

# 集水區水質模式

BASINS模式

# 集水區與水質模式

- 研究報告顯示集水區內之污染源多為非點源污染構成，而非點源之準確性監測困難度高，如何建立一個合理量化系統，將非點源污染納入總量管制(TMDL)，故發展水質模式。
- 水質模式種類繁多，維度及模擬之水文狀態不同(如：steady-state或unsteady state)，分別依其目的發展。

# BASINS模式-目的

---

1977年Clean Water Act為對水體進行總量管制  
(total maximum daily load, TMDL)

及美國各州及地方團體以集水區為導向趨勢，美國環保署於1996年發展，以集水區概念為主要架構，將評估TMDL所需之點源及非點源污染分析整合成為一完整的系統。

# BASINS模式-歷史

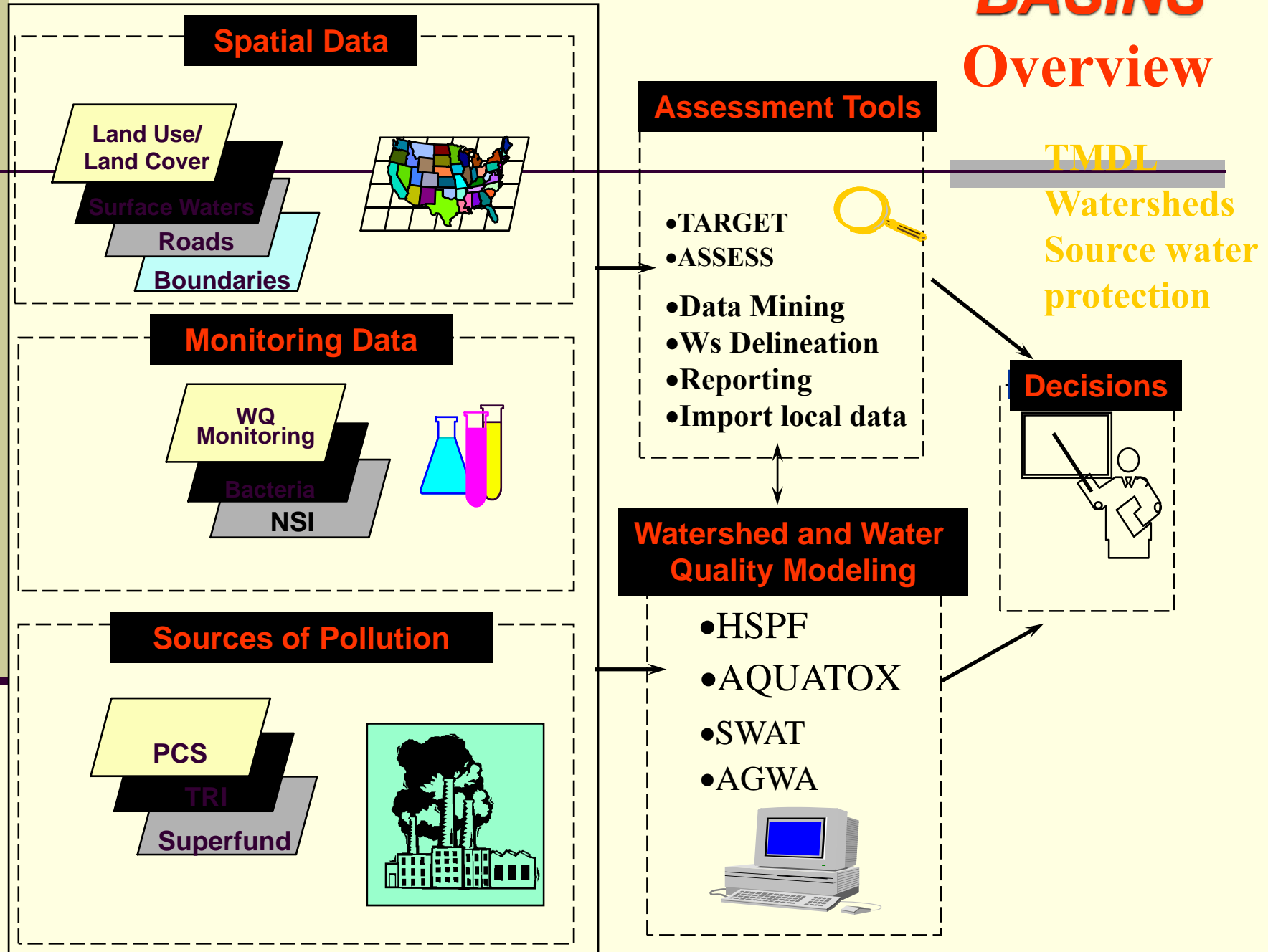
- 1950年的stanford model 發展到1980年的HSPF，為減少多種模式模擬結合上的困擾，模式朝向多目標整合系統發展
- 美國環保署（USEPA）自1996年開始發展BASINS（Better Assessment Science Integrating Point and Nonpoint Sources）集水區多目標環境分析系統

BASINS版本演進	
1.0	1996年5月
2.0	1999年1月
3.0	2001年6月
3.1	2004年8月
4.0	2007年8月

# BASINS模式-硬體需求

硬體／軟體	最小需求	最佳需求
CPU處理器	Pentium 133MHz	Pentium 200Mhz或更高
可用的硬碟空間	250MB	620MB
	(20MB為BASINS程式，130MB為一個集水區的環境資料，及100MB硬碟空間供執行BASINS時使用。)	(20MB為BASINS程式，500MB為一個州的環境資料及100MB硬碟空間供執行BASINS時使用。)
記憶體(RAM)	32MB RAM及32MB的虛擬記憶體。	64MB RAM及64MB的虛擬記憶體。
光碟機	4X 光碟(使用一次)	24X 光碟
顯示器色彩數	設定於16色	設定於256色
作業系統	Windows 95 / 98 / NT*	Windows 95 / 98 / NT*
ArcView之GIS軟體	ArcView Version 3.0a 和	ArcView Version 3.0a和
	ArcView Dialog Designer	ArcView Dialog Designer
	或是 Arcview Version 3.1	或是Arcview Version 3.1

# BASINS Overview



# BASINS模式-模組

## WinHSPF 進入HSPF的介面連接模組

- Interactive interface to HSPF
- Access to all HSPF Features
- Scenario development

## WDMUtil 氣象資料庫模組

- Build/maintain WDM time series file and meteorologic data for BASINS
- Meteorologic data generation and fill-in
- Graphical and tabular display of time series data

## GenScn 圖表呈現模組

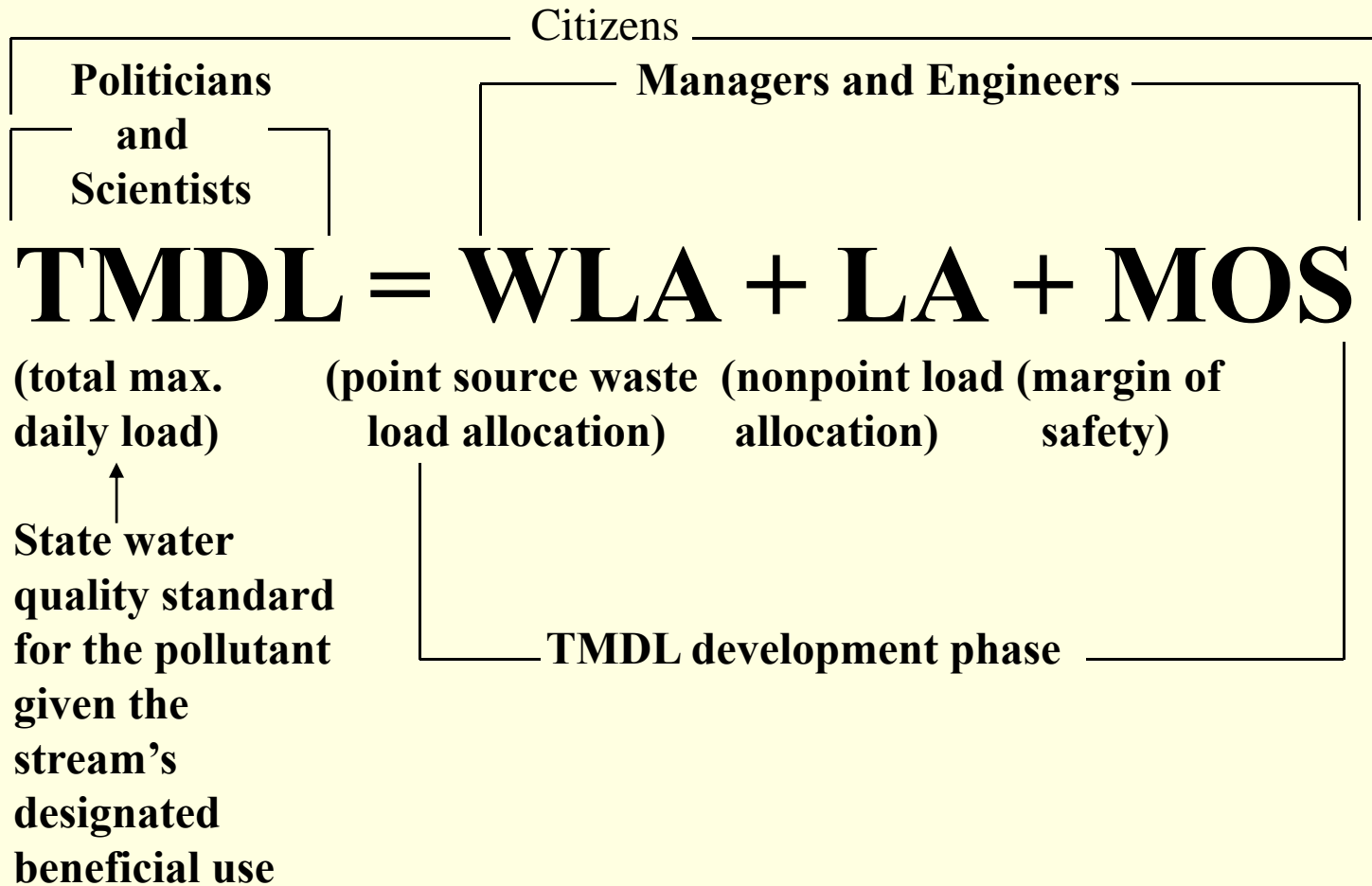
- output postprocessor

## HSPEXP 水質水量模擬模組

- Hydrologic calibration support

# BASINS模式-基礎理論

## TMDL EQUATION





# BASINS模式-基礎理論

---

- **Water balance equation**

$$R=P-ET-IG-\Delta S$$

**Where : P = Precipitation**

**R = Runoff**

**ET = Evapotranspiration**

**IG = Deep/inactive groundwater**

**$\Delta S$  = Change in soil storage**

- **MASS balance equation**

# 主要參數中英對照

PWATER 副程式			
參數名稱	定 義	單 位	範圍值
LZSN	下層土壤名義含水量	in	2~15
INFILT	入滲能力指標	in/hr	0.0001~0.5
LSUR	漫地流長度	ft	100~700
SLSUR	漫地流坡度	ft/ft	0.001~0.3
KVARY	地下水出流參數	1/in	0~5
AGWRC	地下水退水率	-	0.85~0.999
INFEXP	入滲公式指數	-	1~3
INFILD	最大與平均入滲量比值	-	1~3
DEEPFR	地下水入流參數	-	0~0.5
BASETP	基流蒸發散參數	-	0~0.2
AGWETP	地下水流蒸發散參數	-	0~0.2
CEPSC	截留量	in	0.1~0.4
UZSN	上層土壤名義含水量	in	0.05~2
NSUR	曼寧N值	-	0.05~0.5
INTFW	中間流入流參數	-	1~10
IRC	中間流退水率	-	0.3~0.85

# 主要參數中英對照

PWATER 副程式			
參數名稱	定 義	單位	範圍值
LZETP	下層土壤蒸發散參數	-	0.1~0.9
CEPS	截留儲存量	in	0~100
SURS	表面儲存量	in	0~100
UZS	上層土壤儲存量	in	0.001~100
IFWS	中間流儲存量	in	0~100
LZS	下層土壤儲存量	in	0.001~100
AGWS	活動地下水流儲存量	in	0~100
GWVS	地下水坡度指標	in	0~100
HYDR 副程式			
KS	水力路徑之權重因子	-	0~0.99
DB50	底床泥砂顆粒直徑之中位數	in	0.001~100
VOL	河段水量初始體積	acre-ft	0~ none

# 主要參數中英對照

SEDMNT 副程式			
參數名稱	定 義	單位	範圍值
SMPF	操作管理因子	-	0.001~1
KRER	土壤分離係數	-	0~ none
JRER	土壤分離指數	-	none
AFFIX	土壤再壓密率	1/day	0~1
COVER	土壤覆蓋率	-	0.0~1
NVSI	大氣落塵量	lb/ac-day	none
KSER	分離泥砂之沖刷係數	-	0~ none
JSER	分離泥砂之沖刷指數	-	none
KGER	土壤沖蝕係數	-	0~ none
JGER	土壤沖蝕指數	-	none
DETS	分離泥砂之初始存量	tons/ac	0~ none

# 主要參數中英對照

SEDTRN 副程式			
參數名稱	定義	單位	範圍值
SANDFG	泥砂承載之模擬方法	-	1~3
BEDWID	估計河床泥砂深度	ft	1~ none
BEDWRN	河床深度	ft	0.001~ none
POR	河床孔隙率	-	0.1~0.9
DB50	河床泥砂顆粒直徑之中位數	in	0.0001~100
KSAND	泥砂承載公式之係數	-	0~ none
EXPSND	泥砂承載公式之指數	-	0~ none
TAUCD	底床之沈澱臨界剪力	lb/ft <sup>2</sup>	1×10 <sup>-10</sup> ~ none
TAUCS	底床之沖蝕臨界剪力	lb/ft <sup>2</sup>	1×10 <sup>-10</sup> ~ none
M	泥砂侵蝕係數	lb/ft <sup>2</sup> /day	0~ none
SSED(3)	懸浮砂土、矽土、 黏土之初始濃度值	mg/l	0~ none
			2~4 <sup>(矽土、黏土)</sup>
SEDMNT 副程式			
BEDDEP	底床起始厚度	ft	0~ none

# 主要參數中英對照

泥砂特性			
參數名稱	定 義	單位	範圍值
D	有效粒徑	in	0.001~100 <sup>(砂土)</sup>
D	有效粒徑	in	0~0.003 <sup>(砂土、黏土)</sup>
W	沈降速度	in/sec	0.02~500 <sup>(砂土)</sup>
RHO	顆粒密度	gm/cm <sup>3</sup>	1~4 <sup>(砂土)</sup>
PQUAL 副程式			
POTFW	土壤沖刷相關因子	lb/ton	0~ none
POTFS	土壤沖蝕相關因子	lb/ton	0~ none
ACQOP	污染物累積率	lb/ac/day	0~ none
SQOLIM	污染物最大存量	lb/ac	1×10 <sup>-6</sup> ~ none
WSQOP	地表逕流沖刷率	in/hr	0.01~ none
IOQC	中間流濃度	lb/ft <sup>3</sup>	0~ none
AOQC	地下水流濃度	lb/ft <sup>3</sup>	0~ none
初始狀態			
SQO	污染物起始存量	lb/ac	1~none
MON-IFLW-CONC	各月中間流濃度	lb/ft <sup>3</sup>	0~none
MON-GRND-CONC	各月地下水濃度	lb/ft <sup>3</sup>	0~none

# 敏感性參數-PWATER

- **Annual Water Balance -**

$$\text{Runoff} = \text{Prec.} - \text{Actual ET} - \text{Deep Perc.} - \Delta \text{ Storage}$$

Key Parameters:            Repr. Precipitation (MFACT)  
                                 LZSN  
                                 LZETP  
                                 INFILT  
                                 DEEPFR

- **Groundwater (Baseflow) Volume and Recession -**

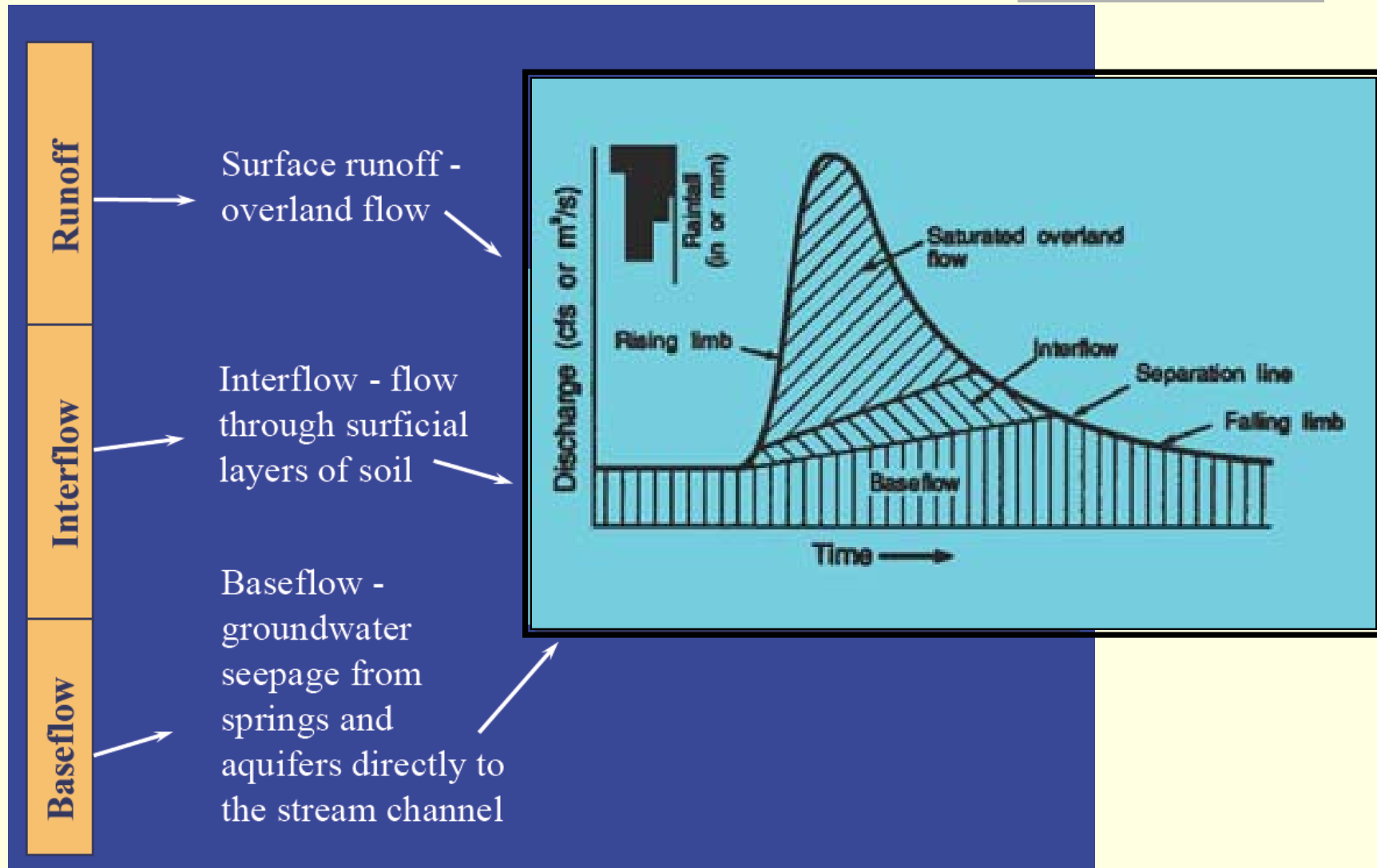
$$\text{Runoff} = \text{Surface Runoff} + \text{Interflow} + \text{Baseflow}$$

Key Parameters:            INFILT  
                                 AGWRC/KVARY  
                                 DEEPFR  
                                 BASETP/AGWETP

- **Surface Runoff + Interflow (Hydrograph Shape) -**

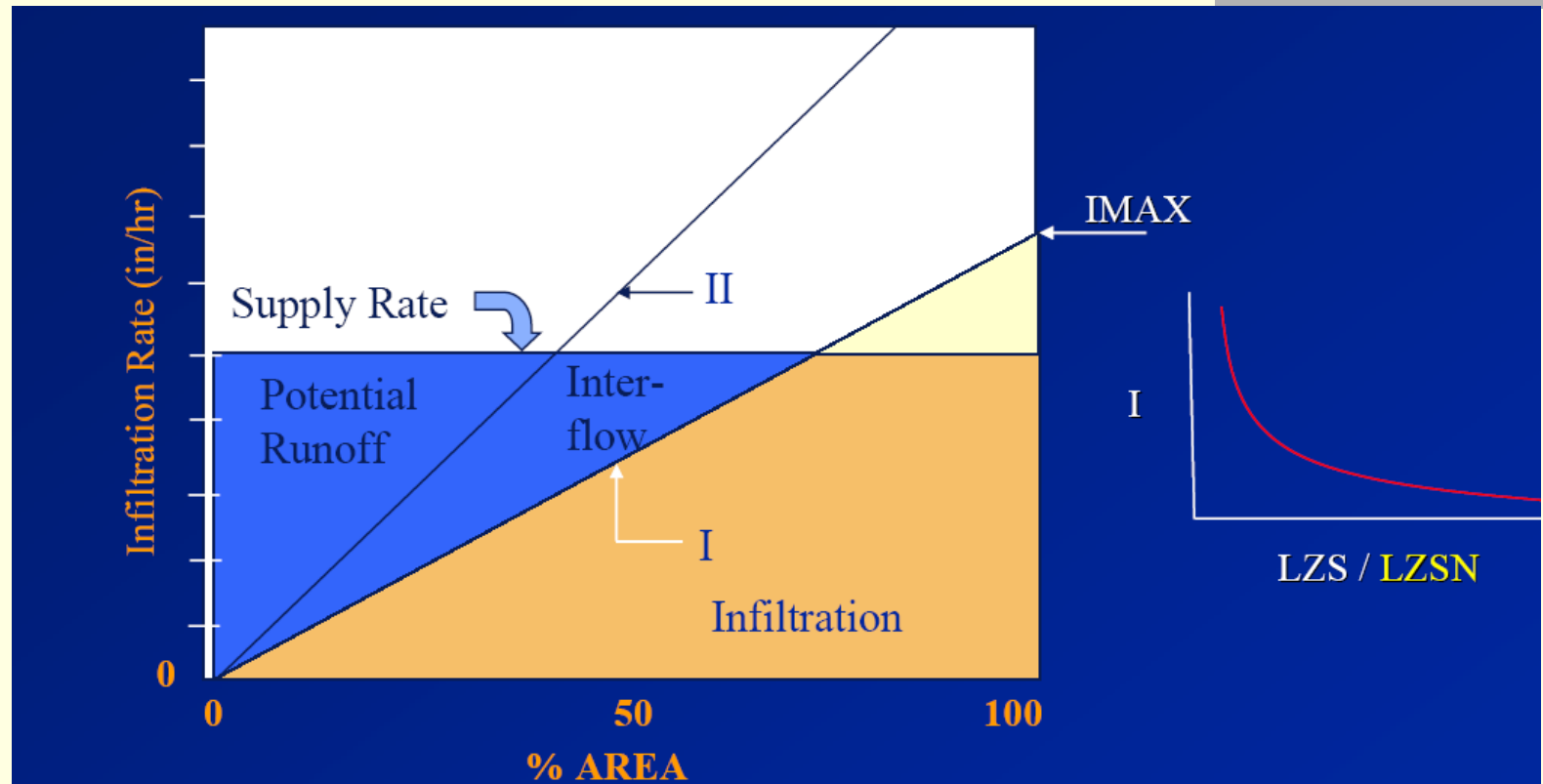
Key Parameters:            UZSN  
                                 INTFW  
                                 IRC  
                                 LSUR, NSUR, SLSUR

# 參數-降雨逕流組成圖





# 參數-INFILD、LZSN



$$I = \frac{\text{INFILT}}{(\text{LZS} / \text{LZSN})^{\text{INFEXP}}} * \text{INFFAC}$$

$$\text{IMAX} = I * \text{INFILD}$$

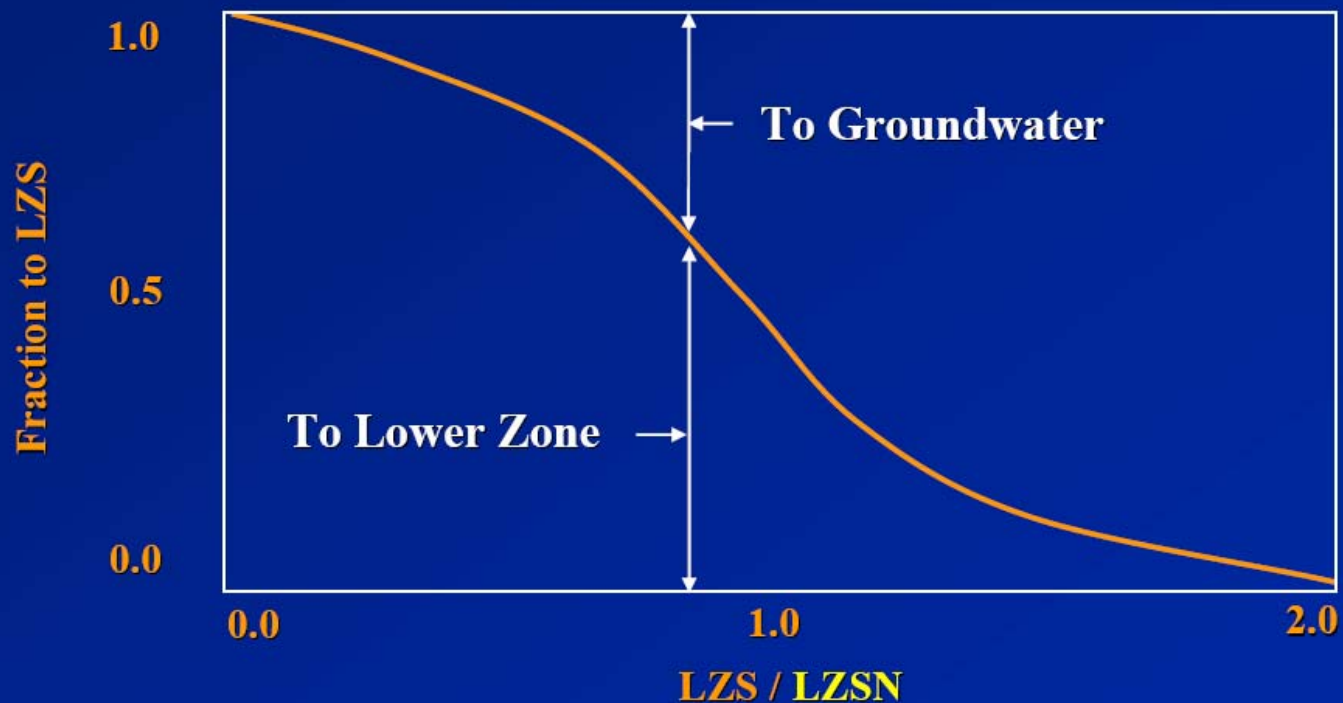
$$\text{II} = I * \text{INTFW} (2.0^{**} (\text{LZS} / \text{LZSN}))$$

# 參數-INFILD、LZSN

## From UZS

$$\text{PERC} = 0.1 * \text{INFILT} * \text{INEFFAC} * \text{UZSN} * \left( \frac{\text{UZS}}{\text{UZSN}} - \frac{\text{LZS}}{\text{LZSN}} \right)^3$$

## To lower zone or groundwater



# 參數-IRC、KVARY、AGWRC

## Interflow

$$\text{IFWO} = \text{K2} * \text{IFWS} + \text{K1} * \text{INFLO}$$

IFWS = interflow storage at start of time step

INFLO = addition to interflow storage during time-step

$$\text{K2} = 1.0 - e^{-\text{K}}$$

$$\text{K1} = 1.0 - \text{K2}/\text{K}$$

$$\text{K} = -\ln(\text{IRC})^{dt/24}$$

**IRC** = Interflow recession parameter

## Baseflow

$$\text{AGWO} = \text{KGW} * \text{AGWS} * (1.0 + \text{KVARY} * \text{GWVS})$$

AGWS = active groundwater storage

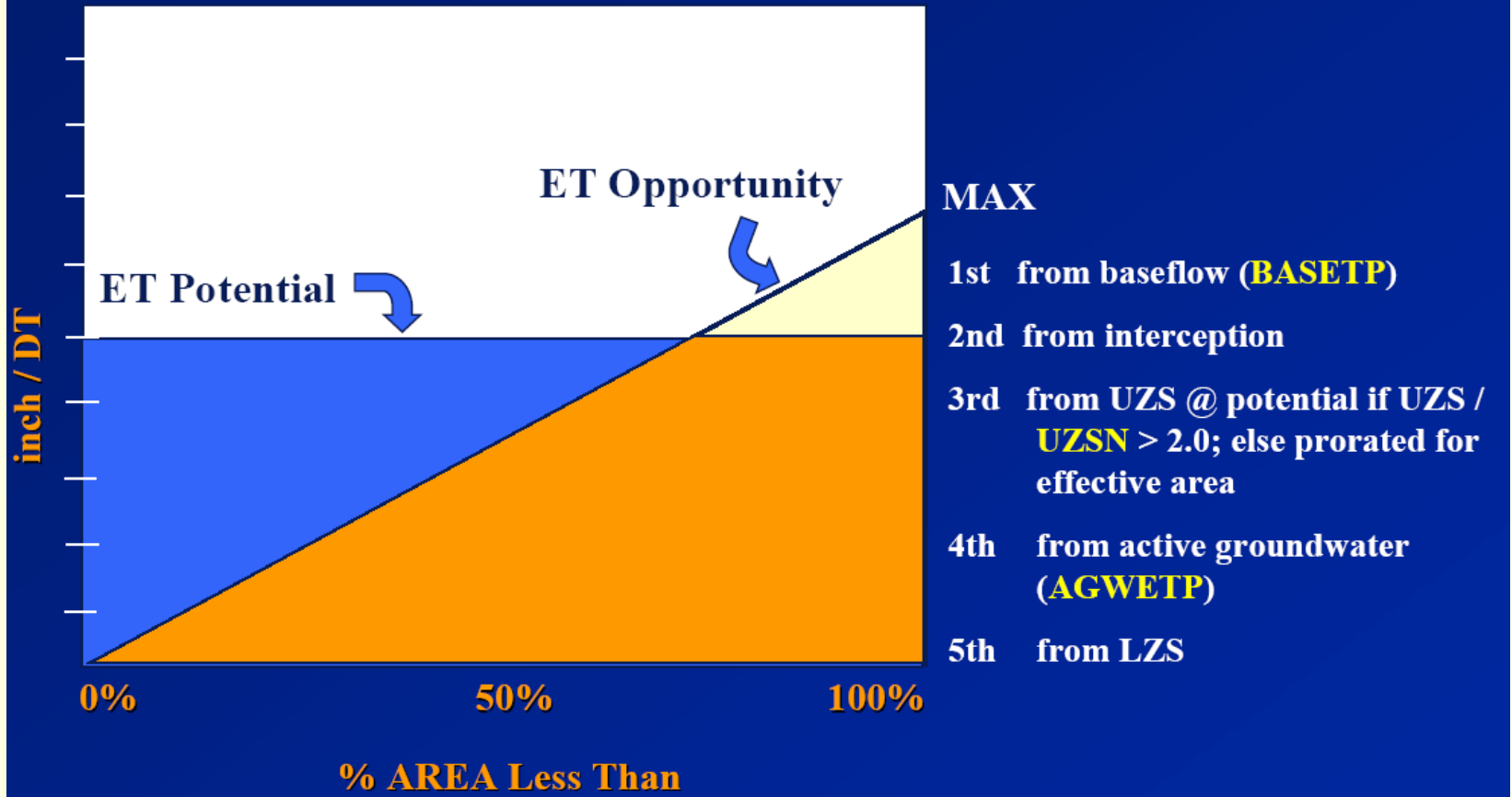
GWVS = antecedent index increased by drainage to AGWS, decreased 3% each day

**KVARY** = input parameter

$$\text{KGW} = 1.0 - (\text{AGWRC})^{dt/24}$$

**AGWRC** = Groundwater recession parameter

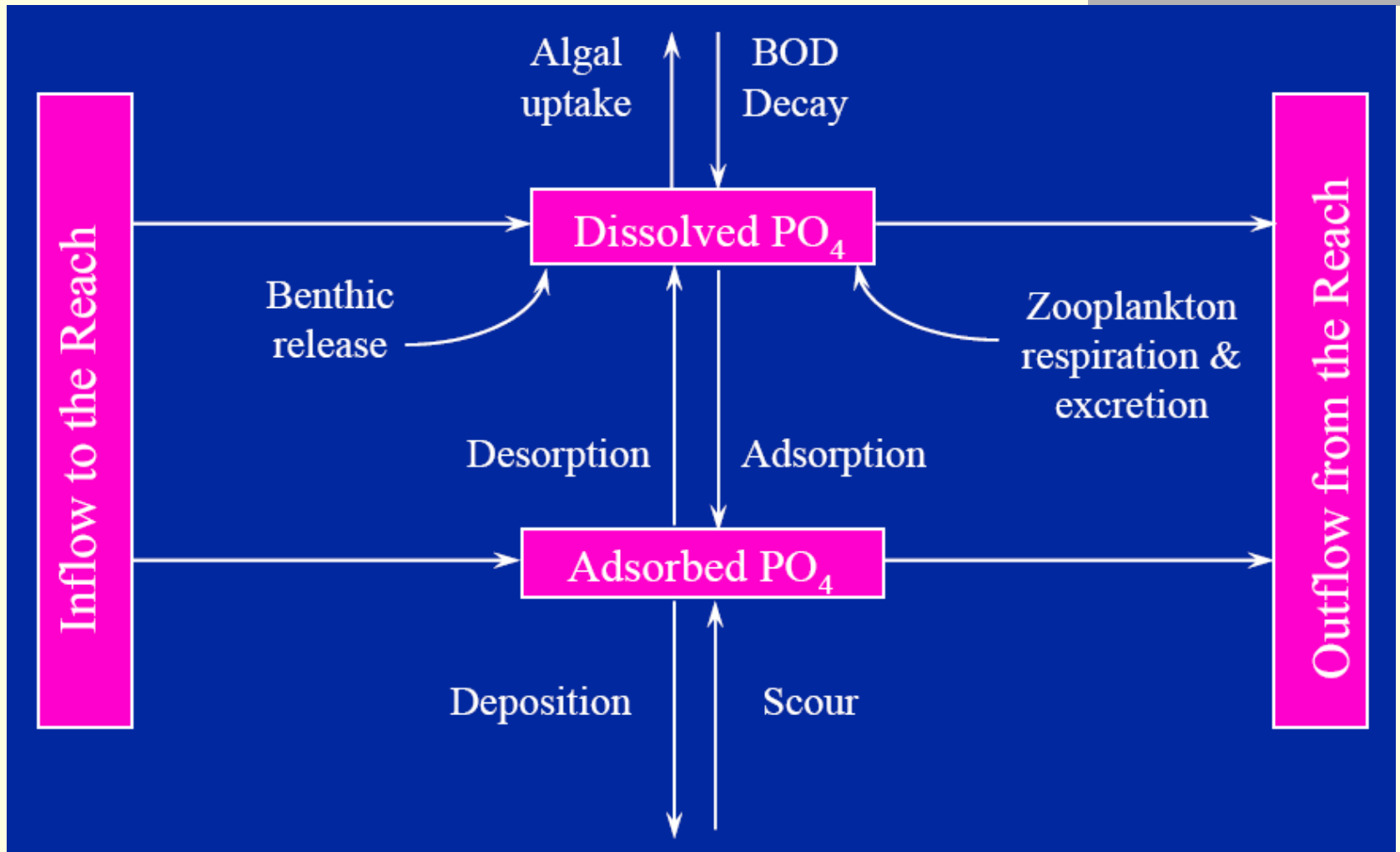
# 參數-LZETP、LZSN



- MAX**
- 1st from baseflow (**BASETP**)
  - 2nd from interception
  - 3rd from UZS @ potential if UZS / **UZSN** > 2.0; else prorated for effective area
  - 4th from active groundwater (**AGWETP**)
  - 5th from LZS

$$MAX = \left( \frac{0.25}{1 - LZETP} \right) * \left( \frac{LZS}{LZSN} \right) * \left( \frac{DT}{24} \right)$$

# 模式中磷反應



# 模擬成效判定

## % Difference Between Simulated and Recorded Values

	VERY GOOD	GOOD	FAIR
Hydrology/Flow	< 10	10 - 15	15 - 25
Sediment	< 20	20 - 30	30 - 45
Water Temperature	< 7	8 - 12	13 - 18
Water Quality/Nutrients	< 15	15 - 25	25 - 35
Pesticides/Toxics	< 20	20 - 30	30 - 40

- CAVEATS:**
- 1.) Relevant to monthly and annual values; storm peaks may differ more.
  - 2.) Quality and detail of input and calibration data.
  - 3.) Purpose of model application.
  - 4.) Availability of alternative assessment procedures.
  - 5.) Resource availability (i.e. time, money, personnel).

Source: Donigian, 2000

## Criteria

R	← 0.75	0.80	0.85	0.90	0.95	→
R <sup>2</sup>	← 0.6	0.7	0.8	0.9	→	
Daily Flows	Poor	Fair	Good	Very Good		
Monthly Flows	Poor	Fair	Good	Very Good		

# BMPs MODULE

除了以下模式內建可選擇之典型處理設施，亦可依照使用者所需之效益輸入模擬

Changes in land use acreage's due to land use planning/management

Wet detention pond

Dry detention pond

Vegetated swales and filter strips  
(various widths)

Stream buffers (25 feet and 100 feet)

User specified sediment and pollutant (nitrogen, phosphorous, BOD, fecal coliform, metals - copper, cadmium, and zinc) load reductions

# BMPs MODULE

設定BMP位置及所能處理的土地利用面積

Select Summary or Reach below BMP: 680:South River, Dooms

Current BMP Details

ID: 680

Description: Wet Detention

Edit Removal Efficiency **CLICK**

**Contributing Sources to Reach 680 (South River, Dooms)**

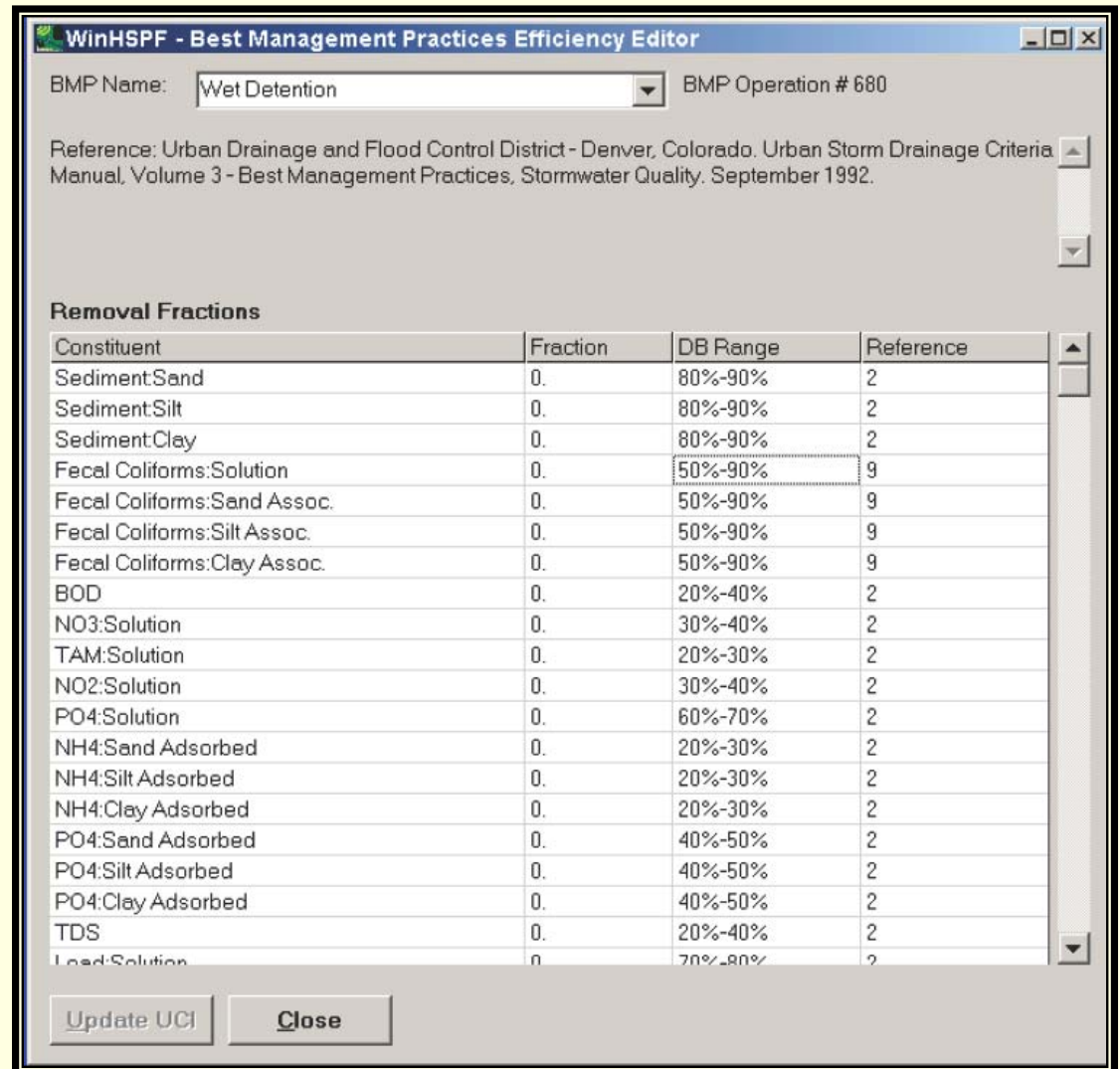
Source	Area	% No BMP	% BMP 680
PERLND : 191 (FOREST)	54275	50	50
PERLND : 192 (HIGH TILL CROPLAND)	1582	50	50
PERLND : 193 (LOW TILL CROPLAND)	3663	50	50
PERLND : 194 (PASTURE)	15561	50	50
PERLND : 195 (URBAN)	10035	50	50
PERLND : 196 (HAY)	8527	50	50
IMPLND : 194 (ANIMAL/FEEDLOT)	34	50	50
IMPLND : 195 (RESIDENTIAL)	3566	50	50

Update UCI Close



# BMPs MODULE

接續前頁之結構性BMP  
設計，可依照設計輸入  
各污染項之處理效益



WinHSPF - Best Management Practices Efficiency Editor

BMP Name:  BMP Operation # 680

Reference: Urban Drainage and Flood Control District - Denver, Colorado. Urban Storm Drainage Criteria Manual, Volume 3 - Best Management Practices, Stormwater Quality, September 1992.

**Removal Fractions**

Constituent	Fraction	DB Range	Reference
Sediment:Sand	0.	80%-90%	2
Sediment:Silt	0.	80%-90%	2
Sediment:Clay	0.	80%-90%	2
Fecal Coliforms:Solution	0.	50%-90%	9
Fecal Coliforms:Sand Assoc.	0.	50%-90%	9
Fecal Coliforms:Silt Assoc.	0.	50%-90%	9
Fecal Coliforms:Clay Assoc.	0.	50%-90%	9
BOD	0.	20%-40%	2
NO3:Solution	0.	30%-40%	2
TAM:Solution	0.	20%-30%	2
NO2:Solution	0.	30%-40%	2
PO4:Solution	0.	60%-70%	2
NH4:Sand Adsorbed	0.	20%-30%	2
NH4:Silt Adsorbed	0.	20%-30%	2
NH4:Clay Adsorbed	0.	20%-30%	2
PO4:Sand Adsorbed	0.	40%-50%	2
PO4:Silt Adsorbed	0.	40%-50%	2
PO4:Clay Adsorbed	0.	40%-50%	2
TDS	0.	20%-40%	2
Lead:Solution	0.	70%-80%	2

# BASINS模式-金瓜寮範例

- 所需相關資料有如下：
- GIS相關資料(資料至少必須涵蓋模擬區域)
  - 集水區之河道流域圖層資料(.adf ; .shp ; .shx)
  - 集水區數值高程圖(.bmp ; .adf ; .bpw ; .mwleg)
  - 土地利用資料(.cpg ; .dbf ; .sbn ; .sbx ; shp ; .shx)
  - 模擬區域之邊界圖層資料(.mwsr ; .shp ; .shx ; .adf)
- (GIS格式檔基本含：.shx ; .shp ; .dbf)

# BASINS模式-金瓜寮範例

## ■ 水文、水質、天氣相關資料

- 模擬區域內及鄰近之氣象測站所得之相關八項資料如下：

每小時降雨量

每小時蒸發量

每小時溫度

每小時風速

每小時輻射

每小時蒸發散潛勢

每小時露點溫度

每小時雲覆蓋量

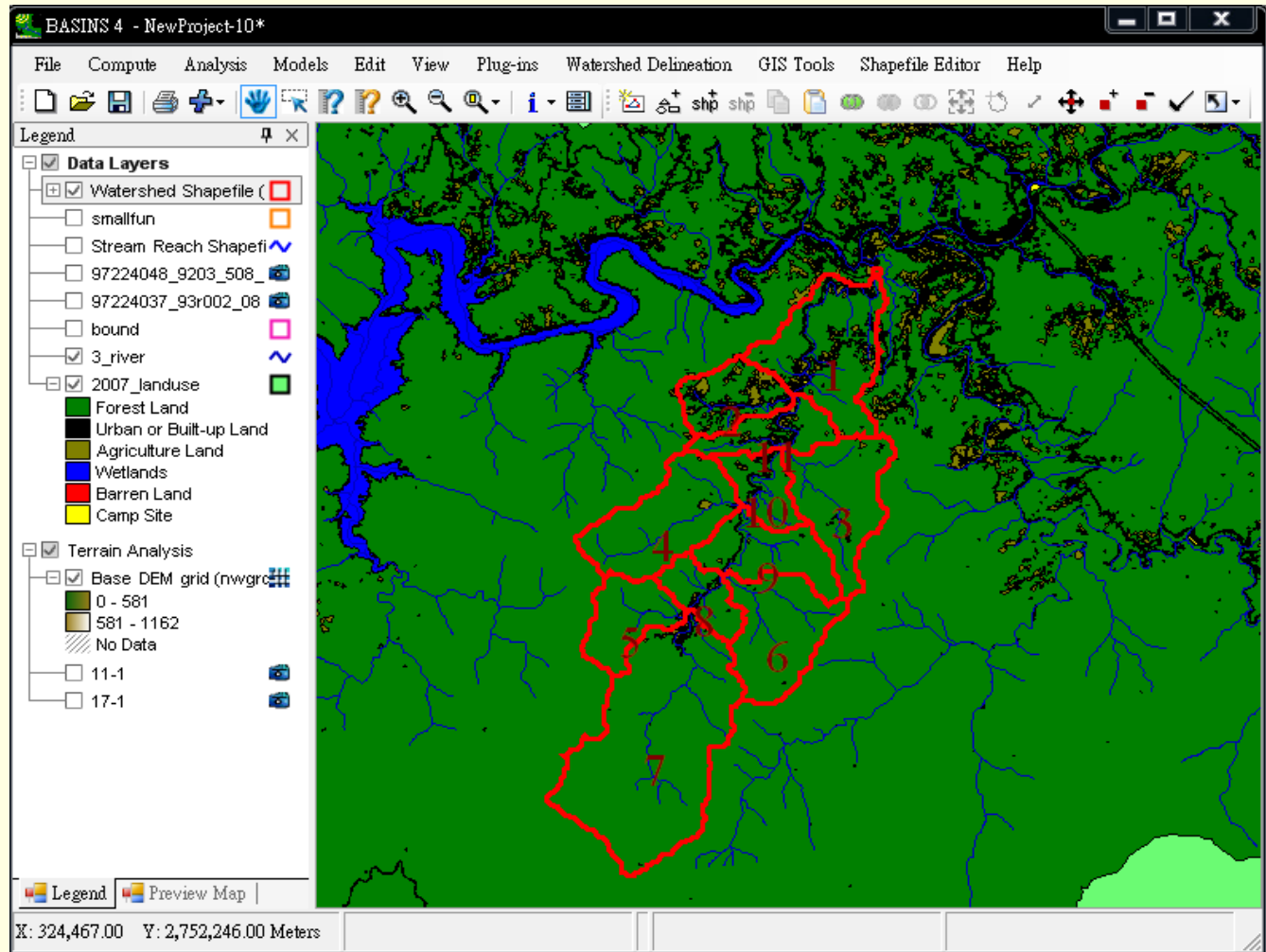
- (Excel格式)

# BASINS模式-金瓜寮範例

- 模擬區域內河川水質歷年監測相關資料  
(BOD、SS、TP、水溫、氨氮、pH、DO等等)
- (Excel格式)
- 模擬區域內各監測站歷年流量(單位CMS)(以每小時數據為佳)
- (Excel格式)
- ps. 監測站、氣象站的地理位置

# BASINS模式-金瓜寮範例

## 建立模式



X: 324,467.00 Y: 2,752,246.00 Meters

# BASINS模式-金瓜寮範例

## HSPF



Hydrological Simulation Program - Fortran (HSPF): NewProject-10

File Edit Functions Help

The interface displays a network of reaches (RCHRES 1 through RCHRES 11) connected in a hierarchical structure. RCHRES 11 is the central node, with RCHRES 10, RCHRES 9, RCHRES 8, and RCHRES 5 connected to it. RCHRES 10 is connected to RCHRES 3 and RCHRES 4. RCHRES 9 is connected to RCHRES 6. RCHRES 8 is connected to RCHRES 7. RCHRES 11 is connected to RCHRES 1, which is in turn connected to RCHRES 2.

Land Surface: PerInld Implnd  
Urban or Built-up

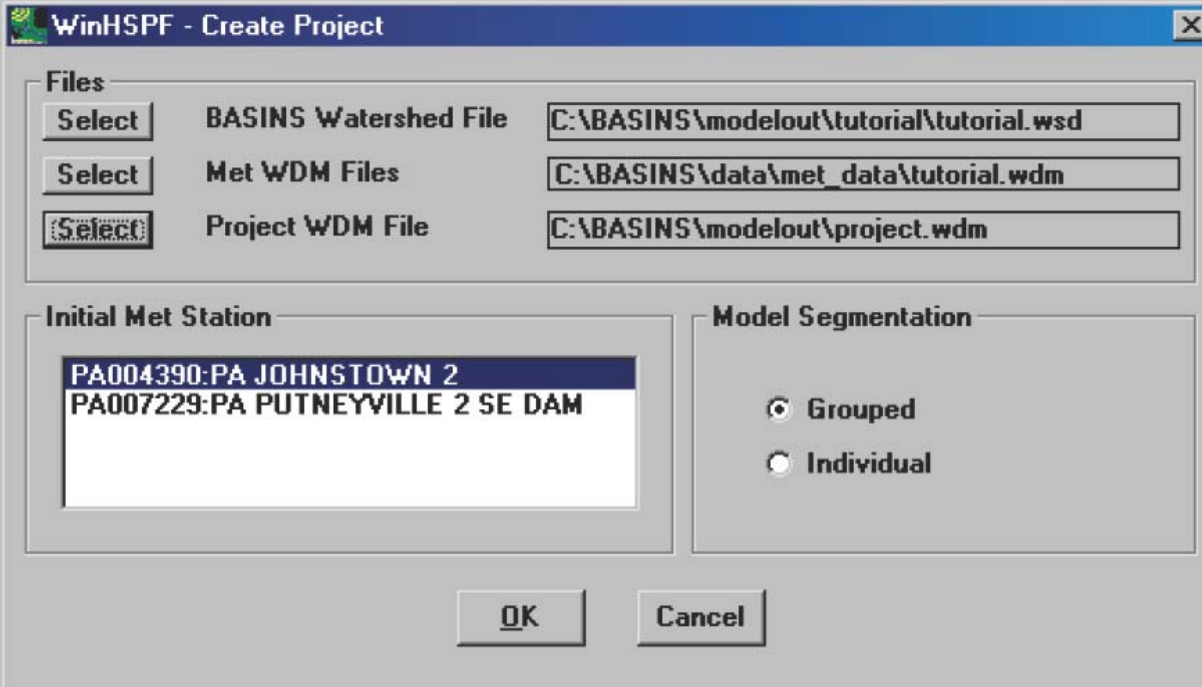
Met Segs: Forest Land

Point Sources: Agriculture Land, Camp Site

Land Use	Reaches	Implnd (Acres)	PerInld (Acres)	Total (Acres)
Total		0.0	0.0	0.0

# BASINS模式-金瓜寮範例

劃分集水區完成後，跳出此視窗  
分別輸入氣象檔輸入的位置、氣象檔輸出的位置



The image shows a screenshot of the 'WinHSPF - Create Project' dialog box. The dialog has a title bar with the text 'WinHSPF - Create Project' and a close button. It is divided into several sections:

- Files:** This section contains three rows, each with a 'Select' button, a label, and a text box containing a file path:
  - BASINS Watershed File:** C:\BASINS\modelout\tutorial\tutorial.wsd
  - Met WDM Files:** C:\BASINS\data\met\_data\tutorial.wdm
  - Project WDM File:** C:\BASINS\modelout\project.wdm
- Initial Met Station:** A list box containing two entries:
  - PA004390:PA JOHNSTOWN 2
  - PA007229:PA PUTNEYVILLE 2 SE DAM
- Model Segmentation:** A section with two radio button options:
  - Grouped
  - Individual

At the bottom of the dialog are two buttons: 'OK' and 'Cancel'.

# BASINS模式-金瓜寮範例

## ■ 錯誤視窗

The screenshot displays the WinHSPF Error View window for 'NewProject-10.ech'. The main window shows the following text:

```
PROCESSING FTABLES BLOCK
FINISHED PROCESSING FTABLES BLOCK
PROCESSING MASS LINK BLOCK
FINISHED PROCESSING MASS LINK BLOCK
PROCESSING PERLND BLOCK
*****
PROCESSING PERVIOUS LAND-SEGMENT NO: 101   TIME STEP (DELT): 60 HINS
*****
*
* ERROR/WARNING ID: 218 2
*
* Operation      : PERLND      Number   : 101
* Table         : PSTEHP-PARM2 Subscript: 1
* Parameter     : 3
*
* No value was found in UCI and no default is available.
*
4
```

Two error dialog boxes are overlaid on the main window:

- HSPF** dialog box:  
c:\basins\data\new feitsui 4\0507txt\0507.wdm  
PERLND 101 PHOS-FSTPM  
ERROR/WARNING ID: 218 2  
Buttons: Pause, Cancel, Output
- HSPF Problem** dialog box:  
Error interpreting UCI File 'newproject-10'.  
See the file 'NewProject-10.ech' for more details.  
Buttons: Continue, View Errors

The bottom status bar of the WinHSPF Error View window shows: << < 3 > >> of 14, FORTRAN Outp, Close, Print, Find, ERROR



# BASINS 模式-金瓜寮範例

## ■ 出圖



The screenshot displays the GenScn software interface for a project named 'newproject-10'. The main map area shows a watershed boundary in red and stream reaches in blue. The interface includes a menu bar (File, Analysis, Map, Locations, Scenarios, Constituents, Time Series, Help) and a toolbar with various navigation and editing tools. Below the map is a legend with two entries: 'Stream Reach Shapefile (net) (nwgrd1net.shp)' represented by a blue line and 'Watershed Shapefile (nwgrd1w.shp)' represented by a red square. On the right side, there are three panels: 'Scenarios' (1 of 8) with a list including 'NEWPROJE', 'OBSERVED', and several 'PT-' entries; 'Constituents' (3 of 14) with a list including 'CLOU', 'DEWP', 'DNUST4', 'DNUST6', 'EVAP', 'FLOW', 'PEVT', and 'PREC'; and 'Time Series (0 of 33)' which is currently empty. At the bottom right, there are sections for 'Dates' (set to '<not set>') and 'Analysis' with a row of icons for various analytical functions.

# 金瓜寮範例-選擇出圖內容

GenScn: newproject-11

File Analysis Map Locations Scenarios Constituents Time Series Dates Help

**Locations**

Graph

Select desired plots, then press Generate.

Multiple WQ Plots

Standard

Residual (TS2 - TS1 vs. time)

Cumulative Difference vs. time

Bar Chart

Flow/Duration

Difference (TS2 - TS1) vs. TS1

Scatter (TS2 vs. TS1)  45 deg/regress lines

Current Period  Storms

W

Stream Reach Shapefile (net) (nwgrd1 net.shp)

bound

**Scenarios**

2 of 5

All  Location

NEWPROJE  
OBSERVED  
PT-1  
PT-2  
PT-25

**Constituents**

3 of 19

All  Location

DNUST4  
DNUST6  
DQAL1  
EVAP  
FLOW  
NUST4  
PEVT  
PREC

**Time Series (27 of 61)**

DSN	Scenario	Location	Constituent	Start	SJDay	E
1014	NEWPROJE	RCH6	DNUST4	2006/1/1	53736	2
1025	NEWPROJE	RCH6	FLOW	2006/1/1	53736	2
1019	NEWPROJE	RCH8	DNUST4	2006/1/1	53736	2
1028	NEWPROJE	RCH8	FLOW	2006/1/1	53736	2

**Dates**

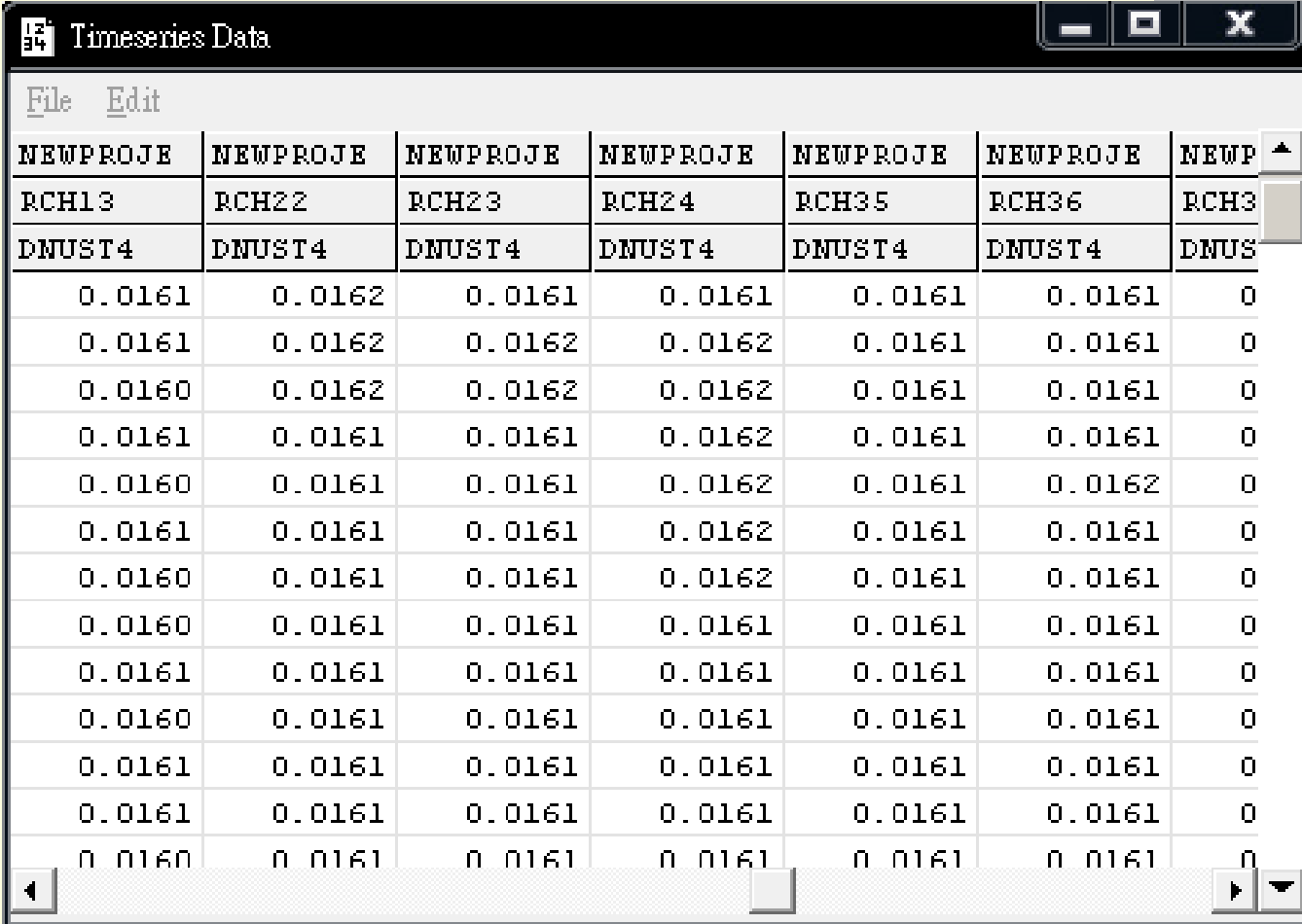
Start  End  TStep,Units

Current  to

Common  to

**Analysis**

# 金瓜寮範例-模式輸出的格式



The screenshot shows a window titled "Timeseries Data" with a menu bar containing "File" and "Edit". The window displays a table with 7 columns and 13 rows of data. The columns are labeled with variable names: NEWPROJE, RCH13, DNUST4, NEWPROJE, RCH22, DNUST4, NEWPROJE, RCH23, DNUST4, NEWPROJE, RCH24, DNUST4, NEWPROJE, RCH35, DNUST4, NEWPROJE, RCH36, DNUST4, and NEWP. The data values are numerical, ranging from 0 to 0.0162. The table is scrollable, with horizontal and vertical scroll bars visible at the bottom and right edges.

NEWPROJE	NEWPROJE	NEWPROJE	NEWPROJE	NEWPROJE	NEWPROJE	NEWP
RCH13	RCH22	RCH23	RCH24	RCH35	RCH36	RCH3
DNUST4	DNUST4	DNUST4	DNUST4	DNUST4	DNUST4	DNUS
0.0161	0.0162	0.0161	0.0161	0.0161	0.0161	0
0.0161	0.0162	0.0162	0.0162	0.0161	0.0161	0
0.0160	0.0162	0.0162	0.0162	0.0161	0.0161	0
0.0161	0.0161	0.0161	0.0162	0.0161	0.0161	0
0.0160	0.0161	0.0161	0.0162	0.0161	0.0162	0
0.0161	0.0161	0.0161	0.0162	0.0161	0.0161	0
0.0160	0.0161	0.0161	0.0162	0.0161	0.0161	0
0.0160	0.0161	0.0161	0.0161	0.0161	0.0161	0
0.0161	0.0161	0.0161	0.0161	0.0161	0.0161	0
0.0160	0.0161	0.0161	0.0161	0.0161	0.0161	0
0.0161	0.0161	0.0161	0.0161	0.0161	0.0161	0
0.0161	0.0161	0.0161	0.0161	0.0161	0.0161	0
0.0160	0.0161	0.0161	0.0161	0.0161	0.0161	0

---

THE END

THANK YOU~