CURSOS SUPERFICIALES (Ríos y Estuarios)

- Modelo unidimensional
- Modelo bidimensional

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- Modelo unidimensional
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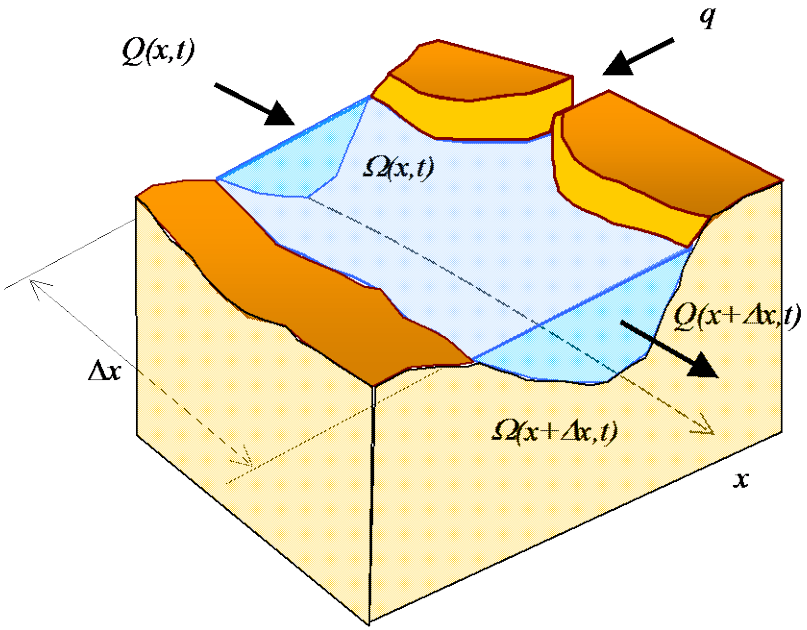
ANALISIS UNIDIMENSIONAL
(ECUACIONES DE SAINT VENANT)



$$\frac{\partial \Omega}{\partial t} + \frac{\partial Q}{\partial x} = q$$

$$\frac{\partial U}{\partial t} + U\frac{\partial U}{\partial x} + g\frac{\partial z}{\partial x} + gI_f = -\frac{q}{\Omega}(U - u_L)$$

$$I_f = \frac{n^2 U^2}{R^{4/3}}$$

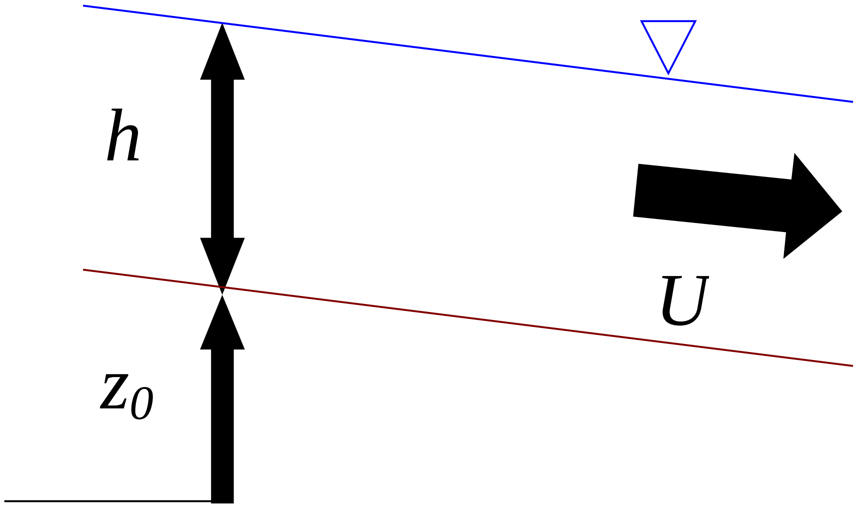
RUGOSIDAD (*n*)

Tipo de curso de agua	Rango de valores normales
Canal alineado o artificial	
Cemento	0.011/0.013
Concreto	0.013/0.027
Canal excavado o dragado	
Tierra, alineado y uniforme	0.018/0.027
Tierra, sinuoso y lento	0.025/0.040
Cortes de roca	0.035/0.040
Cursos naturales menores (ancho < 30 m)	
En planicie	0.030/0.100
Montañosos	0.040/0.050
Planicie de inundación	
Pasturas	0.030/0.035
Áreas cultivadas	0.030/0.040
Arbustos	0.050/0.100
Árboles	0.040/0.120
Cursos naturales mayores (ancho > 30 m)	0.025/0.100

FLUJO UNIFORME

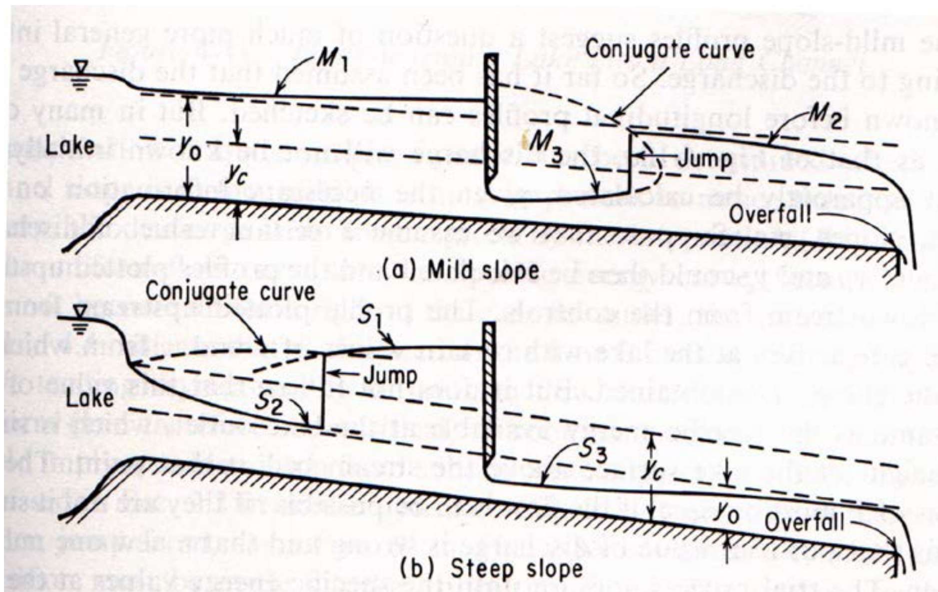
$$\Omega^2 R^{4/3} = \frac{n^2 Q^2}{I_0}$$

Relación algebraica entre *h* y *Q*



- Régimen estacionario
- Pendiente del fondo constante
- Sin aporte lateral
- Profundidad uniforme

CURVAS DE REMANSO



$$\frac{dh}{dx} = I_0 + \frac{\frac{Q^2}{g\Omega^3}\left.\frac{\partial \Omega}{\partial x}\right|_h - \frac{n^2 Q^2}{\Omega^2 R^{4/3}}}{1 - Fr^2}$$

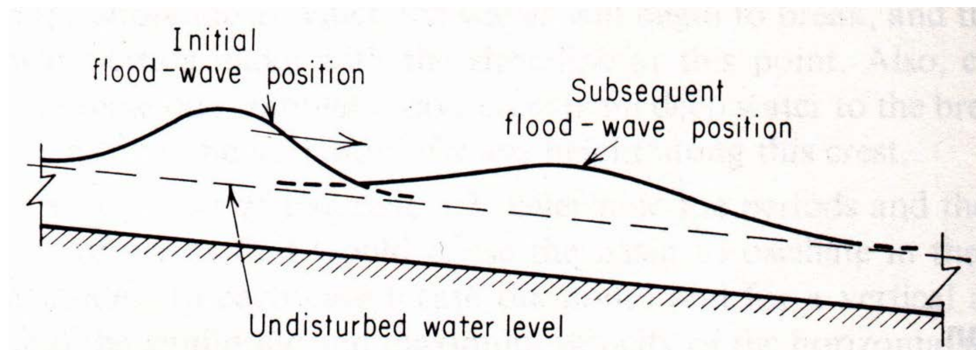
Integración numérica

- Régimen estacionario
- Pendiente del fondo variable
- Sin aporte lateral

ONDA DE INUNDACION

$$\eta(x,t) \equiv z(x,t) - z_o(x) - h_o = \frac{A}{\sqrt{4-Fr_0^2}} \sqrt{\frac{\lambda}{2\pi g h_0 t}} \quad \exp\left\{ -\frac{2\lambda}{g h_0} \frac{(x-c_c t)^2}{(4-Fr_0^2)t} \right\}$$

Solución cerrada

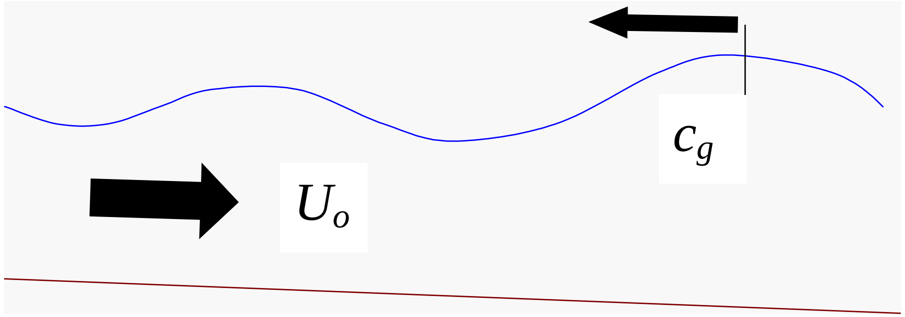


- Canal cuasi-prismático, ancho
- Pendiente del fondo constante
- Flujo de base uniforme
- Sin aporte lateral
- Onda de pequeña amplitud

ONDA DE MAREA

$$\eta(x,t) \equiv z(x,t) - z_o(x) - h_o = a_0 \exp\left(-\frac{\Psi \xi}{|c_g|} \right) \cos\left(\omega(t - \frac{\xi}{|c_g|}) \right)$$

Solución cerrada



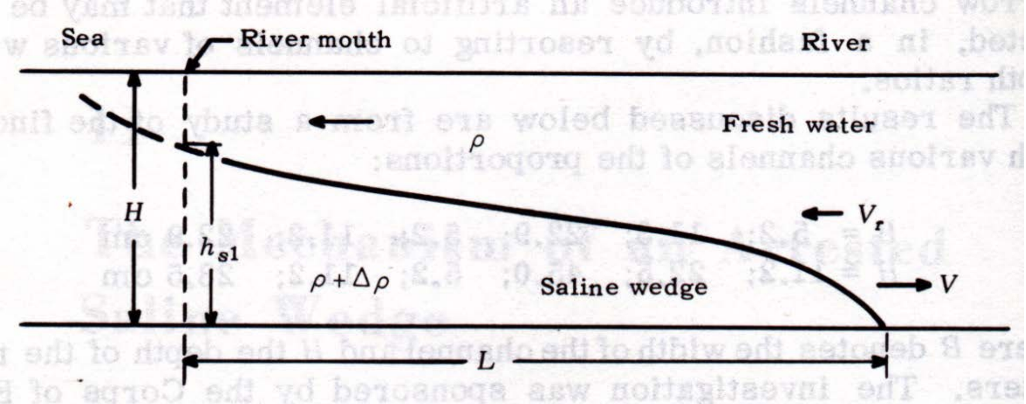
- Canal cuasi-prismático, ancho
- Pendiente del fondo constante
- Flujo de base uniforme
- Sin aporte lateral
- Onda de pequeña amplitud

ESTRATIFICACION SALINA

(modelo de 2 capas)

$$x(a_1) = \frac{2h}{f_i}\left\{\frac{1}{5Fr_0^2} - 2 + 3Fr_0^{2/3}\left(1 - \frac{2}{5}Fr_0^{2/3}\right)\right\}$$

Relación algebraica entre *x* y a_1



- Régimen estacionario
- Canal cuasi-prismático, ancho
- Profundidad uniforme, a dos capas
- Sin aporte lateral

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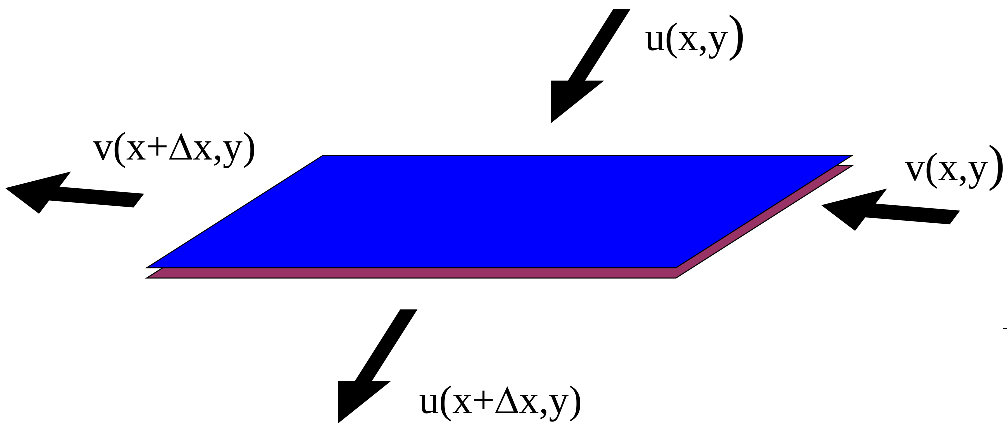
ANALISIS BIDIMENSIONAL

(ECUACIONES PARA AGUAS POCO PROFUNDAS)



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

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}-f_g v+g\frac{\partial(h+z_0)}{\partial x}+\frac{\tau_{fx}}{\rho h}-\frac{\tau_{sx}}{\rho h}-\frac{1}{\rho h}\frac{\partial}{\partial x}(hT_{xx})-\frac{1}{\rho h}\frac{\partial}{\partial y}(hT_{xy})=0$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+f_g u+g\frac{\partial(h+z_0)}{\partial y}+\frac{\tau_{fy}}{\rho h}-\frac{\tau_{sy}}{\rho h}-\frac{1}{\rho h}\frac{\partial}{\partial x}(hT_{xy})-\frac{1}{\rho h}\frac{\partial}{\partial y}(hT_{yy})=0$$

ANALISIS BIDIMENSIONAL
(PARAMETRIZACION)

$$f_g = 2\omega \operatorname{sen} \phi$$

$$\frac{\tau_{fx}}{\rho\, h} = f_r \frac{u\sqrt{u^2+v^2}}{h} \qquad \frac{\tau_{fy}}{\rho\, h} = f_r \frac{v\sqrt{u^2+v^2}}{h} \qquad f_r = \frac{g}{C^2} = \frac{gn^2}{h^{1/3}}$$

$$T_{ij} \equiv \frac{\rho}{h} \int_{z_0}^{z_0+h} \left[\nu \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right) - \overline{u'v'} - (U_i - u_i)(U_j - u_j) \right] dz$$

$$\frac{1}{\rho\, h}\frac{\partial}{\partial x}(hT_{xx}) + \frac{1}{\rho\, h}\frac{\partial}{\partial y}(hT_{xy}) = \nu_t \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right)$$

$$\frac{1}{\rho\, h}\frac{\partial}{\partial x}(hT_{xy}) + \frac{1}{\rho\, h}\frac{\partial}{\partial y}(hT_{yy}) = \nu_t \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} \right)$$