MEMO : EN/INPA/DH-07
SUBJECT: SENSITIVITY ANALYSIS FOR OXY
TO : PPA-ELETRONORTE
FROM : JOHANNES SMITS
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1. INTRODUCTION

THE PURPOSE OF SENSITIVITY ANALYSIS IS TO DETERMINE THE PARAMETERS, FOR WHICH A MODEL IS MOST SENSITIVE. THESE PARAMETERS SHOULD RECEIVE DUE ATTENTION DURING CALIBRATIONS, SINCE THEIR QUANTIFICATION HAS THE HIGHEST PRIORITY. IF NECESSARY, QUANTIFICATION SHOULD BE THE OBJECTIVE OF SUPPORTING RESEARCH.

A COMPLETE SENSITIVITY ANALYSIS IS CARRIED OUT BY MEANS OF RUNNING THE MODEL FOR AN AVERAGE, A HIGH AND A LOW VALUE FOR EACH INPUT PARAMETER. THE SENSITIVITY IS EXPRESSED AS THE PERCENTAGE OF CHANGE OF AN OUTPUT VARIABLE (A WATER QUALITY PARAMETER IN OUR CASE) DIVIDED BY THE PERCENTAGE OF CHANGE OF AN INPUT PARAMETER. IN THIS WAY SENSITIVITY CAN BE ASSESSED FOR EACH COMBINATION OF INPUT PARAMETERS AND OUTPUT VARIABLES. THIS APPROACH IS NOT FEASIBLE IN THE CASE OF OXY BECAUSE:

- THE NUMBER OF INPUT PARAMETERS IS RATHER LARGE,
- EACH MODEL RUN CONSUMES QUITE A LOT OF COMPUTER-TIME,
- THE OUTPUT VARIABLES ARE FUNCTIONS OF TIME AND DEPTH, WHICH IMPLIES TIME- AND DEPTH-VARIANT RESPONSES.

THEREFORE, THE FOLLOWING SIMPLIFIED METHOD HAS BEEN ADOPTED. THE INPUT PARAMETERS WERE DIVIDED AMONG FOUR CLASSES ACCORDING TO THE FOLLOWING QUALIFICATIONS WITH RESPECT TO THEIR VALUES:

1 UNKNOWN,
2 KNOWN BUT FAIRLY VARIABLE,
3 KNOWN AND FAIRLY CONSTANT,
4 KNOWN AND CONSTANT.

THE CLASSIFICATION IS SHOWN IN TABLE 1, WHILE AN EXPLANATION OF THE PARAMATERS IS GIVEN IN TABLE 2. WITH A FEW EXCEPTIONS SENSITIVITY ANALYSIS WAS CARRIED OUT ONLY FOR THE PARAMETERS IN CLASSES 1 AND 2. THE MODEL RUNS CONCERNED AN AVERAGE AND A HIGH VALUE (GENERALLY 2X THE AVERAGE). FOR FMOR AND FAN LOW VALUES (0.5X THE AVERAGE) WAS USED INSTEAD. EXAMINING THE RESULTS TIME- AND DEPTH-AVERAGED ESTIMATES OF THE RESPONSES WERE MADE. STRUCTURAL DIFFERENCES BETWEEN THE UPPER AND LOWER LAYERS AS

WELL AS TEMPORALITY WERE TAKEN INTO ACCOUNT. FINALLY, THE SENSITIVITY OF THE MODEL FOR EACH PARAMETER WAS CLASSIFIED ACCORDING TO THE PERCENTAGE OF CHANGE IN THE OUTPUT PARAMETERS. THE FOLLOWING CLASSIFICATION WAS USED:

- INSENSITIVE IF THE CHANGE < 5%
- SLIGHTLY SENSITIVE IF THE CHANGE > 5% AND < 10%
- MODERATELY SENSITIVE IF THE CHANGE > 10% AND < 30%
- SENSITIVE IF THE CHANGE > 30% AND < 50%
- HIGHLY SENSITIVE IF THE CHANGE > 50%

2. RESULTS

TABLE 3 SHOWS THE RESULTS OF THE SENSITIVITY ANALYSIS FOR A SELECTION OF INPUT PARAMETERS. THESE RESULTS ALLOW THE FOLLOWING GENERAL CONCLUSIONS:

- THE OXYGEN BUDGET IS SENSITIVE TO THE DEGRADATION OF ORGANIC MATTER AT THE BOTTOM AND TO VERTICAL DISPERSION (OPPOSITE EFFECTS NEAR BOTTOM AND SURFACE) AND MODERATELY SENSITIVE TO SEDIMENTATION AND THE BACKGROUND EXTINCTION.
- PHYTOPLANKTON IS SENSITIVE TO SUPPLY OF PHOSPHORUS (DEGRADATION OF ORGANIC MATTER AT THE BOTTOM) AND LIGHT ANDTO MORTALITY. IT IS MODERATELY SENSITIVE TO SUPPLY OF NITROGEN AND TO DEGRADATION AND SEDIMENTATION OF DETRITUS.
- THE NITROGEN BUDGET IS SENSITIVE TO DEGRADATION AND NITROGEN CONTENT OF ORGANIC MATTER AT THE BOTTOM AND TO NITRIFICATION AND DENITRIFICATION. IT IS MODERATELY SENSITIVE TO THE RELEASE ACCELERATION FACTOR, THE BACKGROUND EXTINCTION, DEGRADATION AND SEDIMENTATION OF DETRITUS AND DISPERSION.
- THE PHOSPHORUS BUDGET IS SENSITIVE TO DEGRADATION AND PHOSPHORUS CONTENT OF ORGANIC MATTER AT THE BOTTOM AND MODERATELY SENSITIVE TO THE SEDIMENTATION OF BOTH DETRITUS AND ADSORBED PHOSPHATE, THE PHOSPHORUS CONTENT OF DETRITUS AND THE RELEASE ACCELERATION FACTOR.
- OXY IS INSENSITIVE TO THE FRACTION OF REFRACTORY ORGANIC MATTER, THE CONTRIBUTION OF DETRITUS TO EXTINCTION (LIGHT LIMITATION OCCURS ONLY DURING A SHORT PERIOD), AND TO DEGRADATION OF LITTER IN THE WATER.
- OXY BECOMES SENSITIVE TO THE RATIO OF ANAEROBIC AND AEROBIC DEGRADATION RATES ON THE LONG TERM, WHEN THE SEDIMENT OXYGEN DEMAND AND THE (SUSPENDED) DETRITUS OXYGEN DEMANDS HAVE THE SAME ORDER OF MAGNITUDE.

FINALLY, IT MUST BE STRESSED THAT THE ASSESSMENT MAY CHANGE A LITTLE IF IT IS BASED ON LONG TERM CALCULATIONS, BECAUSE DEGRADATION OF ORGANIC MATTER AT THE BOTTOM WILL BECOME LESS INTENSIVE.

TABLE 1: CLASSIFICATION OF INPUT PARAMETERS FOR OXY

1 UNKNOWN	2 KNOWN/F.VAR.	3 KNOWN/F.CON.	4 CONSTANT
			AMAX,AMIN
			EN,GAMMA
	BEXT,FED,FMOR	RCO1,RCO2	
		SEXT,SIOP,SVOL	
		CKL,CKLMIN	
DMAX,DMIN			
FRICH	FDISP		
GASVP	REAR	DEPTHR	
RDEBB,RNITB			SD,SN
	RDETB,FAN		
ROD1B,ROD2B	RSODB,FREF	SOC,FOD1	
	FAMR,FOPR		
RSAD			
	RVEG	HVEG	
RS1	RS2		
SA1	SA2	SA3	
SP1	SP2,SP3		

TABLE 2: EXPLANATION OF INPUT PARAMETERS FOR OXY

AMAX	:	MAXIMAL SURFACE AREA OF RESERVOIR (KM2)
AMIN	:	MINIMAL (INITIAL) SURFACE AREA OF RESERVOIR (KM2)
BEXT	:	BACKGROUND EXTINCTION COEFFICIENT (1/M)
CKL	:	REAERATION COEFFICIENT (S2/(M2.D))
CKLMIN	:	MINIMAL REAERATION CONSTANT (1/D)
DEPTHR	:	AVERAGE DEPTH OF RIVER NEAR THE DAM (M)
DMAX	:	MAXIMAL VERTICAL DISPERSION COEFFICIENT IN EPILIMNION (M2/D)
DMIN	:	MINIMAL VERTICAL DISPERSION COEFFICIENT IN HYPOLIMNION (M2/D)
EN	:	EXPONENT OF AREA-DEPTH AND VOLUME-DEPTH RELATIONS
FAMR	:	FACTOR FOR AMMONIUM RELEASE FROM DEGRADING ORGANIC MATTER AT THE BOTTOM (1=NOT ACCELERATED COMPARED TO THE DEGRADATION ITSELF, >1=ACCELERATED FAMR TIMES)
FAN	:	RATIO OF ANAEROBIC AND AEROBIC DEGRADATION RATES(1-0)
FDISP	:	RATIO OF HYPOLIMNION AND METALIMNION DISPERSION COEFFICIENTS
FED	:	FRACTION OF DETRITUS CONTRIBUTING TO EXTINCTION (1-0)
FMOR	:	MULTIPLIER FOR MORTALITY RATE (1-0)
FOD1	:	FRACTION OF LITTER IN PHYTOMASS (1-0)
FOPR	:	FACTOR FOR PHOSPHORUS RELEASE FROM DEGRADING ORGANIC MATTER AT THE BOTTOM (1=NOT ACCELERATED COMPARED TO THE DEGRADATION ITSELF, >1=ACCELERATED FAMR TIMES)
FREF	:	FRACTION OF REFRACTORY ORG. MATTER PRODUCED FROM SOD (1-0)
FRICH	:	FRACTION OF DENSITY GRADIENT EPILIMNION IN RICH. NUMBER (1-0)
GAMMA	:	COEFFICIENT OF AREA-DEPTH AND VOLUME-DEPTH RELATIONS
HVEG	:	AVERAGE HEIGHT OF VEGETATION (M)
GASVP	:	VOLUME PERC. OF GAS CAUGHT IN RIVER WATER AFTER SPILLWAY (%)
RCO1	:	TEMPERATURE COEFFICIENT FOR RESPIRATION PHYTOPLANKTON (1/OC)
RCO2()	:	SPECIES SPEC. RESP. COEFF. PHYTOPLANKTON FOR EACH MONTH
RDEBB	:	DENITRIFICATION RATE CONSTANT IN THE BOTTOM AT 20 OC (M/D)
RDETB	:	DEGRADATION RATE CONSTANT OF DETRITUS AT 20 OC (1/D)
REAR	:	FRACTION OF MAXIMAL REAERATION AT THE SPILLWAY (1-0)
RNITB	:	NITRIFICATION RATE CONSTANT AT 20 OC (1/D)
ROD1B	:	DEGRADATION RATE CONSTANT OF PHYTOMASS (LITTER) AT 20 OC (1/D)
ROD2B	:	DEGRADATION RATE CONSTANT OF PHYTOMASS (FRESH) AT 20 OC (1/D)
RSAD	:	SEDIMENTATION/ADSORPTION RATE CONSTANT OF PHOSPHATE (M/D)
RS1	:	SEDIMENTATION VELOCITY OF PHYTOMASS (M/D)
RS2	:	SEDIMENTATION VELOCITY OF DETRITUS (M/D)
RSODB	:	DEGR. RATE CONSTANT ORG. MATTER AT THE BOTTOM AT 20 OC (1/D)D
RVEG	:	INCORPORATION RATE CONSTANT OF PHYTOMASS INTO WATER (1/D)
SA1	:	STOCH. CONSTANT FOR N IN PHYTOMASS (LITTER) (G N/G C)
SA2	:	STOCH. CONSTANT FOR N IN PHYTOMASS (FRESH) (G N/G C)
SA3	:	STOCH. CONSTANT FOR N IN PHYTOPLANKTON/DETRITUS (G N/G C)
SD	:	STOCH. CONSTANT FOR DENITRIFICATION (G N/G O2)
SEXT()	:	SPECIES SPEC. EXTINCTION COEFF. FOR EACH MONTH (L/(MG.M))
SIOP()	:	SPECIES SPEC. OPTIMAL PHOTOR. IRRAD. INTENSITY AT 20 OC (W/M2)
SN	:	STOCH. CONSTANT FOR NITRIFICATION (G O2/G N)
SOC	:	STOCH. CONSTANT FOR THE OXIDATION OF PHYTOMASS (G O2/G C)
SP1	:	STOCH. CONSTANT FOR P IN PHYTOMASS (LITTER) (G P/G C)
SP2	:	STOCH. CONSTANT FOR P IN PHYTOMASS (FRESH) (G P/G C)
SP3	:	STOCH. CONSTANT FOR P IN PHYTOPLANKTON/DETRITUS (G P/G C)
SVOL()	:	SPECIES SPEC. CELLULAR VOLUME FOR EACH MONTH (U3)