A PROTOTYPE OF DECISION SUPPORT SYSTEM FOR ECOLOGICAL URBAN RIVER RESTORATION

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KOREA INSTITUTE OF CONSTRUCTION TECHNOLOGY

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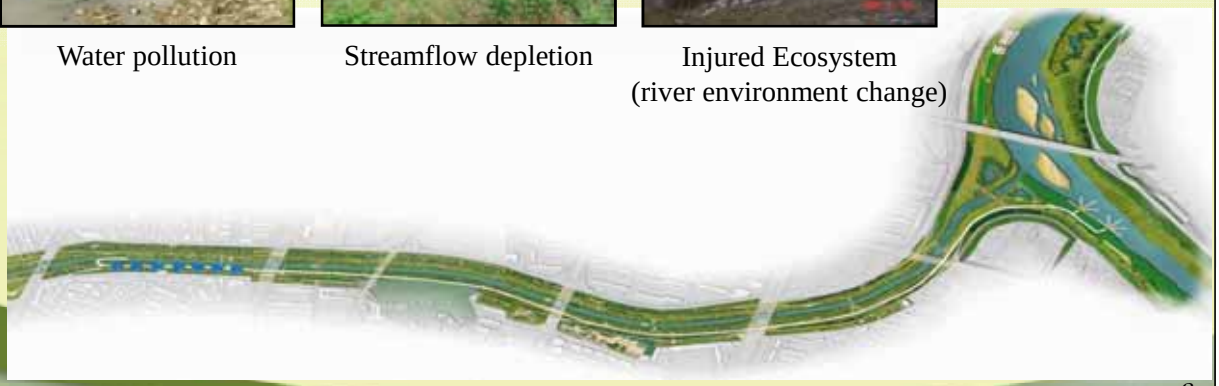
Background Ⅰ

"Peculiar River Environment Deterioration" due to urbanization and expansion of WWTPs

Water pollution

Streamflow depletion

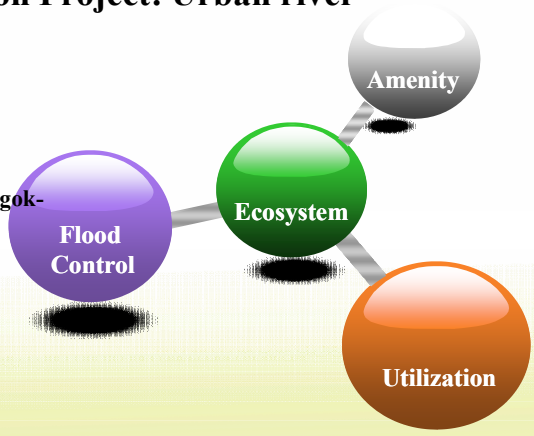
Injured Ecosystem
(river environment change)



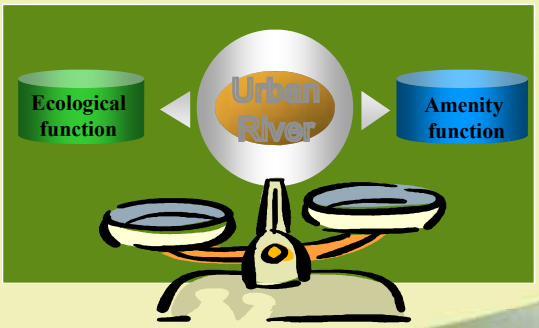
Background Ⅱ

Domestic Cases of Ecological River Restoration Project: Urban river

- **Cheongge-cheon, Bulgwang-cheon, Dorim-cheon in Seoul City**
- **Gulpo-cheon, Seongji-cheon in Incheon City**
- **Sin-cheon in Daegu City**
- **Taehwa river in Ulsan City**
- **Daejeon-cheon in Daejeon City**
- **Anyang-cheon, Hakeui-cheon, Osan-cheon, Gyeongan-cheon, Sangok-cheon in Gyeonggi province**
- **Cheongan-cheon, Wonseong-cheon, Dangjin-cheon in Chungnam province**
- **Jeongju-cheon, Nosong-cheon in Jeonbuk province**
- **Gwangju-cheon in Jeonnam province**
- **Changwon-cheon, Nam-cheon in Gyeongnam province**
- **Sanji-cheon in Jeju province, and so on**



Gyeongan-cheon, Gwangju, Gyeonggi province



Research Objectives

- To review the concept of ecological water resource and the techniques utilizing multiple ecological water resources
- To study the application of integrated water quality & quantity management technique for “ecological river restoration”

Prototype of Decision Support System

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Part 1.

Ecological Water Resources
considering Water Quantity, Water Quality and Ecosystem

Definition of Ecological Instream Flow

❖ Estimation of ecological instream flow

England, America, Australia, Austria and Europe

→ PHABSIM(Physical Habitat Simulation System)

Japan → 'normal flow' etc.

Korea → initial stage to apply PHABSIM: HSI(Habitat Suitability Index) and other indices

❖ Definition of Ecological Instream Flow

- "Minimum maintenance flow satisfying
  Natural function + Artificial function +Ecological function"
- Ecological instream flow = max(Low Flow, Water Quality Maintenance flow, Ecological Maintenance Flow)

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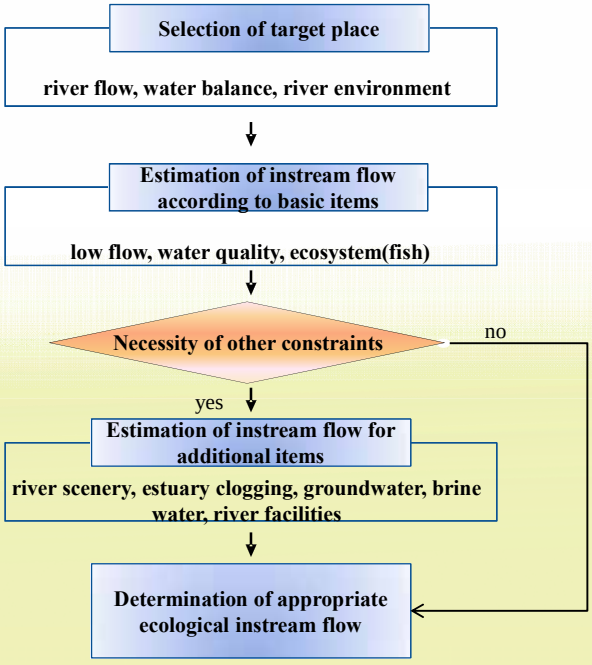
Estimation of Appropriate Ecological Instream Flow

Classification	Estimation Method
Appropriate instream flow	Selection of maximum flow among instream flows for low flow, water quality and ecosystem
Instream flow for water quality	Instream flow for conservation of river ecosystem considering water quality and each river's characteristic
Instream flow for ecosystem	Instream flow by selection of target fish species considering river's regional, natural, social, cultural and economic characteristics



Source: The Study for Estimation of Instream Flow to Improve Natural & Social Environment, **Ministry of Land, Transport and Maritime Affairs, 2007**

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Estimation of Instream Flow for Water Quality Ⅰ

❖ Monitoring Items for Ecoriver

Classification		Item
Water Quantity		flow rate, flow velocity, depth
General Items		pH, water temp., DO, turbidity, BOD, EC, (COD)
Water Quality	Nutrients	T-N, T-P, PO_4-P, (TOC, DOC)
	Amenity	total coliform, fecal coliform, chlorophyll-a
	Ammonia toxicity	NH_3-N, total ammonia
	Heavy metals	Zn, Cu, Cd
	Toxic materials	aniline, chloroform, 2,4-dichlorophenol, naphthalene, phenol, formaldehyde
	Endocrine disruptors	4-t-octylphenol, nonylphenol, bisphenol A, 17β-estradiol, estrogen
Ecosystem	Attached algae	TDI(Trophic Diatom Index)
	Fish	IBI(Index of Biotic Integrity)
	Benthic macroinvertebrates	KSI(Korean Saprobic Index)
	Habitat and waterfront	Habitat and waterfront index

Estimation of Instream Flow for Water Quality Ⅱ

❖ Guideline of Water Quality for Ecoriver

Grade II or "a little better" level: based on "Guideline for River Water Quality and Environment (Korea)"

Target water quality of T-N, T-P, NH_3-N and heavy metals: based on monitoring DB

Grade		Status (Character)	Guideline					
			pH	BOD (㎎/L)	TSS (㎎/L)	DO (㎎/L)	Coliform (Colony/100 mL)	
							Total coliforms	Fecal coliforms
A litter better	II		6.5 - 8.5	Less than 3	Less than 25	More than 5.0	Less than 1,000	Less than 200

Estimation of Instream Flow for Ecosystem

❖ Appropriate range of water quantity and quality according to target fish

Selection guideline
- Regional representative
- Dominant species
- Sensitivity for flow rate change

Consideration

Selection condition
- Growth status of rehabilitation target species
- Ecological requirements
- Habitat hydraulics

Habitat hydraulics (water quantity)
- flow rate(m^3/s)
- velocity(m/s)
- depth(m)

Water quality requirements
- general: 10 items
- nutrient: 5 items
- heavy metals and so on: 17 items

Ecological requirements according to growth status of target species
- juvenile stage
- spawning season
- mature stage

▪ Appropriate water quantity and quality conditions according to target species (mature stage)

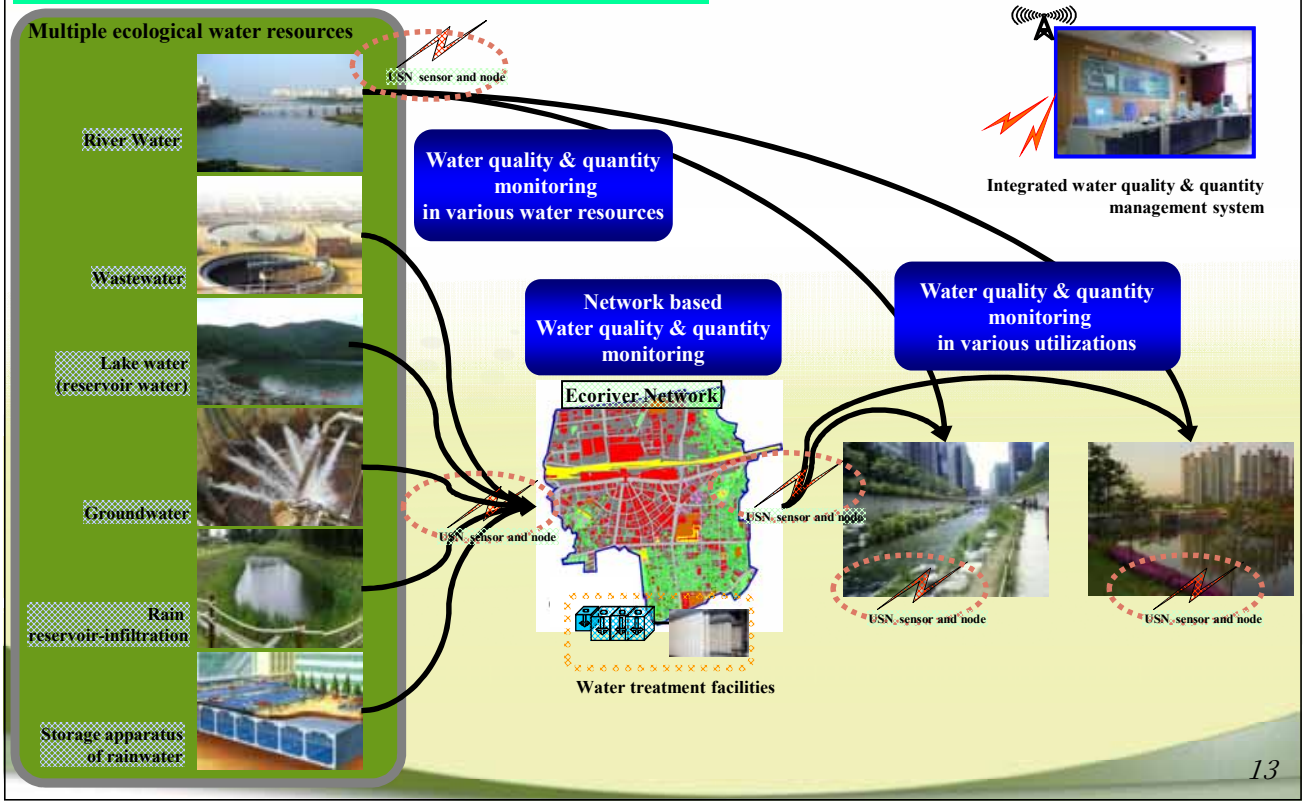
Grade	Representative fish species	Water quantity		Water quality		
		velocity(cm/s)	depth(m)	DO(mg/L)	BOD(mg/L)	pH
Ⅰa (very good) ~ Ⅰb (good)	trout	30~120	0.3~1.0	9+	1~2	7
Ⅰb (good) ~Ⅲ (fair)	Coreoleuciscus splendidus	30~80	0.2~0.5	5+	2~5	7
Ⅲ (fair) ~Ⅳ (poor)	minnow	30~60	0.3~0.5	3+	5~8	7
Ⅳ (poor) ~Ⅵ (very poor)	carp	20~30	0.3~1.0	2+	8~10	6~7

Part 2.

Development of Decision Support System
for Ecological Urban River Restoration & Rehabilitation:
EcoR3-DSS

Hypothetical Network of Ecoriver

Integrated water quality & quantity management system using network sensing



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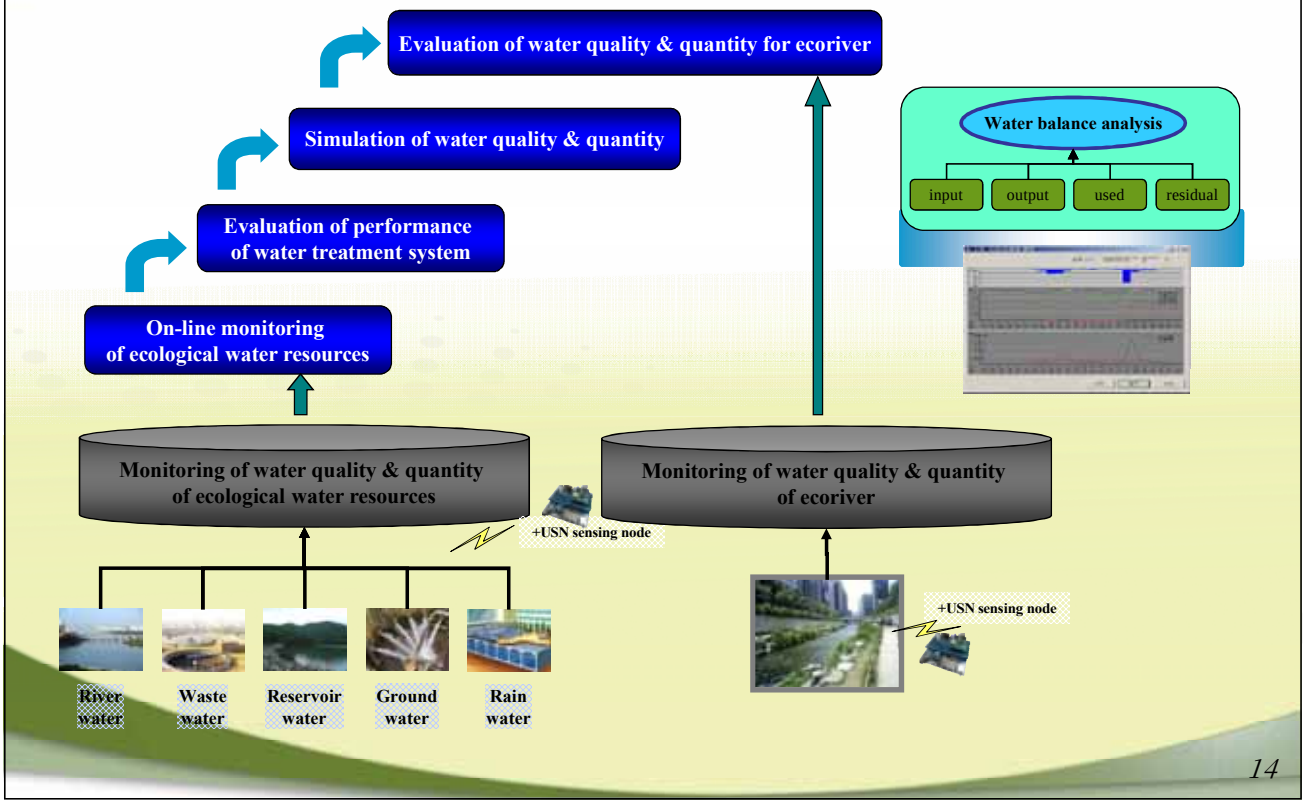
Monitoring, Simulation and Evaluation Steps for Development of Decision Support System



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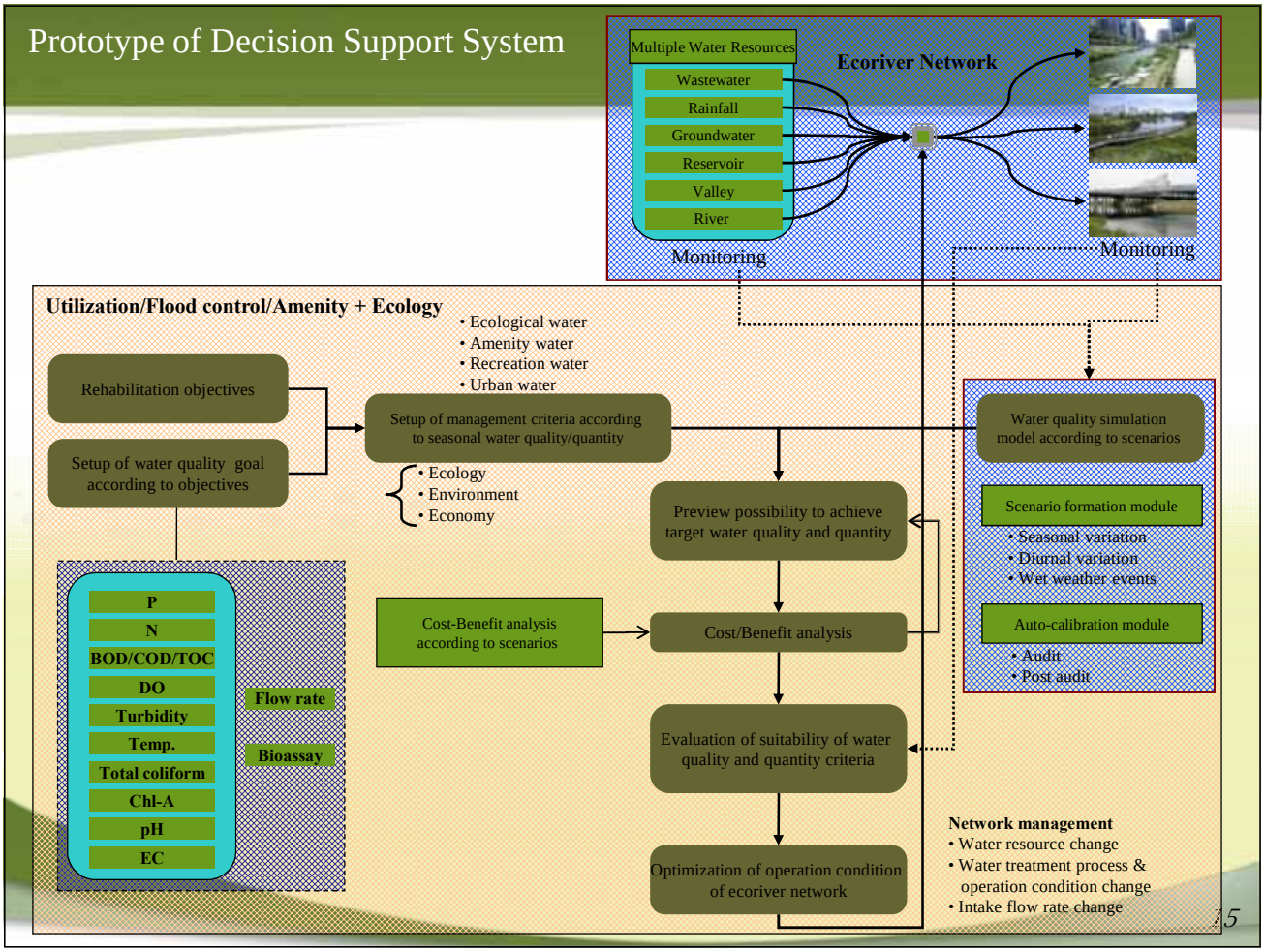
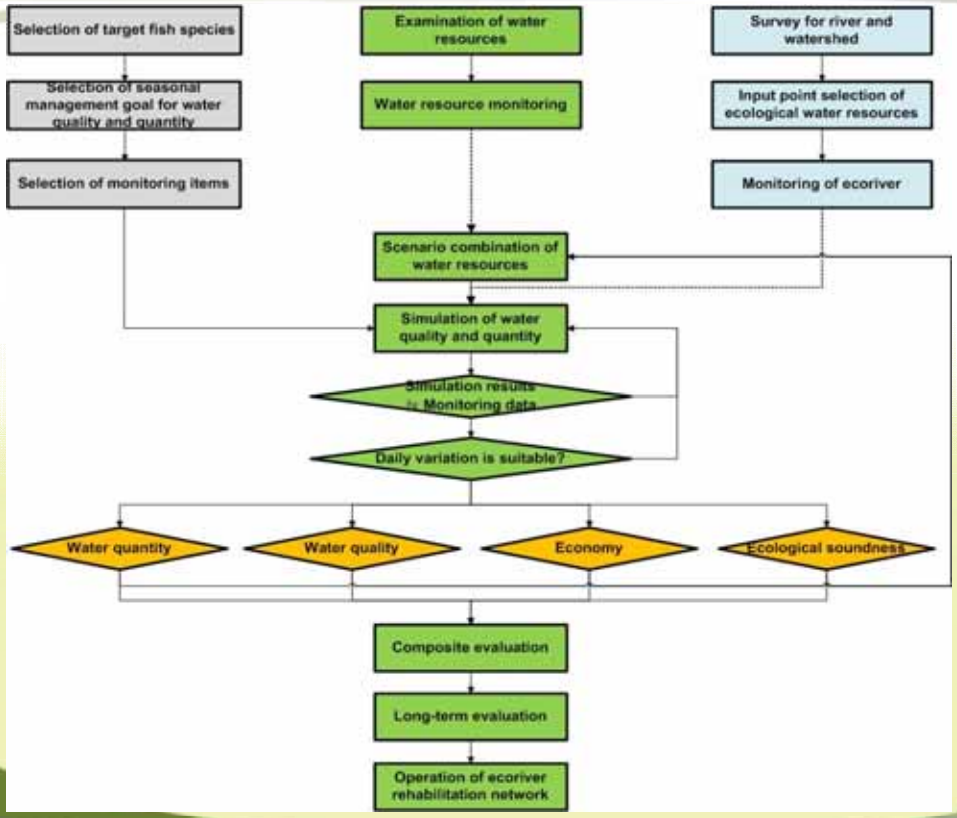
Prototype of Decision Support System



Basic Logic of Decision Support System: EcoR3-DSS



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Part 3.

Application of EcoR3-DSS for a Test-Bed

Preliminary Test-Bed Survey Ⅰ

❖ **Test-Bed site(Saet-gang in Paju City)**

- Non-point sources of farmlands and Paju publishing Center nearby

- Water resource: Detention Pond
- HDF treated Water

- **Target Water Quality: "Guideline for River Water Quality and Environment"**
- **Status: Grade Ⅲ~Ⅵ based BOD**

Preliminary Test-Bed Survey Ⅱ

❖ Water Quality at Test-Bed on 22th July, 2010

	Head Water	Target Spot	End Water
pH	7.2	6.9	7.0
BOD (mg/L)	2.3	5.1	14.8
T-N (mg/L)	1.65	0.20	4.75
T-P (mg/L)	0.36	0.55	1.42
SS (mg/L)	16.0	9.0	60.0
TOC (mg/L)	2.51	3.59	5.32
Chlorophyl-a (mg/㎥)	2.8	2.3	1031.6
Total Coliforms (CFU/mL)	1.56	1.44	517
Zn(mg/L)	0.01	0.02	0.11
Cu(mg/L)	0.000	0.000	0.001


Head Water

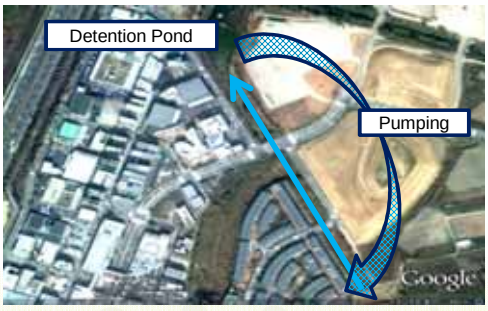

Target Spot

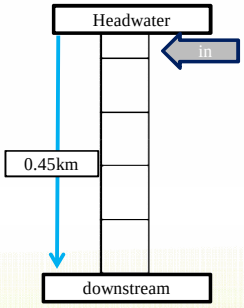

End Water

Endocrine disrupters: N.D
(Heptachlor, Aldrin, Hepta-epoxide, Endosulfan, 4,4'-DDE, Dieldrin, Endrin, 4,4'-DDD and 4,4'-DDT)

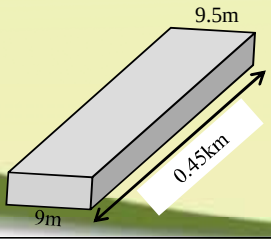
Application of EcoR3-DSS Ⅰ

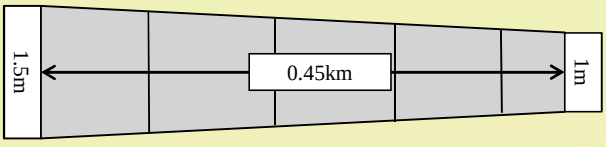
❖ Model Establishment using imbedded QUAL2K





No.	Name	Classification	Length (km)	Width (m)	Elevation (m)
1	S-stream Head	Main stream	0	1.0	9.5
2	S-stream 1	Main stream	0.05	1.1	9.4
3	S-stream 2	Main stream	0.15	1.2	9.3
4	S-stream 3	Main stream	0.25	1.3	9.2
5	S-stream 4	Main stream	0.35	1.4	9.1
6	S-stream 5	Main stream	0.45	1.5	9.0



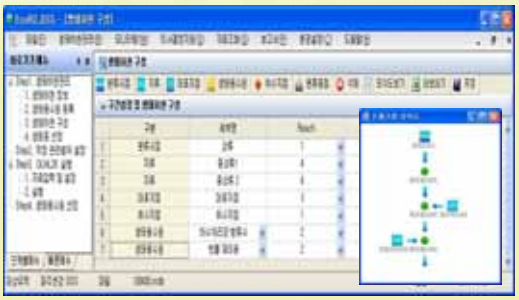


Application of EcoR3-DSS Ⅱ

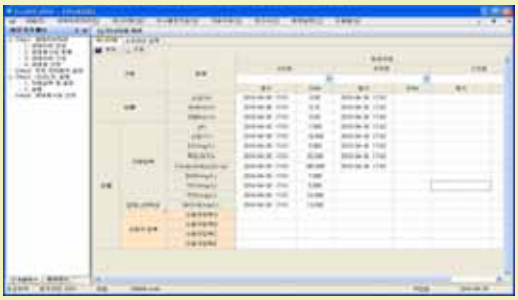
❖ EcoR3-DSS UI(User Interface): Database Input Module

<1. River Information>

<2. Ecological Water Resources>



<3. Configuration of Ecoriver >

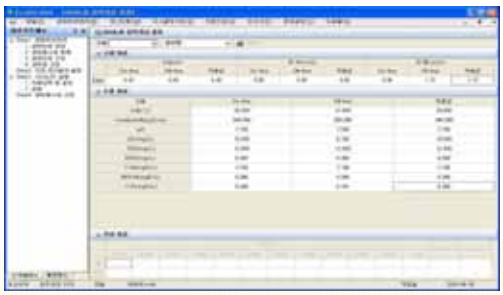


<4. On/Off-line Monitoring>

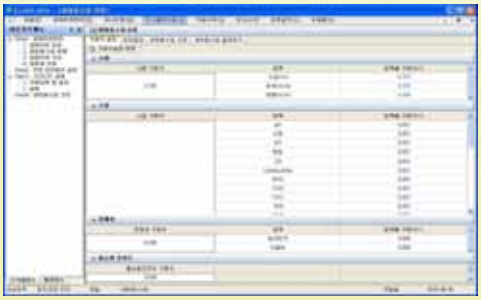
Application of EcoR3-DSS Ⅲ

❖ EcoR3-DSS UI(User Interface): Decision Support Module

<5. Management Range of Water Quality & Quantity>



<6. QUAL2K Input Data>



<7. Selection of Ecological Water reflecting Weighting Factor>

<8. Option Setting>

Application of EcoR3-DSS Ⅳ

❖ Scenarios according to Water Resources

Water Resource	Scenario (ratio %)				Usable max amount (m^3/d)	Water quality					Construction cost (one hundred million)	Production cost (won/d)	Ecological soundness
	S1	S2	…	Sn		BOD	COD	SS	TN	TP			
Pond	0	0	…	0	> 500	7.5	18.6	11.7	4.4	0.26	1.5	20	70
Treated pond	0	30	…	0	500	5.3	13.0	5.8	3.5	0.16	3	50	70
Effluent of WWTP	30	0	…	100	16,000	2.7	4.7	3.4	4	0.20	20	50	60
Rain water	70	70	…	0	250	21	23.6	10	0.49	0.35	1	1	90

application

Application of EcoR3-DSS Ⅴ

❖ Simulation Results

Scenario 1
Scenario 2
Scenario 60

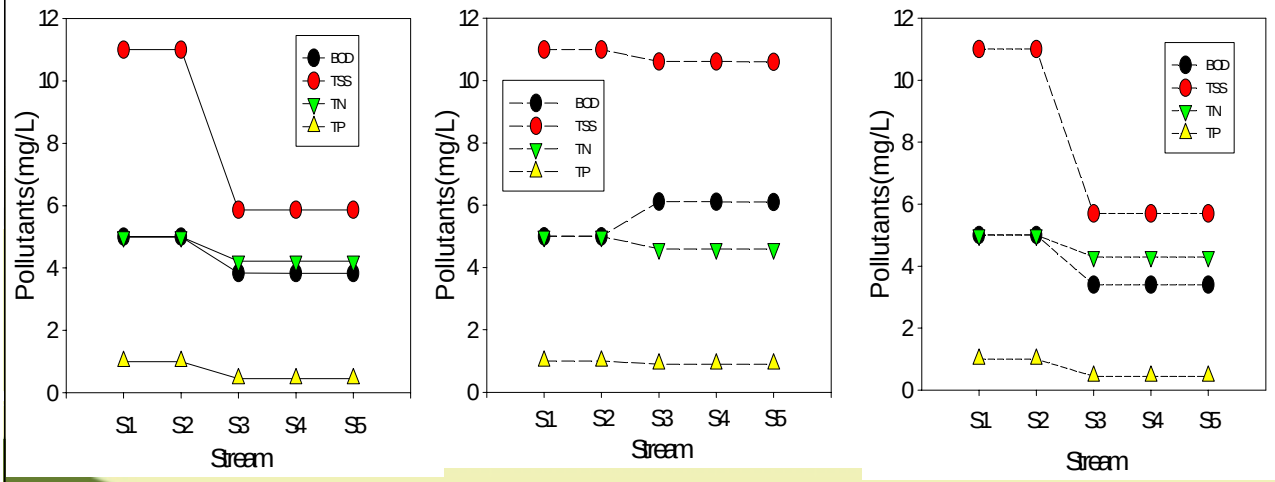
	Total point	Combination ratios			Water quantity				Water quality					
		rain water(%)	WWTP (%)	treated pond (%)	수심	유속	유량	수량점수	수온	Conductivity	pH	DO	SS	BOD
1	51.71	70	30	0	0.173	0.27	0.047	20.118	19.917	111.993	7.576	9.308	13.347	4.557
2	50.62	70	0	30	0.302	0.348	0.105	17.142	20.404	255.002	7.191	8.667	17.034	3.916
3	50.22	70	10	20	0.261	0.328	0.086	16.592	20.315	228.94	7.246	8.79	16.362	4.033
4	50.19	60	0	40	0.347	0.369	0.128	17.793	20.475	275.666	7.152	8.568	17.567	3.823
5	50.09	70	20	10	0.219	0.302	0.066	16.042	20.174	187.602	7.343	8.979	15.296	4.218
6	49.78	60	10	30	0.309	0.352	0.109	17.244	20.417	258.815	7.184	8.649	17.132	3.899
7	49.77	50	0	50	0.391	0.386	0.151	18.445	20.524	290.035	7.126	8.498	17.937	3.758
8	49.39	60	40	0	0.182	0.277	0.05	15.595	19.979	130.422	7.51	9.23	13.822	4.475
57	44.44	10	90	0	0.224	0.306	0.068	16.105	20.194	193.469	7.328	8.953	15.447	4.192
58	44.3	0	80	20	0.313	0.354	0.111	17.306	20.425	261.022	7.18	8.638	17.189	3.889
59	43.89	0	90	10	0.274	0.334	0.091	16.756	20.345	237.891	7.227	8.748	16.593	3.993
60	43.49	0	100	0	0.232	0.311	0.072	16.207	20.224	202.295	7.307	8.913	15.675	4.152

Economy			Ecological soundness (point)
설산단가	사업비	경제성총점	
17.5	36	53.5	81
32.5	21	53.5	84
27.5	26	53.5	83
35	18	53	82
22.5	31	53.5	82
30	23	53	81
37.5	15	52.5	80

Application of EcoR3-DSS VI

❖ **Examples of Simulation Results according to Scenarios (BOD, TSS, TN, TP)**

Scenario 1	Scenario 2	Scenario 60
Ecological water resources :Rain water 70%, Effluent WWTP 30%	Ecological water resources :Rain water 70%, Treated pond 30%	Ecological water resource : Effluent WWTP 100%



Conclusion

I. The **Network** between multiple water resources and ecoriver was reviewed.

II. **Prototype of decision support system** to satisfy both water quality and quantity in ecologically sound urban river restoration was suggested.

III. **Using EcoR3_DSS, several simulations** have been conducted successfully with the consideration of the domestic water quality guidelines, and the applicability of the prototype was examined.

IV. It is expected that the future research would be activated by means of the guidance of the prototype established through the study.

Thank you for your attention…

Background III

Paradigm Shift of River Management
Water Utilization and Flood Control
⇒ Conservation of River Ecosystem

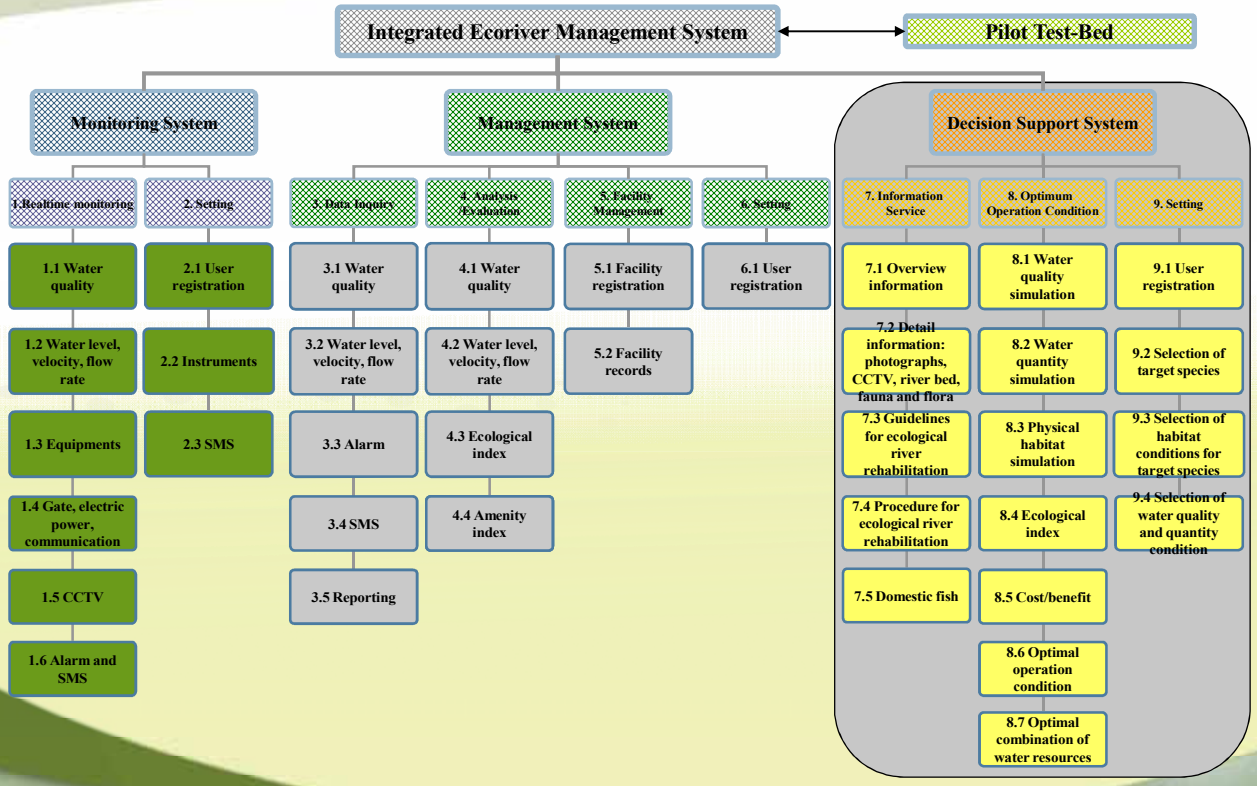
- Ecological soundness: Park → Naturalization
- Integrated Watershed Management: Line → Area
- Substantial Outcome: Work oriented → Target oriented

Ecoriver with fish and children swimming

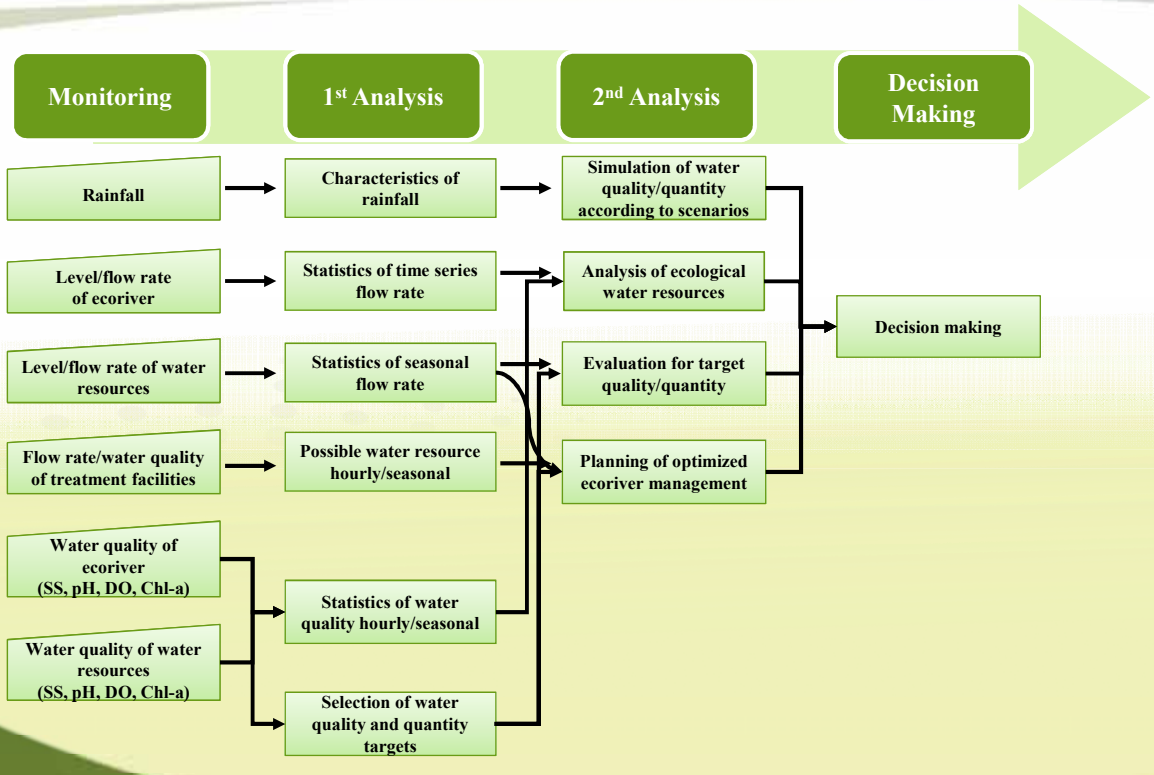
- Habitat for wild fauna and flora
- Environment-friendly place for citizens
- Conservation of ecological soundness

Source: 10-year plan for Ecoriver, Korea Ministry of Environment (2007)

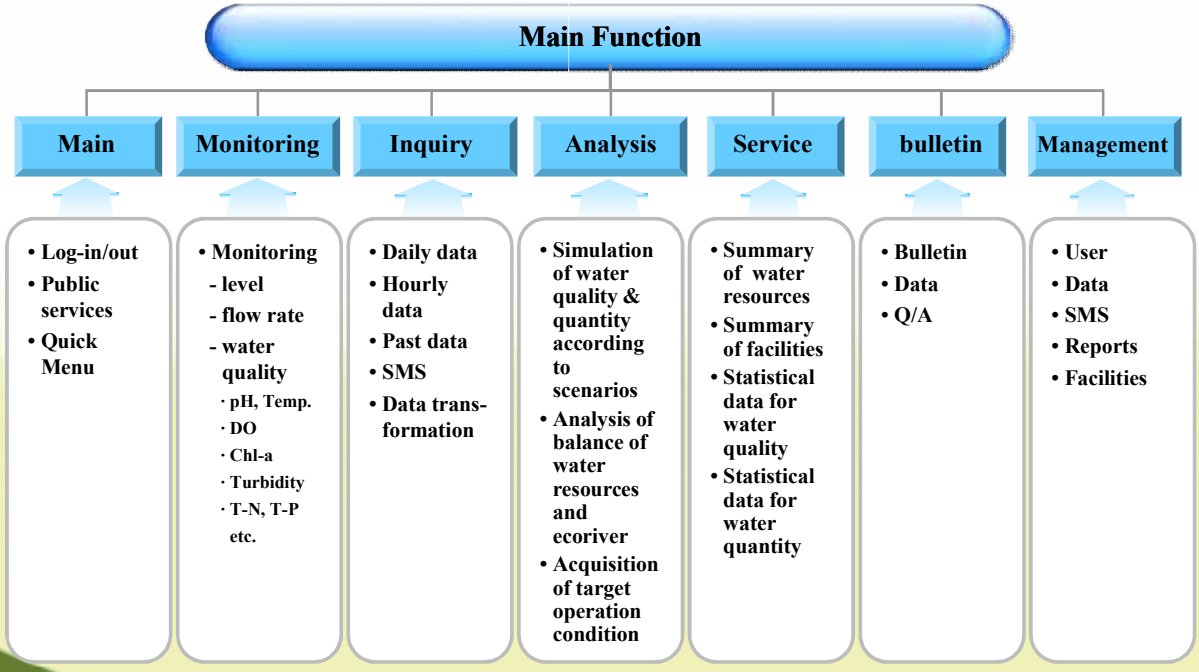
Organization of Ecoriver Management System



System Diagram of Decision Support System



Platform Design of Decision Support System: EcoR3-DSS



Application of EcoR3-DSS Ⅶ

❖ Application Example of EcoR3-DSS