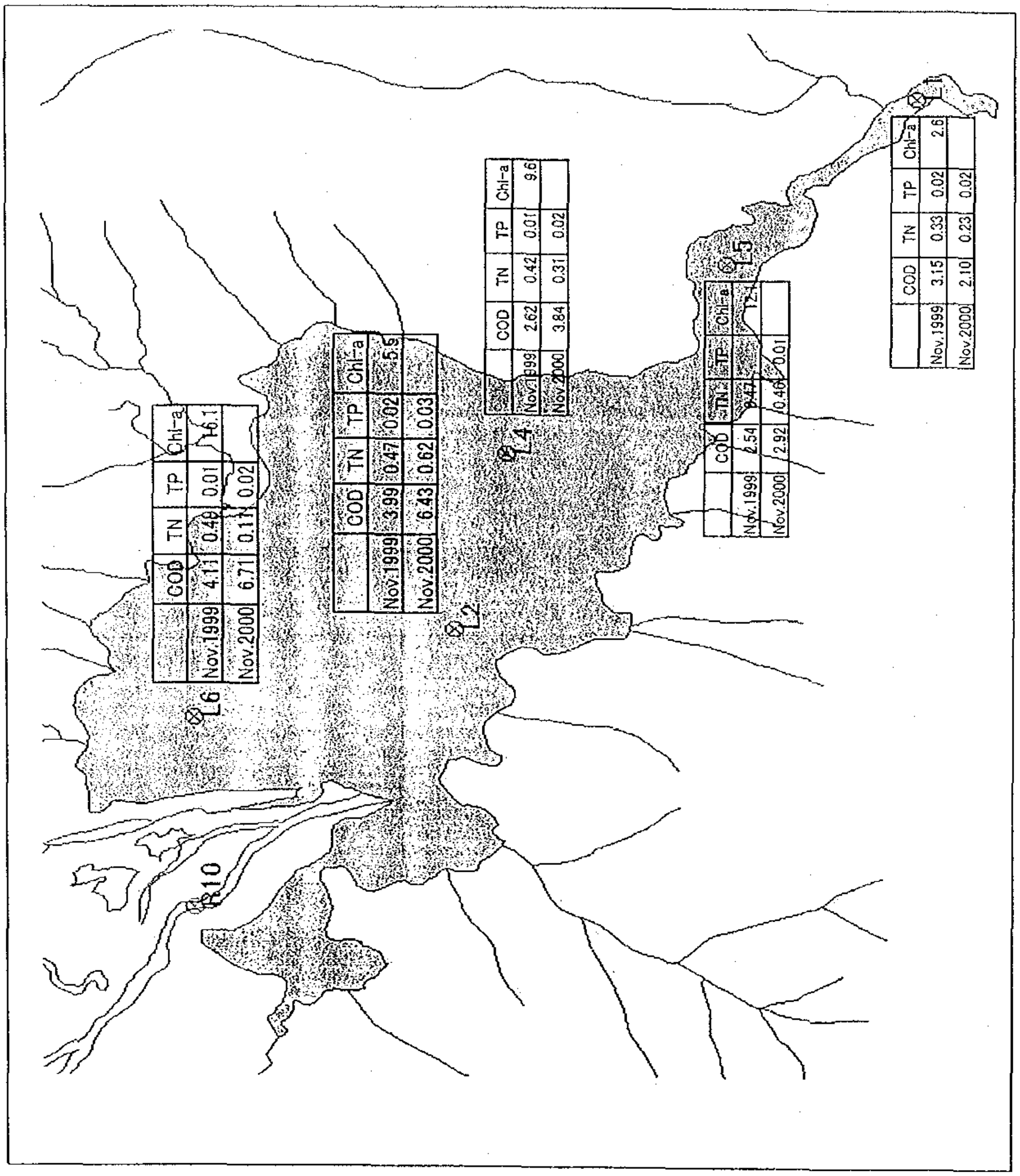
*Japanese survey data (University of Shimane, Nov. 1999 and Nov. 2000)

The above table suggests that the whole Lake is in the state of Eutrophic level during feature season.

1.2.2 Lakewater Current

Current conditions in the Lake are one of the most important factors that determine Lake water quality. River inflow and winds are the external forces that raise the Lake current. Also the retention time is the criterion used to measure the extent of the impact of river water on the Lake.

In view of these influences, the Lake current characteristics are analyzed based on the following:



	COD	TN	TP	Chl-a
Nov.1999	4.11	0.40	0.01	16.1
Nov.2000	6.71	0.17	0.02	

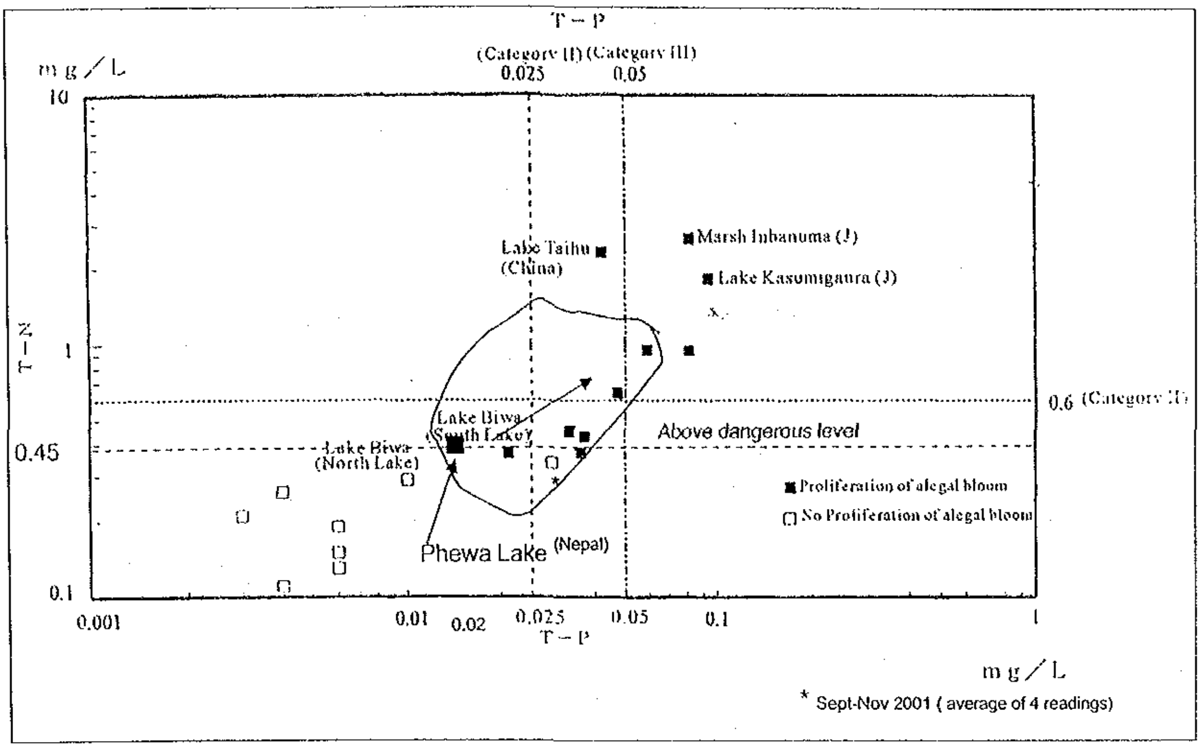
	COD	TN	TP	Chl-a
Nov.1999	3.99	0.47	0.02	5.5
Nov.2000	6.43	0.62	0.03	

	COD	TN	TP	Chl-a
Nov.1999	2.62	0.42	0.01	9.6
Nov.2000	3.84	0.31	0.02	

	COD	TN	TP	Chl-a
Nov.1999	2.54	0.47		12.1
Nov.2000	2.92	0.46	0.01	

	COD	TN	TP	Chl-a
Nov.1999	3.15	0.33	0.02	2.6
Nov.2000	2.10	0.23	0.02	

Spatial Distribution of Lake Water Quality (Nov. 1999 and Nov. 2000)
[Source: University of Shimane (Japan)]



* Sept-Nov 2001 (average of 4 readings)

Fig. I-1.2 : Eutrophication Relationship between T-N and T-P

- **Impact of River In-Flow/Out-Flow and Winds on the Phewa Lake in Generation of Lake Water Current**
- **Lake Water Retention Time**

The retention time of Lake water is a factor that must be known to determine the impact of the river inflow load on Lake water quality. By comparing the estimated river in-flow and out-flow , the retention time of Phewa Lake water is estimated with due consideration of seasonal influences.

- **Eutrophication Factors**

Eutrophication mainly results from the photosynthetic process undergone by phytoplanktons, "internal production", which is restricted not only by the aforementioned hydraulic characteristics but also by meteorological conditions (e.g. light, water temperature), and nutrient salts. The correlation between these factors and internal production are as follows:

- **Correlation between Meteorological Conditions/Transparency and Internal Production**

The assessment of meteorological conditions, e.g. sunlight (amount of solar radiation) and water temperature, are of importance in determining seasonal influences in internal production.

Depending on the type of phytoplankton, the water temperature in some sections of the Lake is considered suitable to phytoplankton growth, and the period where generation is huge also varies by type. The common problem, however, is the huge generation of the blue-green algae, water bloom, from fall to spring.

In addition, light (illumination) within the Lake is also important in the relationship with turbidity and transparency, particularly in Phewa Lake where turbidity inhibits internal production.

The effects of the relationship between the seasonal changes in sunlight and water temperature, and fluctuation and water temperature on internal production are thus been introduced and anlayzed in the model.

- **Correlation between Internal Production and Nutrient Salts**

Of the nutrient salts, nitrogen and phosphorus, are easily depleted in the Lake water and easily act as limiting factors in phytoplankton growth. N and P are taken up by phytoplankton at an average mass ratio of 7.2:1. 2. If the available amounts differ widely from this ratio there will be a limitation of the production. The critical N:P ratio is about 10:1. From the comparative study of TN:TP ratios in algal mass and in Lake water, Forsberg et al. (1978) determined the role of these elements as growth limiting nutrients. According to them P is the limiting factor at TN:TP>12 and chlorophyll A level < 20. At TN:TP<7 and chlorophyll A level >70 (mg/m^3) N is potential growth limiting. Anywhere between these two values would either have limited N or P.

As shown in **Table 1.1-2**, P acts as a limiting factor in the Lake during Autumn.

Table I-1.2: Average Values Observed and TN/TP Ratio

Season	Item / Area	Eastern Area (L6)	Central Area (L2)	Western Area (L5)
Autumn in Sept to Nov.	Chl-a (μg/l)	16.1	5.5	12.1
	T-N (mg/l)	0.55	0.55	0.47
	T-P (mg/l)	0.015	0.025	0.01
	TN/TP	37	22	47

Dry season : Average in September to November on 1999 and November 2000 by University of Shimane(Japan).

1.2.2.1 Source of Nutrient Salts

Nutrient salts are introduced to the Lake by the river inflow load, the bottom release load, groundwater, rainfall, dust fall, etc. The bottom release load is divided into a load that elutes into the Lake in static condition and load that returns due to the wind.

Nitrogen and phosphorus elute easily while in anaerobic condition, but settle easily in aerobic condition. Since the Lake is shallow overall – a condition that decelerates the development of anaerobic conditions – the bottom release load under static conditions can be neglected.

1.3 SIMULATION MODEL APPLIED TO PHEWA LAKE

1.3.1 Basic Condition of the Model

As discussed in previous para the hydraulic and water quality simulation models were developed to assess the impacts of measures for the preservation of Phewa Lake and its surrounding area, in consideration of the following conditions.

1. hydrological and water quality conditions in the entire Phewa Lake area.
2. changes in water quality all year round by month.
3. circulation of organic matter flowing into the Lake as well as amount of internal production by nutrient salts in the Lake.

For spatial accuracy for item (1) above, a lattice interval of 100m will be adopted in order to represent the topography of the narrowest section of the dam site (**Fig. 1-1.3** and **Fig. I-1.4**).

From an overall view of Phewa Lake, vertical changes in water quality are observed to be smaller than horizontal changes. Distribution of water quality can thus be analysed using the single layer model.

However, the simulation model developed is capable of a accounting multilayer scenarios for any given spatial division (multi-layer model or any lattice size) or time interval (day unit, hour unit).

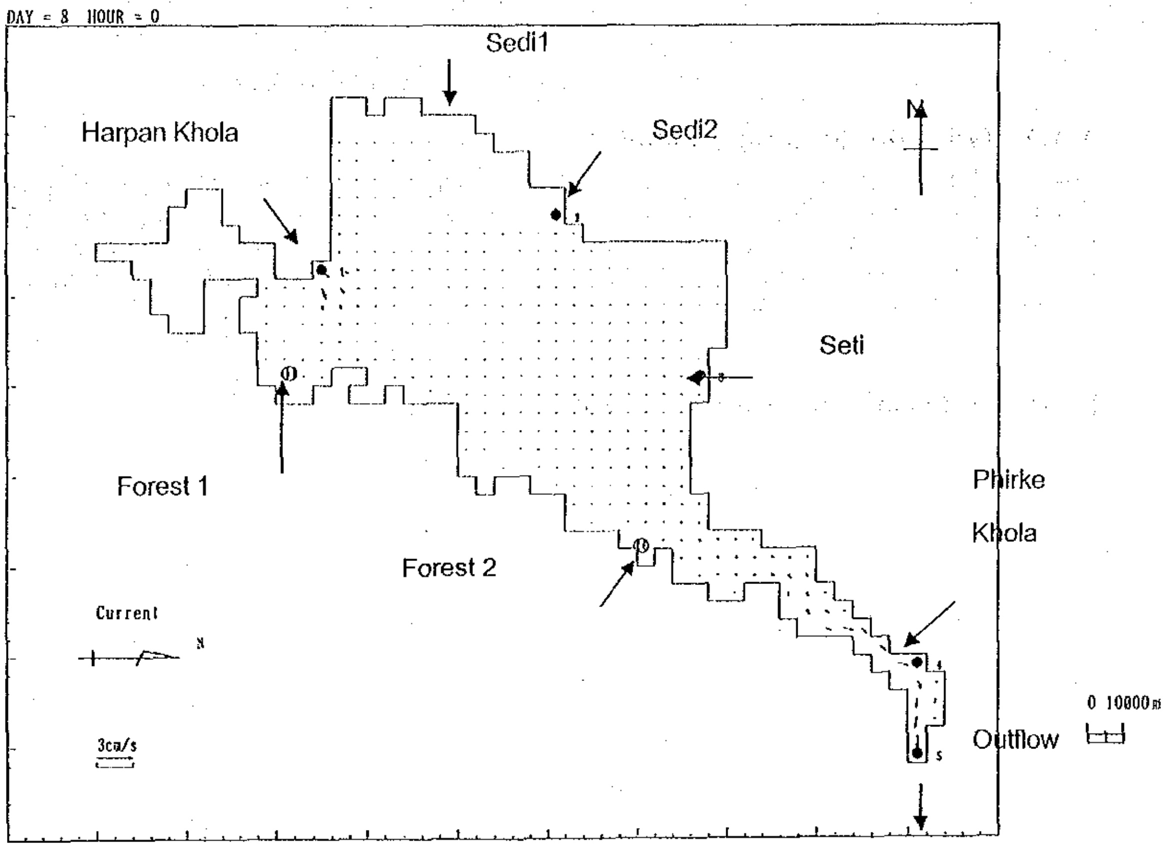
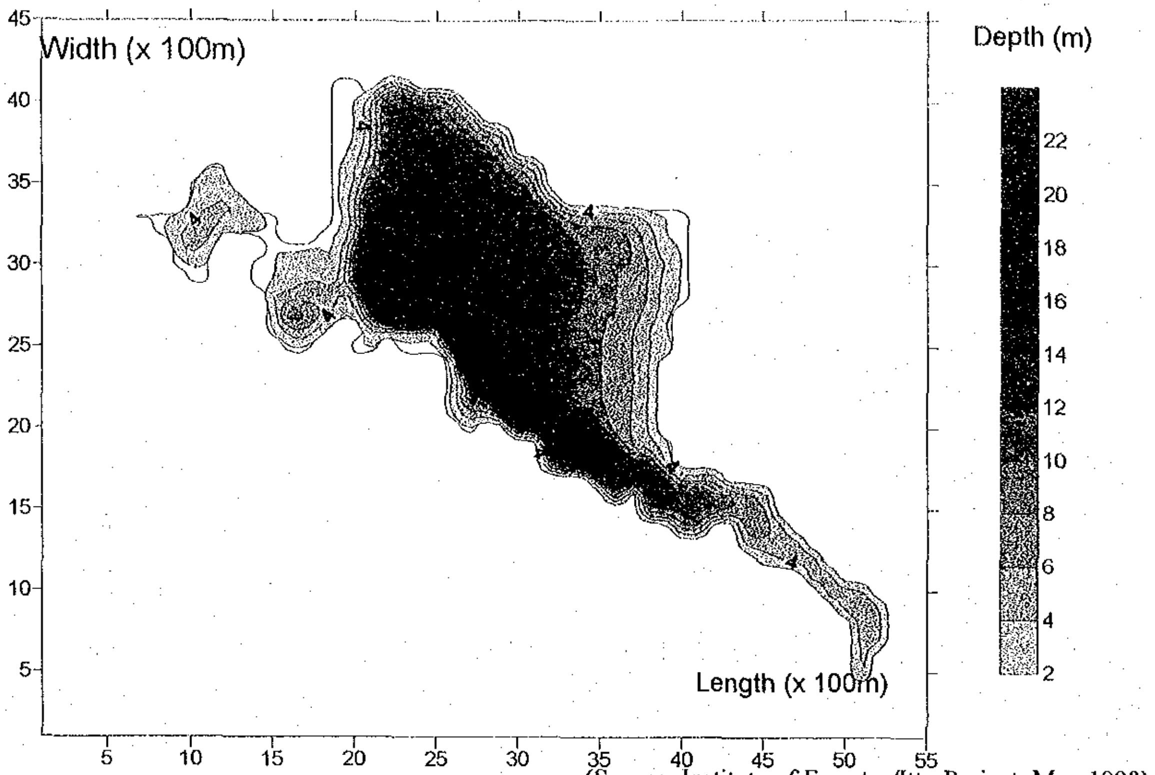


Fig. 1.3-1 Lattice and Inflow Points Map of Phewa Lake

fig001.P01



(Source: Institute of Forestry/Itto-Project, May 1998)

Fig. I-1.4: Water Depth Map of Phewa Lake

1.1.1 Hydraulic Simulation Model

The hydraulic model is developed to simulate flow conditions of the Lake affecting spatial distribution of water quality. The model uses Navior-Stoke's motion equation and the continuity equation as governing equation. River flow, wind, and water level at the dam site are considered as the main external factors that influence the flow. The non-linear diffusion equation was explicitly solved using finite difference scheme.

[Governing Equation for Hydraulic Model]

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0$$

$$\frac{\partial(\rho u)}{\partial t} = -\frac{\partial(\rho u^2)}{\partial x} - \frac{\partial(\rho uv)}{\partial y} - \frac{\partial(\rho uw)}{\partial z} + \rho vf - \frac{\partial P}{\partial x} + \mu_h\left(\frac{\partial^2(\rho u)}{\partial x^2} + \frac{\partial^2(\rho u)}{\partial y^2}\right) + \mu_z \frac{\partial^2(\rho u)}{\partial z^2}$$

$$\frac{\partial(\rho v)}{\partial t} = -\frac{\partial(\rho uv)}{\partial x} - \frac{\partial(\rho v^2)}{\partial y} - \frac{\partial(\rho vw)}{\partial z} - \rho uf - \frac{\partial P}{\partial y} + \mu_h\left(\frac{\partial^2(\rho v)}{\partial x^2} + \frac{\partial^2(\rho v)}{\partial y^2}\right) + \mu_z \frac{\partial^2(\rho v)}{\partial z^2}$$

$$\frac{\partial(\rho w)}{\partial t} = -\frac{\partial(\rho uw)}{\partial x} - \frac{\partial(\rho vw)}{\partial y} - \frac{\partial(\rho w^2)}{\partial z} - \rho g - \frac{\partial P}{\partial z} + \mu_h\left(\frac{\partial^2(\rho w)}{\partial x^2} + \frac{\partial^2(\rho w)}{\partial y^2}\right) + \mu_z \frac{\partial^2(\rho w)}{\partial z^2}$$

$$\frac{\partial \rho}{\partial t} = -\frac{\partial}{\partial x}(u\rho) - \frac{\partial}{\partial y}(v\rho) - \frac{\partial}{\partial z}(w\rho) + \frac{\partial}{\partial x}\left(K_h \frac{\partial \rho}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_h \frac{\partial \rho}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z \frac{\partial \rho}{\partial z}\right)$$

Where,

u , v , w:	Velocity Components in x,y,z Direction	g:	Acceleration of Gravity
g:	Density of water	μ_h , μ_z:	Horizontal and Vertical Eddy Viscosity Coefficient
P:	Pressure	K_h ,K_z:	Horizontal and Vertical Eddy Diffusivity Coefficient
F:	Coriolis Parameter		

1.3.3 Water Quality Simulation Model

Water quality simulation models can be broadly divided into two types: a model that deals with conservative matter such as salt, and a model dealing with non-conservative matter when eutrophication occurs. As the objective of water quality simulation in the course of this Study was to forecast eutrophication, the model dealing with non-conservative matter was adopted.

The items used to evaluate water quality were Chl-a, COD, nitrogen (Inorganic-N, Organic-N), phosphorus (Inorganic-P, Organic-P). In addition to the river inflow load, advection and diffusion, factors such as internal production, elution, settling and decomposition were also taken into consideration.

The governing equation for water quality simulation is as follows:

[Governing Equation for Eutrophication Model]

$$\frac{\partial P}{\partial t} = (Ad)P + (Dis)P + (G_p - k_2 T - d)P$$

$$\frac{\partial C_{IN}}{\partial t} = (Ad)C_{IN} + (Dis)C_{IN} + (-G_p + \eta_N k_2 T)\beta_P P + D_{C,N} + w_{IN} \exp(\gamma_{IN}(T - 20))$$

$$\frac{\partial C_{ON}}{\partial t} = (Ad)C_{ON} + (Dis)C_{ON} + (G_p - \eta_N k_2 T)\beta_P P - D_{C,N} - dC_{ON}$$

$$\frac{\partial C_{IP}}{\partial t} = (Ad)C_{IP} + (Dis)C_{IP} + (-G_p + \eta_P k_2 T)\gamma_P P + D_{C,P} + w_{IP} \exp(\gamma_{IP}(T - 20)) - d_{IP} C_{IP}$$

$$\frac{\partial C_{OP}}{\partial t} = (Ad)C_{OP} + (Dis)C_{OP} + (G_p - \eta_P k_2 T)\gamma_P P - D_{C,P} - dC_{OP}$$

$$\frac{\partial C_{PC}}{\partial t} = (Ad)C_{PC} + (Dis)C_{PC} + \{G_P - (\eta_C + \eta_I)k_2 T\}\delta_P P - D_{C,C} - dC_{PC}$$

$$\frac{\partial C_{SC}}{\partial t} = (Ad)C_{SC} + (Dis)C_{SC} + \eta_C k_2 T \delta_P P + f_{SC} \exp\{k_{SC}(T - 20)\}C_{SC} + D_{C,C}$$

$$G_P = \left\{ p\,\mu_0 \left(-\frac{T^2}{289} + \frac{T}{8.5} \right) + (1 - p)\mu_c k_1 T \right\} \left\{ \frac{L}{(k_L + L)} \right\} \left\{ \frac{C_{IN}}{(k_{IN} + C_{IN})} \right\} \left\{ \frac{C_{IP}}{(k_{IP} + C_{IP})} \right\}$$

$$D_{C,C} = f_C \exp\{k_C(T - 20)\}(C_{PC} - \delta_P P)$$

$$D_{C,N} = f_N \exp\{k_N(T - 20)\}(C_{ON} - \beta_P P)$$

$$D_{C,P} = f_P \exp\{k_P(T - 20)\}(C_{OP} - \gamma_P P)$$

$$(Ad)C = -\frac{\partial}{\partial x}(UC) - \frac{\partial}{\partial y}(VC) - \frac{\partial}{\partial z}(WC)$$

$$(Dis)C = \frac{\partial}{\partial x}\left(K_x \frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_y \frac{\partial C}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z \frac{\partial C}{\partial z}\right)$$

where,

P:	Concentration of phytoplankton (Chl-a)
C_{ON}:	Concentration of O-N
C_{IN}:	Concentration of I-N
C_{OP}:	Concentration of O-P
C_{IP}:	Concentration of I-P
C_{PC}:	Concentration of PCOD
C_{SC}:	Concentration of SCOD
u, v, w:	Velocity components in x, y, z direction
K_h , K_z:	Horizontal and vertical eddy diffusivity coefficient
p:	The rate of diatoms under phytoplankton crowd
μ_0:	The maximum growth rate of diatoms
μ_c:	The maximum growth rate of the phytoplankton crowd except diatoms
k:	The constant about the temperature influence to the growth rate of the phytoplankton except diatoms
k:	Respiratory rate of phytoplankton
k:	Michaelis constant for solar radiation
k_{in}:	Michaelis constant for I-N
k_{ip}:	Michaelis constant for I-P
d_{IP}:	Settling rate
d:	Settling rate by the chemical reaction of I-P
£:	Ratio of C / Chl-a in phytoplankton
β_p:	Ratio of N / Chl-a in phytoplankton
δp:	Ratio of P / Chl-a in phytoplankton
δp:	Ratio of COD / Chl-a in phytoplankton
η_N, η_P, η_I :	Decomposition rate of O-N ,O-P and PCOD accompanied by respiratory rate of phytoplankton
η_C:	Dissolution rate of PCOD accompanied by respiratory rate of phytoplankton
f_N , k_N:	Decomposition rate and the constant of O-N at 20°c
f_P, k_P:	Decomposition rate and the constant of O-P at 20°c
f_C, k_C:	Dissolution rate and the constant of PCOD at 20°c
f_{SC}, k_{SC}:	Decomposition rate and the constant of SCOD at 20°c
δ_{IN}:	Release rate of I-N at 20°c
γ_{IP}:	Release rate of I-P at 20°c

1.4 CALIBRATION AND VALIDATION OF THE MODEL

Flow and water quality conditions in Phewa Lake are affected by river flow, wind conditions and difference in Lake level and seasonal changes in meteorological conditions.

The model was calibrated to reproduce typical flow and lateral distribution of water quality in the Lake, and validated under representative external influences.

1.4.1 Repeatability of the Lake Water Current Pattern

(1) Simulation Run

The hydraulic model was run to simulate Lake water current pattern for typical case shown in **Table I-1.3** for conditions specified in **Table I-1.4**.

Table I-1.3: Calculation Cases for Repeatability of Current Pattern

Case No.	Name of Case	Amount of River Flow	Wind Condition
1	No Wind	Mean in Sept to Nov	0 m/sec

The test runs were carried out for three months period (from Sept. to Nov.) as the generation frequency of the algal bloom is higher than in the other months of the year based on past water *quality data at Khapaudi Cage Area in* Phewa Lake.

The seasonal and annual discharges of tributoring which inflows into Lake at locations shown in Fig. 1.3.-1 are estimated using generated daily flows for year 1999 and 2000. These are presented in Table I-1.5.

The "Model Pattern" of wind conditions is regarded as 0.0 m/sec because the monthly average speed of actual winds at Pokhara Airport observation station is 1-2 m/sec.

Table I-1.4:Run Condition for Hydraulic Model

Item	Condition	Remarks
Lattice Interval	100m×100m (Fig. I.1.3)	
Topography	Fig. I-1.4	
Point of Runoff Load	Fig. I-1.3	
Number of Layers	Single	
Time step	Current: 5sec, Water Quality: 30sec	
Horizontal Eddy Viscosity	2×10^{6} cm^{2}/sec	
Surface Friction Coefficient	0.0013	
Bottom Friction Coefficient	0.0026	
Acceleration Due to Gravity	9.8 m/sec^{2}	
Coriolis Coefficient	-7.27×10^{-5}	-2sin φ(φ=28°13')
Calculation Time	Current: 11 days, Water Quality: 30 days	
Tributaries Inflow	Table 5.4-3	
Water Elevation	0.00m	

Table I-1.5:Tributaries Inflow/Outflow

River Name		Inflow Point No.	(Mesh Number) I	J	Discharge (m^3/s) Average	Dry Season	Rainy Season
Inflow	1.Harpan Khola	1	18	32	7.36	2.44	12.28
	2.Sedi Khola(1)	2	25	40	0.62	0.205	1.035
	3.Sedi Khola(2)	3	31	35	0.62	0.205	1.035
	4.Seti Canal	4	39	26	0.15	0.10	0.20
	5. Phirke Khola	5	51	10	0.19	0.19	0.25
	6.Forest Area(1)	6	16	25	0.41	0.15	0.67
	7.Forest Area(2)	7	27	20	0.41	0.15	0.67
	Sub-total				**9.76**	**3.44**	**16.14**
Outflow	**8.Sub-total (Left Canal+ Pardi Khola)**	8	51	5	**9.76**	**3.44**	**16.14**
Total					**19.52**	**6.88**	**32.28**

(2) Simulation Results (Hydraulic Modal)

The result of the simulation run under the dry season conditions from September to November (the algal blooming season) are shown in **Fig. I-1.6** The results, shows that the modal has well reproduced the existing Lake water current pattern.

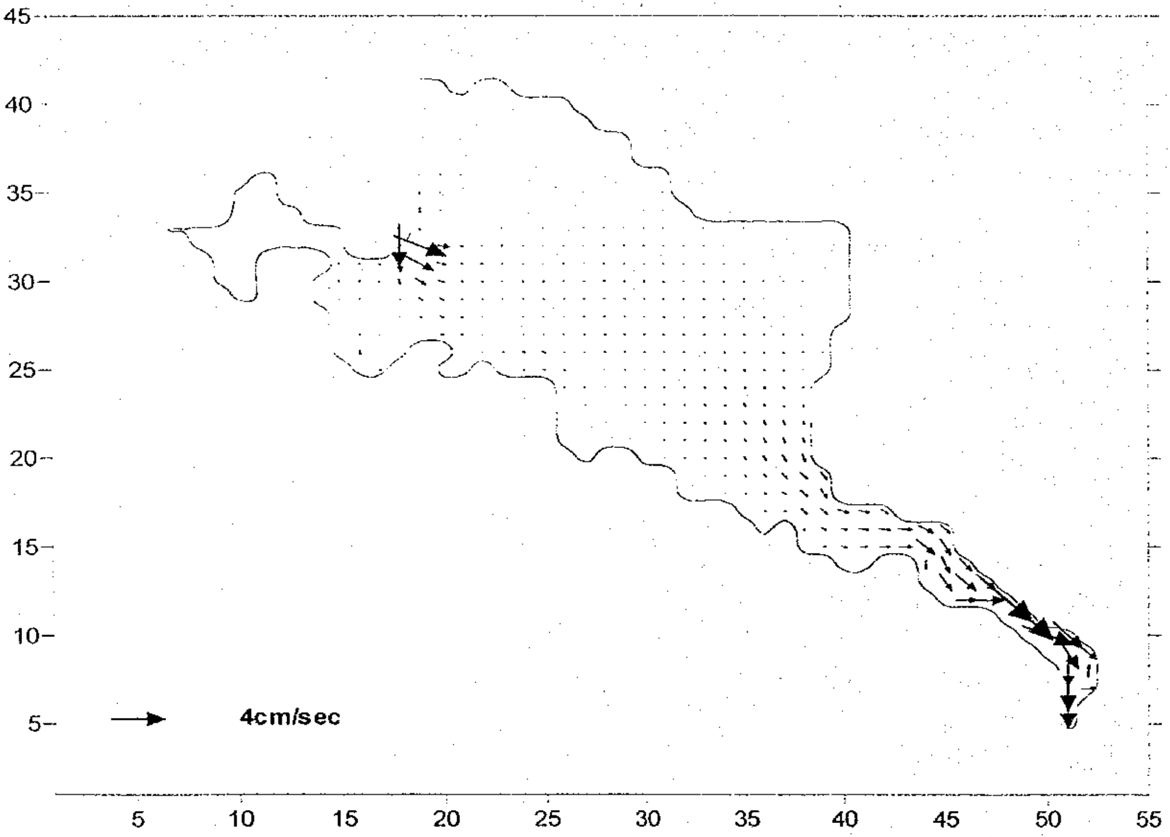


Fig. I-1.6: Current Pattern in Phewa Lake (Dry Season in Sept.-Nov.)

1.4.2 Repeatability of the Water Quality Distribution Pattern

(1) Test Run

The model was run to reproduce Water quality distribution in Phewa Lake under typical cases in dry season, as shown in **Table I-1.5**, for conditions specified in **Table I-1.6**.

Table I-1.5: Calculation Cases for Repeatability of Water Quality Distribution

Case No.	Name of Case	River Flow	Meteorological Conditions and Diatom Ratio
1	Dry Season in Sept. to Nov.	Average in Sept. to Nov.	Water temperature, solar radiation and diatom ratio based on the results of field surveys conducted in September to November.

Table I-1.6: Testing Calculation Conditions for Water Quality Simulation

Item	Condition	*Remarks*
Target Season	Dry season in September and November	Proliferation of Algal bloom in this term
Lattice Interval	100m×100m (Fig. 1.3- 1)	
Points of Runoff Load	**Fig. 1.3- 1**	
Topography	**Fig. 1.3-2**	
Index	Chl-a, T-N, T-P, COD	
Time Step	30 sec	
Open Boundary Condition	None	
Calculation Time	30 days	
Amount of River Load	**Table 1.4-6**	
Horizontal Dispersion Coefficient	$1.0 \times 10^4 cm^2/sec$	
Water Elevation	0.0m	
Water Temperature	Dry Season in Sept. to Nov. : 26.0 °c	Data of Pokhara Airport
Amount of Insulation	Dry season in Sept. to Nov.: $361 cal/cm^2/day$	Data of Pokhara Airport
Wind Condition	Same as in Hydraulic Model	
Rate of Diatoms under Phytoplankton Crowd	Zero	*Field data* Green Algal: Zero

Annex - 1

Item	Condition	Remarks
Max. Growth Rate of Diatoms	0.45 (day^{-1})	Literature
Max. Growth Rate of Phytoplankton Crowd Except Diatoms	0.8 (day^{-1})	Literature
Temperature Influence Constant to Growth Rate of Plankton Except Diatoms	0.035 (^{o}c^{-1})	Literature
Respiratory Rate of Plankton	0.005 (^{o}c^{-1}day^{-1})	Literature
Michaelis Constant for Solar Radiation	86 (cal/cm^{2}/day)	Literature
Michaelis Constant for I-N	25 (mgN/l)	Literature
Michaelis Constant for I-P	2 (mgP/l)	Literature
Settling Rate of Phytoplankton	0.3 (m/day)	
Settling Rate of SS	0.3 (m/day)	Field data, Literature
Settling Rate by Chemical Reaction of I-P	0.0 (day^{-1})	Literature
Ratio of N / Chl-a in Phytoplankton	10 (mg N/mg chl-a)	Literature
Ratio of P / Chl-a in Phytoplankton	1.3 (mg P/mg chl-a)	Literature
Ratio of COD / Chl-a in Phytoplankton	0.1 (mg COD/mg chl-a)	Literature
Decomposition Rate of O-N, O-P, PCOD Accompanied by Respiratory Rate of Phytoplankton	O-N, O-P, PCOD : 0.6	Literature
Dissolution Rate of PCOD Accompanied by Respiratory Rate of Phytoplankton	0.0	Literature
Decomposition Rate and Constant of O-N at 20 ^{o}c	0.05 , 0.0693	Literature
Decomposition Rate and Constant of O-P at 20 ^{o}c	0.05, 0.0693	Literature
Dissolution Rate Constant of PCOD at 20 ^{o}c	0.0.08, 0.0693	Literature
Decomposition Rate and Constant of SCOD at 20 ^{o}c	0.04, 0.0693	Literature
Release Rate of I-N and I-P at 20 ^{o}c	0.0 mg/m^{2}/day	No Field Data, Literature

Table I-1.7: Runoff Load into Phewa Lake (Average Values during September to November)

River Name		Inflow Point (No.)	Discharge (m^3/s)	COD (g/s)	T-N (g/s)	T-P (g/s)
Inflow	1.Harpan Khola	1	6.15	10.8	4.85	0.97
	2.Sedi Khola(1)	2	0.52	1.09	0.92	0.30
	3.Sedi Khola(2)	3	0.52	1.09	0.92	0.30
	4.Seti Canal	4	0.17	1.70	0.85	0.26
	5. Phirke Khola	5	0.22	2.20	1.10	0.33
	6.Forest Area(1)	6	0.40	0.40	0.15	0.024
	7.Forest Area(2)	7	0.40	0.40	0.15	0.024
	Sub-total		8.38	17.68	8.94	2.208
Outflow	8.Sub-total(Left Canal+ Pardi Khola)	8	8.38	17.68	8.94	2.208

1.4.2.1 Simulation Results (Water Quality Model)

The results of simulation run under the above-mentioned conditions are presented in **Figs. 1.4-2** through **1.4-5** for the distribution of Chl-a, T-N, T-P, COD during dry season (September to November).

The simulation runs were also carried out to examine the spatial distribution of COD during dry season for cases (i) after 20% reduction in inflowing load by means of a purification plant system, and (ii) after 100% reduction in flowing load by means of diversion canal system for the purpose of the examination of the permissible load by two measures. The results are presented in Figs. 1.4.-6 and 1.4.13 *respectively*.

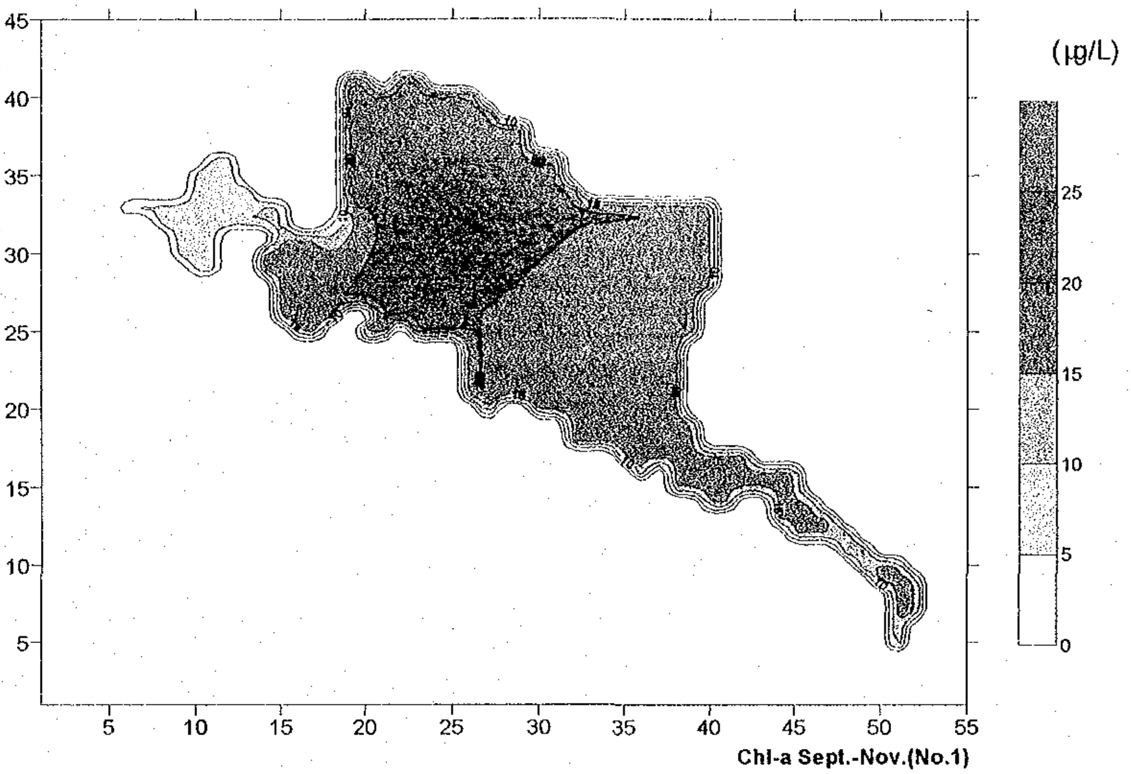


Fig. I-1.7: Spatial Distribution of Chl-a (Present: Dry Season from September to November)

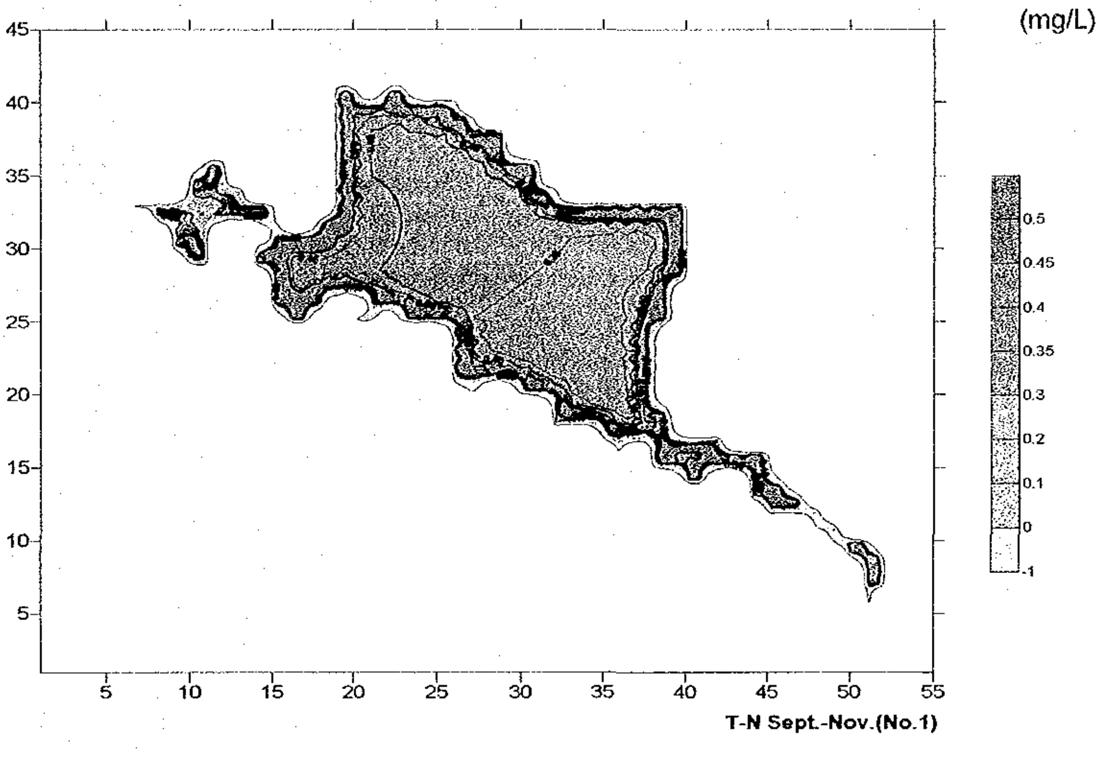


Fig. I-1.8: Spatial Distribution off T-N (Present: Dry Season from September to November)

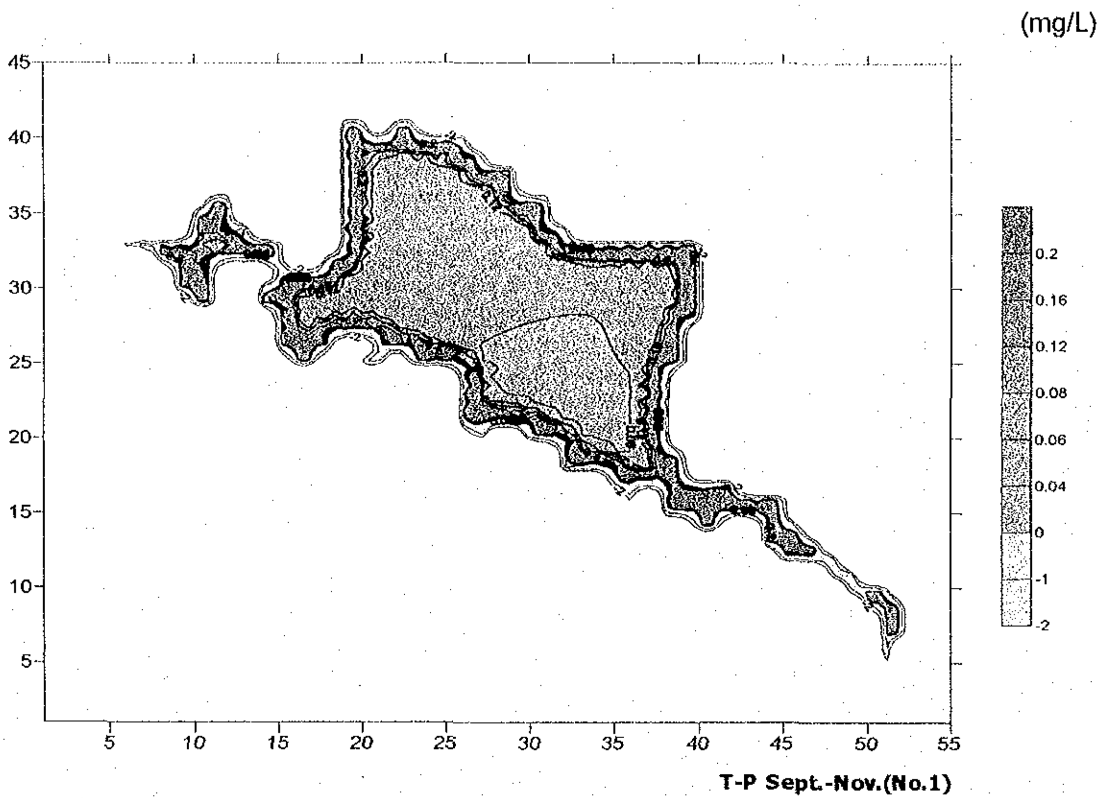


Fig. I-1.9: Spatial Distribution off T-P (Present: Dry Season from September to November)

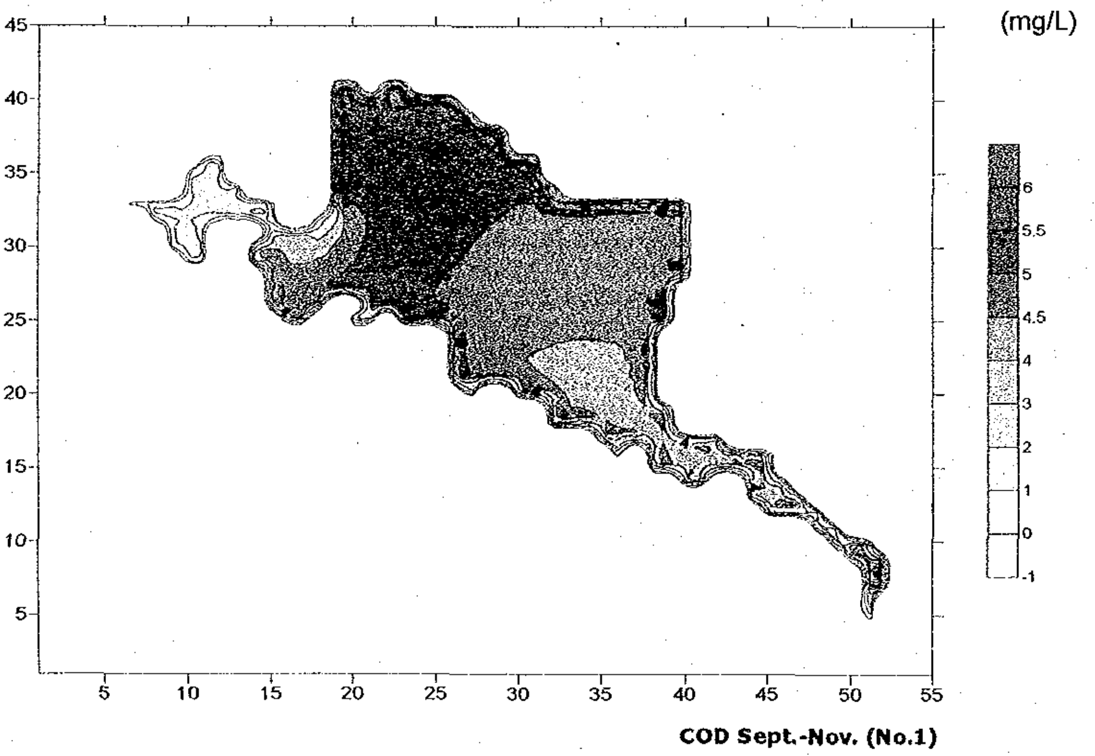


Fig. I-1.10: Spatial Distribution of COD (Present: Dry Season from September to November)

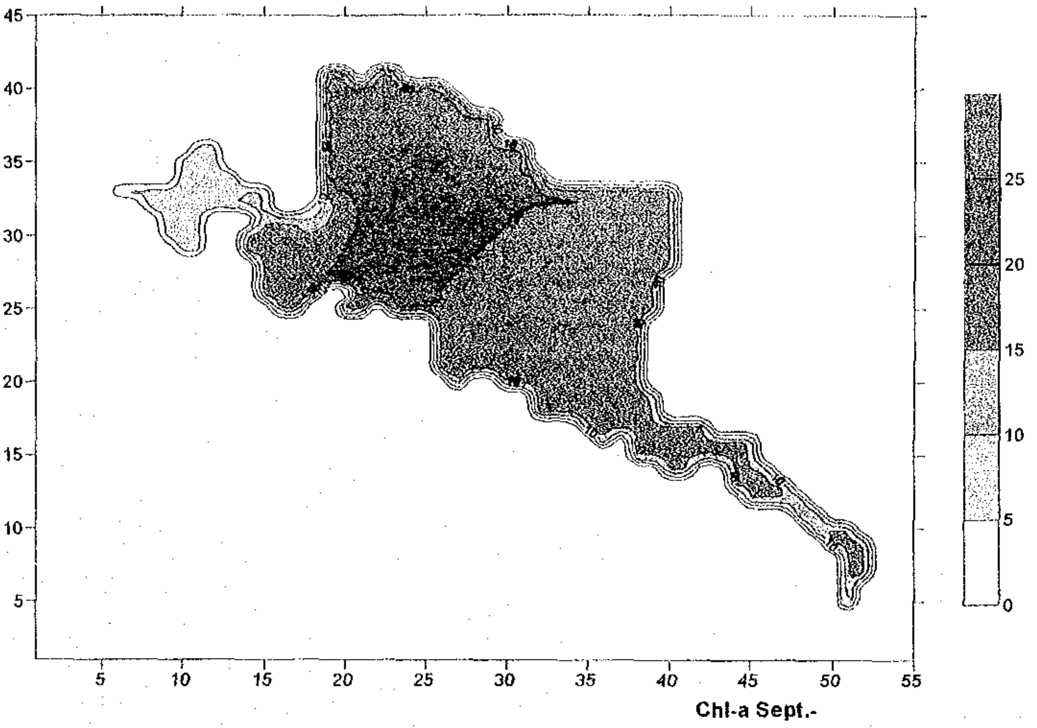


Fig. I-1.11: Spatial Distribution of Chl-a (Present: Dry Season from September to November)

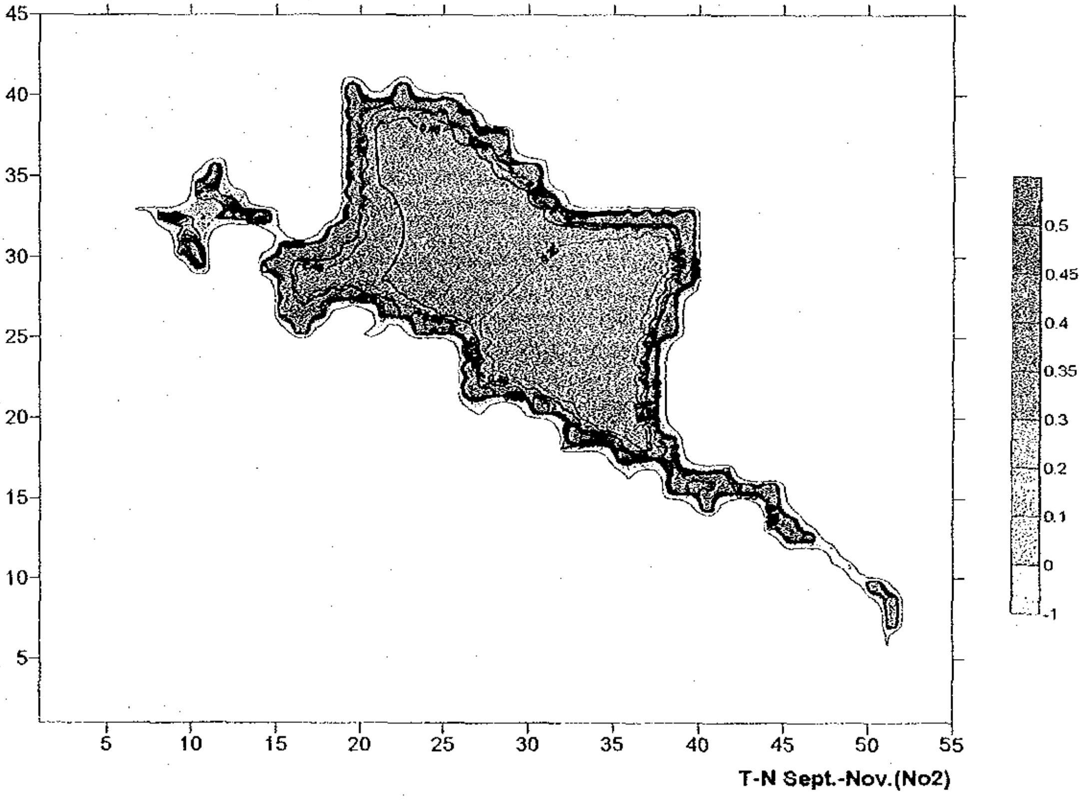


Fig. I-1.12: Spatial Distribution of T-N (Present: Dry Season from September to November)

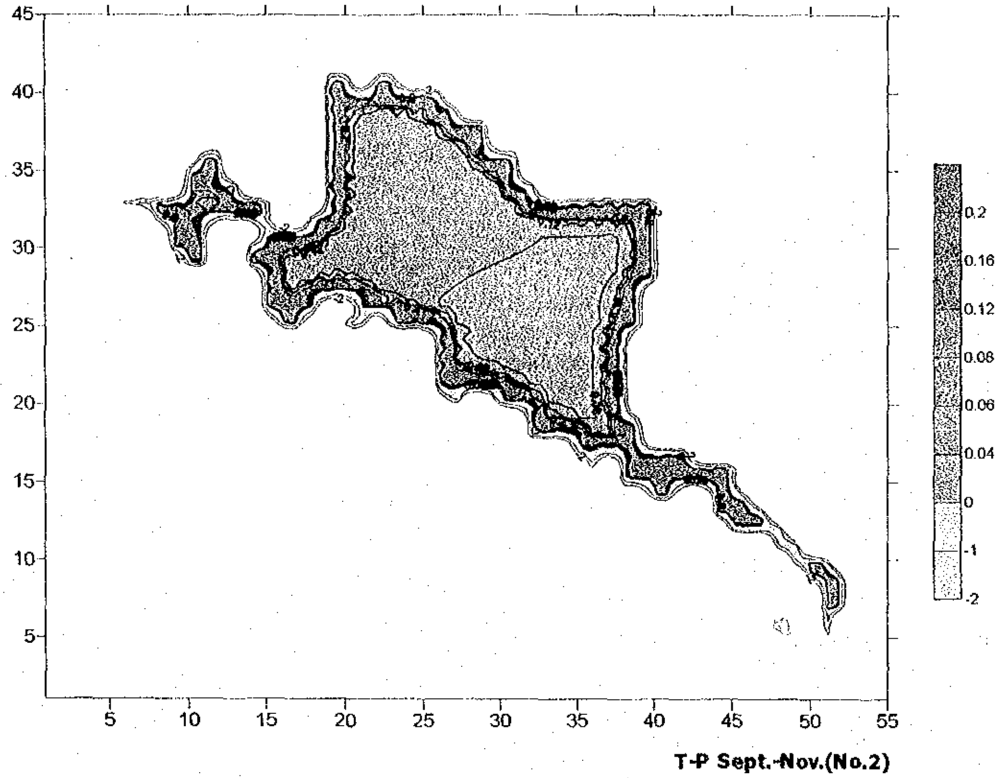


Fig. I-1.13: Spatial Distribution of T-P (Present: Dry Season from September to November)

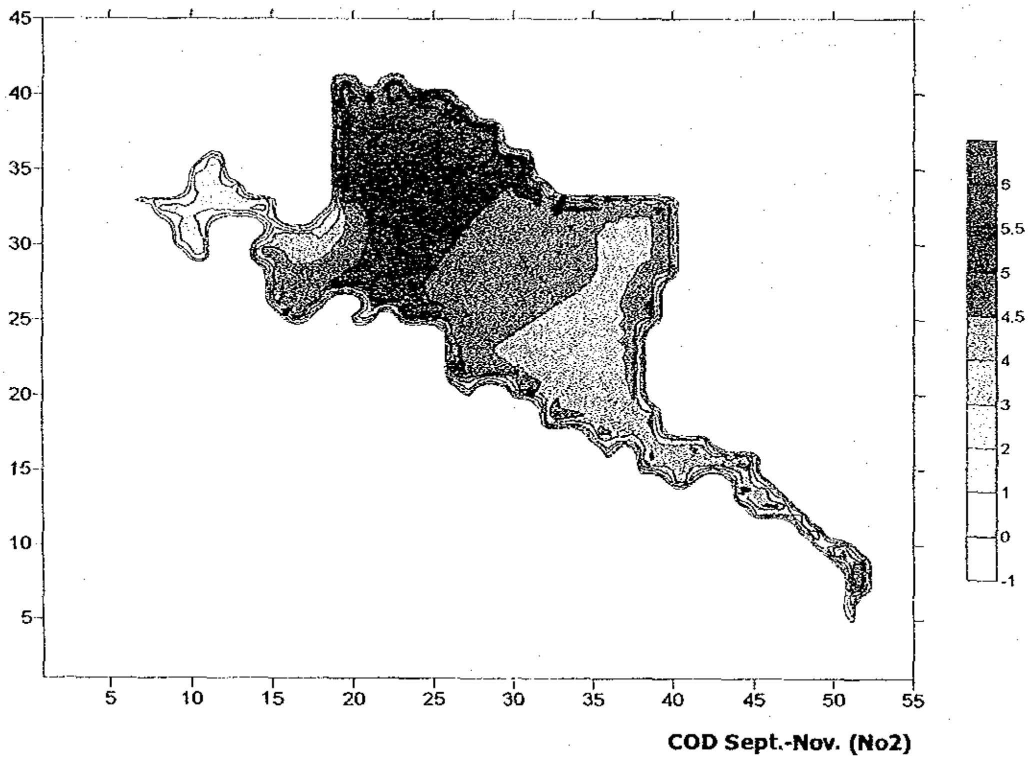


Fig. I-1.14: Spatial Distribution of COD (Present: Dry Season from September to November)

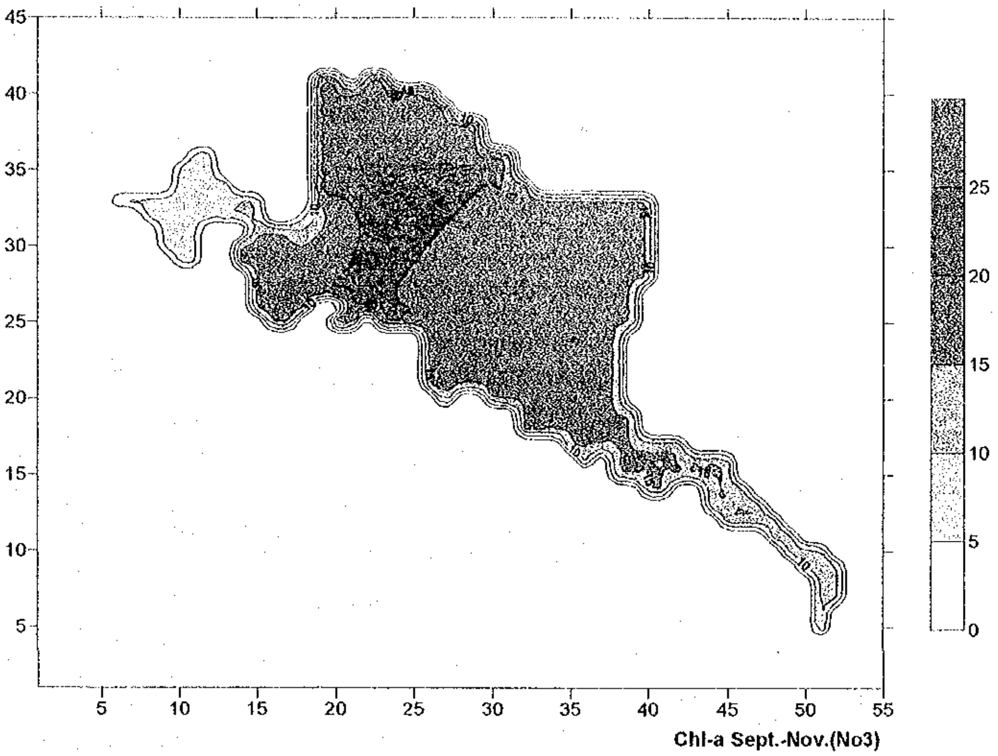


Fig. I-1.15: Spatial Distribution of Chl-a (Present: Dry Season from September to November)

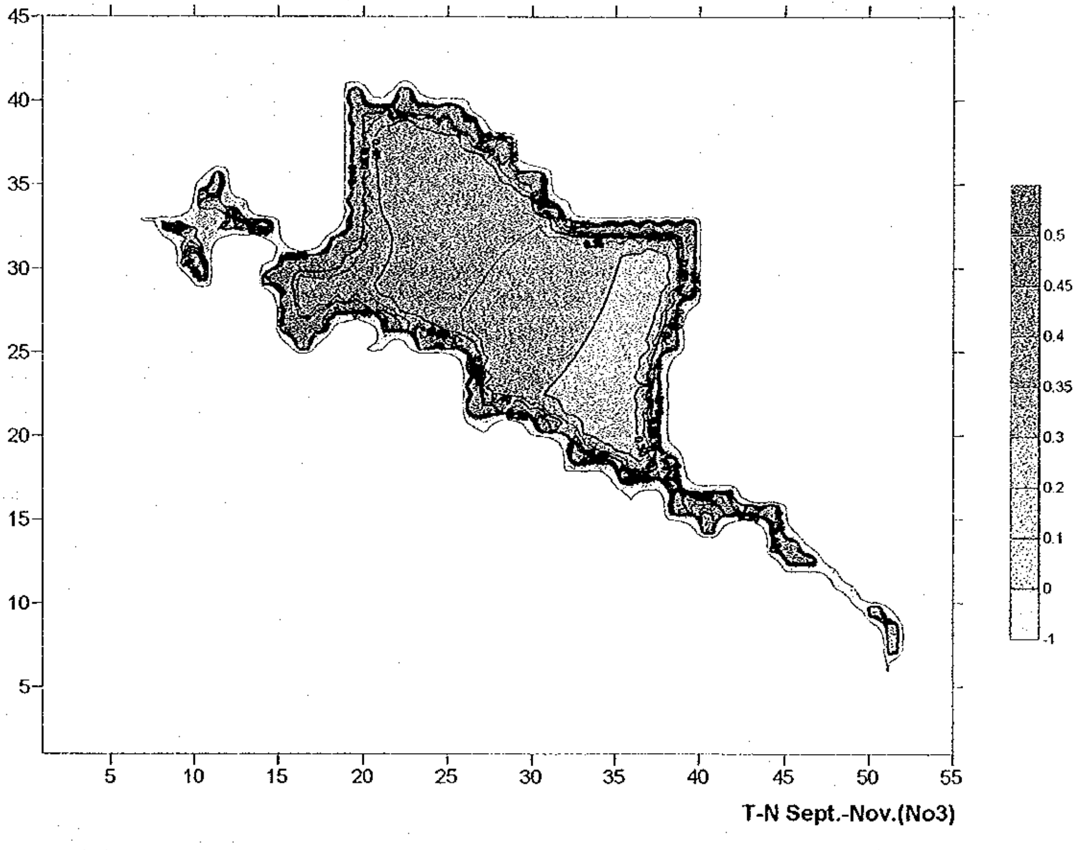


Fig. I-1.16: Spatial Distribution of T-N (Present: Dry Season from September to November)

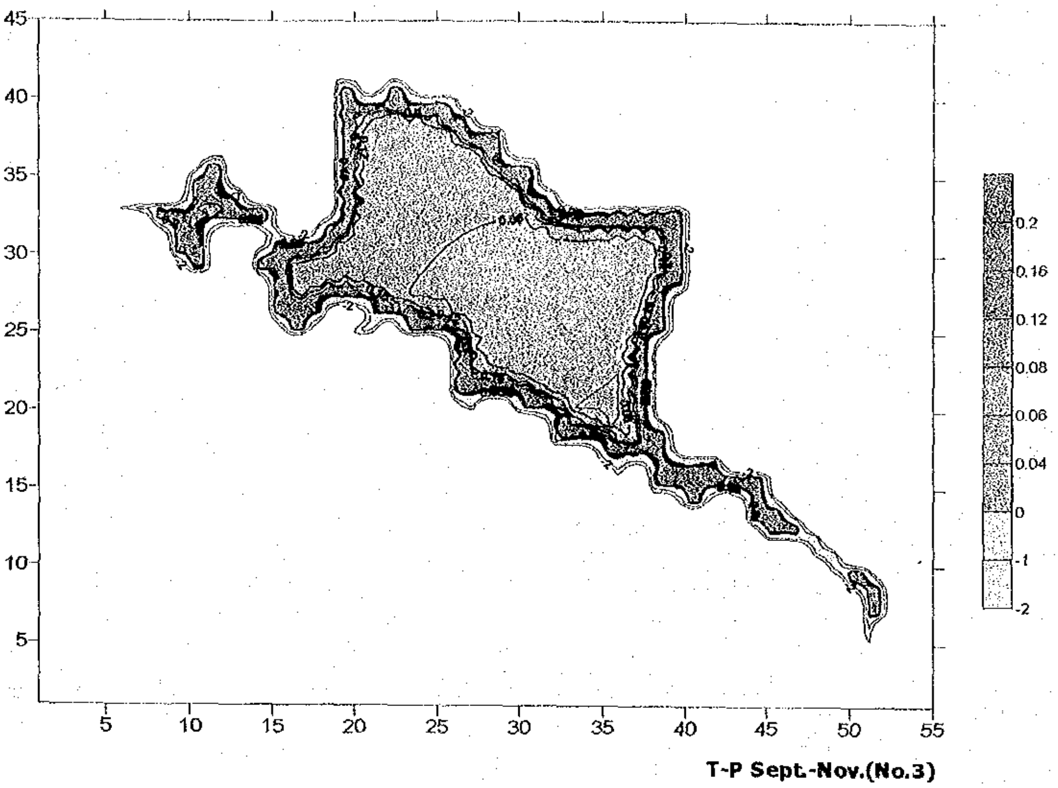


Fig. I-1.17: Spatial Distribution of T-P (Present: Dry Season from September to November)

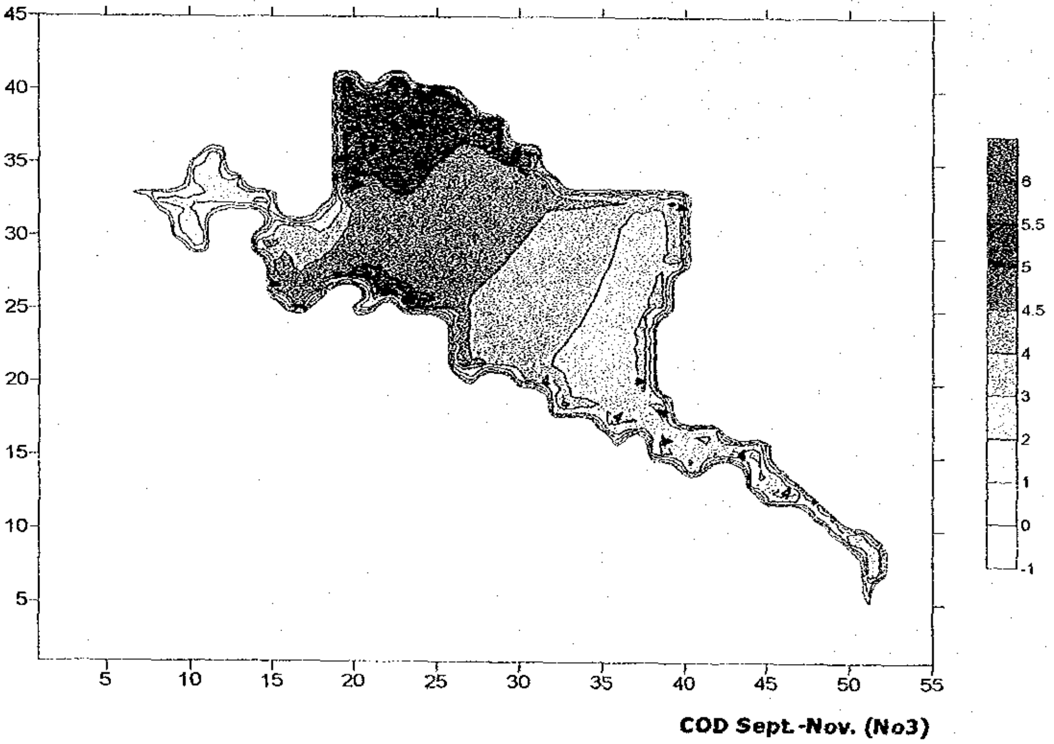


Fig. I-1.18: Spatial Distribution of COD (Present: Dry Season from September to November)