# Comprehensive Treatment for River Pollution in a Coastal City with a Complex River Network: A Case Study in Sanya, China

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**Text S1.** Sampling program.

The long-term historical measured rainfall data, measured river flow, and water level data were obtained from hydrological stations. Water flow and water quality were measured twice on days with and without precipitation for the point source pollution. The sampling time of days without and with precipitation was from March 6th, 2019 to April 6th, 2019 and July 8th, 2019 to August 8th, 2019, respectively, with samples taken once every two weeks. The average value of the two measured results on days without precipitation was ultimately used as the model's input flow and pollutant concentration. As the surface runoff pollution could not be measured in Sanya, the non-point source pollution parameters in this study referred to the calibration results of another city. Subsequently, the simulated results obtained by using this group of parameters were compared with the calculated results for annual runoff non-point source pollution load to ensure the applicability of this group of parameters in Sanya. Whilst there was no sediment deposition in the upper reaches of the Sanya River, there was sediment deposition in the urban section. To obtain the pollutant release rate, the sediment samples were taken at different control units and then tested in the lab. The above monitoring and analysis methods were carried out in accordance with the Chinese *Environmental Quality Standards for Surface Water* (GB3838-2002).

**Text S2.** Water quality model

The river water quality model included the simulation of convection, diffusion, and transformation (attenuation) in the river. Due to the large slope and fast flow rate of Sanya River, pollutants were mainly converted by convection. The transformation of pollutants included pollutants attenuation and dissolved oxygen balance process. This simulation adopted the exponential time type for pollutants attenuation:

$$v = ve^{-c \cdot dt} \tag{S-1}$$

where $v$ is the determinant value, mg/L; $c$ is the exponential decay constant, (1/day); $dt$ is the simulation engine time step, s.

The dissolved oxygen balance process included reaeration, ultimate oxygen demand (UOD), nitrification, denitrification, and so on.

In the absence of a pollutograph profile, the simulation engine will set the initial DO concentration equal to the saturated DO concentration derived from the constant temperature and salinity values set in the Water Quality and Sediment Parameters.

Any inflow from subcatchments will have the DO concentration set to the saturated DO derived from the constant temperature and salinity values set in the Water Quality Parameters.

$$\begin{aligned} DOS = 1.43 \times [ \quad & (10.291 - 0.2809T + 0.006009T^2 - 0.0000632T^3) \\ & -0.607 \cdot S(0.1161 - 0.003922T + 0.0000631T^2)] \end{aligned} \tag{S-2}$$

where $DOS$ is saturated dissolved oxygen concentration (mg/L); $T$ is temperature (Celsius); $S$ is salinity (kg/m$^3$).

(1) Reaeration

Reaeration is the process by which oxygen from the air dissolves in water. The process is limited by the saturation concentration. The rate of reaeration is proportional to the oxygen deficit, that is the difference between the saturation concentration and the actual concentration. Reaeration can be a function of temperature or alternatively be related directly to the hydrodynamics. Reaeration occurs in conduits; in nodes speed is considered to be zero, so there is no aeration. Additional reaeration can be included at structures.

Reaeration is represented by the equation:

$$\frac{dDO}{dt} = K_{air}(DOS - DO) \qquad \text{(S-3)}$$

where $DO$ is dissolved oxygen concentration (mg/L); $K_{air}$ is rate constant ($s^{-1}$).

The rate constant may be represented in one of two ways. It may be calculated from:

$$K_{air} = \frac{f_{air}}{d} \qquad \text{(S-4)}$$

where: $f_{air}$ is transfer velocity (m/hour); $d$ is hydraulic mean depth (A/b) (m); A is cross sectional area of flow; b is water surface width. $f_{air}$ represents the speed at which a front of oxygen penetrates through the water depth. The stronger the mixing processes are, the higher this value will be. Typical values are in the range 0.03~0.1 m/hr. It is also a function of temperature:

$$f_{air}(T) = f_{air}(20)\beta^{(T-20)} \qquad \text{(S-5)}$$

where: $\beta$ is temperature adjustment constant; $f_{air}(20)$ is transfer velocity (m/hr) at a temperature of 20 °C.

Alternatively the reaeration rate, $K_{air}$ can be calculated directly as a function of water depth ($d$) and velocity ($u$). Check the Calculate reaeration parameters option in the Water Quality and Sediment Parameters to calculate reaeration rate in this way. In this case three expressions for $K_{air}$ are used, depending on the hydrodynamics.

If ($d < 0.61$) then use Owens-Gibbs formula:

$$K_{air} = \frac{5.32u^{0.67}}{d^{1.85}} \qquad \text{(S-6)}$$

where: $K_{air}$ is reaeration rate ($d^{-1}$); u is absolute velocity (m/s); $d$ is hydraulic mean depth (m).

If ($d > 3.45u^{2.5}$) then use O'Connor-Dobbins formula:

$$K_{air} = \frac{3.930u^{0.5}}{d^{1.50}} \qquad \text{(S-7)}$$

Otherwise, Churchill's equation applies:

$$K_{air} = \frac{5.026u}{d^{1.67}} \qquad \text{(S-8)}$$

(2) Reaeration at structures

The water quality engine considers a structure to be any control link except for pumps. A global Structure aeration coefficient can be defined in the Water Quality and Sediment Parameters. The global aeration coefficient can be overriden for individual structures using the Structures editor also editable via the Water Quality Parameters property sheet.

Extra reaeration due to flow over structures is simulated by the following equation:

$$C_d = \frac{C_u + (r-1)C_s}{r} \tag{S-9}$$

where: $C_u$ = dissolved oxygen concentration upstream of the structure (kg/m$^3$); $C_d$ = dissolved oxygen concentration downstream of the structure (kg/m$^3$); $C_s$ = saturated dissolved oxygen concentration (kg/m$^3$); $r$ = reaeration coefficient

The reaeration coefficient is defined by the following equation:

$$r = 1.0 + 0.38ak\Delta h(1.0 - 0.11\Delta h)(1 + 0.046T) \tag{S-10}$$

where $k$ is structure aeration coefficient; $\Delta h$ is headloss across the structure (m); $T$ is water temperature (°C); a is coefficient which depends on the quality of the water:

$$a = 0.65 + \frac{C_u}{C_s} \tag{S-11}$$

(3) Ultimate oxygen demand (UOD)

UOD is the total amount of oxygen required for microorganisms to decompose the organic matter in water. UOD is used in the Dissolved Oxygen (DO) processes to reduce DO (or nitrate during denitrification). Either Biochemical Oxygen Demand (BOD) or Chemical Oxygen Demand (COD) can be used to determine UOD.

BOD is the potential use of dissolved oxygen by aquatic microbes to metabolise organic matter. BOD is commonly expressed in terms of the 5-day BOD, which is the amount of oxygen consumed by the decay of the material over 5 days.

When BOD is selected for use in determining Oxygen Demand in the QM Parameters Dialog, the water quality engine derives UOD from the following equation:

$$UOD = \frac{BOD_5}{1 - e^{-5k}} \tag{S-12}$$

where: $k$ is $BOD_5$ decay rate (d$^{-1}$).

Chemical Oxygen Demand (COD) is a measure of the amount of oxygen required for chemical oxidation of pollutants in the system. When COD is selected for use in determining Oxygen Demand in the QM Parameters Dialog, there is no conversion of COD to ultimate oxygen demand. COD is taken as the equivalent to UOD.

(4) Ammoniacal nitrogen

Ammoniacal nitrogen ($NH_3$-N) represents nitrogen which exists in the form of ammonia or ammonium ions. It can be formed by the hydrolysis of organic nitrogen, but also enters a modelled system directly from industrial or sewage effluent. Ammoniacal nitrogen is oxidised to nitrite by nitrosomonas bacteria. This oxidation is modelled as a first order process which is temperature, salinity and suspended solids dependent:

$$\frac{dC}{dt} = -KC \tag{S-13}$$

where: $K$ is reaction rate constant ($s^{-1}$); $C$ is concentration of organic material ($kg/m^3$).

In the case of the oxidation of ammoniacal nitrogen to form nitrite, the reaction rate constant is a function of salinity and suspended solids concentration as well as temperature:

$$K_{AM\theta} = K_{AM20}\left(1+\frac{\alpha}{100}\right)^{(\theta-20)}\left(1+\frac{\beta}{100}\right)^{(S-S_0)}\left(1+\frac{\gamma}{100}\right)^{(f_{BSS}\times SS-SS_0)} \tag{S-14}$$

where: $\alpha$ is temperature dependence factor; $f_{BSS}$ is base suspended solids factor; $S_0$ is base salinity (kg/m3); $SS_0$ is base suspended solids concentration (mg/L); $\beta$ is salinity coefficient; $\gamma$ is suspended solids dependence factor; $K_{AM\theta}$ is nitrification rate constant at θ °C; $K_{AM20}$ is nitrification rate constant at 20 °C.

(5) Denitrification

Under low oxygen or anoxic conditions the nitrification of ammonia ceases. Nitrates and nitrites are then used as a source of oxygen in order to satisfy BOD by denitrification. The nitrogen which is released during the process is released to the atmosphere and plays no further part in the model.

Denitrification occurs when dissolved oxygen is less than 5% of the saturated value.

During denitrification the following decay processes stop:

1.$NH_4$ to $NO_2$

2.$NO_2$ to $NO_3$

3.DO decay from $NH_4$, $NO_2$ and UOD. However, UOD contributes to DO decay once $NO_3$ is exhausted During denitrification and while there is $NO_3$ (Nitrate) present, $NO_3$ decays at the rate:

$$\frac{\partial NO_3}{\partial t} = -K_{NO_2} NO_2 - 0.35 K_{BOD} UOD \quad \text{(S-15)}$$

(6) Oxygen with sediment

When modelling dissolved oxygen (DO) and sediment (SF1, SF2), the effect of particulate BOD/COD on the oxygen balance in the water is also modelled. The transfer of organic material and dissolved substances between the water column, the bed and the pore water is also simulated.

Particulate BOD/COD settles in proportion to the amount of suspended solids that settles. As material passes into the bed layer it decays and exerts an oxygen demand on the entrained pore water.

Dissolved substances (BOD/COD, ammonia, nitrates, nitrites) are passed to the pore water from the water column in proportion to the amount of pore water which is entrained. Dissolved BOD/COD which is entrapped in the pore water will exert its oxygen demand within the pore water. The hydrolysis of organic nitrogen, the oxidation of ammoniacal nitrogen and nitrites, denitrification and the reduction of sulphates are all simulated within the pore water.

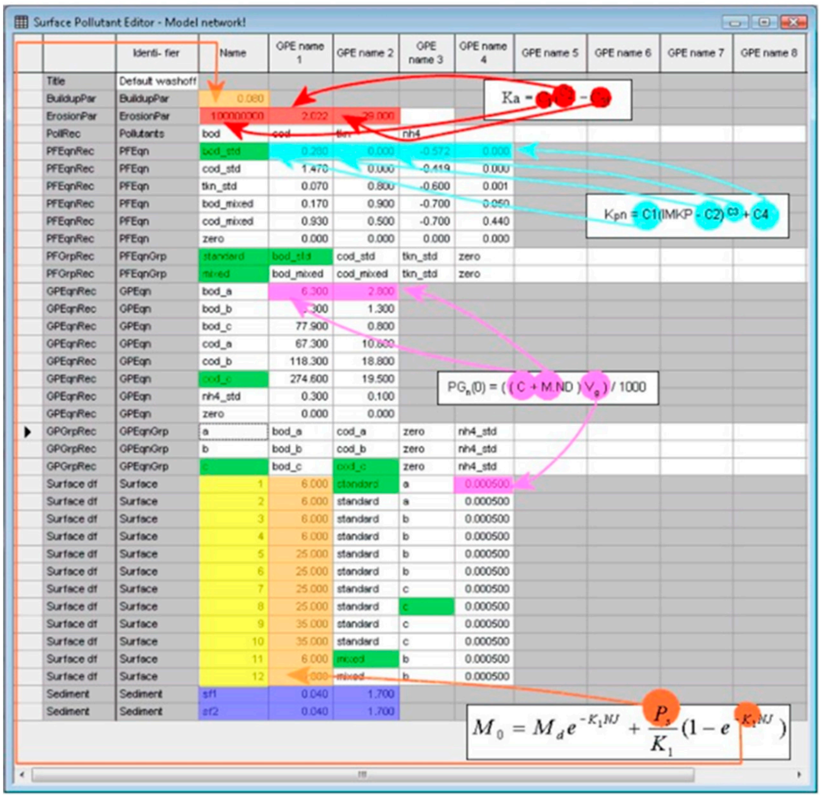
For the purpose of modelling pore water concentrations of dissolved substances, the volume of pore water in a computational cell is calculated as:

sum of mass of sediment fraction × specific gravity of sediment fraction × void ratio for each sediment fraction

where void ratio is taken to be 0.6.

**Text S3.** Non-point source pollution parameters in Infoworks ICM.

The non-point source pollution parameters are listed in the following table. And the explanation is stated as follows.




Related parts of the image are highlighted in the same colour. The arrows show the relationship between values defined in the editor and parameters in the equations used in the model.

| Cell colour | Explanation |
|---|---|
| (yellow) | This colour indicates the ID fields for the Pollution Indices. There are 12 defined in this network. |
| (orange) | This colour shows the parameters for the Surface Buildup Equation. |
| (red) | This colour shows the Surface Erosion Equation parameters. |
| (cyan) | This colour shows the Potency Factor Equation parameters. |
| (green) | The green cells show the links between the different records in the editor. |
| (pink) | This colour shows the parameters for the Gully Pot Equation. |
| (blue) | These are the parameters defining the sediment fraction characteristics. |

1. The surface buildup equation is:

$$M_0 = M_d e^{-K_1 NJ} + \frac{P_S}{K_1}(1 - e^{-K_1 NJ}) \tag{S-16}$$

where $M_0$ is the mass of sediment after the buildup period, or the projected mass of sediment at the end of the time step; $M_d$ is the initial mass of sediment; $K_1$ is the buildup decay factor, and the value of $K_1$ must be greater than zero; $NJ$ (days) is the time step length, or the buildup period at the start of the simulation; $P_S$ is the surface buildup factor defined in the Surface Definition Record.

2. The Rainfall Erosion Calibration-Coefficients are used in the following equation to calculate the rainfall erosion coefficient:

$$Ka(t) = C_1 \cdot i(t)^{C_2} - C_3 \cdot i(t) \tag{S-17}$$

where $Ka(t)$ is the rainfall erosion coefficient; $i(t)$ is the effective rainfall (m/s).

3. Potency factors (Kpn) are used to relate surface mass of sediment to surface mass of pollutant and are calculated using the potency factor equation:

$$K_{pn} = C_1(IMKP - C_2)^{C_3} + C_4 \tag{S-18}$$

where $C_1$, $C_2$, $C_3$ and $C_4$ are coefficients defined in the other four fields of the potency factor equation record; IMKP is the maximum rainfall intensity over a 5-minute period in mm/hr.

4. The Gully Pot Buildup Equation Record defines the coefficients for a gully pot buildup equation of the form:

$$PG_n(t) = \frac{(C + M.ND)V_g}{1000} \tag{S-19}$$

where $PG_n(t)$ (kg) is the initial dissolved pollutant mass in the gully pot (or the projected pollutant mass at the end of the time step); $C$ (mg/L) is the initial pollutant concentration; M is the gradient of linear accumulation in mg/(L·day); $ND$ (day) is the dry weather buildup period or the timestep length; $V_g$ is the gully volume in $m^3$.

| Title | Default | | | | | | |
|---|---|---|---|---|---|---|---|
| BuildupPar | BuildupPar | 0.080 | | | | | |
| ErosionPar | ErosionPar | 950605 | 1.800 | 15.000 | | | |
| PollRec | Pollutants | bod | cod | tkn | nh4 | tph | |
| PFEqnRec | PFEqn | bod_std | 0.280 | 0.000 | -0.572 | 0.000 | |
| PFEqnRec | PFEqn | cod_std | 1.470 | 0.000 | -0.419 | 0.000 | |
| PFEqnRec | PFEqn | tkn_std | 0.070 | 0.800 | -0.600 | 0.001 | |
| PFEqnRec | PFEqn | tph_std | 0.023 | 0.800 | -0.600 | 0.001 | |
| PFEqnRec | PFEqn | bod_mixed | 0.170 | 0.900 | -0.700 | 0.050 | |
| PFEqnRec | PFEqn | cod_mixed | 0.930 | 0.500 | -0.700 | 0.440 | |
| PFEqnRec | PFEqn | zero | 0.000 | 0.000 | 0.000 | 0.000 | |
| PFGrpRec | PFEqnGrp | standard | bod_std | cod_std | tkn_std | zero | tph_std |
| PFGrpRec | PFEqnGrp | mixed | bod_mixed | cod_mixed | tkn_std | zero | tph_std |
| GPEqnRec | GPEqn | bod_a | 6.300 | 2.800 | | | |
| GPEqnRec | GPEqn | bod_b | 15.300 | 1.300 | | | |
| GPEqnRec | GPEqn | bod_c | 77.900 | 0.800 | | | |
| GPEqnRec | GPEqn | cod_a | 67.300 | 10.800 | | | |
| GPEqnRec | GPEqn | cod_b | 118.300 | 18.800 | | | |
| GPEqnRec | GPEqn | cod_c | 274.600 | 19500 | | | |
| GPEqnRec | GPEqn | tph_b | 15.300 | 1.300 | | | |
| GPEqnRec | GPEqn | nh4_std | 0.300 | 0.100 | | | |
| GPEqnRec | GPEqn | zero | 0.000 | 0.000 | | | |
| GPGrpRec | GPEqnGrp | a | bod_a | cod_a | zero | nh4_std | tph_b |
| GPGrpRec | GPEqnGrp | b | bod_b | cod_b | zero | nh4_std | tph_b |
| GPGrpRec | GPEqnGrp | c | bod_c | cod_c | zero | nh4_std | tph_b |
| Surface df | Surface | 1 | 25.000 | standard | a | 0.000000 | |
| Surface df | Surface | 2 | 35.000 | standard | a | 0.000000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Surface df | Surface | 3 | 50.000 | standard | b | 0.000000 | |
| Surface df | Surface | 4 | 6.000 | standard | b | 0.000000 | |
| Surface df | Surface | 5 | 30.000 | standard | b | 0.000000 | |
| Surface df | Surface | 6 | 32.000 | standard | b | 0.000000 | |
| Surface df | Surface | 7 | 40.000 | standard | c | 0.000000 | |
| Surface df | Surface | 8 | 60.000 | standard | c | 0.000000 | |
| Surface df | Surface | 9 | 25.000 | standard | c | 0.000000 | |
| Surface df | Surface | 10 | 55.000 | standard | c | 0.000000 | |
| Surface df | Surface | 11 | 3.000 | mixed | b | 0.000000 | |
| Surface df | Surface | 12 | 6.000 | mixed | b | 0.000000 | |
| Sediment | Sediment | sf1 | 0.040 | 1.700 | | | |
| Sediment | Sediment | sf2 | 0.040 | 1.700 | | | |

**Table S1.** Environmental quality standards for surface water

| Pollutant | Class I | Class II | Class III | Class IV | Class V |
|---|---|---|---|---|---|
| COD | 15 | 15 | 20 | 30 | 40 |
| TN | 0.2 | 0.5 | 1.0 | 1.5 | 2.0 |
| TP | 0.02 (0.01*) | 0.1 (0.025*) | 0.2 (0.05*) | 0.3 (0.1*) | 0.4 (0.2*) |

*The values in brackets of TP are for the requirements of lakes and reservoirs.

**Table S2.** Control units of river pollution.

| Control Units | River Composition |
|---|---|
| Tangtashui River | Tangtashui River (north of Yuechuan Bridge) |
| Liuluoshui River | Shuiyuan Reservoir and the upstream (north of Yuechuan Bridge) |
| Xihe River | Xihe River (south and north of Yuechuan Bridge) |
| Banlingshui River | Banlingshui Reservoir and the upstream (north of Yuechuan Bridge) |
| Donghe River | Donghe River (south of Yuechuan Bridge) |
| Caopengshui River | Caopengshui River (north of Yuechuan Bridge) |

**Table S3.** List of model data.

| Data Classification | Detailed Content |
|---|---|
| Rainfall data | 5-minute time step rainfall data of a typical year or several months of historical rainfall data (The duration should be greater than the time required to achieve the target water quality); rainstorm intensity formula; local rainstorm design. |
| Soil properties | Local soil type, permeability, etc. |
| Topographic data | Elevation point or contour line. |
| Urban surface pollutant accumulation amount and initial rainfall-runoff pollutant concentration | Maximum mass accumulation of surface pollutants for different types of underlying surfaces; the measured concentrations of various pollutants in surface runoff at the early stage of rainfall. |
| Land-use type | The land use of the underlying surfaces in the river catchment, and the division of the catchment area. |
| River axis and cross-section data | All rivers involved in the project. |
| River boundary data | The boundary data of rivers upstream and downstream and the data of river intersections including flow, water level, water quality, etc. |
| Background water quality data of river | Measured pollutant concentrations of each river in the study area. |
| River hydraulic structures | All hydraulic structures on the river and their scheduling rules. |
| Effluent flow and concentration of wastewater treatment plants/factories | Effluent flow and pollutant concentration of all wastewater treatment plants/factories in the study area. |
| Measured data of outfalls | Flow and pollutants monitoring data for all outfalls in the study area. |
| River monitoring data | Daily flow, water level, and water quality data at all stations in the river. |
| The boundary of the catchment area | Catchment zoning based on river and terrain. |
| Specific measures for planning scheme | All specific schemes related to the source and non-point source pollution control, river dredging, and other measures. |
| Water quality of ecological water supplement | Location, quantity, and quality of ecological water supplement in the project. |
| River ecological measures | Location, volume, and pollutants reduction rates for all ecological measures on the river. |

**Table S4.** Discharge outlets and corresponding measured flow and pollutant concentration.

| Node ID | Flow ($m^3/s$) | COD (mg/L) | $NH_3$-N (mg/L) | TP (mg/L) |
|---|---|---|---|---|
| D0+107.4 | 0.0272 | 60 | 8.3 | 0.81 |
| D1+806.0 | 0.0236 | 55 | 1.5 | 0.53 |
| D2+403.3 | 0.0175 | 200 | 3.1 | 0.55 |
| X2+119.6 | 0.0181 | 126 | 10.3 | 1.32 |
| D5+577.5 | 0.0016 | 126 | 10.3 | 1.32 |
| D6+862.4 | 0.0001 | 251 | 1.2 | 1.18 |
| D7+857.0 | 0.0099 | 72 | 1 | 0.37 |
| D9+249.0 | 0.0465 | 55 | 1.4 | 0.35 |
| X8+10.0 | 0.0001 | 140 | 11.3 | 1.6 |
| D12+717.2 | 0.0717 | 20 | 4.7 | 0.2 |
| D5+977.1 | 0.0794 | 150 | 0.38 | 0.27 |
| X2+524.3 | 0.0203 | 75 | 12.8 | 0.75 |
| D3+480.4 | 0.0001 | 53 | 5.7 | 0.42 |
| X4+211.2 | 0.0284 | 28 | 2.2 | 0.15 |
| X5+300.0 | 0.0140 | 44 | 0.2 | 0.1 |
| X5+915.0 | 0.0171 | 201 | 11.7 | 2.11 |
| X6+804.3 | 0.0001 | 72 | 1 | 0.37 |
| X6+995.0 | 0.0151 | 55 | 1.5 | 0.53 |
| X7+788.9 | 0.0001 | 72 | 1 | 0.37 |
| X10+493.4 | 0.0002 | 44 | 5.5 | 0.4 |
| t0+875.2 | 0.0134 | 76 | 0.36 | 0.25 |
| t2+822.0 | 0.0291 | 27 | 4.61 | 0.09 |
| t3+248.5 | 0.0001 | 29 | 0.09 | 0.51 |
| t3+930.0 | 0.0435 | 27 | 0.09 | 0.08 |
| t4+190.9 | 0.0210 | 109 | 0.54 | 5.77 |
| t4+496.1 | 0.0338 | 30 | 13.92 | 0.23 |
| t4+578.0 | 0.0002 | 2 | 0.09 | 0.11 |

**Table S5.** The annual release amount of internal pollution from each control unit.

| Control Units | Pollutants | Release rate in urban reach (mg/m²·d) | Release rate in suburban reach (mg/m²·d) | Urban reach area (ha) | Suburban reach area (ha) | Total pollution amount （t/yr） |
|---|---|---|---|---|---|---|
| Tangtashui River | $NH_3$-N | - | 20 | - | 95.46 | 6.97 |
| | TP | - | 7 | | | 2.44 |
| | COD | - | 200 | | | 69.68 |
| Liuluoshui River | $NH_3$-N | - | 20 | - | 313.00 | 22.85 |
| | TP | - | 7 | | | 8.00 |
| | COD | - | 200 | | | 228.49 |
| Xihe River | $NH_3$-N | 60 | 20 | 154.15 | 59.03 | 38.07 |
| | TP | 15 | 7 | | | 9.95 |
| | COD | 600 | 200 | | | 380.69 |
| Banlingshui River | $NH_3$-N | - | 20 | - | 27.72 | 2.02 |
| | TP | - | 7 | | | 0.71 |
| | COD | - | 200 | | | 20.23 |
| Donghe River | $NH_3$-N | 60 | - | 122.12 | - | 26.74 |
| | TP | 15 | - | | | 6.69 |
| | COD | 600 | - | | | 267.44 |
| Caopengshui River | $NH_3$-N | - | 20 | - | 41.68 | 3.04 |
| | TP | - | 7 | | | 1.06 |
| | COD | - | 200 | | | 30.43 |

**Table S6.** Summary table for pollution before the scheme.

| Control Units | Pollutants | Point source pollution (t) | Rural non-point source pollution (t) | Urban non-point source pollution (t) | Mountain area non-point source pollution (t) | Internal river pollution (t) | Point source water quantity ($m^3$) | Surface runoff quantity ($m^3$) | Total pollution load (t) |
|---|---|---|---|---|---|---|---|---|---|
| Tangtashui River | COD | 417.09 | 839.06 | 1481.48 | 501.54 | 69.68 | 14061714.70 | 30374895.04 | 3308.85 |
| | $NH_3$-N | 35.17 | 22.66 | 40.01 | 13.55 | 6.97 | | | 118.36 |
| | TP | 2.73 | 7.81 | 13.79 | 4.67 | 2.44 | | | 31.44 |
| Liuluoshui River | COD | 0 | 0 | 0 | 1067.04 | 228.49 | 0.00 | 31186195.16 | 1295.53 |
| | $NH_3$-N | 0 | 0 | 0 | 28.82 | 22.85 | | | 51.67 |
| | TP | 0 | 0 | 0 | 9.93 | 8.00 | | | 17.93 |
| Xihe River | COD | 2817.73 | 468.05 | 2984.14 | 6.06 | 380.69 | 15707124.66 | 20524853.96 | 6656.68 |
| | $NH_3$-N | 285.67 | 12.64 | 80.60 | 0.16 | 38.07 | | | 417.15 |
| | TP | 41.25 | 4.36 | 27.78 | 0.06 | 9.95 | | | 83.39 |
| Banlingshui River | COD | 580.20 | 706.40 | 2449.62 | 294.03 | 20.23 | 21491096.05 | 30771245.94 | 4050.48 |
| | $NH_3$-N | 54.65 | 19.08 | 66.16 | 7.94 | 2.02 | | | 149.86 |
| | TP | 5.85 | 6.58 | 22.80 | 2.74 | 0.71 | | | 38.67 |
| Donghe River | COD | 5116.18 | 181.11 | 2013.26 | 0 | 267.44 | 44000267.50 | 12141699.69 | 7578.00 |
| | $NH_3$-N | 359.56 | 4.89 | 54.38 | 0 | 26.74 | | | 445.58 |
| | TP | 56.09 | 1.69 | 18.74 | 0 | 6.69 | | | 83.20 |
| Caopengshui River | COD | 186.15 | 625.26 | 1064.64 | 431.82 | 30.43 | 3102500.00 | 24487263.62 | 2338.29 |
| | $NH_3$-N | 24.82 | 16.89 | 28.76 | 11.66 | 3.04 | | | 85.17 |
| | TP | 3.10 | 5.82 | 9.91 | 4.02 | 1.06 | | | 23.92 |

**Table S7.** Regulation tank.

| Area name | Catchment area (ha) | Storage capacity (m$^3$) |
|---|---|---|
| Hexi area | 200 | 15000 |
| | 200 | 15000 |
| Hedong area | 393 | 20000 |
| Linchun area | 50 | 3000 |
| Yuechuan area | 115 | 10000 |
| | 120 | 10000 |
| North Yingbin Road area | 572 | 33000 |
| | 300 | 20000 |
| Phoenix Water City area | 180 | 10000 |
| Hailuo area | 385 | 22000 |
| Baopo area | 280 | 16000 |
| Fenghuang Town area | 572 | 33000 |
| West Yingbin Road area | 260 | 15000 |
| Total | 3622 | 222000 |

**Table S8.** Agricultural ecological wetland.

| Name | Area (ha) |
| --- | --- |
| Fengmen | 100 |
| Miaolin | 133 |
| Nanding | 76 |
| Hailuo village | 63 |
| Baoyin village | 204 |
| Binglang village | 98 |

**Table S9.** Flood storage wetland.

| Name | Wetland patch area (ha) | Project area (ha) | Design average depth (m) | Maximum water storage (×$10^4$ $m^3$) |
|---|---|---|---|---|
| Jiyang Railway Station Wetland | 2.55 | 2.04 | 1.50 | 3.10 |
| Jiyang Town Wetland | 8.57 | 6.85 | 1.50 | 10.30 |
| Shanshui International Wetland | 14.80 | 12.54 | 1.00 | 12.50 |
| Yuechuan Wetland | 89.02 | 71.22 | 3.40 | 242.10 |
| Hubaoling Wetland | 29.95 | 23.96 | 2.50 | 59.90 |
| Haipo Inland River Wetland | 52.31 | 41.84 | 2.60 | 108.80 |
| Shuiyuanci Downstream Diversion Wetland 1 | 1.77 | 1.41 | 1.50 | 2.10 |
| Shuiyuanci Downstream Diversion Wetland 2 | 3.28 | 2.63 | 1.50 | 3.90 |
| Airport Diversion Wetland | 12.35 | 9.88 | 1.50 | 14.80 |
| Caopengshui Flood Storage Area | 22.12 | 18.80 | 1.50 | 28.20 |
| Banlingshui Flood Storage Area | 15.56 | 13.23 | 1.50 | 19.84 |
| Tangtashui Flood Storage Area | 11.96 | 10.17 | 1.50 | 15.25 |
| Chonghui River Wetland | 28.05 | 23.84 | 1.50 | 35.76 |
| Dabing River Wetland | 16.42 | 13.96 | 1.50 | 20.94 |

**Table S10.** Summary table for pollution after the scheme.

| Control Units | Pollutants | Point source pollution (t) | Rural non-point source pollution (t) | Urban non-point source pollution (t) | Mountain area non-point source pollution (t) | Internal river pollution (t) | Total pollution load (t) |
|---|---|---|---|---|---|---|---|
| Tangtashui River | COD | 3.11 | 671.25 | 854.67 | 501.54 | 69.68 | 2100.24 |
| | $NH_3$-N | 0.24 | 18.13 | 27.20 | 13.55 | 6.97 | 66.09 |
| | TP | 0.02 | 6.25 | 9.40 | 4.67 | 2.44 | 22.77 |
| Liuluoshui River | COD | 0 | 0 | 0 | 1067.04 | 228.49 | 1295.53 |
| | $NH_3$-N | 0 | 0 | 0 | 28.82 | 22.85 | 51.67 |
| | TP | 0 | 0 | 0 | 9.93 | 8.00 | 17.93 |
| Xihe River | COD | 249.00 | 374.44 | 926.16 | 6.06 | 135.15 | 1690.82 |
| | $NH_3$-N | 19.68 | 10.11 | 29.45 | 0.16 | 13.51 | 72.93 |
| | TP | 1.83 | 3.49 | 10.18 | 0.06 | 4.73 | 20.28 |
| Banlingshui River | COD | 0 | 565.12 | 155.73 | 294.03 | 20.23 | 1035.11 |
| | $NH_3$-N | 0 | 15.26 | 4.96 | 7.94 | 2.02 | 30.19 |
| | TP | 0 | 5.26 | 1.71 | 2.74 | 0.71 | 10.42 |
| Donghe River | COD | 1556.53 | 144.89 | 153.46 | 0 | 94.51 | 1949.38 |
| | $NH_3$-N | 55.47 | 3.91 | 4.88 | 0 | 9.45 | 73.72 |
| | TP | 11.35 | 1.35 | 1.69 | 0 | 3.31 | 17.70 |
| Caopengshui River | COD | 547.50 | 500.21 | 1050.06 | 431.82 | 30.43 | 2560.01 |
| | $NH_3$-N | 27.38 | 13.51 | 33.42 | 11.66 | 3.04 | 89.02 |
| | TP | 5.48 | 4.66 | 11.55 | 4.02 | 1.06 | 26.77 |

**Table S11.** The pollutants reduction rate of each control unit after the scheme.

| Control Units | Pollutants | Non-point source pollution | Point source pollution | Internal river pollution | Total |
|---|---|---|---|---|---|
| Tangtashui River | COD | 28.16% | 99.26% | 0 | 36.53% |
| | $NH_3$-N | 22.75% | 99.31% | 0 | 44.16% |
| | TP | 22.66% | 99.39% | 0 | 27.57% |
| Liuluoshui River | COD | 0 | 0 | 0 | 0 |
| | $NH_3$-N | 0 | 0 | 0 | 0 |
| | TP | 0 | 0 | 0 | 0 |
| Xihe River | COD | 62.22% | 91.16% | 64.50% | 74.60% |
| | $NH_3$-N | 57.47% | 93.11% | 64.50% | 82.52% |
| | TP | 57.39% | 95.57% | 52.45% | 75.69% |
| Banlingshui River | COD | 70.58% | 100.00% | 0 | 74.44% |
| | $NH_3$-N | 69.78% | 100.00% | 0 | 79.86% |
| | TP | 69.76% | 100.00% | 0 | 73.06% |
| Donghe River | COD | 86.40% | 69.58% | 64.66% | 74.28% |
| | $NH_3$-N | 85.16% | 84.57% | 64.66% | 83.45% |
| | TP | 85.13% | 79.76% | 50.53% | 78.73% |
| Caopengshui River | COD | 30.16% | -194.12% | 0 | -9.48% |
| | $NH_3$-N | 21.32% | -10.29% | 0 | -4.52% |
| | TP | 21.17% | -76.47% | 0 | -11.90% |

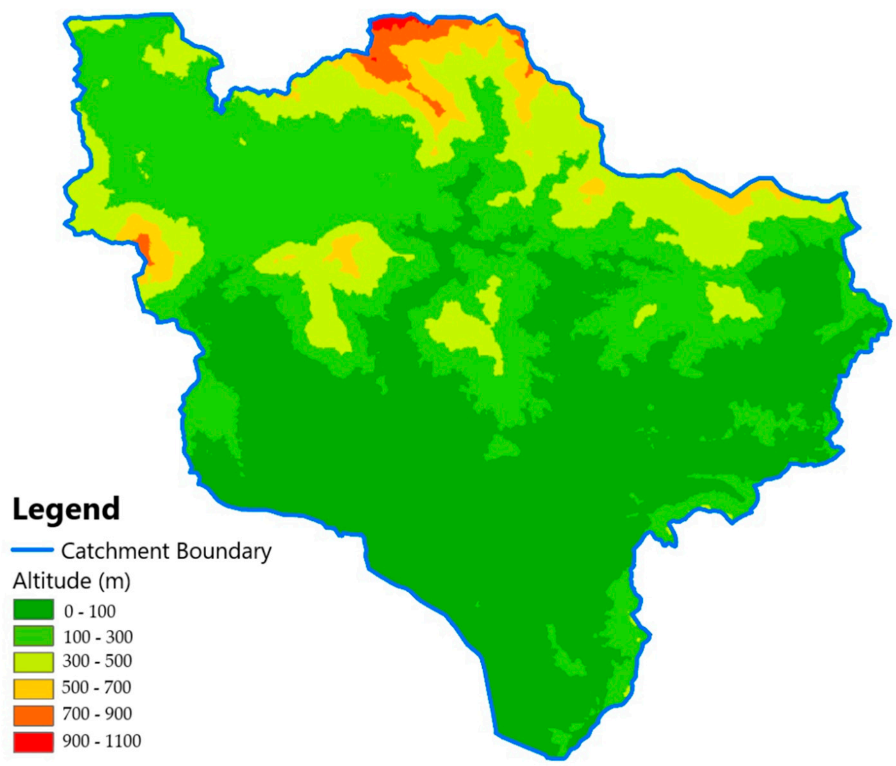



**Figure S1.** Geomorphological thematic maps of Sanya

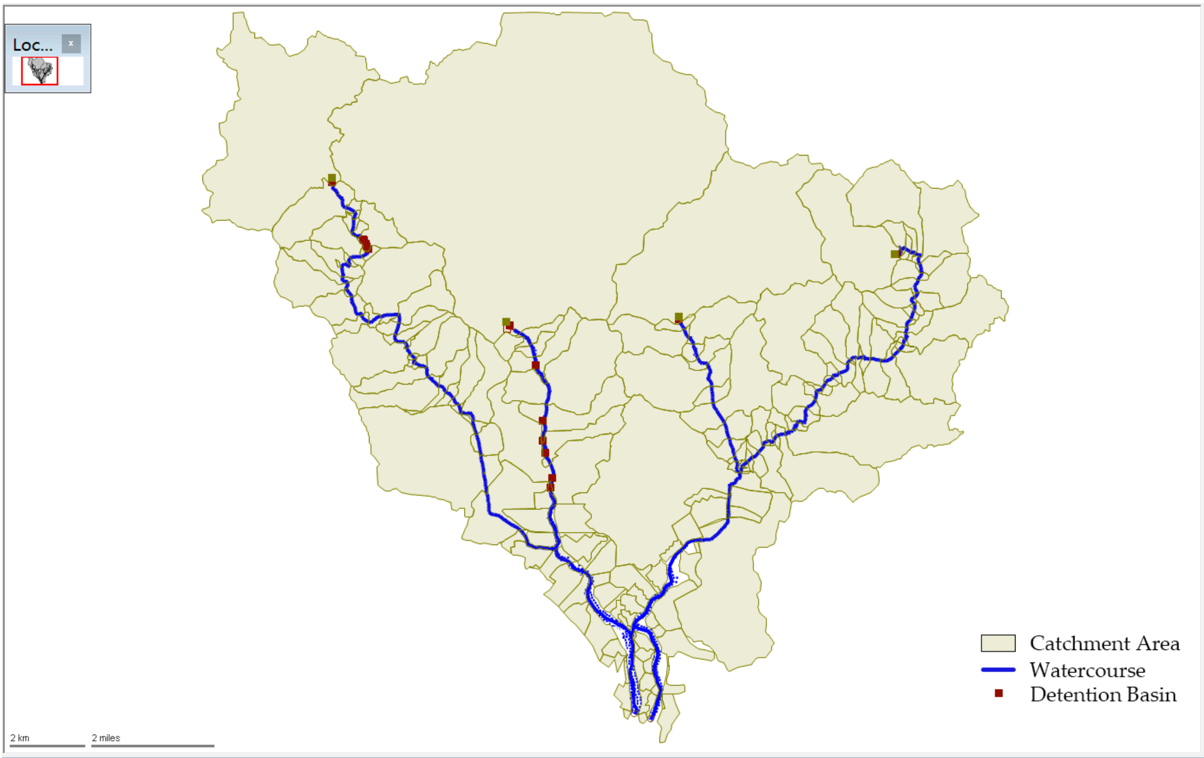



**Figure S2.** 2D hydraulic model diagram of Sanya

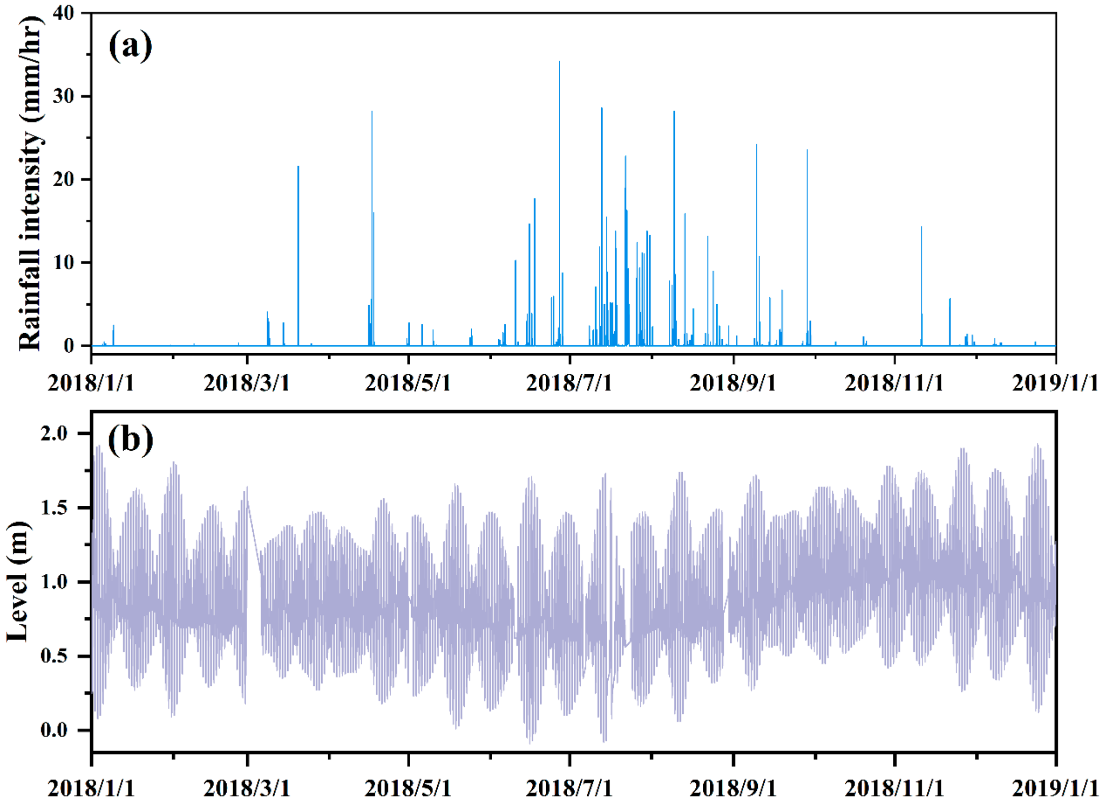



**Figure S3.** The rainfall event (a) and water level variation (b).

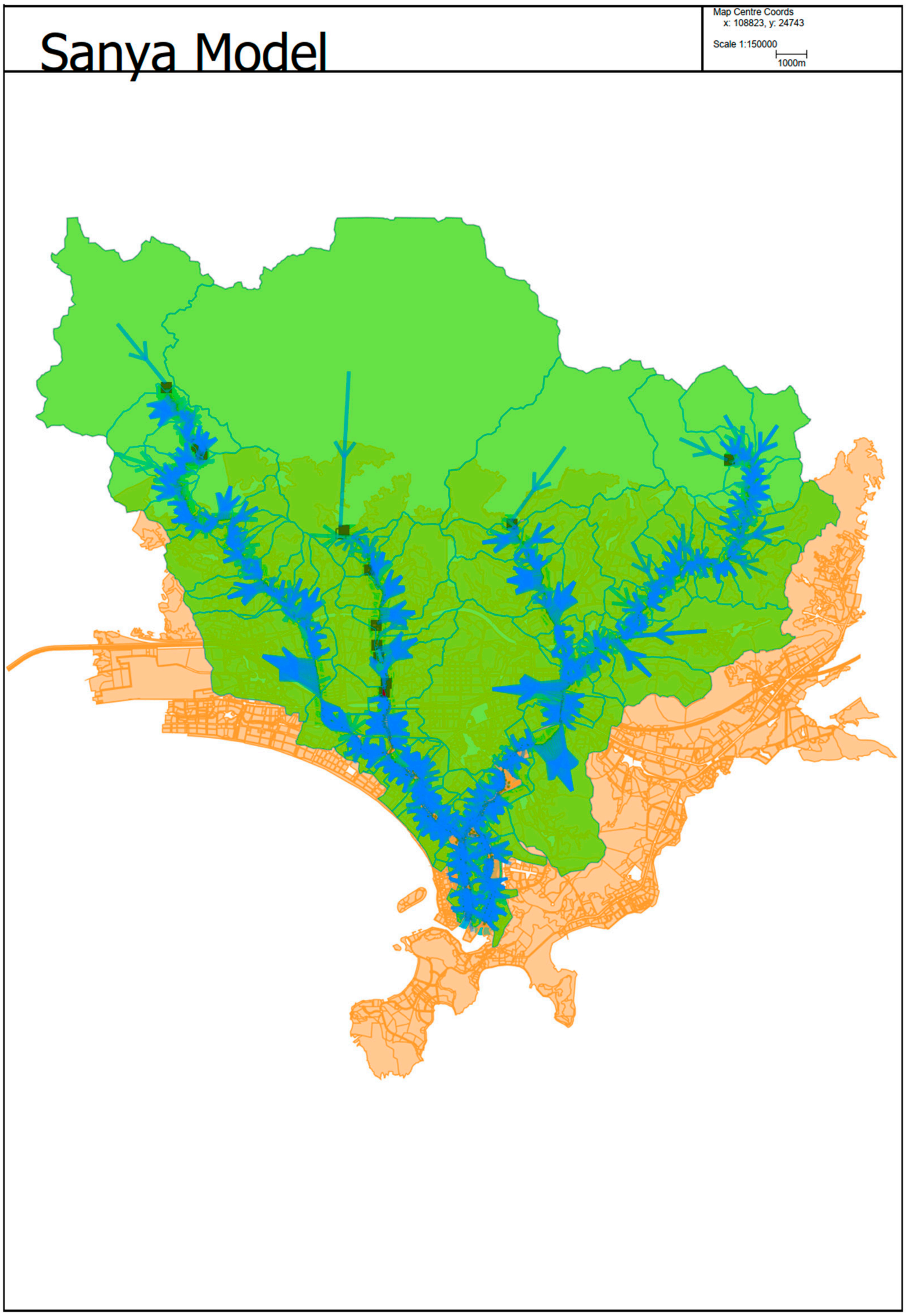



**Figure S4.** The construction of the model and divisions within the catchment area.