THE SCIENCE ASPECTS OF PHOSPHORUS TRADING

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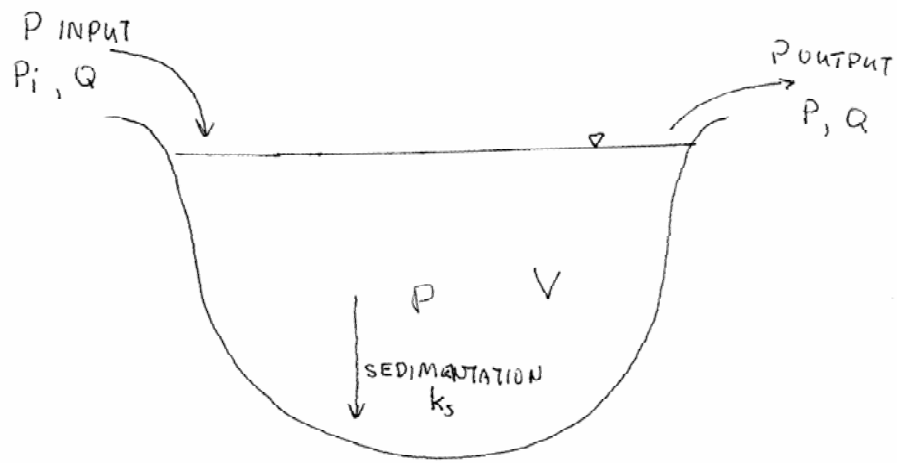
Simple TP Mass-Balance Model Schematic



Simple TP Mass-Balance Model
Model Equation

$$Q P_i - Q P - k_s P V = V dP/dt$$

k_s = sedimentation coefficient
$= \alpha v_s / H$
α = particulate P / TP
v_s = sedimentation velocity
H = average depth

Simple TP Mass-Balance Model
Steady-State Solution

$$P = P_i \left[1 / (1 + k_s \tau) \right]$$

τ = hydraulic detention time
= V / Q

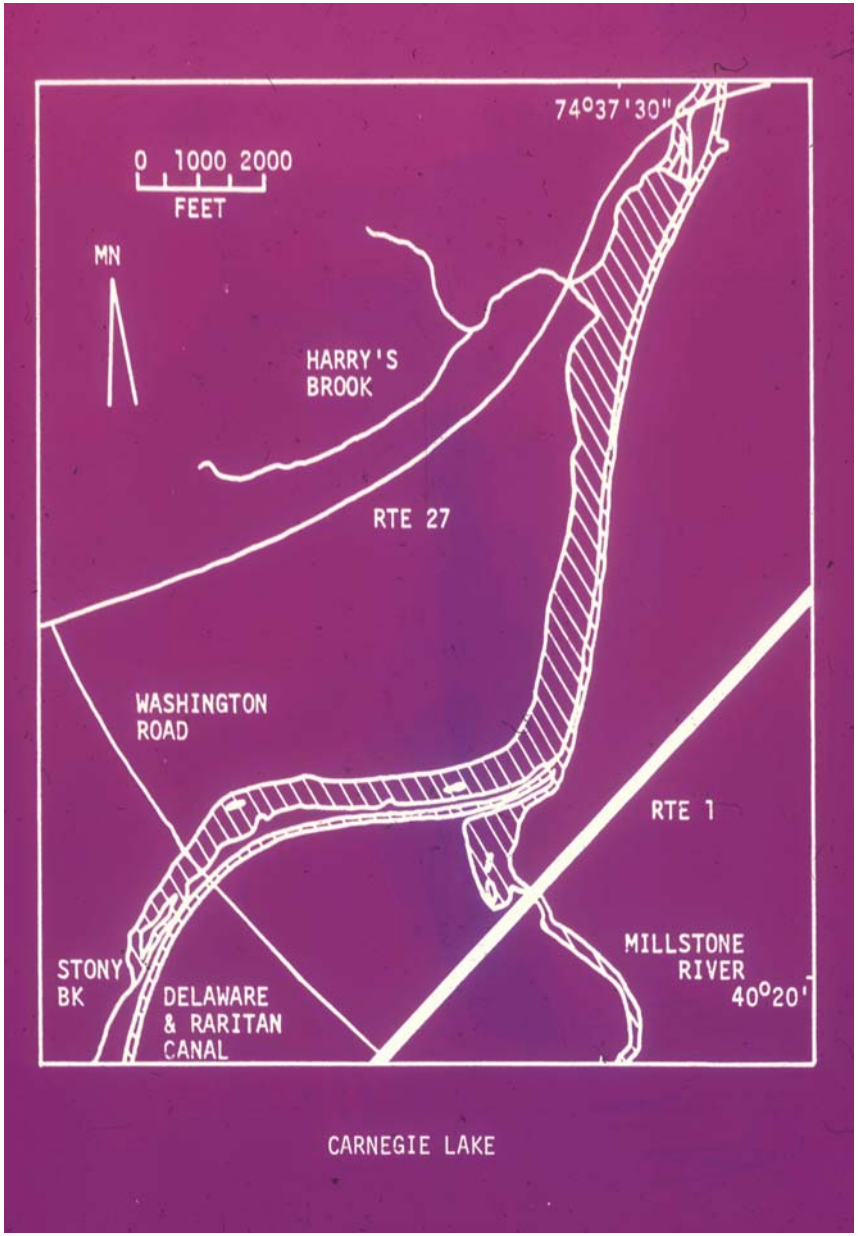
Simple TP Mass-Balance Model Trapping Efficiency

$$R = 1 - (P / P_i)$$

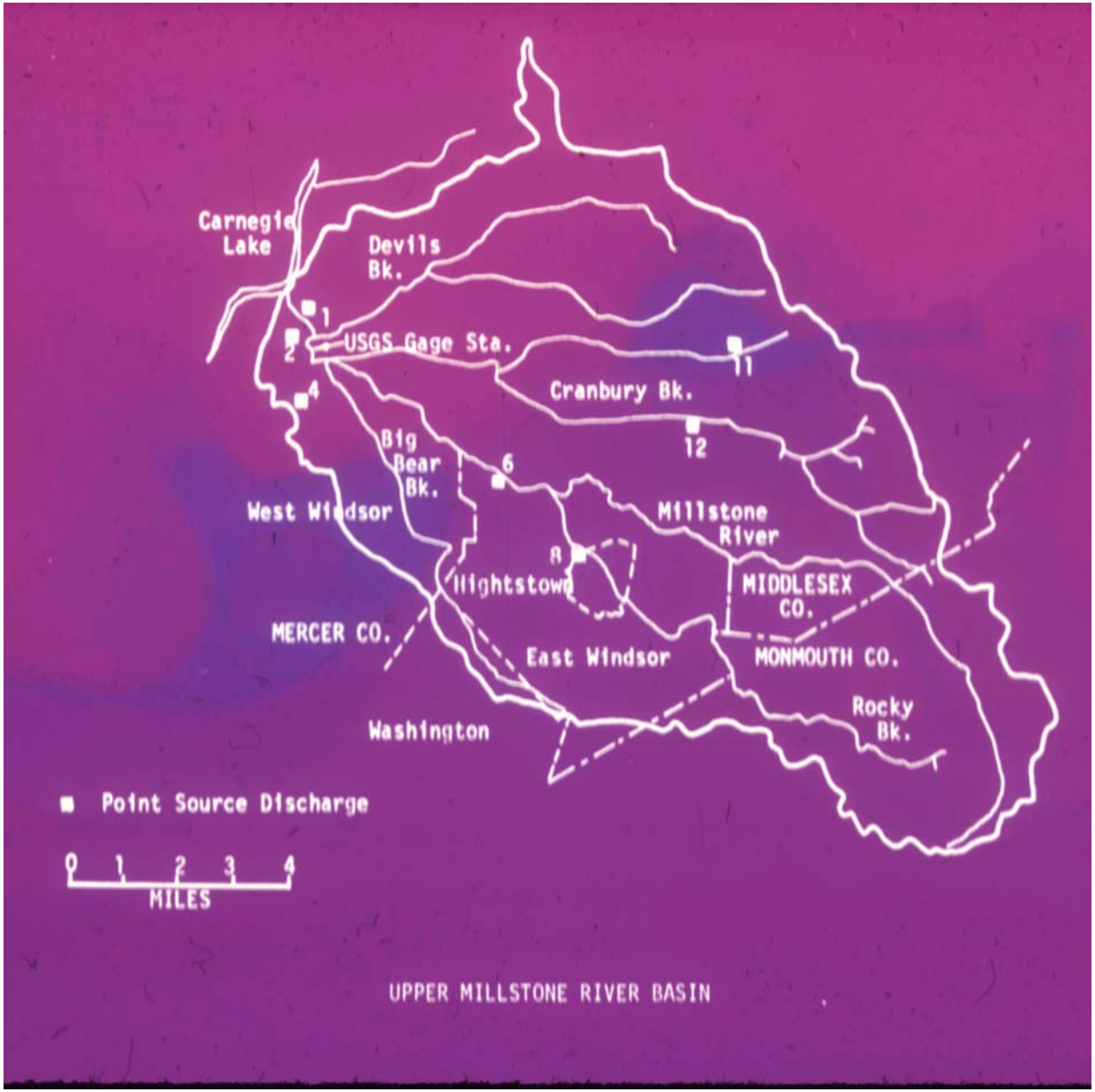
CASE STUDY

Carnegie Lake Watershed

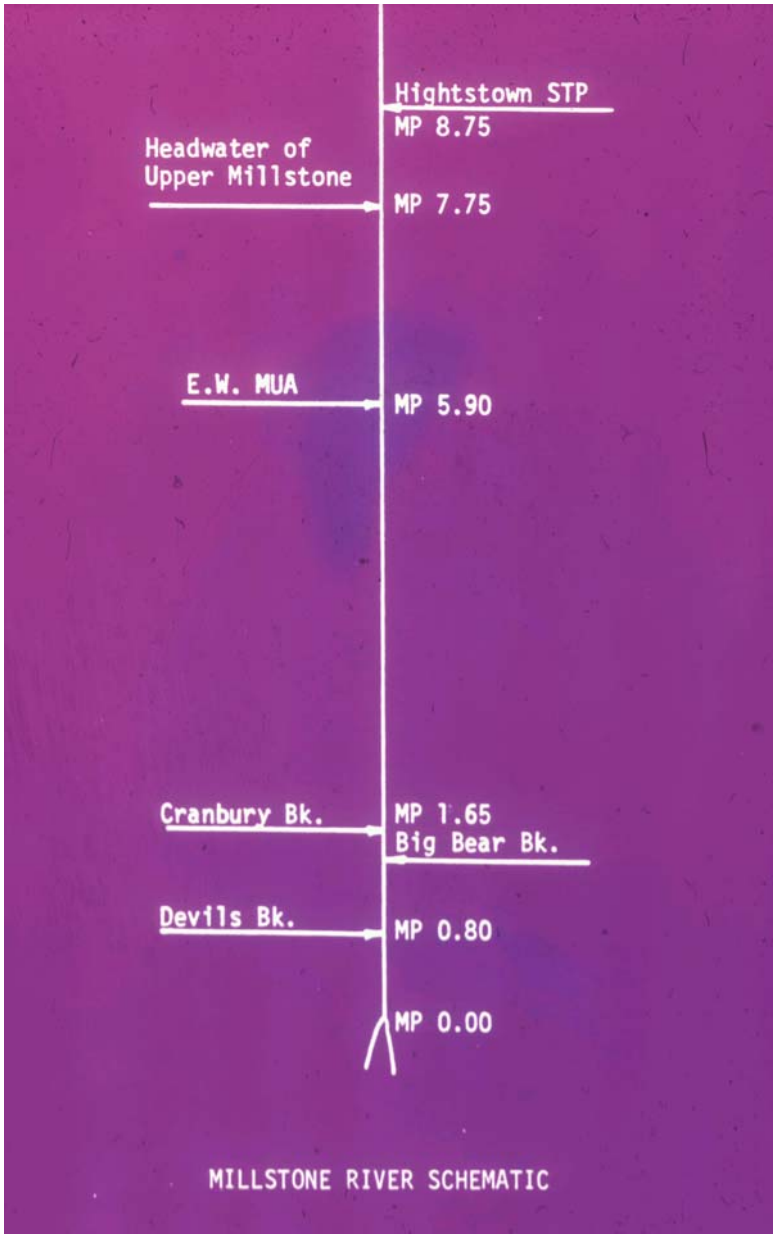
(Jenq, Granstrom, Hsueh, and Uchrin, 1984)



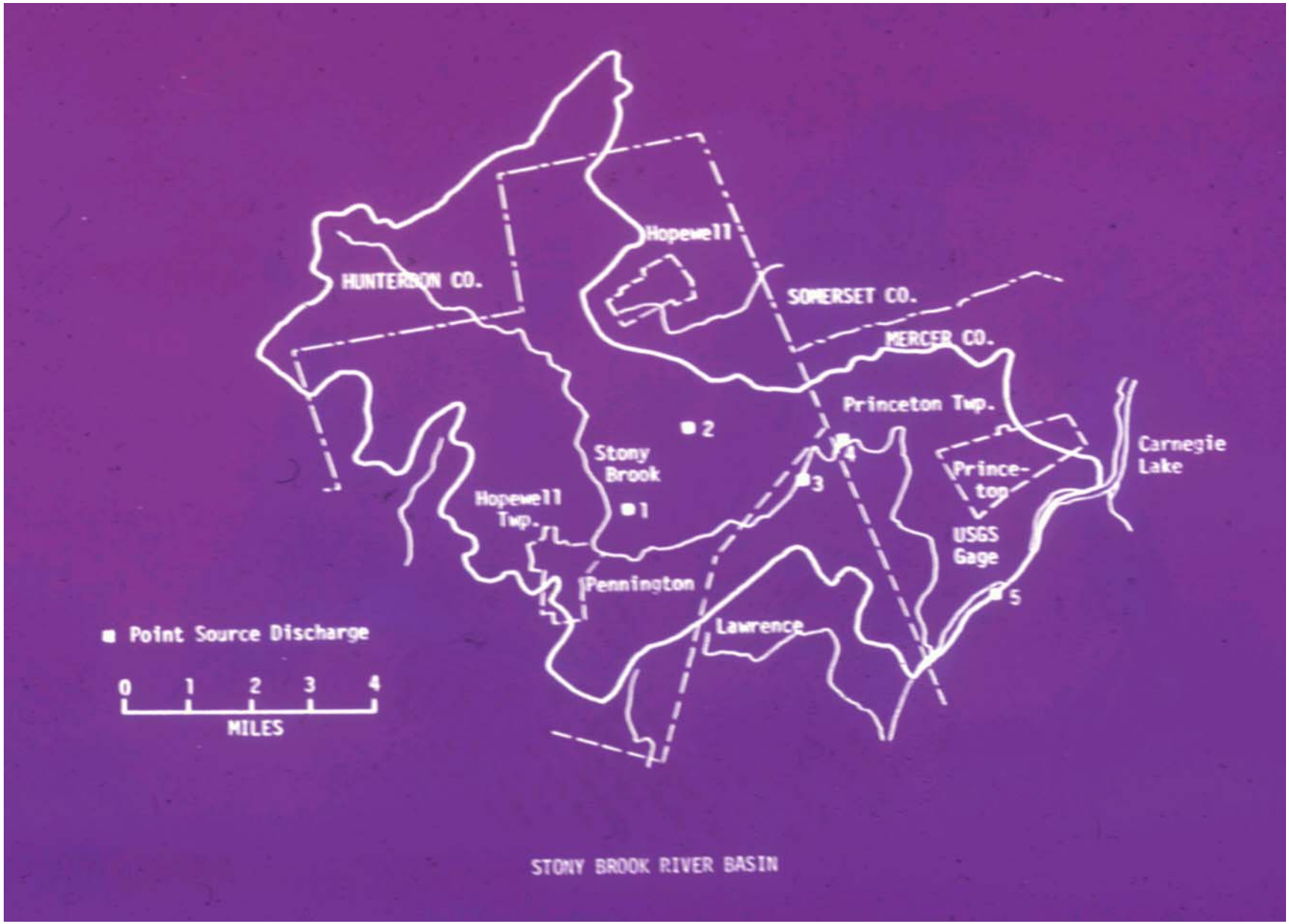
CARNEGIE LAKE



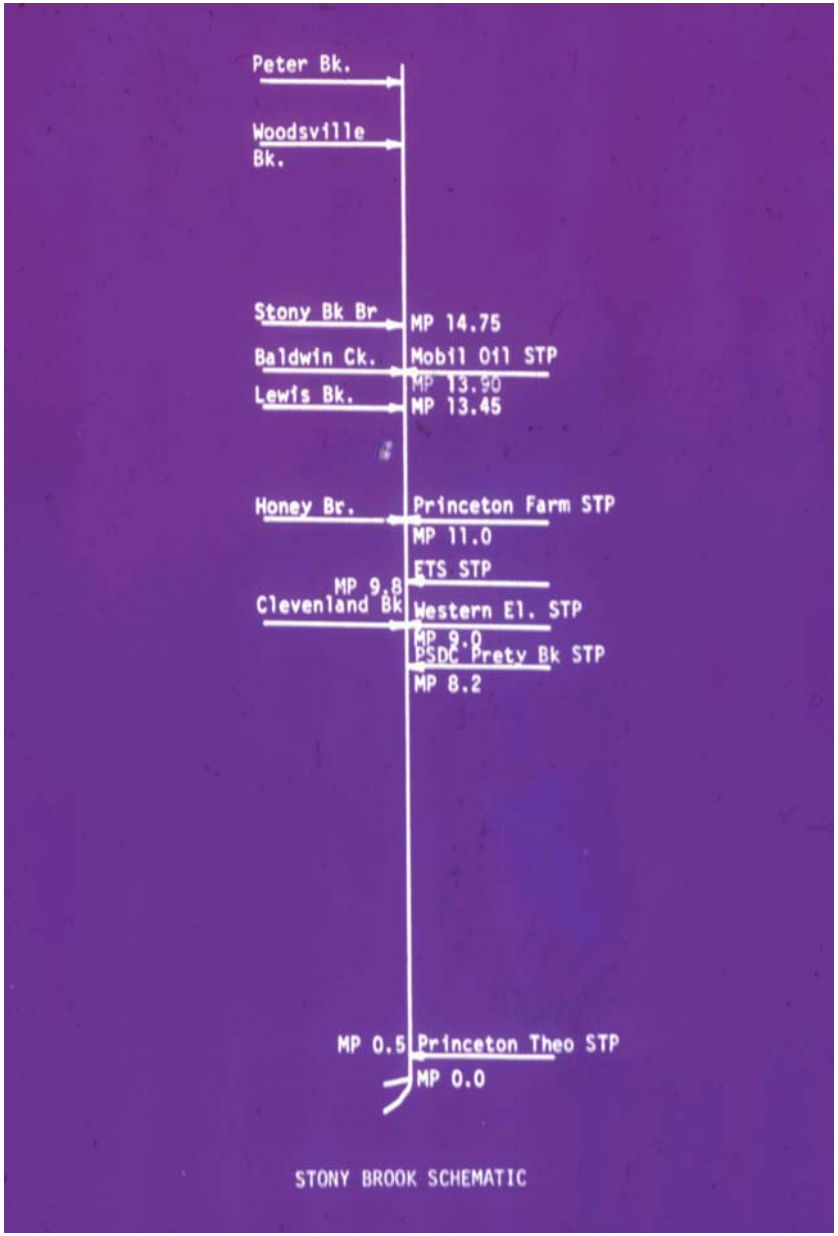
UPPER MILLSTONE RIVER BASIN



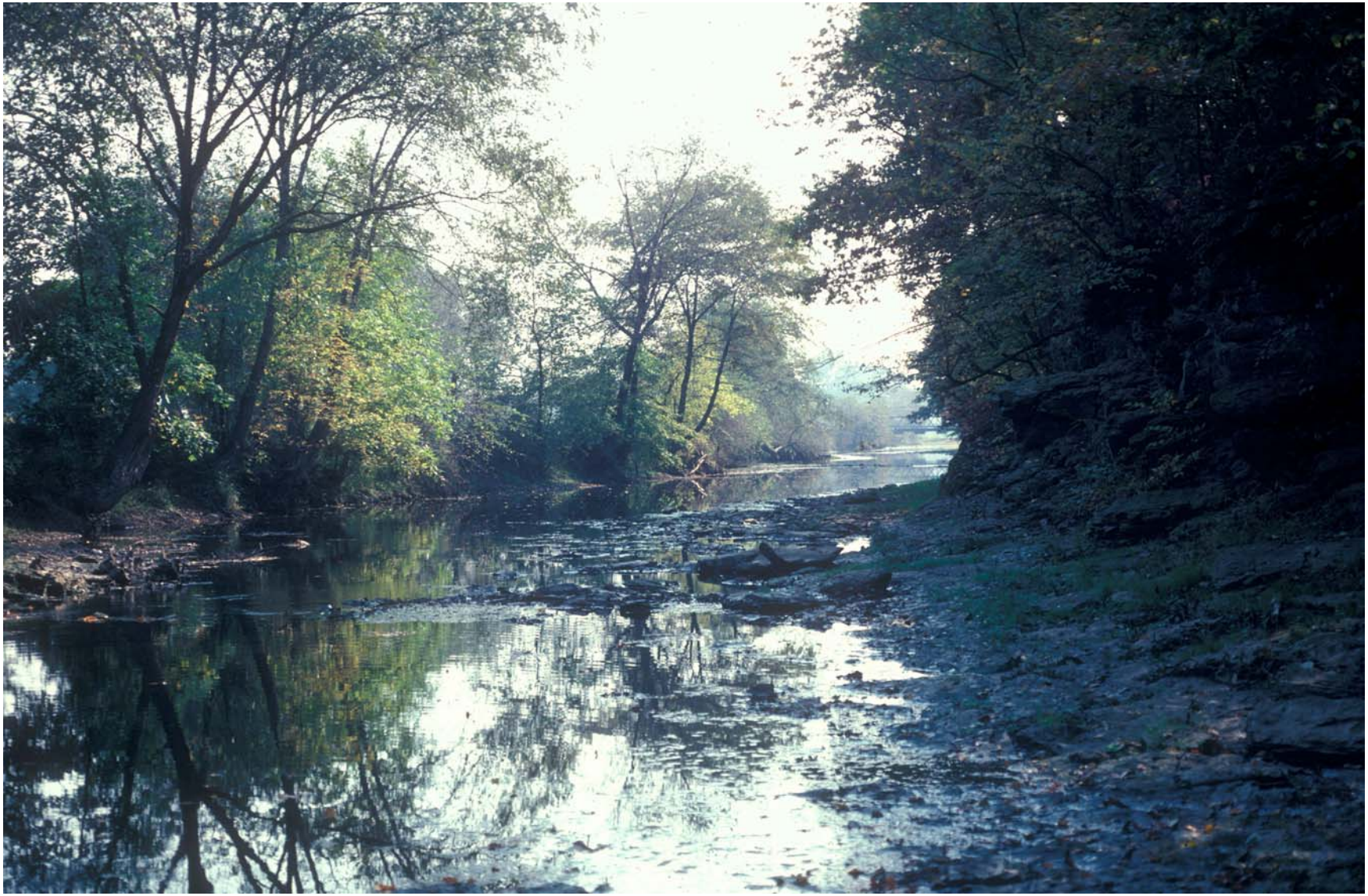
MILLSTONE RIVER SCHEMATIC



STONY BROOK RIVER BASIN

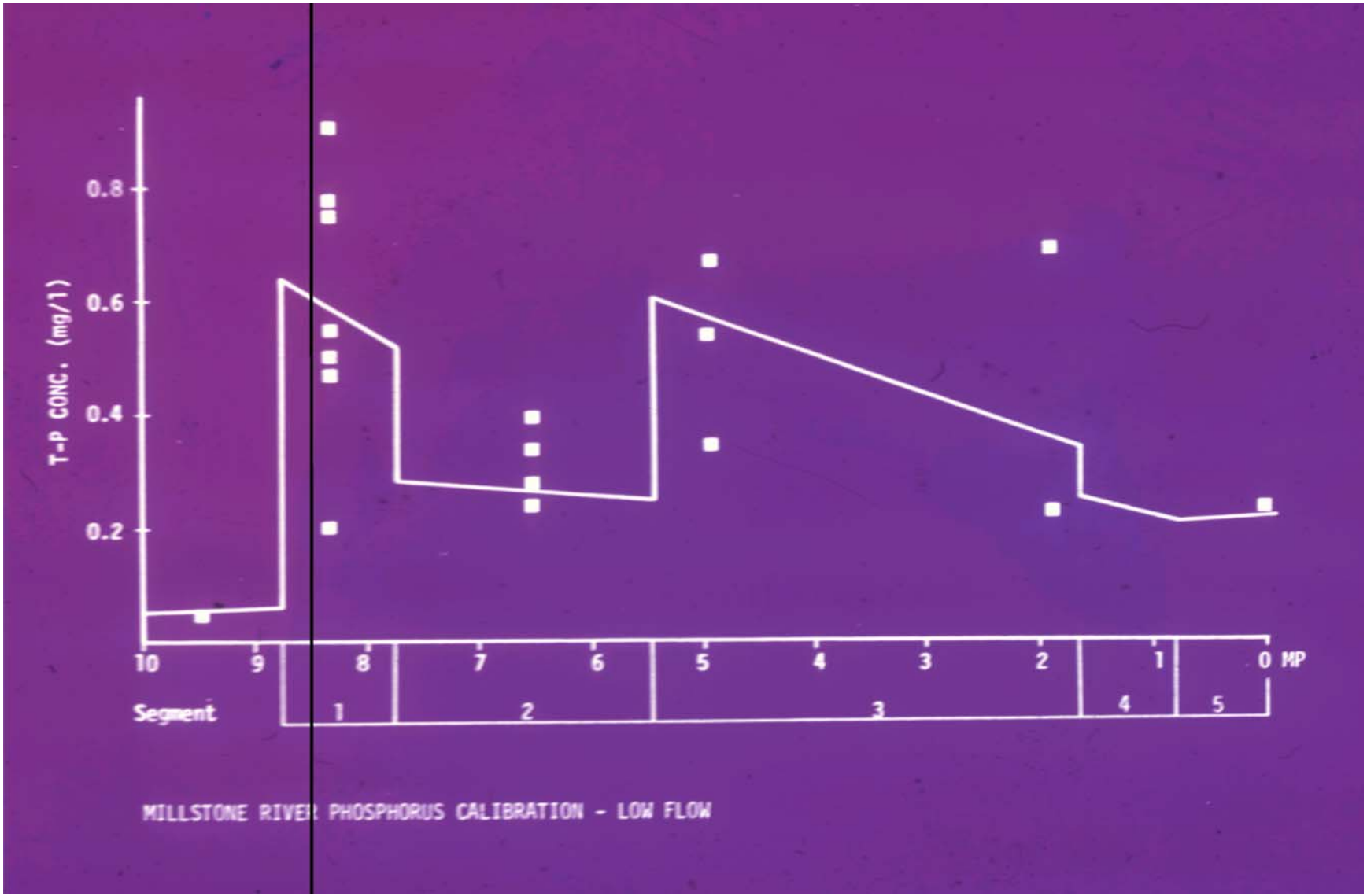


STONY BROOK SCHEMATIC



IN-STREAM PHOSPHORUS MODEL EQUATION:

$$\frac{\partial P}{\partial t} = \frac{Q}{A}\frac{\partial P}{\partial x} \begin{matrix} + \\ - \end{matrix} KP$$



MILLSTONE RIVER PHOSPHORUS CALIBRATION - LOW FLOW

OBJECTIVE FUNCTION

$$\sum_{k=1}^{M} \sum_{i=1}^{N} [C_{ki} (X_{ki}) + C_{ki} (Y_{ki}) + C_{ki} (Z_{ki})]$$

i = tributary counter

j = reach counter

CONSTRAINTS

$$P_{ki} \leq S_{ki}$$

S_{ki} = 0.10 mg/L instream

S_{ki} = 0.05 mg/L point of lake input

Cost Function (1980 $s) for TP Removal WWTP Sources

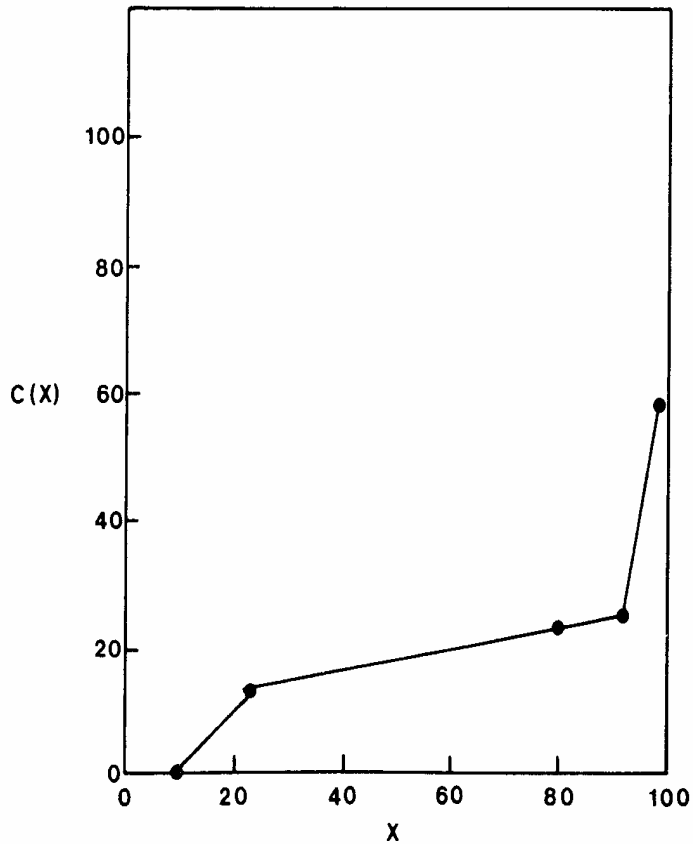


Figure 4. Annual Cost – C(X) [$x1000/MGD] vs. Percent TP Removal – X for Point Sources.

Cost Function (1980 $s) for TP Removal Urban and Rural Stormwater Sources

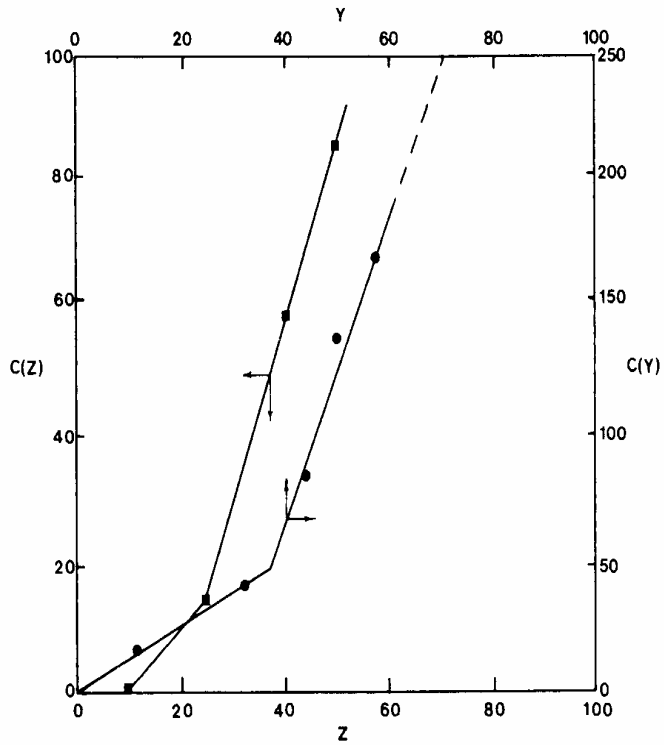


Figure 5. Annual Costs – C(Y) [$/hectare] vs. Percent TP Removal – Y for Urban Nonpoint Soruces and C(Z) [$/hectare] vs. Percent TP Removal – Z for Rural Nonpoint Sources.