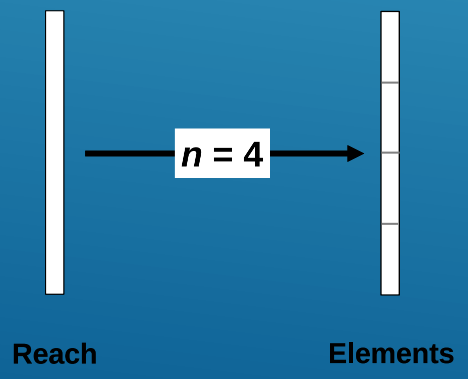
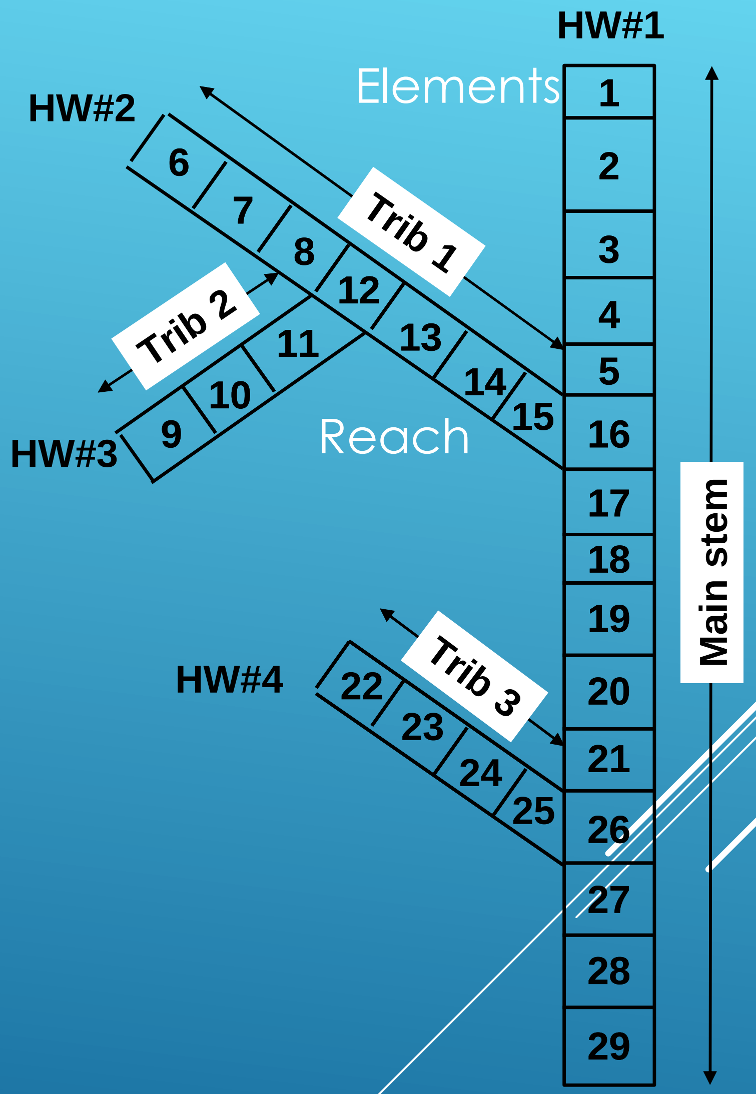
QUAL2K

- SEGMENTATION AND HYDRAULICS

QUAL2K segmentation scheme for (*a*) a river with tributaries. The Q2K reach representation in (*b*) illustrates the reach, headwater and tributary numbering schemes.

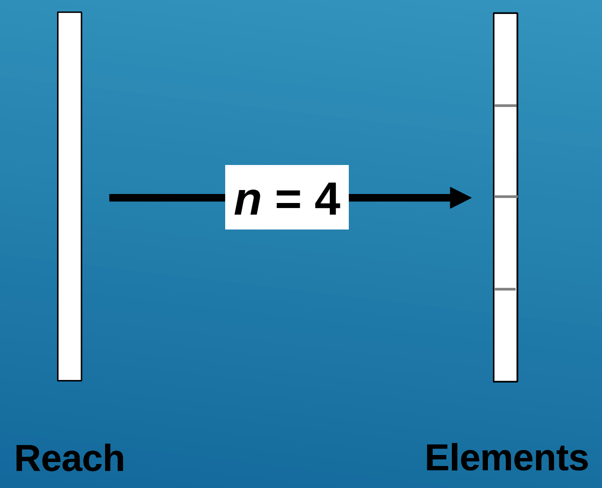


(a) A river with tributaries

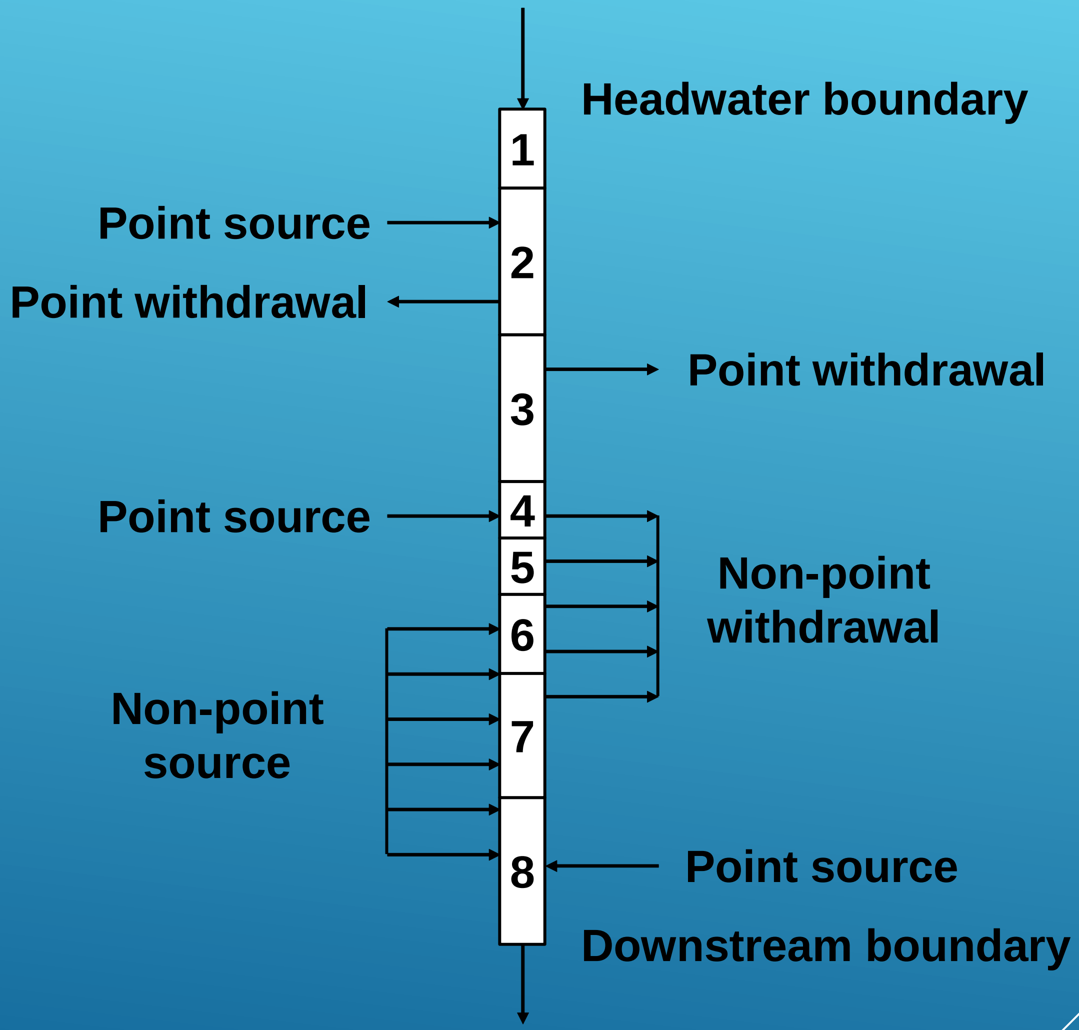


(b) Q2K reach representation

- Reach. A length of river with constant hydraulic characteristics.
- Element. The model’s fundamental computational unit which consists of an equal length subdivision of a reach.
- Segment. A collection of reaches representing a branch of the system. These consist of the main stem as well as each tributary.
- Headwater. The upper boundary of a model segment.



QUAL2K segmentation scheme for a river with no tributaries.

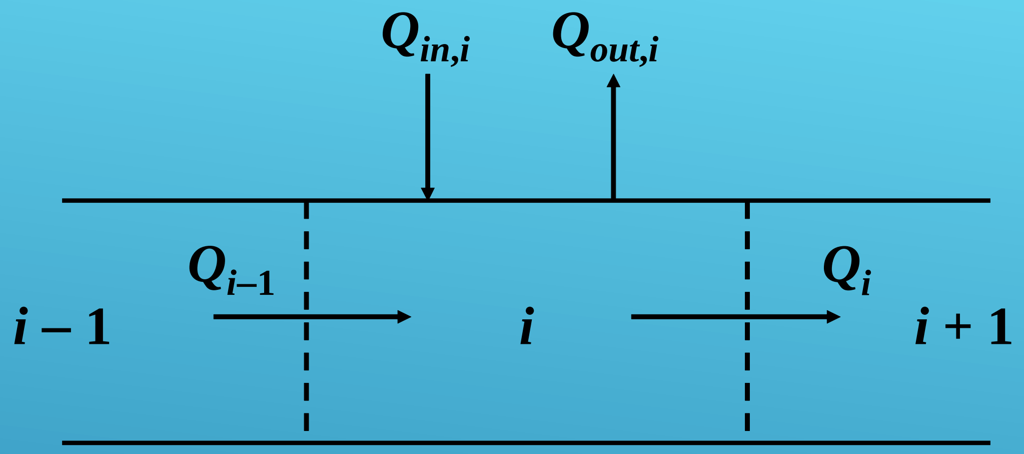


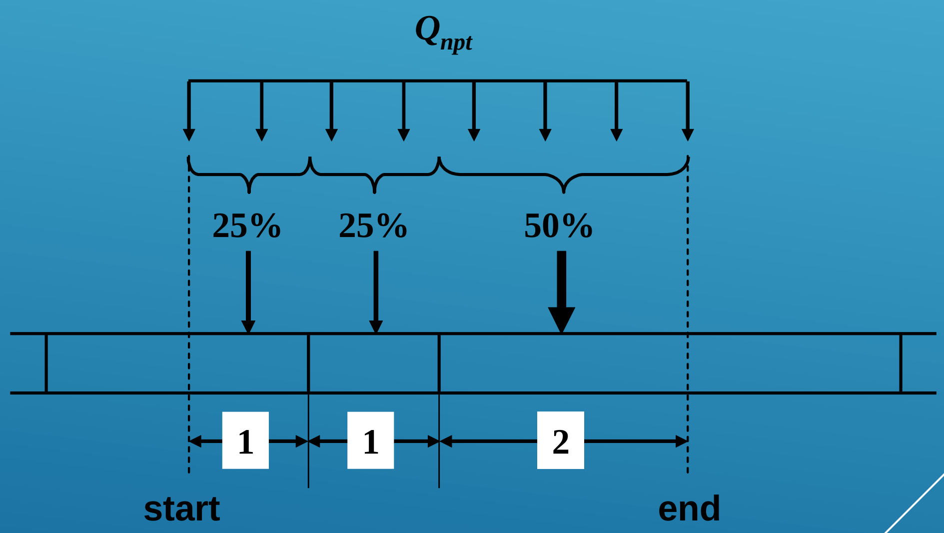
Flow Balance

$$Q_i = Q_{i-1} + Q_{in,i} - Q_{out,i}$$

$$Q_{in,i} = \sum_{j=1}^{psi} Q_{ps,i,j} + \sum_{j=1}^{npsi} Q_{nps,i,j}$$

$$Q_{out,i} = \sum_{j=1}^{pai} Q_{pa,i,j} + \sum_{j=1}^{npai} Q_{npa,i,j}$$





non-point source flow is distributed to an element

Spatial Discreization and Model Overview

$$V\frac{\partial c}{\partial t} = \frac{\partial(A_c E\frac{\partial C}{\partial x})}{\partial x}dx - \frac{\partial(A_c U c)}{\partial x}dx + V\frac{dc}{dt} + s$$

Accumulation | Dispersion | Advection | Kinetics | External sources/sinks

Transport (Dispersion + Advection)

Transport/ Advection

- If weir height and width are entered, the weir option is implemented.
- If the weir height and width are zero and rating curve coefficients are entered (a and α), the rating curve option is implemented.
- If neither of the previous conditions is met, Q2K uses the Manning equation.

1. Weirs

2. Rating Curves

3. Manning Equation

Hydraulic Characteristics

1. Weirs

- If weir height and width are entered, the weir option is implemented.
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$$Q_i = 1.83 B_w H_h^{3/2}$$

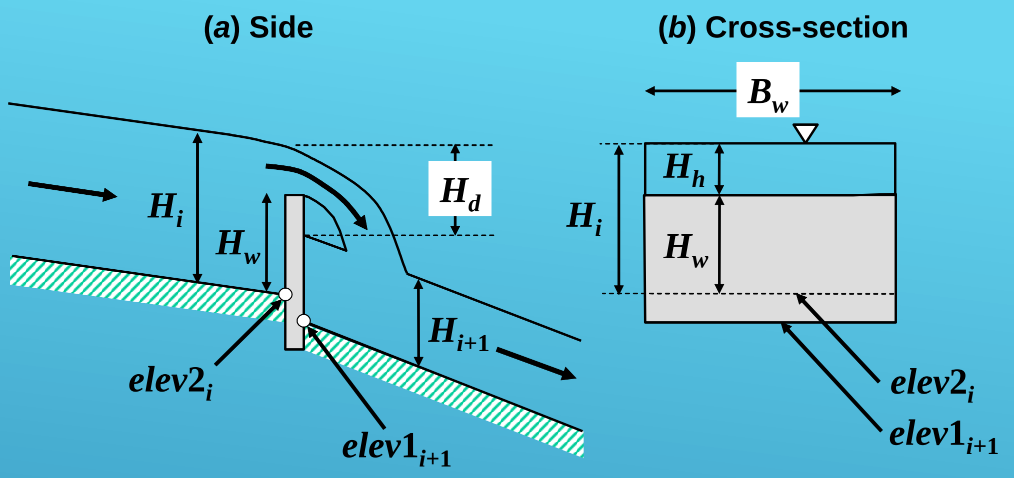
$$H_h = \left(\frac{Q_i}{1.83 B_w} \right)^{2/3}$$

$$A_{c,i} = B_i H_i$$

$$U_i = \frac{Q_i}{A_{c,i}}$$

$$A_{s,i} = B_i \Delta x_i$$

$$V_i = B_i H_i \Delta x_i$$



2. Rating Curves

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- If the weir height and width are zero and rating curve coefficients are entered (a and α), the rating curve option is implemented.
- If neither of the previous conditions is met, Q2K uses the Manning equation.

Equation	Exponent	Typical value	Range
$H = \alpha Q^{\beta}$	b	0.43	0.4-0.6
$U = aQ^{b}$	b	0.45	0.3-0.5

$$U = aQ^{b}$$

$$H = \alpha Q^{\beta}$$

$$A_c = \frac{Q}{U}$$

$$B = \frac{A_c}{H}$$

$$A_s = B\Delta x$$

$$V = BH\Delta x$$

Hydraulic Characteristics

- If weir height and width are entered, the weir option is implemented.
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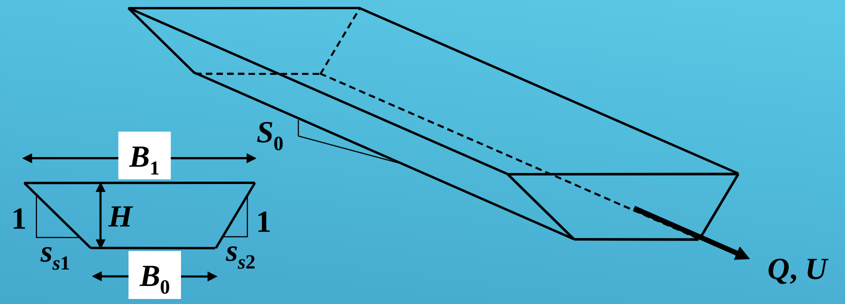
3. Manning Equation

$$Q = \frac{S_0^{1/2}}{n} \frac{A_c^{5/3}}{P^{2/3}}$$



MATERIAL	n
Man-made channels	
Concrete	0.012
Gravel bottom with sides:	
Concrete	0.020
mortared stone	0.023
Riprap	0.033
Natural stream channels	
Clean, straight	0.025-0.04
Clean, winding and some weeds	0.03-0.05
Weeds and pools, winding	0.05
Mountain streams with boulders	0.04-0.10
Heavy brush, timber	0.05-0.20

Transport/ Dispersion

Two options are used to determine the longitudinal dispersion for a boundary between two elements. First, the user can simply enter estimated values on the **Reach Worksheet**.

If the user does not enter values, a formula is employed to internally compute dispersion based on the channel's hydraulics (Fischer et al. 1979),

$$E_{p,i} = 0.011 \frac{U_i^2 B_i^2}{H_i U_i^*}$$

Kinetics

Variable	Symbol	Units*
Conductivity	s	µmhos
Inorganic suspended solids	m_i	mgD/L
Dissolved oxygen	o	mgO_2/L
Slowly reacting CBOD	c_s	mgO_2/L
Fast reacting CBOD	c_f	mgO_2/L
Organic nitrogen	n_o	µgN/L
Ammonia nitrogen	n_a	µgN/L
Nitrate nitrogen	n_n	µgN/L
Organic phosphorus	p_o	µgP/L
Inorganic phosphorus	p_i	µgP/L
Phytoplankton	a_p	µgA/L
Detritus	m_o	mgD/L
Pathogen	X	cfu/100 mL
Alkalinity	Alk	$mgCaCO_3/L$
Total inorganic carbon	c_T	mole/L
Bottom algae biomass	a_b	mgA/m^2
Bottom algae nitrogen	IN_b	mgN/m^2
Bottom algae phosphorus	IP_b	mgP/m^2

* mg/L ≡ g/m^3; In addition, the terms D, C, N, P, and A refer to dry weight, carbon, nitrogen, phosphorus, and chlorophyll a, respectively. The term cfu stands for colony forming unit which is a measure of viable bacterial numbers.

Kinetics

Model kinetics and mass transfer processes. The state variables are defined in Table 5. Kinetic processes are dissolution (ds), hydrolysis (h), oxidation (ox), nitrification (n), denitrification (dn), photosynthesis (p), respiration (r), excretion (e), death (d), respiration/excretion (rx). Mass transfer processes are reaeration (re), settling (s), sediment oxygen demand (SOD), sediment exchange (se), and sediment inorganic carbon flux (cf).